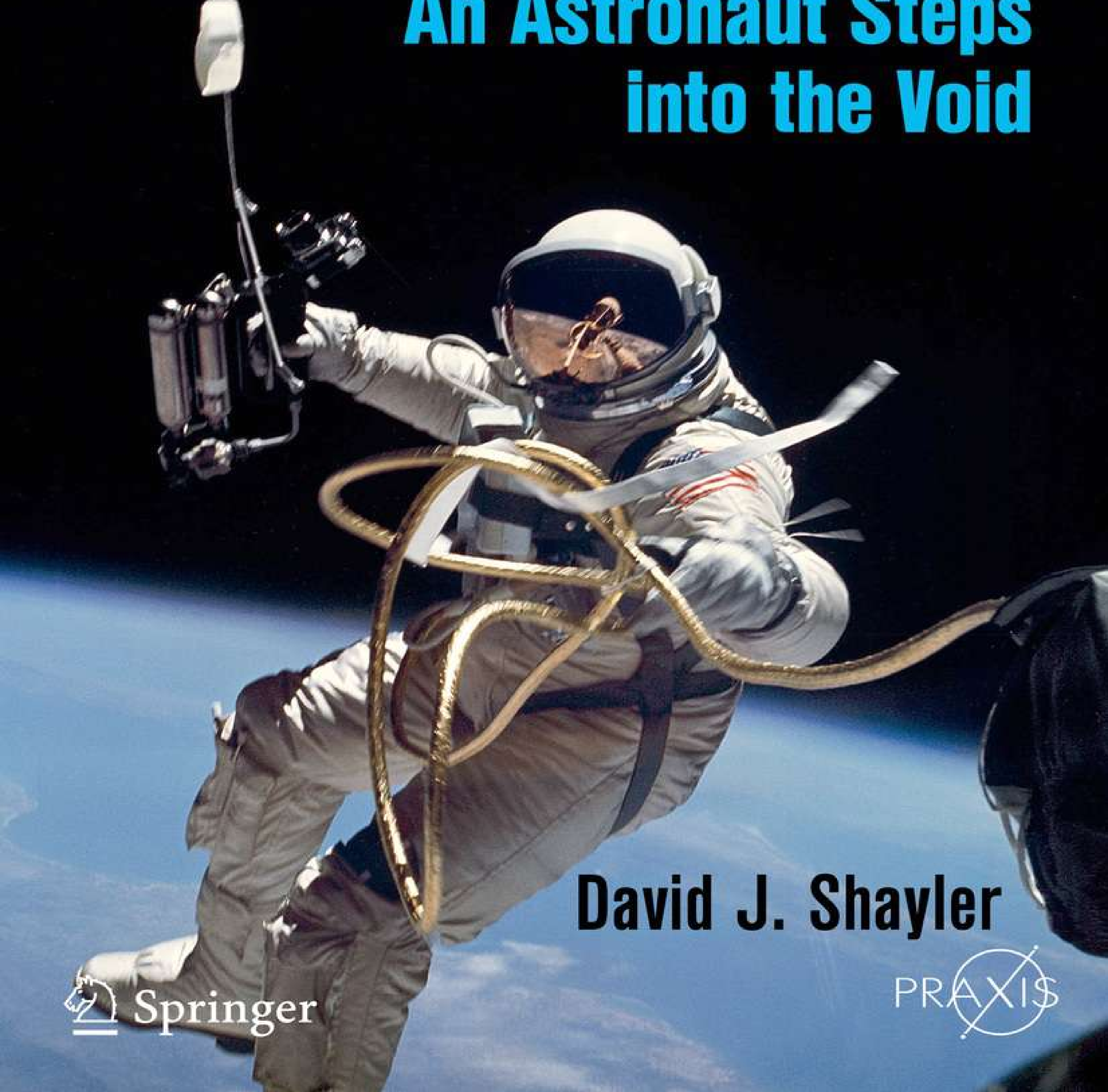
PIONEERS IN EARLY SPACEFLIGHT

GEMINI 4

An Astronaut Steps into the Void



David J. Shayler

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Gemini 4An Astronaut Steps into the Void

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David J. Shayler
Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

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COVER IMAGE CAPTIONS:
(Front Cover): A classic image from Gemini 4. Pilot Edward H. White II becomes the second man and first American to walk in space. June 3, 1965.

(Back Cover) [Top] The Gemini 4 prime crew wearing full G-4C pressure suits. Pilot Edward H. White II (left) is accompanied by Command Pilot James A. McDivitt (right). [Courtesy Ed Hengeveld]. [Bottom] The front cover design for the next book in this series: Gemini 5, Eight Days in Space or Bust.

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Dedication

To the crew of Gemini 4

James A. McDivitt

&

Edward H. White II (1930–1967)

As the previous volume in this series was being completed, the news was announced of the sad loss of the Pilot of Gemini 3 & Command Pilot of Gemini 10

John W. Young (1930–2018)

Then, as this current volume was being prepared, a further blow to the space community was felt with the loss of former Gemini 10 Back Up Command Pilot and later Apollo & Skylab crewmember Alan L. Bean (1932–2018)

This book is also dedicated to their memory and achievements.

Foreword

The space race was heating up in the early 1960s. President Kennedy's famous speech in September of 1962 dropped the official flag on the start of the formal race to the Moon. Sputnik and Yuri Gagarin's flight were just the Soviet equivalent of a teenager revving up the engines of his hot rod at the starting line while glancing over to his competitor; the American kid. But the challenge was accepted, even though the kid's car was a jalopy in comparison.

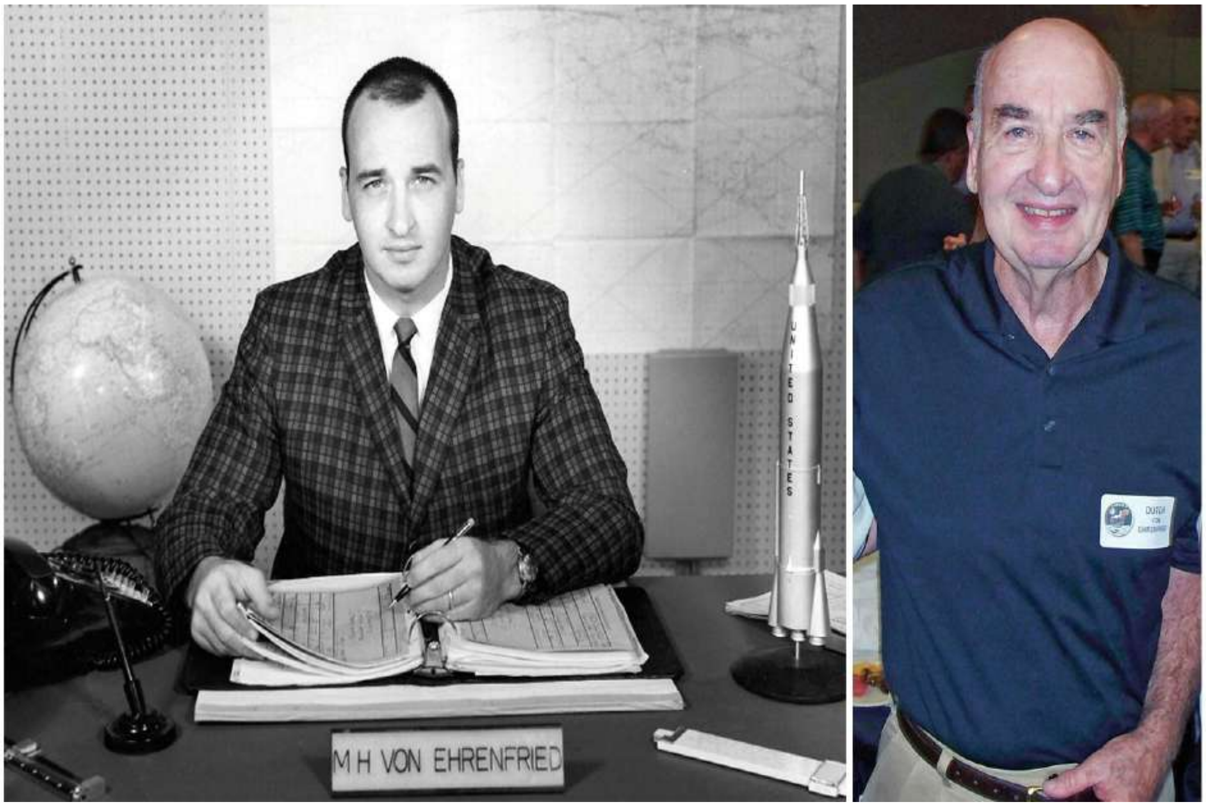
A couple of years after Gagarin, in 1963, the Americans completed Project Mercury, but the Soviets began launching people into space only days apart; even a woman! By 1964, it became a race between the two-man Gemini spacecraft and the three-man Voskhod spacecraft. Then, by 1965, it became a race between who could accomplish a rendezvous and who could conduct an extra-vehicular activity (EVA), now known by the public as a "spacewalk."

On March 18, 1965, the Voskhod 2 spacecraft carrying Pavel Belyayev and Alexei Leonov was launched. On the second orbit, Leonov conducted the first EVA. It was only short, as it was plagued with serious problems not publicly known at the time, even in the Soviet Union. Many years later, I had the opportunity to meet with Leonov personally and discuss his suit problems. At this point in the race, the Soviets beat us to this milestone, just as they had beaten us to others in the race to the Moon.

Less than a week later, on March 23, 1965, the Americans proved that the Gemini spacecraft was a great design, as was the Titan II launch vehicle. Gus Grissom and John Young checked out the spacecraft's new capabilities over three orbits. The following week, the Manned Spacecraft Center Director, Robert Gilruth, convened a group of experts and decided that the next Gemini flight would conduct a full EVA; not just standing up on the seat with the hatch open, as was the original plan. This would require a new piece of equipment called the "Hand-Held Maneuvering Unit" (the HHMU, aka the "jet gun") and involved more planning as well as mission rules should anything go wrong.

GT-4 was to be a mission of relative endurance, as it would be longer than all of our previous manned flights combined. It was also the first mission flown from the new Houston Mission Control Center. Due to the long mission duration, the MCC would require three shifts of flight controllers. The Red Team Flight Director was Chris Kraft, the White Team Flight Director was Gene Kranz (his first mission as a Flight Director) and the Blue Team Flight Director was John Hodge.

Even before Leonov's EVA, Ed White had been training for an EVA of his own. It wasn't until after GT-3's successful flight that Chris Kraft advised Gene own. It wasn't until after GT-3's successful flight that Chris Kraft advised Gene Kranz, Head of the Flight Control Operations Branch, that an EVA was being considered and that Gene should secretly begin developing the mission rules. This activity began in early April and a special subset of Mission Rules, called Plan X, included a rendezvous with the Titan booster's second stage as well as the EVA.



(left) Manfred 'Dutch' von Ehrenfried in 1961. Four years later, he served as Assistant Flight Director (Red Team) for Gemini 4. (right) 'Dutch' von Ehrenfried in 2009. [Courtesy Manfred von Ehrenfried].

While I was the coordinator for the main Mission Rules document, I didn't get the word about the EVA until I was asked to attend a secret meeting with the EVA team. One day in May, I attended a meeting with Ed White, General Bollander from NASA Headquarters, a Crew Systems engineer and another man from the Engineering Department.

We went over the Plan X rules and I reported the results back to Kranz. On May 10, Kranz called in all of the Capcom flight controllers who were deploying to the remote sites around the world and gave them the sealed Plan X package, with instructions not to open them until they got instructions from him. If no instruction was given, they had to be returned unopened. On or about May 27, the go for EVA came down from NASA Headquarters and all the flight controllers were advised and thoroughly briefed.

On June 3, 1965, only 41 days after Grissom and Young had landed in Gemini 3 on March 23, Jim McDivitt and Ed White were launched on Gemini 4. After orbit insertion, the initial attempt to station-keep with the Titan II second stage did not go well. McDivitt's attempt to maneuver closer to the booster resulted in a retrograde maneuver which lowered the Gemini's orbit slightly and increased its speed and separation. The counterintuitive nature of orbital mechanics became obvious. The attempt was cancelled.

As Assistant Flight Director to Christopher Kraft, I was standing next to him during the EVA. Having worked on the Mission Rules, I knew what emergencies could arise and what our available options were for every perceived contingency. On the third orbit, the 'Go/No Go' was given by the Carnarvon Capcom. McDivitt and White began their decompression and suit checks and were given a Go for EVA by Gus Grissom, the MCC Capcom.

The control center was very quiet as all the flight controllers listened to the communications between McDivitt, White and Grissom. White maneuvered away from the spacecraft, while McDivitt took some now-famous photos, one of which hangs on my office wall signed by White. His signature is still vivid after over a half-century, while the sunlight has faded the color photograph.

As the orbit approached darkness, Kraft told Grissom to get White back in, which was relayed to McDivitt. White was having too good a time to come back in and had to be ordered in by the MCC, though this was relayed to White as more of a coaxing; "Come on, let's get back in here before it gets dark," said McDivitt. White responded, "It's the saddest moment of my life. I'm coming."

As races are often measured in small increments, Ed White's EVA would last twice as long as Alexei Leonov's. He would go out more than twice as far and the mission lasted four days vs. one. Like Leonov, Ed White also had some difficulty getting back in and closing the hatch. Fortunately, Jim McDivitt had previously experienced hatch problems in training and knew how to handle the situation.

This book will document one of the great missions of America's space program. It was a time when we realized that we had a space program that was capable of going to the Moon. We could do "the other things, not because they are easy, but because they are hard."

Manfred 'Dutch' von Ehrenfried

Red Team Assistant Flight Director

Gemini-Titan 4

Author's Preface

My earliest recollection of watching 'an astronaut walk in space' comes from fond childhood memories. Six years before I became hooked on real human spaceflight and the careers of those who flew the missions, I was an ardent fan of Colonel Steve Zodiac and his crew on Gerry Anderson's *Fireball XL-5* , as they patrolled Sector 25 in the outer reaches of space. Strange aliens, hostile planets and space criminals added to exciting adventures of this heroic crew. Yes, it was only a TV show and the main characters were marionette puppets, but it left an impression on the seven-year-old me. The 'walking in space' bit was memorable in that the *XL-5* crew simply popped an oxygen pill in their mouths and donned a jet-pack or used a space scooter to venture outside their spacecraft. Ah! The simple, innocent magic of childhood.

Of course a few years later, the teenage me had learned the realities of space flight from factual articles in boys' comics and adventure stories, in that a pressure garment was a necessary piece of kit to venture outside a spacecraft – a spacesuit. Then, when later reading about what the Apollo astronauts were to attempt in walking on the Moon, I also learned about the spacewalks and spacesuits of an earlier program called Gemini, a series of flights which had passed me by in favor of new TV heroes flying the *Thunderbirds* machines under the guise of *International Rescue* . Those vivid images from childhood of spacewalking adventures sowed the seeds for my life-long interest in the techniques and hardware of walking in space, formally called Extra-Vehicular Activity, or EVA.

Today, half-a-century later, science fiction has given way to a keen interest in science fact, the development of EVA techniques and the history of operations. In the ensuing years, I have penned a number of articles, delivered numerous presentations and written several titles focused around EVA and pressure suits. So when I embarked on this recollection of the Gemini missions, it not only enabled me to fill in the gaps I had missed as they happened, as a 10–11 year old, but also allowed me look deeper into the pioneering EVAs and pressure suits used on those missions than I was able to do for my earlier work on Gemini [*Gemini: Steps to the Moon*] in 2001.

The Soviets may have scored another headline-grabbing space first when cosmonaut Alexei Leonov conducted the world's first spacewalk in March 1965, but it was the American Gemini astronauts who took the next step and addressed the challenges of attempting to work and survive in open space. They were the ones to meet and overcome some of the basic problems facing anyone wearing a bulky pressure garment and trying to complete productive tasks in a bulky pressure garment and trying to complete productive tasks in a microgravity environment, with huge variations in temperatures, light and pressure, and always with defined time limits. Today, though never taken for granted, EVA is seen as an operational necessity for space station operations, for the repair and upgrading of satellites and vast space structures, and is famous for the human exploration on the Moon, with plans to return there and, one day, in the not too distant future, to explore the asteroids and the planet Mars.

Despite all the technology, advancement and complexity of modern day EVAs, each can be traced back to that pioneering first step outside a spacecraft by Leonov, and to the Gemini EVAs where humans first realized that leaving the spacecraft and working outside might not be as straightforward as first thought. Lessons learned from Gemini have had direct application over the decades beyond the historic Apollo lunar moonwalks, to dramatic satellite repairs and servicing missions on the Shuttle and on to space station maintenance. For the Americans, their EVA heritage can be traced back to a huge team effort over many years, but in particular to one flight and one man – Gemini 4 and Ed White.

When choosing a topic for the cover image for this book, there could really only be one: the dramatic EVA footage of Ed White outside Gemini 4, taken by his commander, Jim McDivitt, from inside the unpressurized spacecraft. Over five decades after the event, McDivitt’s shots of White’s walk in space on June 3, 1965, remain iconic images of the early years of the space program, somewhat at odds with the fact that White’s photogenic EVA was not the first spacewalk in history. Unfortunately for Alexei Leonov, he had to rely on primitive automated TV and movie imagery, as his commander, Pavel Belyayev, was still inside the pressurized compartment of Voskhod 2 without a suitable viewing window to record the event with better cameras.

Photographically crisper than the grainy images of Leonov’s historic first EVA, the Gemini 4 images, together with the Apollo 8 image of ‘Earth rise’ and the Apollo 11 image of Edwin ‘Buzz’ Aldrin standing on the Sea of Tranquility, are key milestones not only in human space exploration but also in photographic history and technological achievement. The fact that all these images are American is also interesting, because most of the ‘space firsts’ of the early years of the space age were achieved by the Soviets. However, the secretive and hidden nature of the Soviet program was the direct opposite of the openness of most of the American effort to conquer space. That secrecy, coupled with the apparent ease with which the Americans began to succeed, ironically led to problems in ‘selling the idea of human spaceflight’ beyond the Moon in both nations.

But the cover image tells only part of the story of Gemini 4; specifically, that of the first American to leave the safe confines of his spacecraft and venture out, ‘floating’ free in the weightless environment of space. Well, sort of. In truth, the forces of gravity governed every move and action, so ‘spacewalking’ and even ‘space floating’ are not really accurate descriptions. A better term would be ‘space falling’ in microgravity, but we have generally come to accept the terms ‘zero-g’, ‘spacewalking’, and ‘weightlessness’ over the last fifty or so years.

Gemini 4 was far more than just the single, 20-minute EVA early in a mission of over 97 hours, though that is what the mission is mostly remembered for. As the second manned Gemini to fly, this mission would also begin to extend America’s space endurance record, prior to the far more complex Apollo lunar missions. At the end of March 1965, America’s longest space flight experience for Gemini was only three orbits (five hours), from Gemini 3 that month. Indeed, the longest American spaceflight at all was just 22 orbits (36 hours) on the final Mercury flight, MA-9, in May 1963. Gemini 4 alone would push this to an impressive four days, effectively trebling the total American human spaceflight experience that had been accumulated in the six Mercury missions and one previous Gemini mission combined. The EVA itself was not exactly thrown in for good measure, but was included in the flight plan to fulfill an early objective of the program, and partly in response to the historic first snatched by the Soviets a few weeks earlier. But that was not all. Gemini 4 also paved the way for the more complex space rendezvous and proximity operations that would be necessary for project Apollo to reach the Moon using the Lunar Orbital Rendezvous (LOR) technique chosen. Though the exercise on Gemini 4 did not exactly go as planned, it was a step in the right direction pending the more dedicated missions to follow.

Another ‘objective’ for the mission is often overlooked: that of learning to live and work in the confinement of the spacecraft for four days, while also conducting a number of important observations from orbit and operating a range of experiments, thus expanding the scientific return from the flight.

The pioneering missions of Project Mercury and Gemini 3, and indeed those by the Soviets under the Vostok and Voskhod program, had established the fact that humans could survive and endure the launch, orbital flight, and re-entry and landing either on land or water, and could perform some useful smaller experiments and observations while on orbit. For the Americans, Gemini 4 became the flight with which they also began to learn the skills of truly exploring space. The first small step towards what would eventually become more routine operations, Gemini 4 gave NASA experience and confidence, but also early warnings that the skills required for space exploration would not be easily mastered. The mission was another step in the right direction and one from which their experience grew, to the point that today, fifty years later, ISS crews are routinely completing expeditions on the station of about four to six months.

This second volume in the series reveals the four days spent onboard Gemini 4, its buildup and aftermath. It is also about what the crew accomplished after they closed the hatch on America's first spacewalk and opened a new door of opportunity on the road to long-duration spaceflight.

When compiling the draft for this book, I became aware of the huge amount of information gleaned from flying the four-day Gemini 4 compared to the three short orbits of Gemini 3. This significant change in operations for those involved in the program at this time must have been dramatic, suddenly switching from short, relatively 'simple' missions to far more demanding activities with each flight, with little time between them and no time to lick any wounds or celebrate their successes before the next flight was on the pad. There was also a dramatic difference in the flight activities between the first four orbits of Gemini 4 and the entire mission of Gemini 3. Then there is the stark comparison to the rest of the Gemini 4 flight, with four days of paced activities, which at times must have seemed quite mundane to the press and presented a different challenge to the astronauts and flight controllers. These very different levels of intensity on this flight are the reason I have focused on the detail of those first four orbits or approximately six hours, summarized the remaining 58 orbits (90 hours) orbit by orbit, and then returned in some detail to the re-entry, recovery and post-flight activities.

The story of Gemini 4 did not end with the recovery and early analysis of its achievements and failures, however, nor with the two weeks of hectic post-flight activities for the crew. With Gemini 5 just weeks away, the lessons learnt from Gemini 4 had to be applied quickly in order to understand fully what was to come for those who would fly or control the next mission. That mission, in turn, was but a stepping stone to the ultimate goal of a 14-day flight, and that was without adding any docking activities or further EVA. Those activities were planned for the later missions. For this book, an in-depth analysis of Gemini 4's systems and procedures has not been included. Instead, it is carried over to the opening chapter of the Gemini 5 book. That mission would see the focus of the Gemini program intensify as the era of Apollo drew ever closer.

This is the broader plan for this series of books covering the 12 Gemini missions. The current mission was but a step in the overall success of the program and, for many reasons, was key to the planning and operations on next flight in the series. Each book can be read as a standalone title, but from Gemini 4, where the testing of the Gemini system really reached a pinnacle before the operational story took over, the ongoing evolution will be woven through the forthcoming titles. These books, therefore, do not replace, but only expand and supplement my original work on this intriguing program back in 2001.

David J. Shayler
July 2018

Acknowledgements

For this, the second in the series of nine books on the American Gemini missions, the bulk of the acknowledgements remain very similar to those quoted in the first volume, *Gemini Flies: Unmanned Flights and the First Manned Mission* [Springer-Praxis 2018]. As with any work of this magnitude, an ongoing network of contacts and sources is a vital resource and, as with every spaceflight, there is a huge support team on the ground. It is the same for the production of the finished book, with a huge infrastructure behind the scenes for each project, from the initial acceptance of the original proposal, through editing the draft manuscript, to layout, production and marketing.

Specifically for this project, I appreciate the continued support of my brother and Project Editor Mike Shayler, for his professionalism in seeing yet another of my projects through the quagmire of editorial and production levels. For Mike to convert my… unique scribblings and arrive at what you see here is no less than wordsmith alchemy.

Very special thanks are extended to former NASA flight controllers Manfred ‘Dutch’ von Ehrenfried for his excellent Foreword, and Jerry Bostick in recalling the early days of the NASA Mission Control room.

An appreciation is also given for the assistance of the family of Norman Shyken (1932–1978) of McDonnell Douglas Aircraft. Norman helped coordinate the work involved in the Gemini extra-vehicular activity program and was later an unsuccessful short-listed candidate for the NASA 1966 (Group 5) astronaut selection.

Special thanks are due to Ed Hengeveld and Joachim Becker of *SpaceFacts.de* who continue to find those rare images which just have to be included in the book; to my good friend and colleague Colin Burgess, for copies of contemporary Australian newspaper articles from his own collection; to David Harland for the supply of obscure Gemini documents; and to Michael Cassutt for his pioneering research into the workings, myths and realities of the NASA Astronaut Office at JSC. Thanks also to Colin Mackellar and Hamish Lindsey in Australia, for their work on detailing the history of Australian space tracking sites.

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Once again, the majority of images used in this book originate from NASA

Once again, the majority of images used in this book originate from NASA, various military service organisations, the author's own collection and those credited in the individual captions, unless specifically stated. However, despite extensive searches, I have been unable to determine the exact origin of some of the images. I would therefore welcome any input to enable me to credit the appropriate source.

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Finally, thanks go to my mother, Jean Shayler, who continues to be enthusiastic about each project we embark on; to my biggest supporter, my wife Bel, who looks forward to those promised river cruises we will take when I finally 'retire' from writing; and to a very patient and energetic German Shepherd named Shado, who has managed find a new play area in a local field to chase around in (him, not me!) before I get lost in my next project.

To all, a very large thank you.

Prologue

Taking a Walk in Space

Hatch covers are opened…

The spacemen step outside.
The world about them is silent,
with the black vault of infinity around them.
Stars, clear and untwinkling, brighten the somber veil.
Frank Ross Jr., Space Ships and Space Travel, 1956

The highly technical and physical activity of ‘stepping outside’ a spacecraft has always been fraught with danger and risk but, as portrayed in the lines above, it has also been the source for vivid imagination. For over 50 years, *Taking a Walk in Space* has captured the imagination, excitement and awe not only of those who conduct the activity, but also those who follow the exploits of the space explorers as they ‘crack the hatch’ and step outside into the void. Without doubt, the opportunity to perform a spacewalk, officially termed Extra-Vehicular Activity or EVA, ranks high on the bucket list of any space explorer.

Today, EVA is a fairly regular occurrence on the International Space Station. After thirteen years of assembling the bulk of the station, supported by teams of EVA astronauts and cosmonauts, an extensive program of station maintenance and repair is now being carried out regularly in orbit. That capability was honed during the American Shuttle program and by the crews of the Skylab (U.S.), Salyut and Mir (Russia) space stations over three decades, beginning in 1973. The ability to work in open space outside the protective cocoon of a spacecraft or space station is an important and integral element of space exploration, and will continue to be so for decades to come.

The history books rightly marvel at the achievements of Apollo and the series of moonwalks between 1969 and 1972, but the true genesis of operational EVA can be found in the series of EVAs conducted by a handful of astronauts in 1965 and 1966 under the Gemini program. These ten missions were a stepping stone approach to enable Apollo to reach the Moon successfully, but also provided a wealth of experience, a cadre of superbly prepared workers, technicians, engineers, controllers, astronauts and managers, and a range of answers to questions and lessons to learn. Some of these were easy to recognize and apply, others were not. The mission of Gemini 4 offered a real opportunity to test the early theories of rendezvous and proximity operations, an extended-duration spaceflight far longer than the 24 hours Mercury was capable of, and the first inevitable step outside on EVA. It is this last achievement that Gemini 4 is mostly remembered for, though the others should not be quickly overlooked as they contributed to a greater understanding of orbital ballet and long-duration spaceflight that has since been applied to Apollo, the Shuttle and ISS, and has been performed by the Russians and, more recently, the Chinese. For this volume, the focus is upon the EVA, as long-duration spaceflight and rendezvous and docking apply more aptly to later volumes in this series.

The suggestion of ‘dancing around an airlock’ was first seriously proposed by the Russian ‘Father of Cosmonautics’, teacher Konstantin Tsiolkovsky, whose 1933 paper *Album of Space Travel* included an image of a spacesuited astronaut exiting an airlock for access to open space, similar to the real achievement of cosmonaut Alexei Leonov on Voskhod 2 some 32 years later. Then, as recounted in this author’s earlier work, *Walking in Space* [Springer/Praxis 2004], the historical development of what we call EVA took a journey through science fiction and theoretical studies to more formal studies and proposals. During the 1950s, there were serious illustrated articles, books and papers exploring the physiological aspects of an astronaut leaving their spacecraft to work outside. These illustrations often portrayed heavy construction work, with teams of spacesuited astronauts welding, bolting and fabricating huge space stations or complexes high above the Earth. They explored challenges such as the dynamics of handling such massive pieces of hardware safely and efficiently, with the workers able to survive outside for more than a few minutes in adequate garments and life support systems that protected them from radiation and shaded their eyes from harmful solar rays, yet illuminated work areas in periods of orbital darkness.

In the early 1960s, the conditions were right to look seriously at opening the door of a spacecraft to begin operations outside the vehicle. Just a few short years after man first entered space, it was still a risky and daring proposal. The inclusion of EVA was an early objective of Gemini, but although it would be useful experience prior to Apollo, a walk in space would not have too much in common with walking in the reduced gravity environment of the Moon. Gemini provided experience of working in a vacuum, in a pressure garment and with tools and equipment, but the physical challenges on Gemini were more focused upon the upper body. For Apollo, the workloads on the lower limbs would have to be considered in physically walking over the undulating lunar surface. There were training aids available to simulate this as far as possible here on Earth; a selection of fixtures and rigs to simulate lunar EVA and similar facilities for practicing Gemini EVAs. At this stage though, in 1965, the benefits of using large water pools to simulate long periods of EVA in free space had yet to be realized, and the technique would not be applied until almost at the end of the Gemini program. Ed White’s successful excursion on Gemini 4 was an important early step in mastering the challenges of EVA, but its brevity also masked some of the difficulties of working in free space that the later Gemini EVAs astronauts would encounter.

Without doubt, Gemini 4 was a landmark mission for the Americans. They had indeed caught up with the Soviets in terms of technology with Gemini and in fact, without knowing it at the time, had actually moved ahead of them. Gemini 4 was therefore a turning point both for the race to the Moon and for America’s efforts in mastering the techniques of human spaceflight. Clearly there was much more to accomplish, but the mission would provide a strong foundation for further advancements in EVA, rendezvous and docking, long-duration spaceflight and operational activities for crews during longer missions.

Looking back from the perspective of 50 years or so later, Gemini 4 was clearly a game-changer, though in the spring of 1965 this was by no means clear. Indeed, there was still uncertainty over whether to perform a simpler stand-up EVA or a full exit, and there was a conflict before the mission between what was hoped it could accomplish and what actually might be possible. The contrast to the situation post-flight was stark. Suddenly, by the time Gemini 4 splashed down, the American astronauts were demonstrating a maturity of spaceflight that many had not thought possible. Gemini was delivering, the Moon looked closer and NASA was riding high on the success. This was the start of the golden era of NASA and American human spaceflight and Gemini 4 was the catalyst from which it began.

Acronyms and Abbreviations

Distances used in the text (As per The Concise Oxford Dictionary, New Edition, 2003).

Mile (or statute mile) A unit of linear measurement equal to 1,760 yards or 5,280 feet (1.609 kilometers).

Nautical Mile (or sea mile) A unit of measurement of approximately 2,025 yards or 6,075 feet (1,852 meters).

Kilometer A metric unit of measurement equal to 1,000 meters (approximately 0.62 miles).

Apogee A point in an orbit where an object (in this case a spacecraft) is furthest from the Earth (the opposite of perigee).

Perigee A point in an orbit where an object (in this case a spacecraft) is nearest to the Earth (the opposite of apogee).

Orbit The path of a spacecraft under the influence of gravitational forces beginning and ending at a fixed point in space after completing 360 degrees of travel around a celestial body, in this case Earth. This, for clarity, is the term used in these books.

Revolution A circuit of a celestial body, in this case the Earth, which begins and ends at a fixed point on the surface of that body. As Earth is *revolving* in the same direction as the trajectory of the orbital spacecraft (Gemini), this point in space moves further ahead, requiring the spacecraft to 'catch-up' and resulting in more than 360 degrees of travel in an orbit. Therefore, a revolution is about six minutes longer than an orbit. In the early days of the space program, the number of circuits around the Earth was originally given in orbits. Then Mission Control started to quote revolutions, which became confusing to the general public, so they switched back again. Today, the word 'orbit' continues to be the most commonly used term in recording the number of circuits of a spacecraft around the Earth (or other celestial body).

A word on Zero-g, or Weightlessness, or Microgravity A long-term misnomer in space exploration concerns the terms 'zero-g' or 'weightlessness.' The motions of astronauts floating in space were described (for clarity, but incorrectly) as being in zero-gravity (or zero-g) or having no weight (weightlessness). In fact, there are gravitational forces at play in space and a more correct description would be 'microgravity', as those forces are there but are mostly negated by orbital motion. As an object (spacecraft) travels in the cosmos, apparently following a straight-line, it is also ‘pulled’ by the gravitational forces of celestial bodies. A spacecraft circulating around a celestial body is still being pulled towards it by gravity, but if that spacecraft is traveling fast enough, it achieves a state of continuous free-fall around that body. Thus, it is held in ‘orbit’ by a fine balance of motion and gravity until it either accelerates further to raise its orbit and achieve escape velocity, or decelerates to a lower orbit to begin the re-entry and decent to a landing.

A note on Gemini designations The Gemini missions have been identified in different ways, including those which flew solo without an Atlas-Agena target and those which included an Atlas-Agena launch. Normally, the launch vehicle was also added to the description, thus: Gemini-Titan (abbreviated as GT-#) or with an Agena vehicle as Gemini-Titan-Agena (abbreviated as GTA-#) The flight numbers were often designated in Arabic numerals as Gemini 1 through 12, although NASA documentation of the time and the official accounts of the program used the Roman numerals I, II, III, IV, V, VII, VI, VIII, IX, X, XI and XII. To complicate this further, the original Gemini 6 and 9 missions were rescheduled and adopted the designations Gemini 6A (VI-A) and Gemini 9A (IX-A) when they flew. In these books, for clarity, the Arabic identification system has been adopted in most instances.

AC Alternating Current

ACE Attitude Control Electronics

ACME Attitude Control Maneuver Electronics

AFB Air Force Base

AMU Astronaut Maneuvering Unit

ANT Antigua (secondary tracking station)

ASC Ascension Island (secondary tracking station)

BDA Bermuda (PRIMARY tracking station)

BECO Booster Engine Cut-Off

BEF Blunt End Forward (rear of the spacecraft facing the direction of flight)

CAL Point Arguello, California (PRIMARY tracking station)

Cape Cape Kennedy/Canaveral, Florida

Capcom Capsule Communicator

CG Center of Gravity

CNV Canaveral (Cape Kennedy) Launch Control Center, Florida (PRIMARY tracking station)

COSPAR Committee on Space Research (International)

CRO Carnarvon, Australia (PRIMARY tracking station)

CSQ *Costal Sentry Quebec* (PRIMARY tracking ship)

CTN Canton Island (secondary tracking station)

CYI Grand Canary (PRIMARY tracking station)

DAS Data Acquisition System

DC Direct Current

DCS Digital Command System

DEI Design Engineering Inspection

DoD Department of Defense

ECS Environmental Control System

EGL Eglin Field, Florida (secondary tracking station)

ETR Eastern Test Range, Florida

EVA Extra-Vehicular Activity (or ‘spacewalk’)

FAI Fédération Aéronautique International

FDI Flight Director Indicator

FIDO Flight Dynamics Officer

g Gravity (*g*) force

G&C Guidance and Control

GBI Grand Bahamas Island (secondary tracking station)

GET Ground Elapsed Time

GLV Gemini Launch Vehicle (Titan II)

GMT Greenwich Mean Time (UK: Universal or ‘Zulu’ Time)

GPO Gemini Project Office

GSFC Goddard Space Flight Center (secondary tracking station)

GT Gemini-Titan (launch vehicle)

GTA Gemini-Titan-Agena (launch vehicle)

GTK Grand Turk Island (secondary tracking station)

GYM Guaymas, Mexico (PRIMARY tracking station)

HAW Kauai, Hawaii (PRIMARY tracking station)

HF High Frequency

HHMU Hand-Held Maneuvering Unit

HOU Mission Control Center, MSC, Houston, Texas (PRIMARY tracking station)

IGS Inertial Guidance System

IMU Inertial Measurement Unit

IVI Incremental Velocity Indicator

KNO Kano, Nigeria, Africa (secondary tracking station)

LC Launch Complex

LTV Ling-Temco-Vought

MA Mercury-Atlas

Max Q Maximum Dynamic Pressure

MCC Mission Control Center (HOU/Houston)

MDF Mild Detonating Fuse

MDS Malfunction Detection System

MECO Main Engine Cut Off

MET Mission Evaluation Team

MISTRAM MISsile TRAcking Measurements

MOCR Mission Operations Control Room

MOL Manned Orbiting Laboratory (USAF)

MR Mercury-Redstone

MSC Manned Spacecraft Center (Houston, Texas)

MSFN Manned Space Flight Network

MSU Michigan State University

MTR Module Test Review

MUC Perth, Australia (secondary tracking station) – used the same callsign as former Mercury station at Muchea, Australia

NADC Naval Air Development Center

NASA National Aeronautics and Space Administration

NASCOM NASA COMmunications

OAMS Orbital Attitude and Maneuvering System

PAO Public Affairs Officer

PAO Public Affairs Officer

PCM Pulse Code Modulation

POISE Panel On In-Flight Scientific Experiments

PRE Pretoria, South Africa (secondary tracking station)

R&R Rendezvous and Recovery

RCS Re-entry Control System

RGS Radio Guidance System

RKV *Rose Knot Victor* (PRIMARY tracking ship)

RR Roll Rate

RRS Retrograde Rocket System

RSS Reactant Supply System

RTK *Range Tracker* (secondary tracking ship)

SECO Second stage Engine Cut-Off

SEF Small End Forward (nose of spacecraft facing the direction of flight)

SEP SEParation (from Titan booster)

SFRRB Spacecraft Flight Readiness Review Board

SPADATS SPAce Detection And Tracking System (USAF)

SST Spacecraft Systems Tests

STG Space Task Group

T Terminal countdown either before (T-/Minus/or down) or after (T+/plus/or up) lift-off

TAN Tananarive, former Malagasy Republic now Madagascar (secondary tracking station)

TCA Thrust Chamber Assembly

TEX Corpus Christi, Texas (PRIMARY tracking station)

UHF Ultra-High Frequency

VCM Ventilation Control Module

VTR Voice Tape Recorder

WHS White Sands, New Mexico, (secondary tracking station)

WLP Wallops Island, Virginia (secondary tracking station)

WOM Woomera, Australia (secondary tracking station)

Contents

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1. Stepping into the void

David J. Shayler[1]

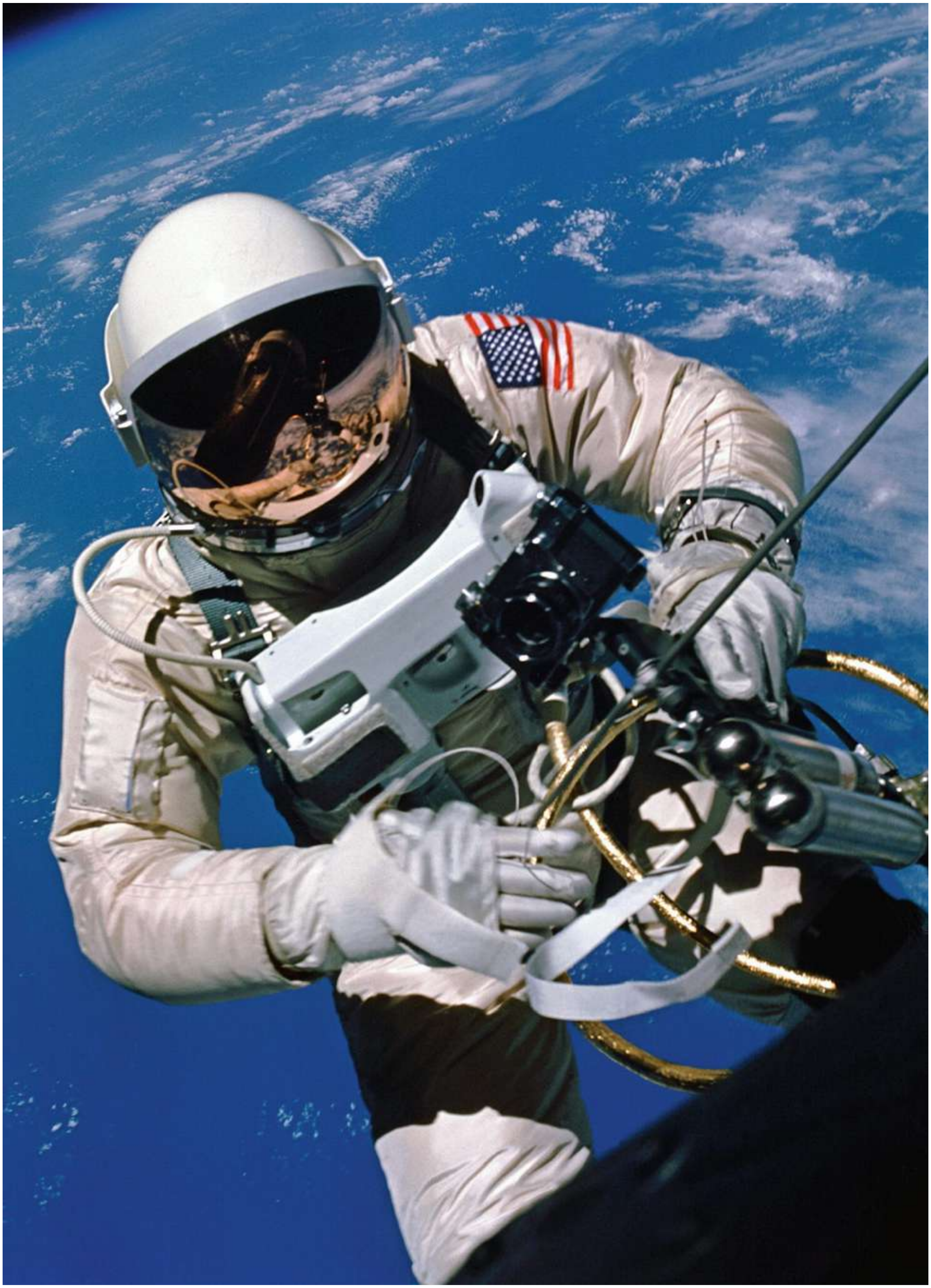
(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

"To place one's feet on the soil of asteroids,
To lift a stone from the Moon with your hand,
Construct moving stations in ether space,
To observe Mars [or] descend to its surface,
A great new era [for a] more intensive study of the heavens."
Konstantin Tsiolkovsky, Beyond Planet Earth, 1920.

Almost a century ago, dreams of developing the technique of leaving the spacecraft to perform useful work in open space were inspired by the Soviet 'Father of Cosmonautics', Konstantin Tsiolkovsky. Nearly fifty years later, that same goal was the genesis for undertaking extensive experiments to learn to work in open space, not only on the surface of the Moon but also in low Earth orbit. Half a century after Gemini, that same desire remains, continuing to expand on the pioneering work conducted during that program and the knowledge and capability acquired since then, to support a renewed interest not only in the exploration and exploitation of near-Earth space, but also a return to the Moon, exploration of Mars and investigations of our nearest asteroids. The theories were derived by Tsiolkovsky and others, and the historic spacewalk of Alexei Leonov in March 1965 proved that the concept was possible, but it would be the Gemini missions that would truly encounter and begin to understand the significant experiences, frustrations and difficulties of performing useful work outside a spacecraft. That journey would begin during the first orbits of Gemini 4, but the path which led to Ed White opening the hatch and stepping into void would not be a straightforward one.

Evolution of a Spacewalk

As early as March 1961, NASA considered that any experiment involving leaving the spacecraft and performing an activity in the vacuum of space would, for safety reasons, require at least two astronauts, even if only one of them actually exited the vehicle. Clearly, this meant that the one-man Mercury capsule could not support such an activity. Not only would the spacecraft have to be enlarged to accommodate a crew of two, but new types of spacesuit, life support system connections, a hatch capable of being opened and closed in a vacuum and a cabin capable of re-pressurization would also need to be developed. From just these relatively basic requirements, it soon became clear that the proposed Mercury Mark II would be the most suitable vehicle to support such early activities external to the spacecraft. These activities have become widely referred to as ‘spacewalking’, but are more officially termed Extra-Vehicular Activity (EVA, meaning ‘activity outside a vehicle’, as opposed to Intra-Vehicular Activity, or IVA, ‘activity inside a vehicle’) [1].



Ed White on EVA June 3, 1965.

Clear and defined objectives for the next American manned space program after Mercury, including EVA, formed a strong case early on for Gemini, which emerged from Mercury Mark II and was designed with the intention of supporting all such requirements. One of the most important decisions in the redesign of Gemini from Mercury Mark II was in the new configuration of the crew hatches, which would make it easier for the astronaut to enter the spacecraft on the launch pad and leave it at the end of the mission. The hatches were also critical to the planned inclusion of ejection seats that would be used in case of an emergency, such as a launch abort at low altitudes or ejection from the spacecraft due to parachute failure during the latter states of recovery. A third benefit, though no one voiced it very strongly at the time, was the possibility of opening the hatch in orbit, allowing one of the crew to exit and work outside for a short period.

With the Gemini program formally approved at the end of 1961, work on devising an operational EVA system continued concurrently with development of the spacecraft. During the latter half of 1962, NASA’s Life Systems Division produced a report on work that had been conducted to evaluate the basic equipment necessary to protect astronauts outside the vehicle. This included the design and workability of pressure suits, ventilation, thermal protection, potential maneuvering units and insulation.

By February 1963, the Manned Spacecraft Center’s (MSC) Crew Systems Division had established guidelines for the possibility of EVA from Gemini and requested that prime contractor, the McDonnell Aircraft Company (MAC, later McDonnell-Douglas), investigate the basic requirements for conducting both a ‘simple’ EVA (in which a single astronaut would open the hatch and ‘stand up’ on his seat, with only his head and upper torso extending out of the spacecraft) and a more complicated, full-exit EVA from the Gemini spacecraft. The following month, during a special meeting of 15 key representatives from the Gemini Program Office, the Flight Crew Operations Directorate, the Crew Systems Division (including James W. McBarron and James V. Correale) and the Astronaut Office (astronaut John Young) at the MSC on March 22 to establish guidelines for Gemini EVA, approval was given for the proposed EVA requirements [2]. These included:

- For the EVA suit, the current Gemini single-wall pressure vessel concept would be used, and “a loose fitting thermal covering will be added if required,” fabricated from materials available at that time. There were study contracts in place, together with MSC in-house capabilities, that were deemed sufficient to obtain the necessary thermal data, including any heater requirements. A sun visor-type device was to be added to the helmet to protect the eyes from heat and glare, with local protection for the gloves and boots added as required.

- No additional instrumentation was required, based upon an assumption that the first excursion would be a preliminary *stand-up* EVA using the spacecraft's biomedical instrumentation.
- The spacecraft's redundant communication (12 wires) system would be employed during the EVA.
- A tether was to be provided for safety at all times, the length of which would be sufficient to allow translation to the Adapter. It was only considered as a means of positively attaching the astronaut to the spacecraft, as other equipment would be provided for "maneuvering and maintaining stability."
- Further testing was to be completed before an emergency oxygen system was provided.

The proposal featured a 30-minute EVA period, with the lone astronaut remaining tethered or attached to the spacecraft at all times for added safety. McDonnell was also asked to include the capability for a (single) crewmember to leave the cabin on *each* mission from spacecraft number 4 onwards. These guidelines suggested that the first EVA from Gemini would be a 'stand-up' EVA, presumably to practice opening and closing the hatch and operating the suit and systems prior to a full exit. They also indicated that provision would be made to allow the astronaut on a full-exit EVA to translate to the rear of the spacecraft, including "ingress to the Adapter." This was a bold plan, given that the EVA astronaut would be out of line of sight of the Command Pilot.

In May 1963, the David Clark Company was awarded the prime contract for the Gemini EVA suit. By the end of that year, the MSC had received and evaluated proposals for an EVA life support package, with the Garrett Corporation's design selected for production.

Gemini EVA Plan

To assist the astronauts with their training for future Gemini missions, McDonnell published the Project Gemini Familiarization Manual. This was divided into sections, covering a description of the intended mission in Earth orbit and details of the major structural assemblies, the crew compartment and the major sub systems. To summarize the much larger document, a slimmer Gemini Familiarization Package was issued in August 1962 by the Crew Engineering branch of the MSC Flight Crew Operations Division. In the introduction, the program's objectives and roles of the two-man crew were explained, together with a comparison between Mercury and Gemini [3].

One of the program objectives listed in the document was to "determine man's capabilities in space during extended missions [up to 14 days] in Earth orbit." Under Crew Tasks, the astronauts were to be "used as a required integral part of Gemini, [to ensure that] increased crew usage [for] onboard command and control wherever logical is implemented in the program."

The Pilot-Commander (subsequently revised to Command Pilot) would have primary control for operating the spacecraft during all phases of flight. Meanwhile the second astronaut, initially termed the Co-Pilot/Systems Engineer (later simplified to Pilot), would provide backup to the Pilot-Commander and would be responsible for managing the operation of both the spacecraft and, on later docking missions, the systems in the Agena target vehicle.

One of the major differences between Gemini and Mercury was the planned capability for the crew to leave the Gemini spacecraft while in orbit. While EVA was intended to be part of the overall program, however, specific experiments had yet to be determined, and indeed the requirements for a suitable pressure suit had still to be defined. But right from the early stages, the design of the Gemini hatch featured the capability for it to be opened by the crew in orbit, allowing for the possibility of conducting an EVA.

Early artist’s impression of an astronaut conducting EVA from a Gemini spacecraft [original of poor quality].

For some time, America’s two-man spacecraft had been termed the ‘Advanced Mercury’, or ‘Mercury Mark II’, suggesting that the pioneering one-man American spacecraft was the genesis of what would officially become Gemini from January 1962. In some ways, at least to begin with, this was true. In its guise as Mercury Mark II, the spacecraft initially featured elements that had been flight-proven in Mercury, notably the launch escape tower and the ocean landing bag (anchor). Early on in the design of the new, upgraded spacecraft, an escape tower still seemed the more reliable and quicker evacuation option than using ejection seats at great speed and height. For landing, as with Mercury, suspending a bag beneath the spacecraft would assist in bringing the capsule back to a gentle (in theory) landing in the ocean, and would also act as a stabilizing sea-anchor. A plan to land the spacecraft on the ground eventually, by means of a paraglider and skids, was still under development and by no means flight proven, but was scheduled for inclusion on later vehicles.

When Titan II was chosen as the launch vehicle for Gemini, the decision was taken to replace the escape tower with ejection seats, which could be used both in the early stages of ascent or the latter stages of descent should an emergency occur. The landing bag, like the escape tower, also disappeared from the design when Mercury Mark II morphed into Gemini. The reason for replacing the escape tower was that the fuels used by the Titan launcher were hypergolic[1] and non-explosive, which would allow the system to recognize a problem and present the information to the crew with enough time for them to exit the vehicle rapidly by ejection seat. The inclusion of these ejection seats therefore required the provision of two large mechanical hatches which could facilitate crew entry and exit from the vehicle, as well as escape by ejection seat. The hatches would have to be opened automatically, ideally with sufficient time before the ejection seats fired.

These requirements also gave rise to the possibility that a suitably attired astronaut could perhaps open the hatch on orbit, leave the vehicle for a short while and perform some useful experiments in the vacuum of open space, then return to close the hatch again and continue the mission. The idea of 'walking in space' was attractive, but was not specifically necessary for Apollo, as the astronauts on that program would be 'walking' on the surface of the Moon, essentially the same as on Earth albeit under a lesser force of gravity. Thus, 'walking on the Moon' would not directly require experiments on Gemini EVA, other than gaining experience in working in a pressure garment. Instead, the Gemini EVAs would explore experiments involving maneuverability in space and the restraint devices intended for work in open space, at satellites, or on larger space stations. The genesis of spacewalking techniques that the Gemini EVAs provided, though not recognized at the time, would extend far beyond Apollo to Skylab, Shuttle and ISS. Of course, there was also a direct interest in EVA from Gemini by the United States Air Force (USAF), for their own plans for military missions in the Manned Orbiting Laboratory Program (MOL).

The design of the hatches thus focused mainly upon their operation on the launch pad, allowing the crew to get into their crew stations on the left (Command Pilot) or right (Pilot) of the vehicle. They would then be sealed for lift-off by the launch team and hopefully would not be opened again until the Gemini capsule was safely floating in the ocean. After splashdown, the hatches would facilitate opening by just a single pararescue diver from the outside, allowing the crew to exit their vehicle during recovery. In the event of a potentially disastrous problem on the pad, during maximum dynamic conditions up to 60,000 feet (18,288 meters) on ascent, or under the same for landing, the ejection system would be able to trigger the hatches to open and then propel the astronauts and their seats safely away from the impending disaster to initiate a separate decent by personal parachute for recovery. For the emergency system, the hatches would need to lock open, providing a clear passage for each seat and its astronaut passenger. If these same hatches were also to be used for EVA, however, then they would have to be sturdy enough to resist the internal pressures of the vehicle during orbital flight and, once the cabin was depressurized, allow a single astronaut to open one from the inside (as assistance from the other astronaut would be difficult) and then close it again for re-pressurization after the EVA. They would also possibly have to be capable of this more than once during a mission.

On September 25, 1963, members of the Crew Systems Division (CSD) held a further meeting concerning EVA at the MSC, resulting in a number of conclusions and action points [4]. This included a progress report on the study into using the Mercury oxygen storage bottle (a nine-inch [23 cm] sphere) as the primary pressurization-ventilation control subsystem for the initial Gemini EVA. This bottle would contain enough oxygen for 25 minutes of normal flow plus 20 minutes backup supply, which would reduce to 15 minutes if used at emergency rates. The system was already flight-qualified, which would help in "getting the system ready to fly on Flight No. 4, which is the present goal," according to the report. Work in progress included providing a warning device to attract the astronaut when his backup or emergency regulator was open and enable an increased flow of oxygen. This environmental control package was to be mounted either on the astronaut's thigh or in the abdominal area, although the package was already deemed to be bulky and limited in supply, with the CSD already working on a different version with a more suitable shape and larger supply of oxygen.

Another problem highlighted at the meeting was the lack of defined data on meteorite particle impacts, noting that "actual flight data from NASA satellite[s] is nonexistent." It was under further investigation, however, with experiments being conducted at Ames Research Center. The meeting suggested that "it is highly desirable to perform experiments on the first manned Gemini flight to gain actual flight data concerning this problem." As all requests for in-flight experiments had to be submitted formally to the NASA In-flight Experiment Panel, this would take time. Urgency was emphasized, with the Gemini Project Office (GPO) requesting support from the Air Force missile and satellite programs.

On a more positive note, preliminary design concept studies on the EVA tether had been completed with two lengths decided upon, the shortest of which had already been received from the vendor. At this time (September 1963), the thermal protective coverall remained the preferred option, but there were signs that a protective layer could be incorporated into the flight suit and eliminate the need for the coverall. Finally, the GPO would check with McDonnell to see whether anything had been done to incorporate facilities in the spacecraft to support EVA. If no directive had been given to MAC (and one wonders why this had not already been done), then a decision would have to be made about the required modifications and provisions in the spacecraft to support EVA, and to indicate these to the prime contractor so that the target of an EVA from Spacecraft 4 could be achieved.

As daring and heroic as the idea seemed to send an astronaut out into the void of deep space with just a tether and a few thin layers of a pressure suit between him and certain death, the thought of actually converting such a science fiction concept into science fact took a while to catch on. By January 1964, things had moved ahead sufficiently to provide a preliminary plan for EVA from Gemini, but it was not suddenly grabbed with both hands and rushed up the program's priorities. Nor was it enthusiastically received within NASA. Indeed, even the press seemed to miss the significance of what was being proposed, less than three years into the era of human spaceflight. At this time, only four Americans and six Soviet cosmonauts had been into orbit, so proposing such a daring plan was bold to say the least, and it is perhaps no surprise that it took a while for the idea to be taken seriously [5].

A Plan for EVA

The original plan for EVA during the Gemini program consisted of three phases. Broadly speaking, the fundamental objective of the EVA program was to evaluate the astronaut's ability to perform "useful tasks" in the vacuum of space. Beyond that, the goal was to expand the capability of the basic Gemini spacecraft and to evaluate new and advanced EVA equipment and procedures in support of future U.S. manned space programs. This did not just mean Apollo, but involved "other national space programs." Reading between the lines, this meant supporting the yet-to-be-authorized space station program, the possibility of repairing and servicing satellites in orbit, and the clandestine and highly classified USAF MOL program. In this plan, three Gemini missions would be assigned to each of the Phases, beginning, ironically, with Gemini 4.

A Phased Approach

The early EVAs, from Geminis 4, 5 and 6, would fall under Phase One and were aimed at demonstrating the feasibility of performing a spacewalk, gaining confidence and experience in using the Gemini system for such activities, and evaluating the ability of the astronauts to perform such a task while wearing a pressure suit. In light of what actually happened, had these goals been met as planned on those three missions, then NASA would have been able to embark directly on more ambitious objectives on the final five missions of the program. If they had, then perhaps some of the difficulties experienced later in the Gemini EVA program could have been addressed much sooner, allowing the lessons learned to be applied to the later missions.

With the Phase One objectives completed, Phase Two would have expanded upon the experience gained with detailed evaluations of the astronauts’ ability to work in ‘free-space’. This work, on Geminis 7, 8 and 9, was envisaged to include the retrieval of data packages and equipment from the Adapter Section of the Agena target vehicle. Other, improved EVA hardware evaluated would have included long-term life support systems and maneuvering devices.

Phase Three would have completed the Gemini EVA program, starting with Gemini 10. This would have seen the astronauts evaluating equipment and work tasks independently of the spacecraft and perhaps, if further missions were approved beyond Gemini 12, performing advanced EVAs which had yet to be authorized or planned in detail, such as satellite inspection, repair and servicing.

Detailed Planning

It was impossible to say what the details of each EVA would be this early in the program, but based upon the individual mission requirements and capabilities, the planning and preparation of EVA from Gemini would have required a multi-directorate MSC support infrastructure.

The 1964 report indicated that the CSD would be responsible for the development and procurement of EVA equipment and for the creation of a ground test program to qualify all the hardware for flight. The Flight Crew Support Division would plan each EVA’s activities in detail and manage the astronauts’ training to accomplish the tasks. The Central Medical Operations Office would be tasked with monitoring the progress of the EVA program within the broader Gemini program, while ensuring that all medical issues and requirements were fulfilled. The Flight Operations Directorate would also monitor the progress of the EVA assignments from within the broader remit of the Gemini program, to ensure the fulfillment of operational requirements. The GPO would retain the overall responsibility for the direction of the EVA project.

Early Equipment Requirements

To fulfill the EVA program during Gemini, a number of hardware developments and modifications would be required. Remembering that this was planned out during 1963, it is interesting to compare this early plan for EVA against what really happened during the missions over the next three years. Such a comparison will be part of the Gemini 12 book in this series, but for this initial account of the first Gemini EVA, the 1964 vision for the subsequent two or three years included:

Portable Life Support Syst

Portable Life Support System

Interestingly, the original plan was to go straight to a portable life support system, rather than utilizing the less complicated but restrictive umbilical connections that were eventually employed. Across the three program phases, the Portable Life Support System (PLSS) was seen to be more independent and adventurous. The CSD was reportedly developing a PLSS for Phase One based on the Mercury 7,500 psi (518 bar) oxygen bottle. This system was being designed to supply the single astronaut with an air flow of 5 cfm (cubic foot per minute; 8.5 cubic meters per hour) open loop oxygen for a maximum of 45 minutes. Taking into account the time required to leave and re-enter the spacecraft and a suitable reserve contingency, this meant that the astronaut would spend just ten minutes outside on actual EVA, which was thought to be sufficient for these early basic evaluations of EVA techniques. However, as Gemini 4 proved in reality, even ten minutes outside the spacecraft would be a challenge.

As the program progressed, the bar for EVA objectives would be raised for Phase Two. It was thought that at least a 30-minute duration outside the spacecraft would be required to meet these objectives, plus adequate supplies to exit and enter the spacecraft and a safe reserve. This would mean that the CSD would need to study and develop an advanced PLSS "to determine the type of system which will meet this requirement." The plan for Phase Three operations using the PLSS was also interesting. According to the report, "It is anticipated that the Phase Two PLSS will be used for egress and ingress during Phase Three operations." More advanced equipment stowed in the back of the Adapter Module would then be used for longer periods outside on EVA. This advanced equipment would be defined at a later date, but was clearly an early indication of what became the USAF Astronaut Maneuvering Unit, intended for MOL and assigned for trials on the later Gemini missions (see below).

Pressure Suit

An advanced, modified version of the standard Gemini pressure suit was to be developed by the CSD specifically for EVA operations. The plan was to retain the single-wall pressure vessel concept for the suit, but with modifications such as an outer visor for the helmet to protect from glare, ultraviolet and thermal sources, as well as improved gloves for thermal protection and a redundant pressure seal closure.

Environmental Protection Measures

Due to the extremes of working in open space, certain measures had to be incorporated into the pressure garment to protect the astronaut from the thermal variations of extreme heat and cold and from meteoroid debris impacts.

Thermal Protection

Thermal protection was to be developed to support each of the three phases. For the early Phase One excursions, where simple activities and short durations were planned, the only requirement against the extremes of open space was thought to be "local protection," so the focus centered on the gloves, boots and knees of the pressure suit. For Phase Two and Phase Three, recent studies prior to the 1964 report had suggested that for excursions in excess of 30 minutes, thermal over-garments would be required. This addition would be investigated and developed by the CSD. The report also stated that "protection from meteoroids" would be required, as there was a 99.9 percent probability that the unprotected pressure suit would be punctured. Based on the understanding of meteoroid environmental protection at the MSC at that time, the mass of soft padding deemed sufficient for the pressure suits for each phase was given as:

- Phase One (10 minute EVA) – 2 lbs. (0.5 kg)
- Phase Two (30 minute EVA) – 3.5 lbs. (1.6 kg)
- Phase Three (60 minute EVA) – 4.75 lbs. (2.2 kg)

Tethers

Another aspect for which the CSD took the lead was the development of a tether safety line combined with communication leads. Originally, there were no requirements to include biomedical data through this tether, but subsequent discussions between the CSD and Medical Operations led to the request to have six specified minimum parameters monitored on each EVA. It was hoped that the method of monitoring these parameters could be incorporated within the safety tether. The exact length of the tether would have to be sufficient to allow the EVA astronaut to traverse easily from the crew compartment to the rear of the Adapter Equipment Section.

Maneuvering Unit

At the time the EVA plan was released, the USAF had already envisioned an EVA maneuvering unit (Experiment 14C) as part of the Gemini/DoD Experiment program. While it was yet to be approved, it was anticipated that this unit would be used in the latter stages of Gemini's Phase Two EVA program and throughout Phase Three. Furnished by the Air Force through an independent contract, this maneuvering unit would have featured its own propulsion, control, communications and life support systems that the EVA astronaut would plug communications and life support systems that the EVA astronaut would plug into once he reached the unit, which would be stored at the back of the Adapter Section during launch.

Modifying Gemini for EVA

To enable the EVA astronaut to move across the exterior surface of the Gemini spacecraft and into the maneuvering unit, modifications to the capsule would include the provision of exterior handholds on the spacecraft at two-foot (0.60 m) intervals, from the cockpit area to the interior of the Adapter Section[2]. The exact configuration and aerodynamic considerations of the handholds were under study by the CSD. One area identified as requiring additional protection was the potential rough edge at the base of the Adapter Section which connected to the Titan second stage. The plan stated that “the astronaut must be able to proceed past this rough edge without the hazard of damage to the pressure suit or the tether,” and that a protective cover for that rough edge should be installed before he ventured over the area.

By January 1964, a more defined Gemini EVA plan had emerged:

- Gemini 4: The first flight with EVA capacity. On this flight, the Pilot would depressurize the cabin, open the hatch and stand on the seat for a brief period during the mission, with his head and shoulders above the hatch line (officially termed a Stand-up EVA or SEVA). This was originally planned for February 1965.
- Gemini 5: The Pilot would practice full egress and ingress procedures.
- Gemini 6: The Pilot would egress and translate to the rear of the spacecraft, where he would retrieve data packages from inside the Adapter Section and then translate back to the hatch.
- Gemini 7 & 8: Further practice by the Pilot of maneuvering along special EVA handholds and tethers on the outside of the spacecraft.
- Gemini 9: Evaluation of an Astronaut Maneuvering Unit (AMU, DoD Experiment 14C).
- Gemini 10 through 12: Further evaluation of advanced AMUs and EVA techniques.

The question of one-man EVAs raises other points. The spacecraft would need to be controlled during each EVA, and as this was a new, largely unknown activity, the decision was made early on to allow only one astronaut, the Pilot, to conduct the spacewalk, with the Command Pilot remaining inside and in control of the vehicle. Note that the plan called for the Pilot to perform the EVAs, not the Command Pilot. The latter would remain inside the spacecraft, monitoring and controlling the vehicle while his colleague was outside. Though the and controlling the vehicle while his colleague was outside. Though the Command Pilot would not participate in the actual EVA, he would also be fully suited, supplied by the spacecraft life support system and exposed to the vacuum of space when the Pilot opened his hatch. The hatch above the Command Pilot would remain firmly closed from pre-launch to post-landing during each of the Gemini missions.

It would also have been realized that in the event of a serious problem, the risk factor was inevitably greater for the EVA astronaut than his colleague inside the vehicle. Within NASA, there would certainly have been discussions about the very difficult decisions that might have to be taken in the event of a major malfunction or tragedy during one of the EVAs. It is sobering to think how difficult it would have been for the Command Pilot to reach across and close the other hatch on his own, or to open his own hatch and leave the vehicle to assist a colleague in trouble. The Command Pilots, who also wore the improved G-4C suit, were not kitted out with complete EVA protection, umbilicals, or an EVA-suitable helmet visor. Once outside, they could not ensure the stability of the spacecraft and would have had great difficulty in returning a semi-conscious or unconscious colleague to his crew seat, restraining him and closing the hatches again without seriously risking his own safety. It has often been said that the solo Voskhod EVA by Leonov was both daring and risky, but also very lucky. The same could be said for each of the Gemini EVAs. It is also worth noting that since Gemini, EVAs have been accomplished by teams of at least two crewmembers for safety reasons, even if the second person is only in a support role standing up in the open hatch (such as Apollo 9, the Apollo trans-Earth EVAs, the first Skylab EVA from the Command Module, and the first EVAs from Salyut).

The Evolution of America’s First EVA

The two Gemini 4 crews pose with a model of the Gemini spacecraft during a news conference in the Manned Spacecraft Center Auditorium. Wearing the original G-2C pressure suits, they are (L to R)] Edward H. White II, prime Pilot; James A. McDivitt, prime Command Pilot; Frank Borman, backup Command Pilot and James A. Lovell, backup Pilot. (Note the large area of the open Pilot hatch at left on the model.) [Courtesy Ed Hengeveld].

On July 14, 1964, yet another meeting on EVA brought developments towards the first American EVA up to date [6]. They included a briefing on the design and status of the Extra-vehicular Life Support System (ELSS) chest pack presented by AiResearch Corporation. Conditional approval was given to the basic design, with certain small recommended changes required. The first design review had been held on July 6, 1964, with two more scheduled for October of that year and January 1965. The plan was for MSC to receive a qualification and test unit in December at the same time as a duplicate unit was tested at

AiResearch. Following the results from those tests, NASA would receive three updated configurations of the ELSS in February 1965 and two flight models in May 1965, one month prior to flying the Gemini 4 mission.

This meeting also reviewed the modifications made to Gemini 4 to support the EVA and the development of the EVA suit. The David Clark Company was to present detailed design configuration information on the full EVA suit prior to July 31, 1964 (see Chapter 2). The prototype suits were to be delivered in September 1964, followed by flight suits for the 'stand-up' exercise (a full EVA had yet to be authorized at this point) by March the following year. The full EVA task definition was also discussed and set out as: checkout and depressurization (10 minutes); egress (10 minutes); EVA task (10–30 minutes); ingress (5 minutes); re-pressurization (10 minutes). A ground rule was also established that the EVA would start at orbital dawn and be performed during the daylight hours.

At this same meeting, an indication of the importance of EVA in the forward planning of the DoD was presented by Air Force Systems Command Field Office (AFSCFO) representatives, a full year before the first EVAs were attempted in orbit. A brief description of the astronaut modular maneuvering unit (AMU/MMU) was given under DoD Experiment D-12. It was requested that a number of committees and working groups should be established to coordinate the incorporation of the MMU into the Gemini program. Five such groups were set up[3].

The Gemini 4 crew assignments were announced on July 27, 1964, with Jim McDivitt and Ed White named as the prime crew and Frank Borman and Jim Lovell as their backups. White and Lovell would train for the SEVA. In a press conference that same month, it was announced that the Gemini 4 crew *might* participate in an EVA, though at that time the MSC had not received permission to plan for one actively.

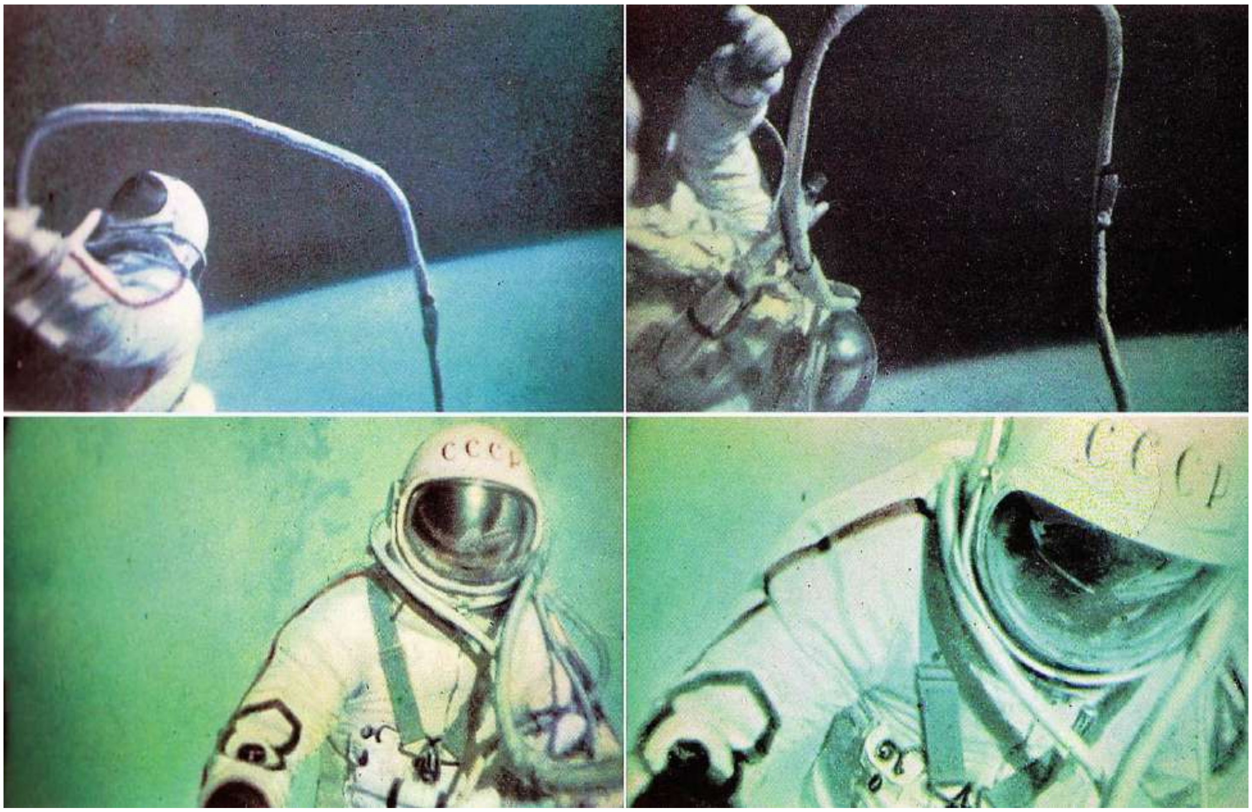
In mid-1964, the Gemini 4 crew discussed with the David Clark Company any possible development problems which might be encountered if NASA went ahead and authorized the work for a special EVA version of the standard G-3C spacesuit. Pressure from the Gemini 4 crew was a factor in NASA authorizing the development of the G-4C EVA spacesuit.

During November 1964, Gemini 3 astronauts Virgil 'Gus' Grissom and John W. Young actively contributed towards an EVA on Gemini 4. As the first crew in training, they offered to use scheduled vacuum chamber time during tests with their spacecraft to confirm whether an astronaut could open the hatch and stand up in a simulated space environment. The astronauts simulated a SEVA at an altitude of 40,000 feet (12,000 m). Though they experienced difficulties in closing the hatch, the concept of an EVA from Gemini was proven feasible. Following their experiences in closing the hatch, Young wrote in 2012, he had McDonnell fabricate a “mechanical advantage grip-fitting device,” which allowed the Command Pilot to reach across and pull the hatch down [7] The added experience and support of the GT-3 crew played a large part in finally getting NASA to allow a full EVA on Gemini 4. Shortly after this altitude chamber test, the Project Approval Document for Gemini, dated December 16, 1964, listed the primary objectives for the program, including EVA.

On March 12, 1965, MSC Director Robert Gilruth approved and circulated a document authorizing altitude chamber tests that would see Ed White open the hatch of Gemini 4 and ‘stand up’ on his seat, putting his head and upper body ‘outside’ into the void of space for a few minutes. This would demonstrate the feasibility of the concept and hopefully provide the confidence to conduct a full exit on the next mission, Gemini 5. Just six days later, however, the Soviets once again stole the headlines by launching a new Voskhod mission with the sole purpose of securing that first full EVA.

Man Steps Out into Space

On March 18, 1965, the two-man Voskhod 2 spacecraft was launched from the Baikonur Cosmodrome. In command of the mission was Colonel Pavel I. Belyayev, 39, and with him was pilot Lieutenant Colonel Alexei A. Leonov, 30. Coming just days prior to the planned Gemini 3 mission, it looked like the Soviets were about to score another ‘space spectacular’ over the Americans. After entering an initial orbit with an apogee of 309 miles (495 km), the two cosmonauts set a new altitude record for a manned spacecraft, but it was their activities during the second orbit that would make the front page headlines around the world. Wearing a full pressure suit with an autonomous life support system, Leonov floated into an extended, temporary airlock on the side of the spacecraft and closed the internal hatches. Opening the outer hatch, he then left Voskhod 2 and entered the history books. “*Man has stepped out into open space*,” Belyayev announced to the world in his role as live commentator for the event. For ten minutes, Leonov tumbled around on the end of his safety tether (he did not have a maneuvering unit to control his movements), translating no more than 16.5 feet (5 m) from the spacecraft. He carried out a number of prescribed studies and observations, including examining the outer surfaces of his spacecraft, operating a film camera, conducting visual observations of the Earth and deep space, and describing his activities. His problems began during his return to the airlock, as his pressure suit had ballooned in size, making it extremely difficult for the cosmonaut to re-enter the spacecraft. After some minutes of struggling, Leonov finally managed to squeeze back inside the airlock – by lowering his suit's pressure to a dangerous level – and close the hatch, exhausted and sweating heavily. It had taken a supreme effort to get back inside the crew compartment, at the risk of his life, although news of the difficulties he encountered was restricted by the Soviets for years. At the time, the headlines focused on the apparent ease and success of the world's first walk in space [8].



A montage of images from Alexei Leonov's historic EVA, March 18, 1965.

The Pace Hots Up

Following the apparent success of Leonov's spacewalk, the pressure to allow Ed White to conduct a full-exit EVA instead of a stand-up EVA intensified, although the initial response from NASA Headquarters remained lukewarm, mainly due to safety concerns. With Leonov's success hitting the world's headlines, the Soviets were naturally promoting a bright future for EVA within their program. On March 18, Vostok cosmonaut Pavel Popovich said on Moscow TV that future cosmonauts would be able to use a "small rocket engine… to return to [their] ship." Vasily Seleznev, identified as a "space official" and a doctor of technology, told Radio Moscow that future EVAs would be used to assemble spaceships and repair spacecraft, while it was hoped that cosmonauts would reach the Moon in the not too distant future. Later reports from Moscow suggested that Leonov could have remained outside Voskhod 2 for much longer than ten minutes. In *Izvestia*, it was reported that future cosmonauts might find working in space easier because of Leonov's achievement.

On March 19, U.S. President Lyndon B. Johnson sent a message of congratulations to Anastas Mikoyan, the Chairman of the Presidium of the Soviet Union, stating "All of us have been deeply impressed by Lt. Col. Alexei Leonov's feat in becoming the first man to leave a space ship in outer space and return safely. I take pleasure… in offering, on behalf of the people of the United States, sincere congratulations and best wishes to the cosmonauts and the scientists and all the others responsible for this outstanding accomplishment." [9] The next day, three days before the launch of Gemini 3, the first manned mission of the series, the President was asked where the American space program stood in relation to the recent Soviet achievements. Johnson replied that he believed that the recent achievements by the Soviets, and the scheduled Gemini 3 mission, demonstrated the important role that man would play in the future exploration of space, and that the progress of the American domestic program was "very satisfactory to me in every respect." Reading between the lines, the President was far from happy at having America beaten to a space first once again.

On March 21, 1965, just a few days after Leonov's flight, George Low met with Robert Gilruth to examine a simple maneuvering unit that an astronaut could carry in his hand, as well as a chest pack that would serve as a back up to the spacecraft's oxygen system. They also inspected the new suit (the G-4C, explained in Chapter 2) designed to support an EVA. By this stage, the equipment was available to support a full EVA experiment, though it had not yet been tested or flight certified. The authorization to perform a full-exit EVA had still not been given, but in light of Leonov's EVA, things were beginning to move rapidly at NASA.

The three-orbit Gemini 3 mission on March 23 was very successful and qualified the basic Gemini design and mission profile for manned flight [10]. It also gave NASA the confidence to take a further step with Gemini 4. The following day, March 24, with the majority of the world's media focusing upon the success of Grissom and Young in *Molly Brown*, Ed White opened the hatch of Gemini 4 to conduct a SEVA in the altitude chamber at McDonnell Douglas, at a simulated altitude of 45.7 km.

However, there was still uncertainty and a lack of formal authorization to proceed when NASA Administrator James Webb addressed President Johnson and the U.S. Cabinet on March 25, reporting on the success of both Gemini 3 and the Ranger 9 photographic mission to the Moon. Webb was questioned about the progress of an American EVA and replied that there might be some possibility of an astronaut opening the hatch and partly emerging from the crew compartment on the next flight (Gemini 4), but that such an exercise was more likely during Gemini 5. He added that although the Russian event was indeed "spectacular," NASA was more interested in developing a spacesuit that would allow astronauts to work outside to assemble larger space centers (meaning space stations) [11].

On March 29, Robert Gilruth, George Low, Richard Johnston and Warren North held an informal meeting, where it was suggested that White could conduct a full EVA out of Gemini 4, to a distance of no more than 16.5 feet (5 m) from the spacecraft. Six days later, on April 3, a full-exit EVA plan for GT-4 was presented to George Mueller, Head of Manned Space Flight at NASA HQ. Mueller was not totally convinced, but relented to allow engineers to continue with equipment qualification tests. These would be completed by May 19. On April 19, Edward L Hays, Chief of Crew Systems at the MSC, announced that the qualified Gemini EVA spacesuit would be available for the Gemini 4 mission. Then, at a news conference in Washington D.C. ten days later, Dr. George E. Mueller, NASA Associate Administrator for Manned Space Flight, revealed that although EVA had not been planned until Gemini 5, NASA was "working hard at trying to qualify the spacesuits and the hatch itself to see if we can accelerate that date." If this could be achieved, Mueller said that Ed White would "lean halfway out of the capsule for perhaps 15 minutes on Gemini 4." [12]

To get things moving, Gilruth arranged for Robert Seamans to view an EVA demonstration, after which Seamans decided that the planned activity was safe enough to move up to Gemini 4. Initially, NASA Administrator James Webb was in favor of the plan, but Deputy Administrator Hugh Dryden was "strongly against it," so Webb asked Seamans to draw up a document making a case for the EVA to be included on Gemini 4.

On May 24, Robert Seamans wrote to Webb outlining the reasons both for and against EVA and the perceived risks involved. One reason against conducting the EVA, Seamans noted, was that the primary objective of Gemini 4 was to extend the astronaut-spacecraft duration in orbit to four days. Adding an EVA would reduce "by a small but finite amount the chance of success," and should thus not be included. For the case in favor of attempting the spacewalk, Seamans noted that risk was present on each flight and that achieving maximum significant return should be a goal, as long as the primary objectives were not threatened or crew safety compromised. The letter ended with his recommendation in favor of conducting the EVA, concluding that the hardware was ready and flight-qualified and the astronauts trained. The flight plan was carefully amended to include the activity, pending the final authorization in lieu of public information releases [13].

The next day, May 25, the letter was returned from Webb to Seamans with a handwritten note added: *Approved after discussing with Dryden, Signed J.E. Webb.* Later the same day, NASA announced that Ed White would perform a full-exit EVA for twelve minutes during the second orbit "if conditions are favorable" during the Gemini 4 mission, secured by a 25-foot (7.6 m) tether and using an oxygen powered 'jet-gun' to propel himself around. The following morning, newspapers around the world carried the story that Ed White would attempt to become the first American to 'walk' in space during Gemini 4. According to NASA, the delay in making the final decision was to allow the qualification tests on the spacecraft, spacesuit, secondary life support system and umbilical to be completed. It was also revealed that Jim McDivitt would not open his hatch but would take photographs and movies of White while he was outside. Though White had "practiced acrobatics," he had no planned program and would "use his own judgment as to what to do" while outside the spacecraft [14]

On May 27, it was reported in the *Philadelphia Evening Bulletin* that President Johnson was disappointed that the Gemini 4 astronauts would not have a TV camera on board to transmit images of the EVA. Apparently, the TV cameras had been "sacrificed for experimental instruments." [15] That same day, during a news conference in San Francisco, Republican George P. Miller (R-California) said that "if Major White leaves his space capsule… it will be only a 'space spectacular stunt'." Miller was the Chairman of the House Committee on Science and Astronautics and had made similar comments after Leonov's EVA a few weeks earlier. Clearly, not everyone was enthralled by the prospect [16].

Three days after the news that Ed White would walk in space came the news that Jim McDivitt would try to steer Gemini 4 to within 20 feet (6 m) of the spent second stage of the Titan rocket that had just launched them on the first orbit, a first real effort at a rendezvous with another object in space[4]. In fact, if all went well, White might be able to use his jet gun to maneuver his way across to the Titan stage, perhaps close enough to touch it.

For the Record

Following the May 25 decision to attempt the EVA, Executive Officer Lawrence W. Vogel put a memo on record entitled ‘Top Management Meeting on Gemini 4 Extra-Vehicular Activity’, in which he outlined the reasoning behind the decision [17]. One of the main concerns was over making changes late in the process, which presented the possibility of overlooking something important. There was also a concern that if Gemini 4 had to return early for any reason then opening the hatch was likely to attract the blame in the eyes of the media or the public. Then there was the obvious conclusion that the Gemini 4 EVA was included only as a direct response to Leonov’s EVA on Voskhod 2.

On the other side of these arguments was the fact that suit development to allow EVA had always been part of the Gemini program and that an EVA of some description had been assigned to Gemini 4 in plans as early as January 1964. The debate was whether to have an EVA *as soon* as Gemini 4, which was only the second manned flight of the program. The EVA was not essential to the basic mission profile, that of checking the reliability of spacecraft and systems over four days, and if the four-day mission was not achieved for some reason then America’s “space posture might suffer.” This concern was allayed somewhat by the recent full systems checkout during Gemini 3.

As for the welfare of the astronauts, it was stated that there was full confidence in the spacecraft and the ability of the crew, who had accumulated about an hour of training time in the KC-135 practicing getting out of and back into a mockup spacecraft. A successful EVA would be a great morale boost for the astronauts and the whole NASA team, but if the EVA was not accomplished on Gemini 4 then it would be a prime objective for Gemini 5. Equally, if the EVA on Gemini 4 was a success then another would not be included on the next mission, because of “the many other things programmed for Gemini 5.”

There was also the question of what risks might be taken on a short flight because of EVA, diverting attention from finding out more about ‘weightlessness’. Dr. Charles Berry suggested that there were no indications that the crew would have problems flying a four-day mission[5], but with Gemini 5 targeted for at least seven days at this time, some experts thought that duration was a risk. The problem of confinement on missions of seven days or longer was of some concern at that time. Then there was the risk of “cracking the hatch” during the four-day mission. There was inevitably an added risk in depressurizing the spacecraft, opening the hatch, resealing it and re-pressurizing the cabin, adding the potential for failure to the associated systems and mechanical devices. Hundreds of tests had already been conducted with no failure, but the potential was always there.

The meeting, at which arguments both for and against an EVA were put forward, noted that an EVA could not be justified solely on the ground that the Soviets had done so, just as a mission could not be justified solely to return items from an Agena target later in the program. However, such an exercise would be a further step in developing the role of man in space. The memo stated that "the sophistication of equipment that we put into space is getting ahead of the sophistication of the experiments we can do." Experiment sophistication could be increased by the *presence* of man in space, but the *usefulness* of man could further be determined by EVA. This could also reveal whether astronauts could repair and calibrate satellites in the future, for example, and as such the EVA on Gemini 4 "should be looked upon as a significant step forward and not a stunt."

Conducting an EVA on Gemini 4 would be as hazardous as on later missions, perhaps more so as this was only the second manned flight of the series. To date, the primary role for astronauts on Mercury or Gemini had been inside their spacecraft, so qualifying the Gemini spacecraft for longer durations in orbit was a more important objective than an EVA, although both would be useful for Apollo. These discussions revealed that it was the consequence of failure on Gemini 4, with the spacecraft yet to be fully qualified, that was considered more risky than it would be for Gemini 5 or 6. There was an obligation to the Government to ensure that the spacecraft was fully qualified, and including an EVA early in the program would detract from that goal and potentially diminish confidence that spacecraft could be guaranteed operationally usable for seven days or more.

It was thought that, in the eyes of the public, Gemini 4 would be a success with an EVA, but actually the decision makers might consider the opposite. At the meeting, it was suggested that if there was a 90 percent chance to fly Gemini 4 successfully for four days, then an EVA would lower this only to 89 percent. The single percentage of greater risk on a four-day flight was worth taking when considering what could be gained from an EVA. Conversely, if the chance of a successful four-day flight was only 80 percent with an EVA, then the risk of not completing the four-day mission was not an adequate trade-off with the gains from that EVA and it should not be attempted on Gemini 4.

Interestingly, the meeting noted that the reaction of the public to their final decision should not be a major concern. The final call should be based on the overall benefits for the program and not public reaction. There still remained concerns over ensuring the reliability of the spacecraft for four days and projections for the seven-day mission. Going for EVA on Gemini 4, and so early in the mission, might jeopardize the returns from the entire flight. If Gemini 4 could not complete the full four days, then it would put NASA in a difficult position to go for seven days on the next mission. There was also the fact that the Gemini program was mission limited, with little margin for error and with the Apollo clock still ticking down towards the end of the decade. That program had still to fly with a crew on board. In his summary, Vogel wrote: “The real question is whether or not EVA is important enough in view of the risk, no matter how slight, of jeopardizing a four-day Gemini 4 flight and jeopardizing a seven-day Gemini 5 flight.”

It was then pointed out that in a review of the Gemini program as a whole, EVA was deemed a logical inclusion for Gemini 4, and that if Gemini 4 flew successfully for at least three days then there should not really be any concerns over flying a seven-day mission. The basic objective was to check out confinement and weightlessness, and in this respect, Gemini 5 was more important than Gemini 4. If any flight time had to be reduced due to an EVA, it was more logical to do this with Gemini 4 than Gemini 5. The meeting summarized that if EVA was approved, then firm and appropriate instructions should be produced to cover the procedure and frank information should be made available to the public to “avoid any misunderstanding and minimize any adverse reactions.” Overall, there was a strong feeling towards authorizing EVA for Gemini 4 to maximize the opportunity, with reservations, and that Dr. Seamans should discuss the matter further with Dr. Mueller and Dr. Gilruth based upon the information available and the discussions in this meeting. The meeting put forward the recommendation to include EVA on Gemini 4, which was subsequently approved by Jim Webb and Hugh Dryden.

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14. Reference 11, p. 248.

15. Philadelphia Evening Bulletin, May 27, 1965.

16. New York Times, May 28, 1965.

17. **Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program**, Volume VII, Human Spaceflight: Projects Mercury, Gemini and Apollo, Edited by John M. Logsdon with Roger D. Launius, The NASA History Series, NASA SP-2008-4407, 2008, Document I-65, pp. 293–6.

Footnotes

1 ERRATUM: In Gemini Flies! Page 20, Line 5, the Titan II propellants were incorrectly identified as liquid hydrogen and liquid oxygen. In fact, Titan II used hypergolic fuels, which spontaneously ignite on contact.

2 At this stage, there were no suggestions about providing foot restraints, though tethers were proposed.

3 On the Interface Control Committee and the MMU/Astronaut Interface Working Group, astronaut Mike Collins represented the Astronaut Office, while Captain Ed Givens (subsequently selected by NASA as an astronaut in April 1966) represented the AFSCFO. Veteran spacesuit tester Norman P. Shyken represented

McDonnell.

4 In August 1962 and again in June 1963, the Soviets had launched a pair of Vostok spacecraft on different days, calling the feats the first joint spaceflights. Not true rendezvous missions, their orbits were matched for a short time by the timing of their launches, as unlike Gemini, Vostok had no capability of maneuvering in space.

5 The Soviets had previously flown a four-day mission on Vostok 3 and three days on Vostok 4 in 1962, as well as five days on Vostok 5 and three days on Vostok 6 the following year.

David J. Shayler, *Gemini 4*, Springer Praxis Books
https://doi.org/10.1007/978-3-319-76675-1_2

2. Dressed for the occasion

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

> *"[The] portable power unit will allow the space voyager to turn, spin and cover long distances with great ease. But the crewmember will have to know how to use the gun properly, because it could cause him considerable trouble."*
> *From Spaceships and Space Travel, Frank Ross Jr., 1956*

The development and composition of pressure garments and their associated equipment for space exploration, especially those to be used for ExtraVehicular Activity (EVA), are fascinating topics to study. The provision of personal protection from the environment and hazards of space has always been a challenge for the designers, engineers, fabricators and medical professionals associated with human space exploration. One of the miracles of modern technology, the spacesuit is essentially a personal spacecraft. When it is used for spacewalks, with independent maneuvering and life support systems and with no physical connection to the spacecraft, its wearer becomes a human satellite.

Today, in the opening decades of the 21st century, the images of space explorers wearing a pressure suit are very familiar, with many Earth-based applications and spin-offs from that technology now more common place. The technology and manufacturing processes for spacesuits can be termed 'state of the art' but, as with most things in the modern era, there is still a constant requirement for upgrades. The ongoing development of space exploration continues to include the need to provide better suits and protection, not only for Earth orbit but also for a return to the Moon and out to Mars, the asteroids and beyond. But the story really began to develop in the early years of the 1960s.

The idea of a garment to protect a human venturing outside of the protective cocoon of a ship traveling in outer space had actually been postulated for decades, as far back as the writings and drawings of Russian teacher and space theorist Konstantin Tsiolkovsky in the early years of the 20th century [1].

Drawing upon the development of deep-sea diving suits, and even earlier, studies into the fabrication and construction of joints for medieval suits of armor, the early ‘spacesuits’ were adapted from pressure garments used in the pioneering aircraft designed to fly ever higher and faster into the upper reaches of the atmosphere, where the layers thinned the higher one ventured. Classed as ‘get-me-down’ suits, these initial garments for space explorers were intended to protect the wearer during critical phases of the mission and in the event of a rapid cabin depressurization. The life support system would isolate the wearer independently from the cabin’s environment, cocooned inside a protective balloon shell so that they could survive long enough to ‘get them down’ at the earliest opportunity. However, as important as these suit designs were, they did not have the capability of supporting a person outside the spacecraft. The designs of the early spacecraft were also too limited to support an EVA, without adapting the life support system, amending the access to and from open space, and providing a dedicated suit of clothing to protect the wearer. By the time of Gemini, NASA needed to re-think the whole concept if they hoped to permit an astronaut to leave his spacecraft safely, perform useful work outside, and then get back inside again safely as well.

On May 25, 1965, a few days prior to the Gemini 4 mission, NASA’s Associate Administrator, Robert C. Seamans, Jr., said “We have spent a great deal of time planning for extravehicular activity and the decision to include the activity on this mission came after a long series of carefully planned tests of the equipment, especially the life support chest pack, and training of the astronauts. It was only when we were satisfied that these tests were successfully completed that we made the final decision to go ahead.” The completed Gemini 4 EVA ‘system’ consisted of the G-4C pressure garment (including helmet and gloves), the life support system, and a hand-held maneuvering ‘gun’. Incorporating this ‘system’ into the Gemini 4 flight plan took just 69 days from concept to orbit.

A test subject at the Manned Spacecraft Center wears the Gemini G-4C EVA suit to be used during the Gemini 4 Mission [Courtesy Ed Hengeveld].

David Clark G-4C ExtraVehicular Pressure Suit

Initially, the pressure garments for Gemini 4 were to have been worn solely for IVA operations, using the G-3C suit similar to those worn by the Gemini 3 crew of Gus Grissom and John Young. However, from July 1964 when the idea emerged that one of the crew might conduct a ‘stand-up’ EVA (SEVA) while remaining attached to the spacecraft’s Environmental Control System (ECS), it became clear that modifications to the suit would have to be made to accommodate the experiment. In addition, if the hatch was opened then the entire internal habitable compartment of Gemini would be exposed to the vacuum and thermal conditions of space, affecting not only the person conducting the SEVA but also his colleague in the other seat, even though they would not be leaving the spacecraft[1]. This also meant that as well as the two astronauts, the interior systems of the Gemini spacecraft would have to perform satisfactorily both during and after each EVA period. For this reason, the

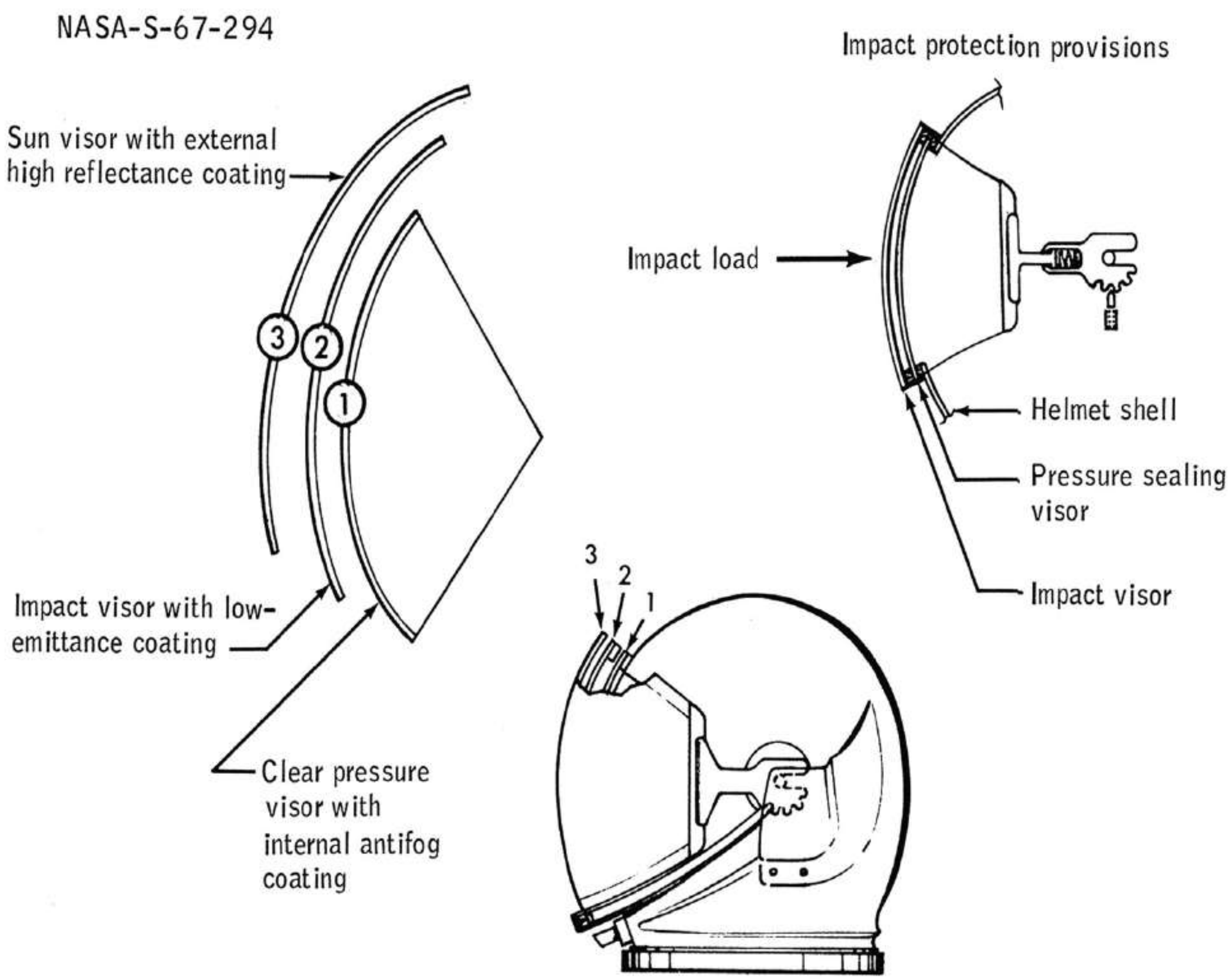
November 1964 simulated SEVA by John Young, in the altitude chamber at McDonnell, went a long way towards checking this system and validating the suit, hatch, and spacecraft interior for the planned EVAs on later missions.

Initial Modifications to the G-3C Suit

The G-3C was only intended to protect the astronaut as an advanced 'get-me-down' suit. For Gemini 4, the new suit was designated the G-4C (which stood for Gemini 4th version, and C for David Clark). They weighed 31 lbs. (14.06 kg) and cost $30,000 (1965) each [2].

The G-4C pressure suit: This came in two versions, both of which had additional layers of Mylar insulation for temperature control (250 degrees F [121 degrees C] in direct sunlight and -250 degrees F [-157 degrees C] in shadow). The Command Pilot's suit retained the removable boots, while the Pilot's version had integrated boots and a detachable sun visor which clipped onto the helmet. This upgrade to the G-3C suit worn on Gemini 3 featured a Nomex (HT-1) 'linknet' restraint layer that replaced the original layer for increased structural strength. A redundant pressure sealing closure was included and the ventilation inlet and outlet fittings were then redesigned to include automatic locking and redundant sealing features. The original Nomex (HT-1) cover layer was replaced by an integrated thermal and micrometeorite cover layer. The integrated layer was white and weighed 3.75 pounds (1.75 kg). Its outer protective layer was a high-temperature-resistant HT-1 nylon fabric with an additional inner nylon felt layer for protection against micrometeorites. Beneath that were seven layers of aluminized Mylar and unwoven Dacron superinsulation, with two additional layers of high-temperature nylon which absorbed impact shocks from micrometeoroids. A second strain relief zipper was added under the pressure sealing zipper of the suit. This was designed to take the strain from the pressure sealing zipper while opening and closing the suit. The EVA cover layer came in two parts. The main section covered the torso but there was also a removable 'jacket' that covered the astronaut's arms and shoulders. Once the astronaut was back inside the spacecraft after the EVA, these could be removed for greater comfort during the remainder of the flight.

EVA gloves: Ed White would wear his standard IVA pressure gloves under a pair of over-gloves for added thermal protection. These were a new design that featured increased mobility and resistance to abrasions. They were only intended for use on Gemini 4, as improvements were already in progress to provide more efficient gloves for later missions. The over-gloves used Silastic palm insulation, which could protect the astronaut's hands from constant contact with objects ranging from +250 degrees to -150 degrees F (121 to -101 degrees C) for up to two minutes.



Gemini 4 EVA helmet details

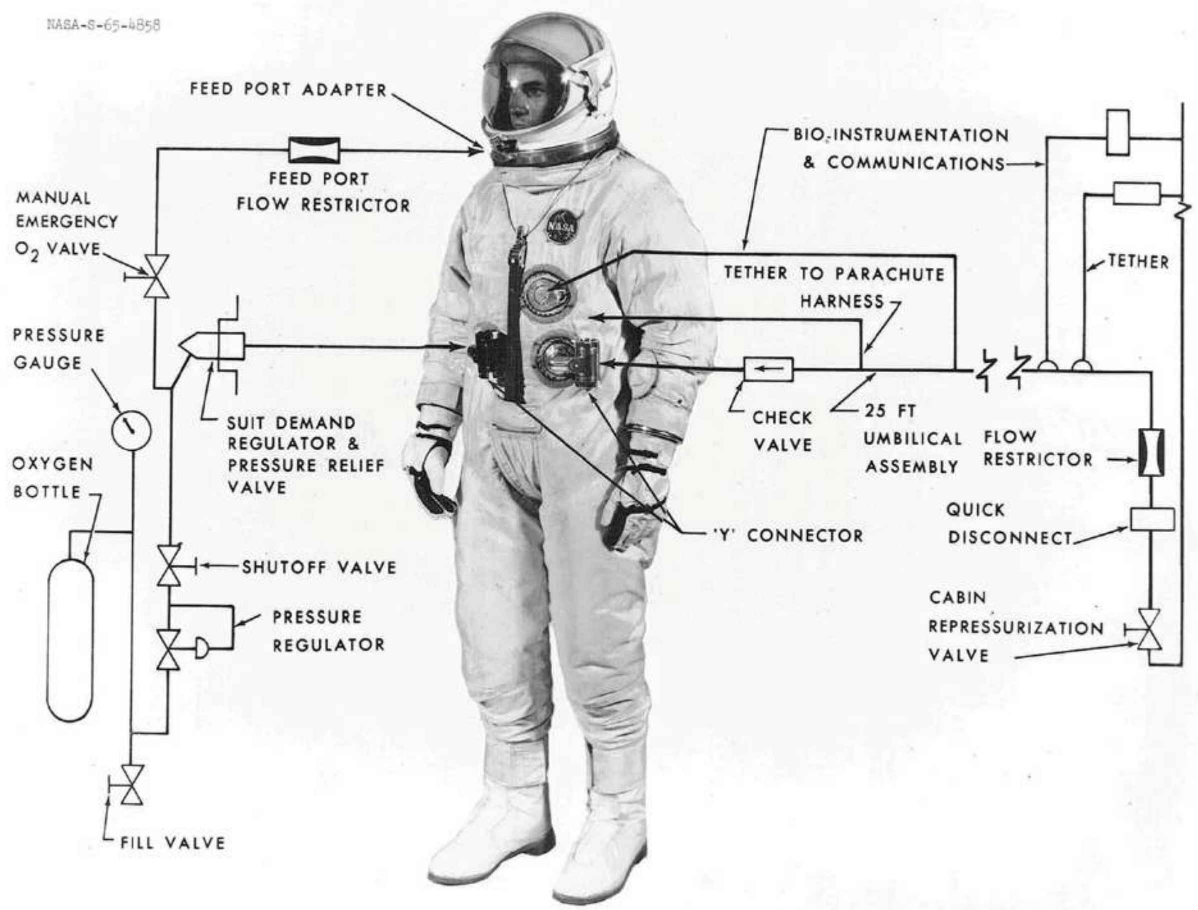
EVA helmet: For Gemini 4, the EVA helmet was fitted with a detachable EVA visor assembly consisting of a pair of over-visors. The outer, or sun visor, was the one which was seen in the photos of Ed White during the EVA, shielding his face from solar light and energy while at the same time masking his features in the photographs. Made from Plexiglass and tinted gray, it had a very thin outer coating of gold film that reduced visible transmittance to 12 percent. The gold covering also protected White's eyes from UV light and reflected much of the solar IR energy. To prevent the gold from flaking, the outer surface was covered with a high-emittance coating which also helped to reduce the surface temperature of the visor when in direct sunlight. The

> second, inner visor was made from a polycarbonate called Lexan (which is thirty times stronger than the plastic used in aircraft canopies) and featured a low-emittance thermal coating on the outer surface. It served as a visual protection against UV energy through a UV inhibitor within the polycarbonate material of the visor. This second visor also acted as an impact resistor for the Plexiglass pressure visor on the main suit. Following the damage incurred by Grissom’s helmet during the Gemini 3 landing phase, the face visor of the Gemini suit was also reinforced from 0.08 inches (2 mm) to 0.125 inches (3 mm) thickness to help resist the type of impact Grissom encountered.

The G-4C was both designed and manufactured by the David Clark Company of Worcester, Massachusetts. Not only did the suits have to be designed to support the EVA, but they also had to operate efficiently during the launch, orbital flight and entry operations, as well as in emergency situations. As with the G-3C suits used on Gemini 3, there were provisions for parachute and floatation systems. Even though the flight of Gemini 4 was planned to last for four days, neither astronaut was to remove their suit completely. The same type of suit was used on all the subsequent Gemini missions apart from Gemini 7, the 14-day long-duration mission.

Early problems were encountered with integrating the thermal protection to the basic Gemini suit, as the seams compressed the thermal layer and created “hot spots.” This was resolved by offsetting the seams of each layer. The aim was to keep any suit leaks to within 250 BTU (British Thermal Unit) per hour, either in or out. In studies, it had been recorded that an average-sized male produces 500 BTU/hour at rest compared to 1,000 BTU/hour when active. This meant that the Gemini system had to handle a range of 500–1,250 BTU/hour. To help stay within the design parameters, all the fittings on the suit featured pouch-like cups to shield any metal from direct solar radiation.


UNDERWEAR
COMFORT LAYER
PRESSURE BLADDER
RESTRAINT LAYER (LINK NET)
BUMPER LAYERS HT-1
ALUMINIZED THERMAL LAYER
FELT LAYER HT-1
OUTER LAYER HT-1


NASA-S-65-4858
FEED PORT ADAPTER
FEED PORT FLOW RESTRICTOR
MANUAL EMERGENCY O_2 VALVE
PRESSURE GAUGE
OXYGEN BOTTLE
SUIT DEMAND REGULATOR & PRESSURE RELIEF VALVE
SHUTOFF VALVE
PRESSURE REGULATOR
FILL VALVE
BIO-INSTRUMENTATION & COMMUNICATIONS
TETHER TO PARACHUTE HARNESS
TETHER
CHECK VALVE
25 FT UMBILICAL ASSEMBLY
FLOW RESTRICTOR
'Y' CONNECTOR
QUICK DISCONNECT
CABIN REPRESSURIZATION VALVE

Gemini G-4C EVA suit layers (above) and features (below)

G-4C EVA Pressure Suit Technical Characteristics: [3]

Function: Used for both IVA and EVA activities
Nominal operating pressure: 3.7 psi (25.5 kPa)
Pressurized Garment Assembly (PGA) weight at 1*g*: 34 lbs. (15.4 kg), ten pounds heavier than the normal Gemini IVA suit (G-3C)
EVA life support system primary: VCM umbilical, not time limited
EVA life support system back up: VCM, 9 minutes
VCM weight at 1*g*: 7.75 lbs. (3.52 kg)
Total G-4C suits manufactured: Estimated at 42, supporting the whole program apart from Gemini 3 and Gemini 7. (It has not been possible to determine the number of suits fabricated purely for the Gemini 4 mission, as the units were reused for other program requirements.)

The G-4C layers were:

- Astronaut's cotton underwear next to his skin
- Cotton comfort layer
- Rubberized pressure bladder
- Restrain Link net layer
- HT-1 'bumper' layers (2)
- Seven Aluminized Mylar thermal layers (interspersed with six, 0.00025-inch-thick layers of non-woven Dacron)
- Thick felt layer (HT-1) for micrometeoroid protection
- White reflective nylon outer layer (HT-1)

Suit numbers used in flight:

McDivitt: G-4C-3 (gloves: GG-3C-13; boots: GB-4C-3; helmet: GH-4C-3)

White: G-4C-8 (gloves: GC-3C-10 (left) & 3C-14 (right); boots: GB-4C-8; helmet: GH-4C-4)[2]

Suit Testing Program

The test and qualification program for the G-4C suit incorporated all the modifications that were introduced for the G-3C test program, as well as a complete qualification program for all the new elements. There was a three-phase test program that included the selection of suitable thermal cover layer materials and screening tests for those materials; the testing of a complete production configuration suit assembly worn by a thermal dummy in the space environment simulator, which reproduced the thermal conditions produced by man under the environmental conditions of orbital flight; and the evaluation of flight-qualified suit assemblies, which focused upon suit temperature profiles, internal suit temperature, evidence of heat loss or gain, the effectiveness of the sun visor, the feasibility of wearing the IVA suit inside the spacecraft with one hatch open, and evaluations of micrometeoroid protection. The odds of the suit being punctured by a micrometeoroid were stated to be 10,000 to 1 and during tests, the suit was subjected to impacts using splinters of plastic fired at 25,000 ft./sec (7,620 m/sec).

NASA suit technician Joe Schmitt performs final checks on the Gemini 4 spacesuit. The U.S. flag is sewn on the left shoulder of each suit for the first time [Courtesy Ed Hengeveld].

NASA engineer Bill Huffsterter examines the 25-foot (7.6 m) umbilical line that would carry oxygen from the spacecraft to Ed White's suit during his EVA on Gemini 4.

Separate tests were completed on the G-4C EVA gloves, until they were withdrawn from the testing due to early failures and replaced by the IVA gloves with thermal coverings. Fabrication of the helmet was completed late and it was therefore tested separately. There were also evaluations of rapid cabin decompression on the suit, visor tests, and mechanical and pressure cycling tests. In total, there were 500 test cycles for the neck disconnection systems, 500 for the wrist disconnects, 500 for the entrance zipper and 500 for the inlet and outlet ventilations. There were also 75 complete suit don (putting on) and doff (taking off) cycles, 500 pressure cycles with an entire (manned) suit assembly, and 500 wrist flexure cycles completed.

On October 17, 1964, the first prototype of the Gemini EVA suit was received by the Crew Systems Division at the MSC. To evaluate this suit in the spacecraft's mission simulator, the Astronaut Office assigned an astronaut as a test subject. This was Jim McDivitt, who had been assigned as Command Pilot for the first Gemini flight to incorporate an EVA, in eight months' time. This would be a useful exercise for him in understanding the characteristics of the garment under pressure. From his experiences in the test, McDivitt reported the bulkiness and immobility of the suit when unpressurized, but improved mobility when pressurized. Although further work would be required, it was a significant step in the development process (see sidebar: *Anonymous 'Astronauts'*).

Anonymous 'Astronauts' The visible human elements of each spaceflight are the flight crew and their backups, all serving astronauts. In the early years of their respective programs in particular, both the United States and the Soviet Union employed a large cadre of talented pilots and engineers, from within the space program, the military and the aerospace industry, who were called upon to support the countless tests and simulations of space equipment, procedures and evaluations. They could often be found in the images of such procedures (usually in the background away from the limelight) in their roles as test subjects on routine, often mundane, but highly important checkouts of space hardware prior to it progressing to flight. In the secrecy of the early Soviet program, images of these usually unidentified individuals dressed in spacesuits helped to give rise to rumors of 'missing cosmonauts'. In the United States, some of these astronaut standins were identified, but their work – sometimes lasting many years – was largely overlooked. Recently, some of their stories have appeared on social media, revealing just how much work they accomplished before the 'real' astronauts got anywhere near the equipment they would be using in space.

There were many such individuals supporting the development of hardware and systems during Project Gemini. One of these, Norman P. Shyken of the McDonnell Company, almost made the transition to the NASA astronaut team in 1966. Born in November 1932 in Omaha, Nebraska, Shyken joined McDonnell in 1960 straight after graduation from university. He learned to fly and joined the Missouri Air National Guard, participating in the Berlin Airlift during 1961 and 1962. Discharged from active duty and back at McDonnell, he was assigned to a new program called 'Gemini', where he participated in a number of parabolic flights in the KC-135 (as illustrated in *Project Gemini: A Chronology*, NASA SP-4002, p. 164) and experienced high *g* forces while riding the human centrifuge. He worked with astronauts on early habitability issues of the Gemini crew compartment and helped coordinate the work involved in assigning the EVA to Gemini 4. He also helped design some of the Gemini crew emblems worn by the astronauts on later Gemini missions and was frequently seen on TV during 1964 and 1965 as a guest on ABC science editor Jules Bergman's news program.

Norman Shyken, McDonnell Douglas engineer and pilot, with a model of the Gemini spacecraft [Courtesy the Shyken family, used with permission].

In 1965, Shyken applied for NASA's 1966 Group 5 selection and though he made the shortlist of 44, he was not selected in the final 19 [4]. Resuming his McDonnell assignments as a Senior Engineer once the Gemini program had ended in November 1966, he was reassigned by McDonnell to Washington D.C. and completed a three-week USN Scuba course in Florida with the astronauts in 1967. Among his many assignments, Shyken participated in the Gemini Summary Conference, co-authoring a paper, and served on the Apollo AS-204 Review Team (In-Flight Fire Emergency Review Panel with astronauts Jim Lovell, Ron Evans and Jack Swigert) [5]. Between 1968 and 1972, he worked for McDonnell on assignment in Israel.

After returning to the United States, he continued to work at McDonnell until just shortly before his death from a lymphoma on July 3, 1978, aged 45.

There are dozens of such unsung workers who were crucial to the preparation and development of space hardware. The achievements of many, like Norman Shyken, have often been overlooked in the pages of space history, but though they were not astronauts, their stories are worth recording and retelling as an integral part of the varied tapestry of early human spaceflight development. (The author wishes to express his thanks to the family of Norman Shyken for permission to use the images and biographical details.)

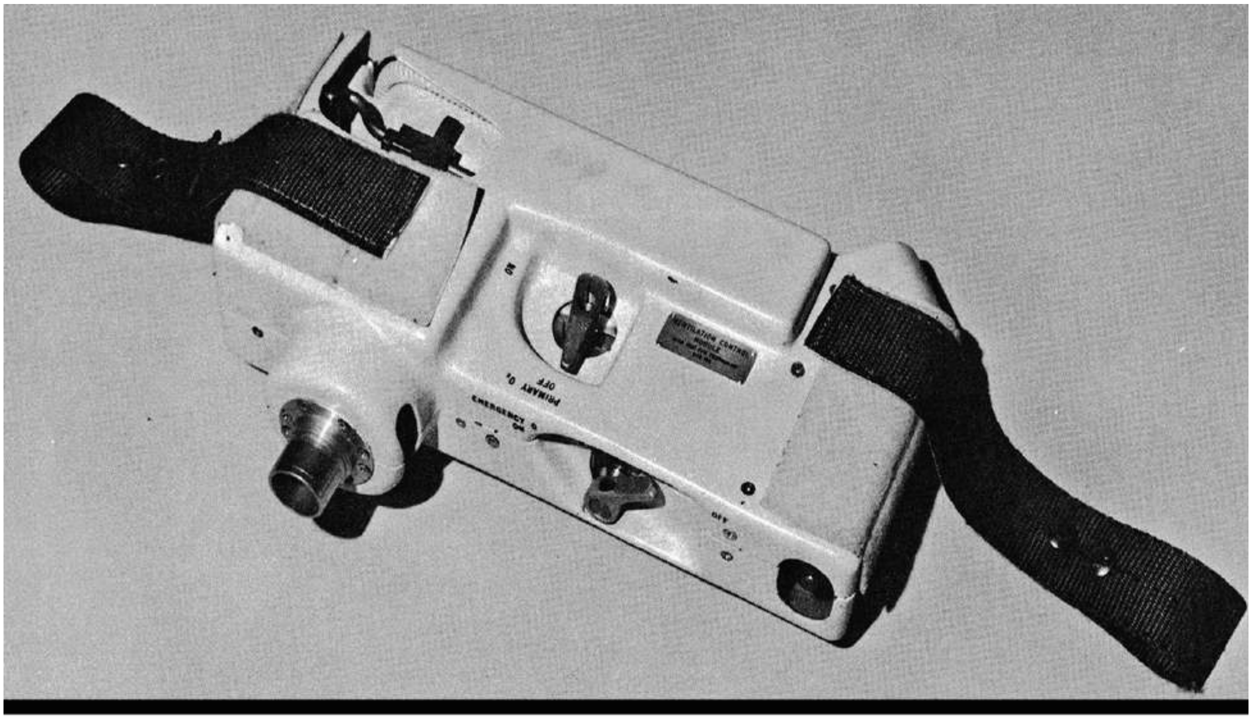
Ventilation Control Module (VCM) System

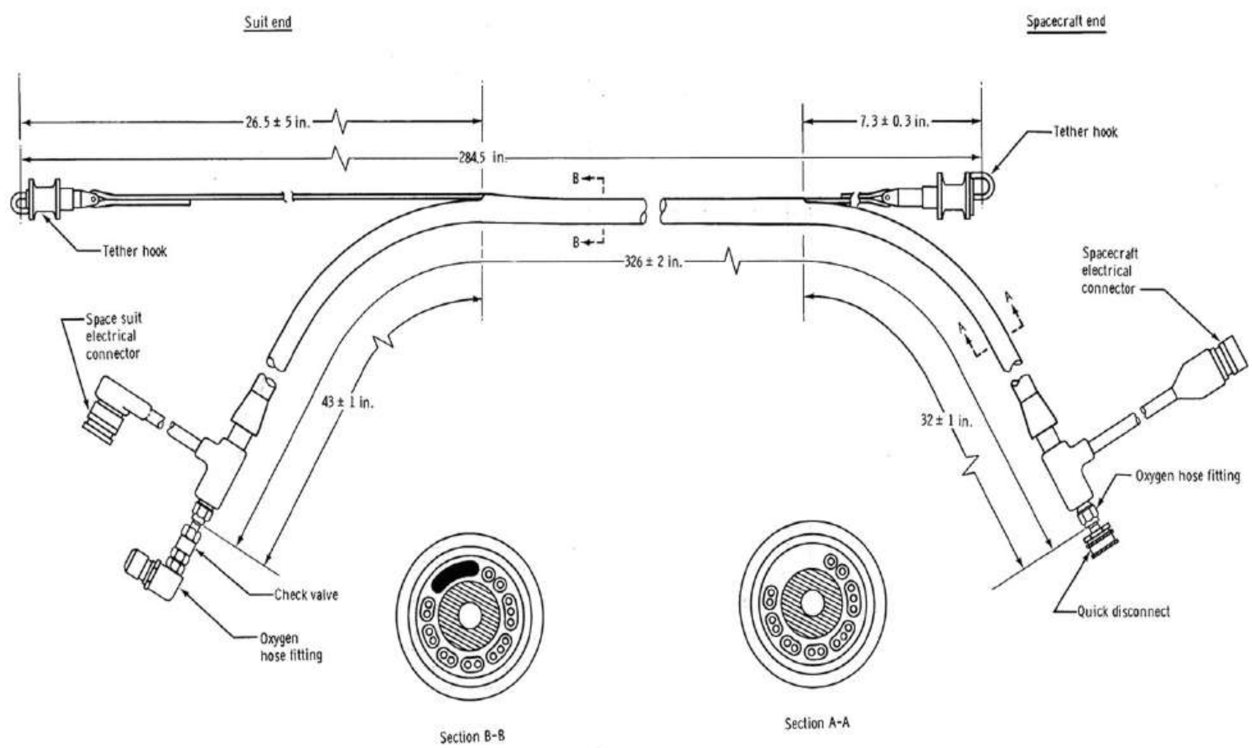
Developed in-house at the Manned Spacecraft Center (MSC), this box-like structure measured 13 inches long, six inches wide and two inches in depth (33 x 15 x 5 cm). It was designed to regulate the pressure within the suit at a constant rate and also incorporated a nine-minute oxygen supply from a small bottle, as a backup in case of a system failure with the umbilical air supply.

The VCM system included the umbilical assembly as an integral element, as well as a pair of multiple gas connectors and two restraining straps. The oxygen supply was mounted on the chest of the astronauts and drew directly from the spacecraft's supply. The two retaining straps snapped around the parachute harness and attached to the front of the VCM by Velcro.

Twenty-Five-Foot Umbilical Assembly

The AiResearch-supplied umbilical was wrapped in Scotch™ plastic tape, gold coated and then heat treated. The actual cord measured about one inch (2.5 cm) in diameter and consisted of a 0.5-inch (1.25 cm), flat, 24.5-foot-long (7.5 m) nylon tether, a 1,000-pound (453.5 kg) test line, a silicone rubber oxygen hose with an internal diameter of 0.25 inches (0.6 cm), four electrical leads and a communications lead. Together, the components of the umbilical weighed just over nine pounds (4 kg). The umbilical was designed so that all the load was carried by the tether to prevent straining on the other components. At the spacecraft end, the umbilical was attached to the elbow rest of White's seat, while the other end was attached to the 'D' ring of the astronaut's parachute harness, which was disconnected but not removed during flight.





(above) The Ventilation Control Module (VCM). (below) Detail of the Gemini 4 umbilical assembly

The umbilical assembly for Gemini 4 included a hose nozzle that would attach to the dual connector installed in the suit inlet fitting. A quick disconnect fitting was installed on the spacecraft end of the umbilical and was connected to a mating quick disconnect on the cabin re-pressurization valve, which was located on the lower section of the forward central control panel. The quick disconnect also featured a flow-limiting device which restricted the flow of oxygen from the spacecraft. Normal flow was set at 7.15 lbs./hour (3.24 kg/hour) at 60 degrees F (15.5 degrees C) with inlet pressure of 94 psia (6.48 bar) and outlet pressure of 81 psia (5.58 bar). Maximum flow could be increased to 10.2 lbs./hour (4.42 kg/hour) at 40 degrees F (4.4 degrees C) with inlet pressure of 111 psia (7.65 bar) and outlet pressure of 40 psia (2.76 bar).

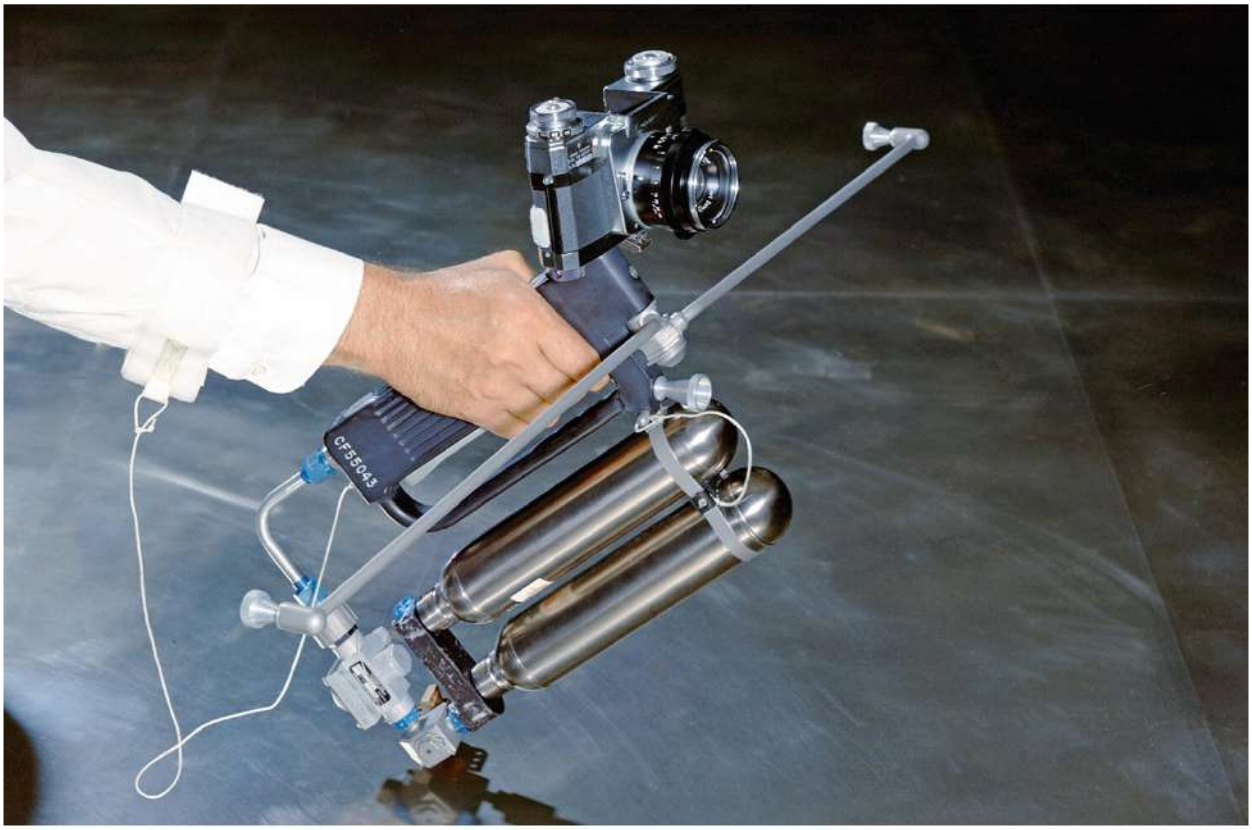
Hand-Held Maneuvering Unit (HHMU)

The HHMU was also designed and developed at the MSC and allowed for movement in six degrees (i.e. forwards or backwards; right or left; up or down) as the astronaut desired. The camera, attached to a bracket on the upper part of the unit, was a Zeiss 35-mm with a 50-mm lens and color film. White also used it to take images from inside the spacecraft.

Mission requirements necessitated that the device should be stowed inside the crew compartment. This required the propellant gas to be safe in the event of a leakage and therefore gaseous oxygen was chosen as the propellant for the HHMU. To enable it to be stowed, the device came in two parts – the hand assembly section and the high pressure section – which were joined together by connecting a coupling at the regulator section and then inserting a pin adjacent to the pusher nozzle to secure it.

HHMU Characteristics:

Thrust (Tractor or pusher, lbs.)	0 to 2	(0 to 8.8 N)
Total impulse, lbs./sec	40	(177.6 N)
Total available velocity increment, ft./sec.	6	(1.82 m/sec)
Trigger preload, lbs.	15	(66.6 N)
Trigger force at maximum thrust, lbs.	20	(88.8 N)
Storage tank pressure, psi	4000	(276 bar)
Regulated pressure, psi	120	(8.28 bar)
Nozzle area ratio	50:1	
Empty weight, lbs.	6.8	(6.34 kg)
Oxygen propellant weight, lbs.	0.7	(0.31 kg)
HHMU weight, lbs.	7.5	(3.40 kg)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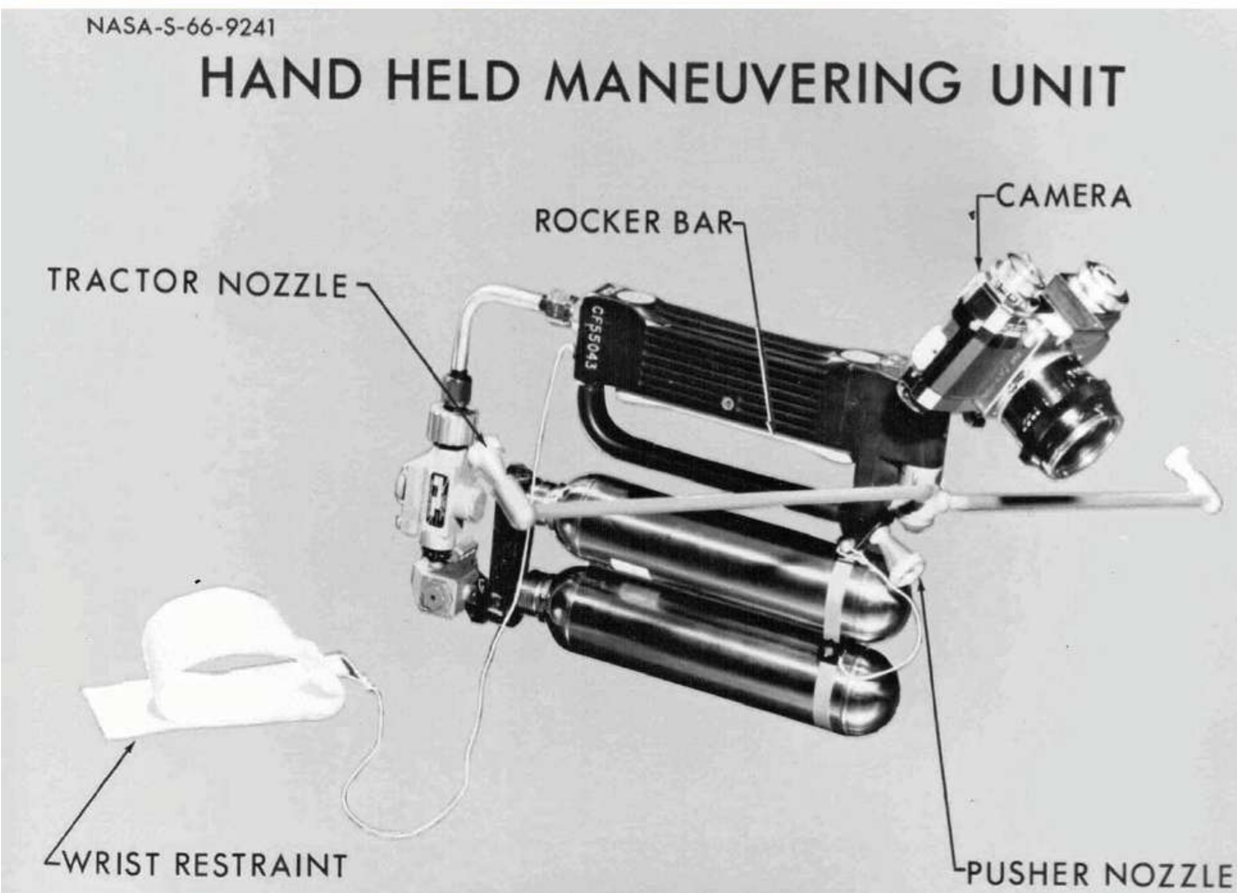
NASA-S-66-9241
HAND HELD MANEUVERING UNIT
CAMERA
ROCKER BAR
TRACTOR NOZZLE
CF55043
WRIST RESTRAINT
PUSHER NOZZLE

The Hand-Held Maneuvering Unit (HHMU). This integral unit contained its own high-pressure metering valves and nozzles to produce controlled thrust. The camera mounted at the front allowed Ed White to photograph Gemini and the Earth while on EVA. As a safety measure, the unit was attached to the EVA astronaut by a cord that fastened to the arm of his spacesuit [Courtesy Ed Hengeveld].

Operating the Device

The HHMU was an integral device that incorporated its own high-pressure cold gas supply, together with the necessary metering valves, nozzles and operating devices to produce a controlled thrust. Two cylindrical bottles contained approximately 0.68 lbs. (0.30 kg) of oxygen pressurized at 4,000 lbs. psi (per square inch *276 bar). The oxygen flowed initially through a manually operated ON*OFF valve, which White had to command to open prior to its use. The gas then flowed through a pressure simulator that dropped the pressure to a constant 120 lbs. psi (8.28 bar). The oxygen then entered the handle of the device to feed two spring-loaded poppet valves that could be controlled by the astronaut using a rocking trigger.

Pressing the front half of the trigger opened the front poppet valve, allowing the oxygen to flow through a hollow vertical shaft on the front of the unit and then via two hollow arms to a pair of small valve-shaped nozzles at the end of the arms. When the trigger was fully depressed, each nozzle produced a thrust of about one pound (4.4 N), for a combined pull (tractor) of two pounds (8.8 N). Pressing the rear trigger sent the oxygen through the rear poppet valve to the bottom of the device and the larger bell-shaped nozzles in the center of the unit. These nozzles produced about two pounds (8.8 N) of push (braking) when the trigger was fully depressed. Therefore, to move forward, the astronaut squeezed the front half of the trigger, then pressed the rear half of the trigger to stop or move backwards. The total change in velocity was about six feet per second (1.82 m/sec), with distance limited only by the attached umbilical and the fuel available in the unit.

As with the pressure garment, all these elements of the EVA equipment (the VCM, the umbilical and the HHMU) went through an extensive program of manned and unmanned tests and qualifications.

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3. **U.S. Spacesuits**; Kenneth S. Thomas and Harold J. McMann, Springer-Praxis, 1st edition, 2006, pp. 57–62 & 354.

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5. **Summary of Gemini Extravehicular Activity** , **Chapter 11, Gemini Summary Conference,** February 1-2, 1967, NASA SP-138, pp. 127–146.

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Footnotes

1 This remained true for all the EVA operations during Gemini. Every time a hatch was opened, both the Pilot performing the EVA and his Command Pilot in the other seat were exposed to the vacuum of space, even though none of the Command Pilots involved, McDivitt (GT-4), Stafford (GT-9A), Young (GT-10), Conrad (GT-11) or Lovell (GT-12), actually performed any EVA activity.

2 For Gemini 3, Grissom wore gloves: GG-3C-1; boots: GB-3C-1; helmet: GH-3C-3. Young's items were GG/B or H-3C-4. Young's suit was initially assigned to KSC Space Mobile (an education resource) on August 23, 1966.

David J. Shayler, *Gemini 4*, Springer Praxis Books
https://doi.org/10.1007/978-3-319-76675-1_3

3. Jim and Ed

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

> *"That second group of astronauts is probably the best all-around group ever put together."*
> *Deke, (1994), Deke Slayton.*

The opinion that the nine astronauts chosen by NASA in September 1962 were perhaps the best group that NASA has ever selected did not just come from their boss, former Mercury astronaut Donald K 'Deke' Slayton, who was the Director of Flight Crew Operations at the time of their selection. Over the ensuing years, many within and outside of the program have suggested that the second group of NASA astronauts, chosen primarily for the Gemini program and early Apollo missions leading to the first lunar landings, were the most talented and experienced group of pilots the agency had ever chosen, certainly during the first decade of the Astronaut Office. They have been considered better even than the famed 1959 'Original Seven' Mercury selection, or any of those selected in the several decades since, though the criteria connected with later selections changed considerably from the 1978 group onwards.

These nine men certainly made their mark during the formative years of American human spaceflight, encompassing the end of Project Mercury right through to the to the early years of the Space Shuttle. In reviewing each of the backgrounds of the 'New Nine', as they became known, there can be little doubt about their talents at the time of their selection, nor how that small group was destined to play key roles in the Gemini program, in particular the pair chosen from that group to fly the second manned Gemini mission, U.S. Air Force (USAF) officers James A. McDivitt and Edward H. White II.

Gemini 4 prime crew Ed White (left) and Jim McDivitt pictured aboard NASA Motor Vessel *Retriever* during recovery training in the Gulf of Mexico.

James Alton ('JIM') McDivitt, Command Pilot Gemini 4

In 2008, Jim McDivitt told the author that he had no plans to write his autobiography because, as he put it, "I would never be able to write what I wanted to say." That statement indicated a frustration with the direction the American space program had taken since he left it over thirty-five years earlier, but also showed a devout sense of duty and honor, a code he had followed all of his life.

James A. McDivitt was of Irish descent, born to power company executive and electrical engineer by trade James McDivitt and his wife Margaret (Maxwell), on June 10, 1929, in Chicago, Illinois. He considers Kalamazoo in

Michigan to be his hometown, however, as that was where he spent much of his childhood, graduating from Central High School there in 1947. McDivitt joined the Boy Scout movement in his youth and attained the rank of Tenderfoot, was a fan of the Buck Rogers serial, and had aspirations of becoming perhaps a novelist or an explorer, which he certainly lived up to, though of course at that time exploring space was not yet an option. Following high school, McDivitt worked as a water boiler repairman for a year before entering Jackson Junior College in Jackson, Michigan, in 1948. He graduated with an Associate of Arts (AA) higher education degree two years later. This early training and understanding of mechanics gave him an appreciation for how things worked in his later career, a skill he would find useful in his preparations for spaceflight.

In his 1999 NASA Oral History, McDivitt explained that although he had earned a scholarship to go to Michigan State University, “I didn’t have enough money to go there. So I had to go back to work.” The Korean War had escalated as his course came to a close and at 20 years of age, as he recalled, McDivitt was “prime bait” for the military draft. He chose to join the Air Force, being accepted as an aviation cadet on January 11, 1951 [1]. Though he was accepted by the Air Force to train as a pilot, the fact that he had never been in an airplane, let alone actually flown one, could have caused serious problems, but fortunately events turned out well for him. He liked aviation training and it seemed to come naturally to him. Indeed, he became the first of his pilot training class to fly solo, despite the fact that some of his classmates already had over 100 hours of flying time before joining the Air Force. “I just took to it,” he recalled, as flying apparently came instinctively to him.

Because of the Korean War, he was informed by the Air Force that his draft had been deferred, not cancelled. He could either let the deferment expire serving with the USAF, or run the risk of being drafted by the U.S. Army anyway after the war. He opted to join the Air Force. Now in his early twenties, the thought of being assigned as an enlisted man for what might have been four long years was not an attractive option and, not wishing to wash out of pilot training, he decided to focus his efforts and pass flight school first time.

McDivitt completed his pilot training at Williams Air Force Base (AFB) in Arizona, receiving his wings and a commission as a 2nd lieutenant on May 10, 1952. This was followed by six months of combat training and gunnery school at Luke AFB, also in Arizona.

Combat Flying

In November 1952, McDivitt began a ten-month deployment with the 35th Bombardment Squadron in Korea, flying F-80s and F-86s on 145 combat missions. In the 1950s, communications – even military ones – were nowhere near as immediate as they are today, so there was an agreed twelve-hour period for continuation of hostilities after the formal cessation of the fighting. This allowed the message that the war was over to reach all the outlying units. As a result, McDivitt completed his final combat mission some two hours after the signing of the armistice. With the war in Korea over, McDivitt chose to remain in service and to make a career out of the Air Force. He stated in his Oral History that his pilot training and the tour in Korea had given him more focus about the future and that he had found a purpose in his chosen career.

In September 1953, he returned to the United States to serve as a pilot and assistant operations officer with the 19th Fighter Interceptor Squadron at Dow AFB, Maine. This was followed by eight months of advanced flying instruction at Tyndall AFB in Florida, starting in November 1954. From July 1955 until June 1957, McDivitt served as a pilot, operations officer and later as flight commander with the 332nd Fighter Interceptor Squadron, based at McGuire AFB, New Jersey. During this time, he had been dating Patricia (‘Pat’) Ann Haas of Cleveland, Ohio, and the couple married in June 1956. They would go on to have four children.

(left) Air Force Pilot Jim McDivitt [Courtesy USAF]. (right) McDivitt's official 1968 USAF portrait.

Further Education

A year later, in June 1957, the recently promoted Captain McDivitt began to become fascinated by the growing interest in, and prospects for, flights into space, but was also keen to advance his education. Under the Air Force Institute of Technology Program, he returned to his studies and attended the University of Michigan, earning "straight As" when he graduated in June 1959, first out of a class of 606, and receiving a Bachelor of Science degree in Aeronautical Engineering. One of his classmates was Air Force pilot Edward H. White II.

Instead of returning to civilian life following his term at Michigan, McDivitt chose another commitment with the USAF as a regular officer, deciding to pursue his master's degree with their support. He wanted to go further and study for a graduate degree, but his application was turned down and he was instead assigned as an engineer in a project office at Wright-Patterson AFB, Ohio, "which was the last thing in the world I wanted to do," he admitted in 1999.

When Ed White had completed the course at Michigan, he had been accepted for Test Pilot School, and this was a possibility that also interested McDivitt, who was not looking forward to a non-flying position at Wright-Patterson. Very who was not looking forward to a non-flying position at Wright-Patterson. Very late in the process, McDivitt decided to try to apply to Test Pilot School as well, and was accepted for the same class as White just two weeks later.

Test Pilot

Thus, in June 1959, McDivitt found himself on his travels again, this time to the prestigious Edwards AFB in California as a student test pilot in Class 59-C. He graduated in March 1960. Once again, he was classified as an outstanding pupil, becoming the first student to achieve all three school awards: for most outstanding graduate, the best all-round flying performance, and the best academic student. After he had completed the course, McDivitt remained at Edwards with the Air Force Test Center as an experimental test pilot, which he has described as "a great job, probably the best job that I ever had."

McDivitt's time at Edwards was fortuitous, as it occurred during a period of reorganization at the school which saw the introduction of an Aerospace Research Pilot Course, for which the students studied a curriculum of space-related topics. At the completion of the course, the graduates were identified as 'military astronaut designees', intended for possible selection as managers, instructors or participants in future military space programs, though the exact details of these remained vague. McDivitt's academic and practical skills, coupled with his experience, therefore enabled him to be selected for the first ARPS class (Class 1), of only five members, in June 1961. Class 1 completed the pioneering course in December of that year. The establishment was re-designated as the USAF Aerospace Research Pilot School (ARPS) on October 12, 1961. McDivitt and the rest of his class, the first to go through this process, were also being groomed as potential instructors for subsequent ARPS classes [2].

Before enrolling in the ARPS class, however, McDivitt, who was now enjoying the fruits of his labor, responded to being informed by his boss that he was being assigned to ARPS by promptly telling him "I was not interested in it whatsoever." McDivitt thought that he had gone through enough schooling and now just wanted to fly airplanes, continuing what he was doing as a test pilot. When he was told in no uncertain terms that he was indeed going to be in that first class, he knew he had no choice in the matter, "so I saluted and said, 'Yes Sir!'."

This program was so new that there were few who could teach the topics, so McDivitt and his fellow students in this vanguard class created the curriculum as they went. Not only did they teach each other, but they also put the school's flying curriculum together, designed the course, wrote the specifications for simulators and effectively created the program from scratch. Upon graduation simulators and effectively created the program from scratch. Upon graduation, McDivitt remained at Edwards as both an experimental test pilot and an instructor at the school until July 1962, when he was assigned to the Manned Spaceflight Operations Branch, Edwards AFB, California. That same month, Colonel Charles E. 'Chuck' Yeager became the commandant of the school and suggested that McDivitt should apply for astronaut training at NASA.

An Opportunity Arises

With his previous Air Force experience, education, and excellent skills as a pilot, it was not long before new opportunities began to present themselves to McDivitt. Just after completing the ARPS course, he was asked to become the replacement backup for the prime USAF X-15 pilot[1]. At that time, the current Air Force pilot, Robert M. 'Bob' White, was leaving and his backup, Robert Rushworth, was moving up to prime pilot position, thus leaving a vacant position for McDivitt. This was an opportunity which he jumped at. At the same time, he was also informed that he was to be project pilot for the F-4 *Phantom* program that was under consideration for the Air Force as well. This period was certainly a positive one for McDivitt, because he was further informed that he was also under consideration for the USAF's X-20 Dyna Soar program. With all these options in front of him, the prospects of a flight into space beckoned and he thought he should learn more about that field too.

To review the X-20 program[2], McDivitt went to prime contractor Boeing for a few days, but was not impressed with what he saw. He thought that the X-20 would never fly, which turned out to be a correct assessment. When he returned to his unit, he told his superior he was not interested in pursuing that option, the first time that an Air Force test pilot had turned down a premier Air Force program. McDivitt was adamant that the X-20 would never fly and he was proven right, with the program eventually cancelled in December 1963.

In line for the X-15 program and concurrently assigned as the new project officer for the USAF F-110 *Spectre* (the original USAF name of the Navy's F-4 *Phantom* until 1962), McDivitt was about to go to France for a month to flight-test a selection of French fighters and bombers when he was told that a new NASA selection was about to be announced while he was gone. He was asked whether he wanted his name submitted. At that time, he did not, because he wanted to stay at Edwards and fly the X-15. After returning from France, he became more involved with the X-15 and started work on his F-110/F-4 assignment, but also began to have second thoughts about applying to NASA. His decision not to try for astronaut selection began to bother him, after all the Air Force had done for him in furthering his education and experience.

He was undecided between what he *wanted* to do, which was fly the X-15, and what he thought he *should* do, which was to make his best contribution to his country and his service as an astronaut. So he called Bob White, and the two of them spent some hours discussing his options. Apparently, White told McDivitt that he should do what he felt was right for him and if that meant pulling out of the X-15, he should not feel as though he was letting down White (who McDivitt thought had nominated him as a replacement) in declining the assignment.

One problem for McDivitt was that the NASA astronaut application period had been completed a couple of months previously, but Bob White thought he could help because the Air Force was having its own selection to nominate candidates prior to submitting them to NASA. After a few phone calls, McDivitt was told his application to NASA would be accepted, even though it was a couple of months late, as long as they received the application immediately. That raised another problem, in that McDivitt could not type, so White once again helped him by preparing his application for posting (remember, there were no fax machines or email in the early 1960s). He gave it to the secretary of the colonel who was assigned as the instructor of flight tests, to have it signed and posted straight away as NASA was waiting for it. The next day, the colonel came storming in to where McDivitt was completing his admin for his last test flight and, throwing the application to the floor, called McDivitt a traitor to the Air Force and insisted that he withdraw his application to NASA. McDivitt said he could not do that as he had already made up his mind, Bob White was involved, and AF Headquarters was by now expecting it. The colonel was not pleased, “and so he yanked me off the X-15 program right there,” McDivitt recalled. He was told that not only was he off that program, but that his Air Force career was over. “So I had all my eggs in one basket [NASA’s] and fortunately I got selected,” McDivitt explained. Several years later, after McDivitt had left the Air Force, he received a letter from that same colonel, who had retired by then. While sitting out on his patio, the colonel had reflected on his Air Force career, including both the great and the really bad decisions he had made. He had come to realize that he should never have threatened McDivitt the way he did.

A more humorous version of the NASA Group 2 (‘The Next Nine’) image depicted in *Gemini Flies* p. 163. (Clockwise from top right) Frank Borman; John Young; Tom Stafford; Pete Conrad; Jim McDivitt; Jim Lovell; Elliott See; Ed White; and Neil Armstrong [Courtesy Joachim Becker/Spacefacts.de]

One of Nine

Jim McDivitt was one of the nine test pilots chosen by NASA on September 17, 1962, the agency’s second intake of astronaut trainees. On being selected as one of America’s latest astronauts, he commented that “there’s no magnet drawing me to the stars. I look on this whole project as a real difficult technical problem – one that will require a lot of answers that must be acquired logically and in a step-by-step manner.” [3] Unlike the groups selected since 1978, the astronauts chosen in the 1960s did not have to undergo a candidate training program prior to graduating with the title of ‘astronaut’. From the day they were selected, the early groups were fully fledged but unprepared astronauts, who then completed a variety of training and preparatory courses prior to their first spaceflight assignments. This training usually lasted between six and twelve months following selection. As the program became more complex and broader in scope, their basic training was supplemented by a number of technical and support assignments, where one or two members of the Astronaut Office followed certain elements of hardware, systems or procedures and then reported on the progress – or indeed lack of it – to the rest of the astronauts.

Edward Higgins (‘Ed’) White II, Pilot Gemini 4

If there is one book which is surely missing from any space library, it is an authoritative biography on Ed White. Despite the tragic and early end to his life, White accomplished enough in his relatively short career to suggest that far greater achievements would have been ahead of him had he lived. His place in spaceflight history is assured, as the first American to walk in space, but there was so much more to the man which remains to be told [4].

Official 1966 USAF portrait of Edward H. White II.

A Rich Ancestry

Born on November 14, 1930, in San Antonio, Texas, the future pioneering American spacewalker was raised in a military family, so it was no surprise when Ed White joined the "family business" and opted for career in the armed forces. He came from an impeccable pedigree. His father was General Edward H. White, USAF Retired, a pioneer in American military aviation who had flown almost everything the Air Force had that could get him off the ground, from balloons to jets, across a 35-year career that began in the U.S. Army Air Corps. When Ed was just twelve years old, barely old enough to strap on a parachute, his father took him aloft in a T-6 trainer and allowed his son to take the controls for a short while. At that moment, the young Ed was doing something which felt to him like the most natural thing in the world and he was immediately hooked by aviation. It was a path which, two decades later, would take him much higher and faster than either he or his father could ever have dreamed of that day in the T-6. But the pedigree stretched further than just Ed's famous father. Two of his uncles were also career military officers. James White served in the U.S. Army, while John White served in the U.S. Marine Corps, both attaining the rank of colonel in their respective parent service. From such a rich heritage, it was natural that the young Ed White should learn values and lessons that would serve him well in his adult life.

In his early years, being the son of an Air Force officer meant moving around the United States, and he was brought up on bases from the East Coast to Hawaii, wherever his father's assignments took him, before the family finally settled in Washington D.C. There, the young Ed attended Western High School, graduating in 1948. He won a place in the prestigious U. S. Military Academy in Washington D.C., but it was not straightforward. Normally, acceptance required a continuous residency, but constantly moving around precluded the opportunity for a congressman to appoint him to West Point. Taking the initiative, White walked up and down the hallowed halls of the U.S. Congress trying to gain a place as an 'at-large appointee'. After knocking on enough doors, he was able to do so and therefore followed his father and one uncle into the famous West Point Academy. Because of his red hair, Ed was known to many as "Red," but his prowess on the sports field spared him any harassment at mealtimes because he could eat at the "team tables." During his years at West Point, Ed met fellow student and future moonwalker Buzz Aldrin. Aldrin was a year in front of White, and on one occasion, having sat at the dinner table with White, Aldrin noted that "as a lanky man, without an extra ounce of fat, Ed White could eat a lot of food."

[5]

Almost an Olympian

Despite the constant relocations, Ed White had always demonstrated good academic and athletic skills, especially in hurdling, reaching as high as number two in the Washington D.C. area at one point. Throughout his life, he had a passion for fitness and sport across a number of disciplines, especially at West Point, where his athletic talents continued to shine. He set an academy record in the 400 m hurdles that stood until 1965. In fact, he was good enough to try out for the 1952 United States Olympic track team, but unfortunately failed to qualify, just missing out in that event.

Throughout June 1952, the men's U.S. track and field trials took place in preparation for the 15th Olympiad of the modern era. The preliminary meetings had been held earlier in the month in Long Beach and Berkeley, but final qualification for the team was to be held over two days (June 27 and 28) at the Los Angeles Coliseum, California. The 400 m hurdles trials were completed on the afternoon of June 27, with Ed White drawing a place in the first of two heats. The first three from each heat would then qualify for the final, which was held just over an hour later, to select the final fastest trio to go to the Games. In the end, White was the fastest non-qualifier of the twelve participants, timed at 53.1 seconds and finishing a respectable fourth in his heat, just 0.4 seconds behind the third man Roland Blackman who qualified for the final with 52.7 seconds. The heat had been won by Charles Moore in 52.0 seconds, with Lee Yoder claiming second place at 52.3. In the second heat, Bob DeVinney won at 52.7, Don Halderman came in second at 53.1 (the same time as Ed White in his heat) and the third man, taking the last place in the final, was Jack Sage at 53.2 seconds, which was 0.1 seconds slower than White had run in the first heat. When the final was run an hour later, Moore again won, in 50.7 seconds, with Yoder (51.3) and Blackman (51.6) coming in second and third and both qualifying for the Olympic team. DeVinney (also 51.6), Halderman (52.3) and Sage (54.6) completed the lineup but missed out on the final selection.

It had been a close thing, and if White had been in the second heat his time would have gotten him into the trials final, and maybe given him a good shot at qualifying for the team. But it was a tough call, as author Richard Hymans noted in his 2008 review of the history of U.S. track and field Olympic teams: "Make the top three in your event, and you are on the team. Have a slightly off day and you are out." Making the team was no guarantee of winning a medal at the Games, of course, a comparison that could be reflected in the early selections for the astronaut program and the slim opportunity, even after selection, of being assigned to a crew and going on to make a flight into space. White may have missed out on being an Olympian, but thirteen years later he was destined to make a far higher leap into history than jumping over a track hurdle would have afforded him.

Less than a month later, at the 1952 Summer Olympics held in Helsinki, Finland (July 19 – August 3), Charles Moore went on to win the Olympic title and gold medal, setting a new Olympic record in the 400 m hurdles with a time of 50.8. The heats and quarter-finals had been held on July 20, with the semi-finals (in which both Yoder and Blackman were eliminated) and final the following day [6].

Over the years, Ed White's passion for physical fitness was evident, enjoying squash and handball (at which he became one of the best players in the Astronaut Office), swimming, and golf. He had even played as a center back for the West Point soccer team, a sport which was barely noticed in the United States at the time.

Even after his selection as an astronaut, White still found time for personal fitness. Maintaining individual fitness remained the responsibility of each of the astronauts, and they needed to look no further than Ed White for inspiration on how to approach the challenge. During his NASA years, White would jog two miles a day, squeezing a small rubber ball as he ran in order to strengthen his hands and arms in preparation for strenuous work inside a pressure suit, such as EVA, during missions. As well as running he sometimes cycled, and it was never an issue for him to pull fifty pushups and then suddenly flip over and add fifty sit-ups without checking his breathing rate. He even had a 40-foot length of rope fixed in his back yard at home, so he could climb it on rare days off. He was clearly considered, by many of his peers and the medical staff alike, as one of the best, if not the best, physical specimens of all the early astronauts of that era. He was a large man but also physically strong. On top of all this, he even found time to pursue his hobby of photography.

If the failure to make the Olympic Team was a disappointment to White, he never seemed to let it show. Nor did it hamper his career, which moved to the next phase on June 3, 1952, the same month as the Olympic trials, when he graduated 128th in a class of 523 cadets. One of his classmates who graduated with him was another future NASA astronaut, Michael Collins [7]. At around this time, while he was at a West Point football weekend, White met a local girl called Patricia E. 'Pat' Finegan and from there his life changed. They were married in January 1953 and would have two children.

NASA Group 2 during desert survival training near Stead AFB, Nevada, August 1963. (Front row from left) Frank Borman, Jim Lovell, John Young, Pete Conrad, Jim McDivitt and Ed White. (Back row from left) Raymond Zedekar (Astronaut Training Office, MSC), Tom Stafford, Donald K. 'Deke' Slayton (Group 1 astronaut and then coordinator of astronaut activities in the Astronaut Office), Neil Armstrong and Elliot See.

Joining the "Family Business"

Upon graduation from West Point, White entered pilot training at Bartow Air Base in Florida, earning his wings in October 1953 and being promoted to 2nd lieutenant. His next assignment took him to the James Connally AFB back in his home state of Texas for advanced jet pilot training on the T-33 (*Shooting Star*), before he was relocated with his wife and first child to Germany in 1954. He was stationed with the 22nd Fighter Day Squadron at Bitburg AFB, near the Luxembourg border, flying the F-86 (*Sabre)* and F-100 aircraft, as well as attending the Air Force Survival School at Bad Tolz. White's second child was born during their time in Germany.

At some point in 1957, White read about the possibility of a USAF Man-in-

Space program. The prospect intrigued him and he decided to focus all his attention in that direction, striving to add further academic education to his practical experiences to help steer his course towards selection. The family returned to the United States later in 1957 and White entered the University of Michigan in September of that year under the Air Force Institute of Technology program. He graduated with a master's degree in Aeronautical Engineering in 1959. While he was a graduate studying at UM, he met and became friends with AF Captain James A. McDivitt. Promoted to Captain himself in March 1958 after graduating from UM, White, together with McDivitt and Tommy Bell (who later attended the 4th ARPS class and became a test pilot on the Rockwell B1), was selected to attend the Air Force Experimental Test Pilot School at Edwards AFB, California, graduating with Class 59-C in June of 1960. By this point, White had also applied for NASA's first astronaut selection in 1958 for the Mercury astronaut program, but was not on the shortlist of 32 from which the final seven were selected.

Upon graduation from the Test Pilot School, White was assigned to Wright-Patterson AFB in Dayton, Ohio, where he served as an experimental test pilot with the Aeronautical Systems Division. Part of his preparation for test flying was to undergo a series of stringent medical exams, which he passed on June 20, 1960. This could only have helped his later selection process with NASA. While at Wright-Patterson, he served as a pilot with the cargo flight test division, flying the KC-135 in ('zero-gravity') parabolic profiles and extended flight simulations. During this time, White served as the pilot for weightless simulation flights with Mercury astro-chimpanzees Ham and Enos, as well as for Mercury astronauts John Glenn and Deke Slayton as part of their preparations for flying into space, another assignment which added to his increasingly impressive curriculum vitae.

During the eight months he was assigned to the Aeronautics Systems Division at Wright-Patterson, White logged approximately 1,200 parabolic profiles and accumulated over five hours of weightless flight, the equivalent of just over three orbits of the Earth (a total which exceeded that of four of the Mercury astronauts when flying their missions[3]), which he thought gave him useful experience towards his selection to the astronaut program. As a test pilot, in addition to his parabolic flights, White participated in numerous research flights and weapon systems development programs, authored a number of technical reports and put forward recommendations for improvements in aircraft design and construction [8].

Undeterred by his earlier failed application for spaceflight training, White tried again in April 1962 when the call for the second group of astronauts was made. The basic criteria for selection remained the same as in 1959, focusing upon experienced test pilots with extensive experience in high performance jet aircraft. A bachelor's degree in engineering or the physical sciences was also a requirement, but the upper age limit was reduced from 40 to 35 and the maximum standing height allowed was increased by an inch to six feet (1.82 m). This time, White made the last 32, passing his medical on July 30 at the Air Force School of Aerospace Medicine in his home town of San Antonio, Texas. On September 17, 1962, Ed White was one of the nine test pilots chosen by NASA in its second group of astronauts.

Ed White examines a piece of lava during a 1964 geological field trip to Meteor Crater, Arizona. This was part of the astronaut's scientific studies, conducted in conjunction with his Gemini training, in support of a future assignment to an Apollo (possibly lunar landing) crew.

Training the Next Nine

Alongside Jim McDivitt and seven colleagues, White reported to NASA MSC in Houston, Texas, on October 1, 1962, to begin the academic training program, which entailed six hours a day for at least two days a week over a four-month period. The training, which was completed on February 6, 1963, included a program of basic space sciences, encompassing rocket propulsion, flight and orbital mechanics, the medical aspects of spaceflight, astronomy, navigation, environmental control systems, meteorology, star recognition, communications, computers, space physics, and guidance. On top of this were briefings on Project Mercury, familiarization classes covering the components and systems of the Gemini spacecraft, the Titan, Atlas and Agena boosters and the plans and components of the Apollo program, visits to contractors and NASA field sites across the continental United States, and subsequently, a series of survival training courses [9]. On January 26, 1963, the Director of the MSC, Robert Gilruth, announced assignments of specialization for the astronaut team. McDivitt was initially assigned to track several guidance and navigation issues and was later assigned to the Astronaut Office Apollo Branch on July 8, 1964. This became a dual assignment on July 27, when he was also named as Command Pilot for Gemini 4.

Ed White was assigned to a technical role in flight control systems and was also then assigned to the Astronaut Office Apollo Branch, under Gordon Cooper, on July 8, 1964. Less than three weeks later, he was named as Pilot on the Gemini 4 crew alongside his friend Jim McDivitt, and was administratively transferred to the Gemini Branch of the Astronaut Office under Virgil Grissom.

Interestingly, in flying Gemini 4, Jim McDivitt became the first American astronaut to command an orbital space mission without having first served on a backup or support crew, or having flown on a previous mission (excluding, of course, the pioneering 1961 suborbital flights of Al Shepard and Gus Grissom). In his 1974 biography, Michael Collins wrote that he thought Jim McDivitt was “one of the best. Smart, pleasant, gregarious, hardworking; his thoroughness was legendary.” [10] A perfect choice for the four-day Gemini 4 mission.

Two for Four

In 1988, Collins wrote that “like Gus [Grissom] and John [Young], McDivitt and White were also a matched pair – but of an entirely different sort.” [11]

Astronauts, especially from the early selections, have been labeled as supreme over-achievers, which would imply that they were at the top of their game, striving for the peak of the pyramid. In such small, at times elite circles, it was natural that the paths of several of them should cross more than once as their careers developed towards selection to the space program, and an even more elite group.

Three years before McDivitt and White sat in front of the press being introduced as the nation's latest astronauts, both were classmates at the University of Michigan and friends who lived just a block or so down the street from each other. McDivitt said in 1999 that "my relationship with Ed could not have been better; he was the best friend I ever had." At Michigan, they had taken classes together and flew together as often as possible. McDivitt was the scheduling officer for the Air Force Pilots at Michigan (which totaled 150–200 at its peak) and was able to schedule them to fly together when he could. They also then attended test pilot school together before White went off to Wright-Patterson and McDivitt remained at Edwards.

During the Air Force's pre-NASA astronaut selection process, the shortlisted officers were summoned to the Pentagon for interviews, and as McDivitt was taken into the waiting room, White was already there. White said he knew McDivitt would be in the group, and McDivitt replied that he knew that White would be there as well.

Even at NASA, they shared an office for a while in downtown Houston before moving to the newly created Manned Spacecraft Center. At the MSC, although they were now in separate offices, their technical assignments (McDivitt in guidance and navigation and White in flight controls) were intertwined from an engineering standpoint and they often worked together.

Choosing a Crew

When Deke Slayton was looking at likely and compatible pairings for the long-duration Gemini missions, he had already made up his mind as early as 1963 to assign a rookie Group 2 member to one of the initial flights, giving him an early chance of a command position. The first manned Gemini missions each had distinctive requirements: Gemini 3 was the first manned flight of the vehicle and essentially an engineering test-flight; Gemini 4 was planned at that stage for a challenging seven days; Gemini 5 was scheduled for the first rendezvous and docking with an Agena target; and Gemini 6 was going to be the 14-day space marathon. Each of these would require a good crew pairing to ensure that the objectives were achieved early. The remaining six missions would follow similar profiles and expand upon the experiences of rendezvous and docking as a prelude for Apollo. Each would last for about four days, perhaps with EVA, and probably with some of the experienced Group 2 pilots taking their first command seats.

As the program developed, Slayton looked to assign an experienced Mercury astronaut as Command Pilot and a rookie Group 2 astronaut as Pilot for Gemini 3, 5 and 6. But Gemini 4 was planned as the first long-duration mission. Later, a basic EVA program was added, initially only a stand-up activity in the hatchway, and then an early opportunity arose for a rendezvous or station-keeping exercise with the Titan upper stage. Slayton reckoned early on that Jim McDivitt would be the perfect choice to assign to such a demanding mission as Command Pilot, with Ed White as Pilot. Both were from the USAF, former classmates from the University of Michigan and good friends. Compatibility was the key to these long missions, where long periods of tedium would be the low point of spending several days looking out of the window at Earth. For the backup assignments, Slayton looked at their Group 2 colleagues, selecting Pete Conrad as Command Pilot and Jim Lovell as Pilot. They were both from the navy and had been classmates of the USN test pilot school, and were again very compatible with each other.

However, just when Slayton thought he had the flight seats sorted, several events beyond his control forced changes to these carefully planned assignments. Originally, Gemini 3 was to have been flown by America’s first man in space, Al Shepard, along with Tom Stafford, backed up by Gus Grissom and Frank Borman. This backup crew would then become the prime crew for the 14-day Gemini 6 mission. The Gemini 5 docking mission would be flown by Wally Schirra and John Young. However, Shepard was grounded during 1963 due to Ménière’s disease, an inner ear problem that cost him the Gemini 3 command and in fact threatened his future as an astronaut. Then came the news that the Agena docking target would not be ready for Gemini 5 and had slipped to Gemini 6. Crew changes would be necessary to address all this.

As this news circulated, Slayton’s crewing system of backing up one mission, then missing the next two to fly the third was under threat. If he was going to keep Schirra on the docking mission he desired, he would have to back up Gemini 3 and then fly Gemini 6, so Slayton teamed him with Tom Stafford. As Grissom and Borman were not getting along as well as Slayton had hoped, he split them up and assigned John Young to fly with Grissom on Gemini 3. He then decided to move Conrad to Gemini 5 along with Gordon Cooper and allocated Borman to the 14-day mission, promoting him to Command Pilot and assigning Lovell to join him on Gemini 7. The pair would first serve as the backup crew to McDivitt and White on Gemini 4. Therefore, on July 27, 1964, NASA announced the crewing for Gemini 4 as Jim McDivitt and Ed White, with Frank Borman and Jim Lovell as their backups.

When McDivitt learned the he and White had been selected to Gemini 4, from Slayton and Shepard at a regular Astronaut Office pilots’ meeting before it was announced publicly, he thought he should tell his children about it first before the public announcement. As they were still young, around seven or eight, McDivitt thought it would be better coming from their father first. He decided to tell his children over breakfast on a Saturday morning, building himself up for the surprise that Dad was going to fly in space soon. But his eldest son surprised him instead, saying, “Oh yeah, I heard that at school,” a fact also confirmed by his daughter, who was more concerned about finding a fly in the milk bottle on the kitchen table than the fact that their dad was to be rocketed into space. At that breakfast table, McDivitt came down to Earth with a bump, well before returning from his first space mission, realizing that, in a local community where most of the people worked in or were associated with the space industry, his so-called big news was already old news.

When he was asked why he thought he had been selected as Command Pilot ahead of his colleagues during his NASA Oral History interview in 1999, McDivitt had no idea. Indeed, many of the astronauts never found out why they were chosen for a particular flight seat ahead of their peers, or indeed why they were not chosen. McDivitt modestly and humorously suggested “Well, I was the best-looking astronaut there was, and so they picked me on looks… and the greatest personality!” [12]

Keeping an Eye on the Time

Some images of Ed White performing his EVA show an Omega Speedmaster timepiece on his left arm over his spacesuit, strapped to his wrist with a Velcro band. But was it his own watch or an official NASA timepiece? Introduced in 1957, the Speedmaster was part of the Omega company’s “Professional Collection” and was designed as a racing and sports chronograph. In 1962, Wally Schirra wore his own Speedmaster for the Mercury 8 mission, as did Gordon Cooper on Mercury 9 the following year, but these were the astronauts’ own watches and had nothing to do with NASA. However, the astronauts were pushing for more accurate timing devices, requesting a suitable wristwatch as a backup device to the onboard clocks. Aware that flying ‘private’ items could cause a lot of problems, NASA decided in 1964 to evaluate and certify a watch that could officially be part of the astronauts’ flight kit.

The assumption that NASA ‘bought’ the Omega watches is a misconception. As NASA is a government agency, it is not allowed to ‘buy’ items; they have to be formally ‘procured’ through a competitive government evaluation. In 1964, Flight Crew Operations Director Deke Slayton sent a memo requesting “a highly durable and accurate chronograph to be used by

Gemini and Apollo flight crews." A letter and corresponding list of specifications was sent to a number of watch manufacturers, including the U.S. agents or importers of those based outside the United States. Ten candidates were invited to submit a suitable timepiece for evaluation. They were: Benrus, Bulova, Elgin, Gruen, Hamilton, Longines, Luchin, Mido, Omega, Piccard, and Rolex. Of those, only Hamilton, Longines, Omega and Rolex responded and each sent three watches; one for testing, one for the astronauts to evaluate during training, and a spare in case the others were damaged.

A program of tests for the watches was organized by test engineer James H. Ragan, who had only recently joined NASA and was assigned to equipment procurement and testing for the Gemini program. The Hamilton watch, a military chronograph pocket watch, was immediately rejected as it was outside the guidelines stipulated by NASA. The program of eleven Qualification Test Procedures ran between October 21, 1964 and March 1, 1965. The tests included 48 hours at high temperatures (160 degrees F/71 degrees C) followed by 30 minutes at 200 degrees F/93 degrees C and then four hours at a low temperature of 0 degrees F/-18 degrees C. This was followed by fifteen cycles of temperature pressure testing, by heating to 160 degrees F/71 degrees C and then cooling to 0 degrees F/-18 degrees C, both for 45 minutes at 10^{-6} atmospheres (atm). There was a relative humidity test of at least 95 percent for 240 hours at temperatures between 68 and 160 degrees F (20 and 71 degrees C) and the watches were exposed to 48 hours in a 100 percent oxygen environment at a pressure of 0.35 atm. They were then subjected to shocks (physical, not electrical) of 40 *g* in six different directions, each of 11 milliseconds duration, and were accelerated from 1 *g* to 7.25 *g* within 333 seconds along an axis replicating that of the longitudinal axis in a spacecraft. They endured 90 minutes decompression in a vacuum of 10^{-6} atm and temperatures of 160 degrees F/71 degrees C, then 30 minutes at 200 degrees F/93 degrees C. There was another high pressure test at 1.6 atm for an hour, three cycles of vibration tests varying from 5 to 2000 Hz and finally exposure to acoustic noise of 130 DB over a frequency range of 40 to 10,000 Hz for 30 minutes. After these tests and following calibration, one of each watch was issued to the Gemini 3 astronauts to wear during their training. They would report on each watch's ability to withstand the rigors of training, its reliability and usability.

The only one to survive all the tests was the Omega Speedmaster and it was certified for operational use by NASA astronauts. Reportedly, as the tests and results had been held within NASA, the first time that Omega in

Switzerland learned of the use of their watches was when they saw the pictures of Ed White wearing a Speedmaster Professional during his EVA on Gemini 4. The Speedmaster went on to become the official watch of the Gemini and Apollo astronauts. As for the others, the Rolex did not perform well in the humidity and high temperature tests, suffering a misshapen hand, while the Longines sample failed due to its crystal giving way under the heating and vacuum tests [13].

Names, Flags and Emblems

Unlike Gemini 3, the crew of Gemini 4 was not allowed to name their spacecraft officially, although they had pushed for the patriotic “American Eagle.” With the inclusion of the spacewalk, the name “Little Eva” was circulated by journalists for a time, the feminine name ‘Eva’ a clear link to the short, pioneering spacewalk, or EVA.

There was no official emblem for the mission either, though commemorative emblems were produced post-flight for collectors. There was, however, an insignia of the “American Eagle,” the intended callsign, which was reproduced on the commemorative medallions carried onboard the spacecraft but was not formally reproduced as an emblem until years after the mission. The mission patch was produced based on this design in 2008 and was given the seal of approval by Jim McDivitt. It is the closest to what a formal mission emblem would have looked like if it had been authorized, though that honor would have to wait until the next Gemini crew.

An artist’s representation of the proposed but unofficial Gemini 4 “American Eagle” mission emblem [Courtesy Joachim Becker/Spacefacts.de].

What the Gemini 4 crew can claim credit for is becoming the first American astronauts to display a replica of the U.S. Stars and Stripes national flag on the shoulder of their suits. They proudly considered that this was their mission emblem as well. “The original flags we had sewn on we purchased ourselves,” McDivitt recalled. “Later on, of course, NASA made this an integral part of the pressure suit.” [14] Early on, the astronauts had planned to carry a small U.S. flag for White to release into orbit during his EVA. Then, a couple of days before the flight, they thought of the idea of wearing the flag on their suits and asked for them to be sewn on. The plan was to wear one flag on the detachable sleeve of White’s EVA suit, which he would discard overboard during the second hatch opening. As that second opening never occurred, the flag returned to Earth with the crew [15].

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4. Other than the 'basic' USAF and NASA biographies, there is regrettably very little detail on the life and career of Ed White, one of America's space pioneers. One of the more informative biographies, written by Mary C. Zornio on January 8, 1997, was released by NASA in 1997 to mark the 30th anniversary of the Apollo 1 (AS-204) tragedy. Another extensive review of the life of America's first spacewalker was offered by Kate Doolan in **Fallen Astronauts, Heroes Who Died Reaching for the Moon**, Colin Burgess and Kate Doolan, with Bert Vis, University of Nebraska Press, 2003, pp.110–134.

5. **Fallen Astronauts, Heroes Who Died Reaching for the Moon**, Colin Burgess and Kate Doolan, with Bert Vis, University of Nebraska Press, 2003, Chapter 3, Countdown to Disaster, p. 116.

6. **The History of the United States Olympic Trials – Track & Field,** Richard Hyman, ATFS 2008, USA Track & Field, pp. 98–105.

7. **Carrying the Fire: An Astronaut's Journeys**, Michael Collins, Farrar, Straus & Giroux, 1974, p. 140.

8. **Men and Women of Space,** Douglas B. Hawthorne, Univelt Incorporated, 1992, pp. 795–7.

9. **Moon Bound: Choosing and Preparing NASA's Lunar Astronauts**, Colin Burgess, Springer-Praxis, 2013, pp. 161–174.

10. Reference 7, pp. 59–60.

11. **Liftoff**, Michael Collins, Grove Press, 1988, pp. 85–6.

12. NASA Oral History Project, James A. McDivitt, June 29, 1999, pp. 12.30–12.31.

13. Omega Speedmaster History Part 1 – the early pre-moons, Brice Goddard, August 8, 2014 https://monochrome-watches.com/omega-speedmaster-history-part-1-early-pre-moons/; The Speedmaster Stellar Legacy, Cheryl Chia, Cultural Perspectives, *The Hourglass Australia*, July 5, 2018, https://launch.thehourglass.com.au/cultural-perspectives/the-speedmasters-stellar-legacy/ Last viewed July 15, 2018.

14. **All We Did was Fly to the Moon**, Dick Lattimer, The Whispering Eagle Press, 1985, p. 23.

15. *I Felt Red, White and Blue All Over*, Edward H. White II, *Life Magazine*, June 18, 1965.

Footnotes

1 The X-15 was a joint USAF/USN/NASA rocket-powered aircraft designed to fly at speeds of up to Mach 6. Three aircraft were built and 199 free flights conducted between June 1959 and October 1968. There was

no formal selection process for the 14 pilots directly associated with the program, only 12 of which flew the aircraft. Never considered as a spacecraft, in ten-minute free flights the X-15 could nevertheless attain an altitude in excess of the 50 miles defined by the USAF as a spaceflight, or the 62 miles (100 km) defined by the Fédération Aéronautique Internationale (FAI) as the threshold of spaceflight. Thirteen such flights were accomplished during the X-15 program.

2 The USAF X-20 Dyna-Soar (for "DYNAmic SOARing") project was envisaged as a manned glider, launched by Titan into orbit and capable of runway landings. Six pilots were chosen to fly the vehicle but the program was cancelled in December 1963 without a flight occurring, in favor of the USAF Manned Orbiting Laboratory (MOL) – see *The Last of NASA's Original Pilot Astronauts.*

3 The four were: Shepard: 15 minutes 28 seconds; Grissom, 15 minutes 7 seconds; Glenn, 4 hours 55 minutes 23 seconds; and Carpenter, 4 hours 56 minutes 5 seconds.

David J. Shayler, *Gemini 4*, Springer Praxis Books
https://doi.org/10.1007/978-3-319-76675-1_4

4. Steps towards space

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

"I think Mercury, Gemini, and Apollo were really one program. You know, the same guys pretty much flew them, they were all exploratory.
Every flight was an engineering test flight.
You were always getting into something that nobody had ever done before."
James A. McDivitt, NASA Oral History, June 29, 1999.

During 1961, as we have seen, NASA began considering the possibility of sending a suitably protected astronaut outside their spacecraft into the vacuum of space on Extra-Vehicular Activity (EVA). That same year, plans to develop an advanced two-man version of the Mercury spacecraft were being explored under what was then called Mercury Mark II. At this time, the two avenues of study were not formally linked, and though it would not be long before they were, the primary reason for creating what became Project Gemini was to investigate other areas of spaceflight. These included space rendezvous and extended duration missions, key areas that would be required for regular spaceflight operations.

A Not-So-Secret Rendezvous

At the end of 1961, America had precious little experience in human spaceflight, with only two successful – but rather brief – Mercury missions, neither of which had reached Earth orbit. With the Presidential challenge to reach the Moon by the end of that decade less than six months old and the target date only nine years away, the new precursor program to Apollo had to be accomplished as promptly and efficiently as possible, not only operationally but also in its administration and finance.

The technique of joining two vehicles together in space was seen as a required skill, for reaching the Moon, for the creation of large orbital platforms and, eventually, for supporting the exploration of the planets. The process became known formally as rendezvous and docking, and it soon became apparent that to achieve this quickly would require more orbital experience, together with essential studies into human adaptation and endurance in space. It was clear that this would be beyond the scope of the original Mercury program.

During October 1961, NASA’s Space Task Group (STG) prepared a summary projection of U.S. manned spaceflight for the period 1963 to 1965. This plan focused around the development of the two-man version of the Mercury II spacecraft launched by Titan II, and on using an Atlas-Agena combination to place a target vehicle into orbit. The next step in U.S. manned spaceflight was projected to be the development of space rendezvous and long-duration missions. Mercury had the capability of supporting one man in space for up to one day or 18 orbits (and potentially for up to three days), but to achieve what was suggested by the STG projection would require a multi-crewed spacecraft capable of a range of missions, which could contribute to the development of rendezvous and docking by also exploring extended duration spaceflight and gathering data on the psychological and physiological effects from such missions on the crew.

By modifying the Mercury capsule, utilizing proven technology and introducing modularized components, it was predicted that these critical goals could be achieved. Two months later, this plan was formally accepted as the follow-on to Project Mercury and as a prelude to Project Apollo. By January 1962, Mercury Mark II had formally been renamed ‘Project Gemini’.

The October 1961 summary listed a total of twelve missions, starting with an unmanned orbital qualification flight (Gemini 1) in May 1963. This would be followed by a flight every two months, until the completion of the program in March 1965 with Gemini 12. ‘Gemini 2’ was projected as a manned, 18-orbit, one-day test and qualification flight, while ‘Gemini 3’ and ‘Gemini 4’ were planned as long-duration missions of up to 14 days each. The remaining eight missions would explore the mysteries of orbital rendezvous and docking [1].

Following the July 11, 1962 announcement that Lunar Orbit Rendezvous (LOR) had been chosen, after much deliberation, as the mission mode selected for Apollo[1], the investigation of various profiles of rendezvous and docking on Gemini missions significantly increased in importance. This decision added to the pressure to get Gemini designed, built and test flown quickly in order to embark on the packed series of objectives now planned for the program. The configuration of the Gemini spacecraft had been formally 'frozen' on March 31, 1962, and over the next three years, the effort to build the vehicle, test it and confirm its suitability for operational missions became a race against the clock; a battle with changing budgets and challenges with the hardware, systems and launch vehicle. The development of rendezvous and docking techniques for Gemini will be explored in more depth in the Gemini 6 and 8 titles in this series, but for Gemini 4, the saga of the rendezvous and extended duration objectives are detailed briefly here.

A Changing Target

In October 1961, Gemini 4, the planned third manned flight, was intended as a 14-day rendezvous and docking mission, which was an optimistic target at the very least. Just three months later, problems with the electrical installations had seen the schedule slip slightly. The slippage would become more significant as difficulties were encountered with the ejection seats, man-rating the Titan II, qualifying the proposed land-landing system, and developing the fuel cells that were intended to power the longer missions instead of the chemical batteries used for the shorter flights. There was also the question of new systems being introduced into the design, rather than adopting former Mercury components which had been the original plan, while slippages in the Agena target vehicle program also necessitated a change to plans for the first four Gemini missions.

By April 1963, a revised flight schedule saw substantial changes to the program. The first mission became an unmanned orbital test flight of the compatibility of the Gemini-Titan II system, but without recovery, as opposed to an unmanned suborbital test flight to qualify systems and procedures. The second mission now became an unmanned ballistic test flight to evaluate the heat shield and recovery system, not the first manned flight. That first manned flight, on the third mission, would now be a short, three-orbit test flight rather than an 18-orbit mission, and a planned experiment with a Rendezvous Evaluation Pod (REP) to practice the final stages of rendezvous was deleted. This all had an impact on Gemini 4, which would now fly in January 1965 on a seven-day mission instead of the previously planned 14-day flight (now assigned to Gemini 6). The crew of Gemini 4, the second manned flight, would retain the REP, with the full rendezvous and docking with an Agena reassigned to Gemini 5.

On January 1, 1964, further changes were made to the plans for Gemini 4. The REP was reassigned to Gemini 5, with the first flight of the Agena postponed to a later flight (Gemini 6). The radar system was also deleted from Gemini 4, and with it any major experiments with rendezvous. Later in the year, the duration of Gemini 4 was amended again because it would have to use chemical batteries, as the fuel cells were not yet ready. Though a full-scale rendezvous with an Agena or even the REP had been removed from the flight, the suggestion remained that the crew could attempt to rendezvous with the second stage of the Titan launch vehicle early in the mission. Over the coming months, this plan was developed alongside the idea that Ed White might not just open the hatch and stand on the seat, but actually emerge for a full-blown EVA, if only for a few minutes.

In the weeks leading up to the mission, a plan emerged that would see McDivitt separate Gemini just six minutes after launch and fire the spacecraft thrusters to turn it around and face the spent rocket stage, holding in a tight formation flight at a distance of about 300 feet (91.5 m). Then White would begin his EVA on the second orbit, and if a decision was made to go for a full-exit spacewalk, he would use the hand-held maneuvering unit (HHMU) to maneuver slowly over towards the Titan stage in a controlled manner. He would also film the scene with a 35-mm movie camera, which even Flight Director Gene Kranz thought was "pretty sporty for the first American EVA." [2], The EVA was planned to end after about ten minutes outside. Once White was back inside the spacecraft, with the hatch closed and cabin pressurized, McDivitt would fire the thrusters to separate Gemini from the stage by about 16 miles (25.75 km). It was then planned to re-rendezvous with the Titan stage over Africa on the fifth orbit some five hours later, closing to within about 10 feet (3 m) to evaluate the efficiency of using the flashing beacons on the Titan stage to approach another orbiting spacecraft. The astronauts would then separate from the stage to continue their four-day mission [3].

Longer Duration Missions

Concurrent to these plans to develop rendezvous and docking on Gemini, studies were being conducted on how the two-man crew's physical condition would be monitored during all Gemini flights, not just the long ones. The parameters being considered were, in order of priority: blood pressure, with electrocardiogram and phonocardiogram as first and second backup; electroencephalogram; respiration; galvanic skin response; and body temperature. The approved measurements were: electrocardiogram, respiration rate and depth; oral temperature; blood pressure; phonocardiogram; and nuclear radiation dose. The biomedical instrumentation required to record these had yet to be designed, developed, tested and authorized, however [4]. On June 4, 1962, as part of a long series of ground-based isolation simulations, two men began a 14-day simulated long-duration Gemini ‘mission’ at the USAF School of Aviation Medicine, Brooks AFB, Texas. The pair were to live in a 100 percent oxygen atmosphere environment, maintained at the proposed Gemini level of 5 psi. This was one of several ground simulations conducted to collect baseline data for future long-duration missions, important milestones in both the United States and the Soviet Union for subsequent pioneering missions to the Skylab and Salyut space stations respectively, over a decade later.

As studies continued in the background for extending the duration of space missions far beyond a few hours or days, developments of the hardware intended to support these missions did not always keep pace. In January 1964, McDonnell reviewed the status of the Gemini fuel cell program and the development of an improved fuel cell model. The following month, the decision was made to incorporate this improved fuel cell into Gemini, but not until Spacecraft 5, thereby deleting the fuel cells intended for both Spacecraft 3 and 4. The direct result of this was soon seen in the amended duration of the Gemini 4 mission which, while still listed as a ‘long-duration’ flight, would now be powered by short-lived batteries.

The success of the Gemini 1 unmanned flight and the naming of the first Gemini crew in April 1964 had given the program a confidence boost, but there was still much to do, in particular the preparations for evaluating the important heat shield on the suborbital, but still unmanned Gemini 2. On July 10, yet another review of the Gemini launch schedule was announced. In the new plan, Gemini 4 would now fly a four-day mission using batteries for power. Gemini 5 would fly an open-ended mission of up to seven days, with the REP and radar system, to evaluate rendezvous techniques and procedures as a prelude to the first Agena docking during the short-duration (two-day) Gemini 6 flight. Gemini 7 would now be the flight that attempted the long-duration open-ended mission of up to 14 days. Just 17 days later, astronauts Jim McDivitt and Ed White were named as prime crew for Gemini 4, with Frank Borman and Jim Lovell as the backup crew. The latter pair would be expected to rotate in the crewing system to become the prime crew for Gemini 7. During a subsequent press conference on July 29, Deputy Gemini Program Manager Kenneth S. Kleinknect casually mentioned that an astronaut would be “exposed to the hazards of outer space without full spacecraft protection” during Gemini 4 [5]. Initially indicating the astronaut would be “stepping into space,” which was taken to mean EVA, he later clarified his statement to say that this meant nothing more than opening the hatch and standing up on the seat, not a full exit. At least, not on this flight.

Exactly two months later, on September 29, yet another ‘new’ flight schedule was presented to the Gemini Management Panel by Program Manager

Charles Mathews. This time, however, the changes were not hardware related, but were due to recent lightning strikes at the Cape and storm activity during the annual hurricane season in Florida, which had delayed preparations for Gemini 2. This latest schedule listed the Gemini 2 launch for November 17, with Gemini 3 now moved to January 30, 1965 and Gemini 4 on April 12, the fourth anniversary of Yuri Gagarin's historic first manned spaceflight.

Unfortunately, the December 9 launch abort of Gemini 2 delayed the flight schedule into the new year, but it at least allowed more time to work on plans for the first two manned orbital missions. The successful suborbital flight by Gemini 2 in January 1965, followed by the highly successful three-orbit test flight of Gemini 3 '*Molly Brown*' in March, gave a huge boost to the program and the confidence to develop an even more ambitious flight plan for Gemini 4.

The Hardware

Due to the limited number of items of flight hardware planned for the Gemini program, there was a simplicity to the official vehicle numbering system. The Gemini IV space vehicle, as it was known in official documentation (but more commonly referred to as Gemini 4), consisted quite simply of Spacecraft No. 4 and the Titan launch vehicle assigned to the program, Gemini Launch Vehicle No. 4 (GLV-4).

The Gemini 4 Launch Vehicle

Construction of the program's fourth primary launch vehicle began in November 1963 with the welding of propulsion tanks at the Martin facility in Denver. The assembly continued during 1964, together with the numerous checks and tests required, leading up to the acceptance inspection in December of that year. Details of the GLV manufacture and testing history can be found in Table 4.1.

Table 4.1 Gemini Launch Vehicle-4 (GLV-4) vehicle manufacturing and testing histories

Event	Date
Start major welding of propellant tank of Gemini Launch Vehicle at Denver	**1963**
	November
Delivery of GLV propellant tanks to Baltimore	**1964**
	March 6
Completion of GLV assembly	September 4

Completion of GLV horizontal tests	October 23
GLV erected in vertical test facility	October 28
Power applied to GLV	November 4
Completion of GLV Subsystems Functional Verification Tests	November 19
Completion of GLV Combined Systems Acceptance Test	November 25
Inspection of GLV by the Vehicle Acceptance Team	December 11[1]
	1965
GLV Department of Defense Form DD-250 – Material Inspection and Receiving Report (MIRR) completed	March 21
GLV delivered to the Eastern Test Range, Florida	March 23
GLV erected at Launch Complex 19	March 29
Power applied to GLV	–
Completion of Subsystems and Combined Systems Tests	April 16
Tanking exercise	–
Spacecraft mated to GLV	April 23
Joint Combined Systems Tests	April 30
Countdown practice exercises completed included West Mock Simulated Launch.	May 13
Final Status Simulated Flight Test	May 29
Launch	June 3

Notes:
[1]A delay from December 19, 1964 to March 19, 1965, permitted modifications at Baltimore that were usually done at the Cape.
Data obtained from Aerospace, *Gemini Program Launch Systems Final Report* and Martin, *Gemini-Titan II Air Force Launch Vehicle Press Handbook*, as presented in Appendix 3, Project Gemini, a Chronology NASA SP-4002, 1969 pp. 277–8.

On March 23, 1965, the same day that GLV-3 left the launch pad at Cape Kennedy boosting Gemini 3 into orbit, GLV-4 arrived at the Eastern Test Range in Florida. Six days after its arrival at the Cape, the vehicle was erected on the launch pad. Over the ensuing two months, GLV-4 underwent a series of systems tests and tanking exercises intended to confirm its qualification for flight.

Launch Vehicle Modifications

Essentially, the Gemini 4 launch vehicle was very similar to the previous three vehicles, which had all been launched successfully. After the first launch in April 1964, only minor modifications had been made to the second and third vehicles prior to their own missions in January and March of 1965 respectively. Following the Gemini 3 mission, however, a further program of modifications was implemented for the Gemini 4 launch vehicle [6].

On the first stage of the launch vehicle, the oxidizer feed line conduit circumferential lapped joints were replaced by butt-welded joints, while provisions were added to the fuel tank aft skirt to allow for remote charging of the oxidizer standpipe, addressing the problem of the leaking oxidizer line encountered on Gemini 3. The only modification to the second stage was the removal of the heating insulation from the forward skirt on the oxidizer tank.

In the propulsion systems, revisions were made to the pogo installation by adding a heat shield to the fuel dampener assembly to protect the potentiometer and bearing from heat. In addition, the material used in the fuel dampener piston shaft bearing was replaced with ceramic-filled Teflon. To protect the fuel tank level sensors from autogenous gas contamination, shields were added to the prisms.

For the flight control subsystem, the program was revised to make the pitch program compatible to the requirements of the Gemini 4 mission. No amendments were made to the guidance or hydraulic systems, but provision was made in the electrical area for controlling the charging or bleeding of the oxidizer standpipe. As a rendezvous experiment was to be attempted on the mission, a flashing beacon light was installed on the second stage.

Additional insulation was applied to the Stage I Malfunction Detection System and control harness in compartment 5, but no other modifications were required. In the instrumentation, the devices that had provided sixteen structural integrity measurements during the GLV-3 powered flight were removed for GLV-4, but additional instrumentation was fitted to compartments 1 and 2 to provide data on sound pressure levels. Radio Guidance System (RGS) decoder discrete units 2, 4 and 8 were also added.

No modifications were made to the ordnance separation systems, but for range safety purposes, the destruct system circuitry was modified to prevent switch cycling, in the unlikely event that both ‘set’ and ‘reset’ signals were inadvertently applied during testing.

The Gemini 4 spacecraft undergoing assembly at the McDonnell plant in St. Louis, Missouri [Courtesy Ed Hengeveld].

The Gemini 4 Spacecraft

The Gemini 4 spacecraft arrived at the launch site on April 4, 1965, just two months prior to its launch. The equipment had been installed in the spacecraft back in January of that year, and the Re-entry and Adapter Sections were mated together the following month. Then came a series of tests and checks prior to its delivery to the Cape. Ten days after arriving in Florida, Gemini 4 was mechanically mated to its launch vehicle, ready to undergo a series of tests and simulations. Details of the Spacecraft 4 manufacture and testing history can be found in Table 4.2.

Table 4.2 Gemini spacecraft 4 (S/C #4) vehicle manufacturing and testing histories

Event	Date (1965)

Event	Date (1965)
Equipment installation	January 31
Mating of the Re-entry and Adapter Sections	February 23
Systems Assurance Tests	March 2
Environmental Control System validation	-
Simulated Flight Test	March 8
Altitude Chamber Test	March 25
Shipped to ETR	April 4
Complex 19/EIIV and G&C	April 14
Mechanical mating of spacecraft with launch vehicle	April 23
Joint Combined Systems Test	April 30
FCMT/ Final Systems Test	May 7
Wet Mock Simulated Launch Demonstration	May 13
Final Simulated Flight Test	May 29
Launch	June 3

Data from Appendix 3, Table D, Project Gemini, a Chronology NASA SP-4002, 1969, p. 281.

Spacecraft 4 Modifications

No major structural changes were made to the Gemini 4 spacecraft, which was generally identical to the ones that had been flight tested on the first three Gemini missions. While the structure and major systems remained the same, the main changes or modifications were made to specific systems on the spacecraft, as described below. The lack of significant revisions to the design and components of the Gemini vehicle was simply down to the fact that the spacecraft had performed successfully on the previous missions, together with an extensive and wide-reaching ground and airborne testing program. Not only did this save time, it also gave confidence in the reliability and rigidity of the design in anticipation of the more demanding missions that lay ahead [7].

System Modifications

Communications

Generally, the communications subsystem installed on Spacecraft 4 was very similar to that used during Gemini 3, except for a few modifications noted here. In the Adapter Equipment Section, a C-band transponder replaced the S-band

In the Adapter Equipment Section, a C-band transponder replaced the S-band radar transponder flown on Gemini 3. As a result, both the C-band transponders in the Adapter and Re-entry Sections of the spacecraft were tuned to the same assigned transmitting frequency and the same receiving frequency. The C-band antenna system had to be modified so that the system in the Re-entry Module could only radiate by using the three-helix antenna in the re-entry assembly. Equally, the system in the Adapter Module could only radiate through the annular slot antenna on the Adapter Section.

To alleviate a potential problem during re-entry, the high-frequency antenna used during orbital flight was installed in the Adapter Module. This saved deploying the similar HF whip antenna from the Re-entry Module, which would now only be extended and used during post-landing activities. It had been found that a potential heating problem could occur during re-entry if the Re-entry Module whip antennas deployed on orbit did not retract for the return. This problem was negated by affixing a separate second unit.

Instrumentation and Recording

As well as equipment similar to that installed on Gemini 3, additional instrumentation was used to obtain data on the horizon sensor performance for Gemini 4, hopefully to understand further the problem encountered on Gemini 3. The biomedical instrumentation and recording equipment was very similar to that flown on Gemini 3, apart from the addition of time-correlation systems.

Environmental Control

Once again, this was basically the same as flown on Gemini 3, but with the following amendments made as a result of feedback from that flight.

The urine disposal system was modified by means of a solenoid valve and a heated line, so that urine could be dumped directly overboard into the vacuum of space. The option to pass the liquid through the launch-cooling heat exchanger, as had been used for urine disposal on Gemini 3, was retained as a backup system on this mission.

For the four-day duration of Gemini 4, four water storage tanks were installed in the Adapter Section of the new spacecraft, rather than the single tank that had been used on the shorter previous mission. The long-duration mission requirements also meant a change to the CO_2 and odor absorber carried in the suit loop, requiring large quantities of absorbent material to be inserted into the system.

Due to the inclusion of the EVA operation, other changes to the Environmental Control System (ECS) equipment had to be included to accommodate the connections for the oxygen umbilical.

accommodate the connections for the oxygen umbilical.

Guidance and Control

In general, the guidance and control systems were identical to those of Gemini 3. However, following that mission, all the systems were re-examined and the recorded data closely analyzed. This revealed small anomalies in the flight data, which led to a few minor changes to the system flown on Gemini 4. These changes included a redesign of the three electronic modules within the Inertial Measuring Unit (IMU), and a redesign of a single unit of the Attitude Control Electronics (ACE). A different computer operating program was also installed.

Time Reference

Little changed here for Gemini 4. A time-correlation buffer was included, which served as a conditioner for the time-correlation signals supplied to the Voice Tape Recorder (VTR) and the two biomedical tape recorders. As suggested by Gus Grissom following Gemini 3, an additional GMT clock was installed on the Command Pilot’s instrument panel.

Electrical

As with Gemini 3, the Gemini 4 spacecraft was powered by battery units located in the Adapter Module rather than by the fuel cell module that was planned for the longer flights, starting with Gemini 5. As Gemini 4 would be a significantly longer mission than Gemini 3, six silver-zinc batteries were included in the spacecraft, as opposed to the three on the earlier mission. These were intended to power Gemini 4 during orbital flight until the Adapter Module was separated towards the end of the mission. The only other electrical change for this mission was the removal of the Z100 separation sensor switches.

Propulsion

With the formal testing phase of the Gemini program over, the operational equipment that had been omitted from Gemini 3 was now incorporated into the remaining spacecraft, beginning with Gemini 4. Though essentially the same as Gemini 3, there were a few significant changes made to the new spacecraft. The dummy OAMS Thrust Chamber Assemblies (TCA) installed on spacecraft 3 (TCAs 13, 14, 15 and 16) were replaced with operational units. In addition, all the TCAs were boundary-layer-cooled (long-life) units. The B-package burst diaphragms in the Re-entry Control System had not been installed on Spacecraft 3, but were included on Spacecraft 4.

Pyrotechnics

Pyrotechnics

In addition to the regular pyrotechnic devices installed on the previous spacecraft, there were a number of additional modifications to Spacecraft 4. A pyrotechnically-actuated door was installed to provide added protection for the MSC-1 experiment during the launch phase, while a pyrotechnic guillotine that was designed to sever the magnetometer-book locking cable was included with the installation of experiment MSC-3.

To eliminate the possibility of improper installation of the pyrotechnic cartridges, a series of keyways were machined into the electrical connectors of each charge. In the parachute recovery subsystem, an aluminum breech and pyrotechnic charges were installed into the high-altitude drogue parachute motor, instead of the steel breech and ORDO (ordnance) cartridge that was utilized on Spacecraft 3. Across the spacecraft, unused pins on the electrical connectors to initiators were removed.

Crew Station Furnishing and Equipment

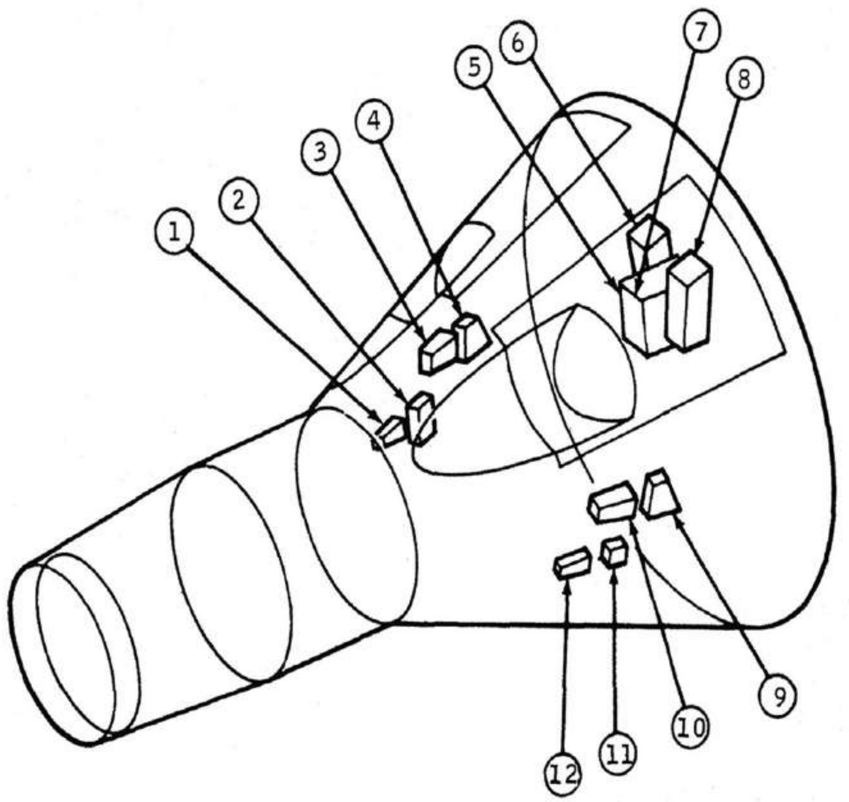
The instrument panel controls and displays of Spacecraft 4 were very similar to those on Gemini 3, except for the amendments suggested by the experience gained on the first manned mission and by the increased flight duration and inclusion of an EVA on this one.

Most notable of the changes was the relocation of switch positions and amendments to nomenclature. These changes included moving the logic switches for the Attitude Control and Maneuver Electronics (ACME) from the pedestal panel to the overhead switch/circuit breaker panel. The control switches for the RCS propellant shut-off valves were also relocated, from the pilot panel to the pedestal panel. Another change saw the inclusion of the fuel-cell purge switches and Reactant Supply System (RSS) crossover switches on the Pilot panel, although for this flight they were not operational.

Both the drinking water system and urine disposal systems on Spacecraft 4 were similar to Spacecraft 3, although the controls for urine disposal were modified to accommodate the overboard urine dump as well as through the launch-cooling heat exchanger. To advise the astronauts of the operation, an additional light indicator was incorporated into the spacecraft's water management panel to indicate 'HEATER ON' during direct overboard urine dump operations.

Modifications to the ejector seats included a redesign of the retracting mechanism on the parachute risers, as a result of a problem encountered on Gemini 3. To avoid inadvertent actuation, a safety pin was added to the ejection control handle, while the ejection kit configuration was remodeled into a lower profile to provide more headroom for the astronauts in the capsule, following recommendations by the Gemini 3 crew.

In total, twelve containers for flight crew equipment were installed on the spacecraft, which contained a range of equipment and provisions for the crew on their four-day journey. There were 78 separate items included on the manifest, several of them as multiple supplies (see sidebar "*Reconfiguring the Stowage for Gemini 4*").



Gemini 4 equipment stowage diagram. Key: 1. Right sidewall fairing container (on wall below R-H switch/circuit breaker panel); 2. Container (for periscope viewer); 3. Forward sidewall container (on wall below hatch sill); 4. Aft sidewall container (on wall below hatch sill); 5. Center stowage box door mount; 6. Right aft food box; 7. Center stowage box; 8. Left aft food box; 9. Aft sidewall container (on wall below hatch sill); 10. Forward sidewall container (on wall below hatch sill); 11. Pouch (on wall, adjacent armrest) and 12. Left sidewall fairing container (on wall below L-H switch/circuit breaker panel).

Reconfiguring the Stowage for Gemini 4

Allocating stowage space for additional equipment and supplies is often a major issue on any spaceflight, especially in a spacecraft as small as Gemini. For Gemini 3, a short three-orbit mission, this did not become a serious problem, but from the four-day mission of Gemini 4, things would have to problem, but from the four-day mission of Gemini 4, things would have to change as the duration of the remaining missions increased. The center and aft stowage areas were redesigned to include both a central stowage rack containing between one and three fiberglass containers, and left and right aft food boxes.

For Gemini 4 and 5, the three central containers were intended for cameras and their accessories, with a mounting adapter for the 200-mm lens located on the center stowage rack door. However, when the equipment was being fitted into Spacecraft 4, it was found that these containers did not have enough space for all the camera accessories. An evaluation of how often the equipment would be used on the mission defined their new locations. It was predicted that the three camera lenses would not be used often and these were stowed in pouches in the right-hand aft box. The film magazines needed to be accessed quickly and, being more resilient to shock and vibration than the other accessories, could be stowed in the side food boxes.

For Gemini 4, the left-hand aft food box was used for food as intended, but the right-hand aft food box was used for “infrequent items” such as the in-flight exerciser (Experiment M-3), the blood pressure adapter, the urine receiver and hose, and the umbilical guide, together with defecation bags, the suit repair kit and similar items. The left and right sidewall boxes were used for items that needed to be reached easily, or were small in volume, such as personal hygiene towels, waste containers, pen lights, and VTR (Voice Tape Recorder) cartridges. On most flights, two meals were stowed in each sidewall box, eliminating the need to unpack the aft boxes until after the first sleep period, once the crew had settled down into their mission.

The sidewall extension boxes were installed on each flight starting with Spacecraft 4, but access was limited due to the location of the ejector seat. On this mission, the boxes were used for the lightweight headset and defecation equipment. Some of the stowage on Gemini 4 replicated that of Gemini 3, such as the in-flight medical kit located between the left-hand seat and sidewall and the VTR between the right-hand seat and sidewall. The plot board pouch was on the inboard sidewall of the left footwell. On Spacecraft 4, the Ventilation Control Module (VCM) was located in the right footwell, while the Orbital Utility Pouch installed under the right instrument panel contained the hatch closing device. The Torque Boxes on Spacecraft 4 were used for the Dose Rate Indicator – Type 5 (removable) and Dose Rate Indicator – Type 1 (fixed).

Experience of the reconfigured stowage layout on Gemini 4 would be useful in planning the longer flight, as well as for standardizing the configuration for the remaining missions.

Landing

The landing equipment on Gemini 4 remained in the same configuration as that installed on Gemini 3, apart from the pyrotechnic equipment noted previously.

Post-landing and Recovery

There was little change to the post-landing or recovery equipment following Gemini 3. The only modification was a redesign of the operating switch for the recovery light beacon. In the upper position, the switch would now operate both the recovery beacon and the flashing light. If the switch was flipped to the lower position, only the recovery beacon would be activated. To turn both off, the switch had to be returned to the central position.

Astronaut Preparations

The Gemini 4 post-flight mission report noted that the crew's performance on the mission reflected "a high level of proficiency in spacecraft system knowledge, spacecraft operation and the accomplishment of planned mission objectives." This was achieved, the report stated, through their participation in a wide range of systems tests and task simulations. Added to the training load, at a late stage, was the expansion of the EVA from stand-up to full-exit, and the station-keeping maneuvers and rendezvous exercise.

Crew Training

The Gemini 4 prime and backup crews were formally identified on July 27, 1964, just three months after the names of the Gemini 3 quartet had been announced. Both groups of four would prepare for their missions separately and while the general training processes were similar, there were significant differences between preparing the Gemini 3 team for their short, three-orbit mission and the Gemini 4 team for a four-day mission and possible but unconfirmed EVA. Discussions continued for some time over the possibility of opening the Pilot hatch and having Ed White 'stand up' on his seat for a short excursion into the vacuum of space, without actually leaving the vehicle. The decision to complete a full EVA came very late in the preparation process. Whatever the final mission plan, NASA now had to accommodate four pairs of astronauts requiring simultaneous mission training, something the agency had not had to cope with previously. For Mercury, the lengthy gaps between the one-man missions had enabled the prime and backup astronauts assigned to the upcoming mission to focus upon their short flights relatively easily, without being overly concerned with organizing their logistics with other crews.

Gemini was a different program. The requirement to fly ten manned missions in a relatively short timescale was daunting in itself, without the added complication of having a team of four astronauts per mission, not two, or the likelihood that there would eventually be several crews in various stages of mission training, flight operations, post-flight debriefing and public tours at the same time. At the beginning, during 1964, this was not such an issue for the mission planners, trainers and schedulers, but as Gemini started to fly and more crews were announced the following year, so the training schedule expanded and evolved into a continuous flow of crew rotations in the various classes, simulators and trainers. Then from 1966, as Gemini began to wind down, the Apollo crews began their training programs and the whole Astronaut Office membership suddenly expanded by almost 50 percent, with the arrival of the scientist-astronauts from flight school and the 19 new pilot astronauts selected for Group 5. The Astronaut Office would never be the same again, with the original, unique, personalized role created by the Mercury Seven changing rapidly. This began an extensive era of crew training profiles – starting with the introduction of the Gemini 4 crew into the training process in the summer of 1964 – which would continue for the next decade.

Of course, the process of 'training' was not new to the astronauts, as most of those selected during the 1960s had come to NASA from the military. For the 'civilian' astronauts who had come from other backgrounds, such as most of the scientists of Group 4, some were required to complete a 52-week jet pilot course prior to attending more academic and survival courses with the space agency. All the 'new' intakes at NASA in the 1960s were immediately designated as 'astronauts' from the day they were formally named, so from day one they began a training program to ease them into their new role. They attended dozens of classroom lessons and lectures, visited contractors, suppliers, field centers and wilderness training sites, learned to address the public and the politicians and deal with the news media, and became familiar with the vehicle they were to ride on or fly in. They were assigned to support tasks for other crews, in various standin roles or on duty as part of the Mission Control and support team. However, when an astronaut was formally named to a flight crew, a whole new world opened up to them. Now, they were not just astronauts in training, they were astronauts undergoing 'mission training'. This changed the way they were perceived and treated, as well as their own perspective. For the veterans this was nothing new, but nonetheless was still demanding. For the rookies, who were not yet bona fide 'space men', their elevation to a new status as the next in line was a strange position to find themselves in.

In his 1988 biography, Frank Borman noted that, as a team of four astronauts, the Gemini 4 crews "had too many facilities to visit and too much equipment to understand and learn how to operate." They created an "Unresolved Problem List" (UPL), with Ed White as coordinator. The idea was to allow each man to focus on a specific area of training and inform the group only when there was something to worry about. This made it much easier to track developments as the program progressed, although it became more difficult to operate closer to the mission; so much so that when the crew relocated to the Cape the week prior to launch, Alan Shepard took over outstanding issues duties. The UPL proved so successful that it was adopted by each successive Gemini crew and carried over into Apollo [8].

Gemini 4 Crew Training

Spacecraft Tests

Each prime crewmember logged approximately 60 hours inside Spacecraft 4 during a series of major systems tests conducted at the McDonnell Douglas facility in St. Louis and at Cape Kennedy.

Simulators

The plan was for each crewmember to complete 110 hours on the mission simulators. In fact, from the start of training on the Gemini mission simulator #2 on November 30, 1964, McDivitt and White each spent about 130 hours in the mission simulators, while Borman and Lovell logged approximately 105 hours each. Each of the four men spent approximately 30 hours of that training suited up in the Gemini pressure garment. The first sessions were devoted to familiarizing the crew with the interior of their spacecraft.

Station-Keeping

As part of his mission preparations – and very late in the process – McDivitt developed and practiced visual rendezvous procedures on the rendezvous engineering simulator at McDonnell's facility in St. Louis and on the translation and docking trainer at the MSC. This simulator provided a view of the target vehicle (in this case the Titan II) with a stellar background and was programmed to simulate the final six miles (9.65 km) of the rendezvous profile. Though a rendezvous with the upper stage of the Titan was planned, no simulation training was accomplished to prepare the crew for the station-keeping procedures, with the crew only receiving briefings in the final days leading up to the mission [9].

Briefings

As a natural progression in mission training, the crew undertook numerous informal briefings in conjunction with the various training activities, including detailed systems and experiment updates. Flight plan and mission rules reviews were conducted periodically throughout the training program as the plans for the flight developed, changed and became established. Each of these normally lasted for two or more days and were held at the MSC in Houston, Texas, the McDonnell facility in St Louis, Missouri, or at Cape Kennedy in Florida. In addition, two experiment briefings were held at the MSC and a short experiment review conducted at the KSC.

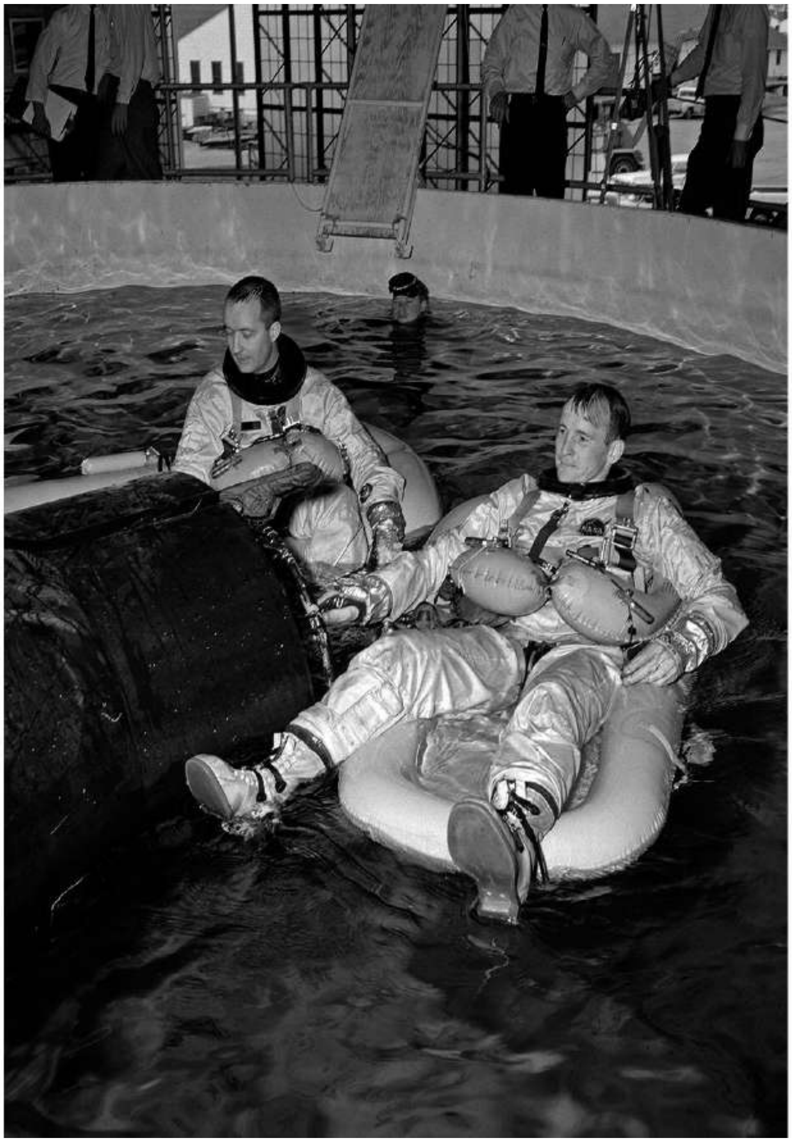
Reviews

The crews participated in mock-up reviews, Service Engineering Department Report (SEDR) reviews, subsystem tests and spacecraft acceptance reviews.

Launch, Launch Abort and Re-entry Accelerations

This training was conducted at the Naval Air Development Center, Jacksonville, Florida, following a program specific to Gemini 4. The prime crew completed two programs of centrifuge training at the Naval Air Development Center, Johnsville, Pennsylvania. These programs included launch and entry acceleration profiles, with the crew controlling the ‘spacecraft’ during normal and selected abort simulations.

In addition, each crewmember participated in three launch abort simulations on the moving base simulator. This simulator replicated vibration cues in conjunction with the numerous abort situations. Use of this simulator helped to define the optimum abort procedures for a wide variety of malfunctions in either the Titan launch vehicle or the spacecraft’s systems.



Water egress training at Ellington AFB, Texas. On the left is Jim McDivitt, with Ed White on the right [Courtesy Ed Hengeveld].

More realistic open water egress training in the Gulf of Mexico, supported by scuba divers. Ed White is sitting on top of the spacecraft at the rear, while Jim McDivitt is in the water just in front of the small end of the spacecraft [Courtesy Ed Hengeveld].

Egress and Recovery

This training utilized both boilerplate and actual recovery equipment and personnel. Water egress practice was conducted in October 1964 in the floatation tank at Ellington AFB, Texas and in the Gulf of Mexico, using a test spacecraft (boilerplate). Like all survival training, this course consisted of briefings, films and demonstrations on the use of egress and survival equipment, then practice in shirtsleeves, followed by runs with full egress equipment including suits (from January 15, 1965).

Jim McDivitt (right) and Ed White (left) are shown at the Morehead Planetarium, North Carolina, checking out celestial navigation equipment to be used on their mission [Courtesy Ed Hengeveld].

Celestial Recognition

This training took place at Morehead Planetarium, Chapel Hill, North Carolina. There were three trips to Moorhead, where the training focused upon the celestial sphere close to their planned orbital track. The objective of this type of training was to provide the crew with a backup option for orientating the spacecraft, or for navigational purposes in the event of inertial platform or communications failures during the mission. It also provided astronomical observation training.

Parachute Descent

This was practiced over both land and water using towed parachute techniques. Each of the four astronauts completed a number of parachute tows with attendant

Each of the four astronauts completed a number of parachute tows with attendant release, followed by a drop onto land or into the water to simulate recovery from Mode I Abort ejection scenarios.

(left) Jim McDivitt having his spacesuit fitted by technician Clyde Teague during a Wet Mock simulation test at Cape Kennedy. (right) Ed White awaits his spacesuit helmet during the same tests. In the background is suit technician Joe Schmitt [Courtesy Ed Hengeveld].

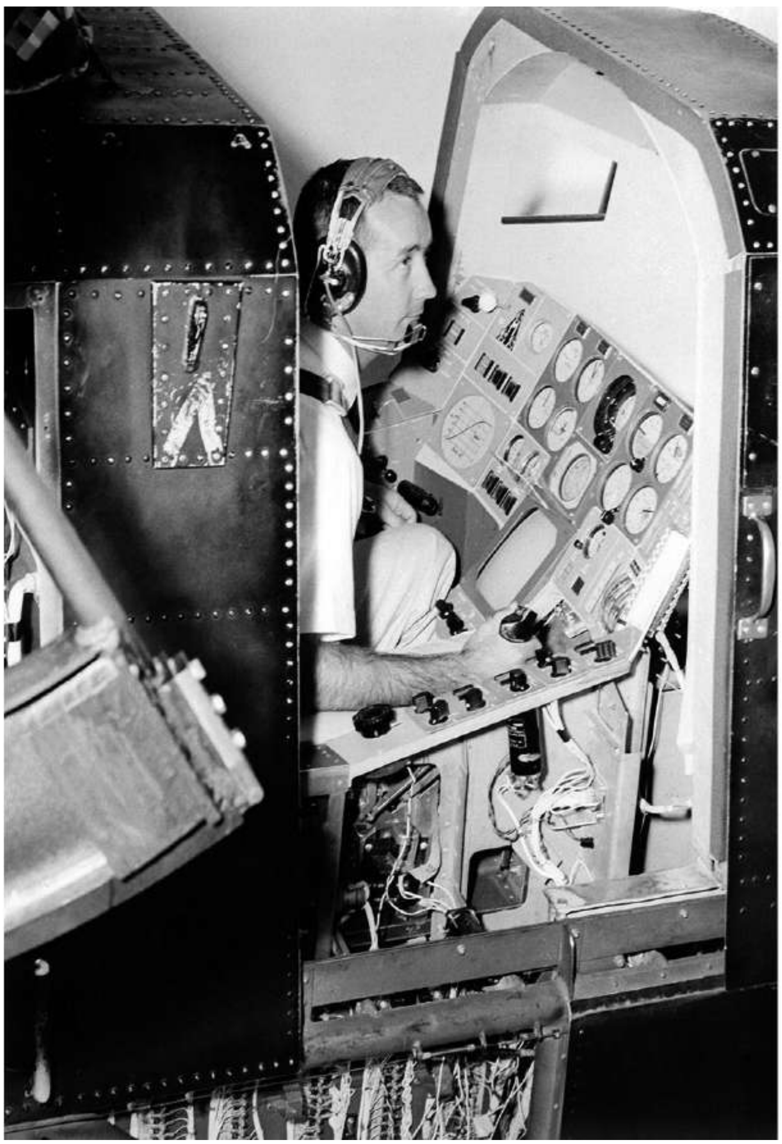
Suit, Seat and Harness Fitting

On October 17, the Gemini EVA prototype suit delivered from the contractor was assigned to McDivitt for evaluation in the Gemini mission simulator. During the test, he complained about its bulkiness and immobility when not pressurized, but this did not appear to hinder its mobility when pressurized. The thermal/micrometeoroid cover layer installed on a test suit was sent to Ling-Temco-Vought for further thermal testing in a space simulation.

Later that month, Rusty Schweickart spent eight days in a Gemini suit to evaluate the biomedical recording instruments. He flew several ‘zero-gravity’ simulation flights and a simulated four-day mission, as well as logging several runs in the centrifuge.

Launch Abort Simulations

The crew made two trips to Ling-Temco-Vought (LTV) for abort simulations, where they found that they could complete a great number of runs in a short period (about 160 in one day) and get their procedures "down pat." The astronauts were supportive of the training at LTV Aerospace in Dallas, Texas, but welcomed the plan to set up a comparable simulator at the MSC to cut down on the travel.



Jim McDivitt is shown in the gondola of the realistic spaceflight simulator developed by the Astronautics Division of Ling-Temco-Vought, Dallas, Texas.

Hatch Opening and Stand-Up Exercises

These were conducted three months before the flight at the McDonnell Aircraft Corporation pressure chamber, at a simulated altitude of 150,000 feet. Between March 20 and 25, the Gemini 4 crew and their flight spacecraft conducted a series of five runs:

- Run 1: Unmanned.
- Run 2: Manned, with prime crew McDivitt and White flying a simulated mission, although the chamber was not evacuated.
- Run 3: Repeat of the second run, with backup crew Borman and Lovell.
- Run 4: Prime crew in simulated altitude conditions of 150,000 feet. (White opened the hatch, stood up and operated equipment before sitting down and closing the hatch.
- Run 5: The backup crew repeated the process of Run 4, with Lovell conducting a simulated stand-up EVA.

At the end of these runs, the spacecraft was prepared for shipment to KSC on March 25.

Zero Gravity Evaluation

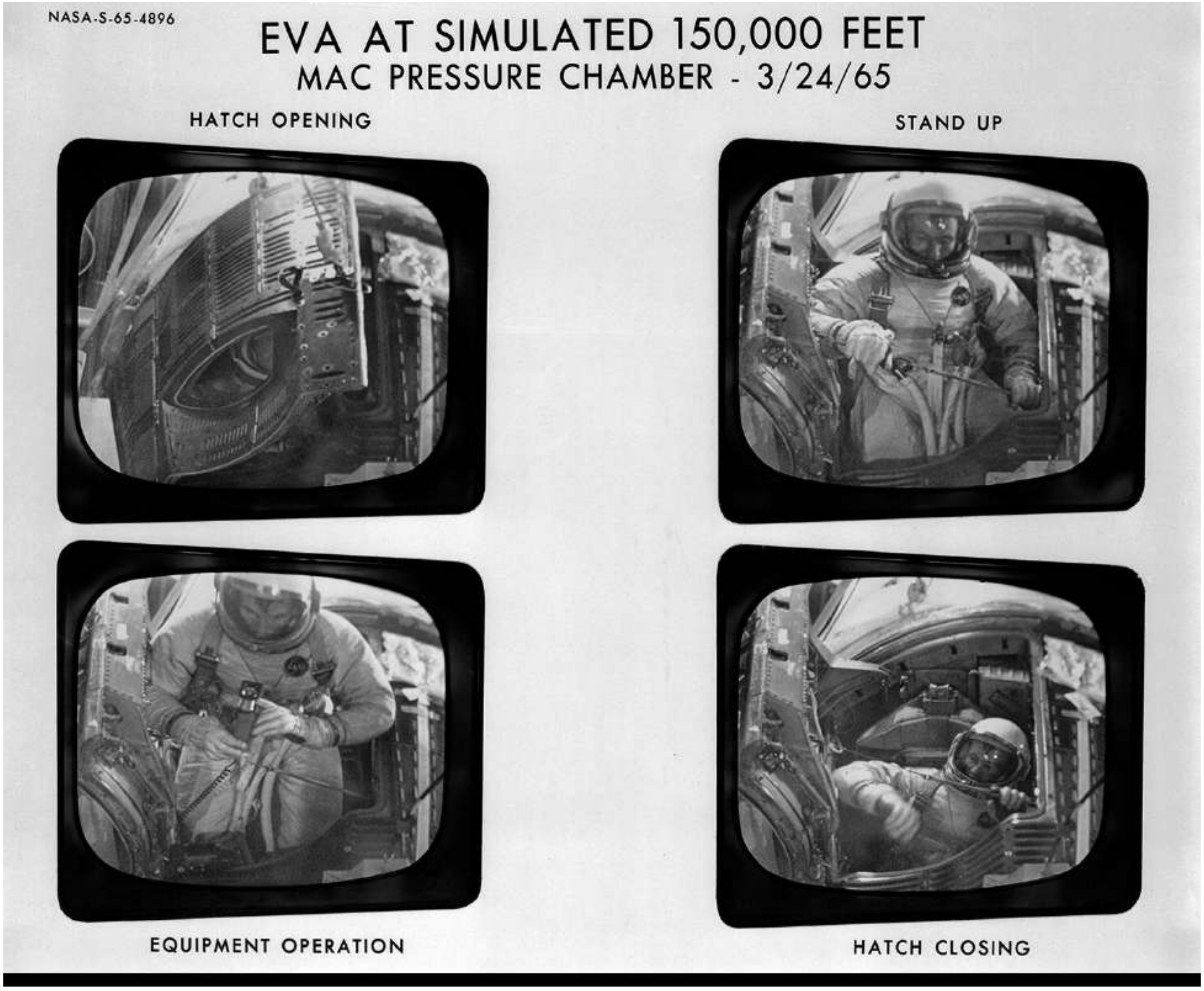
Several years prior to the first EVAs being performed, a variety of simulation techniques were developed to try and explore ways and means of preparing a crewmember for EVA prior to the actual flight. These included the use of aircraft flying Keplerian trajectories (known more commonly as the zero-g airplane, or "Vomit Comet"), air-bearing devices, various rigs designed to support a varying mass of the wearer, 1 *g* simulations and, eventually, neutral-buoyancy water immersion. While each of these had their merits, only the neutral-buoyancy water immersion could successfully reproduce unrestricted six-degrees-of-freedom for extended periods of time. Today, this has become the standard method of preparing crews for EVA. For Gemini, even though such studies had been conducted since the early 1960s, they were not incorporated into EVA simulations until 1966. This development will be explored in later books in this series.

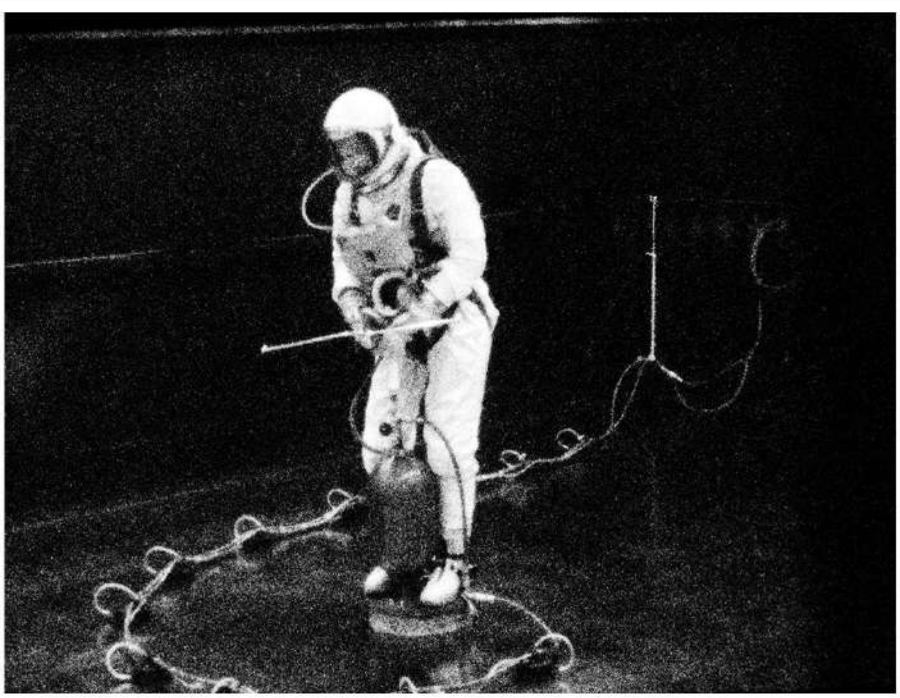
For Gemini 4, this training involved aerial simulations of EVA activities, food preparation and intake, and other onboard tasks. The flight crew made two trips to the Wright-Patterson AFB in Ohio for zero-gravity flight training using the KC-135 aircraft. During these parabolic flight programs, the crew practiced food and waste management, opening and closing the Pilot hatch, and egress and ingress while using a pressurized Gemini suit. Ed White later made his own, third visit for further EVA training using a Gemini G-4C EVA suit.

The crew station mock-up and altitude chamber work was completed at the MSC, in order to familiarize the crew with the EVA environmental control equipment. The all-important operation of the hatch closing mechanism, which had troubled the Gemini 3 crew during their altitude chamber run, was accomplished for Gemini 4 during altitude chamber tests, zero-gravity flights, and personal inspection of the mechanism in 1 *g* conditions. The flight crew also received special briefings on the hatch latching mechanism’s design and operation, potential problem areas and malfunctions, and any corrective actions required to overcome these. This would prove extremely useful to them during the flight, underlining the importance of contingency training.

On the MSC frictionless platform (air-bed), space propulsion testing was conducted in five sessions, which also included evaluation of the tether dynamics.

The Gemini 4 crew began flight tests of the Gemini mock-up in the KC-135 aircraft on January 12, 1965, with the idea of evaluating EVA activities under simulated (but short duration) weightless conditions. The Gemini 3 crew of Young and Grissom practiced hatch opening exercises, which were duplicated the following day by the crew of Gemini 4, but the decision to go for a full EVA would not be made officially for another four months, publicly at least, as revealed in Chapter 1 [10]. The equipment and capability was there, but publicly the plan remained just to open the hatch and stand up. Plans for conducting a full-exit EVA were under evaluation and were being developed in secret, known only to a very few key people inside NASA.


NASA-S-65-4896
EVA AT SIMULATED 150,000 FEET
MAC PRESSURE CHAMBER - 3/24/65
HATCH OPENING
STAND UP
EQUIPMENT OPERATION
HATCH CLOSING



(above) Simulated Stand-up EVA at 150,000 feet (45,720 m) on March 24, 1965, in the pressure chamber at McDonnell Aircraft Corporation, St. Louis, Missouri. (below) Early full EVA training in building 4 at the MSC under the secretive Plan 'X'. White, in a pressurized EVA suit, uses a HHMU while riding the Balance EVA Training Platform, separated from the level steel floor by a 0.001-inch (0.0254 mm) cushion of air. Even the simulated umbilical line is 'floating' on air, with the aid of 11 small air pads, giving as accurate a simulation as possible of an EVA in zero-g.

Keeping Plan 'X' a Secret

As Manfred 'Dutch' von Ehrenfried wrote in the Foreword to this book, the plan to change the stand-up EVA into a full-blown spacewalk was developed in secret, under the not-so-imaginative title of 'Plan X'. At the end of March 1965, one week after the Gemini 3 mission, Gene Kranz was in Chris Kraft's office at the MSC discussing the results from the three-orbit flight, when Kraft closed the door to his office and told Kranz in confidence that it was time to push for more with the next mission. Gemini 4 was to attempt a short, full-exit EVA, for which White had been training in secret since January. Preparations were to be conducted in confidence, as Kranz wrote in 2000: "I began leading two lives in flight control. Daily, I worked at running the Flight Control Branch and preparing as a Flight Director to lead my team on Gemini 4. I left work at 5:00 pm, went home for dinner then returned to work on the EVA plan. Each night, I worked with the [EVA] task force's spectacular engineers, sitting in on briefings and studying the spacesuit operations, and then went back to my office to work into the night writing the rules for this high profile mission." [11] According to Kranz, the EVA task force for Gemini 4 was "the most creative effort I had witnessed to date in the space program." There would be no public briefings, or even to the wider team for now, though an information data pack was prepared for the remote site Capcoms who would be on duty during the planned rendezvous with the Titan stage and EVA. This was handed over to them on May 10, with instructions that it was only to be opened in the event of a decision to go for the EVA, and only on the direct authority of Kranz. He gave that authorization on the day after the formal 'Go for EVA' had been given.

When NASA formally announced the plan to conduct a full-exit EVA just nine days prior to the launch, the skeptics initially thought that it was nothing more than a publicity gag. This really annoyed Chris Kraft, who quickly corrected that assumption. "We're not playing Mickey Mouse with this thing. We're carrying out flight operations. I don't think its fair to suggest we're carrying out a propaganda stunt." [12]

Forty years after flying the mission, Jim McDivitt recalled the early training process for the original stand-up EVA. He was asked whether it was always intended to be Ed White's job, or whether any consideration had been given to him doing the stand-up procedure himself. "Well, when we first started we both did it all together. He'd [White] practice something, and I'd practice something, so we just went along in parallel like that. Then, by the time we got around to doing it [the full-exit EVA], it was one of those things where I was the commander and that was a full-time job, and so I talked it over with the other powers around NASA and we decided Ed ought to do it." [13]

McDivitt could not recall the details of the stand-up EVA, or indeed talking much about the full EVA at the start. "It was forty years ago," he said at the time of the interview. But he did say that once the decision was made to prepare for some sort of exit, it was all done very quietly at first. "Nobody had really been talking about doing an EVA, and then very secretly somebody decided we ought to try one. So Ed and I practiced at night, and we did all the EVA [training] stuff real late in the evening. We did discover early on that the seat was not quite the right height, so we had to do some modifications to the seats so we could make sure we could get the guys back in the spacecraft. We did it all very secretively; nobody in the Astronaut Office knew we were doing it." Then the Russians completed the first EVA some weeks prior to their mission. "We were really planning on doing the [world's] first one, but they beat us to the punch," McDivitt said.

Final Preparations

The Wet Mock simulated launch was conducted on May 14 at the KSC. This occurred in the early afternoon and McDivitt observed post-flight that the sun had shone straight into the windows of the spacecraft at this time, creating a significant amount of reflection inside his helmet and making it difficult for him to see the instrument panel, sometimes blocking it out completely. "Those first few seconds are extremely critical on launch," he stated. "You have to be able to see those tank pressure gauges. We ought to keep this in mind for those late afternoon launches [later in the program]." He found himself having to put his hand up to block out the light so that he could read the panels. Fortunately, this early into the ascent the *g* loads would be minimal, so that he would be able to raise his arm easily on the actual launch. The astronaut further suggested that the sun could also present a problem through the window at pitch over on an early morning trajectory, again blocking the view of the displays and controls.

On May 28, Gemini 4 was demated from the Titan on Pad 19 to enable the replacement of a battery in the Adapter Equipment Section. By 18:00 EST, the battery had been replaced and re-mating was completed. The spacecraft was powered up ready for simulations the next day, when the prime and backup crews performed final simulated launches at the KSC, as well as orbital exercises, system checks and communications checkouts on both the UHF and HF frequencies. MSC Director Robert Gilruth reiterated that the plans for Gemini 4 were not motivated by propaganda but were clear objectives for the program. “We know there are risks with all these flights. There is the risk of getting into orbit and of returning from orbit. But once we make orbit, we feel we should do everything we can and are prepared to do before we come back.”

A mission review was held on June 1, with a discussion of flight issues held afterwards by Chris Kraft, Ed White, Deke Slayton, Charles Berry, Jim McDivitt and Al Shepard. The pre-flight physical was conducted that same day. Ten days prior to the launch, the astronauts had undergone a minor medical examination. It was followed eight days later by this far more extensive examination process. This seemed out of sequence, as by its very nature, this more thorough examination was very uncomfortable to endure and could have risked the crewmembers’ ability to be fully prepared for the launch 48 hours later, let alone complete the demanding mission. Even the official mission report suggested that this examination was “time consuming in a period when time is very critical to flight preparation.” [14] However, the process was observed and completed without incident and the crews were pronounced ready to fly. It was now time to put all this preparation and training into practice.

In the final days prior to the mission, two small issues threatened to delay the launch. On May 27, an undersea communications cable which linked the tracking stations in the Atlantic Ocean was reported to have broken off the coast of San Salvador. This meant dispatching the cable repair ship *Omega* to repair the fault, although heavy seas hampered the early attempts. Alternative cable and radio circuits were available, but they would struggle to handle the amount of data generated from the Gemini mission. The cable was not operational again until June 5, with communications provided downrange via a commercial cable until then.

The following day, a leak was reported in the spacecraft cooling system when two tanks of water were loaded. Four gallons leaked into a lithium hydroxide canister used to remove carbon dioxide from the spacecraft cabin. That canister was easily replaced while the problem was investigated over the next day. It was found that the two valves in the cooling system had been installed the wrong way round and the fault was easily resolved without delaying the planned launch.

A night time scene at Pad 19, Cape Kennedy, as the Gemini 4 spacecraft is hoisted up to the White Room at the top of the gantry for soft-mating with the Titan in support of the Wet Mock Up exercises [Courtesy Ed Hengeveld]

Gemini 4 Mission Objectives

As late as May 21, 1965, two weeks before the launch of the mission, page five of the Gemini 4 press kit quoted a “possible extra-vehicular activity,” stating, “No decision has been made whether in the Gemini 4 mission the crew will engage in extra-vehicular activity. This will depend on the qualifying of the extra-vehicular space suits and hatch… A decision to undertake the extra-vehicular test can be made as late as the day before the [June 3] launch.” [15]

Four days later, the authority was given to proceed with a full-exit EVA, amending the objectives of the mission [16]. For the second manned flight of the program, three primary objectives were listed. These were:

1. To evaluate the effects of prolonged exposure of the two-man flight crew to the space environment.
2. To demonstrate and evaluate the performance of the Gemini spacecraft systems for a period of approximately four days in the space environment.
3. To evaluate previously developed procedures for crew rest and work cycles, eating schedules, and real-time flight planning for long-duration flights.

There were also six secondary objectives:

1. To demonstrate extra-vehicular activity in space and to evaluate attitude and position control using the hand-held propulsion unit or the tether line.
2. To conduct station-keeping and rendezvous maneuvers with the expended second stage of the launch vehicle.
3. To conduct further evaluation of the spacecraft systems as outlined in the in-flight systems test objectives.
4. To demonstrate the capability of the spacecraft and flight crew to make significant in-plane and out-of-plane maneuvers.
5. To demonstrate OAMS capability to operate as a backup for the retrograde rocket system.
6. To conduct 11 experiments.

The proposed flight plan was certainly intended to keep the two astronauts busy during their four days in space, amid rumors from some media sources that the Soviets would launch a new Voskhod mission "in a few days" as a dramatic reply to the plans for Gemini 4. The rumors were unfounded.

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3. Astronautics and Aeronautics, NASA SP-4006, 1965, pp. 255–6.

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5. Reference 1, p. 151–152.

6. Gemini Program Mission Report, Gemini IV, MSC-G-R-65-3, June 1965, pp. 3–8 to 3–9.

7. Reference 6, pp. 3–1 to 3–7.

8. **Countdown**, Frank Borman with Robert J. Sterling, William Morrow, 1988, p. 114.

9. Reference 6, p. 7-15.

10. Reference 1, p. 177.

11. Reference 2, pp. 133–7.

12. *Time Magazine*, Vol 85, No. 24, June 11, 1965, p. 15.

13. Telephone interview by Colin Burgess with Jim McDivitt, January 18, 2005.

14. Reference 6, p. 7–16.

15. Gemini 4 Press Kit, May 21, 1965, Release No. 65–158.

16. Reference 1, pp. 272–3, Appendix 2 – Gemini Program and Mission Objectives.

Footnotes

1 Other mission modes evaluated for Apollo were Direct Ascent (DA), Lunar Surface Rendezvous (LSR), and Earth Orbital Rendezvous (EOR).

David J. Shayler, *Gemini 4*, Springer Praxis Books
https://doi.org/10.1007/978-3-319-76675-1_5

5. School for controllers

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

"There is a school at the
NASA Manned Spacecraft Center
from which no one ever graduates
and where there is no summer vacation."
NASA News Release, March 1965.

In March 1965, just ten days prior to the launch of Gemini 3 and three months prior to the mission of Gemini 4, NASA issued a News Release which began with the above quote [1]. This short release was a general introduction to the new Mission Control Center, Houston (MCC-H) that would be inaugurated with the Gemini 4 mission and which would go on to become an icon in the history of NASA's quest for the Moon and beyond. Indeed, over fifty years after those words were written, a new Mission Control room at the Johnson Space Center, Houston (the Manned Spacecraft Center was renamed after former President Lyndon B. Johnson in 1973) is in constant contact not only with the crew on board the International Space Station, but also with control centers in Moscow, Russia, in Germany, and in Japan. The two words "Hello Houston" have been synonymous with America's human spaceflight program for over five decades and will continue to remain at the forefront of America's future in space for some time to come.

An aerial shot, taken in 1965, of the NASA Manned Spacecraft Center in the Clear Lake area about 30 miles (48 km) south of downtown Houston, Texas. The Mission Control Center [arrowed] is the windowless white building in the upper left center of the image.

“This is School House, Houston”

Admittedly this does not have quite the same ring as the more familiar “This is Mission Control, Houston” that we have become accustomed to, but the Mission Control Center at the Johnson Space Center (JSC, formerly MSC), in Clear Lake, 30 miles south-east of downtown Houston, is where the graduates of the mission controller semesters ply their trade.

The building associated with ‘Mission Control, Houston’ was in fact merely named Building 30 for many years, until it was dedicated to Christopher C. Kraft in 2012 in recognition of his contribution to the U.S. manned space effort. Kraft was a key figure in establishing the control center infrastructure and ethos which has become part of the NASA heritage, as seen in movies such as *The Right Stuff*, *Marooned*, *Apollo 13* and more recently *From the Earth to the Moon*. During the Gemini years, however, the building was still referred to by its number, or as MCC-Houston, a fledging facility yet to make its mark on space history. Its role in the Gemini missions certainly built upon the foundations that had been laid during Project Mercury, so that within a decade that mark on space history became indelible.

Today, fifty years after Gemini gave way to Apollo, the original Mission Control Center room has become a national treasure, and the mantle has passed to a new, state-of-the-art, 21st century Mission Control Room and new generations of flight controllers, as well as to other communication centers around the globe. Modern day controllers wrestle with the 24/7, 365-days-a-year, mammoth task of 'controlling' the huge International Space Station, with its mass in excess of 400 tons. Back in June 1965, that legacy was still in its infancy, as Mission Control-Houston took charge of the considerably smaller 7,880 lbs. (3,570 kg) Gemini 4. For the next thirty years, the two Flight Control Rooms at MCC-Houston would become the primary control center for all U.S. manned spaceflights, from Gemini 4 to Apollo-Soyuz in July 1975, and for the Space Shuttle until well into the 1990s when the new, upgraded control rooms in Building 30 South (30S) took over.

Building 30, MSC, Home of MOCR

Viewed from the outside, the first impression of Building 30, such a historic landmark in American history, could easily be one of disappointment. The main building is, on first inspection, a drab, gray and white, windowless block of concrete yielding no clues to the magic that was woven inside. There are three stories to this main building. On the first floor, apart from the sterile entrance, are the rooms containing the Real-Time Computer Complex (RTCC) and associated communication support systems and functions. The 'mission control rooms' are located on the second and third floors and were formally known as Mission Operations Control Rooms (MOCR, pronounced 'Mocker' or 'Mowker'). Each MOCR also included a number of Staff Support Rooms (SSR), and as both were identical, either floor could support a mission[1].

MOCR-1 was located on the second floor and for Gemini 3 in March 1965, this room was used only to monitor the mission, as an evaluation of the system's ability to handle the remaining Gemini missions instead of the older, but upgraded, Mercury Control Room over at Cape Kennedy [2]. This was deemed a success and so the decision was made to control all future Gemini flights (GT-4 through GT-12) from Houston, though not from MOCR-1 which was used to support the early unmanned Apollo/Saturn 1B missions. Later, MOCR-1 was employed for the Skylab and the Apollo-Soyuz Test Project missions before it was modified again to support early Shuttle missions. The Gemini missions would be controlled from MOCR-2 up on the third floor, before this was also handed over to the Apollo Saturn V missions and eventually on to early Shuttle missions.

A Space-Age 'School' for Controllers

When new controllers joined the Flight Operations Directorate at MSC, they embarked on an extensive training program which never truly ended, even after they had begun to work there in earnest. Like the astronauts, their role was a constantly changing one and the subjects they were taught, such as launch vehicles, spacecraft, systems, procedures, and methodology, were continually evolving. As a result, each controller had to keep up to speed not only with his own specialty (in the mid-1960s, there were no female flight controllers; that came during the Shuttle era) but with associated fields as well.

Training a flight controller in the mid-1960s involved about 140 hours of classroom instruction and familiarity sessions with both the spacecraft (in this case Gemini) and the ground support systems. They also had to learn to operate the flight controller console and associated equipment that they would be working with during live missions. As part of their classroom studies, new controllers were required to attend about 30 hours of spacecraft trajectory instruction, which was tutored by members of the Mission Planning and Analysis Division. In addition, they were instructed on how the worldwide spaceflight tracking network functioned, operated by Network Controller staff from the Flight Support Division. Where possible, the instructors used in the classroom were the existing Flight Controllers who worked the same consoles during missions, which offered practical coursework based on actual flight experiences.

The second phase of training involved detailed on-the-job assignments, where the novice controllers gained valuable knowledge about the operations role they were embarking upon. In addition, there was an extensive library of spacecraft systems and flight manuals at their disposal, together with hundreds of engineering drawings (still on paper in the 1960s) and a plethora of highly detailed contractor documentation and associated volumes. The third part of their preparation involved each controller honing their skills at developing and writing operational handbooks and procedures, while all the time keeping abreast of the latest data through refresher courses in spacecraft systems. They were constantly updating the hours of instruction and study they had just completed, to bring them up to speed with the latest update to the most recent amendment.

By this time, the trainee controllers had progressed to the fourth tier of their preparation, one in which “his own initiative is his best teacher.” It was here that the true dedication of a self-motivated controller came into its own, as they constantly absorbed the latest developments in flight operations. This, together with even more refresher courses and visits to the primary and secondary contractors, allowed each controller to keep pace with the constant changes in designs and the frequent introduction of new developments.

All that they had gone through up to this point would be called upon in the next phase of preparation, when their individual training merged as they became part of a flight controller team. This phase involved monitoring a real spaceflight, as well as participating in very realistic computer-generated simulations of missions in cooperation with an astronaut flight crew. The astronauts were located in simulators within other buildings at the MSC that were linked to the Mission Control, so that the flight crew’s actions and the ‘simulated’ status of spacecraft systems were shown on the consoles and displays of the MCC as they would be in actual flight situations. Isolated from the outside world, in a room with no windows or outside distractions, their focus could remain on the job in hand; the often intense and always demanding work of a spaceflight controller.

The simulations they followed would vary between nominal, planned events where very little went wrong to having unexpected major anomalies and situations suddenly inserted, from which the controllers, astronaut crews, or most often a combination of both, would quickly have to evaluate a safe way out of the situation they found themselves in. For the flight controllers, this “playing devil’s advocate” could include the introduction of single or multiple system failures, a partial or total loss of communications with the crew or tracking stations, and specific displays of console failures or errors. The objective of these challenging simulations was to build the confidence and experience of each flight controller, which could mean the difference between a successful or unsuccessful conclusion to the mission or objective in a real emergency. This approach gave rise to the mission simulation group motto: “Never give a flight controller [or astronaut] an even break.”

When the control center in Houston came online, the opportunity presented itself to prepare the flight controllers for their roles at the remote tracking stations around the world, such as Guaymas in Mexico, Kauai in Hawaii or Carnarvon in Australia, but without having to go to the time and expense of sending the controllers to those sites prior to the mission. To achieve this, two simulated remote sites were replicated on the second floor of Building 30 at MSC. Here, each ‘remote’ team would await its turn to receive the imaginary spacecraft and flight crew within its radar and voice communications range, as they would on a real mission.

During these simulations, tapes were played to generate accurate and realistic displays in front of each controller, supplemented by real data recorded from previous missions and played back through the MCC computer system. The simulations were so accurate that any visitor who happened to put on a headset to listen in to the simulation could easily have been fooled into thinking they were listening to a real mission with an actual crew in space. From all these weeks of preparation and repeated assignments over several missions, a competent and qualified controller would be ready to perform his role on a genuine flight, and to receive the coveted title of ‘mission flight controller’ as a member of a specific team on a real mission. (For controller assignments on Gemini 4, see Table 5.1.)

Table 5.1 GT-4 mission control center flight controller assignments [3]

1. Mission Control Center – Houston (Orbit Phase)			
Position	Red Shift	White Shift	Blue Shift
Flight Director	C. Kraft	E. Kranz	J. Hodge
Asst. Flt. Director	W. Platt	M. von Ehrenfried	C. Harlan
Ops and Procedures	J. Roach	J. Tomberlin	L. Armstrong
	R. Sutton	D. Holkan	R. Goodwin
Flight Surgeon	C. Berry	A. Catterson	D. Coons
Capcom	V. Grissom[1]	R. Chaffee[1]	E. Cernan[1]
		F. Borman[1]	J. Lovell[1]
GNC Engineer	A. Aldrich	G. Coen	G. Griffin
EECOM Engineer	J. Aaron	R. Glover	R. Loe
Flt. Dynamics	C. Charlesworth	E. Pavelka	J. Bostick
Retro Controller	J. Llewellyn	T. Carter	J. Massaro
Guidance Officer	W. Fenner	C. Parker	K. Russel
Network Controller	A. Piske	W. Arellano	R. Nickerson
	E. Randall	D. Call	H. Nichols
M and O Supervisor	J. Hatcher	R. Jones	G. Egan
Public Affairs Officer	P. Haney	[T. White?]	[A. Chop?]
[illegible]	[illegible]		

Martin Monitor	M. Goodkind		

2. *Mission Control Center – Cape Kennedy (skeleton crew – launch only)*	
Flight Director	G. Lunney
Ops and Procedures	L. Armstrong
Network Controller	R. Sheridan and G Ayers
Tank Monitor	C.C. Williams[1]
Booster Monitor	C. Harlan
Martin Monitor	C. Cicchetti
Capcom	A. Shepard[1]
Flight Dynamics	J. Bostick
Guidance – Pitch	C. Long
Guidance – Yaw	W. Fenner
GE/Burroughs	V. Norris/G. Liner

3. *Mission Control Center – Houston*		
	<u>Countdown</u>	<u>Launch</u>
Flight Director	J. Hodge, E. Kranz	C. Kraft
Asst. Flt. Director	M. von Ehrenfried	M. von Ehrenfried
Ops and Procedures	R. Sutton	J. Roach
Flight Surgeon		C. Berry
Capcom		V. Grissom[1]
GNC Engineer	G. Griffin	A. Aldrich
EECOM Engineer	R. Loe	R. Glover
		L. Bell*
Tank Monitor		E. Cernan[1]
Booster Monitor		W. Platt
Flight Dynamics	E. Pavelka	C. Charlesworth
Retro Controller	T. Carter	J. Llewellyn
Guidance – Pitch	K. Russell	C. Parker
Guidance – Yaw		J. Clements
Guidance – RGS		A. Sexton
Network Controller		A. Piske
		E. Randall
M and O Supervisor		

M and O Supervisor
PAO
**Larry Bell was assigned to MOCR for launch phase*

4. Remote Sites					
Site	Capcom	Systems	Aeromed	Astro Sim	Observer
CYI	P. Ealick	J. Moser	R. Shamburek	S. Present	
			Q. Jones		
CRO	Ed Fendell	H. Smith	R. Pollard	J. Ferry	D. Scott[1]
		J. Fuller	M. Alston		
			J. Walsh		
HAW	A. Davis	A. Barker	C. Jernigan	W. Young	W. Cunningham[1]
GYM	W. Garvin	J. Walsh	J. Wamsley Nugent	M. Lowe	W. Anders[1]
		F. Claunch	J. Zieglschmid		
TEX	G. Scott	B. McGhee	D. Graveline[2]	L. Keyser	
			W. Walter Jeffrey	M. Haynes	
CSQ	C. Lewis	T. White	F. Humbert	J. Borches	
		C. Link	C. Sawyer		
RKV	K. Kundel	G. Muse	F. Kelly	S. Russell	
		G. Bliss	L. Enders		
Standby Orders		~~D. Hunter~~ [3]			
		J. Tomberlin			
		A. Roy			

NOTES:

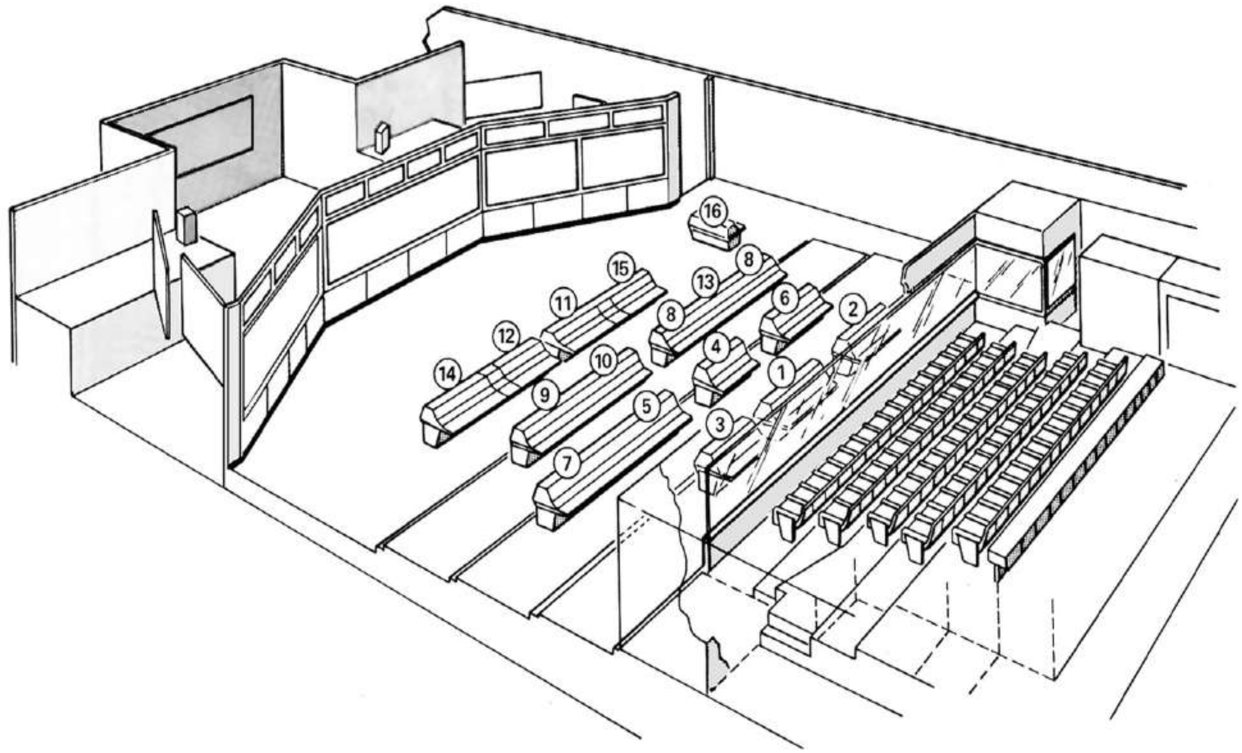
1. Astronauts
2. Duane Graveline was one of six scientist astronauts chosen by NASA on June 27, 1965, but resigned less than two months later, on August 18, for personal reasons.
3. On the original memo, Dan Hunter was listed but manually crossed out. Following the incident at Carnarvon between Hunter and astronaut Pete Conrad just prior to Gemini 3, the controller was reassigned to Goddard Space Flight Center in Maryland (see *Gemini Flies: Unmanned Flights and the First Manned Mission*, David J. Shayler, Springer, 2018, pp.123–5 & 275–6).

Gemini Flight Control

Gemini Flight Control

The Mission Operations Control Room that was situated on the third floor of Building 30 at the Manned Spacecraft Center (MOCR-2) was promoted during its construction in 1964 as the focal point for America – and indeed the Western world – for future manned spaceflight operations, not only during Gemini and Apollo but "for years to come." This bold statement was borne out by the fact that the same building and control rooms were used as the primary American control center for all national human spaceflight missions for the next 30 years, until the new facilities in the adjacent Building 30 South were constructed in the 1990s to support the more demanding requirements of the International Space Station. That facility became operational in 1998. The dedication of the 'original' Building 30 to Christopher C. Kraft Jr., was performed in 2012.

In his excellent 2018 book, author and former Flight Controller Manfred 'Dutch' von Ehrenfried observed that "the actual room, like the tip of an iceberg, is only about 2,940 square feet (273 sq. m), less than eight percent of the overall [third] floor area." [4] The room measured approximately 46 feet (14 m) wide and 64 feet (19.5 m) from the front central display screen to the viewing room behind. Duplicating the MOCR-1 room below it, the MOCR-2 room (formally identified as Room #330) became a 'National Historic Landmark' because of its role in all but one of the Gemini missions (it was used to monitor the Gemini 2 flight and served as the backup control room for Gemini 3, becoming prime control room from Gemini 4), and for all Saturn V-launched Apollo missions (Apollo 4, 6, and 8–17).



Gemini Mission Operations Control Room-2 (MOCR-2).

Vastly expanded from the former Mercury control room located at Cape Kennedy, the new facility at the MSC featured four rows of consoles facing large display screens at the front. There were glass-partitioned viewing rooms at its rear, as well as adjacent support rooms (see figure above). The front row, which became known as “the Trench”[2] during Apollo, included four console positions and an adjacent position to the right. There were five positions on the second row, a further four on the third row and another three consoles on the fourth and final row. The roles fulfilled by the consoles during Gemini in this layout were as follows: *Back Row:*

The *Mission Director* (Console 1 in the diagram), who was seated in the rearmost central console in the MOCR, held overall responsibility for test operations and for rescheduling any mission which may have been scrubbed. During each Gemini mission, the Mission Director would be the man who made real-time decisions to follow an alternative flight plan if problems arose, such as would unfold during Gemini 8 in 1966. To his right was the *Department of Defense Representative* (*DoD*, Console 2 in the diagram) who provided the direct link between representatives of NASA and the global DoD support network, including the vast resources deployed as recovery teams across the globe for nominal and contingency recovery operations. To the left of the Mission Director was the *Public Affairs Officer* (*PAO*), also known as “the voice of Mission Control” (Console 3). Each PAO provided status information to the listening public over the open voice communications loop during the operational phase of each mission, from the final phases of the countdown to the recovery of the spacecraft and its crew at the end of the mission. PAO commentary supplemented the voice communications from the spacecraft and offered updates and explanations to the general public about mission status and key events as each flight progressed.

Third Row:

Directly in front of the back row were four controller positions. In the middle of these was the *Flight Director* (*FD* or *Flight*), who was effectively the man in charge of Mission Control (Console 4). Officially in charge of the operational control of each mission, from the moment the vehicle cleared the launch tower at the Cape to the recovery of the crew and spacecraft at the end of the mission, each Flight Director was responsible for ensuring that the mission achieved its primary goals efficiently, while constantly aware of ensuring the safety of the crew in attaining them. Where necessary, the Flight Director could deputize for the Mission Director. To his left sat the *Assistant Flight Director* (Console 5) who assisted the Flight Director during the mission and could act as Flight Director in his absence if required. To the right of the Flight Director was the *Network Controller* (*Network*, Console 6), who looked after the operational control of the Ground Operations Support System (GOSS) network. At the opposite end of the third row (Console 7), to the far left of the Flight Director and next to the Assistant Flight Director, was the *Operations and Procedures Officer* (*Ops*), who handled the detailed operational control and implementation linking MCC and GOSS procedures.

Second Row:

Five controllers sat on the second row, occupying two banks of consoles. On the right (Console 8) were two *Vehicle System Engineers* (*Systems*), whose task was to monitor and evaluate all the onboard subsystems on the Gemini, such as electrical, mechanical and life support. During the later Gemini-Agena rendezvous missions, they would also monitor the electrical and mechanical systems on the target spacecraft. Sitting between these positions (Console 13) was the *Guidance Officer* (*Guido*), who monitored the performance of the Titan booster on its ascent, carefully observing the Stage I and Stage II slow rate deviations and other planned programmed events over the few minutes of the ride to orbit. This controller also verified the nominal performance of the Gemini

Inertial Guidance System and would recommend any required actions directly to the Flight Director. Across the gap on the other bank of consoles sat the *Flight Surgeon* (*Surgeon*), on the extreme left of the row (Console 9), who was responsible for all medical activities and constantly monitored the health and vital statistics readings from both of the astronauts during the course of the mission. Next to him on the right was the *Spacecraft Communicator* (*Capcom*, Console 10), who was the primary vocal link to the crew on orbit, handling voice communications with the astronauts and exchanging information on the progress of the mission. The name derived from the early days of spaceflight, where the spacecraft were called 'CAPsules' (much to the irritation of the first astronauts, who preferred to call their vehicle a 'spacecraft') and those who talked with them were designated 'COMmunicators', hence the abbreviation to Capcom. The position was traditionally, and mainly, held by fellow astronauts[3].

Front Row:

The front row consisted of four controllers, again on two banks of consoles. On the extreme left (Console 14) was the *Booster Systems Engineer* (*Booster*), who monitored the propellant tank pressurization systems of the launch vehicle and notified both the flight crew and the Flight Director of any anomalies that might have occurred during the ascent. Once the spacecraft separated from the launch vehicle, this position was taken over by the *Experiments Officer* (*Experiments*), who monitored the suite of experiments on the given mission and provided updates on each investigation until re-entry. Next to him on the right (Console 12) was the *Retrofire Officer* (*Retro*), who constantly monitored impact prediction displays for contingency landings and updated the predicted re-entry retrofire times for the end of the mission. Across the walkway on the right-hand bank of front row consoles was the *Flight Dynamics Officer* (*FIDO*), who monitored and evaluated the constantly changing parameters of the orbit throughout the orbital flight phase (Console 11), discerning the necessary requirements to maintain the appropriate orbit successfully during the flight and presenting 'GO' or 'NO-GO' recommendations to the Flight Director. Next to him (Console 15) was the *Assistant Flight Dynamics Officer*, who was charged with monitoring and evaluating the Gemini launch vehicle's systems and reporting any off-nominal situations to the Flight Director. The final position on the extreme right of the row (Console 16) was the *Maintenance and Operations Supervisor*. This controller oversaw the performance of MCC equipment and its ability to support the missions in progress, ensuring that any problem was addressed and resolved as soon as possible to ensure a smooth operational flow.

In addition to the control room at Building 30, the facility also housed two other floors of staff support rooms, including a duplicate Flight Control Room and a supporting computer complex. Technical specialists in the support room, some employed by NASA and others representing contractors or subcontractors, monitored and evaluated the stream of data being fed into the building from the missions and the hardware being flown. They also used the data to derive performance trends, comparing this real-time data and projections with previously captured baseline data from simulations and tests, as well as from previous flight data as the missions increased in number. After sifting, sorting and sequencing all the data, their reports were sent – fairly rapidly – to the control personnel in the MOCR, to allow the controllers to make informed decisions based on the recommendations from the support rooms, in the areas of:

Flight Dynamics: The controllers could monitor and evaluate the data during powered flight and orbital insertion, allowing them to modify or make recommendations to improve the trajectory to the best advantage to meet the prescribed mission objectives, while constantly being aware of crew safety at all times. This data could also be used to explore possible maneuvers and in support of actual or potential contingency situations throughout the flight, hopefully keeping one step ahead of real events.

Vehicle Systems: During the period of orbital flight, the status of the Gemini vehicle (and subsequently the Agena target vehicle) was monitored to reveal specific trends in the systems, subsystems and physical components of the spacecraft. This provided real-time information to the controllers who were monitoring operations and gave them information that would allow them to avoid, correct, or perhaps work around potential onboard failures that might risk both the safety of the mission and, potentially, the lives of the crew.

Life Systems: From the moment of lift-off through to splashdown at the end of the mission, the physiological and environmental conditions onboard the spacecraft were recorded and transmitted to the ground, revealing not only the conditions within the crew compartment, but also the physical wellbeing of each astronaut.

Flight Crew: In addition to monitoring the Life Systems, there was also a coordinated, non-medical program of actions which related specifically to controlling and moving the Gemini and any crew or scientific equipment.

Network: Behind the scenes of the flight operations lay a complex infrastructure of communications, scheduling and activities, intended not only to check and verify that the next remote tracking sites or stations were able to support the upcoming pass, but also to accept and then hand over communications from the previous station to the next one in the global network.

The Gemini 4 Flight Directors are shown around the Flight Director's console in the MOCR, Building 30, MSC. (Clockwise from bottom left) Eugene Kranz (White Team); Glyn Lunney (Black Team, FD at the Cape for terminal countdown and launch phase); John Hodge (Blue Team); and Chris Kraft (Red Team and Mission Director) [Courtesy Ed Hengeveld].

Operations and Procedures: A significant number of staff prepared and supported the highly detailed technical and administrative workloads. These included mission plans and operations, and the communication plans and procedures of MOCR. These technicians were able to produce documentation change notices not only for the individual MCC flight controllers but also around the network, including the remote sites.

New Flight Directors

With the expansion of flight operations, a new cadre of Flight Directors was required to support Chris Kraft, who had handled all the short-duration Mercury missions together with Walt Williams (who had just retired). With Gemini missions planned to last for several days and controllers required to be on station around the clock, teams of controllers would have to be assigned to the flight, each headed by a Flight Director and with a more senior figure serving as Lead Flight Director for a specific flight. In August 1964, the first Gemini Flight Directors were announced, with each subsequently choosing a 'team color' for his shift. Each Flight Director would take a code name (initially a color, then precious stones, and later astronomical symbols etc., as the cadre grew over the decades) which remained active throughout their length of service. When a controller retired, their identification code was also retired in honor of their service.

The 'original' Flight Directors who supported the early Gemini program were: Chris Kraft (Red Shift), Gene Kranz (White Shift), John Hodge (Blue Shift) and Glynn Lunney (Black Shift)[4]. For the second Gemini mission, extending over several days, three 8-hour shifts were prepared. Kraft's Red Team was the 'Lead Shift' and would cover the working day operations, while Gene Kranz and his White Team served as the 'Systems Shift', looking after the state of the spacecraft and its onboard consumables while working the evening shifts. The Blue Team under John Hodge worked as the real-time planning shift.

Because this was the first time the Mission Control in Houston would be prime for a mission, a backup plan saw Glynn Lunney heading up a 'Skeleton Crew' in the old control center at the Cape during the launch phase. This temporary crew consisted of Lunney as FD, with Arnie Aldrich as EECOM and CNC; Jerry Bostick as RETRO, FIDO and GUIDO; and Alan Shepard as Capcom. In 2017, Jerry Bostick recalled his experiences in the Gemini 4 'Skeleton Crew'. "We had a week of simulations [before the flight], none of which Shepard showed up for. Because the Capcom console had switches which controlled our ground computers, located at [Goddard Space Flight Center in] Greenbelt, Maryland, I had to also work that position. On launch day [June 4] Shepard showed up and I had to explain how to operate the computer switches. At first he was arrogant [clearly adopting his 'Icy Commander' role], but finally realized he needed help [reverting to his 'Smilin' Al' persona]. They did lose power momentarily in Houston during launch, but did not turn control over to us at the Cape. We all flew back to Houston for shifts there in the orbital and entry phases." [5]

Providing a Tracking Network Across the World

In the official history of the Gemini program, the responsibility of the different elements of the Worldwide Tracking Network (see Table 5.2) supporting each of the Gemini missions was stated to be [6]:

1. *NETWORK FUNCTIONS*:
   - Communications between network stations and control centers
   - Tracking and control of two vehicles (Gemini and Agena, or Gemini with Gemini in one case)
   - Voice and telemetry communications with the spacecraft
   - Dual command data to two orbiting vehicles simultaneously
   - Reliability of all onsite systems for extended periods of time.

Table 5.2 Gemini 4 tracking network configurations and station capability

Stations	S-Band Radar	C-Band Radar	Acquisition aid	Telemetry Receiver & Recorder	Telemetry Real Time Display	On Site Data Processor (1218)	Gemini Launch Vehicle Command	Digital Command System
Mission Control Center (Cape)		X	X	X	X	X	X	X
Merrit Island Launch Area		X						
Ascension Island		X						
Grand Bahama Island		X	X	X		X	X	
Antigua		X		X		X	X	
Bermuda	X	X	X	X		X		
Grand Canary Island	X	X	X	X	X	X		X
Kano,			X	X				

Nigeria								
Tananarive, Madagascar			X	X				
***Coastal Century Quebec* (ship)**			X	X	X	X		X
Carnarvon, Australia	X	X	X	X	X	X		X
Kauai, Hawaii	X	X	X	X	X	X		X
Woomera, Australia		X	X					
***Range Tracker* (ship)**		X	X	X				
Canton Island, (Mid Pacific)			X	X				
***Rose Knot Victor* (ship)**			X	X	X	X		X
Point Arguello, California	X	X	X	X				
Guaymas, Mexico	X		X	X	X	X		
White Sands, New Mexico		X	X	X				
Corpus Christi, Texas	X		X	X	X	X		X
Eglin Field, Florida		X	X	X				
Grand Turk Island		X		X		X	X	

Original table published in the Gemini 4 Press Kit, NASA Release No. 65-158, Washington D.C., May 21, 1965, p. 45

The facilities provided to achieve this included: *Network Equipment Systems:*

- Acquisition Aid
- Radar Tracking
- Telemetry
- Remote Site Data Processors
- Command
- Communications
- Consoles

Remote Station Consoles:

- Maintenance and Operations
- Gemini and Agena Systems Monitors
- Command Communicator
- Aeromedical Monitor

2. *MISSION CONTROL CENTER (MCC) FUNCTIONS:*

    - Direct the overall mission
    - Issue guidance parameters and monitor guidance computations and propulsion capability
    - Evaluate the performance and capability of space vehicle equipment systems
    - Evaluate the capabilities and status of spacecraft, crew and life support systems
    - Direct and supervise the activities of ground support systems
    - Direct recovery activities
    - Conduct simulations and training exercises
    - Schedule and regulate the transmission of recorded data from sites
    - Support post-mission analysis.

    To achieve this, the MCC required:
    MCC Equipment Systems:

- Real-Time Computer Complex
- Communications
- Displays
    - Computer Interface Subsystem
    - Timings Subsystem
    - Television Subsystem
    - Group Display Subsystem

  - Console Subsystem
- Command
- Gemini Launch Data
- Simulation Checkout and Training.

NASA’s Manned Space Flight Network

Keeping track of the spacecraft once it had left the launch pad, monitoring the weather at primary, secondary and contingency landing sites, and maintaining direct communications between the flight crew, Mission Control and other sites in the network, were priorities for any spaceflight. For the second manned flight of the Gemini series, NASA was able to call upon a proven and extensive tracking and communications network called the Manned Space Flight Network (MSFN). This was headed up by three NASA field centers: Cape Kennedy on the Atlantic central coastline of Florida (KSC – the primary Mission Control for countdown and launch); Goddard Space Flight Center in Greenbelt, Maryland (GSFC – the real-time computer and communications center); and the Manned Spacecraft Center in Houston, Texas (MSC – the primary mission control from launch to post-splashdown). The MSC retained overall management responsibility of the Gemini program, and was also responsible for the direction and mission control of the MSFN immediately preceding and during a mission simulation or the actual flight. As with Gemini 3, there would be seven primary land tracking sites around the globe for Gemini 4, as well as two ocean-going ships and six additional smaller land stations.

The seven primary land sites were: Cape Kennedy, Florida and its associated downrange USAF Eastern Test Range Sites; Bermuda; Grand Canary Island; Carnarvon, Australia; Kauai, Hawaii; Guaymas, Mexico; and Corpus Christi, Texas. The two primary tracking ships were the *Rose Knot Victor* and *Coastal Century Quebec*. The six additional land stations were: Kano, Nigeria; Tananarive, Madagascar; Canton Island, Pacific Ocean; Point Arguello, California; White Sands, New Mexico; and Eglin AFB, Florida. This network was also backed up by a fleet of relay aircraft, instrumentation ships, relay stations, and communications and weather satellites, which could be called up as required and then integrated into the wider network.

The network stations located in Australia remained under the remit of the Weapons Research Establishment, Department of Supply, Commonwealth of Australia, who retained the responsibility for maintaining and operating the various stations in support of NASA’s programs through contractual arrangements and various agreements.

Meanwhile, the United States Department of Defense (DoD) retained

Meanwhile, the United States Department of Defense (DoD) retained responsibility for the maintenance and operational control of its assets and facilities that were required to support each Gemini mission. These facilities included network stations located at the Eastern Test Range, Western Test Range, the Air Proving Ground Center and the White Sands Missile Test Range.

Goddard’s Role in Gemini

Of the three primary NASA field centers involved in the Gemini missions, the Kennedy Space Center provided the checkout, test and countdown facilities for both the Titan (and later Agena) launch vehicles and the Gemini spacecraft, while from Gemini 4, the MSC in Houston provided primary mission control support and was of course the home of the astronaut training processes. The third center was the Goddard Space Flight Center, whose primary responsibility was for the planning, implementation and technical operation of the tracking and data acquisition for each mission. This was defined as the operation, modification and maintenance of the tracking and data acquisition facilities, to enable the network to function as an instrumentation resource that would be able to respond to varying mission requirements. In particular, Goddard’s remit included:

> *Countdown Phase:* During the countdown of each Gemini mission, the Real-Time Computer Complex located at MSC (MSC-RTCC) was backed up by the Real-Time Computer Center at Goddard (GSFC-RTCC). During the prelaunch countdown, the Goddard Center was responsible for checking that the MSFN was ready to support Gemini 4 (and subsequent missions) by means of its CADFIS (Computer And Data Flow Integrated Subsystems) tests. In addition, the GSFC-RTCC provided primary computer support for all the network’s tracking and data acquisition systems, which included radar, digital command systems, the pulse code modulation telemetry and the Launch Monitoring Subsystem. Data flow tests from the worldwide network to the MSC-RTCC were conducted under the guidance of Goddard’s CADFIS test director.
>
> *Launch Phase:* As the Titan launch vehicle ascended from the pad, the real-time computers at Goddard received launch trajectory data via the tracking station in Bermuda. The real-time trajectory was then computed and displayed on the plot boards and the controller console at MCC-Cape Kennedy. During the launch phase, a flight control team was on hand to take over immediate flight direction and control should communications break down with MCC-Houston. Real-time display and command-and-control capability was available to a flight control team. MCC-Cape also provided flight dynamics

simulations for both Houston and Goddard's computers in support of critical "GO/NO-GO" decisions. As the Titan ascended, all the GLV data and spacecraft telemetry was captured by the Air Force Eastern Test Range stations, processed in real-time at Kennedy MCC, and then forwarded to the RTCC at Houston.

Orbit Phase: With Gemini safely in orbit, the computing center at Goddard received updates on orbital parameters and other data from network radars located around the globe, allowing the orbital parameters to be refined and the updates displayed at MCC-Cape Kennedy.

Mission Control Center – Cape Kennedy: From Gemini 4, the control center at Cape Kennedy was supervised, operated and maintained by Goddard, serving as a full time backup to the new primary Mission Control Center in Houston and operating on a 24-hour basis in support of Houston's requirements. During the Gemini 4 mission, an opportunity arose for the Kennedy MCC to provide control center positions to the Gemini spacecraft checkout team. In previous missions controlled from the Cape there had not been enough room to do this, but with the transfer of the main MCC to Houston, there was an opportunity for the team to revisit the analysis of the spacecraft throughout the mission, supplementing the data captured at MCC-Houston.

NASA Communications Network (NASCOM): Another of Goddard's responsibilities was to establish and operate the worldwide ground communications grid between each station and control center in the network. This amounted to 89 stations, of which 34 were overseas, providing teletype message, voice and data communications. To achieve this, the network of circuits and terminals amounted to 100,000 route miles and 500,000 circuit miles. The overall NASCOM system for Gemini 4 was very similar to that employed during Gemini 3, although with an expected increase in communications traffic, additional voice and data circuits were established between Goddard and MSC Houston. During the Gemini 3 mission, a Syncom II communication satellite located over the Indian Ocean had relayed voice communications between the stations on the ground and the astronauts in orbit. A similar exercise was planned for the Gemini 4 mission, but this time using an improved Syncom III satellite located over the Pacific Ocean, expanding the coverage for each orbit. A voice communications network called SCAMA II (Station Conferencing And Monitoring Arrangement) was also part of NASCOM, and this featured switchboard systems using multiple dual-operating consoles that could allow a single operator to participate in mission conferences. This system was initially capable of handling 100 lines, with plans to expand to up to 200 lines. From Gemini 4, all the available lines could be connected to a single conference line with no loss of quality. The SCAMA operator also had the capability to add or remove conferees, as well as managing which of the conferees could talk and which could only listen. This enabled the network to communicate across the globe and to respond to real-time changing circumstances and updates to the flights. It represented a tenfold improvement over the network system used during the Mercury flights.

The Gemini 4 flight control team at Carnarvon, Australia. Back row from left: Dick Simons (M & O) , Fred Mitchell (AWA Company Manager); Lewis Wainwright (Station Director) and Dave Scott (Astronaut). Front row from left: Dr. Bill Walsh (RAAF Flight Surgeon); Harry Smith (Gemini Systems Engineer); Dr. Michael Murrey-Alston (RAAF Flight Surgeon); John Ferry (NASA Simulations); Ed Fendell (Capcom); Joe Fuller (Gemini Systems Engineer) and Dick Pollard (NASA Flight Surgeon) [Courtesy Colin Mackellar and Hamish Lindsey, used with permission].

Spacecraft Communications

Each of the stations in the MSFN had both high frequency (HF) and ultra-high frequency (UHF) spacecraft communications capability. These could be controlled either by the respective station, or remotely from Goddard, Houston, or the Cape Mission Control Centers.

From Gemini 4, the following sites had a Capsule Communicator (Capcom), who was responsible for controlling communications between the site and the spacecraft and via MCC Houston. These sites were: Grand Canary Island; Carnarvon, Australia; Kauai, Hawaii; Guaymas, Mexico; Corpus Christi, Texas; and the two ocean-going tracking ships. The remaining stations did not have Capcoms and instead reported to the appropriate MCC. These included: Grand

Bahamas Island; Tananarive, Madagascar; Kano, Nigeria; Bermuda; Grand Turk Island; Antigua Island; Ascension Island; Canton Island; Point Arguello, California, the ship *Range Tracker*; and the various voice-relay aircraft.

Following the situation at Carnarvon station prior to Gemini 3, where a disagreement over who was in charge of the remote Australian station during the mission flared up, it was decided to send astronauts to three remote sites for one last time, but only as observers to gain experience and support the main tracking station team [7]. The primary Capcoms during each flight controller's shift were located at MCC-Houston, with the backup during the ascent phase stationed at the Cape. These assignments were:

MCC-Cape Kennedy: Alan B. Shepard

Carnarvon, Australia: David R. Scott

Kauai, Hawaii: R. Walter Cunningham

Guaymas, Mexico: William A. Anders.

David R. Scott, a rookie astronaut selected on October 1963 in the third astronaut group, thought that being assigned to a Capcom position was a coveted opportunity. "It was widely regarded as taking you one step closer to being selected for a mission," he wrote in 2004. "Whatever we were doing, we knew our performance was being judged – informally, but judged all the same." It was not until he was on the plane on the way out to Australia that he was passed pages marked 'Confidential' from the Gemini 4 flight plan, which revealed for the first time to the team on their way to Carnarvon that Ed White was to go for a full-exit EVA. Ed Fendell, the leader of the five-man NASA team on the plan, declared: "Well I'm proud to be an American. We're going to beat those Russians yet." [8]

Walter Cunningham wrote that the final decision on sending astronauts out to these remote sites depended in part on how they evaluated their roles for Gemini 4. "We were in the odd position of being able to cut our own throats on what was really a choice duty by reporting that the tracking stations could get along nicely without us. Which they could and subsequently did… Later [after the mission], with great reluctance and a sense of loss for the astronauts yet to come… Dave Scott and Bill Anders reported to Deke Slayton that the tracking stations could manage just fine without us." [9]

Mission Rules Each mission into space depends on detailed planning, clear objectives and extensive preparations. During the mission itself, clear instructions and precise actions result in both the success of the mission and the safety of the crew. Before each flight, a set of Mission Rules is devised as a guide for both the flight control team and the flight crew, to assist in the decision making process. Each set of Mission Rules is developed around the hardware, procedures, objectives and constraints of a given mission and is published as a policy document within the program. It is a collection of agreements from a variety of directorates and parties, both within and outside of NASA, connected to the mission, and defines the course of action to be taken in off-nominal in-flight situations. These rules include guidelines on: performance criteria of spacecraft system and subsystems; trajectory and guidance; flight aborts; selection of alternative missions; ground support requirements; medical aspects of the flight and crew; mission "GO/NO GO" decision making; criteria for EVA, rendezvous and docking; flight experiments; and launch and recovery windows. As Jim McDivitt recalled in his 1999 NASA Oral History: "You couldn't ad hoc this stuff [meaning flying in space] as you went along, or you shouldn't because it's too dangerous. If you don't have an understanding on the ground and in space of what the other guys are going to do, you don't have any confidence in them. And we used to really argue those Mission Rules hard and long before flights. And when we finally got to a Rule, that was 'The Rule'. Flight training and simulation form the basis for the Mission Rules. You could have a Mission Rule [and] you're getting into training, and you find out one day [when] you simulate that thing that [the] Mission Rule is wrong. You change it in the simulation. You don't change it in-flight, but you change it in the simulation. And that's why, once those Rules were pretty much set, you didn't want to change them in-flight because a lot of these consequences weren't obvious to the casual observer. You know, you had to be there and see what would happen."

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7. Reference 2, pp. 123–5

8. **Two Sides of the Moon: Our Story of the Cold War Space Race**, David Scott and Alexei Leonov, Simon & Schuster, 2004, p. 127.

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Footnotes

1 In the latter stages of the Gemini program during 1966, as Apollo was gearing up, both rooms were employed simultaneously, as the first unmanned Apollo missions were prepared and flown at the same time as the final Gemini missions.

2 This term is attributed to former Apollo controller John Llewellyn, after it reminded him of the firing range he remembered from his years as a USAF officer.

3 In recent years, non-astronauts have also taken this role occasionally during ISS operations.

4 At the end of 1965, following the mission of Gemini 7, Chris Kraft moved over to support the mission control requirements for the forthcoming Apollo Block 1 missions, which were expected to begin in early 1967. Following Gemini 8 (March 1966), John Hodge was reassigned to Apollo under Kraft and was replaced by Cliff Charlesworth, who chose ‘Green’ as the color for his team identification. Later, when Gene Kranz moved over to support preparations for Apollo 1 with Kraft and Hodge, Glynn Lunney and Charlesworth headed the control teams for the final three Gemini missions, supported where necessary by the other controllers.

David J. Shayler, *Gemini 4*, Springer Praxis Books
https://doi.org/10.1007/978-3-319-76675-1_6

6. "We're on our way, buddy!"

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

"We are 301 man-orbits and 443 man-hours behind the Russians in spaceflight time." Taken from a wall poster displayed in MCC-Houston on the morning of Gemini 4's launch.

That simple, but clear message to everyone in the new Mission Control Center in Houston was a defining rally call. Prior to Gemini 4, the U.S. had accumulated almost 65 man-hours in space and the successful completion of the mission would raise this to about 257 man-hours (or about 154 manned spacecraft hours). This mission was where the Americans began the long, slow, but methodical climb to catch and ultimately overtake the Soviets in their quest for space dominance and in the race for the Moon. In the first half of the 1960s, most of the 'space spectacular' headlines had been credited to the achievements of the Soviet Union, with the United States running a poor second. But from June 1965, and for the next decade, all this would begin to change. Leading the resurgence were astronauts Jim McDivitt and Ed White, the prime crew for Gemini 4.

It's the Final Countdown

On June 2, 1965, some twelve hours prior to the planned launch, the Martin ground crew began fueling the Titan booster on the pad at Cape Kennedy, carefully calibrating its propellant loads. Meanwhile, inside Gemini 4, the backup crew of Frank Borman and Jim Lovell were progressing through the sequence of switch positioning, tests and checks of the communications circuits, alleviating these chores from the prime crew who had retired for the night at 20:30. During the crew debriefing after the flight, both astronauts thought that having the backup crew participate in the mid-countdown switch set up was a good idea. “I wouldn’t have wanted to participate in any more of the countdown than I did,” recalled White. McDivitt agreed. “The flight crew participation should be in the final count, not the mid-count and pre-count. It doesn’t tire the prime crew out doing a lot of chores that they don’t really have to do [but] I think it’s a good procedure.” White concurred. “I found the switches all where they were supposed to be… I certainly appreciated the work the backup crew did getting the cockpit all set up for us. Everything was ready to go when we strapped in. That’s the way it should be.”

Launch Day: June 3, 1965

“This is Gemini Control, Houston. Good morning,” announced PAO Paul Haney, over the mission commentary link on launch day. He then went on to recall the events that had taken place earlier that morning, as the count slowly advanced according to plan, for now.

The two astronauts were awakened at 04:10 (all times in this section are given as Eastern Standard Time or EST). Following a brief physical examination, they enjoyed the traditional breakfast of steak and eggs with invited guests. These guests initially included Dr. Charles A. Berry and the backup crew of Frank Borman and Jim Lovell. They were later joined by Dr. D. Owens Coons, Center Medical Officer, MSC; Dr. Eugene F. Tubbs, KSC; Reverend James Heiliky (McDivitt’s priest at Cocoa Beach, Florida); and Monsignor Irvine J. Nugent.

The crew enjoy an early morning breakfast prior to their mission. Seated around the table (clockwise starting front center) Dr. Own Coons, Chief MSC Center Medical Staff (back to camera); Jim McDivitt (in shirt), Dr. Eugene F. Tubbs, KSC; Rt. Rev. James Heiliky, McDivitt's priest at Cocoa Beach, Florida; Msgr. Irvine J. Nugent and Ed White.

After breakfast, Jim McDivitt and Ed White departed the Merritt Island crew quarters at 05:22 and arrived at the Pad 16 suiting area just 13 minutes later. With medical sensors attached, both men were now providing the doctors with a stream of biomedical data on their heartbeat, respiration and temperature as they were suited up. During the suiting process, overseen by suit technicians Joe Schmitt and Clyde Teague, both astronauts wore face masks to allow them to pre-breathe pure oxygen, with only minor breaks in the process as they transferred to the suit system and closed their visors. The pre-breathing process would purge their bodies of nitrogen prior to the flight, preventing aeroembolism (commonly known as 'the bends'). An extra cover had been added to White's gold EVA visor, to protect against scratching prior to entry into the spacecraft. This would be removed as his hatch was closed and sealed.

While the men were undergoing the suiting operation, they were briefed on the status of the countdown and their spacecraft by backup Command Pilot Frank Borman. The outside temperature was recorded at 80 degrees F (26.6 degrees C) and there were no reported issues for the contingency landing areas should they be required early in the mission, despite the two tropical storms that were being tracked in the Pacific. Meanwhile, over at Pad 19, backup Pilot Jim Lovell was back inside the spacecraft completing the checks prior to the crew's arrival.

(left) Ed White is helped into his spacesuit by suit technician Joe Schmitt. The astronaut went through a pre-oxygenation to purge his body of nitrogen before the flight, a process which began at 05:25 EDT on the morning of the launch because of the planned depressurization of the spacecraft and the EVA. (right) Jim McDivitt reviews the crew procedures flip-book as he waits in the crew ready room at LC-16, prior to departing for LC-19 [Courtesy Ed Hengeveld].

Staff at the Cape MCC

Nearly 1,000 miles (1,609 km) away, across half the continental United States, Flight Director Christopher C. 'Chris' Kraft was in charge of the new Mission Control room at the Manned Spacecraft Center (MSC) in Houston. Sitting at the

Capcom console, waiting to communicate with the crew during the ascent to orbit, was Gemini 3 commander Virgil I. ‘Gus’ Grissom, who was joined by fellow astronaut Walter M. ‘Wally’ Schirra Jr. Behind them, in the separate visitor viewing area, were Houston Congressman Robert R. ‘Bob’ Casey (Democrat, House of Representatives, Texas 22nd District), NASA Associate Administrator Dr. Robert C. Seamans, and retired astronaut John H. Glenn Jr., now a business executive with Royal Crown Cola.

Events at the Cape were being watched by a TV audience across the United States, as well as a wider audience in a dozen European nations, courtesy of the newly-orbited U.S. commercial telecommunications satellite, Intelsat I[1], known as *Early Bird* (from the proverb “the early bird catches the worm.” See sidebar: *In the Eyes and Ears of the World*).

In the Eyes and Ears of the World

With increased satellite coverage and the availability of the *Early Bird* communication satellite to beam ‘live’ images to Europe, Gemini 4 became headline news as it sat on the pad before launch. Broadcasting to 12 European nations, and with the prospect of an EVA shortly after entering orbit as well as the use of the new Mission Control in Houston, international interest in Gemini 4 increased significantly. It would never be matched again in the Gemini program.

Early Bird was the first commercial communication satellite, launched on April 6, 1965. Following a series of tests, by April 23, successful and good-quality simultaneous two-way TV tests via *Early Bird* had been held between U.S. and European ground stations [1].

On April 22, Paul Haney, a Public Affairs Officer at the MSC, suggested that daily newspapers might be given 30-minute interview slots with the prime crew of Gemini 4, on the same basis as the TV networks and wire news services. These interviews would be held over two full days in May [2].

There was a significant increase in requests to cover the story from the MCC, which became a major challenge for NASA officials in Houston. On May 13, NBC had announced that it planned to televise the launch of Gemini 4 live and in color for the first time.

In planning the MSC, a purpose-built 800-seat auditorium in Building 1 (the administration building) had been created to accommodate news and television representatives. However, for its first use during Gemini 4, NASA had received 1,100 requests for accreditation for the 800 available seats. To solve the problem, the MSC had to lease one of the local offices of an aerospace company in the new buildings being constructed across the main highway from the center.

NASA christened the new location as “Building 6” and identified it as the NASA Gemini News Center. This became “the base for the 1,068 newspaper, magazine, radio, and television representatives, in addition to the 60 public relations staff from the various industry companies.” During project Mercury, it had been customary to open the news center at Launch minus five days, but for Gemini 4 the new News Center was opened on May 25. And that was where the troubles started, according to the official NASA history of Gemini, when the cost of this was revealed. The annual rent for these offices was $96,165. On top of this was a bill for $166,000 to modify it from the administrative role it was planned for into the media facility it became, including $8,000 for television monitors and $6,600 for 610 chairs. The expense was not mitigated by the fact that the building would mainly be used when Gemini flew, as most of the time the facility would remain largely empty [3].

In 2003, respected former BBC correspondent Reginald Turnill recalled his experiences in covering the early space program, including how *Early Bird* completely transformed interest in the program beginning with Gemini 4. “At last, millions of people around the world could watch it happening,” he wrote [4]. He also revealed the cost of such a privilege. The price, to the European nations, was $22,000 per hour, although it was possible to purchase ten minute segments. “For the BBC… it meant that prelaunch coverage with a film crew sending back rolls of film, followed by live radio coverage, was no longer sufficient.” Already a veteran space reporter, Turnill also noted that his previously unchallenged BBC news coverage “was increasingly invaded by cohorts of current affairs commentators, technicians and producers.”

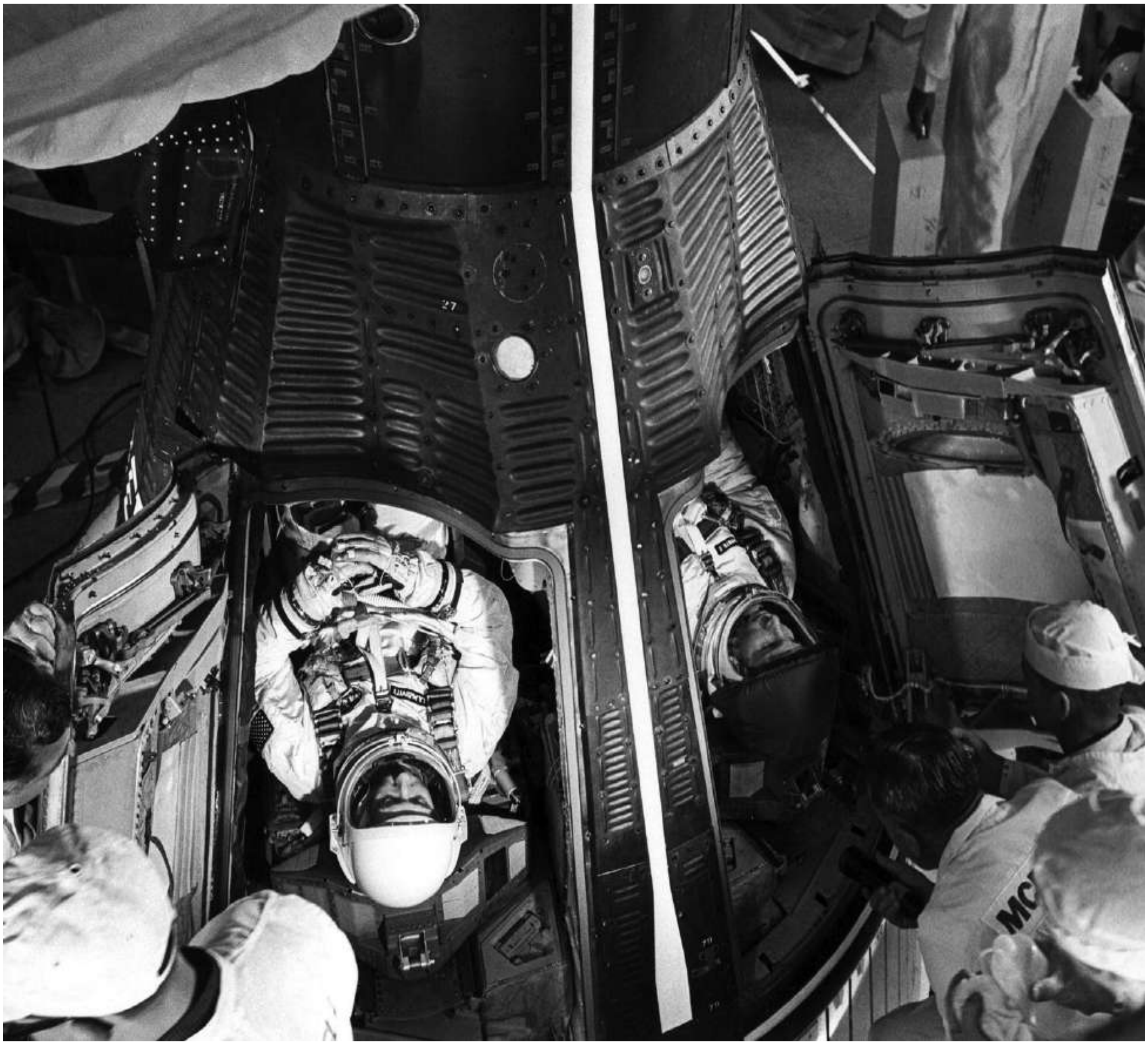
The other challenge for the news media was where to site their correspondents. With the inauguration of the MCC in Houston, 1,000 miles from the Cape, it was now impossible for a single correspondent and media crew to follow a short mission from Florida – while enjoying the relaxing sunshine and motels of the Cocoa Beach – from prelaunch to post-recovery. As flights became longer and with the control of the mission switched to Houston, coverage would now require a larger team across the two sites, or completing prelaunch and launch coverage at the Cape before scrambling to get to Houston for the rest of the mission, usually in time to encounter overbooked motels as the press descended on Texas en masse. In today’s world of instant global communications, it is hard to envisage the logistical nightmare that every media organization’s “special correspondent” had to contend with when following the missions in the 1960s.

Once they were suited, the astronauts left the suiting area shortly after 07:00 carrying their portable air conditioners. After a short ride down the Barton FREEway to Pad 19, they arrived at the base of the launch tower at 07:08 [5]. As they walked up the ramp to the elevator, McDivitt, leading the way, gave a broad smile, while just a few steps behind him White gave a confident ‘thumbs-up’ sign to the representatives from the media, a TV cameraman, photographers, contractors and NASA personnel witnessing the event around the base of the pad.

Jim McDivitt is followed up the ramp at Pad 19 by Ed White (giving a confident thumbs-up) as they head to the elevator that will take them to their spacecraft at the top of the Titan II booster [Courtesy Ed Hengeveld].

Four minutes later, at T-100 minutes, both astronauts “went over the sill” into Gemini 4 and were securely strapped into their launch positions by the ground crew. Getting into the spacecraft had been relatively straightforward, but shortly afterwards Ed White’s pressure suit faceplate fogged up, requiring him to start the suit fan to clear the moisture that had built up inside. This was not the first time this had happened to him, as the astronauts recalled during the post-flight debriefing. “We did have a problem with crew insertion on the Wet Mock [up],” recalled McDivitt. Normally, once they were on the suit loops, the fans were not turned on, requiring clearance from the Spacecraft Test Conductor before any switches were thrown in the spacecraft. But as McDivitt observed, “After we almost died of carbon dioxide poisoning during this [earlier] test, we got this matter clarified. As soon as we got in the spacecraft and one of us was on the suit loop, we would go ahead and put the switches on to put us on two fans. It worked really well.” On launch day, however, White recalled thinking, “I’m just going to always fog up on that suit of mine. We turned the fans on quick, but with the visors closed [the moisture] does not go out.” Just prior to hatch closure, with White’s faceplate now clearing, each astronaut completed a short series of blood pressure tests for the flight surgeons in the blockhouse. Ed White’s hatch was closed first, at 07:31, followed just a minute later by McDivitt’s hatch.

Generally, the crew’s cockpit procedures prior to launch went smoothly, running up to 12 minutes ahead of schedule, with the exception of one of the valves on the water management panel that had to be repositioned after the hatches had been closed. To do this, McDivitt had to loosen his restraint straps and use the swizzle (extended reach) stick located in the overhead switch/circuit breaker panel between the two astronauts to allow him to reach and reposition the valve. He then had to resume his position for launch, stow the swizzle stick and re-tighten his own seat straps, rather than having a member of the ingress crew do it for him. After the flight, McDivitt said that on launch day “I did feel some concern. This was not about personal safety, [but] if something [prevents the launch]… all that work [is] for nothing [6].”



The astronauts are inside Gemini 4 in the White Room, Pad 19, with McDivitt on the left and White on the right [Courtesy Ed Hengeveld].

Phone Home

Shortly after entering the spacecraft, McDivitt was able to put in a five minute ‘phone’ call to his wife Pat, back at their home in Houston. As White was busy with a series of communication checks, it was unclear whether or not he managed to call his wife, also called Pat and also back in Houston.

Over at MCC-Cape, Chief Astronaut Alan Shepard was at the Capcom console, along with the backup crew of Frank Borman and Jim Lovell. In the viewing room nearby were Gemini 5 Pilot Pete Conrad and backup Command Pilot Neil Armstrong, as well as NASA Associate Administrator Dr. George Mueller. Also at the Cape to witness the launch was Congressman Olin Teague of Texas, the Chair of the House of Representatives Space Committee, together with other members of the committee.

The weather looked good for the day's launch, with cloud cover at 3,000 feet (914.4 m), winds at 5 to 10 knots (5.75 to 11.5 mph, or 9.25 to 18.5 kph) from the east and a temperature of 80 degrees F (26.6 degrees C). Mission Control was informed that the weather conditions at the various tracking sites and recovery locations across the globe were in a 'GO' condition for launch. Out in the Atlantic, the extensive cloud ceiling was about 1,500 feet (457.2 m), with scattered showers south of Bermuda, something to keep an eye on should there be an abort during the ascent. Over in the mid-Pacific, there were reports of scattered, broken cloud with a ceiling of 1,000 feet (304.8m), while what had previously been Typhoon Carla a few days earlier had now been downgraded to Pacific Storm Carla and was not expected to cause any problems for the mission.

At T-63 minutes, the crew completed purging the atmosphere in the spacecraft to introduce 100 percent oxygen into the cabin, then confirmed the switch positions on the panels between and in front of them. Meanwhile, the controllers in the blockhouse reported on the status of the Titan II launch vehicle and the Gemini 4 perched on top. A test of the Air Force Eastern Test Range (ETR) missile tracking telemetry system was conducted prior to launch.

As vital data were being received from the Titan, the spacecraft and each astronaut, everything looked on track, though there remained some minor issues at a couple of the tracking network stations. At Tananarive, in the island republic of Malagasy (now Madagascar) in the Indian Ocean, there was a lack of voice contact relay, while out on the *Rose Knot Victor* tracking ship stationed in the Pacific about 1,000 miles (1,609 km) off the coast of Chile, South America, they had no teletype facilities. However, everything else was up and running ready for the mission, which was a good sign.

The 'Ups and Downs' of the Launch Vehicle Erector

Suddenly, and without prior warning, the count was put on hold at T-34 minutes 59 seconds. The reason was an issue with lowering the launch vehicle erector, which had stuck at a 12-degree angle. In an attempt to clear the fault, the erector was raised again to its full height and lowered for a second time, but promptly stuck again. The hold, which it had been hoped would be no more than 30 minutes, actually lasted for 75 minutes while the problem was resolved. In reviewing the data, the launch vehicle test conductor reported no redline problems showing in the blockhouse, which did little to help identify the difficulty encountered in lowering the erector.

During the hold, members of the launch pad crew returned to Pad 19 where, after numerous tests and checks of equipment and systems, the technicians discovered an incorrectly installed connection in a junction box. Once this had been exchanged, the erector was cycled to raise it to its full position a third time. This time when it was lowered again, it successfully attained its launch position and the countdown could continue. Inside Gemini, as the pad team worked the problem, Ed White reported to the blockhouse (‘Stoney’) communicator, fellow astronaut Russell L. ‘Rusty’ Schweickart, that both he and McDivitt were “all squared away” and ready to go.

As the work continued on solving the problem with the erector, all the crew could do inside Gemini was wait and take short cat naps, with Schweickart advising them that he would rouse them when the count was due to be picked up again. Ed White later commented on this extended period of lying on his back during the hold. “Initially, the first 20 or 30 minutes, I was squirming around and I felt a little uncomfortable. But after I had been in [the launch position] for 30 or 40 minutes, I didn’t feel there was a real restriction on staying for several more hours… while they fixed the gantry instead of pulling me out.” (His comments were made after the mission had been launched successfully later that morning, once the problem had been fixed.) He then added “I would [however] have been very disappointed if they had said, ‘Well you have been in there long enough and we will work on this gantry and try again tomorrow’.” He subsequently commented that the simulator was actually more uncomfortable to lie in, before adding his opinion that the decision over how long the crew could remain on their backs in the vehicle out on the pad should be down to them, not an operational procedure. McDivitt concurred, but added “Although I didn’t want to get carried overboard, we should scrub due to crew fatigue. When I first got assigned to the crew, I always felt one of the toughest things to do would be lying back for an hour and 40 minutes or so prior to launch. The time we spent in the simulator lying on our back I thought was in a very uncomfortable position. As we went through all the training and testing at McDonnell, and again at the Cape, my back got callouses on it. I got used to lying with my feet [higher than] my head. [but] at launch time I was a bit tired from lying on my back.” In their final simulation, they had become so used to being in this position that they forgot to ask the simulation engineers to tilt them up 30 degrees to relieve their discomfort. They inadvertently ran the whole four-hour simulation on their backs, which stood them in good stead on the actual day of launch.

After 75 minutes the erector was finally lowered, and while this unforeseen delay had not caused the crew any excessive discomfort, it did raise a few concerns regarding any impact it might have on the EVA planned for three hours into the mission, near the end of the second orbit. After reviewing the situation, Mission Director Chris Kraft decided that it would have no effect and the EVA was given the go-ahead as planned. Twelve years after the event, the official Gemini history recorded that by 1965 “space travel was becoming operational,” as this hold was the only problem encountered during the Gemini 4 countdown. Considering that this was only the second manned mission of the series, it showed the maturity of the system. In contrast, four years earlier in July 1961, the launch of Mercury-Redstone 4/*Liberty Bell 7*, the second manned flight of the Mercury series, had been “scrubbed twice and was plagued by six holds that totaled 4 hours 1 minute” [7]. Once the countdown for Gemini 4 resumed, the remaining procedure was turned over to the automated sequencers in the blockhouse, which automatically checked 70 different items during the terminal phase prior to ignition and lift-off. One positive that came from the enforced hold was that both the voice relay problem at Tananarive and the teletype circuitry problem on RKV were resolved before the launch.

At T-25 minutes, Ed White began a series of verifications of the various voltage and current readings from his instrument panel with the controllers in the blockhouse, who confirmed they were at the correct levels prior to proceeding with the count. By T-20 minutes, the brief OAMS thruster check in the Adapter Module (except the forward-firing thrusters) had been completed successfully and this was followed by a complete systems check by the team of controllers in the blockhouse.

One issue which did cause some concern was that both astronauts had to turn the volume control for the preflight communications fully up. The concern was that if communication was difficult with the blockhouse only a short distance away, what would it be like shortly when it would be required to operate at much greater distances? “I had to turn my UHF volume all the way up to hear anybody,” McDivitt said after the flight. “I was at max. There we were, sitting right on the pad, talking to a guy [just] two miles away with the volume full up. It didn’t give me much confidence as to the reception I was going to get when I was two hundred miles away, or three, four, five hundred miles away. I thought that the volume control on the radio was inadequate.” White also wondered what reception they would be getting when they were up in orbit, especially during the EVA, as even at max volume, they could not hear what was being said over the system clearly enough.

The crew was regularly kept informed of the various status levels during the count, and especially during the hold. “The first three or four minutes, I was hearing the Booster Test Conductor,” recalled McDivitt post-flight. “I heard what was originally on his loop, and I was listening to him get checks in from all of his guys. I really wasn’t getting a clue as to what was going on.” McDivitt explained that he was supposed to get booster information from the Test Conductor about when they were going to gimbal and when the pre-valves would be opened, but he didn't. "We were getting a lot of other information that made a lot of sense to the Booster Test Conductor, but not an awful lot to us." Then, in the last three minutes, communications were coming to the astronauts from three different sources; the Spacecraft Conductor, the Booster Test Conductor and Al Shepard, the Cape Capcom. On top of this, they could hear two unsynchronized countdowns between T-10 seconds and lift-off. This resulted in a massed chatter of mixed voices and the crew had difficulty in understanding any of the three communicators.

McDivitt suggested that this constant stream of information had come about because of Gemini 3, when Grissom and Young had said that they did not get enough information about their booster. On this next flight, the Test Conductor loop was fed to the astronauts as well, but according to McDivitt "We had too many guys talking. I think if just Capcom talked from three minutes down we would be all right… I'd say we got over-informed there at the end."

As the 15-minute mark ticked by, Ed White conducted a test with the ETR on the telemetry between the range tracking system and the guidance and associated equipment on board the Titan, whose status was checked yet again for launch. At T-7 minutes, another status check recorded that all elements were GREEN and GO. KSC Spacecraft Test Conductor Frank Witteck then formally signed off Gemini 4 to Jim McDivitt with the message, "OK Jim, have a good flight," whereupon Frank Carret of the Martin Company conducted one last status check of the Titan which also came back GREEN. Now, the Titan was transferred to internal battery power, with all systems looking good there as well.

(left) View of the Gemini-Titan 4 vehicle on Pad 19, Cape Kennedy on launch day, with the erector being lowered. (right) "American Eagle flies." Gemini 4 is launched from Pad 19 at 10:16 EST, June 3, 1965 [Courtesy Ed Hengeveld].

American Eagle Flies

PAO – Cape: "This is Gemini Cape control. T-60 seconds and counting. T-50. T-40. T-30 and counting. All final checks in the countdown still looking good at this time. T-20 seconds and counting… Minus 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0! IGNITION… Bolts… LIFT-OFF."

Back in Houston, PAO Paul Haney exclaimed: "LIFT-OFF. We have a lift-off at 16 minutes after the hour… climbing very nicely."

McDivitt: *"Counting. We're on our way, buddy!"*

Gemini 4 was airborne.

At lift-off, the heart rates of the crew were recorded at 150 for McDivitt, an expected value, and 120 for White. In comparison, Mission Director Chris expected value, and 120 for White. In comparison, Mission Director Chris Kraft's heart rate was up to 135, while Flight Surgeon Dr. Berry's rate was an unusually low 81. Lying on their backs inside Gemini 4, both astronauts were surprised by the very loud noise and extreme vibrations as the pre-ignition valves opened on the Titan nearly 100 feet below them. They could both hear and feel the engines start and though it was a described as a smooth lift-off, they could certainly feel it. White commented that it shook the whole spacecraft, and at one point McDivitt thought the vibrations would knock them off the Titan and lay them flat on the pad before they were launched!

In his post-flight observations of the launch, White recalled seeing the gantry lowered and the White Room disappear, revealing a clear sky through his small window. "I thought that we were going to launch," he recalled. McDivitt thought that the final seconds prior to launch were impressive. "That's when I sort of got excited, when the gantry went down. That's a new realm [and one not experienced in the simulations]."

McDivitt commented post-flight that the Capcom had given them a good cue at lift-off. "You could feel the acceleration at release. There wasn't a doubt in my mind that it was loose." White was more enthusiastic with his recollection: "Boy, you could feel the first little motions of the booster as it went up. It was really great!" After the initial movement, the vibration decreased rapidly and smoothed out. The noise had not given them much clue that they were going, but the movement certainly did.

(above) At the Cape Control Center during the lift-off of Gemini 4 are (from left) astronauts Clifton 'CC'Williams Jr., Frank Borman and Alan Shepard. (below) Gemini 3 astronauts Gus Grissom (left, Capcom for the Red Shift control team) and John Young are seated at the Capcom console just prior to lift-off of Gemini 4, waiting to communicate with the astronauts as they ascend from the Cape [Courtesy Ed Hengeveld].

Just Like Riding an Old Saddle

The roll program was initiated just nine seconds into the planned 98-hour mission, and successfully completed eleven seconds later. This was followed immediately by the pitch program, both of which the crew noted due to the change in lighting conditions inside the crew compartment. As the vehicle turned, Ed White confirmed that all systems were looking good. "*Swell. Boy that sun is bright*," McDivitt called from Gemini 4, recalling his experiences in the early afternoon 'wet mock' simulations where the sun had obscured his view of the instrument panel. At 40 seconds into the flight, Flight Surgeon Charles Berry reported that everything looked fine. The initial ascent looked close to the nominal values, so refinements to the ever-present abort modes were not necessary as the Titan streaked towards orbit.

As the vehicle passed the moment of maximum dynamic pressure (Max Q), the crew experienced the most vibrations and noise as the vehicle shook. "It was the loudest noise we received the whole flight," recalled White. After the mission, McDivitt tried to explain the sensations they had experienced at Max Q. "You can't simulate this in a simulator. You get more vibrations than you do noise. The only thing they have in the simulator is noise; they don't have vibrations. It was pretty loud and the spacecraft was actually shaking around a lot. It was really vibrating." In fact, it was vibrating more than even Ed White had expected. "The whole thing was really going at it," McDivitt continued. "Almost like an F-80 [Lockheed *Shooting Star*] or a T-33 [Lockheed *Shooting Star* trainer] at about Mach 0.8," which White agreed was a good analogy. The reduction of noise following Max Q was also remarkably rapid.

At 2 minutes 12 seconds, McDivitt reported to Capcom Gus Grissom in Houston that Gemini 4 was 'GO' for staging, which occurred without incident a few seconds later. Telemetry data suggested that the Titan/Gemini 4 combination had rolled at the planned rate and to the desired flight azimuth. The data recorded that the first stage had attained a higher altitude due to a slightly lower pitch program rate, and that the thrust from the first stage was greater than expected. Despite this, the profile remained well within the trajectory boundary.

A "good staging" was how the first stage separation event was termed, but it startled White when the stages separated, as he was concentrating on updating the DCS. "I'm the button pusher. I [did] everything about pushing the buttons [on the ascent]," he commented. At the time of BECO, White realized that they would feel the separation. "It was a very distinct feeling when we separated… we immediately dropped in the thrust. There wasn't any question, we had a good separation in my mind. It was very clear that was what had happened." McDivitt concurred. "There wasn't any doubt about it when that first stage shut off – Vroom!"

The separation of the two stages was initiated at 152.43 seconds into the mission, with physical separation beginning just 0.31 seconds later, a second earlier than planned. Houston Capcom Grissom advised McDivitt that "*everything is going great*," with McDivitt reporting that his onboard display looked as good as those on the ground. Indeed, the pilots reported that both stages of the Titan had operated as they should during the ascent. The *g* forces were tolerable and according to White after the flight, they felt "just like riding an old saddle." As they ascended, McDivitt was paying attention to the sequencing clocks, while White monitored the system gauges.

At 3 minutes 40 seconds, Chris Kraft pooled opinions from his controllers, who reported confidence in the performance from each system they were monitoring.

Grissom: *"Gemini 4, Houston gives you a 'GO'."*

McDivitt: *"Roger. Looks great up here."*

After status checks at MCC Houston prior to the second stage engine cut-off (SECO), a further 'GO' was passed up to McDivitt. At five minutes into the ascent, "point 8" was reached, which meant that 80 percent of the required velocity had been achieved. The second stage engine shut down 34 seconds later. As with the first stage, the thrust from Titan's second stage was higher than nominal and, as before, the shutdown of the engine was early. The now-lofted trajectory was corrected during Radio Guidance System (RGS) steering, and the slight oscillations in pitch, yaw and roll due to the propellant sloshing around ('pogo') were finally dampened out near SECO.

Just 31.8 seconds after SECO, the Gemini 4 spacecraft was physically separated from its booster, with the aft-firing thrusters burning for five seconds. Intermittent communications delayed the reading of spacecraft separation, but McDivitt confidently reported the separation maneuver, which had been completed at GET 369.7 seconds, as 20 ft./sec (6.1 m/sec) forwards, 11 ft./sec (3.35 m/sec) right and 2 ft./sec (0.6 m/sec) down. Inertial velocity was recorded at 25,746 ft./sec (7,847.38 m/sec) and the resulting elliptical orbit was subsequently confirmed as 87.6 nautical miles by 152.2 nautical miles (100.74 x 175.03 miles or 62.54 x 108.67 km), compared to the planned initial orbit of 87 nautical miles by 159 nautical miles (100.05 x 182.85 miles or 62.1 x 113.52 km). Gemini 4 was in orbit and was already chasing the booster that had just launched it.

The moment Gemini 4 entered orbit, the home-made U.S. Stars and Stripes flag and a Gemini program flag that had been carried on Gemini 3 were hoisted outside Building 1 at the MSC in Houston. They would remain flying until Gemini 4 had landed successfully, a ritual that would be repeated for the duration of each of the subsequent Gemini missions over the next 17 months.

In the first 20 seconds after SECO, McDivitt unstowed the maneuver controller, rolled Gemini 'right side-up' from the 90-degree bank angle, and fired the translation thrusters at least twice in one axis to nullify the down rate in pitch and yaw, although the fairings were yet to be jettisoned. The plan was to remain on the booster for 30 seconds after SECO, and 20 seconds in, McDivitt recorded the Incremental Velocity Indicator (IVI). "I felt we were certainly in orbit. At least, the IGS [Internal Guidance System] was telling us we were in orbit," he recalled. He told White that he was going to do some maneuvering, but would not separate from the Titan stage yet, so that White would not push the SPACECRAFT SEP button when he heard the thrusters firing. They had practiced the routine to separate Gemini and when McDivitt eventually called "*Thrusting, separate*," White punched the SEPARATE button and flipped to RATE COMMAND, as McDivitt thrusted the spacecraft forwards for about five seconds. Except they were not going forwards. "We came off crooked," recalled McDivitt later. "We didn't seem to come off straight ahead. We seemed to be getting some sort of oscillation that got us going in a different direction than we had been going on the booster." White suggested that one side of the separation plane had come off with more force than the other, separating the spacecraft at an angle.

McDivitt thrusted and separated Gemini 4 from the booster and then, after just a short time, he started to turn the spacecraft and jettisoned the fairing, which separated with a loud bang. He saw the cover of the horizon scanner go but never did see the nose fairing separate and just assumed that it had. "We were already in just a mass of debris up there, because when we separated from the booster there was stuff all over," he explained. The debris flew to the side of the Gemini, as McDivitt later recalled. "It was all over the place. As we were turning around, it looked like we were going through a snowstorm. Finally we got around, in about a minute and a half, and we could see the booster there."

Post-insertion Checklist

As McDivitt turned the spacecraft around, Ed White was busy with the post-insertion checklist, a process he had refined during many hours in the simulators. “We don’t just take a checklist and run down it item for item,” he explained post-flight, “because there are things you have to be doing, and it just doesn’t sequence like that.” Realizing that this was exactly the way it was going, he took his pencil and checked off items as they were completed, and if they had not done something on that list when they should have, it was left unchecked to return to later. “You just can’t expect to run down the checklist item for item, because you’re not ready to un-stow your life vest or get up out of your seat belt. You don’t do that for some time. I think the logic on the checklist was… a very good sequence,” he reported. McDivitt revealed that they had revised the checklist over and over again preflight and the one they took to orbit was probably the 50th version. “I don’t think it could have been arranged better for the two of us,” he said. White added that “the checklist does not have to be accomplished item for item, completely done in numerical sequence.” Clearly, on Gemini 4 it was not.

White lamented that he did not have a camera ready to take some pictures of the booster as they came around. The pilot suggested that a still or 16-mm camera with normal lens that was semi-stowed could be included on future missions: “Just tuck it to the side on your left,” he suggested. “If I had thought about it, I think this is what I would have done.” McDivitt was more philosophical about missing the opportunity his colleague had wished for. In his mind, they had to be prepared to come home if they found they had a bad spacecraft, and needed to be ready to re-enter on that first orbit. “This is the kind of bind we find ourselves in up there,” he said. “During the first orbit, we really had a lot to get ready for halfway through the second orbit [the EVA], but on the other hand, we had to be in good enough shape so we could re-enter.” McDivitt confirmed that they did not have anything actually wrong on their flight, at least not enough to warrant a quick return, but from lift-off plus one second, they had to be ready to eject, “and you don’t want to be sitting there holding a camera or something like that. Both your hands are busy,” he said.

Ed White, though, was not totally convinced, commenting in the post-flight debriefings that “You could stow it [the camera] beside you in the seat. I think we over-emphasize the necessity, particularly for ejection, of having to have everything stowed, and at very slow speeds. We certainly have a heck of a lot more working against us in our airplanes we’re flying around.” McDivitt agreed with his colleague, but still thought that trying to do too much on the first orbit conflicted with being able to re-enter quickly if they needed to. Both agreed that more thought needed to be put into this, and that photo opportunities were being missed, as they could have taken some beautiful pictures of the booster when they got close to it. Ed White looked as closely as he could at the nozzle skirt and the aft end of the booster, and saw no damage whatsoever. The nozzle skirt was completely intact, indicating a clean separation from the Titan's first stage during the ascent to orbit.

White released his seat harness, which enabled him to complete a few tasks knowing that McDivitt would remain restrained for the time being. Relatively safe in orbit, the astronauts could now get more comfortable, or as White put it after the flight "I had a lot of things I had to squirm around and do." This mainly involved safing the ejection seat, but as White had discovered during the preflight weight and balance checks, his suit hoses were not long enough to permit him to turn all the way around and still remain connected to them. In the close confines of Gemini, such movement was never easy at the best of times, but as they were close to launch, there was nothing they could do to change the hoses prior to their flight. This would be a useful suggestion for subsequent missions, though of course the down side was that longer hoses meant more material to stow when they were not in use. White also found that his vision was restricted as he tried to locate the drogue pins in the seat to secure them. McDivitt actually commented that the design of these was "lousy," and White agreed: "In two words, it stinks."

As McDivitt was "just trying to stick with the booster at that time," White set about unstowing equipment from the right-hand stowage compartment. Specifically, he was eager to retrieve the cameras, as he was "dying to get a picture of that booster," followed by the film and tape cartridges, all of which he stuffed down the side of his footwell. Both pilots reported that they had decided to use the launch day [temporary] urine bags for as long as they could, and that they had "hoped to use them right through to the EVA." As it turned out, they did.

Orbital Flight

Once Gemini 4 was safely in orbit, it received its own international object designation of 1965-043A from NORAD, meaning that it had been the 43rd major object successfully placed into low Earth orbit that year. Following the separation from Gemini 4, the spent Titan II second stage continued on its trajectory and was inserted into an orbit of 87.6 nautical miles perigee and 150.1 nautical miles apogee (100.74 x 172.61 miles or 62.54 x 107.17 km), receiving the designation 1965-043B. It would remain in orbit for just over two days, until it re-entered and burned up on June 5 [8]. Now that the spacecraft was established in orbit, the crew could proceed with the next phase of their mission, with McDivitt very clear about identifying specific mission elements.

"I think that the orbital flight should be broken down into some very distinct sequences," McDivitt explained during post-flight debriefing. He suggested, for the purposes of the debriefing, that their flight ought to be divided into three stages. The first three or four orbits, when they were trying to remain close to the booster and then performing EVA, was Stage 1. Stage 2 of the mission included the middle 50 orbits or so, where most of the scientific experiments were performed and where they finally completed the flight plan they had started out to do. Finally, Stage 3 was concerned with preparations for the return to Earth, the retrofire and re-entry.

Station-Keeping

Immediately after separation, McDivitt began the station-keeping exercise by turning Gemini 4 around to face the booster behind them. In total, 74 maneuvers were completed over a period of 80 minutes during the station-keeping exercise in the first orbit, and they resulted in the use of 115 pounds of propellant and a total incremental velocity change of about 102 ft./sec (31 m/sec).

McDivitt: "*Okay, I got the old second stage. Its spinning away and looks pretty… It's starting to tumble a little.*"

Back at the control center in Houston, Capcom Gus Grissom asked how fast the booster was tumbling, but at that time McDivitt was unable to give a clear reply, merely stating, "*I can't give you that… It's slowly rotating.*" Gemini 4 was approaching the point where communications would switch from the Cape to Grand Canary Island, but McDivitt did update the Capcom prior to that: "*Before I leave you, let me tell you the lights are working… the booster lights are flashing.*"

Canary Capcom: "*Gemini 4, Canary Capcom.*"

McDivitt: "*Hello Canary, Gemini 4.*"

Canary Capcom: "*Your status is GREEN from here.*"

McDivitt: "*Roger, thank you.*"

Gemini 4 had been in flight for only 15 minutes and they were already almost crossing the eastern shores of the Atlantic Ocean. After they had run through a few system checks and switch settings, Capcom asked how far they were from the Titan stage.

White: “*Right now we’re aligning the platform and it’s [the Titan stage] going below our lower left, and we’ll be going down after it in a moment… We’re after it right now… We presently don’t have it in sight.*”

McDivitt: “*I have it sighted at this time. It’s directly below me about 400 to 500 feet. I’m going to thrust down…*”

White noted that the light was coming through the windows quite clearly and that they were “*passing over a big desert now.*” McDivitt advised: “*There isn’t enough time to get a good platform aligned there. I don’t want this thing [the Titan stage] to get too far from me.*”

Inside Gemini 4, astronauts McDivitt (foreground) and White attempt formation flying with the spent Titan second stage, the first objective of their mission. This image, taken during training, clearly shows the cramped confines of the Gemini, their home for four days.

Playing the Rendezvous Game

McDivitt had started to turn the spacecraft around to face the spent booster as soon as Gemini 4 separated from the Titan, rolling ‘right side up’ as he yawed around to the left. As soon as the astronauts saw the booster, they realized that it was at a peculiar angle, and McDivitt gave his estimate of separation at about 400 feet (122 m). White guessed it was a lot closer than that, possibly at 200 to 250 feet (60.96 to 76.2 m). McDivitt selected RATE COMMAND and this triggered the thrusters for about five or six seconds to cease the separation velocity. By the time he had activated the computer’s CATCH UP MODE, the spacecraft had already starting thrusting at about 2 to 3 ft./sec (0.60 to

0.91 m/sec). McDivitt assumed they had stopped, “although I couldn’t tell that quickly,” he said later. Retaining the Delta V, he in fact found that they had not stopped the relative velocity to the booster as he thought, so he applied a further 4 to 5 ft./sec (1.21 to 1.52 m/sec) burn, and with that their relative velocity appeared to zero out. At this point, McDivitt thought the distance to the booster was now 500 to 600 feet (152.5 to 182.88 m), but again White thought it was a little closer.

The astronauts thought that something in the spacecraft separation maneuver had built up a lot of relative velocity between them and the booster, but they had no idea what. At this point, they also realized that they were no longer in the same plane as the booster, which was off to their left, or south. It was still on their orbital track but was rapidly losing altitude.

McDivitt eyeballed the booster, “and it looked like it wasn’t going from us anymore,” he explained post-flight. Concerned about conducting the station-keeping, but also mindful that they were still early in the mission and that anything could happen, he later explained “I wanted to get the platform aligned somewhat, in case we had to come down [early]. We really hadn’t had much chance to check over the spacecraft yet.” As he aligned the platform, the booster started falling behind them again and disappeared from their view out of the window. McDivitt felt that he could let it go for 30 to 60 seconds and not have it go too far away, but when he pitched down to look for it again, it appeared to have gone a lot further down than he had expected. He thought that the spacecraft and booster were no longer in the same orbit and at the rate he saw, it appeared to be descending.

Knowing that he did not have a good alignment on the platform, and aware that he could not remain where he was and have the booster close by, McDivitt flipped the Gemini around and pitched straight down. “And here’s where the problems started,” he recalled later. In his desire to get down to the booster and attempt a long rendezvous-type maneuver, he should have remained horizontal and fired the retrograde rockets, taking some of the velocity out of the spacecraft, to ‘drop’ it to a lower orbit. “When you do this,” McDivitt explained, “the booster continues to pull away from you for a while, and then eventually you are going to drop down below it. Then you are in a lower-altitude orbit and you are going to pick up [speed] and catch up with the booster.” Unfortunately, time was running out for the crew on board Gemini 4 to complete this maneuver, as darkness was only a few minutes away and approaching fast. Realizing that he did not have time “to play a rendezvous game with it,” McDivitt instead used brute force, thrusting right at the booster and naturally assuming they would close in on it. In fact, they did not, so he fired the thrusters again, and again;

probably three or four times, he estimated.

McDivitt also discovered how much more difficult it was searching for a target against the moving backdrop of Earth, as opposed the blackness of space. During this time, the booster's tumbling velocity increased, to the point where Ed White estimated it was taking only eight seconds for a complete revolution of the stage. In the first three minutes after orbital insertion, its rotational rate had increased to about 40 to 50 degrees per second. "Its rotational rates stabilized," McDivitt explained, "but I don't believe its rotational mode ever stabilized. It didn't rotate in a plane as I thought a long body like that would rotate. It seemed to oscillate in just a random tumbling fashion. It was all over. It looked to me like it was rotating in three axes in a completely un-programmed manner."

McDivitt thought that this tumbling of the Titan stage may have been caused by the roll nozzle venting fuel. "You could see the fuel squirting out of the roll nozzle in a big fan," he explained. "I had the impression that if the booster were perfectly stationary [he meant not tumbling], the fuel would have been coming out of the nozzle in a big cone the way you would expect it to, but because the booster was tumbling so rapidly it was coming out in a long, twisted [fashion]… like a Horn of Plenty."

At this point, Ed White was looking out of his window at what he thought was the pitch black sky, noting little sparkles everywhere. "It looked like almost a starlit sky, but it just didn't quite look right to me; it looked like an artificially starlit sky… like some of those star displays [the simulator engineers] have created for us," he said. Looking over to his left at Jim McDivitt, he noted that his colleague was in bright daylight, and that this was the first time he had seen the daylight-dark experience of one astronaut looking into a pitch black night and the other looking into a completely daylit window. "Jim remarked rather disgustedly to me, '*We are pointed straight at the ground*'!" White then realized that he was seeing a profuse quantity of the famed 'fireflies' first noted by John Glenn in February 1962. He assumed that they had been created by the vaporizing fuel leaking from the Titan, combined with that from their spacecraft's thrusters. McDivitt added that there was a lot of 'junk' from the launch vehicle separation as well. Throughout their mission, these 'fireflies' would be observed at sunrise or sunset, or each time they dumped urine overboard. "It was really something," said White. "The sun would pick these particles up and they would just act like little magnifying glasses and make very bright spots… It was really something, the whole sky within my view was covered with these little particles, thousands of them."

By now, the lights on the booster were very apparent, and as darkness approached they had moved to approximately 2,000 feet (609.6 m) above it as it dropped away further. McDivitt realized that he would have to catch the booster up again during the night pass, so that as they emerged back into daylight, he would have to have moved Gemini 4 into position next to it to allow them to take the required photos. “[I] thrusted some more right at the booster, trying to overcome orbital mechanics with brute force. It was too late to start playing fancy games with orbital mechanics. Finally, I got us down to what I considered a good position,” which he estimated was just prior to flying over the Carnarvon ground station in Australia.

McDivitt was watching the two flashing lights on the booster, to determine the relative rates and to have at least some idea of how far away they were, but it was difficult at best. Gradually, he was able to determine whether the distance to the booster was increasing or decreasing, so that he could tell if they were closing in or moving further away. But with the booster tumbling in what he termed “this screwy manner,” he could not maneuver around it as it was tumbling so fast. All he could do was to try to get close enough to it not to lose sight of it. For a substantial part of the night time pass, he held position with the booster, feeling that he had the situation under control but that estimating the separation distance as they entered darkness would be difficult, varying between 1,000 to 2,000 (304.8 to 609.60 m), or even as much as 3,000 feet (914.4 m). By the time they were flying over Carnarvon for the first time, McDivitt thought they were in reasonable shape, closing in rapidly on the booster and noting both lights as he expected. At one point he estimated that they were as close as 200 feet (60.96 m), although White suggested it was more like 700 to 1,000 feet (213.36 to 304.8 m). Then suddenly, he could no long see any lights and could not find them for quite some time, guessing that the booster must have been moving away rapidly. Despite it being some 28 feet (8.53 m) long, 10 feet (3.04 m) in diameter and with a mass of about 6,000 pounds (2,721.6 kg), roughly the size of a Winnebago RV, they discovered that the booster was not that easy to see.

Back in Houston, Public Affairs Officer Paul Haney updated the listening world with the status of the mission.

> PAO Haney: “This is Gemini Control, Houston. We are 20 minutes after the hour and during the recent pass over Carnarvon, and some two minutes ago, Gemini 4 was given a go for three orbits. Even more important, Dr. Berry, our Flight Surgeon, had made an evaluation of the medical data at this point and he had advised Mission Director Chris Kraft that the pilot, Ed White, as far as the surgeon is concerned, is ‘GO’ for the extra-vehicular activity… very shortly, McDivitt and White should be seeing the first of, hopefully, about 62

sunrises they should observe in the next four days."

On orbit, the booster stage was easy to spot during the few times it was against the black sky, but against the backdrop of Earth, the task was much more difficult. McDivitt thought that they had lost the station-keeping opportunity, but they had not lost sight of the booster, though it was becoming increasingly harder to see. As the darkness gave way to the gray of the daylight side of the Earth, they suddenly located it clearly, some two or three miles (3–5 km) in front of them, although its lights had disappeared. "It had gotten that far away in such a short time," McDivitt observed after the flight, "and it was down [below them]. I think what really gave me the clue that we were losing it again was that I had it on the horizon and it had started going down below us." Despite a couple of thrusts, it was still some distance away. "So here again, we were faced with the same kind of problem to catch up with the booster," admitted McDivitt. "What I should have done was to retrofire right then to drop down, get into a lower [faster] orbit, and come back up. But we had to get the booster right then or we weren't going to get it [at all], because we had the mission [objective] to take photographs of it across the States." McDivitt thought that if he could have closed in with at least 10 or 15 feet/second of thrusting, then he could overcome the problem, but in trying to get to that point he discovered that he could not gain on the booster, which continued to pull further away as they approached the Hawaiian Islands.

"By the time we got to Hawaii, I told [the ground] I thought we were having difficulty doing it [meaning the station-keeping]. [I] had decided by that time that if we were going to do the [rest of the] mission at all, the only thing we could do would be to leave the booster. The fuel was down to around 75 percent on my gauge and the gauge kept going up and down, so it wasn't a heck of a lot of help [and] I had burned around 85 or 90 ft./sec [25.9 or 27.4 m/sec]." McDivitt had made up his mind that it appeared to be a hopeless task, faced with conflicting numbers as he changed attitudes and thrusting maneuvers, so he decided that they had better stop, otherwise they would use up all the fuel for the whole mission. In retrospect, McDivitt theorized that they may have been able to initiate a larger retrograde burn and drop below the booster and then catch it again on the second or third orbit, but that would have used even more fuel.

The flight plan was set to have the EVA completed within the first three orbits and, as he had discussed with Chris Kraft prior to the flight, the priority was for the EVA over the station-keeping, so McDivitt reasoned correctly that it would be best to abandon trying to chase the booster. Ed White also thought that the booster's orbit had changed so much compared with their own that it may have affected the duration that they could have remained in orbit had they have affected the duration that they could have remained in orbit had they burned more fuel. By the time they had reached the United States at the end of their first orbit, the booster was estimated to be five miles below them. A later opportunity to try to return to the booster would have seen them risk moving from a good orbit for Gemini 4 down to 130 miles, which was not optimum for the planned four-day orbital lifetime while still leaving a margin of safety.

Faced with this, McDivitt admitted that he was confused by the orbital dynamics, as they should have been closer together approaching perigee than they were, and were further apart at apogee, which did not help the tracking. “It was extremely difficult to track across the water,” McDivitt explained, “and as we got to the land it was almost an impossibility to track it.” He had also experienced the sunlight coming across the window, effectively blocking out any good viewing, which would not be a good thing during a full-scale rendezvous mission. White added that the windows were also now dirty, with a white film of material deposited on the outside from debris particles, which reflected in the sunlight and also made it difficult to get a clear view of the target.

McDivitt felt that the biggest problem they had was their optimism for the first three orbits of the mission, which became even more apparent as they tried to prepare for the EVA and found to their disappointment that they could not complete the preparations in the time allocated. In retrospect after the mission, McDivitt felt that had he not had the constraints of having to be next to the booster in the first daylight pass, then taking pictures, preparing for EVA and having White ready to emerge, all within two hours of launch, then there might have been time to rendezvous with the booster. “I just felt that if I had more time, I could have gone ahead and done some of this without using brute force to overcome the difference between the booster and [us].”

By the time they flew over Guaymas, a decision needed to be made about whether or not to continue to chase the booster. At this point, their remaining fuel was down to about 50 percent of OAMS capability. It was clear that they were not getting any closer to the booster, and in fact were still pulling away from it. “If they [Mission Control] wanted to go for it, they had to make up their minds, and we would [have] really [gone] after it,” McDivitt confirmed later, adding that he did not think it would have been a wise move if they had. Mission Control agreed with him and confirmed the decision to terminate the booster experiment.

McDivitt: “*This is Gemini 4. Do you really want me to make a major effort to close with this thing or save the fuel?*”

Chris Kraft: [to Capcom Grissom]:“*I think we should save the fuel… I don’t* *think it’s worth it.*”

Grissom: [to McDivitt] “*We want to save the fuel* [and] *you’ll be advised over the Cape.*”

Kraft: [to Grissom]: “*You might tell him that as far as we’re concerned we want to save the fuel. We’re concerned about the* [mission’s orbital] *lifetime more than we are matching that booster.*”

McDivitt: “*I just can’t wait till I get to the Cape. OK guys we’ll just have to watch it go away. I’d like to save enough* [fuel] *to help bring me down. I don’t want to get down to wherever it’s going.*”

Kraft: [to Grissom]: “*Tell him to forget it.*”

Grissom: “*OK, I guess well scrub it… Knock it off – no more rendezvous with the booster.*”

McDivitt: “*OK.*”

> PAO Haney: “This is Gemini Control, Houston. The spacecraft at this time is over the Canary station. We are 1 hour 51 minutes into the mission. Since the pass across the United States, the Mission Director and his System Advisors have consulted and, based on the usage of fuel up to this point – the usage has been an estimated 160 feet per second… out of a total of 360 feet per second available, leaving him 200 feet per second – the Mission Director has decided not to attempt any closer approaches to the booster. That is, the Gemini 4 spacecraft will not attempt to come closer to the booster during this [second] revolution when we will attempt extra-vehicular activity, and he will not attempt to come any closer during the fifth revolution as previously announced.”

The objective of staying with the booster was to see what problems the astronauts might encounter on future missions when they had to rendezvous with their spacecraft, both in Earth orbit and around the Moon. Gemini 4 certainly discovered some of the problems involved in space rendezvous, as McDivitt reflected later. “We were going to try to fly formation with it [and at the end of the first orbit] Ed would be ready to do his EVA and I’d fly up close to the booster and he would float over [using the HHMU] and take a piece of material that had been placed on the outside of the upper stage to see how the effects of launch heating went. It was an excuse to do something, and we wanted to do something out there. Well, there were two things that we didn’t do very well. One is that people forgot that the booster tanks went into a vent condition once it got into orbit… expelling the residual propellants, and that acted like a small rocket engine. So instead of the upper stage being stable it was maneuvering the whole time. Then, when we got to the dark side [of the orbit], we had put two strobe lights on the stage so that we could see them. Well, that was probably the worst thing in the world we could have done, because if you look at a strobe light at night, it's so damn blinding that you can't see anything [else]." McDivitt also mentioned that these strobe lights were placed on opposite sides of the large cylindrical stage, and as a result he could never see both at the same time, hindering his search for the booster [9].

On to the Next Task

With the rendezvous with the spent Titan stage abandoned, the crew could at last focus totally on preparations for the EVA, which was planned for the very next orbit. It soon became clear that they would require more time to prepare for it, however. McDivitt's concern about pushing for two significant and large objectives as soon as they got into orbit was being realized, but both men were committed to trying to get the EVA preparation done and the spacewalk completed before they settled into their four-day flight. Despite the concerns and the cramped crew compartment, with all the EVA gear being prepared, the two astronauts were about to make history and embark on what would become a milestone in U.S. space exploration.

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5. **Gemini Flies, Unmanned Flights and the First Manned Mission**, David J. Shayler, Springer-Praxis, 2018, pp.137–8.
6. *What a real thrill it was to zap-up*, Jim McDivitt, *Life Magazine*, June 18, 1965.
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8. **The R.A.E. Table of Earth Satellites, 1957–1989,** Desmond G. King-Hele, Doreen M.C. Walker, Alan N. Winterbottom, J. Alan Pilkington, Harry Hiller and Geoffrey E. Parry, Royal Aircraft Establishment, 4th edition 1990, p. 79.

9. Colin Burgess telephone interview with Jim McDivitt, January 18, 2005.

Referred to extensively in this and the following sections were:

• Composite Air-to-Ground and Onboard Voice Tape Transcript of the GT-4 Mission. NASA Program Gemini Working Paper No. 5035 , NASA MSC, August 31, 1965

• GT-4 PAO Mission Commentary Transcript (undated)

• GT-4 Flight Crew Debriefing Transcript, NASA Program Gemini Working Paper No. 5038, NASA MSC (Undated)

• Gemini Program Mission Report Gemini IV MSC-G-R-65-3 June 1965.

Footnotes

1 The International Telecommunications Satellite Consortium, or INTELSAT, was established in August 1964 on the basis of agreements between governments and operating entities to provide a global satellite communications network.

David J. Shayler, *Gemini 4*, Springer Praxis Books
https://doi.org/10.1007/978-3-319-76675-1_7

7. “He’s out! He’s floating free!”

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

“We were looking to find out:
‘Could man control himself in space?’
And the answer is yes,
Man can control himself in space.
He needs a little more fuel than was provided to me.”
Ed White’s post-flight comment on his EVA

Once the station-keeping exercise with the Titan booster had been terminated, the focus turned to the planned spacewalk by Ed White. As McDivitt commented post-flight, they started the preparation work almost immediately. “[After] we reverted from the station-keeping which we were both attempting to do, to EVA preparation which we both *had* to do, that’s when Ed went after the [hand-held maneuvering] gun and we started our preparation. We weren’t really far behind at this time. All we had to do was get the gun out and the maneuvering unit. The cameras were already out.” White had already unpacked the Zeiss camera along with the Hasselblad from the same storage location, finding little difficulty in unzipping the center container. He also found assembling the components of the maneuvering gun very easy, having practiced it many times during training.

Go for EVA

At 1 hour 33 minutes into the mission (GET 1:33), Houston Capcom Gus Grissom came online with an update for the next objective of the mission.

Grissom: *"We're giving you a 'GO' for your EVA at this time.*"

Four minutes later, Ed White updated the status of his preparations.

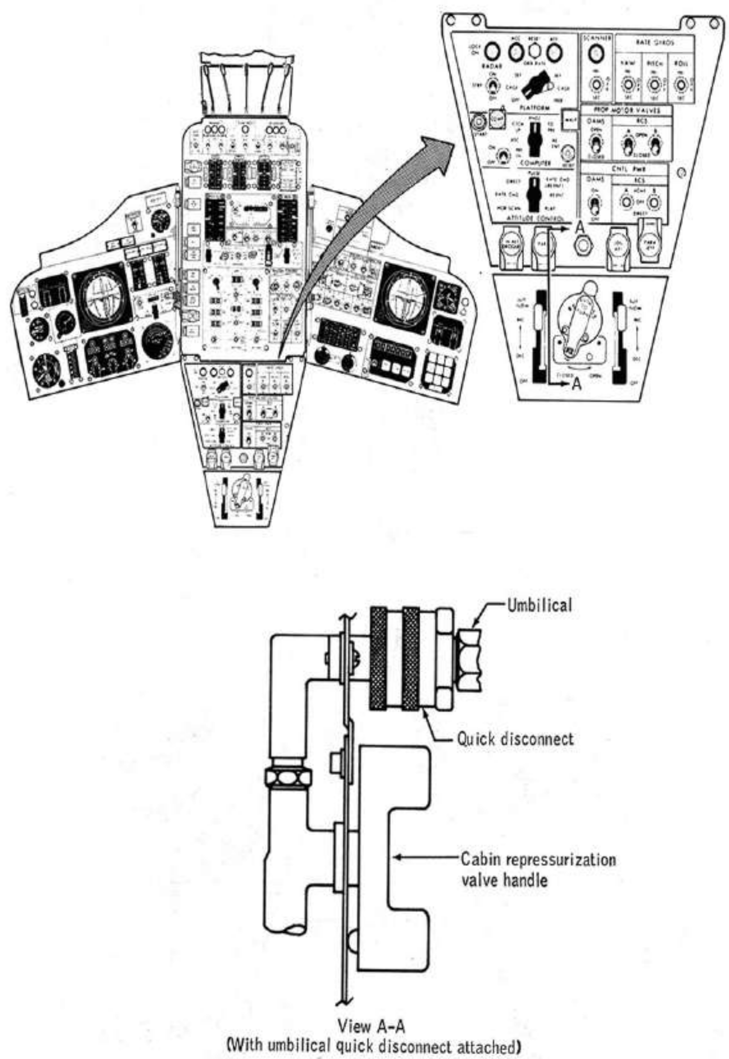
White: *"Be advised the gun is out and stowed and assembled and we've got out [the] cameras and we'll be going after the* [other] *equipment.*"

As Gemini 4 flew over Bermuda, the Capcom requested a blood pressure reading from White when they flew over the Canary Islands, but as McDivitt indicated in his reply, the Pilot was more than a little busy.

McDivitt: *"He's unstowing stuff right now, so you may have to wait a second.*"

In the post-flight report, White explained his actions at this time, with McDivitt reading off the EVA checklist. "I had to get back into the right-hand box and I unstowed items [from] there. The first time I went back in there I took the first items out, [but] I did not [plan] to unstow the full box." However, he found that everything was floating out anyway. Fortunately, in anticipation of this, each item had been attached to a lanyard. The intention was for him to remove the items one by one as he needed them when he pulled on the lanyard, leaving the rest in the stowage box until required, but this did not quite go to plan. "I pulled the whole lanyard out and the cockpit was full of little bags," he recalled. White said that he was really glad that he had listened to his trainers and accepted that the equipment should be attached to a lanyard, as he had originally thought not to use it on the mission. In the simulations it had seemed easier to work without it, but when he reached orbit it made sense. "I highly recommend that everybody keep that stuff on a lanyard," he advised **[** 1 **]**. McDivitt agreed that it would have been a lot messier if all these items had floated around. "It was bad enough as it was," he added. There were about ten of these little bags all tied onto one string, and the snap attachment on each made it easy to unstow and selectively pick out the items White wanted.

Next, he unpacked the long umbilical (the tether that would keep him attached to the spacecraft when he was outside) and that was where the problems really started. "I had a little difficulty," White explained. "It took me about three tries to get it out. It's [a] fairly big package to come through a small hole. It was a good thing that we had taken the Velcro off the hatch because there was no tendency for anything to hang up as we removed it. On the third try I got it out." McDivitt thought that his colleague had done a pretty good job and seemed to do it quicker than during training in Houston or down at the Cape. But White was it quicker than during training in Houston or down at the Cape. But White was not as convinced, recommending that nothing should be on the outside to stop the umbilical from coming out, as it was a really tough task in the confines of the spacecraft, even in zero-g.



Location of the umbilical connections in the spacecraft.

The 25-foot (7.62 m) umbilical/tether combination was the original version designed for Gemini. From this basic design, and the practical experience gained during Gemini 4, improvements were made to this version which were flown on Gemini 8 and Gemini 9 (these improvements will be discussed in those titles) and larger umbilicals were developed. Evaluations were also made of the stowage and attachment of the system. The spacecraft cabin re-pressurization outlet valve was modified to incorporate a quick-disconnect half that could be mated to the umbilical. Fortunately, little spacecraft modification was required, because the existing shut-off valve was used and its controls were already installed on the central console in the crew compartment. This meant that the attachment point for the oxygen umbilical was within easy reach of either astronaut. For the tether attachment, on Gemini 4 only, the raised inboard elbow restraint on White's seat proved to be an adequate and structurally sound attachment point. The umbilical was stowed for launch by coiling it in a figure-of-eight method, stowing it in a bag and placing the bag in the aft food box **[** 2 **]**.

Fortunately, they were easily able to keep track of most of the other items. The Ventilation Module chest pack had been stowed on the floor at White's feet and that came away from its stowage locks without difficulty. At this point, White thought they were in front of the checklist, which they were scheduled to start at GET 1:44 but had actually begun to work on at GET 1:35. However, as they progressed through the checklist and started putting things together for the EVA, they seemed to find themselves more rushed. White said after the flight that he remained confident that he could have gone through everything and hooked all the equipment up, having done it so many times in training, but he thought that trying to do so to the checklist actually slowed them down. As McDivitt later commented, "We set the procedure up so that when we finished with it, it would be right. I think this helter-skelter thing that we were involved in was for the birds. So as we got further along, it became apparent to me that the thing to do would be to stop."

White found no difficulty in connecting the 'Y' connectors, the hoses and the chest pack, nor in connecting the chest pack to his harness, commenting that the Velcro fastening helped with his movements to connect the inlet hoses to the EVA suit. Though he felt they had progressed and that they had completed every task, at the time he did not feel that it had all been done thoroughly, which was a concern to McDivitt as well. "When we got to Tananarive, I said that we were running late and that we would probably not do the EVA on this particular [orbit]. I knew that we had another [orbit] on which we could do it. It looked to me like we had all the stuff hooked up, but we hadn't really had a chance to check it. I also noticed that [Ed was] getting awfully hot. Starting to perspire a lot. I didn't like the way [he] looked." McDivitt informed Tananarive that they would not go ahead as originally planned, but would let them know at the next station if they were ready to depressurize.

Inside the spacecraft, White was also struggling to get the blood pressure equipment out as well as his EVA equipment, prompting the Flight Director to step in.

Grissom: *"Flight advises if you're busy we'll disregard the blood pressure* [reading]."

McDivitt: *"I wish you would."*

White: *"It was a wrestling match, but I won… be advised that [I] had [my] left glove off for stowage purposes. I've had it off for approximately fifteen minutes. This is standard faceplate OPEN position."*

The ground then gave an update regarding re-positioning the spacecraft at the start of the EVA, advising orientating it with the blunt end forward (BEF) and 180 degrees in roll, with White moving out from the spacecraft forwards to attain the optimum sun angles for photographic purposes. The two astronauts were told that they could configure the spacecraft in any attitude they liked, either hatch up (to space) or down (towards Earth) during the EVA. McDivitt acknowledged this, indicating, "*Boy is it crowded in here, Gus,*" to which the veteran astronaut back on the ground replied, "*I'll bet.*"

> PAO Haney: "The new elements for the spacecraft have resulted in maneuvering during the first [orbit] of 103 miles [165.7 km] perigee – that's statute miles – and 180 miles [289.6 km] apogee. White has been busy the last five minutes unstowing his extra-vehicular equipment and adjusting it, getting ready for the hatch opening. This is Gemini Control at one hour and 52 minutes into the flight."

Picking Up on the Next Pass

As Gemini 4 approached the west coastline of Africa, Ed White was busy progressing through a very detailed 40-point pre-EVA checklist, retrieving his gear from various stowage boxes, putting it all in place and relocating switches to the correct position. At just after two hours into the mission, White noted again that there was full daylight in McDivitt's window and full night in his. "*It looks very strange for me to look out Jim's side and see daylight and look out my side and it's just pitch black,*" he observed.

The crew reported that they could still see the spent booster, either because of its flashing beacon or through reflections from the sun giving away its position, about two or three miles from them. At GET 2:24, flying over Carnarvon, Australia, McDivitt indicated to Capcom Ed Fendell that they were behind in their preparations for the EVA.

McDivitt: “Listen, you might advise Flight by way of land lines that we’re running late on this thing [the EVA preparation]. There’s a lot to do and we’re having trouble keeping track of all this stuff.”

While both men were struggling to prepare for the EVA, the ground also asked for blood pressure readings, but McDivitt found that his pressure blub just “popped off,” adding to their frustrations.

Capcom: “Gemini 4, you are ‘GO’ for EVA and decompression. Disregard the blood pressure unless you’ve got a few minutes [to] *try and get it for us. We’d appreciate it.*”

“*We don’t have any time at all! We’re really pressed here,*” McDivitt shot back, concerned that Houston might not be aware of the predicament they were finding themselves in. “*Listen, has Houston been advised yet that we're running a little late and we might not be ready at Hawaii?*” On hearing this, Mission Director Chris Kraft told the Capcom that if the crew felt rushed at all on the flight plan, then they could hold off for one orbit and attempt the EVA next time around.

Capcom: “Okay… Houston advised that if you are unable to make it [this time], *take your evaluation and we’ll pick up on the next pass*.”

McDivitt: “Roger. Understand that. That’s what we want to get clear.”

Ed White, who was checking and rechecking that the faceplate on his EVA helmet was closed and locked, was naturally eager to go, but like McDivitt, he was erring on the side of caution. After the flight, he stated that he had the same feeling as McDivitt at this point; that it would be smart if they had another 20 minutes “to just sit real still” before he went out. With the benefit of hindsight, McDivitt reckoned that things might have gone well if they had progressed as originally planned, but at that point they had only completed about 80 percent of what they really needed to have done as far as checking was concerned. “I just didn’t feel that we were in the right shape, and neither did Ed,” McDivitt explained in the post-flight debriefing. “I could see Ed [but] he couldn’t see himself. Ed looked awfully hot, and he looked like he was getting a little pooped out from playing around with that big suit. I thought the best thing for his sake, and I knew he wouldn’t admit it, was to let him rest up for another orbit.” Post-flight, White agreed that it had been the right judgment call at the time.

White: “We have the cameras, the gun and all the equipment assembled. We’re completing the final suit checks and I believe we’ll be ready to go.”

McDivitt: “Next pass around. I don’t think we want to try it.”

Capcom: “Roger. Understand, next pass around… We’re happy with that…”

McDivitt: “That’s what we’re doing right now. We just couldn’t quite hack it.”

Inside Gemini 4, as Hawaii dropped out of communications, McDivitt and White rested, taking a welcome break in the flight plan to allow them to finish their preparations and checks for the EVA and to chat about their activities and maneuvers with the Titan booster.

> PAO Haney: “This is Gemini Control, Houston. Jim McDivitt has apparently decided that things were a bit of a rush and has elected to wait until the next pass around in order to attempt the extra-vehicular activity. The first indication we had of this was a cabin pressure reading on the ground which still showed something over five pounds [0.345 bar] of cabin pressure. Within a second of that, Jim McDivitt’s voice came up on the loop and he said that they had decided to wait until the next [orbit]. Apparently, all the connections and the unstowing of articles got a little hectic there over Carnarvon. We did note that Ed White was working awfully hard to get all of his connections strapped on. The feeling here was that if they so [decided], they could certainly wait another [orbit] and they have taken that choice. The spacecraft at this time is some 700 to 800 miles [1,126 to 1,287 km] southeast of Hawaii, proceeding towards the United States. I want to reaffirm that the status aboard appears to be excellent at this time. Two hours and 53 minutes into the mission. This is Gemini Control, Houston.”

As the three-hour mark of the mission slipped by, Houston Capcom Grissom reminded the two astronauts that they were going to be on a live microphone as they flew over the United States. In other words, they needed to be careful about their choice of words, as the whole world would be listening. This did little to help alleviate the stress of the upcoming spacewalk. McDivitt simply acknowledged the call, however, and asked if there was anything the ground wanted them to say for the global audience, to which Grissom replied, “*Suit yourself.*” A few minutes later, Grissom told McDivitt that he had done a “*smart thing*” in deciding to terminate the rendezvous with the booster and conserve the onboard fuel supplies.

McDivitt: "Yes, Gus. It would have been a short flight if we'd kept chasing that mother around."

Grissom: "Yes. Sounds like you've been awfully busy the first couple of orbits."

McDivitt: "It would have been impossible. We would never have done the EVA at all. We're finally getting a chance to look out [the windows] *here, Gus, and its really nice."*

With Gemini 4 now flying over America, Grissom asked McDivitt to describe the way the cockpit was laid out with all the EVA gear unstowed.

McDivitt: "Okay. Well, we've got to the get-out position here, and when we finally called it quits it was quite obvious that we weren't going to make it that time without really rushing. I didn't want to do that. Ed has most of his equipment on him right now. I've got the gun and the camera and the hatch fittings to tie the two suit hoses together. Ed has all the other paraphernalia on him right now, but he's on suit circuit. He's got the REPRESS valve OFF and we're just about all set to go. I think when we get over Africa we are going to go through the check list again, and when we get to Carnarvon well be all set."

Grissom: "Have you taken any pictures yet?

McDivitt: "No. As a matter of fact, we really have not had time to do much… It's a nice spacecraft though, Gus."

As they flew over the southern continental United States, McDivitt noted that it looked like they were flying over Texas, which Grissom confirmed as "*The Big 'T'*." Then they were over the Gulf of Mexico. During these exchanges, White had been very quiet as he was busily preparing for the EVA; so quiet, in fact, that Grissom asked if he was still there and whether he had got pretty heated up with all the EVA gear on.

McDivitt: "Yes. He doesn't like to talk, I guess."

White: "I'm sitting here enjoying the view. I got… we got pretty warm."

White said that he felt "*pretty fine now*," after resting, and was now observing Florida out of his window.

White: "We've got quite a good view of the whole State of Florida, and we're *passing over it now. We can see it from top to bottom. In fact, we're looking down at the Cape now.* [I] *can see the launch complexes down there. It quite clear.*"

As Gemini 4 continued on its journey over the Atlantic, the two men went through the EVA checklist once more, reviewing what steps they were to make prior to exit. There was no voice contact over Bermuda, only good solid telemetry, as the previous voice contact with that station had proven a little noisy.

"*When we actually start the depressurization modem,*" McDivitt recorded on the onboard tape as he chatted to White about the procedures they were to follow, "*Cabin Vent valve goes to 2 psi, and then we close the vent valve. Then we install both blood pressure pump plugs, which I don't seem to be able to find*." Investigating this, nether astronaut could find the plugs on their suits despite a thorough search.

White: "*Aw, baloney. Neither of our suits have the blood pressure plug*."

After the flight, McDivitt expanded upon the problem they had discovered with regard to the blood pressure check. "We depressurized the cabin and got down to 2 psi to check our blood pressure. We tried to put our blood pressure plugs in the blood pressure plug port and found that we didn't have any blood pressure plugs on either suit. This was quite a surprise – an unpleasant one, I might add. Well, we decided that from our past experience and our knowledge of the suit that even if we did spring a leak in the blood pressure cuff, the size of the hole that we had in the suit would not be catastrophic, and we decided to go ahead with the EVA."

McDivitt: "*Just a casual comment here* [to Capcom and the onboard tape recorder]. *We looked out and thought we saw the horizon. It turned out it was obviously air glow. We could see the stars well below its edge. We'll talk about this some more later when we've got more time*."

Going for "EEE…VEE…AAA"

By now, White had noted a familiar pulsing in the suits when they had the RE-CIRCUIT closed all the way down and the dampers open fully in both suits, commenting that he had experienced the same phenomena in the altitude chamber and during testing. As the mission's four-hour mark came up, the communications passed to Carnarvon, who asked the astronauts about their status on EVA. McDivitt informed the ground that this time they were "*GO for EVA.*"

With this, McDivitt received the authority both to depressurize the spacecraft and to proceed to open the hatch, an instruction that they were not supposed to get until they were over Hawaii. During the post-flight debriefing, White commented on the fact that they had then remained depressurized for almost a full orbit. "I don't think people quite realize that," he noted. McDivitt added that he would "remind them" of the fact.

Capcom: [GET 03:58:39] "*OK. You're 'GO' for EVA, Stand by for depressurization.*"

McDivitt: "*The status is 'GO' for EVA.*"

White: "*The cabin appears to be venting at about 5.3. Just heard the vent valve going… for Eee…Vee…Aaa.*"

After White's enthusiastic outburst, while they were still in communication with Carnarvon, they received the 'GO' for depressurization and the spacewalk, whereupon McDivitt asked Capcom to call again when they reached Hawaii, as they were busy.

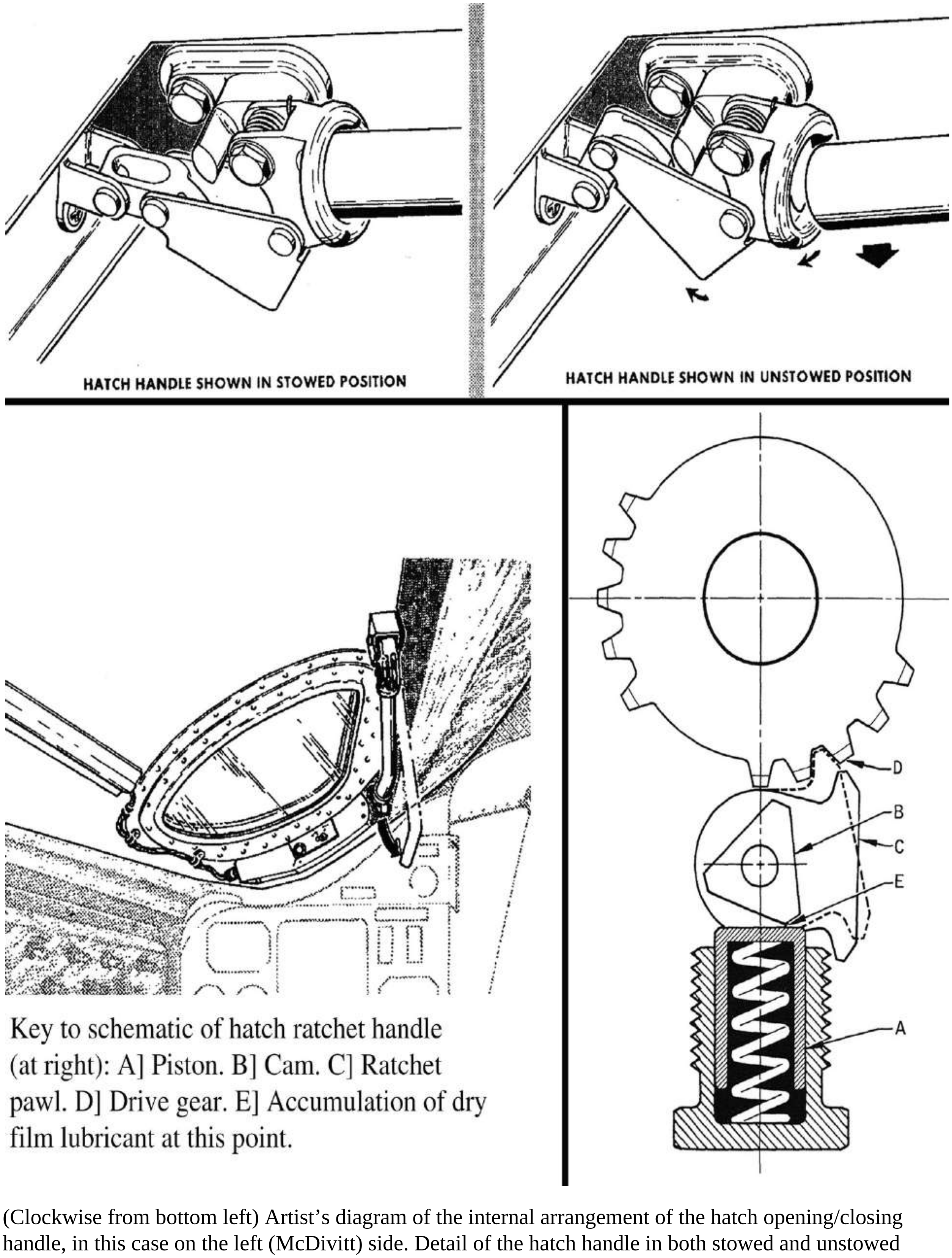
Capcom: "*I'll be standing by here on the ground and keep the conversation down*."

The conversation was not the only thing that went down; so did the cabin pressure, with White reporting that the hatch locks were "*open*."

White: "*Roger. We're in a vacuum now but the right suit* [meaning his, as he was occupying the right-hand seat] *is holding at 4 and the flow is satisfactory. I'm not overly warm.*"

McDivitt: "*Okay, we've got the cabin vent valve open… cabin at zero. Time to unlock the hatch.*"

White: "*Roger. Time to unlock the hatch.*"



(Clockwise from bottom left) Artist's diagram of the internal arrangement of the hatch opening/closing handle, in this case on the left (McDivitt) side. Detail of the hatch handle in both stowed and unstowed position. Schematic of the hatch latching ratchet.

At this point, White hit a snag, as the hatch refused to budge. He reminded McDivitt that this was why he had had his thermal gloves made removable, so that he could take them off to work better in his pressure gloves. Despite recycling the locks three times, however, the hatch still refused to budge. McDivitt was not too concerned over this, as they could try on the next orbit or even the next day, but he was worried about the visibility White had, or rather did not have, through his EVA visor in the darkened spacecraft. As his pilot rested, McDivitt observed: "*You know, it's a good thing we cannot get it open and not closed,*" little realizing that these words would come back to haunt him in less than 30 minutes.

Recalling the issue with the hatch mechanism after the flight, McDivitt stated that the gain gear, or the ratchet as he preferred to call it, did not want to engage into the UNLOCK position. "We fooled around with it a few times and it finally engaged in the UNLOCK position, and Ed was able to go ahead and start."

"The first indication of trouble was when I unstowed the handle to open the hatch," explained White after the mission. "The handle freely moved up and down with no tension on it at all. I knew right away where the trouble was. It was up in that little spring on the gain pawl." McDivitt remembered that the hatch had failed in a similar way during tests at McDonnell. He knew that it was a spring that had to be pushed back and advised White to do the opening under manual control, then to be sure to relock it again. As McDivitt rolled the spacecraft to the orientation where he wanted it, White heaved on the hatch to try and finally open it.

"So I went up and manipulated it back and forth in the hope that I could break the lubrication loose in the spring to get it to work," recalled White. "We must have spent several minutes with the hatch." He could ratchet it open, but the hatch itself would not budge, so it became apparent that the problem lay with the pawl. White jimmied it back and forth and then decided to try the hatch handle, bypassing the operation of the spring by mechanically moving the gain pawl up and down, replicating the work the spring was supposed to do. This was the first time they had tried this wearing a suit and under near-vacuum conditions. In his post-flight debriefing, White explained "It requires you to press up with your left arm to get at the gain pawl, and at the same time to hold yourself down. I felt it start to engage and start to ratchet the lugs out. Jim also verified that they were coming open. I backed them off, and at that time it popped."

McDivitt: "*Oops! Not too fast!*"

The hatch suddenly popped open, jumping up three or four inches (76–100 cm). “I was expecting the hatch to come open with a ‘bang’,” McDivitt recalled, speaking metaphorically, as there would have been no ‘bang’ to hear. “Although we had the cabin to VENT and it had bled down to where there was nothing registered on the Cabin Pressure gauge, we still really had the REPRESS valve on. [It] was bleeding right into the spacecraft. We never got down to a [pure] vacuum and even though we only had a cabin pressure of only a tenth of a psi, we spread it over the entire area of that hatch, and that puts a pretty door-sized face on it. I had a real tight hold of the hatch closing device, and when it popped I was able to snub it. [When] it popped I couldn’t stop it the first inch or so. Then of course, as soon as it opened, that much pressure bled off. I just snubbed the thing to stop it from flying all the way open.” McDivitt estimated that even if he had not been restricting the opening, the hatch would not have opened more than two or three feet. White thought there was more force on the hatch actuator than he expected. “I had to actually forcibly push it open,” he recalled, “similar to the force [with] which I opened the hatch lying on my back under 1-*g* [simulation]. That’s about the force that I had to [put] on the hatch to open it.

White: “*What a view! By golly. You can see the black sky up above… Door’s a little harder to move than I thought… It sure is clear and crystal smooth*.”

White then wanted to get his head and shoulders out to install the cameras, wishing that he had asked for Velcro to assist him in securing them outside. Even with his visor down, the sun was very strong and he was having to turn away, so that he noticed the thruster firings and began taking pictures. He asked McDivitt if he [White] had inadvertently hit any of the switches on the instrument panel on the way out. “*Yes, you were really all over them Ed,*” McDivitt replied.

As only the second man in history to leave his craft in orbit, White was suddenly able to relate to his predecessor, Soviet cosmonaut Alexei Leonov, the world’s first spacewalker, and clearly understood that while their activities might have seemed basic in comparison to the images of EVA construction workers in science journals of the 1950s, these were the first two times that anything like this had occurred, so caution was the byword.

White: “*Got plenty of time, Boy, Oh Boy! Oh Boy…*”

McDivitt: “*Pretty neat, huh?*”

White: “*Yes, it’s something… As Ol’* [cosmonaut Alexei] *Leonov says. I’m* *doing some work out in space. It isn't very much but I'm doing something*."

McDivitt: "*Pretty black out there, isn't it?*"

White: "*Yes.*"

McDivitt noted the reaction of the spacecraft, because White's motions outside also moved Gemini 4 as they carefully fed out the umbilical while trying not snag the switches.

> PAO Haney: "This is Gemini Control. Four hours and 24 minutes into the mission. We have been advised by Flight Dynamics that the second stage booster is approximately 65 miles [104 km] in front of the spacecraft and about three miles [4.8 km] below it. It is not known whether the Pilot or the Command Pilot will be able to see it."

Standing on the Seat

As Hawaii came into communications range, the Capcom asked how things were going, to which McDivitt replied "[He's] *Got the outside 60-mm camera mounted and he's getting the gun ready right now*." On the ground, the controllers were also checking to see if it was safe to proceed for a full spacecraft exit, with the Flight Surgeon (Charles Berry) having a direct input into the decision. He was monitoring the status of both astronauts, but predominantly White, and was talking directly to the Flight Director on the controllers' loop:

Surgeon: "*Roger Flight, we're 'GO!' He's [White] got some nice elevated* [heart and breathing] *rates which we expected and he's really speeded it up, but he looks great. Let's go.*"

Satisfied with this report, the Flight Director informed the Capcom out at Hawaii. "*Hawaii, Houston… Tell him we're ready to have him get out when he is.*" The Hawaii Capcom (A. Davis) contacted the spacecraft.

Hawaii Capcom: "*Gemini 4, Hawaii Capcom. We just had word from Houston we're ready to have you get out whenever you're ready. Give us a mark when you egress the spacecraft.*"

White: "[I'm] *Outside the spacecraft as a matter of fact.*"

McDivitt: "*Roger, he has the hatch open. He's standing in the seat*."

White proceeded to mount the external bracket and 16-mm sequence camera at the back of the hatch near the forward part of the Adapter, to obtain the widest field of view, and installed the umbilical guard (to protect the umbilical from wear as it rubbed on the edge of the open hatch) on the edge of the door, observing that they worked well but already thinking of improvements in systems or procedures for future excursions, such as a better engaging device when working in a pressurized suit. White found that the umbilical guard took a little longer to install than he had thought. Although he had taken off his thermal gloves to work on the hatch opening mechanism, he did not feel the need to put them back on as he had not noted any extremes in temperature. He quickly decided to put the EVA equipment in place wearing his plain pressure suit gloves, as they gave him much more ‘feel’ than the thermal over-gloves he had been provided with. This decision was an early indication of the challenges of working in gloves under pressurized conditions, a task which remains difficult even now, over fifty years later. In fixing the umbilical guard, it took White four or five tries to secure the lugs which locked it on to the hatchway door. He then noted that the secured umbilical storage bag had floated up and out of the spacecraft. Rather than disconnect the umbilical to push the bag back down, he left it there because he did not want to disconnect the attachment cord. With the bag no longer floating right in front of him, McDivitt also had a better view of White’s EVA operations. White then reported to McDivitt that he was finally ready to exit the spacecraft fully.

Having managed to get the hatch open early, White found that he had a little extra time available. He had planned to take a few short sequences of pictures of the egress out of the hatch, so with the EVA camera recording, he lowered himself back down again and then came out a second time to capture the process for post-flight analysis. That done, he took a short sequence of images showing him putting one of the thermal gloves back on, again for later post-flight analysis.

With the ‘GO’ for EVA confirmed by the Capcom at Hawaii, White actually delayed the time that he physically left the spacecraft so that he could activate the camera on the outside and make sure it was running. By this time, White was working quite hard on his tasks and McDivitt told him to slow down a little.

The plan was to have White place a finger in one of the nozzles of an RCS thruster as a makeshift fingerhold to help him float out of the spacecraft, but those planning the action, prior to the flight of course, had no real experience or evidence of actually doing it in space. Instead, White and McDivitt had decided what they were going to do before the flight, as White was not convinced that the planned method of exit would have worked. Unable to grasp the gun, put a finger in the RCS nozzle *and* hold the hatch at the same time, White had instead decided to depart the spacecraft with no velocity other than that imparted by the hand-held maneuvering unit (HHMU), which is what he did. When he fired the gun the first time, he was unsure if his legs were still inside the hatchway, so he pulled himself out until he could see that his legs were clear (which was confirmed by McDivitt) and without imparting any input into the spacecraft as he left. McDivitt commented later that he had left Gemini 4 "as clean as a whistle."

White: [GET 04:30:26] "*Okay, I' m separating from the spacecraft… my feet are out.*"

McDivitt: "*Okay, he's separating from the spacecraft at this time, Hawaii.*"

White: "*I think I'm dragging at little, so I don't want to fire the gun yet… Okay, I'm out.*"

McDivitt: [GET 04:30:38] "Okay*, He's out! He's floating free!*"

McDivitt: "*Oops! There goes your* [thermal] *glove. Well, we'll just let it go*."

White: "*Okay. I rolled off and I'm rolling to the right now. Under my own influence…It really looks funny to see my glove out there, Jim.*" [as the unrestrained glove twisted out of the hatch and away from them].


A still from the 16-mm film, taken at the start of White's EVA [Courtesy Ed Hengeveld].

Feeling Like a Million Dollars

"I left [the spacecraft] entirely under the influence of the gun, and it carried me straight out, a little higher than I wanted to go," White explained after the flight. He had wanted to move over to McDivitt's side so that he could be seen by the Command Pilot. When he was about a half, to two-thirds out on the tether, he passed the nose of Gemini and fired the gun to move himself to the left, reporting that the device worked really well. As he subsequently came back towards the spacecraft, he found that he was tumbling in a combination of pitch, yaw and roll, but elected not to correct it by using the gun in order to save its limited fuel. Instead, he tugged on the umbilical, later commenting "This [was] the first experience I had with tether dynamics and it brought me right back to where I did not want to be," which was on the top of the spacecraft by the

Adapter Section. McDivitt suddenly called out, concerned that he could not see his colleague, who was supposed to remain in full view of the Command Pilot at all times for safety, but White replied that he was fine. “I could see the attitude thrusters firing, a little white puff out of each one. I wasn’t very close.” The firings looked exactly like he had been told they would, about 18 inches (45 cm) or more of plume from the spacecraft but certainly not ominous. “In fact, it looked like the spacecraft was really alive and working down there. I knew Jim was doing his job holding attitude for me,” he recalled.

White: *“I can spin around now… I feel like a million dollars. All right, we’ll pitch up and yaw left. I’m coming back to you.”*

McDivitt: *“Okay, just a second. You’re right in front, Ed. You look beautiful.”*

Grissom: *“Gemini 4, Houston Capcom.”*

Down in Mission Control Houston, Gus Grissom put in his first call to the spacecraft to try to get their attention at GET 04:32:16, and had to repeat the same call five more times over the next minute before McDivitt finally answered him.

Keeping Gemini in Attitude Hold

At the start of the EVA, Gemini was in the BEF (Blunt End Forward) attitude, banked about thirty degrees to the left for the most appropriate sun angle. The plan was to have the hatch opening towards Earth, and although ground control had told McDivitt that it did not matter which attitude they were in, that was indeed the way they were oriented when the hatch was finally opened. For the first part of the EVA, McDivitt held the attitude essentially stationary with respect to the local horizontal, and he felt that unless White wanted the spacecraft stabilized to maintain a sense of balance, he would not fire the thrusters. As White moved back above the spacecraft and behind the hatch area, where the Command Pilot could not see him, McDivitt decided that it would be a lot safer not to fire the thrusters at all, unless the spacecraft’s rate of tumbling increased. He decided to let Gemini drift, so that White would not be on top of a thruster when it fired. Once the Pilot was clear, he was able to initiate small firings to trim the tumble rates as they increased, but it was a tricky operation requiring his full attention, as he was not sure which way White would tumble on the end of the umbilical.

White: *“The gun works real great Jim… I’ll come in and take a look at you* *now… this gun is very good.*”

McDivitt: “*Who’s calling Gemini 4?*”

Grissom: [GET 04:33:20] “*Gemini 4, Houston Capcom. Has he egressed?*”

McDivitt: “*He’s out Gus and it’s really nifty. Listen, our VOX doesn’t work very well, and I don’t seem to read anybody. [I] will have to relay. The gun works swell. He’s been able to maneuver back over the front, back under the nose, and he’s back out again.*”

Grissom: “*That’s great!*”

Clearly, they were to have trouble hearing the ground throughout the EVA, as VOX communications kept dropping in and out.

Interestingly, when McDivitt was asked in 2005 about his own feelings on seeing White floating outside, he said he was rather relaxed about it. It was “… nothing special. That was part of the mission, so I was taking some pictures of him and it wasn’t a big deal… I didn’t really have any big thought [such as wishing he was outside]. No, it wasn’t a big deal, not for me anyway.” He could not recall a special surge of emotion when Ed stepped out, they had practiced the event so many times in various ways, and there was so much more serious work to do after the EVA. Shortly after the flight, he had commented “Frankly, when Ed first opened his hatch and we were both at the mercy of the vacuum, my strongest impression was simply that now we had a bigger window and a better view.” Neither of them felt any major sense of danger, but they were fully aware of the remote possibly of equipment failure, though they had faith in the equipment and their procedures, with very few alternatives to fall back on. McDivitt was convinced that “unless something happened to my suit, I’d be able to get Ed back in” **[** 3 **]**.

After White had returned to the vicinity of the spacecraft the first time, he decided to go back out again. He reported post-flight that “this is one of the most impressive uses of the gun that I had. I decided that I would fire a pretty good burst. And I literally flew with the gun along the edge of the spacecraft, right out to the front of the nose and out past the end. Then I stopped myself with the gun. It was easier than I thought.” He had decided not to take pictures while maneuvering with the gun, as this would have been more difficult, but during drifting flight he was able to snap a couple of images.

White: “*I’ve drifted off to the side… I’m taking pictures now, Jim.*”

McDivitt: “*Make that flag* [referring the Stars and Stripes on White’s suit] *look pretty… I ought to be getting some tremendous pictures of you. Let me try again with the Hasselblad*."

White: [GET 04:34:31] "*Okay. I think I've exhausted my air now*."

White had fired the gun through the line of his center of gravity, trying a few moves in yaw and pitch. He was able to stop his movement with the gun, and that was when the gun ran out of fuel. He had found that the best way of utilizing the gun had been to fire short, one-second bursts, noting that the results were "tremendous… [a] rather efficient way to operate." He would have preferred a larger bottle of gas, of course, "The bigger the better," he reported. Having found that it was quite easy to control the gun, he surmised that if he had had more fuel, it would have been possible to move back to the aft end of the spacecraft. He had actually done this on the EVA by pulling on the umbilical tether.

White had developed the technique on the air-bearing tables during training and found that it was very representative on the actual EVA, especially in yaw and pitch. He stretched his empty left hand out to the side and held the gun in his right hand, as close to his center of gravity as he could. He commented that he felt very confident using the gun in pitch and yaw, but less so in roll, as that used up too much of his limited fuel and it was difficult to control and stop the roll. They had planned for about four minutes of maneuvering with the gun and when its fuel was exhausted he would use the tether. During the flight, the astronauts estimated that White had indeed used a little more than four minutes on the gun.

McDivitt: "*Okay Ed. They're* [Mission Control] *receiving you…tell them what you think.*"

White: [to Grissom at the Capcom console] "*It's very easy to maneuver with the gun. The only problem I have is that I haven't got enough fuel. I've exhausted the fuel now and I was able to maneuver myself around the front of the spacecraft, back, and maneuver right up to the top of the Adapter. Just about came back into Jim's view. The only thing I wish is that I had more* [fuel]. *This is the greatest experience… it's just tremendous! Right now I'm standing on my head* [metaphorically], *and I'm looking right down, and it looks like were coming up on the coast of California. I'm going into a slow rotation to the right. There is absolutely no disorientation associated with it.*"

McDivitt: "*One thing. When Ed gets out there and starts wiggling around, it sure makes the spacecraft tough to control*." [noting the effects of White's movement on the umbilical connected to the spacecraft, and his efforts to keep

Gemini 4 stabilized]

With the gun out of fuel, this was when White began to have difficulties in controlling his movements. Using the gun, he was confident in his ability to move to a particular section of the spacecraft, but on the tether alone it was not so easy. During this time, McDivitt avoided executing much attitude control maneuvering. White later wished that he had taken the camera off the gun once it ran out of fuel and had handed the maneuvering system back to McDivitt, but he did not. As he tried to take pictures, he found himself battling with the tether dynamics, finding that the tether was mounted on a plane oblique to the angle he wanted to move in. White remembered from his training on the air-bearing device that when he was at an angle from the perpendicular where the tether was mounted, it followed an arching trajectory back in the opposite direction, like a weight on a string. Recalling this experience when he pushed out in one direction, it nearly sent him on a long arc back in the opposite direction upon reaching the end of the tether.

When his trajectory carried him back to the Adapter Section of Gemini 4, he told McDivitt not to fire the thrusters any more as he closed in, as he was less than 18 inches (45 cm) from them. He had already observed earlier that this was about the length of a thruster plume when it did fire and he noted post-flight that, quite naturally, "I didn't want to sit on a firing thruster." He estimated after the flight that he had spent about 70 percent of his time trying to get away from the thruster area at the back of the Adapter. Chris Kraft had clearly told White to stay out of that area and he had agreed to do so, but now here he was inadvertently lingering there. "I was doing my level best to keep out, but the tether dynamics just put me back there all the time," he said.

Thankful for the Experience

Back on the ground, Mission Control was eager to encourage the astronaut to capture the moment on film, as live TV was not yet possible from Gemini – as it would be on Apollo – and the few images that had been released from Leonov's spacewalk had been grainy. This was not merely to provide some good publicity shots for the media or the public. There was a serious objective behind the request for post-flight evaluation of the EVA, so that they could work on further planning and training to determine where improvements could be made or difficulties averted.

Grissom: "*Is he taking pictures? Take some pictures.*"

White:

White: “*Okay, I’m going to work on getting some pictures, Jim.*”

McDivitt: “*Okay. Get in front where I can see you again… I’ve only about three* [images] *on the Hasselblad.*”

Grissom: [Reminding the crew of the planned EVA time remaining] “*You’ve got about five minutes*.”

White: “*But I want to get out and shoot some good pictures. I’m not satisfied with that. Okay, I’m drifting down underneath the spacecraft*.”

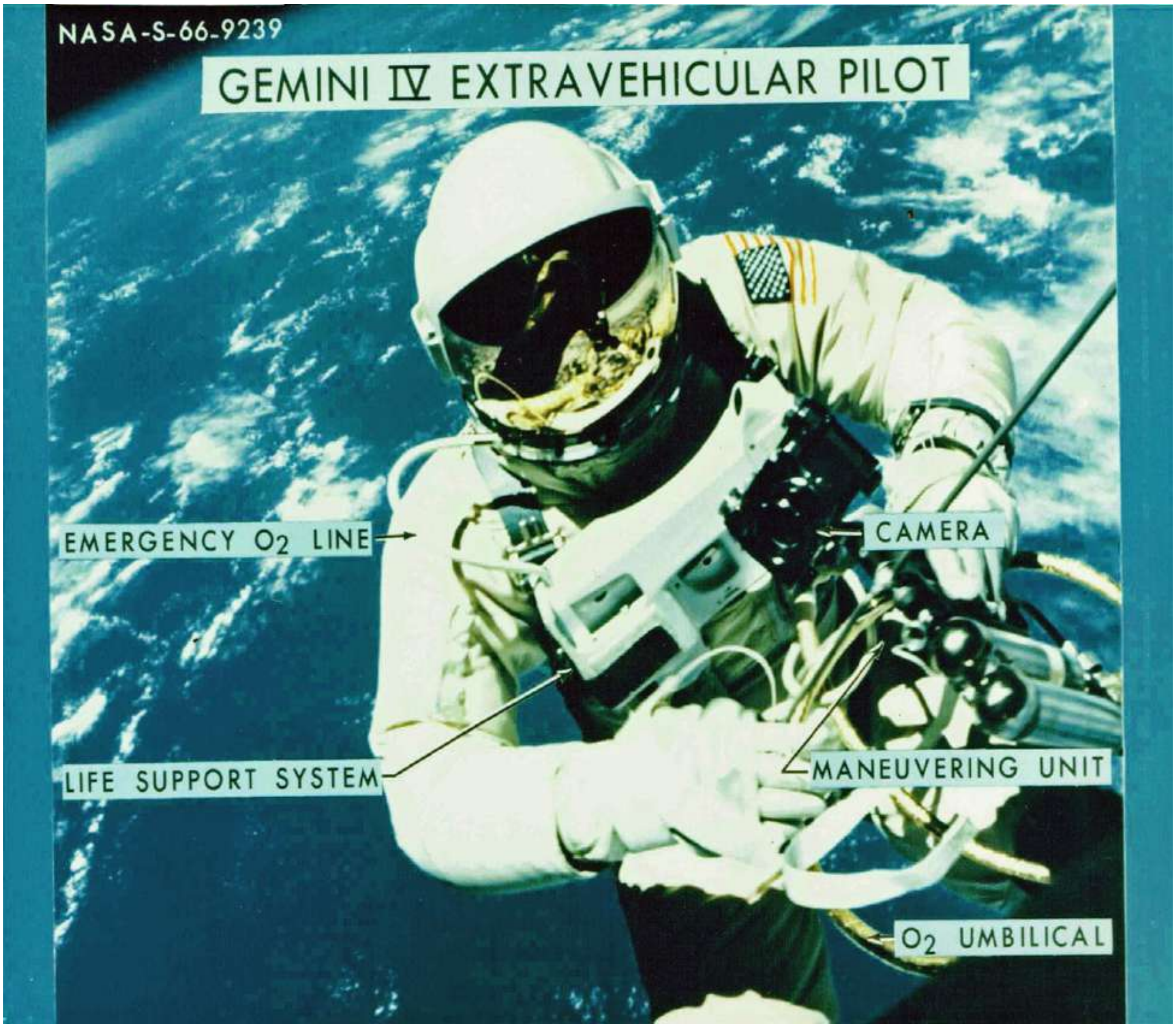
McDivitt: “*Okay, I’m going to start firing the thrusters now*.”

McDivitt explained after the flight that they had decided that the control mode of the spacecraft should be set to PULSE MODE rather than the HORIZON SCAN MODE. In the latter mode, McDivitt would have been free to use both hands to take pictures of White but would not have had control of the spacecraft and, as it would have been in AUTOMATIC MODE, it would have fired the thrusters whenever the system deemed it necessary. With no flexibility in this mode, McDivitt opted for PULSE MODE instead, so that he would not have to worry about a thruster firing when White was directly over it.

White: “*All right. There’s no difficulty in re-contacting the spacecraft. It’s all very soft, particularly as long as you move nice and slow. I’m very thankful to have the experience. It’s great Gus. Right now I’m right on top of the spacecraft – just above Jim’s window… Right now I could maneuver much better if I didn’t have the gun with the camera on it, because I have to tie one hand up… What I’d like to do is get all the way out, Jim, and get a picture of the whole spacecraft. I don’t seem to be* [capable of] *doing that.*”

McDivitt: “*Yes, I noticed that. You can’t seem to get far enough away.*”

One of the many famous views of Ed White during the EVA, taken by Jim McDivitt from within the spacecraft, which have gone on to become icons of the early space program.



Detail of the EVA equipment used by White on his spacewalk.

The images that were taken covered a wide spectrum, including different views of Earth and the horizon, and of the EVA with Earth in the background (see sidebar: *Gemini 4 EVA Photography*). In one of the images, taken while he was three to four feet from the rear of the Adapter Section, White snapped a picture showing the rather jagged separation area that had been connected to the upper stage of Titan during the launch a few hours earlier, and which now looked to have sharp edges. This gave an early indication that there might be a potential hazard on later flights, as this was where the Astronaut Maneuvering Unit was going to be located, in the aft Adapter Section at the very rear of the spacecraft. On this first venture outside Gemini, Ed White did not go all the way round to the back, although he estimated that he could have done. “I felt that if I got going, I could have swung all the way around and had my umbilical right on the [rough] edge, without anything to hold onto or any gun to control myself. They [the rough edges] didn't seem at all safe. And I had told Chris [Kraft] that I wouldn't go behind the craft. So I didn't go back there."

White: *"Okay, now I'm taking a look back at the Adapter and equipment back there. I can see the separation plane; it's quite clean* [strangely not commenting on the rough edge, as he would during post-flight debriefings]. *The thrusters are clean. The thermal paint, the thermal stripping looks quite good. Also, the Velcro that we put on seems to be in good shape right by the camera. I'm coming back down on the spacecraft. I can sit up here and see the whole California coast… the sky sure is black. Let me work back* [towards McDivitt's window]. *It's all the difference in the world without this gun. When that gun was working, I was maneuvering all around… Boy, I sure could use that gun.*"

McDivitt: *"A pretty neat little contraption, huh?*"

Now two thirds through the planned EVA, White maneuvered once again to take some pictures, imparting force to get away from the spacecraft and into a position where he could take a picture of as much of Gemini 4 as he could. Yet each time he tried, he seemed to be 180 degrees away from the spacecraft, with what he described as "beautiful views of the ground," but could not see Gemini 4. He realized that it had been a mistake to leave the camera installed on the gun, as it made it difficult to use, finding that he not only had to point the camera, but also the gun with its long thruster arms as well. Realizing the importance of such an image, he did not want to take a picture of Gemini 4 with a lot of clutter in the field of view, such as the tie-down strap.

Gemini 4 EVA Photography

It is surprising how areas of research suddenly spring from a comment or observation made by others. In the correspondence section of the May 1983 edition of the British Interplanetary Society magazine *Spaceflight*, a reader asked about the publication of images taken by Ed White using the 35-mm camera mounted on the HHMU, as they were "historically important: the first photographs taken by an astronaut outside his spacecraft"**[** 4 **]**. In replying, the editor stated that "after a little research, the Johnson Space Center confirmed that their photographic lab processed the film. However, no prints were ever released because they were blurred or with the side of the spacecraft filling the frame. They were simply too poor to publish." Follow-up correspondence later noted that at least one of the images had appeared in

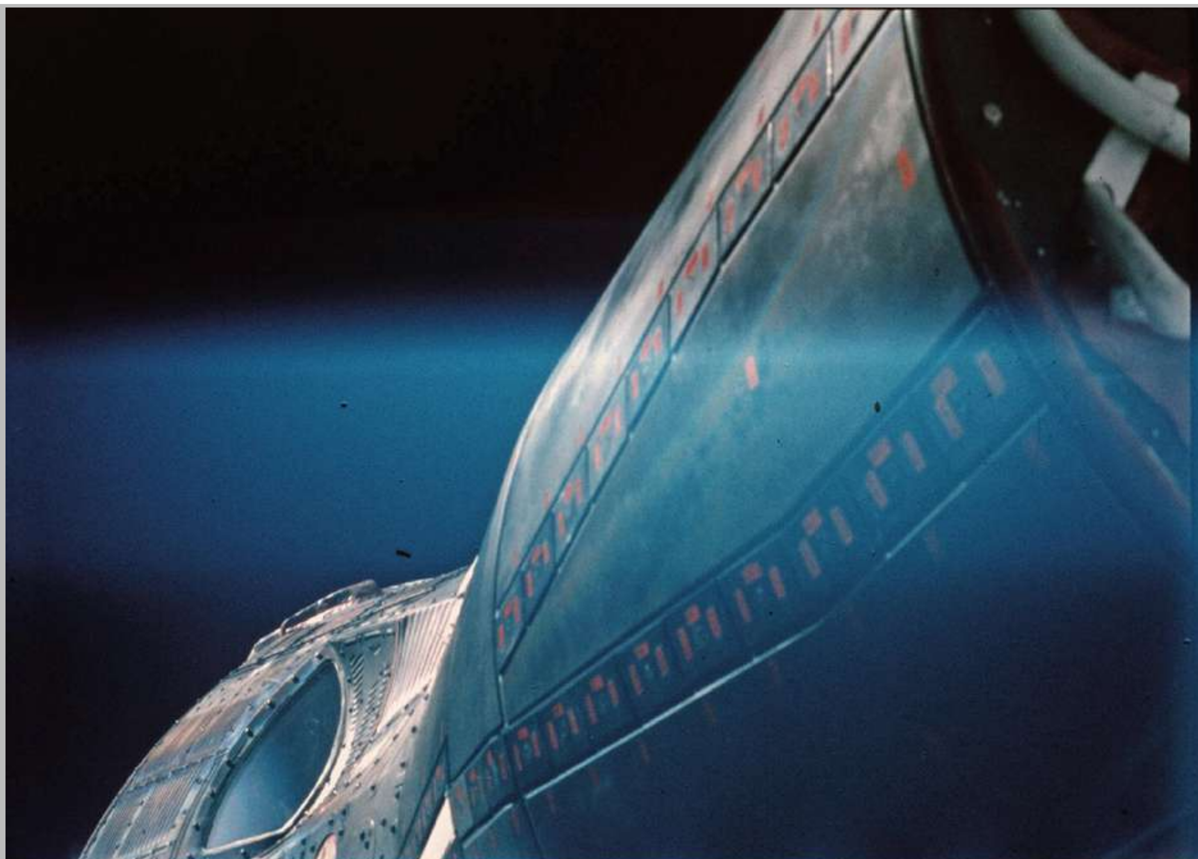
Gemini, America's Historic Walk in Space, published by UPI in 1965, while another had appeared in the NASA film *The Four Days of Gemini 4.* This question gave rise to some in-depth research in the UK by H.J.P Arnold of Space Frontiers Ltd., culminating in an excellent article on the subject which was published in the May 1984 issue of the journal of the BIS **[** 5 **]**.

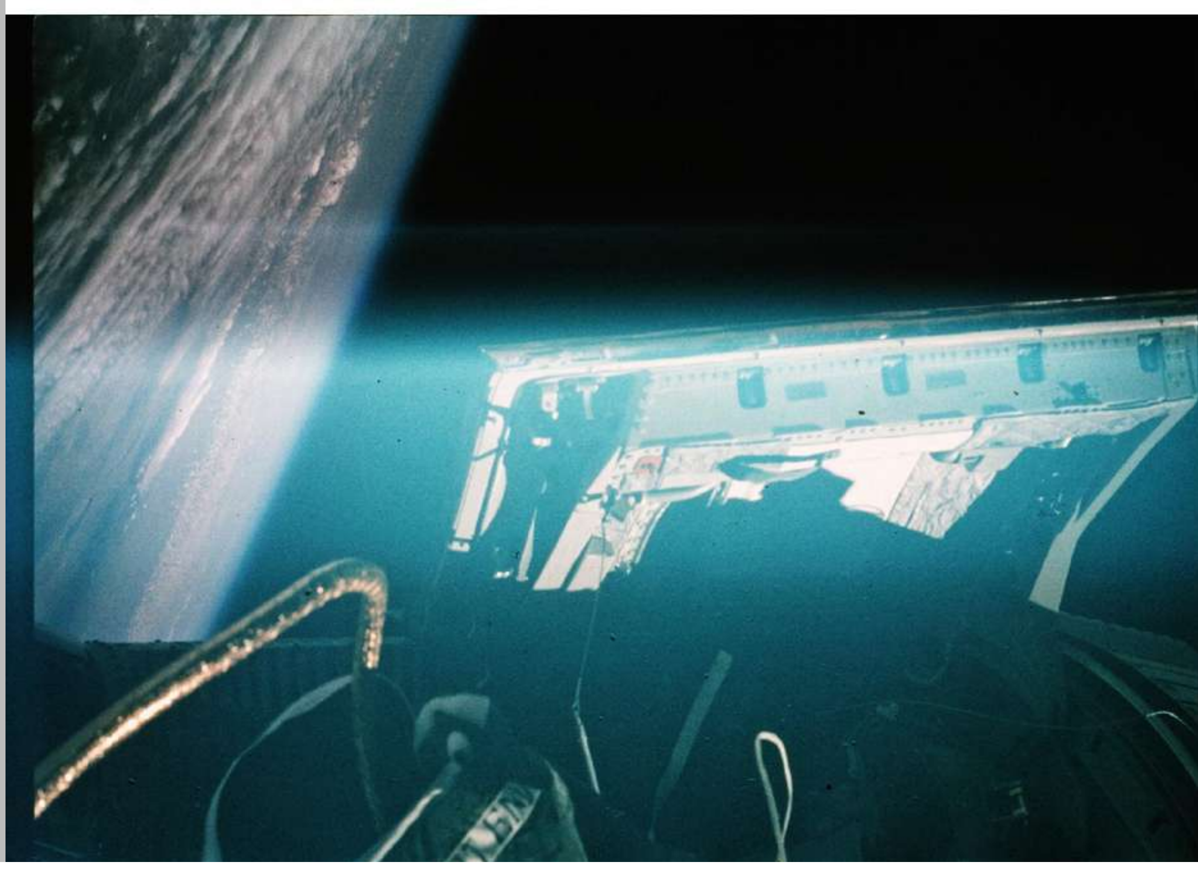
Having discovered that at least one of the images had been published, Arnold investigated why these images had not been released and what the subject was of those frames which were exposed. The majority of the sixteen 70-mm frames exposed by Jim McDivitt using his modified Hasselblad 500C camera became iconic images of the space program shortly after they were released, together with the footage taken on the McDonnell 16-mm movie camera. Conversely, little attention had been paid to the photographs taken by Ed White during his EVA using the Zeiss Ikon Contarex Special 35-mm single lens reflex camera.

Once the decision had been made to conduct the EVA with the assistance of the HHMU, the idea was raised of attaching a camera to the maneuvering unit. This was later attributed to Dr. Robert Gilruth, then Director of the MSC. The reasoning was that the images taken could capture a visual engineering record of the condition of Gemini 4's exterior after launch and, for the first time, could provide views of a manned vehicle in space that were newsworthy enough to release. The main challenge was to have the camera attached to the HHMU, as White would be unable to operate the hand unit and the camera at the same time. The camera actually came from the USAF, which had purchased it to support the photography experiments originally scheduled for Gemini 4 that had been reassigned to Gemini 5 when the EVA had been added to the earlier mission. To allow White to use the camera during EVA, it was modified by increasing the size of the film winding lever and shutter release button to enable the astronaut to use it while wearing the bulky pressurized EVA gloves. Another change was the removal of the viewfinder, as White was unable to put the camera against his eye or use a waist-level viewfinder. The film chosen was Ansco D-200 transparency color at a fixed 'nominal' exposure of 1/500s at f/11. The faster film with higher shutter speed, and selection of an aperture with a greater depth of field, was chosen to try to anticipate any difficulties White might encounter during the EVA.

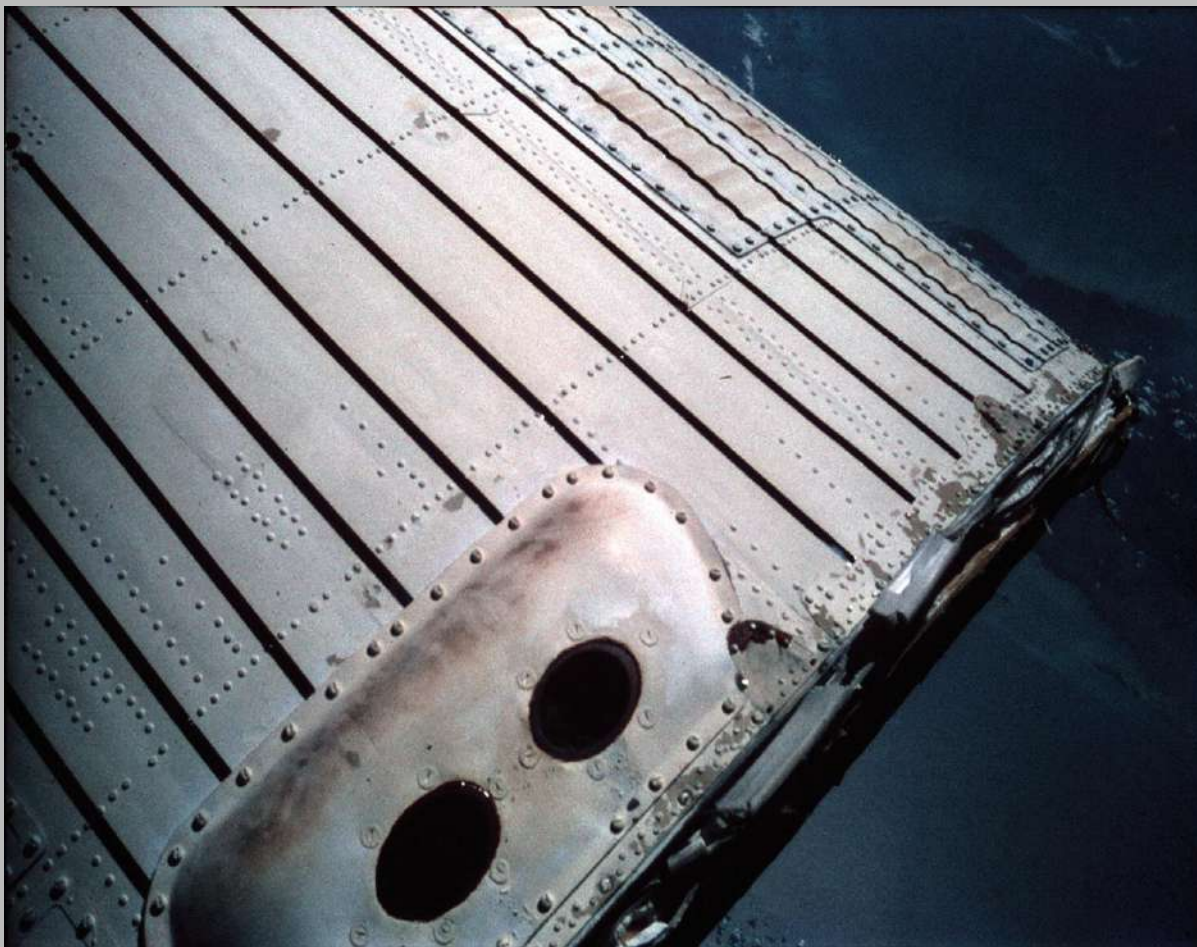
In total, White exposed 40 frames and it has been identified that at least the first 12 were exposed outside the spacecraft during the EVA. In re-examining the film and the images taken from it almost 20 years after the event, it was not clear whether Frames 13–17 had been exposed outside the spacecraft or once White had returned inside at the end of the spacewalk. However, frames 18–28 were exposed from within Gemini and the remaining 12 were blank.

The quality of the film was described as “very uneven,” with only a couple of images described as “good shots.” Others were heavily underexposed or completely blank, probably due to incorrect settings for the lighting conditions or the camera controls.





(above) A view of the nose of Gemini 4 (Frame 2), taken by White using the camera located on top of the HHMU. (below) A second image (Frame 3) from the HHMU camera, this time showing the open hatch on the right of the spacecraft, through which White emerged and returned from his EVA.



This view from the HHMU camera (Frame 12) shows the other end of the spacecraft. The Adapter Section clearly shows signs of the separation from the Titan upper stage. The edge also looks particularly rough, especially at the right-center of the frame, indicating a potential hazard for future EVA astronauts who were to venture past this section to don the Astronaut Maneuvering Unit on later flights.

The problem was the sheer difficulty White had in taking any images at all. Simply operating the camera was difficult enough while maneuvering around outside the spacecraft. Being naturally right-handed, White held the maneuvering gun in that hand as close as possible to his center of gravity while his left hand was stretched out to the side. To move the film on the camera, White had to move his hand across the top right hand side of the camera and operate the shutter from a control on the left. Restricted by the gloves and the EVA visor, this was by no means straightforward.

Adding to the difficulty in obtaining the detail of these images was the

Adding to the difficulty in obtaining the detail of these images was the passage of time, as well as the tragic fact that the prime participant was no longer alive. Further confusion came from the press release issued by Zeiss Ikon AG at the time of Gemini 4, which stated that an electric motor had been built into the camera to transport the film forward. In fact, while such a device was available it was not used on the Gemini 4 camera. As to the publication of images after the mission, Arnold's research found nothing untoward in the official handling of the material. The ground imagery taken by the astronauts later in the mission was of much higher quality, so the photographic competence and ability of the astronauts was never in question.

There was one particular image, Frame 12, which showed the separation damage on the aft edge of the Adapter Module at the point of separation from the Titan second stage. This was useful engineering data and revealed a potential danger for future EVAs in that area (where the USAF AMU would be stowed). If these images had been released more widely in 1965, it is possible that they would have generated more interest as the first images of a manned spacecraft in orbit. In summary, it appears that most of the exposed images were simply not of sufficient clarity or quality, certainly not as good as the images taken by McDivitt or the movie camera.

During a January 2005 interview, Australian author Colin Burgess mentioned to McDivitt that the photographs he had taken of his colleague on EVA 40 years earlier were still some of the most iconic and recognizable from the space program. "Fantastic, aren't they," the astronaut agreed. "My wife and I were having our picture taken over at the Country Club [recently] for a book they are putting together, and I was asking the photographer about his cameras and stuff, and he said 'Gee, you really know a lot about cameras. You seem to be interested in them.' I said 'Yeah, you know…' and so he was telling me all his credits, and stuff like that, and I said, 'Yeah, well, I've got a couple of *Life* magazine covers.' He looked at me like I was nuts and my wife said to him, 'Yeah, he really does! But you know, they're sort of special.' So [when he was told which covers] he was really impressed" **[** 6 **]**.

As he was working close to the spacecraft, White had found that the stowage bag, tethers and things associated with the bag were being tangled up with the camera and gun. He had to use his free arm to move things out of the way to take images, only to find that he had moved away from where he wanted to take a shot and instead had to take a couple of images in desperation, hoping that he had managed to capture at least part of the spacecraft in the frame. "But I never got the picture I was after," he regretted afterwards. "I wanted to get a picture of

Jim sitting in that spacecraft, through the open hatch, with the whole spacecraft. I know I didn't get that. In fact, as time went on, I realized that I wasn't going to get much of a picture [at all]." Try as he might, he could not stabilize himself enough to turn around and take the shot, with the tether dynamics working against him. McDivitt told White that he was pushing against the spacecraft, imparting a two degrees per second rotational velocity. With all the maneuvering, tethers and limited windows in the spacecraft, McDivitt was also having difficulty in capturing good images on his cameras. At one point, in desperation, McDivitt took the Hasselblad camera and stuck it out through the open hatch on White's side of the spacecraft, asking if White could see the camera and could direct him as to which way to point it to try to get a clean shot that way. Unfortunately, White could not see anything at the time as he was at the back of the spacecraft, so another opportunity had been lost.

White: "*All the strings* [meaning tethers] *that are attached to me tend to dampen out my travel on the lanyard* [umbilical]."

Grissom: [GET 04:41:10] "*Gemini 4, Houston Capcom… You've got about 4 minutes 30 seconds left* [to the end of the planned EVA period]."

White: "*Okay, I'm going to free drift a little bit and see if I can drift into some good picture-taking positions.*"

McDivitt: "*Okay. Here, let me control the spacecraft… Just for your information Ed, we're only down to 48 percent on our* O_2. *EDC* O_2 *pressure is about 830, so it's staying right up there.*"

Dirty Windows

White: "You *know one thing about this. Where we have this tether attached, I can't get a good push-off... There's nothing particular to get a push-off on. If I didn't have the gun I could do a little better… there just isn't anything to push on.*"

On this first U.S. EVA, the problem of a lack of hand and footholds became apparent, though it would not be addressed until the end of the Gemini program nearly 18 months later, on the EVAs of Gemini 12. The lesson was eventually learned, but rather late for Gemini.

As White floated right up to McDivitt's window, the movie camera was not operating. Problems with their cameras would reoccur throughout the flight, with some seeming to run occasionally but not at other times. When White was less than a foot away from the window, he could clearly see McDivitt sitting inside the spacecraft, and this was where White thought post-flight that he had marked his commander's window, leaving a smear. He had indeed brushed the window with his space-suited arm or shoulder and had then pushed away from the spacecraft with his gloved hand.

McDivitt: "*You smeared my windshield, you dirty dog!*"

White: "*Did I really… well, hand me out a Kleenex and I'll clean it.*"

McDivitt: "*Ha! See how it's all smeared up there? It looks like there is a coating on the outside and you've rubbed it off… that's exactly what you've done.*"

Grissom: [GET 04:42:54] "*Gemini 4, Houston Capcom… Gemini 4, Houston Capcom…*"

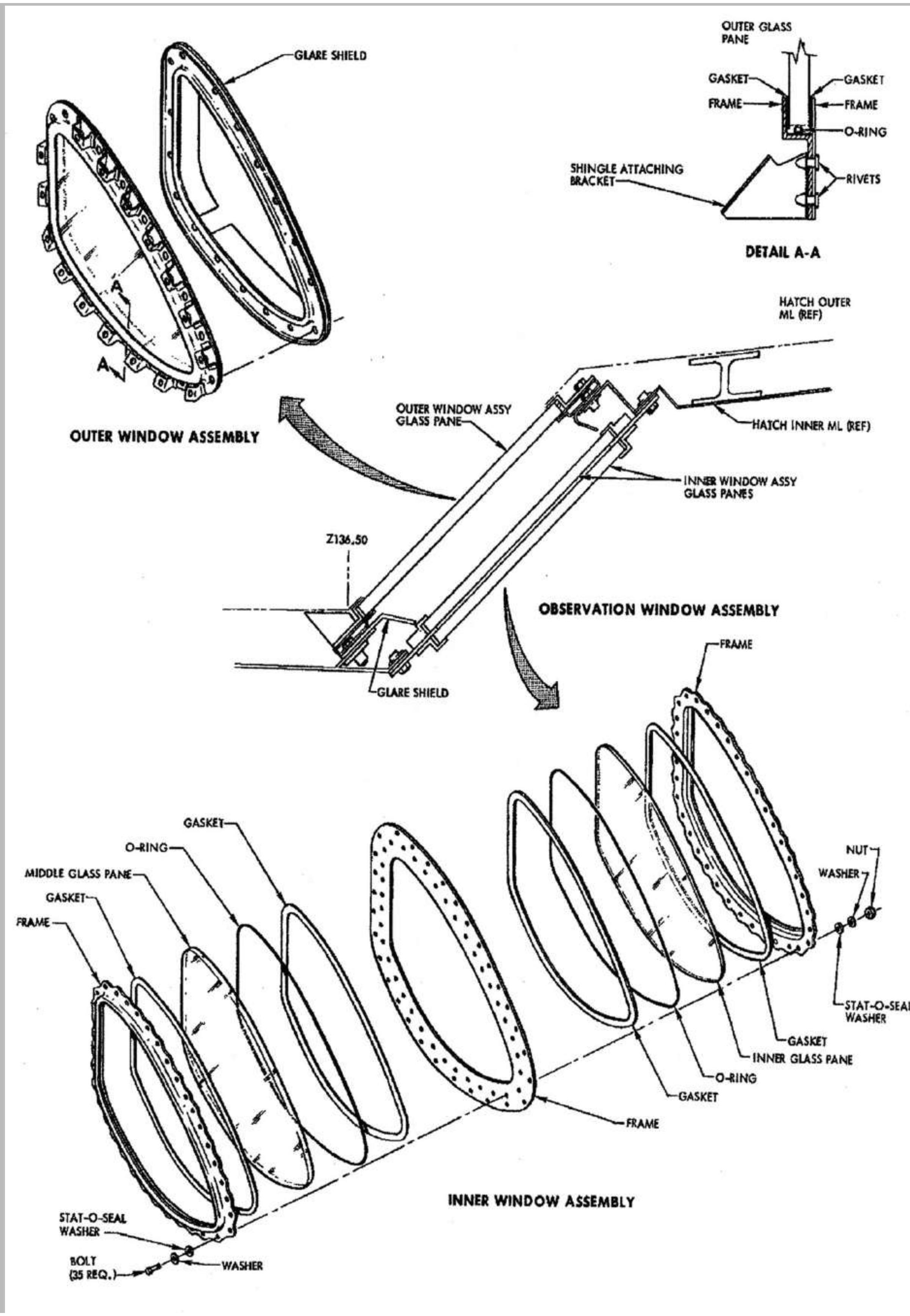
Their ongoing problems with VOX meant that neither McDivitt nor White appeared to have heard Grissom who, over the next three minutes, called in vain to the spacecraft no less than 14 times.

White mentioned post-flight that it was a shame that he could not have been given a Kleenex, so that he could have cleaned up the two windows, but then he thought that he might also have smeared them further, making visibility worse for the rest of their flight than it already was. "When you looked at the window of mine from the inside," McDivitt recalled later, "while the sun was shining, it looked like a black paint smear, which was [like] if you had a piece of white linoleum and a black rubber-soled shoe and made a mark on the linoleum. It had that kind of consistency. It was absolutely opaque. Just as black as it could be." White added a different perspective. "When I hit it, I could see from the outside it turned white." He guessed that he had smeared a film on the outer pane, but McDivitt was not so sure. "When I got [the spacecraft] turned around a different way with the sun on [the window], it was perfectly clear, as if you had taken the coating off, and what I was seeing was a perfectly clear surface. So I don't know really whether the thing was black, that you placed something on the window that would make it black, or whether you'd taken something off that was very white, very thin."

A few days later, with the spacecraft on the recovery carrier, McDivitt had the opportunity to take a closer look at its windows and could still see the marking on his side. To him, it looked as if a layer, or part of a layer, had been removed, possibly during re-entry, but he could not work out why it was so black and opaque when the sun shone on it at certain angles.

Window on the World

For the first time in human spaceflight, the extended duration Gemini missions in Earth orbit provided the opportunity for valuable observations of Earth and the stellar background. In addition, as rendezvous and docking was a primary objective, the astronauts had to have reliable viewing ports through which to view their target during close proximity operations. Though imagery and observations from these windows did provide valuable information, it was found that the windows were contaminated to varying degrees on each flight by thruster residue, outgassing and fogging. This was such a problem on the early missions that an outer protective pane was added to the Pilot's window later in the program, which could be jettisoned once in orbit to reveal clean glass beneath. These additional panes were cannibalized from some of the earlier flown Gemini spacecraft. The issues with the windows on Gemini will be covered in each flight and reviewed in the final title in the series. Here, we overview the components for this first extended duration mission of the series.



GLARE SHIELD
A
A
OUTER WINDOW ASSEMBLY
OUTER GLASS PANE
GASKET
GASKET
FRAME
FRAME
O-RING
SHINGLE ATTACHING BRACKET
RIVETS
DETAIL A-A
HATCH OUTER ML (REF)
OUTER WINDOW ASSY GLASS PANE
HATCH INNER ML (REF)
INNER WINDOW ASSY GLASS PANES
Z136.50
OBSERVATION WINDOW ASSEMBLY
GLARE SHIELD
FRAME
GASKET
O-RING
MIDDLE GLASS PANE
GASKET
FRAME
NUT
WASHER
STAT-O-SEAL WASHER
GASKET
INNER GLASS PANE
O-RING
GASKET
FRAME
INNER WINDOW ASSEMBLY
STAT-O-SEAL WASHER
BOLT (35 REQ.)
WASHER

Detail of the Gemini observation window.

The two observation windows on Gemini, one in each crew hatch, were quite small by today's standards. They were manufactured by Corning Glass Works of Corning, New York, the same contractor which had fabricated the windows for the Mercury missions and would later also fit out the Apollo spacecraft. The Gemini windows were half-moon shaped, measuring just eight inches (20.3 cm) wide and six inches (15.24 cm) deep. They featured three panes, each different in composition, with air between each pane. The two inner panes on each window were coated to reduce reflection, glare and UV radiation, and the windows were installed with insulation and fiberglass fitted around the outer edges for heat protection and pressure integrity [see cross-section diagram]. The Command Pilot window (left hatch) consisted of two outer panes of 96 percent silica glass joined to an inner panel of tempered aluminosilicate glass. The Pilot window (right hatch) was designed to give improved clarity when used for optical experiments and photography, which was one of the Pilot's roles on each flight. On this window, the inner panel was a 96 percent silica panel with an optical transmission capability of over 99 percent. The pane was increased from 0.22 inches to 0.38 inches thick to make it as strong as the aluminosilicate glass on the Command Pilot's inner pane **[** 7 **]**.

Tether Dynamics

White commented on the ease (or not) of operations outside on a tether after the flight. "If you've ever tried to hang on the outside of a water tower, or about an eight-foot diameter tree, you can visualize the problem I had out there." He noted that the decision to leave his hatch open was probably one of the best they made, as there was nowhere else to grab hold of outside the spacecraft. He again related trying to shimmy up an eight-foot diameter tree to trying to stabilize himself against the relative smoothness of Gemini. He made what he called "gentle contact" at one point, touching the bottom side of the open door which he then rolled around. Then he contacted the bottom of the spacecraft with his back and also the rear of his helmet. He also found that a gentle push-off from Gemini was the best way to avoid an uncontrollable attitude. McDivitt thought that White had actually hit the spacecraft hard at least once. As he pushed off with some force, the tether dynamics brought him back and he bashed into Gemini pretty hard again, with McDivitt remembering a pretty solid thump.

White envisaged some of the types of restraints he would have needed to control his actions better. "I felt I certainly could have controlled myself without the gun out there if I just had some type of very insignificant handholds or something I could have held on to. I believe that I could have gone on back to the Adapter [Section] with a minimum of several handholds to go back there, going from one to the other. I actually looked for some type of handholds out there. I remember that the only one that I saw was the stub antennae on the nose of the spacecraft. I could see the ceramic covering over it, [but] I felt it wasn't quite the thing to grab on to. I certainly had the urge to hang on to the antenna and push myself out, but didn't. And there really wasn't anything to hold on to." All he found were smooth corners and he forecast the difficulties that the Gemini astronauts would have during EVAs on the later missions: "You really need something to stabilize yourself." He also noted that he had "worked around the open hatch."

McDivitt suggested placing handholds inside the nose cone, or a position to connect a second attachment point for the tether to on the nose of the spacecraft. The antenna was pretty sturdy but as it was required through the flight, White did not want to mess with it.

With the hatch open and initially a small but noticeable pressure level difference inside and out, there was a great outflow of things through the hatch, including a piece of foam that was used to pack the HHMU in its box and the discarded thermal glove that floated out and away at a good velocity. As a safety precaution, White had wanted the door left wide open throughout the EVA in case he had to get back inside quickly, but even after 20–25 minutes they were still seeing small particles floating out through the hatch. This was clear evidence that the flow was from inside to the outside, and a downside to leaving the hatch door open.

The spacecraft – and White out on the tether – had been drifting around, but as they looked down, both men noticed that they were over Houston, Texas and tried to contact Mission Control, not knowing if they could hear them.

McDivitt: "*Hey Gus. I don't know if you can read, but we're right over Houston.*"

Grissom tried again to make contact without success, as McDivitt suggested he should "*Run out and look* [up]*!*" as they flew overhead.

White: "*I'm looking right down on Houston. My golly, I'm looking right* [at] *the [Galveston] Bay there.*"

Grissom: "*Gemini 4, Gemini 4. Houston Capcom.*"

White: “*I’m behind the Adapter. I’m trying to get some pictures* [which later revealed the rough edges]. *I’m still not satisfied with the pictures I’m getting, I’ve only gotten about three or four*.”

McDivitt: “*Is that right? I’ve taken a lot but they’re not very good. You’re in too close for most of them. I finally put the focus down to about eight feet or so. Oh yes, that’s great, the clouds and water behind you...*” [witnessing White ‘float’ in space with the Earth as a spectacular backdrop]

Get Back in

White acknowledged post-flight that although he did not look at his watch, his time outside went really quickly. McDivitt, however, was keeping an eye on the time, noting that he saw four, six and eight minutes into the EVA. But then they got involved with taking pictures and McDivitt heard that White was going behind the crew compartment, out of view. Communication with the ground was still sometimes being blocked out by their use of VOX (Voice Operated Communication). “Our VOX must have been triggered constantly, because whenever we were on it they, the ground, couldn’t transmit to us,” said McDivitt after the flight. At 15 minutes 40 seconds into the EVA, McDivitt called the ground asking for any messages, but as they were still on VOX, they could not hear anything for quite a while.

McDivitt: “*I’m going out to PUSH-TO-TALK and see what the Flight Director has got to say… Gus, this is Jim. Got any messages for us?*”

Grissom: [GET 04:45:35] “*Gemini 4, get back in!*”

White: “*What are we over now Jim?*”

McDivitt: “*I don’t know. We’re coming over the West now and they want you to come back in now*.”

White: “*Back in?*”

McDivitt: “*Back in…*”

Grissom: “*Roger. We’ve been trying to talk to you for a while here.*”

White: “*Aw, Cape, let me just find a few pictures.*”

McDivitt: “*No. Back in. Come on.*”

White: “*Coming in. Listen, you could almost not drag me in, but I’m coming.*”

Grissom: “*You have about four minutes until Bermuda LOS.*”

White:

White: *"I'm coming."*

Walking During a Spacewalk

"I did a few things after this time that I wanted doing, deliberately to stay out," White explained post-flight. "But I was deliberately trying to do one last thing; I was trying to get that last picture [of McDivitt inside the spacecraft]. A couple of times, I knocked off the spacecraft really hard to get out to the end of the tether, [but] I wasn't successful in getting the position so that I could get a picture [of the whole spacecraft in frame]. I felt this was the one part of the mission that I hadn't completed." It was also the period where he told McDivitt that he was "walking on top of the spacecraft," taking hold of the tether and pulling to draw himself 'down' onto the surface of Gemini 4. "I walked from about where the angle starts to break the nose section and the cabin section. I walked from there probably about two-thirds of the way up the cabin and it was really quite strenuous." McDivitt could not see this, but he certainly felt the thumping on the outside. At this point in the EVA, White was laughing quite hard and McDivitt called sternly for him to get back inside the spacecraft.

White: "*I'm coming.*"

McDivitt: "*Okay, okay. Don't wear yourself out now. Just come on in… How are you doing there?*"

White: "*I'm doing great.*"

McDivitt: "*The spacecraft really looks like it's outgassing because all the – whatever little piece of dirt or something goes by – it always heads for the [open] door and goes right on out… Okay let's take it easy now, take it easy.*"

White: "*I'm standing on top* [of the spacecraft] *right now.*"

McDivitt: "*Boy this load on our spacecraft is fantastic. You can put in a two degree/second attitude change in nothing flat. Can't you get a hold there Ed?*" [Seeing White struggle to get a firm purchase to pull himself into the hatch.]

White: "*Yeah… now… No sweat… I'm trying to get a better picture of the spacecraft now.*"

McDivitt: "*No, come on in… Ed come on in here!*"

White: "*All right. Let me fold the camera and put the gun up.*"

McDivitt: "*Okay. Let's not lose that camera now. Okay, I got it.*"

McDivitt then commented on the lack of space or adequate locations to stow the camera after White had handed it to him.

McDivitt: “*Let’s get back in here before it gets dark.*”

White: “*Okay, now I can enter. This is the saddest moment of my life.*”

McDivitt: “*Well, you’re going to find a sadder one when we have to come down from this whole thing.*”

In the newspapers covering the flight, it was implied that White had disobeyed the call from the ground, did not really want to get back inside and so stayed out, but this was not the case. It was merely another example of media ‘misinterpretation’ for the sake of a story. One of the problems was that the crew simply had not heard the ground instructing them to terminate the EVA. There were no transmissions from the ground after White had ‘stepped outside’ until they went off VOX a couple of minutes before he returned to the hatch. White explained that there were certain things that he had to do before he came in, and there was no way he was going to hurry, taking care to proceed slowly, the way they had been trained. But he also wanted to take the pictures, as McDivitt stated post-flight: “At that time, I got a little irritated and hollered at Ed too. Then he started back in. We were three minutes 40 seconds late in getting started back in because we just lost track of time. Neither could I see Ed any longer and I was trying to keep track of what he was doing. I think he delayed probably a minute or a minute-and-a-half before he started back in. There were delays and we started back in after 12 minutes. From then on all the time was spent in just trying to get back in.”

White had to disassemble the gun inside the spacecraft, which he did very slowly before disconnecting its electrical connections and handing it over to McDivitt. After that, he had to disconnect the umbilical guard, the little tether that he had put on the pull ring, and then discard the umbilical cord. McDivitt was relieved to get rid of some items overboard, as “we had so much other junk that we didn’t want” in the cabin after the EVA.

McDivitt: “*I’m just pulling all this stuff down here… No time to talk now… I’m pulling in [the] air hose. Okay, have any messages for us Houston?*”

Grissom: “*Are you getting him back in?*”

McDivitt: “*He’s standing in the seat right now. His legs are down below the instrument panel.*”

Getting Back into Gemini

Getting Back into Gemini

The next task was to get White back to his seat and then close the hatch. The first challenge was having to position himself to glide back into the open hatchway, which was easier said than done. “I had one thermal glove on my left hand,” White explained after the flight. “I always wanted my right hand to be free to operate that gun and camera, [but] the way the camera was mounted, I had to use both hands; one hand to stabilize myself using the gun and the other hand to reach over. Again, I think dynamics played a little bit of a role there. Every time I brought my hand in from a position out to my left, it tended to turn me a little bit, which was exactly what we found happened on the air-bearing tables. I think the camera should have been Velcroed to my body somewhere and used independently of the gun.” McDivitt thought that they should have taken the camera off first and then discarded the expelled gun, while White thought that he should have folded the extending gas jet arms first and then passed it to McDivitt. He still felt that he had not accomplished all that he had wanted to do with the camera (which seemed to continue to irritate him even during the debriefing after the mission). He took the lanyard off the camera and handed in the gun and then the camera to his commander. Then he dismantled the 16-mm camera and discarded the umbilical guard overboard. This, as White explained, “was where the fun started. I found it was a lot more difficult coming back in than I remembered in the zero-g training. It seemed like I was contacting both sides of the hatch at the same time, much firmer than I had on the zero-g airplane.”

McDivitt corrected him, saying that he was hitting both sides of the hatch opening but not the actual hatch. White felt that it was a much firmer edging than he remembered from his training, which he put down to the pressure of the suit, similar to the ballooning that Leonov had experienced at the end of his EVA but to a lesser degree. “I just might have been a little fatter,” he surmised. “I did notice that the suit was a little harder,” which was something he had experienced in training and on the simulators, so it was not a total surprise, but he did have a sense of being slightly larger in the suit getting in than he had been when he got out of the spacecraft just 30 minutes earlier. The arms and legs were stiffer, and to McDivitt they looked a lot more rigid, as White was not bending them around as much. White was talking into the onboard tape all the time, giving a running commentary of his exploits as he decided to come in slower, which was a little tougher than he had expected.

McDivitt: “*He’s coming back in. He’s having some trouble getting back in to the spacecraft it looks like.*”

As they were approaching the pass into the night side of the orbit, Grissom warned them:

Grissom: “[Have] *You got your cabin lights up bright in case you hit darkness?*”

McDivitt: “*I can’t read you… say again…* [still no clear contact with MCC]. *Listen, we are kind of busy. If you really don’t have something for us, wait a couple of seconds*.”

Shortly after this point, they lost communications through Bermuda.

> PAO Haney: “This is Gemini Control, Houston. We apparently have lost the signal in Bermuda after an extraordinary 20-minute conversation with Jim McDivitt and Ed White. The conversation was certainly stimulating and at the last report we have Ed down in the seat and they’re about to close the door on that. We expect to get a cue from the Flight Director as to when we’ll next depressurize and open the spacecraft. This is according to the original plan, to jettison some of the bulker gear. Among the items to be discarded into space will be the chest pack, the emergency chest pack that Ed used, the space maneuvering unit, the umbilical and a number of items. This is Gemini Control, four hours and 53 minutes into the mission”

There was some question during the preparations for the mission as to whether the HHMU would be discarded after the EVA as it was not too bulky. Its empty oxygen propulsion bottle would be thrown overboard, though the thruster engines may have been retained. What was not picked up in the commentary was that at around the same time, at GET 4 hours 53 minutes into the mission, Gemini 4 surpassed the mission duration of Gemini 3 from just over two months earlier. This time, however, they kept on flying.

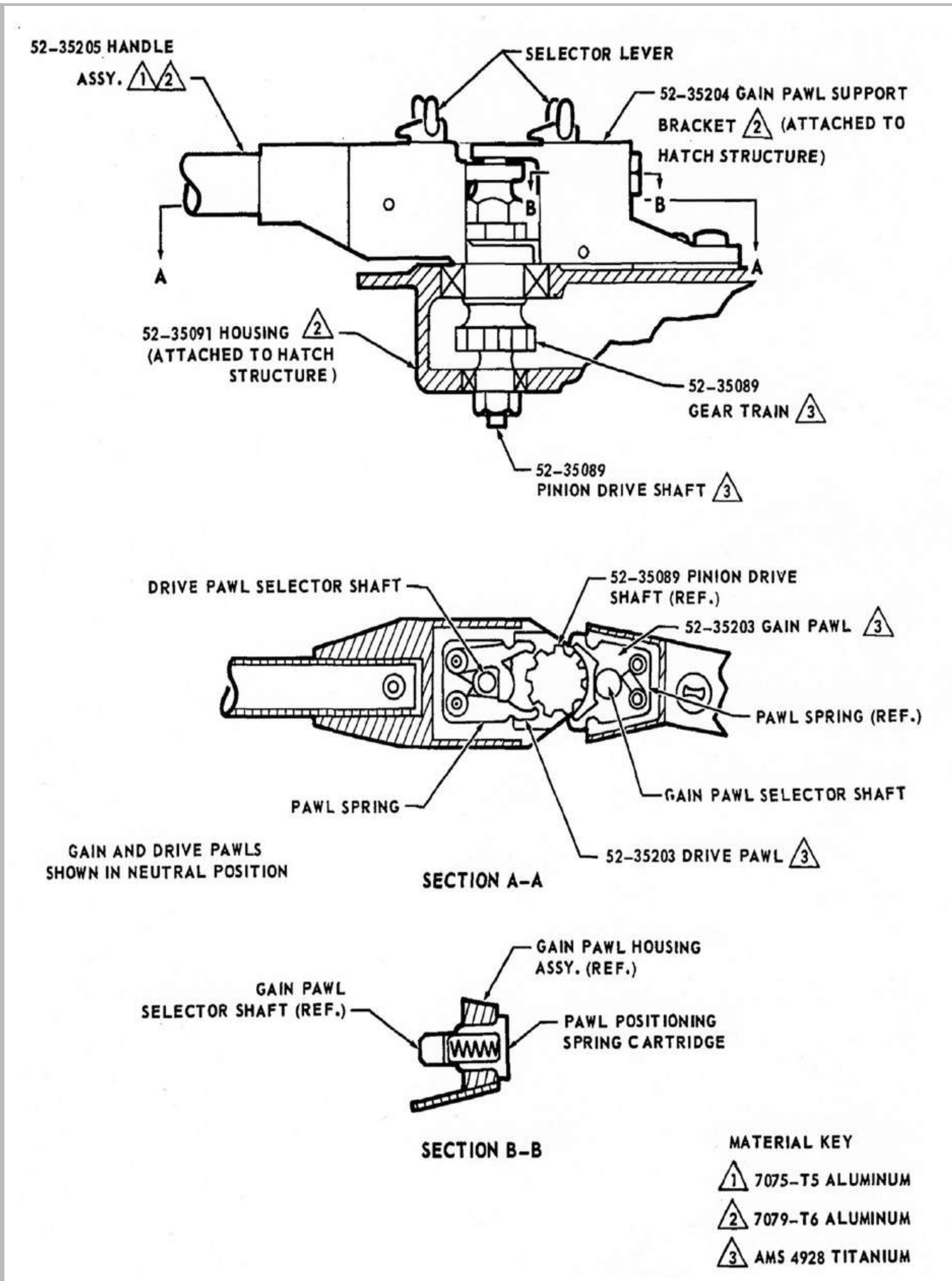
McDivitt said that he helped pull White into the crew compartment, although his colleague said he never felt the assistance. White was holding on to the top edge of the hatch and swiveling, without much mobility and ability to straighten his arms and twist his body against the forces of the suit to settle down into his seat. He managed to get his left arm underneath the circuit breaker panel and pulled himself down, which was the first real progress he had made in actually getting back in. McDivitt could only steer him inwards, not being in a position to use his strength to pull his colleague down from the other side of the spacecraft. Both men were concerned about inadvertently striking the circuit breakers between them, so much so that White had practiced using the underneath of the instrument panel in the zero-g aircraft dozens of times and knew the technique quite well. Maybe it was the suit being stiffer, but it took longer than they thought it would, even challenging the supremely fit and prepared Ed White. “I got two fat cramps at the bottom of my thighs in both legs, [at the back] where [my] muscles started to ball up a little,” he admitted after the flight. That meant he had to get back up again to stretch his legs before trying again to come back into the cabin – still with all his equipment on – and then pull the hatch down far enough to close it, reaching up to grab the handle to complete the process. As he did so, McDivitt noticed that the handle was moving easily but the latching dogs were not moving at all. White commented at this point that he could not see with the sun visor still on his helmet and reluctantly decided to throw that overboard as well.

The normal hatch closing process was for the Pilot to lower himself into the seat area and wedge himself down, so that he could grab a small canvas handle on the bottom of the hatch and apply a downward force to lower and soft-close it (see sidebar: *Hatchway to Space*). He would then use his right hand with the handle to ratchet down the hatch. This was how it had always worked in the simulations, but in reality up on Gemini 4 it was not working as it should have and it took them three or four minutes to realize this. White found that he could not hang on to the canvas handle with enough force to operate the handles while trying to prevent himself rising up off the seat. He also found that the chest pack was in the way of fully depressing the handle. Wanting to gain a better view of the procedure, but not really wanting to dispose of the visor in case he still needed it, White reluctantly made the decision to open the hatch about 18 inches (45 cm) and threw the visor out. He came down again, still with the cramps, but this time the problem in securing the hatch was of far greater magnitude than his personal discomfort.

Hatchway to Space

The Gemini spacecraft incorporated a pair of hatches. Each hatch featured the three-pane observation window [see *Window on the World* p. 165] and was contoured to the shape of the conical crew compartment. They were positioned on what was generally identified as the ‘top’ of the spacecraft, with the hinges located on the outboard side of each door. The outward-opening hatches could be manually operated either from the outside by ground or recovery crews, or from the inside by the astronauts themselves. The latching mechanism was also mechanical. This type of design, which could open relatively quickly, was not included on the early inward-opening inner hatch of the Block I Apollo Command Module. If it had been, perhaps it may have saved the lives of the three astronauts killed in the Apollo AS-204 (Apollo 1) fire during a ground test at Cape Kennedy on January 27, 1967. In that tragedy, the inward-opening inner hatch was effectively sealed shut against the outer thermal shield hatch by the internal pressure created by the flash fire. Despite their known efforts, the crew, including former Gemini 4 astronaut Ed White, were unable to open the hatch in time. In the redesign of the Apollo CM hatch following that disaster, the North American Aviation engineers were assisted by McDonnell engineers, who could call upon their experience with the Gemini outward-opening hatch system.

Having the large hatch directly above the crewmember on Gemini enabled exiting the spacecraft in orbit for EVA to be relatively simple. The difficulties experienced in opening and closing the hatch during Gemini 4 led to amendments in the design of the manual control mechanism, which were incorporated from Spacecraft 6 onwards.



Detail of the hatch manual control mechanism detailing the changes made following Gemini 4 to prevent a similar problem reoccurring.

Originally, when using the manual handle, the pinion drive shaft that operated the latch linkages of the hatch was driven by engaging a drive and gain lever called a pawl. This featured a catch to engage the teeth of a bar in a ratchet-type action. During Gemini 4, the automatic return of the drive and gain pawls failed to operate correctly due to friction, forcing the crew to operate the selector manually. Following the mission, the system was redesigned to reduce the effect of friction and increase the return mechanical advantage by a factor of ten. In addition, a sawtooth 'gain hold' device was also installed on the hatch sill for use in conjunction with the hatch closing device. This helped to hold the hatch closed against the seal pressure just prior to the final latching operation. The new manual control operation was endurance tested in both temperature and pressure environments for over 1,000 cycles to qualify it for flight.

When White tried to use his left arm to close the hatch, he found that he could not apply the force needed, simply because raising his arms that high was not the way the suit was designed to allow him to move. Consequently, he had to get up out of the seat once more, with his helmet wedged right up against the inside of the hatch door. From that awkward vantage point, he could finally see the ratchet dogs, and the lever and spring they had had so much trouble with when trying to open the hatch at the start of the EVA. At this point, teamwork came into play, with McDivitt pulling on his colleague while White pulled on the hatch handle and operated the gain lever. It worked, as the hatch came down and the ratchet dogs came in to engage the lever, permitting them to come out fully and lock. "[This] was the most interesting moment of the flight," White recalled afterwards. "I think… it was probably the most dramatic moment of my life – about those 30 seconds we spent right there. The dogs started latching. I could feel them going in, and I could tell they came over dead center. Jim called out that the dogs were in." McDivitt and White were fully aware that they had to close the hatch, preferably in daylight. "It was going to be a major problem [if] we couldn't get it closed. We were going to burn up on the way in," recalled McDivitt in 2005. Their teamwork and knowledge of how the hatch latching system worked enabled them to close and secure the hatch for the rest of the mission. They then let the controllers on the ground know of the problem. McDivitt knew that, other than the technicians who built the hatch, there would have been few people on the ground who could have helped them, but they did not have time to wait and, as there was no Mission Rule for the situation, McDivitt just worked it out as he went along, saving the mission and probably both their lives as well.

Once the latching dogs had engaged, McDivitt and White realized that they would finally have the measure of the hatch. Based on their experiences, White knew in his mind that the bar, the attachment on the bar and the lanyard were nowhere near strong enough to do the job they were designed for. Having broken the same type of equipment three or four times in the zero-g airplane, McDivitt agreed. “Every time, they kept telling us that it [the equipment on the airplane] wasn’t made out the right kind of stuff, [but] the ‘stuff’ we were going to have in the spacecraft would be the right material.” Fortunately, it didn’t break in the spacecraft, but the thought crossed McDivitt’s mind. “I was thinking that the success or failure of this hatch closure depends on whether this hatch closing device stays hooked onto that spacecraft and doesn’t break off.” If it had, as McDivitt wryly surmised, “we would have been in deep trouble!” They would have been left with just the canvas strap with which to close the hatch and keep it in place. During the post-flight debriefings, both astronauts strongly recommended a more robust hatch closing mechanism for future EVAs, “[if] for nothing else [other] than a psychological purpose.” They had pulled almost as hard as they dared to, or had the strength to, in the suits and in the difficult position they were both in. As White heaved down on the handle, he sensed that it was giving way and he was expecting it to break suddenly. Fortunately for all concerned, it didn’t.

As Gemini 4 came back into contact, Capcom Grissom tried again and again to establish voice contact with the spacecraft.

Grissom: [GET 05:07:47] “*Jim, if you’re trying to transmit, you’re completely unreadable. I’m getting nothing but noises.*”

> PAO Haney: “This is Gemini Control, Houston. We are five hours and ten minutes into the mission. To review the approximate times of the extra-vehicular activity of Major White, we estimate here that the right hatch was open at 42 minutes after the hour. We have a time hack on his actual push away from the spacecraft at 45 minutes after the hour. He was back in and standing on the seat five minutes after the hour, some 20 minutes after he left the spacecraft. We have not [at this time] had an approximate time of [hatch] closure, however. The mission seems to be proceeding very nicely. This is Gemini Control Houston.”

Clearly, Haney was not yet aware of the difficulties the astronauts had just encountered in closing the hatch. With the hatch now closed, the astronauts could take time to recover from their efforts. The next major station on this orbit was Carnarvon in Australia. With the spacecraft now on the dark side of the orbit, it was estimated that the crew had used about two pounds (0.90 kg) of fuel to maintain attitude during the EVA.

On board Gemini 4, both men were recovering from the struggle to get White back inside, close the hatch, stow the gear and prepare for the rest of the long flight. When they could not contact the ground, they looked at the flight plan and realized they were not scheduled to talk to anyone until Carnarvon at GET 05:35 (13 minutes later), but decided to send a message on the tape anyway.

McDivitt: *"Houston, do you read Gemini 4? Gemini 4 transmitting in the blind. We're back in. The cabin's resealed. We're all set and all safe. We're going to do a delayed tape playback over Carnarvon."*

A Close Decision

In the post-flight debriefing, both astronauts revealed their thoughts on what might have happened had they not focused upon the hatch and its mechanism during training. White was very clear about the decision to go ahead and open the hatch. "If we hadn't done so much work together with this hatch, and run through just about every problem that we could possibly have had, I would have decided to leave the hatch closed and skip the EVA. We had encountered just every conceivable problem that we could possibly have had with the hatch. If it failed, we'd know exactly what it was."

Jim McDivitt, probably thankful for his engineering background, added that he "personally had disassembled this cylinder and piston and spring combination up at McDonnell prior to the altitude chamber, so I knew exactly what it was made of. I am sure the problem was that the dry lubrication coagulated and was causing the piston to stick. I knew how we could do this thing. [McDonnell's] Carl Stone and I had dismantled it, cleaned it out and put it back together and it operated fine. We figured out how to make the thing work when it was not working properly, by using your finger as the spring." This was the technique they used on Gemini 4, and as McDivitt noted: "If we hadn't had the training together that we had, and had not encountered all these problems before, I know darn well I would have decided not to open the hatch."

On the mission, they had the option to continue the work towards an EVA for a couple more orbits, and there were other options available to them, but their efforts worked pretty close to the prescribed time, if not exactly first time. However, when White was finally back in and the hatch was sealed, he was

However, when White was finally back in and the hatch was sealed, he was completely soaked in perspiration, and McDivitt noted how “bushed” he appeared to be. “Sweat was just pouring [metaphorically],” White explained. “In fact, I could hardly see. It was in my eyes.” In space, perspiration remains in place and does not run down the face as it would on Earth. McDivitt told White not to move for at least the next half-hour while they re-pressurized. “I closed the vent valve,” McDivitt recalled, “and we had a lot of instructions from the ground to close the water seal and a whole bunch of other things that didn’t make any sense. I knew that the spacecraft was re-pressurizing. I watched [the gauges]. There wasn’t anything else that we had to do right then, and we were both bushed, especially Ed. He was perspiring so that I could hardly see him inside the faceplate.” They both just sat there and let Gemini coast around in its orbit, until they got within range of Carnarvon about three minutes later, whereupon McDivitt informed the ground that they were re-pressurizing and had the hatch closed. Both astronauts were pleased and relieved to see the pressure gauge rise, even half a psi, knowing that the hatch was sealed and the EVA was over.

Everybody’s Feeling Great

During the quiet period between ground stations, the crew recorded their comments on the onboard tape, with McDivitt noting that a dayside pass was just not long enough for an EVA. White agreed, stating, “*You have to go like gangbusters*” to get it all ready and accomplish everything. During the post-EVA checks of the spacecraft, White made sure that his comments were on tape: “*Note that, recorder. You just do not have time.*”

Twenty minutes after re-entering the spacecraft, White finally began to cool off after all his exertions. Getting ready for the EVA, opening the hatch, getting out of the spacecraft, performing the EVA, getting back in and then closing the hatch and stowing as much gear as he could had all taken place within five-and-a-half hours of leaving the launch pad, together with the earlier work in trying to keep station with the spent Titan stage. It had been a busy start to their mission.

> PAO Haney: “We have a report that both Mrs. McDivitt and Mrs. White are en route to the Control Center [at MSC] now. This is an unscheduled visit. I think they want to stop by and shake a few hands with some people here that followed the extra-vehicular activity very closely since its beginning. This is Gemini Control at five hours and 32 minutes into the flight.”

A few seconds later, at GET 05:32:04, the Carnarvon Capcom finally established good voice communications with Gemini 4.

Capcom: “*Gemini 4, Carnarvon Capcom.*”

McDivitt: “*Hello Carnarvon. Hello Carnarvon. Gemini 4. How do you read me? Over.*”

Capcom: “*I read you loud and clear. How me? Over.*”

McDivitt: “*Loud and clear. It’s nice to have someone to talk to again… We are back inside the spacecraft. We are re-pressurized to 5.2 psi. We are not, I say again, we are not going to depressurize the spacecraft again.*”

Capcom: “*Roger. Understand. How are you feeling?*”

McDivitt: [GET 05:33:11] “*Everybody’s fine. Feeling great.*”

PAO Haney stated that McDivitt had noted the long break in the network and had been given an update and a ‘GO’ for at least six orbits. This was the next nominal contingency landing should any problem develop, emphasizing that such a call was a routine update. Haney also reported that despite the plan to depressurize the spacecraft to dump unwanted material outside, the crew had elected not to do this. Haney suggested that the crew wanted to keep the equipment as a souvenir, which was not exactly true. The hardware was government equipment and was not, in reality, theirs to keep. It would probably head for a museum eventually. The real reason was that after so much trouble opening and closing the hatch once for the EVA, they were not about to open it again until they had splashed down at the end of their four days.

A series of routine tests followed, with a request to configure the spacecraft for the remainder of the mission and report the status of various systems. This was difficult, with all the EVA equipment floating around in front of them.

Capcom: “*We’re going to give you a ‘GO’ for six more [orbits] I’ll update load for you with maneuver.*”

McDivitt: “*We won’t wait for that one now. We’ve got all this equipment in the spacecraft right now and we’re trying to get it stowed away in a reasonable manner.*”

Capcom: “*We’ll copy the times when you are ready.*”

McDivitt: “*It looks like our booster’s still out there flashing away… it looks like it’s about five or six miles perpendicular to our flight path. Maybe it’s more than that? It could be as far out as 20 miles perpendicular to us.*”

PAO Haney: “Both Pat McDivitt and Pat White, the wives of these two pilots, are here in the control center. They’ve been here approximately half-an-hour

> are here in the control center. They've been here approximately half-an-hour. They have been chatting with Dr. [Robert] Gilruth [Director of MSC], and with Congressman [Robert 'Bob'] Casey. This is Gemini Mission Control at six hours and seven minutes into the mission."

As the spacecraft flew over the south central United States, it was an unusually quiet pass, largely due to the fact that McDivitt had been taking an oral temperature reading and was off comms. Frustratingly, the communications remained troublesome at this time, due to issues with the ground sites or the spacecraft itself. Medical values were read out at six hours 21 minutes into the mission while flying over the United States, with Flight Surgeon Dr. Berry in direct communication with both astronauts. Ed White had reported very strongly that at no time during his EVA had he felt disorientated, no matter what orientation or position he found himself in, which was encouraging.

With the launch, rendezvous, and EVA behind them, both men were naturally tired, but there was a full program of experiments and activities ahead of them and so, approaching six-and-a-half hours into their mission, the first rest period was scheduled. As this was still a relatively new spacecraft and only the second time astronauts had been on board in orbit, however, it had been decided that only one of the astronauts would rest at a time, ensuring that the other was awake to monitor the systems, perform or receive updates to the flight plan and continue the science and observation program.

> PAO Haney: "[Ed] White has been advised to go to sleep for about a four-hour period. Jim McDivitt, meanwhile, who sounds a little sleepy too, has advised that he will pick up the flight plan as it exists and began to program his fuels against his various experiments. This is Gemini Control at six hours and 22 minutes into the mission."

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8. A streamlined Gemini capsule

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

"One of the prettiest sights I saw was
when I looked down and saw the tip of Florida
and the islands of Cuba and Puerto Rico and Santa Domingo.
It was really quite a view. The colors of the blue
and the hues as the water deepened out there."
Ed White commenting on FD2
about his view of the Caribbean during his EVA on FD1.

With the EVA completed and the hatches safely sealed again, the crew was instructed to allow Gemini 4 to drift and therefore conserve the spacecraft's propellants. This mode was maintained for the next two-and-a-half days. As a result, the flight plan was continually updated and amended, as a number of operational checks and experiments were scheduled then rescheduled as necessary in real-time. The crew were required to monitor a variety of terrestrial objects or targets and orientate the spacecraft, depending upon the attitude it happened to be in at the time. This affected their performance when operating the experiments and conducting the various checks required throughout the remainder of the mission. A direct result of this was that many of the planned experiments and checks had to be rescheduled to later phases of the mission, when fuel consumption restrictions were lifted. These real-time planning amendments also meant rescheduling the crew's sleep cycles to suit the new requirements, which in turn required further re-planning of activities around the new sleep periods. While challenging for both the crew and the flight controllers, this was a valuable lesson learnt and clearly revealed the realities of long-duration spaceflight.

Settling into the Flight Plan

Accurately recording events and activities on a spaceflight has always been a challenge for the writer, as different times or methods of recording data were often used. It all depended upon where the information came from, but even formal NASA documentation could – and indeed still does – vary in presenting so called 'official' times for events. In the early days of the program it was relatively easy, as the missions were short and relatively uneventful, but as the duration increased and the activities expanded, so the complications arose. Should the missions be recorded from the time they left the pad to the moment of splashdown, in what was termed Elapsed Time, or use the local launch time? From Gemini 4, NASA started citing 'revolutions' (approximately 96 minutes) around Earth instead of 'orbits' (approximately 90 minutes), although this practice ceased after a few flights and 'orbits' became the norm once again. However, Gemini 4 also brought up a new issue: the time zone. Between May 1961 (Mercury-Redstone 3) and March 1965 (Gemini 3), Mission Control had been at the Cape, so Ground Elapsed Time was the same as local or Eastern Time. Moving the MCC to Houston from Gemini 4 onwards, however, changed the time zone to Central, so the time that the vehicle left the pad was different (one hour in front) to the local time in Houston. There was no clock inside the windowless Mission Control room that referred to local time. Instead, Greenwich Mean Time (GMT) in England was used to standardize with the various tracking stations around the world. For this account of Gemini 4, mission events are described using GET, while noting which orbit or revolution they occurred on. All actions on the spacecraft or on the ground were marked in Ground or Mission Elapsed Time (GET or MET)[1] at Mission Control.

A broad view of the Mission Operations Control Room (MOCR) during the early stages of the mission, with members of the Red Shift on console. [Courtesy Manfred ‘Dutch’ von Ehrenfried]

Flight Day One: Thursday June 3. Post-Eva Activities

With the crew back inside Gemini and the hatch finally shut and sealed, early suggested causes of the hatch problem focused upon the cold of space affecting the malleability of the seal. Fortunately, the hatch was a part of the spacecraft that would be recovered, along with the astronauts, so post-flight analysis would be able to explore the possibilities after the mission.

Meanwhile, with the launch, station-keeping and EVA having been completed in less than six hours, it was time for a change of shift at MCC, as Lead Flight Director Chris Kraft’s Red Team had been on console since two hours prior to the start of the mission. The next eight hours of the mission would be under the guidance of the next shift – Gene Kranz’s White Team. Kranz recalled his first stint at occupying the FD chair in his 2000 biography. “[Chris]

Kraft handed me the logbook as if it was a baton in a race. With a broad smile, he gave me a nod. 'Young man, it's yours', he said, then left for the post-EVA press conference. Mission Control was mine." Kraft noted that this was the first time he had donned the white vest (waistcoat) made by his wife in recognition of his team color, for which he would become famous when on duty. "I felt like a matador donning his suit as I put on the vest." His attire was picked up on the TV in the control room, with echoes of "Nice vest, Flight!" rippling around the control center. The following day, images of Kranz wearing his vest were shown, the start of an unintentional icon of the early American space program over the next 28 years.

GET 05:35 (Orbit 4/Rev 4) – GET 07:50 (Orbit 6/Rev 5)

During these initial orbits following the EVA, the crew could begin to focus upon the scientific objectives of their mission. McDivitt took a blood pressure reading and the MSC-1, -2 and -3 experiments were turned on. The onboard tape recorder was played back and a status update was given to the crew for a contingency landing at the primary site on their 18th orbit/revolution. Ed White began his first three-hour rest period, while McDivitt updated work on the D-8 experiment.

Five-and-a-half hours into their flight, one of the crew's first priorities while waiting for the Capcom to inform them of pending maneuver updates was to clear some of the equipment out of the way, so that they could progress with the rest of the flight. This was the period that McDivitt categorized after the flight as Stage 2: after the EVA and prior to re-entry. He also stated that they could now settle down for what he called "the long haul," aware that it would perhaps have been a longer haul for those on the ground.

McDivitt: "*While we are waiting for that* [the update]*, we've got all this equipment in the spacecraft right now and we are trying to get it stowed away in some reasonable pattern.*"

A few minutes later, as they were flying over Carnarvon, McDivitt informed the ground that the booster was still in sight, perpendicular to their flight path about five or six miles (8–9.6 km) away. Not that it was easy to determine exactly how distant 'away' was. "*Maybe it's more than that,*" said McDivitt, "*It could be as far out as 20 miles* [32 km]."

The astronauts on board Gemini 4 had been in contact for about an hour with the tracking ship *Coastal Sentry Quebec* (CSQ) stationed in the Indian Ocean, and with MCC in Houston via the remote loops at the Guaymas and California stations, when White had been advised to take his first sleep period. First, however, he was required to gather biomedical data Type 1, which included the use of the in-flight exerciser (experiment M-3). McDivitt informed the ground that they had not yet un-stowed the exerciser, so a full Type 1 medical was not possible at this time, although White did manage to capture an oral temperature reading. Flight Surgeon Charles Berry recommended that White should go ahead and pump up the blood pressure cuff to get a single blood pressure reading and do without the exerciser for this pass.

White informed the ground that both men had taken in water, with McDivitt taking ten swallows of water and himself about 12, maintaining their fluid intake following their excursions in the earlier orbits. He also commented that they had yet to eat and were both "*awfully hungry*."

Berry informed them that the planned sleep period was to be modified, letting White rest for about four hours. If McDivitt got sleepy during that time – and it was agreeable to Chris Kraft – they would let him sleep for some of this period as well. White commented that he did not feel that sleepy but would give it a go, though both men were still alert from their earlier activities.

The flight crew activity schedule was designed to have just one of the astronauts sleeping, while the second remained awake to monitor the spacecraft's systems and continue the experiment program and activities in the flight plan. However, it was becoming clear already that both men might be tired after such an eventful day. As this was the first significantly extended orbital mission for the Americans with more than one crewmember on board, the intention was to explore the alternate sleep pattern to add an element of safety to the missions. After all, this was only the sixth time that American astronauts had been in orbit, and the first time their mission would extend to more than one terrestrial day and night cycle, so it would therefore be the first time that the challenges such a plan presented would be encountered[2].

White was not scheduled to awaken until GET 11 hours 10 minutes (11:10). Meanwhile, McDivitt received the 'GO' from MCC for at least 18 orbits, or a full 24 hours aloft. The tracking ship CSQ informed the Command Pilot that, based upon data received on the ground, his spacecraft looked in a very good position, to which he replied that indeed Gemini 4 was in a 'GO' condition.

During the pass with CSQ, McDivitt gave blood pressure readings as part of the standard medical operations for both men throughout the flight. Following the excitement and intensity of America's first spacewalk, things now calmed down for the rest of the mission. After they had unintentionally used more fuel than expected trying to station-keep with the spent Titan stage at the start of the mission, McDivitt asked about the plan to handle the fuel levels from now on.

Capcom: “*As best as I can tell you right now, you’ll be able to accomplish practically all of the flight plan with the fuel that you have remaining at this time. We’ll keep updating you in real-time.*”

Data suggested that there would be no further requirement to maneuver the spacecraft to maintain its orbital altitude during the four-day mission. With Gemini 4 orbiting the world at about 185 statute miles apogee and 103 statute miles perigee (297.6 x 165.7 km), it was calculated that there was a greater level of fuel on board than anticipated, as the second rendezvous exercise with the spent Titan second stage had been scrubbed. Oxygen levels were nominal. On the ground, they were trying to work out why Gemini 4 had needed more fuel than expected to station-keep with the booster in the first place and until they had done so, the Capcom advised the crew to proceed with the flight plan while they worked the problem through. “*We had a couple of pretty exciting moments there*,” McDivitt remarked about the rendezvous.

Now that White was no longer dependent upon the long umbilical to feed oxygen and was back on the suit ECS circuit, the Capcom wished him a good nap. McDivitt then queried why they wanted the ECS O_2 switch turned off, to which the reply came that it was no longer needed as the pressure inside the spacecraft would sustain itself at 42 percent. It was now time to shut down most of the spacecraft’s systems in order to save both fuel and electrical energy on their batteries. The longer-life fuel cells would not be flown until Gemini 5.

McDivitt: “*It is now 6+35 elapsed* [6 hours 35 minutes since launch], *and I’m powering down the spacecraft completely. We had turned off the platform and the computer earlier after checking with the ground and completing our EVA. I’m powering down the rest of it at this time.*”

White suggested that they both needed to eat, which McDivitt confirmed: “*I’m about starved to death*.” Both astronauts chuckled at the thought of their ‘big’ meal, which amounted to a few bacon and egg bites. By now, both men were feeling like they were standing on their heads (as the fluids in their bodies shifted towards their heads in zero gravity), and that they kept touching “*the ceiling*” of the spacecraft hatch doors.

With a lull in activities, the astronauts took the opportunity to discuss their rendezvous with the booster and the spectacular view of it orbiting nearby rendezvous with the booster and the spectacular view of it orbiting nearby. Noting that they were now pointing right down towards the ground, and marveling as the terrain passed below them, they went through the EVA operation for the benefit of the ground teams, with McDivitt again highlighting the benefit of all the training they had done in the altitude chamber, the zero-g aircraft and the crew procedures trainer. His colleague agreed.

White: “You’re not kidding. I’ll second that the things that occurred were not the things that we hadn’t done before, and things we hadn’t worked out procedures for before. The things we did, I think paid very heavy dividends today.”

He was also thankful for all the support from the training team and the fact that McDivitt had been working up his muscles on the dumbbells, which gave him the strength to stay in place while securing the hatch after the EVA.

As the seventh hour of the mission passed, White also commented on the initial aspects of actually working inside the spacecraft with the equipment they had trained on, and how small, unforeseen problems were cropping up now they were on orbit. One of the first items, an apparently insignificant problem, was the type of ring attachment for the loose-leaf pages of the Flight Data Books (remember, this is in the days long before computer laptops, tablets or smart phones), as some of the pages were already ripped after taking them out only three or four times in just a couple of hours. They suggested better reinforcements for the punched holes and ring bindings. Another issue was the water gun, with the little teat that stuck out of the end still allowing water to seep out even after the trigger was released. This required care in taking the gun out of the food package after reconstituting the food so that water did not escape. By crimping the drinking water hose, which they found easy to do, they were able to stop the flow of liquid.

Twenty minutes later, McDivitt confirmed that they had finally un-stowed the M-3 bungee cord exerciser, but they were still not ready for a Type 1 aeromedical pass as they were still trying to stow unwanted equipment. “*We’ve got a major housekeeping problem here with all this equipment on board that we’d expected to get rid of,*” claimed McDivitt. They had meant to throw most of that equipment overboard in the now-cancelled second hatch opening and equipment dump shortly after the EVA.

A series of readings followed: firstly from the main battery, which showed 9 amps and 23 volts; then a good blood pressure reading from McDivitt; and finally Adapter Section equipment readings. As White continued to prepare to take his first sleep period, the team back on the ground was having difficulty in receiving all the commentary via UHF from the spacecraft, but they confirmed "*You look good on the ground*."

McDivitt: "OK, we've got everything going fine for us up here, except for all this junk we have inside. Be advised Ed is going to start trying to go to sleep at this time."

With White settling down for a well-earned rest, or at least trying to, McDivitt was told to power down the computer for about the next hour.

Capcom: "We have a long dry spell [in communications] *here until comms are restored at CSQ, and we'll try to leave you alone and let you rest. You have a* [Experiment] *D-8 update. D-8 will be performed. Normal time is 02+30 GMT*."

As Gemini passed over Southern California, the Capcom there requested that the EVA glove worn by White as he brushed against McDivitt's window during the spacewalk should be put in a plastic bag and sealed for post-flight analysis, to determine what material had brushed off with it.

Experiment Introduction

Experiment MSC-1 (Electrostatic Charge)

The aim of this experiment was to gather measurements to define the electrostatic potential of a Gemini spacecraft during the orbital phase of a 'typical' mission. To do this, an electrostatic potential meter (EPM) measured the electrical field on the spacecraft at the point of the sensor unit. To determine the actual spacecraft potential, measurements were taken in an electrolytic tank on the ground using a scaled-down spacecraft model, which allowed conversion from the electrical field at the sensor on the spacecraft. In the flight plan, the experiment was scheduled to be operated during seven separate periods, when one or more of the following conditions were present:

- There was an extensive use of the OAMS
- The spacecraft passed through the South Atlantic Anomaly
- During a period of good definition of the orientation of the spacecraft, and
- During retrofire.

The intention behind this experiment was to discover whether a spacecraft would build up an excess electrical charge, to a level that could be considered a hazard for the subsequent Gemini-Agena docking missions. The measurements were taken from the electrical field terminating in a small area of the retrograde Adapter Section of Gemini and extrapolated from this to calculate the total spacecraft charge potential.

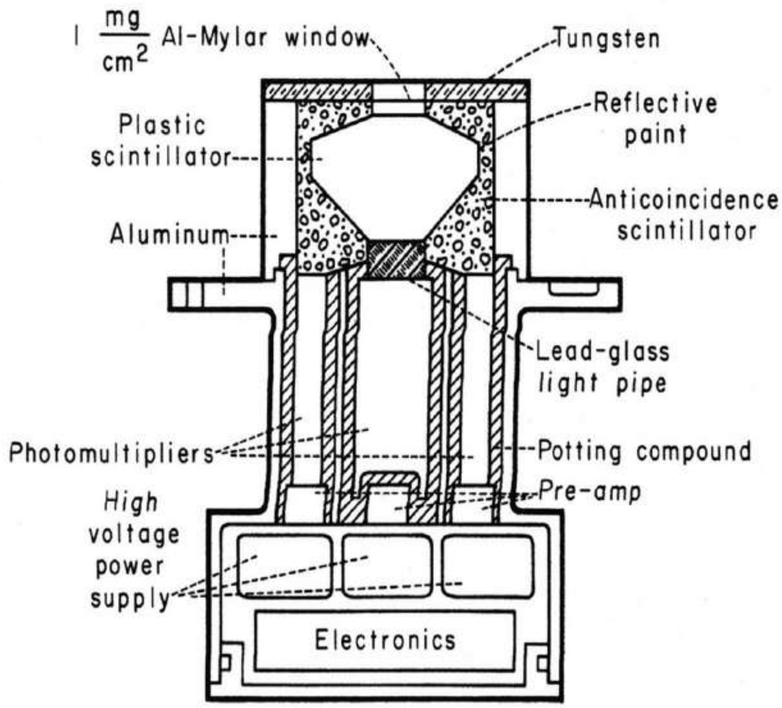


Diagram of the MSC-2 proton/electron spectrometer flown on Gemini 4.

Experiment MSC-2 (Proton-Electron Spectrometer)

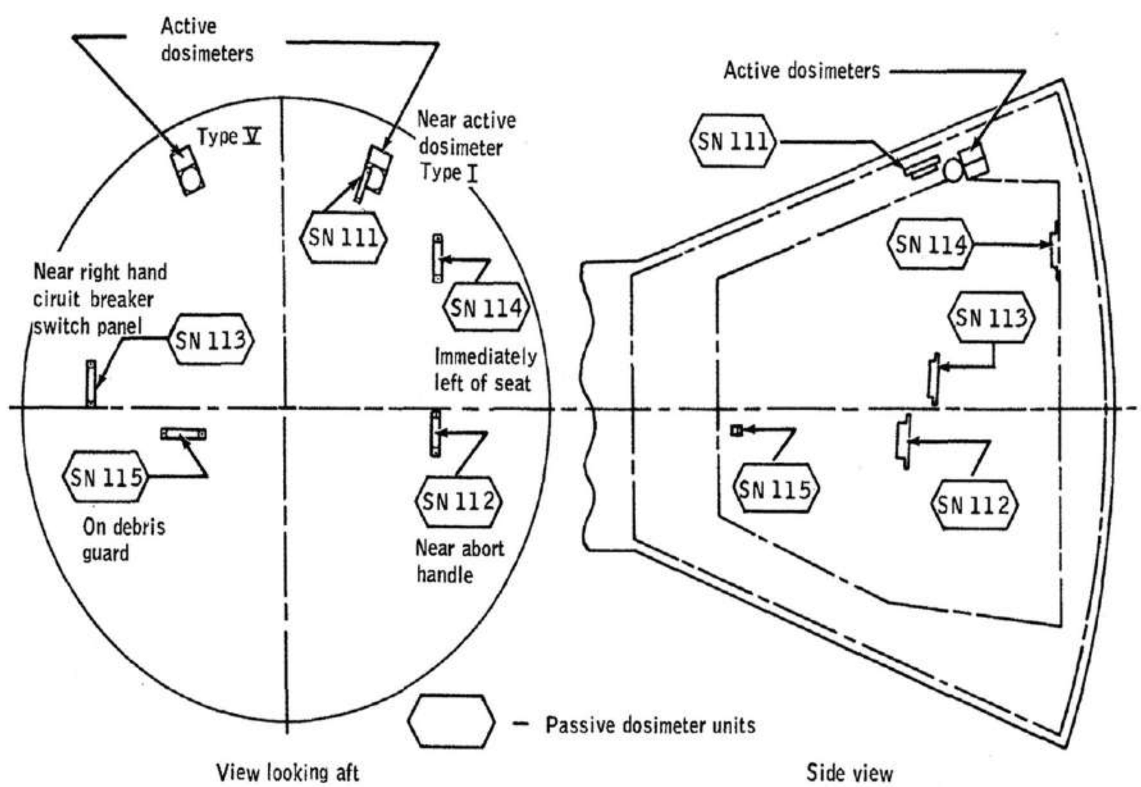
This experiment was designed to detect and measure protons and electrons during the typical orbits of Gemini 4, specifically when the vehicle passed through the so-called South Atlantic (geomagnetic) Anomaly, a region defined by the geodetic latitudes of 15 degrees and 55 degrees South and the geodetic longitudes of 30 degrees East and 60 degrees West. Specifically, the experiment was calibrated to record the flux and energy of protons of energy $17<E<80$ MeV, and electrons of energy $0.5<E<4.5$ MeV.

To achieve this, a proton-electron spectrometer was installed on a support assembly and fixed to the center of the Adapter Equipment Section blast shield door. The plan called for four activations during the flight, with the experiment remaining active on each occasion for at least three revolutions during periods when Gemini would pass through the Anomaly.

Experiment MSC-3 (Tri-Axis Flux Gate Magnetometer)

Supplementing and supporting the information provided by the MSC-2 experiment, this research effort was designed to determine the magnitude and direction of the Earth's geomagnetic field in the South Atlantic Anomaly, with magnetic field line orientation with respect to the spectrometer.

This experiment featured an electronics package whose sensor unit was mounted on the end housing an extendable antenna boom, with an interconnecting cable linking the two units. The boom was extended following orbital insertion and remained in that position for the duration of the orbital flight. The experiment was to be activated four times during the mission and, like MSC-2, remained on for three consecutive orbits each time as Gemini 4 passed through the South Atlantic Anomaly.



Spacecraft installation locations for the D-8 Radiation in Spacecraft experiment.

Experiment D-8 (Radiation in Spacecraft)

This experiment investigated the total amount and quality of radiation levels that penetrated the crew compartment of Gemini 4. The absorbed dose required detailed evaluation of the ionizing and penetrating power of the various types of radiation and their contribution to the total levels recorded, according to their profile, type, time and position inside the cabin.

Two general types of dosimeters were provided to record such data: active dose rate indicators and passive dosimeters. The active indicators featured two tissue-equivalent current-mode ionization chamber instruments, which marked the variations in absorbed dose rates inside the spacecraft as a function of time. The passive indicators included five dosimeters placed at various locations inside the cabin. One unit was located in close proximity to the fixed active dosimeter to provide correlations between the actual dose measured by that unit and the energy-dependent dose recorded by the passive dosimeter. The other four units were installed at other locations within the Gemini spacecraft to record values of integrated dosage from lightly shielded and heavily shielded positions.

The experiment began with the launch of the vehicle, with both the active instruments completing normal operations and constantly monitoring levels of radiation throughout the four-day mission. During passes through the South Atlantic Anomaly, the sensor head of the portable active dosimeter was removed from its mount on the right hatch, then positioned by White in various places around the crew compartment for one minute per location. These included:

A. Against the chest of White, with the sensor head covered with a glove.

B. Between the pilot’s legs in the area of the groin.

C. Under White’s left armpit.

D. In front of the right-hand cabin window.

E. In front of the instrument panel, approximately midway between the floor of the spacecraft and the ceiling.

F. On the floor of the spacecraft between the astronaut’s feet.

The collection of such data (radiation environment, shielding interactions, levels and rates of dosage) was prerequisite for studies to plan for future missions, and necessary “to ensure protection of the crewman against ambient and occasionally harmful space radiation.” [1]

GET 08:30 (Orbit 6/Rev 6) – GET 09:30 (Orbit 7/Rev 6)

With White still resting, McDivitt used the exerciser as part of the M-3 experiment, prior to further updates for a possible contingency landing on the first opportunity during the 18th orbit. The onboard tape was played back while McDivitt took a meal break, being recorded by RKV.

As the spacecraft flew high over the Pacific Ocean in daylight, Flight Surgeon Dr. Dwayne Catterson commented that the medical data from the flight looked "*real great*." With the Pilot still asleep, the doctor reported that White had consumed some bacon and egg bites, toast and orange juice prior to starting his sleep period, but had not commented on the food at the time.

Wanting to keep the activity inside the spacecraft to a minimum to allow White to sleep, Flight Director Gene Kranz ordered all voice communications with Gemini to cease for the time being. The position of the spacecraft relative to the ground stations also made any communications difficult and thus afforded the crew some quiet time on the flight. In fact, thanks to the different elevations and angles as the spacecraft passed over the various tracking sites, communications could at times be troublesome and could occasionally result in a period of no communications at all for 30 to 45 minutes. When that happened, the crew recorded their comments and observations on the onboard tape, to be downloaded and played back over the next ground station they were in contact with.

Experiment M-3 (Inflight Exerciser)

Ed White was the first to use the M-3 in-flight exerciser on the mission. In the original plan, this exercise device was scheduled to be used for 17 exercise periods by Ed White and just four by Jim McDivitt. The exerciser consisted of a pair of rubber bungee cords, with a handle attached to one end and a nylon strap at the other into which the astronaut inserted their foot. The exercise involved 30 pulls at one pull per second, with each pull requiring 63 pounds (279.7 N) of force to achieve a full extension. A stainless steel stop cable limited the stretch length of the rubber bungee cords and created a fixed workload. During each session, the standard Gemini bioinstrumentation was used to record the cardiovascular activity of the astronaut as they used the apparatus. With the increased orbital duration of this mission, the objective of the M-3 experiment was to determine cardiovascular reflex activity in response to a given physical workload (in this case simple exercise) and, in doing so, to evaluate the general capacity to perform a measured amount of physical work under spaceflight conditions.

physical work under spaceflight conditions.

McDivitt: [GET 09:25] "*Weather photography, at about 00:41 on the first day. A whole series of clouds in a very peculiar pattern down on the ground. The light wasn't very good.*"

PAO "This is Gemini Control. We are now at nine hours and 38 minutes into the mission… communication has been difficult due to the elevation and angles at which the spacecraft has been passing over the [RKV] tracking station. For that reason, Flight Director Gene Kranz has ordered that voice communications with the spacecraft be kept at a minimum. This is Gemini Control."

GET 10:00 (Orbit 7/Rev 7) – GET 11:00 (Orbit 8/Rev 7)

Following his meal break, Jim McDivitt turned off the MSC-1 experiment. During the pass over Hawaii, the onboard tape was played back and the Command Pilot was asked to check the communications, switching to the UHF re-entry antennas. Late in the pass, Ed White gave a Type 1 medical data procedure, and updated contingency landing data was passed up to the crew [3].

As the tenth hour of the mission passed, Flight Director Kranz requested that the crew return to the regular flight plan, programming times for measurements of the radiation levels outside the spacecraft and of the Earth's magnetic field relative to the spacecraft. There were also plans to measure the radiation levels inside the crew compartment.

With Gemini over Hawaii, Kranz asked the station to conduct a UHF communication check with the spacecraft as it was maneuvered around, but advised McDivitt to use a minimum amount of fuel to achieve this. The Capcom at Hawaii radioed these instructions up to Gemini 4.

Capcom: "*During your pass* [over Hawaii] *we would like to perform a UHF check. I would like to stress – use minimum fuel, minimum fuel. Place your UHF Antenna Select Switch to RE-ENTRY* [and] *give me a short count.*"

McDivitt complied, after which the Capcom added:

Capcom: "*Now I would like for you to roll heads-up. Suggest using PULSE.*

Use minimum fuel. While you are rolling, perform another voice check on RE-ENTRY… also would like you to build up cabin pressure to 5.4 psi [0.37 bar] *using O_2 rates.*"

McDivitt: "*OK, looks like I'm pointed just about straight up at the sunlight now. I'll try to roll around so I can see the horizon. I'll talk as I'm doing this.*"

Capcom: "*When you get heads-up, place your UHF Antenna Switch to ADAPTER and give me a short count.*"

As McDivitt initiated the maneuvers using his right hand on the central control stick, he was again careful to use as little fuel as possible.

McDivitt: "*I'm just about upside down now, about 120 degree bank. I'll start rolling around… I'm about 90 degrees right now and I'm starting to come out.*"

As Gemini rolled, so McDivitt gave the count at different stages ("*1, 2, 3, 4, 5 – 5, 4, 3, 2, 1*") and again as he returned to level flight, switching between the ADAPTER and RE-ENTRY modes to check the communications through the UHF channel.

With communications now coming via the *Rose Knot Victor* (RKV) located off the coast of Peru, South America, the tracking ship then relayed updates in blocks for both planned and contingency landing areas in six orbital increments.

GET 11:10 (Orbit 8/Rev 7) – GET 12:35 (Orbit 9/Rev 8)

White ended his first rest period at the start of this orbit and both astronauts participated in a briefing update before McDivitt started his first rest period. Observations were made of Typhoon Babe and work continued with the D-8, MSC-2, MSC-3 and S-6 experiments.

Though his rest period was officially due to end at GET 11:10, Ed White awoke earlier than that and reported his status. He updated the flight surgeon with details of an aeromedical Type 1 pass, taking a blood pressure reading and an oral temperature check, as well as using the M-3 exerciser. The Pilot also reported on his intake of food and water, but this was not received clearly the first time and he had to repeat the information before commenting on the quality of his sleep. While he had managed to get some sleep, he reported that it had not been a sound sleep period.

White: *"This is Gemini 4. Pilot got up about 20 minutes ago and had about three-and-a-half hours of rest. It wasn't deep sleep. It was an on-and-off type sleeping, but there was some sleep associated with it. I had for breakfast small cereal, orange juice, bacon and egg bites, and calcified… bits. I've had 12 mouthfuls of water in just a few minutes."*

With McDivitt now preparing for his first sleep period, White occupied himself with the D-8 radiation experiment, taking measurements on himself. "*Starting D-8 experiment. Starting it over the chest… Holding it there for one minute...*" In between reporting on the progress of that experiment, he conversed with his colleague about whether to sleep with his gloves on or off. White told McDivitt that he had not been comfortable wearing the gloves (a contingency in case of a sudden cabin depressurization) before returning to his report on Experiment D-8: "*Going up to the armpit. Completing the run in ten minutes.*" The Pilot was also occupied with experiments MSC-1 and MSC-2. The results from these experiments were to be relayed to the Hawaii station as Gemini passed overhead. White also reported on his observations of the Earth.

White: *"I took an* S-6 *picture of cloud formation over the Pacific* [weather photography, though the air-to-ground transcript incorrectly reported that it was an S-5 [Earth terrain image], *coming on the* Coastal Sentry Quebec *area at 03:00* [GMT] *using f/11 at 150. It was frame no. 28.*"

White reported that he was taking several pictures as he was right above the tropical storm Carla.

White: *"It's very heavily overcast right now. I'll take a few* [pictures] *of the cloud formations. They have some interesting formations interlaced on the top of them. Perhaps the camera will pick them up?*"

He found the storm very bright and changed the settings to 250 at f/16 for frames 28 to 31 as he passed right over the weather system far below, marking the time on the air-to-ground for later post-flight interpretation. As he worked the cameras, he found that at least one shutter did not seem to work correctly and reported that fact to the ground.

White: *"The shutter to the Hasselblad seems to be delayed in dropping. I hope it's not ruining… occulting the pictures… Looks like we're pretty well out of the* *typhoon area. I'll wait until I get out just a little further and try to get a broad all-over shot that covers the whole area.*"

A few minutes later, White reported that all was going well on board with McDivitt now asleep and that he was preparing to eat again, this time a dinner of roast beef and cream corn. He also informed the ground that they (the crew) had decided to delay the next D-9 run on the flight plan "*because we feel that we should be both up for it. It requires coordination.*" White also added more observations to the post-EVA summary, stating that he found his ability to maneuver during the EVA was very good when using the maneuvering unit, and that he had little trouble when not using it.

Now in the daylight side of the orbit, voice communications via the CSQ in the Pacific remained quiet, with only data from a medical pass being transmitted. At MCC-Houston, as hour 13 of the mission approached, members the Blue Team of controllers headed by John Hodge, with Capcom Gene Cernan and surgeon Dr. D. Owens Coons, began arriving an hour early to take over from Gene Kranz's White Team.

EXPERIMENT S-6 (SYNOPTIC WEATHER PHOTOGRAPHY)

The primary objective of this experiment was to obtain a series of high-quality photographs of a number of specific cloud formations and meteorologically interesting weather systems. A secondary objective was to obtain images of areas concurrently being viewed by the TIROS weather satellite, in order to aid in the interpretation of the high-altitude satellite TV-type photos with lower-altitude still images of the same formations.

To achieve these objectives, the astronauts were provided with a 70-mm camera, which would be used for this and other experiments. The actual experiment equipment was a single 55-frame, 70-mm film magazine, but with the camera being used for a variety of objectives, it was determined that the S-6 images could not all be taken in one magazine. Gemini 4 carried five such magazines and the astronauts had to ensure that at least one magazine's worth (55 out of the 275 frames available) was reserved for executing the S-6 experiment objectives during the mission.

With constantly changing weather patterns, this experiment required a coordinated effort between meteorologists of the U.S. Weather Bureau's National Weather Satellite Center (NWSC) and the flight crew. The crew had been briefed immediately prior to launch on June 3 about the weather systems which existed at that time and about which of these should be photographed. During the mission, meteorologists at the NWSC referred to worldwide

During the mission, meteorologists at the NWSC referred to worldwide weather maps and recently-received TIROS pictures to select specific areas of interest likely to include weather systems worth imaging. Then, when operationally feasible, this information was communicated to McDivitt and White on board Gemini 4 so that they could locate and photograph these targets.

For about 30 minutes, with contact with CSQ having ceased and with McDivitt still asleep, White silently passed over the dark side of Earth towards the RKV's communications region. He recorded his observations out of his small forward viewing window, dictating into the onboard tape recorder and offering a unique perspective of the stellar backdrop as Gemini moved stealthily at five miles a second. It must have been a serene and awe-inspiring experience.

White: [recording into the tape from GET 12:28:42] "*I'm looking at the stars now. Its light, not full dark. It appears that the window gives you a filter that cuts down the smaller magnitude stars. I'm looking out right now at the Big Dipper and right on down to Arcturus and it appears to me that what I'm seeing right now are primarily the second and third order stars. The smaller ones are pretty well out of the picture at the present time. As you get deeper into the night, I think more of them will come out, but you definitely don't see as many stars as you do flying at 40,000 feet* [12,192 m] *in an airplane on a good clear night… The star of Corvus is right out in view right now. It seems to be in pretty full view. I'm picking up probably down to about fourth order stars right now*."

As Gemini flew 'deep into the night', White was amazed at seeing stars down to the fifth magnitude, though still not as many as he remembered seeing though the canopy of an aircraft flying at night. Dimming the onboard lights on Gemini 4 made the view even more spectacular: "*I've got a horizon comprised mainly of clouds. The stars, as they start to go down into the main airglow… are more difficult to see* [than those they had observed earlier in a thicker layer of air glow]." After nearly 20 minutes of observations, the Pilot recorded: "*This time of evening and at night, the skies are quite black and the stars are quite visible, I can see at least fifth order*."

Capcom: [GET 12:37:22] "*Gemini 4, RKV Capcom.*"

The peace and tranquility of a silent orbital night pass was shattered as communications were established through RKV. White was asked to ensure that a High Rate of O_2 was maintained in the cabin, as well as a source pressure of between 930 and 960 psi (64.1–66.2 bar) in the fuel bladder tanks. He then reported further on his stellar observations, so transfixed by the stellar display that he realized he was late in turning off the MSC-2 and -3 experiments.

White: "MSC-2 and MSC-3 are being turned off at 04:19:40 [GMT]. *I'm afraid I was watching the stars so much I forgot to turn it off at the proper times. Right now, it's daylight over on Jim's side* [it was found that they could keep the spacecraft orientated so that one side remained dark while the other side was bathed in sunlight]. *This was one of the things which surprised me earlier in the flight when I was looking out at all the little fireflies from the booster and remarked how dark it was and how it looked.* [Then] *I looked over to Jim and he was looking out of a perfectly daylight window. That's actually the way it's supposed to be, but it was a quite interesting time – the first time you see it.*"

Later, passing over Africa, White snapped further S-5 images of the terrain below. "*I'm just over the Sahara Desert. It's really a beautiful view,*" he observed.

GET 13:35 (Orbit 10/Rev 9) – GET 14:15 (Orbit 10/Rev 9)

When the spacecraft was within range of the CSQ tracking station once more, some of the communications involved routine but essential regular updates on the performance of spacecraft systems, changing orbital parameters and re-entry information or upcoming experiment activities. Such exchanges did not make for good headlines or media copy, but were necessary information sequence exchanges on these early missions. In this case, retrofire information was passed up to White but once again communications were irregular, requiring the Capcom to re-transmit the data.

CSQ Capcom: "Area-11 DELTA: T zero. GMTRC 01 days 07 48 58. RET 400 K, 15+26. Area 12-DELTA: V 96. T 2+05. GMTRC 01 days, 8 hours, 46 minutes, 55 seconds. RET 400 K 07 +30. RET reverse bank 13+31… are you copying?"

After confirming he had the figures, White advised the Capcom that their O_2 pressure was holding a little higher than 960 psi (66.2 bar), adding: "*I'm not* *going to O_2 High Rate at this time* [GET 13:43:01] *because the Command Pilot is sleeping pretty well and I'll let him sleep*."

Flight Day Two: Friday June 4

As hour 14 of the mission approached, Ed White carefully monitored the O_2 pressure level. During the periods he was awake by himself, the pilot recorded how difficult it was to spot something to photograph and grab the camera in time before the spacecraft's orbital velocity moved them past the intended photo target.

White: "It looks like I just passed over some of the Marshall Islands down there [in the Pacific]. *They were quite clear and you can see the atolls and stuff around the islands themselves. I tried to get a picture of them, but I caught them just a little too late. They were very clear and easy to pick out*."

By now, McDivitt was stirring from his sleep period, coming onto the air-to-ground at GET 13:53:40: "*Roger. Command Pilot awake, over*."

GET 14:15 (Orbit 10/Rev 9) – GET 16:00 (Orbit 11/Rev 10)

> *The Rose Knot Victor tracking ship updated the information for the Earth reference map aboard Gemini. Shortly after McDivitt awoke from his rest period, he passed on Type 1 medical data. With both astronauts now awake, another joint 20-minute briefing was held between the ground and the crew. This orbit also saw the first run of the orbit navigation check exercise, but without using fuel.*

During the next orbit, the Capcom at RKV (K. Kundel) uplinked new instructions for the flight plan. For a period of about 40 minutes, the communications between the ground and Gemini 4 were quite good, but then became intermittent on the C-band frequency.

During this time, White asked one of the tracking site Capcoms to relay a message to Houston that they had found a burned-out bulb in the aft window of the sextant. The crew asked for further instructions, wanting to know if there was a spare bulb aboard the spacecraft. The message soon came back that there was no spare, and the suggestion from Houston was to use the fingertip lighting on their spacesuit gloves to illuminate the sextant instead.

The Capcom reported negative C-band tracking over Ascension and queried what the attitude of the spacecraft was at the time to check where the error may have occurred. McDivitt reported: "*… the small end was pointing up at the stars primarily, and we were in free drift*," while White explained once again about the poor communications they were experiencing. The Pilot also took this opportunity to update the ground on his progress with the S-5 experiment over the African continent, the east coast of Africa, the Arabian Peninsula and as they flew over the Himalayas.

White: "*We're passing over the Himalayas, I believe. Very close to the pictures that Gordo* [Cooper] *took on his orbital flight* [Mercury 9 in May 1963]. *I believe Jim is looking out through his window at it now.*"

McDivitt then announced that they had been able to get the used urine bags dumped overboard successfully, proudly reporting the avoidance of any spillages of water inside the cabin, so far. Meanwhile, the Capcom gave the crew new data for observing and photographing a Typhoon just off Hong Kong during their 11th pass over the area.

Capcom: "I have an update for photographic opportunities on the eleventh revolution… Typhoon Babe, GMT 07:56 south of Hong Kong. It will be north of the ground track."

GET 16:00 (Orbit 11/Rev 10) – GET 17:15 (Orbit 12/Rev 11)

This was a quiet orbit, with McDivitt taking a 40-minute meal break and the crew receiving further updates to planned and contingency landing areas.

As they flew over the Mediterranean, McDivitt commented on how easy it was to recognize vessels on the sea: "*I see a couple of very large ships. They started off from Beirut.*" This was similar to the sightings that Gordon Cooper had reported two years earlier, though at that time he was not totally believed.

Then, 15 minutes later, White added: "*I shot off the Contarex* [camera] *trying to get Hurricane Babe. It wasn't very successful. The hurricane itself isn't very prevalent. Looks like another group of clouds.*" Later in the orbit, communications with the ground improved, to which McDivitt commented: "*It's very nice talking to people I can understand. It doesn't happen very often.*"

Capcom: "*Everything still looks real good to us on the ground.*"

McDivitt: "*Roger. It looks pretty good up here too.*"

Capcom: “Roger. It would.”

McDivitt: “I think I’ve looked at the Earth from every conceivable angle over the last 6 to 8 hours.”

Capcom: “Yes, I can imagine.”

The improved communications finally allowed McDivitt to update the ground on some habitability issues on board the Gemini.

McDivitt: “It is really good to talk to somebody that I can understand and somebody who can hear me.”

Capcom: “Roger, we are kind of in the same shape here. Sitting out on this boat [RKV], *we have a little trouble getting communications with the rest of the world… How’s the sleeping going up there, floating around?”*

McDivitt: “Actually it doesn’t go too well, because unfortunately we don’t have any way of shutting off the radio. So when we’re talking like this, Ed can hear you and me though his volume is down, I’m sure he hears us right now. And it’s awfully cramped. We’ve got all this extra equipment on board that we’d hoped to dump out and it is really crowded.”

McDivitt agreed with Capcom that it was similar to ‘soft sleeping’, without the pressure of weight.

McDivitt: “It is, but you are still restricted to a certain position, just like sitting in a bus seat. Although you do not sit on your fanny, you still have to sit in the same shape.”

He went on to explain that most of the extra equipment (which he referred to as “*that junk*”) was down in the footwells, “*and I guess we are going to have to hold some of it during re-entry*,” he surmised.

McDivitt: “So far, our major problem, aside from the hatch and a few other exciting moments, is trying to figure out what to do with all the stuff we’ve got.”

Capcom: “Oh Boy! That sounds like a lot of fun… Well, let’s see. There’s a lot of empty space out there around you.”

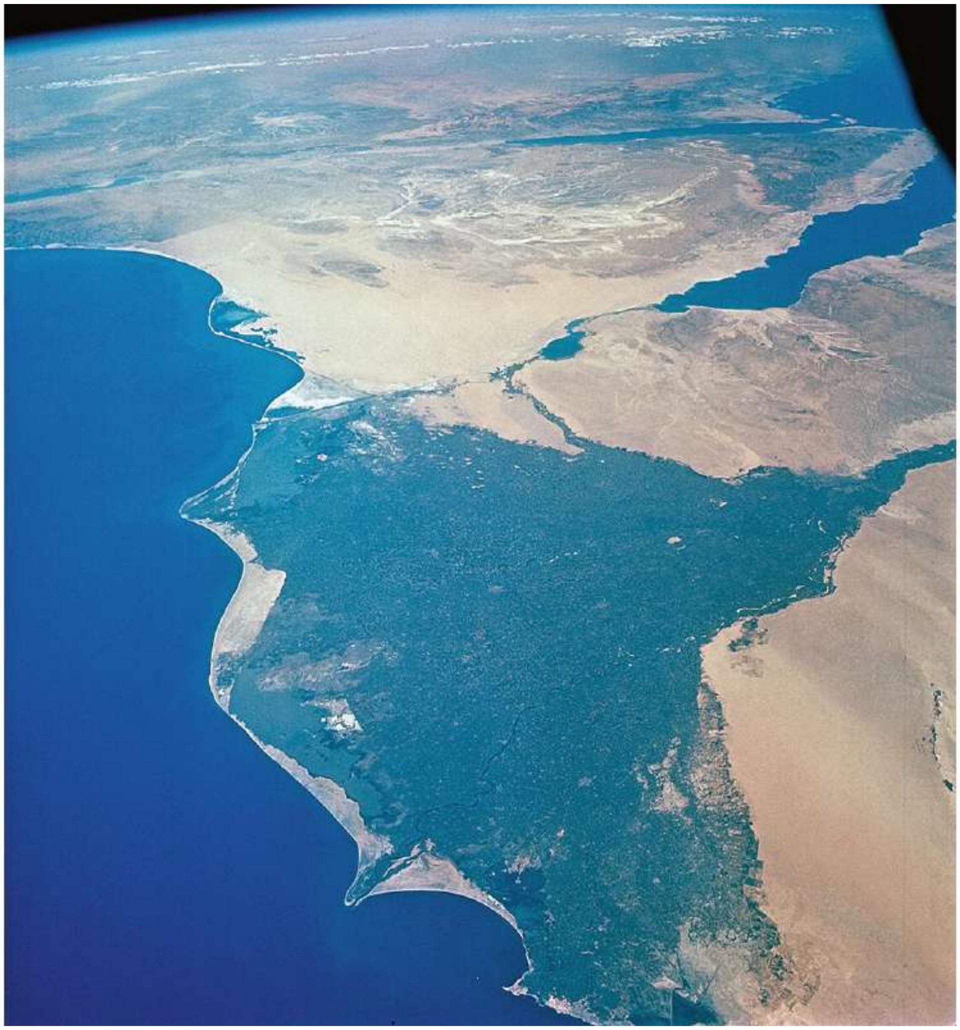
McDivitt: “And I sure wish I could get at it.”

McDivitt was also asked by the Capcom, upon advice from Flight Director

Kranz in Houston while there was good communications on the air-to-ground, to go over the problem with the hatch closure again.

McDivitt: "There are two gears that we have that go around when you pull the handle back and forth. One of them is the gear that sort of acts as a ratchet, a little cylinder with a piston in it and a spike behind it that engages the ratchet. And we were having a little trouble with that before we got it on, and after we got it open we had difficulty getting this ratchet to work. Also, we had a great deal of difficulty getting the hatch closed far enough so that we could even start latching it. Then, Ed had to push the ratchet with his hand on every go until we got the thing started. And I was pulling on the thing until I thought probably I was going to break a lug right out of the hatch. And we finally got it going, and it finally came forwards. So I don't think we ought to try opening it up anymore… I'm not sure what the trouble was when we got it down closed but I tell you one thing, I'm glad that we spent so much time training in closing – opening and closing hatches."

Capcom: "Sounds like a good idea to keep it closed… all that extra training sure pays off at times."



Taken from Gemini 4 during the 12th revolution/13th orbit on the second day of the flight, this photograph shows the Nile Delta, Egypt, the Suez Canal, Israel, Jordan, Syria, Saudi Arabia and Iraq.

GET 17:40 (Orbit 12/Rev 12) – GET 18:50 (Orbit 13/Rev 12)

During this orbit, both astronauts took a meal break, work continued with Experiment S-6 (without fuel) and the M-3 exerciser, and there was a further update to nominal and contingency landing areas.

Flying above the South Atlantic and up towards Africa, White was busy photographing cloud formations and an old African volcano, reporting the number of the film pack he was using and the frame numbers he was taking. This would be important for photo analysis back on the ground after the mission, to cross reference with the timeline to pinpoint exactly where they were in the orbit when they took the photos. Suddenly, McDivitt exclaimed "*I just saw the booster in the sunlight, at a distance I would estimate of 50 miles or so. Time is*

09:16 and a half [GMT – or GET of 18:00:21]. *I don't know which way I was pointing when I saw the booster. Can't see the ground at the present time.*"

As the orbit progressed, the RKV Capcom advised: "*I've got a whole lot of things to pass up to you.*" That list included a world map update, corrections to the flight plan on times to dump the onboard tape recorder data, and more updates to the contingency retro burn opportunities on orbits 13 through 17.

GET 19:10 (Orbit 13/Rev 13) – GET 20:35 (Orbit 14/Rev 13)

> *With the meal break over, it was back to work. The crew received an update to the first planned Apollo Landmark run, including an astro-orbital navigation check run, and without propellant use in ATTITUDE CONTROL mode. The crew also switched biomedical recorders before McDivitt began his next planned five-hour rest period.*

Earlier, McDivitt had asked for an update to their orbital parameters from the Capcom stationed at Grand Canary. This was given as an apogee of 155.7 miles and perigee at 88 miles (250.5 x 141.5 km), with the Capcom reporting that a more accurate determination would be sent up after analysis of the radar track data. This was followed by even more updates to the flight plan, while Ed White changed the biomedical recorders from Number 1 OFF, to Number 1 ON and Number 2 OFF.

White then began searching for the sextant, asking McDivitt if he knew where it had been put and whether it had been stowed back in its box or elsewhere. White wanted to use it during McDivitt's next sleep period and asked if he had managed to get the failed bulb to work. Passing the sextant to his colleague, McDivitt said that he had not. The Command Pilot then checked with the ground that they were still planning on "*getting back on the fuel line*," and reverting, from GET 22:00, to the rest of the original schedules on the flight plan. This was confirmed. With that agreed, McDivitt then checked with the ground that the onboard flight plan was up to date – and matched the one on the ground – before he started his next sleep period.

GET 20:50 (Orbit 15/Rev 14) – GET 22:05 (Orbit 16/Rev 15)

> *This was a quiet orbit for White, but included the second orbital navigation check (without fuel usage).*

With McDivitt now in his sleep period, White was back in communication with the Capcom at Carnarvon, who requested that he put an oral thermometer in his mouth and pump the blood pressure cuff up. He did so, and the readings were picked up on the ground. However, as the M-3 exerciser was stowed over on the left (McDivitt's) side of the cabin at this point, and White did not want to disturb his commander, he decided not to exercise at this time. He advised that he would delay the M-3 session until after McDivitt had woken up, to which the Surgeon agreed before asking White to report again on what he had consumed and his quality of sleep so far. "*I had a very deep sleep for about four hours,*" he reported, "*then woke up and then went back to sleep for a least two-and-a-half hours. Jim had to actually blow reveille for me to get up,*" he admitted, adding that he had consumed six swallows of water since getting up but had yet to eat Meal D.

For comfort, White had taken off his suit gloves and had removed the sleeves of his suit after his first sleep period, but McDivitt had elected to keep his gloves on while he slept. At GET 22:08, Gus Grissom, on duty as Houston Capcom, passed on an update to their fuel usage and projections for the rest of the mission.

Grissom: "We *want you to resume your normal flight plan. We base this on the fact that we feel that you have 203 ft./sec* [61.8 m/sec] *V left and 63 revolutions* [of the Earth]. *You'll still be in an 81 by 125.7* [130.3 x 202.2 km] *orbit... That will leave enough for OAMS retro which we think will be 113 ft./sec* [34.4 m/sec] *at that time… Your orbit isn't decaying as fast as we had expected… has a decay factor of approximately 0.8. So we are happy with your orbit and we don't feel you're going to need an orbit adjust. This is based on the amount of fuel used up in your first orbit. We're using this as a basis.*"

White: "*That sounds good. This is a streamlined Gemini capsule.*"

Grissom: "*Go ahead and try your Apollo Landmark Identification but remember the thing* [meaning the ground target] *is 92 miles* [148 km] *away so don't use very much fuel looking for it. I recommend you reduce your use of fuel from one on.*"

As Gemini 4 was flying over Bermuda again, Grissom came back online to ask White about the comfort onboard with the cabin fans on. White reported that they had just one fan on at that time and had been in that situation for the previous two hours.

White: "*It's not bad. It gets little warm in here. It seems to get warm when I go to sleep. I don't know why. It should get cold then, but seems to warm up* *then and we put both [fans] on for about three hours while I was asleep… It seems to get a little warmer in this bunny suit.*"

Despite the science and engineering tasks on the flight plan, it was not all work-related communications between the ground and Gemini 4. Now that the rendezvous and EVA had been completed, this was the start of a quieter period in the mission as far as significant events were concerned, and so the routine was often interrupted by news from home to keep up the crew's spirits. Of course in 1965, there was no Internet, video link or social media, and their connection with Earth was through a person reading up news over the radio. With McDivitt still asleep, Grissom asked White to pass on the news when he woke that the baseball team McDivitt's son played for, The Hawks, had beaten The Falcons 3-2 in their Peewee League match. Grissom also informed White that McDivitt had made the headlines in the *Houston Post* that day with his apparent comment: "*Aw Ed, Please Get Back in the Spaceship.*" Following up on their report of the historic spacewalk, White made another comment to Grissom about the difficulty of getting back into the spacecraft, and the tough decision to end the EVA. "*It was something out there*!" he recalled fondly, to which Grissom replied, "*Yes, I bet! I envy you.*"

A few minutes later White took his meal break, which consisted of soup followed by chicken salad, finished off with fruit salad and orange juice. He expanded upon the view of the Houston area he had seen during the EVA the day before. White explained to Grissom that he could see the Gulf of Mexico and Galveston Bay right up into Clear Lake, the location of the Manned Spacecraft Center and Mission Control, and the neighborhood for many of the astronauts' homes. Grissom asked if he had spotted the new Astrodome stadium (which had formally opened on April 9, 1965):

White: "*I was looking for it but I couldn't pick it out. I didn't see it, [but] if I could have spent time looking down I could have seen a lot. I [could] see a heck of a lot more from outside the spacecraft than inside. Things are very much clearer. One of the prettiest sights I saw was when I looked down and saw the tip of Florida and the islands of Cuba and Puerto Rico and Santa Domingo. It was really quite a view. The colors of the blue and the hues as the water deepened out there around the islands was quite a view.*"

Using the hand-held Hasselblad camera, the crew took this image of the coastline of Florida. The Cape Kennedy area is in the lower-left of the frame, where the LC-39 Pads A and B and the crawler way can clearly be identified.

White then corrected a misunderstanding over whether he had said that he could see buildings during the night pass, which he had not, adding:

White: “*You might relay to the Australians that they’re sure running up the big electricity bill. I could see as we came over on the last pass. I could see the lights of Sydney loud and clear and the usual thunderstorms up north.*”

White then added his thoughts on future EVA operations with a tether, as he had used his to pull himself down onto the surface of the spacecraft. He was hoping that the next time he had the chance to perform an EVA with a tether, it would that the next time he had the chance to perform an EVA with a tether, it would be a pretty good experience.

White: "*It is still hard to get any traction on the top [of the spacecraft], but if you pull yourself down you can get a little bit. It looks like it will be pretty good on the Adapter, too, so that might help a lot.*"

GET 22:35 (Orbit 16/Rev 15) – GET 23:35 (Orbit 16/Rev 15)

With White in control as his commander slept, the Pilot completed the first Apollo Landmark Identification, without fuel usage, on attitude control. He also gave a further update on Experiment S-5, again without fuel usage, and commenced his meal break at GET 22:55.

As Grand Canary came into range, they informed White, who was still eating, that all the onboard systems looked green. He replied that it looked good from his perspective on orbit too, with the O_2 level remaining down around 940 to 947 psi (64.8–65.3 bar) but nothing else to report. He joked with the Capcom: "*You just caught me with a mouthful…* [Capcom apologized, then White added] *I'm just kidding you. Everything's fine up here.*"

While they were operating in a minimum power configuration to save electrical energy as the pass over Carnarvon continued, White asked the Capcom whether procedures could be worked out to take some "*inside the spacecraft pictures*" instead of images through the small hatch windows (of which they had taken very few). He said that he had taken some already, but that they still had 200 feet of film left. White thought that the experts on the ground could suggest some light meter readings to help the images come out better and added that they might be able to take some internal movie images with the 16-mm as well.

At just under 24 hours into the mission, the problem of housekeeping was also beginning to become a priority, and thoughts were turning to restraining the equipment they had been unable to jettison for re-entry, with the Capcom asking if the "*junk*" was floating all over the cabin. White said that, at that point in the flight, the clutter was not too bad, with the bulk of all the extra stuff stored underneath their legs behind their heels.

White: "*It's stuff you don't use very much anyhow, so it's not much of a discomfort. But we've got the cameras and bags and refuse bags pretty well stuck all around on the Velcro.*"

The Capcom asked if they had tried to get any of the items back into the aft food boxes, to which White said they had not as they planned to put the refuse bags in the right food box later. The umbilical was a problem, and White explained that if they stuffed it back into the aft food box, then all the garbage bags would be cluttering the crew compartment instead. For re-entry, he was planning to hold the umbilical on his lap. They had also slept on the idea of reopening the hatch to get rid of some of the unwanted items, but now this was no longer on their agenda, especially after the difficulties of closing the hatch after the EVA, they believed they could live with all the clutter for the duration of the mission. Even with all the items around them, they could still stretch themselves out. White confirmed that they had successfully dumped some used urine bags overboard, but had yet to try the solid waste collection bags. Dr. Berry was not surprised by the fact that either man had yet to have a bowel movement, due to the low residual diet, and noted that it would not surprise him if neither astronaut did so until the following day. They had also not noticed any undue moisture problems from humidity in the spacecraft so far.

GET 23:35 (Orbit 16/Rev 15) – GET 25:15 (Orbit 17/Rev 16)

White ended his meal break at GET 23:35 and completed an exercise period with experiment M-3. Meanwhile, Guaymas updated him on the times for the planned HF test.

Over Grand Canary, White asked whether Houston could update them on the specific time for forthcoming experiments, in order to help them to prepare in good time now that they were back on the regular flight plan agenda. The Capcom at Grand Canary also congratulated them for having flown for 24 hours, and on everything looking good on board from data received on the ground.

White: “*Roger. We got three* [days] *more… three more to go*.”

Over Carnarvon, White reported that they were powered down once again.

White: “*All the lights – looks like I am pulling about 13 to 14 amps – and everything are down. The lights are down and I am observing stars right now, and the Command Pilot is still asleep… Everything is normal in the spacecraft… She* [Gemini] *is orientated up towards the stars*.”

Capcom: “*You said the Command Pilot is asleep. He doesn’t happen to have that oral probe in his mouth does he, for a temperature?*” [they were receiving a reading on the ground.]

White: *“No. I’m afraid he’s not that cooperative.”*

As Gemini flew over Canton, communications again became frustratingly sporadic, which White assumed was because they were flying small end forward (SEF) with the nose of the spacecraft pointed straight up, out to space. Then, over Guaymas, White was asked whether he wanted to pass on anything to the Capcom before they put him on live on TV and radio over the United States pass. There was not, but he cautiously asked: *“Is there anything in particular they* [the media] *are looking for*?” The Capcom replied in the negative and added: “*I guess they just want to make you famous.*” The reply from White was a brief “*Oh yeah?*” Answering media questions was always a challenge for astronauts, and doing so while flying a mission added to that challenge.

References

1. **The Gemini Program Physical Science Experiments Summary**, Edward O. Zeitler and Thomas G. Rogers, NASA/MSC, September 1971, NASA Technical Memorandum TM-X-58075, p 227

Footnotes

1 During the Shuttle program, Eastern, Central and Pacific Times were utilized, but with international cooperation from around the world on the ISS, time on the station is standardized to GMT or Universal Time, although national launch and landing times are also given in local time.

2 For each 24 Earth hours, the crew would complete about 16 day/night cycles along their orbital path (or 15 cycles per 24 hours if calculated using revolutions, as a revolution is about six minutes *longer* than an orbit), which made following a terrestrial-based timing system more difficult. At the time, procedures were being evaluated in local (Central) time at Mission Control, Houston, (Texas), while the count up from the moment of leaving the pad (Ground Elapsed Time – GET) was being calculated using Universal Time (Greenwich Mean Time in London, England), which complicated the tracking of missions even more.

3 The crew had to perform two medical procedures during the flight. Medical Data Procedure 1 (which was the higher-grade evaluation) required the astronaut to take a blood pressure measurement, then perform the M-3 exercise followed by a second blood pressure measurement. Medical Data Procedure 2 (a lesser-grade evaluation) involved just taking blood pressure and oral temperature measurements without performing any exercise.

David J. Shayler, *Gemini 4*, Springer Praxis Books
https://doi.org/10.1007/978-3-319-76675-1_9

9. Something else up here

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

"[We] would like to congratulate the new American space flight record [holders]. Congratulations!"
Hawaii Capcom to Gemini 4 upon surpassing the single U.S. space flight record of 34 h 19 m 49s set by Gordon Cooper aboard Mercury Atlas 9 on May 16, 1963.

As with each flight before and since, Gemini 4 was all about achieving its mission objectives not breaking records, although such records were – and still remain – a supplementary achievement and a headliner for the media. By the end of their second flight day in orbit, Jim McDivitt and Ed White became holders of two world space 'firsts' and had set three U.S. space records. A few minutes after surpassing Cooper's record at 21:41 EDT, the two astronauts together logged more time (68 hours 51 minutes) than all the eight previous U.S. astronauts combined. About six hours earlier, the Gemini 4 astronauts had also surpassed the duration record (26 hours/17 orbits) for a multi-crew spacecraft, set by the Voskhod 2 crew of Pavel Belyayev and Alexei Leonov less than three months earlier. It was also reported that White became "the first man to use a self-propulsion unit to maneuver in space away from his capsule," during his EVA on June 3. **[** 1 **]** That same day, Gemini 4 achieved an altitude of 183 miles (294.4 km), surpassing the record attained by Wally Schirra on Mercury 8 in October 1962 by seven miles (11.2 km); and there were still three days of flight remaining before splashdown.

Discussing the Gemini 4 flight in the Mission Control Center are astronaut Donald K. Slayton (left), Assistant Director for Flight Crew Operations and Paul Haney, MSC Public Affairs Officer.

Flight Day Two: Friday June 4

GET 25:20 (Orbit 18/Rev 17) – GET 26:50 (Orbit 19/Rev 18)

> *This orbit started with an update for a contingency landing in three orbits' time, should they require it. Once the latest rest period for McDivitt was over, both astronauts participated in a briefing before resuming their activities. They also switched biomedical sensors and McDivitt completed a Type 2 medical data procedure. The orbit also saw an HF test at orbital sunset and another during the night pass.*

As White copied down new burn, sunrise and sunset, and orbit times, McDivitt was ending his rest period. When the Capcom heard his voice, he joked "*Hey! Sounds like a new voice… you've been asleep for days.*" McDivitt then reported on his last sleep period, in response to a question about whether he had slept well. “*Not particularly*,” he said, “*I just rested, and I’ve been dozing on and off, but I haven’t had a sound sleep this last time.*” He reported that the radio had kept him awake and suggested that there should be some method to allow the crew to turn it off completely, without violating safety regulations. He also explained that they had not tried the fingertip lights to illuminate the sextant and were trying to find a different source: “*It just means that the [sextant] operation is going to be slowed down, and I’m sure we can do it as it was designed.*”

McDivitt also said that he had not eaten yet but had taken about five swallows of water, having taken a similar amount in the middle of his nap. The Capcom replied: “*Okay, the sawbones* [1] (Flight Surgeon) *advises you ought to go ahead and get something to eat now.*” McDivitt complied. A few minutes later, he reported on what he was looking at out of the window of Gemini as he maneuvered the spacecraft around for a better view.

McDivitt: “*It is now 17:21 G.M.T. and I don’t know exactly which way I’m pointing but there is a bunch of rays, all extending up from the Earth towards the sky. It looks like it’s predominantly the sunrise. The rays are actually sticking up vertically and I’m taking two pictures of them with the Contarex* [camera]. *It looks a lot like the Northern Lights…*”

After his meal, McDivitt reported his food intake to the medics, as well as the fact he had not had the orange juice out of Meal C as he had “*lost that some place. I don’t know where it* [went]”. He also did not eat the toast because it was just too crumbly to use on orbit. Both astronauts had agreed not to eat the toast too often because of the potential problem with the crumbs finding their way into the suits (which would irritate them, being unable to remove their suits), or behind the display panels (potentially causing a short circuit). McDivitt also reported difficulty with his blood pressure cuff.

McDivitt: “*I can’t get it to stay in my suit, and when I do get it in, it doesn’t want to bleed down. So if you see some erratic pump-ups, it’s because I’m not having much success with it. I have had the same problem since lift-off. I can’t get the darn thing to stay in my suit* [fitting]. *It keeps popping out of my suit, and then I have quite a difficult time getting it to bleed down sometimes.*”

The Flight Surgeon asked whether he had ensured that he did not have his thumb over the holes where the air came out, stating that the ground had received valid blood pressure readings but that the pressure seemed to hold up for quite a time prior to bleed off. McDivitt agreed that the air seemed to bleed out around where he plugged it in, rather than through the hole it was supposed to bleed from. At this point, the Surgeon went offline to investigate the probable cause and find a remedy for the problem.

As Gemini 4 flew over Hawaii, the astronauts were advised by the Capcom that both their wives were at Mission Control in Houston and were ready to communicate with them as they flew over Guaymas. Prior to this, as Gemini flew into contact range with the Californian station, information relayed from the Houston Capcom had once more provided an update to the flight plan. Due to cloud cover over the intended Apollo Landmark sites, Runs 2 and 3 would be deleted. There was also a suggestion to accomplish the next D-9 experiment run in drifting flight, if they attempted it, as the ground felt that it was not advantageous to waste any fuel completing this data take.

A few minutes later, the Capcom updated the crew with the latest news and sports, including details of a tragic military air crash the previous night, in which five air crewmen had been killed during the landing of a KC-135 tanker (63-8042) at Roswell-Walker Air Force Base, Roswell, New Mexico[2]. The Capcom then told the Gemini 4 astronauts that most of the rest of the news focused upon their own flight, "…*and you know pretty well what's going on there, so I won't repeat that to you*." McDivitt commented that they did know what was going on, with the Capcom warning him "*Don't admit it if you didn't!*"

Soviet Rivals Pass on Best Wishes

In an interview conducted with the Bulgarian news agency B.T.A., following Ed White's EVA, Soviet cosmonauts Alexei Leonov and Pavel Belyayev wished the crew of Gemini 4 "happy landings" but regretted there were no TV pictures of their EVA. Three months after their Voskhod 2 mission, the cosmonauts were on vacation at a Black Sea resort. Leonov reportedly said "To me, as a man who [has] already been in outer space [meaning EVA], it would have been interesting to see how my American colleague achieved the same thing and make a comparison." He suggested that apparently the American space experts had "learned many things from the Russian flight," and that the experiences from Voskhod 2 had "served as a considerable encouragement to the Americans to carry out their very interesting Gemini 4 flight."

For the first time in the space program, the astronauts' wives took turns on the Capcom console to talk to their husbands on orbit. In this image, Pat White is talking to her husband while Pat McDivitt sits behind listening in, having taken her turn on the console earlier.

AN Update from Home

Pat McDivitt and Pat White came into the control center at about 26 hours and 30 minutes into the mission (GET 26:30). Chris Kraft invited them to talk to their husbands as they flew over the United States. Pat McDivitt was first on the console, encouraging her husband with support for what they were achieving and telling him that all was well at home. She also informed him that his young children thought he was still down at the Cape and told him to "*behave himself*." McDivitt replied: "*I don't have much choice. All I can do is eat, sleep and look out the window,*" noting that, because of the curled up umbilical they had hoped to discard, there was no room to move about, as "*Ed's cluttering up the place*." After a few minutes, the wives swapped places and Pat White took her turn on the console, also giving words of encouragement as the spacecraft swept high over Texas. "*It looks like you were having a wonderful time* [on the EVA] *yesterday,*" she commented to her husband. "*Quite a time we had. It was quite a time,*" White replied. She closed by saying she looked forward to talking to him about it. With the call ending at GET 26:49:55, it had been a welcome four-minute interlude in their long journey. The two wives remained at the control center talking with Dr. Berry and Chris Kraft and were joined by backup Pilot Jim Lovell.

GET 27:00 (Orbit 19/Rev 18) – GET 27:55 (Orbit 19/Rev 18)

This orbit's activities featured an HF test during the day pass and one at orbital sunrise.

Following the interlude with their wives, it was back to business for both men, with updates to the fuel and delta V situation. McDivitt was cautioned to be careful about the use of fuel. It was not a serious situation, and as a precaution some items might be cut from the flight plan, but most were to be performed as planned. This was followed by the HF test in daylight over Bermuda.

[GET 26:59:32]: "*This is Kano on air-ground on HF. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 – 9, 8, 7, 6, 5, 4, 3, 2, 1 . Kano out.*" Then, 35 seconds later: "*This is Tananarive on HF. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 – 9, 8, 7, 6, 5, 4, 3, 2, 1. Tananarive out.*"

A few minutes later, McDivitt reported that he had taken two Hasselblad pictures of a sunset. At this time, the astronauts were to take a meal break and start stowing the garbage which was beginning to accumulate in the cabin. Ed White stated that he needed to defecate, which was tough enough in the cramped confines of Gemini anyway, without all the added equipment and their suits to contend with. The operation, never a favorite activity of the astronauts especially in these early days of the program, had to be carefully controlled and monitored in case some of the feces escaped the defecation bag and floated into the cabin. It was one of those activities that was necessary but contributed nothing to the glamor of being an astronaut, nor, thankfully, made it into the media reports.

GET 28:05 (Orbit 19/Rev 18) – GET 30:00 (Orbit 21/Rev 20)

McDivitt performed a Type 1 medical data procedure, and an experiment M-3 exercise session was completed before White began a two-hour rest period. On this orbit, McDivitt reported sighting a satellite "with arms."

With Gemini now flying over Hawaii on the way to Guaymas, McDivitt was reminded that he was scheduled to conduct a Type 1 medical pass over that station. Later, with that task completed, the Surgeon asked if the crew had eaten yet, to which they replied in the affirmative and added that White was about to take his next sleep period. In Mission Control, Gene Kranz's White Team was taking over from Chris Kraft's Red Team. Upon leaving the MCC, Kraft said "I don't see anything at this moment to keep us from going four days, and we will probably do an OAMS re-entry."

During the early phase of this orbit, there was an attempt to download the onboard tapes, but White reported that they might have lost the dump of at least two of the tapes due to poor communications over the United States. The Pilot also reported his dissatisfaction with the O_2 pressure gauge display in many respects.

White: "*Not only does it not have enough scale, but in our case now, the* [setting] *is low enough so that it is setting in the normal operating range,* [but] *we're causing it to go to* O_2 *High Rate all the time to bring it down.*"

McDivitt: "*Actually, it's not the gauge itself. It's the fact that the vent pressure is set lower in* [the cabin]. *It vents low in our cabin. The cabin holds at about 4.8 or 9 – normal. And the cabin vents at 5.3.*"

White: "*I can see them working on McDonnell now on this gain. I can image there's fur flying. It's going to be when we get back. I'm going to hit them hard on it.*"

The astronauts then once again discussed between them the problem they had found in closing the hatch after the EVA, a problem that they had never experienced before during training and simulations. McDivitt suggested that the rubber sealing must have hardened and commented that he had never before needed to help White to close the hatch. White reminded McDivitt that he was concerned that his commander might pull too hard and snap the handle and also commented that he had encouraged him to "*heave, heave!*" McDivitt could not recall that, stating, "*Too bad that wasn't all on tape*." White replied "*If it is, it'd be tremendous, wouldn't it?*" Flight Director Gene Kranz also asked them to recycle the hatch handle latches to see if the spring was holding them in the lock position, as the ground continued to troubleshoot the problem.

As a photographic opportunity approached, White looked for the Contarex camera, asking McDivitt if he had seen it lately. Clearly, after barely more than a day in space, things were becoming misplaced even inside the small cabin of Gemini 4. McDivitt offered: "*It used to be over here, [but] I don't know where it is now*." With the internal volume being so small they soon located the camera, but this was an early sign of a problem which would plague future crews in larger spacecraft, one that remains a challenge a half-century later. On board the ISS, where color-coding of items has been replaced by barcoding, the need for accurate tracking and logging of supplies and equipment remains critical.

As they moved around in the limited confines of their individual seat areas, the Gemini 4 crew talked between themselves – and recorded on the onboard tapes – about the problems of stowage and moisture on a longer flight, and whether sleeping with the visor open added to the humidity inside the spacecraft. White did not seem to mind either way: "*It doesn't bother me*," he told McDivitt, "*I feel lousy every time I wake up. It takes you a while to get feeling good again*." He also observed: "*We've got a lot of movie film we might as well take*," while McDivitt reminded him that "*We've got a lot of other kinds of film we better take* [too]." White noted that "*The only thing [is], we're not keeping good books on it* [taking images or movies] *right now. You keep the books then miss other things* [while filling in the details of what they had recorded]." McDivitt admitted that they had been using blank paper to keep up and had missed out a whole section of the formal paper record they were supposed to fill in.

As White prepared for his sleep period, they flew over the Australian Carnarvon station, where McDivitt reported the loss of information over the radio link from one of the ground stations. In the previous reports, McDivitt thought that this may have been because the spacecraft was not parallel to the ground with the SEF pointing up towards space, but now, while talking to Carnarvon Capcom, he had Gemini pointing straight down towards the Earth where communications were obviously much clearer. The Capcom at Carnarvon noted: "*Roger. I'm receiving you now, better than we have on almost any pass.*" McDivitt reported that they were currently on the Adapter antenna, which they had switched to when they started the HF checks and had just left open, as they had found it seemed to work as well as the Re-entry antenna did. McDivitt then switched between the Adapter antenna and the stub nose antenna to check both systems, all of which seemed to be working fine. The Capcom preferred that they stayed on the Adapter antenna for now.

As Gemini 4 approached Hawaii, McDivitt was advised of new flight plan changes, deleting the D-8 experiment which had been planned for two hours' time and deferring it until seven hours later. He was asked to use the minimum of fuel for the next S-6 experiment and was also reminded to turn on experiments MSC-2 and -3. In the same exchange of information, McDivitt also reported a sighting, at GET 29:52:17 (see sidebar *Identifying the Unidentified*).

McDivitt: *"I just saw something else up here with me. But just as I was getting close enough to it to take a good picture, the sun got in the way and I lost it… Let me see if I can find this thing again… There are a great number of thunderstorms around at the present time. Lightning is actually lighting up the interior of the spacecraft… It doesn't look like I'm going to see him* [the object he noted] *again."*

Capcom: *"You still looking at that thing up there?"*

McDivitt: *"No, I've lost it. It had big arms sticking out of it, it looked like. I only had it for just a minute. I got a couple of pictures with a movie camera and one with the Hasselblad; but I was in free drift, and before I could get the control back I drifted and lost it."*

Capcom: *"Good show."*

Identifying the Unidentified

Over the years, there have been several missions where some small incident or episode has taken over as the main story and become more famous than the mission itself. The infamous 'corned beef sandwich' on Gemini 3 was one such incident. Three months later, during Gemini 4, it was Jim McDivitt's sighting of an 'unidentified object' flying in front of them. Inevitably, the world's media ran headlines about this object and while it was suggested that it was probably a Russian or American satellite, the newspapers typically ran cartoons inferring unidentified objects from beyond Earth. When McDivitt described the object as resembling a "beer can with an arm sticking out," initial suspicion fell on the Pegasus satellite and its solar array 'wings', but that was found to have been 1,000 miles (1,609 km) away at the time. Of course, the UFO advocates had a field day, though to be fair some have dismissed the link between what McDivitt thought he saw and UFO reports as "media dramatizations." McDivitt has always maintained the same story, relating exactly what he saw, but unable to define categorically what it was. According to the *Baltimore* Sun at the time, ABC Science Editor Jules Bergman had suggested that it was a secret U.S. military reconnaissance satellite, whose classified existence nobody would admit to **[** 3 **]**.

In 1981, Jim Oberg wrote a detailed article analyzing the facts (eye irritation, dirty windows, sun reflections etc.) and myths surrounding the brief observations and comments **[** 4 **]**. Oberg reexamined the case and gave reasoned explanations for each argument. In his 1999 NASA Oral History, Jim McDivitt added his recollection of the incident:

"The story of how I became a UFO expert! Well… Ed was asleep, and I was doing something in the spacecraft. I looked outside, just glanced up, and there was something out there. It had a geometrical shape similar to a beer can or a pop can, and with a little thing like a pencil or something sticking out of it. It was all white. We were a battery-powered spacecraft, so we were trying to save electrical energy (tumbling through space, end over end) and I immediately reached up and… pushed in the circuit breakers, because I thought I might have to maneuver around this thing, whatever it was. I couldn't tell how close it was, how big it was. I grabbed a camera and took a picture. It was just floating there. And then the spacecraft rotated around where I couldn't see it. Finally, the electronics warmed up. Remember, these were the Dark Ages. It takes a while to warm up! And so, by the time they got to where they'd worked, I didn't have any attitude indicators. We had all the instrumentation shut off, too, and we were looking at the black sky. I had no reference whatsoever. So, I tried to fly the spacecraft back down to where I thought it was. And I never did see it again.

"The fact that I could see it… pretty much meant to me that it was in our orbit… It probably was a piece of ice that had fallen off the spacecraft someplace. Or maybe a piece of Mylar that had come off.

"The thing that really exacerbated the problem was when the film got back to Houston. We were still out on an aircraft carrier. They printed up all the EVA film, which was of great interest because nobody had ever seen an EVA before, and had a huge press conference. All that stuff was shown at the press conference. Some reporter wanted to know about the UFO [but] NASA said they hadn't printed all of the photos. They would print them later that night. He hung around and eventually they got them all printed. This guy and a photo tech went through all the photos and they picked out one that looked like a bunch of spacecraft from some foreign planet. They were disc-shaped things with a tail. I think there were three or four of them in an echelon formation. And then that got printed someplace. I never did see it until years and years later, when I started getting all these requests to appear on UFO shows. I went back and then I saw what the thing was… a reflection of the bolts in the windows. The windows were made up of about three or four or five panes of glass… and these little things, when the Sun shined on them right, they'd multiply the images off the different panes. And I'm quite sure that's what this thing was. But anyway, I became a world-renowned expert in UFOs. Unfortunately."

GET 31:10 (Orbit 22/Rev 20) – GET 31:40 (Orbit 22/Rev 20)

This orbit began with McDivitt completing his meal break and the end of White's latest rest period. Following a briefing for both astronauts, they continued their housekeeping chores. Experiments MSC-2 and MSC-3 were turned on and the third Orbital Navigation Check Run was completed.

With White now awake again, both men were occupied with observations and photography of the various cloud and weather patterns below them.

McDivitt: "*Clouds. They look like stratus, but they certainly have a moderate effect to it. I wonder if this weather is going to be in the Hawaiian land area?*"

White: "*It looks like there are several layers to it. A very high cirrus layer… a little less cirrus… take some pictures of a series of clouds. It looks like we've got a high cirrus layer with fair weather cumulus below it.*"

Capcom: "*Also* [on the] *S-5 experiment. MSC requests the crew take terrain photos of any clear areas along the ground track and not wait until the last day. Crew should identify which areas they are.*"

McDivitt: "*We would like to save some film, though, until we get the opportunity to make a pass across the southwestern United States tomorrow, and take a bunch of surveillance photos along there if this is okay.*"

Capcom: "*Roger, that's fine with us. Go ahead.*"

Then, some ten minutes later over Guaymas, the Capcom there advised the crew:

Capcom: "*You might look for a tropical storm over the west coast of Mexico. You should be right on top of it… about now.*"

McDivitt: "*I just took pictures of two thunderstorms that look like big pancakes, with a lot of cirrus running out of the side of them but different tops.*"

White: [Using the green filter on the sextant] "*I'm coming down on the horizon now, and you can certainly see the definite two layers to the air glow. The one that is quite thick [is] at the top, and you can see the stars as they drop through. They occlude a little bit, then they pop out on the left-hand part and you can actually see them go all the way out as they hit the true horizon down at the bottom.*"

White found that using the green filter on the sextant made his view of the event cleaner and more defined than with no filter at all. He then asked McDivitt if he wanted to take a look as well, which he did, so White simply let go of the sextant and pushed the device across to him with ease.

White: "*Here it comes… Sure is easy to move things around* [in 'zero-g']. *That 8-pound sextant, you just handle it like it weighs an ounce*."

White then commented on using the onboard tape recorder.

White: "*Jim, I'm going to take a check on the tape recorder. I don't trust it since the bulb didn't work on it last time. Will the lights bother you?*"

The cabin lights were dimmed at this time, as McDivitt was looking at the stellar background through the sextant, but he was apparently not concerned by the cabin lights being turned up as White checked on the tape recorder.

White: "*It looks like the tape is still running through and I haven't got to the red light yet. That is sure unsatisfactory – the location of the tape recorder light.* [In fact] *the whole tape recorder operation is wrong. It ought to be something you can have on continuous so you can talk over the radios as well. Particularly on launch – you end up not getting any of that* [crew in-cabin comments] *on tape*."

With that check done, he turned the lights down again and returned to the observation of stars through the airglow and the odd flash of light falling down to Earth.

White: "*Oh! Did you see that flash? A very bright flash in the airglow… There! Out your side… It was shooting down towards the* [Earth]. *That one was much lower. Wonder what that was?*"

McDivitt thought these may have been "*falling stars*" meteoroids hurtling through the upper atmosphere. They normally saw these above them in the night sky from Earth, but now they were observing the phenomena below them. "*It sure looks funny right down below us,*" McDivitt mused. He then reflected on how White had been protected from meteoroids in his bulky EVA suit.

White: "*Yes, I checked my suit very closely, and I saw no meteorite holes,* *much to my delight.*" [Post-flight, White did mention that, after closer examination, he found that his suit had been struck but fortunately was not punctured. See page 314.]

The two men continued their observations and, while witnessing the Coronas Australis, or the 'Southern Lights', noted the unusual position they were observing from. "*It just doesn't work when the world is upside down,*" McDivitt observed.

GET 32:35 (Orbit 22/Rev 21) – GET 33:15 (Orbit 23/Rev 22)

> *McDivitt started his two-and-a-half-hour rest period as White worked with experiment S-6 and turned on MSC-1. White also provided a Type 1 medical data procedure.*

With Gemini 4 in contact with CSQ, the Capcom requested that they turn on their computer for a [Rev] 33-1 retro load update. White then reported that he was switching the medical recorder from 1 OFF, to 1 ON and 2 OFF, and that McDivitt was preparing for his next sleep period. Before he did so, the CSQ Capcom advised that Houston wanted to know what the relative bearing was when he sighted the satellite he had reported earlier.

McDivitt: "*Roger CSQ… The satellite was up near the sun.* [Gemini 4's] *small end was up above the horizon, so I could not see the horizon.* [The object] *started drifting up on us, drifting slightly. And I saw the thing over the small end which I think was pointed to the east. As it came around toward the sun I saw… this other satellite, but then as the sun came in through the window I lost it because the sun was so bright.*"

With that report completed, McDivitt started his pre-sleep preparations. A few minutes later, White explained the difficulty they had been having with one of the cameras on board.

White: "*I'm taking some general – normal lens on the 16-mm – photographs of the water and the clouds at the present time. We've been having a lot of trouble with the ON/OFF button on this camera. It goes only about every third or fourth actuation. This might explain some of the reason why Jim didn't get as much film in our EVA work.*"

A few minutes later, as he tried to operate the camera, the astronaut commented further regarding the problem.

White: “[It] *Feels like the shutter* [is] *sticking on at the Hasselblad at the present time on some of these pictures. This is the second series of the S-6 pictures over the Atlantic. The film-advance mechanism is definitely causing erratic operation of the Hasselblad. I’ll be operating it manually from here on.*”

After he had completed the S-6 photography task, White had to take further Aero-Med Type 1 pass readings, but was advised to abandon the attempt due to very poor communications with the ground. At approximately 32 hours into the mission, a decision had been made to upgrade the Type 2 medical data passes to Type 1, and both astronauts were given permission to perform unscheduled exercises. Their pulse rates were determined by counting beats at 15 second intervals for two minutes prior to exercise and for two minutes after exercise, and during the first and last 15-second intervals of their exercise session. White was then instructed to turn Gemini, from the blunt end forward (and ‘heads down’ towards Earth) orientation for the MSC-2 and -3 run and the pass through the South Atlantic Anomaly, to a ‘heads up’ [towards space] orientation for a crucial test tape dump over Hawaii, where the air-to-ground commentary was to be carried live on U.S. television.

GET 33:30 (Orbit 23/Rev 22) – GET 34:45 (Orbit 24/Rev 23)

Gemini was flying with the Blunt End (or heat shield) Forward (BEF) for experiments MSC-2 and -3. The MSC-1 experiment was turned off and work continued with the D-8 experiment, together with another Type 1 medical data set for White.

Over Hawaii, White was requested to try his Aero-Med Type 1 pass again, this time over RKV, to make up for the one missed earlier. After reading out map updates, the Capcom informed White, at GET 34:23:26 that he “*would like to congratulate the new American space flight record [holders]. Congratulations!*” Ed White, and the now awake but still resting McDivitt, had surpassed the U.S. single spaceflight record of 34 hours 19 minutes and 49 seconds set by Gordon Cooper aboard Mercury Atlas 9 in May 1963. “*Roger. We have quite a few more to go… Thank you very much,*” McDivitt acknowledged.

GET 34:55 (Orbit 24/Rev 23) – 36:15 (Orbit 25/Rev 24)

Experiment D-8 continued as McDivitt’s rest period ended. Both pilots *participated in another briefing and switched the biomedical recorders, turning the new ones on. Experiments MSC-2 and-3 were turned off. McDivitt also took a meal break on this orbit.*

At GET 35:12, White asked McDivitt: "*Hey, Jim, babe, are you* [still] *sleeping?*" enquiring whether he had gone back to sleep, which he had not.

White: "*I didn't think you were. I let you overshoot 15 minutes' worth. I was doing* [experiment] *D-8 and there wasn't any reason for you to wake up. Do you think we're sleeping too much? All we do is sleep. I think it's an eat period myself, but I think we should both eat. In fact, I got so hungry while you were asleep that I didn't [wait?]* [Entry is incoherent and incomplete at this point]."

White then mentioned that he had asked the ground if they could remain in drifting flight, powered down, and that the message had come back to confirm that was the intention. White then continued updating the Command Pilot on his activities while McDivitt had been asleep, and on the status of the MSC-1, -2 and -3 experiments, then added that he was about to change the biomedical recorders and let them both run. At this point, McDivitt suggested leaving White's unit 'off' for a while longer, as he had been running his more than McDivitt had. A few minutes later, the Capcom at CSQ came on the air-to-ground and advised them to "*leave both biomed recorders on for the remainder of the mission.*" McDivitt responded: "*Roger. We've used them a little out of sequence. I think we'll leave No. 2 off for another 30 minutes*," to which the ground concurred, so that both records could be brought up to date.

Following further updates and discussions with the ground about their status, White mused about a possible extension to the flight:

White: "[It] *May be that they're doing their computing very carefully* [to determine] *whether we can go for the extra* [24] *hours… You know, go for the five-day* [duration record – set by Bykovsky]… *We've got an extra load of food on board*."

McDivitt voiced a not very enthusiastic reply: "*Oh No! Ha! Ha,*" and pointed out that there was also the question of dealing with the added trash and lavatory products bags. White replied that he was "*just being unbearable!*"

The decision to pair the two men up for this flight had been an inspired one by Deke Slayton, as they remained mostly good humored throughout the mission. Clearly, their long association and friendship played a part in this. Conversations between the two men naturally flitted between subjects as the flight progressed. For example, they commented that even though they had not initially wanted to eat the cinnamon toast bites, they had actually found them pretty palatable when they tried one. A few minutes later, White told McDivitt that he was going to add an extra exercise period on the M-3 device, as the second period he completed was not part of the official exercise routine planned. Less than a minute later, White recorded that he had managed to pull on the exerciser for a total of 60 stretches. The topic of discussion then turned to the number of pencils both men still had. White had started the flight with five but could now only find three, while McDivitt still had both the pencils he started out with[3].

Both men also regularly reflected on the sheer magic of weightless flight, such as simply letting go of an object and seeing it float in front of them, or moving it with just the slightest contact. Sometimes, of course, they found that they could lose an item quite quickly, even in the limited confines of the Gemini crew compartment. Towards the end of this orbit, they commented once again on their actions during the EVA. Both found humor in the "*Get back in*" comments from Gus Grissom at the end of the EVA and White thought that instruction had come from Chris Kraft, not Grissom. Having talked about the EVA, White realized that he still needed to put his comments about the spacewalk down on tape while the memories were still fresh in his mind, so that they could be reviewed after the mission. He commented on what he thought would be required for future EVAs.

White: "*What we need is a big spacecraft with a big inward opening hatch – just like they have on a submarine… so the pressure inside seals the hatch* [4] *.*"

McDivitt seemed to disagree, but the air-to-ground became indistinct at this point.

GET 36:30m (Orbit 25/ Rev 24) – GET 37:55 (Orbit 26/Rev 24)

A three-and-half-hour rest period started for Ed White as McDivitt ended his meal break, and later completed another medical data procedure. Orbit Navigation Check Run 4 (no fuel) was completed and spacecraft humidity check results reported to the ground.

"*Look at that lightning storm,*" White indicated as he prepared for his next sleep period. "*I wonder where we are Jim?... Let me check and then I'll go to sleep…* [he added on the air-to-ground at this point that he hated going to sleep] *Let's just check what time these* [thunderstorms are] *and then we can find out where we were later. Saw a great many thunderstorms down below us. It looks like we're going approximately small end forward and we're upside down. Very, very heavy thunder and lightning activities.*" McDivitt informed his Pilot that "*We're presently over the Arabian Peninsula*."

The second flight day ended at GET 36:57:11.

References

1. Gemini Sets 2 World, 3 U.S. Space Records, *California Desert Sun*, June 5, 1965, #261.

2. **Voices from an Old Warrior: Why KC-123 Safety Matters,** Christopher J.B. Hoctor, 2013, Galleon's Lap, e-book pdf www.theboomsignal.net/pdf/Voices_from_an_Old_Warrior.pdf last accessed April 11, 2018.

3. Astronautics and Aeronautics, 1965, p 271, entry for June 6.

4. *The Gemini UFO: A Skeptical Analysis*, James Oberg, UFO Report Magazine, Fall 1981.

Footnotes

1 The slang term 'sawbones' derives from the 18th and 19th century, perhaps earlier, when surgeons often had to amputate limbs by sawing through them. This procedure, with such a drastic outcome, naturally caught the attention – and fear – of the public and so the word stuck as a nickname for a surgeon, often shortened to just 'bones'.

2 The KC-135 was assigned to the 6th Air Refueling Squadron. It had descended below the glide slope on a night instrumented approach to runway 21 and had lost electrical power. **[** 2 **]**

3 Prior to the flight, it was reported that the MSC had purchased 34 special propelling pencil sets, comprising a nylon cord, take-up reel and baseplate, to be installed in each Gemini spacecraft. Each set cost $128.84. It was hoped that restraining the pencils would make it easier to take notes in space. The first were due to be installed in Gemini 4, but the crew's in-flight discussion indicated that this had not been the case.

4 This was exactly the type of inward-opening hatch design that contributed to the outcome of the Apollo 1 pad fire and the loss of White with Grissom and Chaffee in January 1967.

David J. Shayler, *Gemini 4*, Springer Praxis Books
https://doi.org/10.1007/978-3-319-76675-1_10

10. This thing isn't very big

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

"Those are the Himalayas,
I'm quite sure. [I] have seen Gordo's
picture that he took. It was such a good one."
Ed White observes the Asian mountain range
on Day 3 of the mission.

Looking down on the Earth was one of the highlights of the mission for the astronauts, both in the pursuit of their experiments and in simply seeing the planet in all its glory below them. Meanwhile, the world's newspapers were reporting a variety of stories related to the mission, but not all were directly concerned with the activities of the astronauts. In the primary recovery area south of Bermuda, the USS *Wasp* dispatched planes to fly over a Yugoslavian freighter, the *Kapetan Martinovic.* After being buzzed by the U.S. warplanes, the crew of the freighter informed the Americans that they would be out of the area before the planned landing on June 7. Also during this third day in orbit, the spent second stage of the Titan launch vehicle finally re-entered the atmosphere and was destroyed.

To give the general public an idea of the effort Ed White had exerted on his 20-minute EVA, NASA medics related his heart rate of 180–200 beats per minute to the effort required to pedal a bike, slowed with a heavy load, up a steep mountain road. On the other side of the world in Djakarta, the *Indonesia Herald* praised the Americans on their EVA achievement, but then said that they had marred the achievement by taking a 'gun' into space. "Why couldn't the first American in open space [meaning EVA] be given an instrument which could convey to the world that America meant to use outer space for peaceful purposes?” the paper asked, clearly mistaking the HHMU for a weapon!

Wallpapering Gemini

Excess moisture generated by presence of the crew led to experimentation with an absorbent blotting paper-like material. It was suggested that this material might adequately absorb the excess moisture inside the crew compartment of the spacecraft, but not effectively control the temperatures on its own. This so-called ‘wallpaper’ was made from urethane foam or regenerated cellulose. On Spacecraft 4, sheets of AMERCO sponge cloth were stitched to cotton broadcloth and then treated to bring them to fire resistant standards. Approximately 7,000 square inches (45,160 sq. cm) was installed wherever it was practical to fix it, including bulkheads, sidewalls, the floor, hatch sills, the hatches themselves, console sides and stowage boxes. There remained some concern over the potential for any absorbed water held within the wallpaper to boil during re-entry, and indeed there was evidence of steam on Gemini 4, but not sufficient to warrant redesigning the wallpaper before the next mission.

Flight Day Three, Saturday June 5

GET 38:00 (Orbit 26/Rev 25) – GET 39:30 (Orbit 27/Rev 25)

As the third day of the mission began, the focus was on the preparations for the S-6 experiment, including an update of its status and its operation without the use of fuel from GET 38:30 to GET 38:50. During the orbit, the crew was given the latest update to the landing opportunities, further map updates were passed up to them and a humidity check was made of the inside of the crew compartment. As the orbit ended, McDivitt completed another blood pressure reading.

Capcom, Houston: [GET 38:22:27] “*If you can, get your left and right cabin wall temperatures using the thermostat. Also, report on visible moisture, if any, and is your blotting paper wet to the touch? Over.*”

McDivitt: “*I took the wall temperature quite some time ago in the left-hand food box and it was 75* [degrees F/23.8 degrees C]. *The blotting paper* [meaning the ‘wallpaper’] *is not wet to the touch and there is no visible moisture.*”

The Capcom then enquired about the status of the D-9, S-6 and S-5 experiments, requesting an estimate on the completion of those investigations. McDivitt replied that they had not done anything with the D-9 as "*it's going to be pretty tough to get a D-9 without any fuel*." The D-9 was a 'simple navigation' experiment, which had been a space position-fixing task investigated by the Air Force for over four years prior to the mission.

McDivitt added that they had gathered a fair amount of images for the S-6 experiment and had secured some scattered S-5 pictures, but he advised that they would need at least one long pass over the southwest United States, with the nose of the spacecraft pointing at the Earth, to secure the desired series of 35 images. If it could be worked into the flight plan, they also wanted another S-5 pass over North Africa. Based on that information, the Capcom advised them to prioritize their targets of opportunity where possible, firstly with S-5, then with S-6 and finally with D-9.

When contact with the Houston Capcom ceased, it would be another 20 minutes before they could talk to the next station. On this pass, that station was the RKV, who gave the crew the next ground target as the city of Cairo. That target would be 12 miles (19.3 km) northwest of their ground track at a slant range of 90 nautical miles. With that update completed, the Surgeon came on the air to get some updated information from McDivitt.

Surgeon: "*I have a couple of questions for you. First about the blood pressure. I don't want to bug you very much on it, but did you change the O-ring?*" [in his blood pressure device.]

McDivitt: "*No I didn't. I looked… and I don't think it's the O-ring. I think it's my* [suit]. *I noticed when I got checked out the other morning, just before launch, that they had a little trouble with it then. The blood pressure* [device] *moves. It looks like a problem with my suit.*"

McDivitt asked if another reading was required, but the Surgeon told him that there was no need to do so at this point, although if he was less busy at the end of the pass he could try then. It was more important, at least for the medics, to get an update on McDivitt's general condition and quality of sleep. "*Well it's not very restful,*" the astronaut replied. "*This radio feeds through into the other helmet. He* [White, who was in his sleep period at this time] *can hear it,* [although] *not very loud. He can hear all the radio transmissions and it keeps waking you up.*" The Surgeon noted that the astronaut's voice sounded a little dry and asked if he was taking enough water. McDivitt replied that he did not feel that he was dry or dehydrated, but that during either the sixth or seventh orbit he had consumed quite a bit of water and felt better. He had been eating and drinking well since then. “*I think I am being dried out by the oxygen*,” he suggested, adding “*My nose did bleed... after launch*.” As a remedy, he was advised to keep consuming the water as there was plenty on board, but the astronaut expressed caution in doing that, saying: “*Well, I’d hate to run out after only three days*.” With that, he retook his blood pressure reading and was informed by Surgeon that: “*You are full scale – beautiful! – that’s a beautiful record, Jim*.”

GET 40:55 (Orbit 28/Rev 26) – GET 41:30 (Orbit 28/Rev 27)

A few minutes after the onboard tape was downloaded to RKV, Ed White completed his scheduled rest period and both astronauts participated in another briefing period, this time lasing about 30 minutes, including communications with ground controllers.

During this orbit, the Capcom explained the split-burn operation to McDivitt.

Capcom: “*Anytime your OAMS burn is greater than 120 ft./sec* [36.5 m/sec], *we will give you a split-burn; 84 feet* [per sec/25.6 m/sec] *out of the forward thrusters and the balance* [36 ft./sec, 10.9 m/sec] *out of the aft thrusters.*”

Once again, this was a relatively quiet period during the mission and with the Surgeon in Mission Control, Houston, he would be on standby at each of the remote sites, ready to have a conversation with McDivitt if he felt lonesome while White slept.

The Capcom came back on the air to advise McDivitt that the Gemini 4 backup Pilot, Jim ‘Shaky’ Lovell, was at the console, and that he was going to give White one more chance to change seats with him. Lovell added: “*Hey, Jim. This is Shaky, the Assistant Surgeon. How’s the waste management coming along?*” As Lovell was in training to fly a 14-day mission with Frank Borman, this was an important and relevant question. McDivitt replied: “*Hey, listen. The only free water we’ve got in here is every time we’ve tried to use that urine system.*” This was not what Lovell really wanted to hear, as his own space marathon was only six months away. Lovell then signed off, telling McDivitt to “*have fun*” and that anytime he felt lonesome, they were standing by to talk via a remote site.

White awoke a few minutes later, an hour earlier than planned, and reported his observations of a desert passing beneath them. He noted that there were very distinct fire marks on the ground and advised that he had taken a number of S-5 terrain images as he flew over. He also reported a fault in the No. 7 magazine, as though the teeth of one of the cogs was not catching the film and that it was backing up, which meant there were unlikely to be many good results from that magazine. McDivitt added an update on some of the other film equipment. "*The lens is crapped out on this* [camera]… *screwed up on that* [camera]. *The 16-mm doesn't run about half the time…*" White wanted to get to work on the cameras, but McDivitt was adamant that he should get some more sleep.

McDivitt: "*Come on! Go to sleep. Listen, you'll be awake in an hour. You'll have five or six hours to sit around and play with that camera. Now, put it down and go to bed!*"

GET 41:25 (Orbit 28/Rev 27) – GET 42:32 (Orbit 29/Rev 27)

Ed White completed a Type 1 medical data procedure before both astronauts took a meal break. This was followed by the start of another rest period for McDivitt, while White recorded updates from the RKV tracking ship for the Apollo Landmark Investigation, and updates for experiments S-5 and S-6 in preparation for the next scheduled work period on those investigations.

When White awoke again, he completed an Type 1 medical pass after McDivitt had been updated with Apollo Landmark data. That target would be 46 miles (74 km) south of the ground track, but they were not to use any of the attitude control systems for the maneuvers. After he had taken another blood pressure cuff reading, White updated the Flight Surgeon regarding his previous sleep period.

White: "[I have] *just got up from a long nap. I had a four-and-a-half-hour nap. Out of that time, I probably had three-and-a-half hours' sleep. I've had three swallows of water. Before I went to bed, I finished Meal A of Day 2 and I'm getting ready to eat Meal B of Day 2*."

There were 49 different items in the meals planned for the flight, with slight differences between the two menus due to individual preferences although the calorie balance was the same. The plan was for McDivitt and White to consume four meals a day. There were 14 two-man meals and four one-man meals stored in a total of 18 packages in the compartment above McDivitt's left shoulder. Each was marked by day and meal and stored so that the first day's meal was at the top and the final meals at the bottom of the container. Each package was connected by nylon lanyards, to avoid any mix-up when they were floating free in the storage compartment.

McDivitt began his next sleep period as the tracking ship RKV slipped out of communications range, with the astronauts being advised by the ground that everything looked good on their spacecraft from the data on the ground, and that all systems were looking 'green'.

GET 42:43 (Orbit 29/Rev28) – GET 44:15 (Orbit 30/Rev 28)

Work continued on experiments S-5 and S-6, as well as another Apollo Landmark Investigation, updates to the maps and landing areas, a download of the onboard tape and burning off the Attitude Control and Maneuver Electronics (ACME).

As they were flying over North Africa, White updated the ground regarding the control of Gemini.

White: "We used Pulse Control in a minimum amount. The target of number 12 was obscured by clouds. I had the time and location pretty well squared away. I could have tracked [it] *if I could have seen the target, I believe. Target number 13, it was in the clear, and I was able to pick up on the city of Alexandria. The airport, I think… but I haven't been able to put my attention on looking for the airport. I could have spotted the airport. I went ahead and operated the camera and took some pictures as I passed over it. The location of the target from the data called up was satisfactory*."

GET 44:20 (Orbit 30/Rev 29) – GET 45:53 (Orbit 31/Rev 29)

This was a busy time for Ed White, with McDivitt asleep. He worked on the S-6 experiment, exercised on the M-3 device, took a 43-minute meal break, provided a Type 1 medical data procedure and updated the status of the D-9 experiment. McDivitt's rest period formally ended at approximately GET 45:53.

As Gemini flew over the Canary Islands, White was asked for his primary O_2 tank pressure reading, which he gave as a little under 950 psi (65.5 bar). A short time later, the Carnarvon Capcom radioed up.

Capcom: "You're looking good here on the ground. What's your status?"

White: "The status is 'GO' up here and everything is looking good."

McDivitt was now awake and asked the Capcom which station they were

McDivitt was now awake and asked the Capcom which station they were communicating through. He was informed that they were going through Bermuda. McDivitt informed the ground that he had slept better this time than in the previous sessions, and while he had not disconnected his radio this time, he was so tired that the noise had not bothered him.

A Pit Stop at Indianapolis

GET 46:05 (Orbit 31/Rev 30) – GET 47:25 (Orbit 32/Rev 31)

> *This was a quiet period, with communications between Gemini and the tracking stations they flew over, taking the opportunity to download the onboard tape recorder as they flew over Carnarvon.*

At GET 46:55, the PAO reported a further change of shift at the MCC. This was quickly becoming a well-drilled practice, taking about 30 to 45 minutes of discussion between the outgoing and incoming shift member on each console. The changeover was usually completed when there was little ground station contact or activity on the mission, so that the controllers could be briefed on the preceding eight hours of activity. The PAO also reported on how well Mission Control was functioning, with only a transformer on one console overheating and requiring replacement. This was accomplished “something like a pit stop at Indianapolis,” by three people in a couple of minutes.

As Gemini 4 passed over Grand Canary, McDivitt held a conversation with the Capcom regarding not having to relieve the atmosphere through the cabin if they could avoid it and instead selecting the Cabin Recheck Valve rather than the O_2 High Rate. McDivitt informed the ground that they had nowhere else to put the oxygen other than in the cabin and that they had just finished using the O_2 High Rate option to get the ECS O_2 pressure down to 910 psi (62.7 bar). The ground explained that the reason for the re-pressurization was to avoid turning off the fans and to cut down noise levels inside the cabin. It was noted that their O_2 usage over the previous two or three hours had been about 25 percent higher than normal.

Capcom: *“Your rate, even at your present rate – you have five or ten hours more than you need plus secondary O_2.”*

McDivitt: *“Our cabin’s been holding all right. There really doesn’t seem to be much we can do about that. That tank pressure goes up and that is just about all* *there is to it. We're actually venting oxygen overboard that we don't need to… I'll try to take your advice and not vent any overboard, but I just don't know how I'm going to do that.*"

McDivitt also reported that the propellant quantity was at about 61 percent, fluctuating up to about 63 percent, while the OAMS source helium temperature was showing 58 degrees F (14.4 degrees C) and its pressure under 2,000 psi (138 bar). Both men were now so busy preparing for experiment D-9 and a run on Apollo Landmark tracking that neither had time to talk to the ground very much.

In trying to track the stars, they were initially way too high for White to confirm their tracking, and then too much horizon showed in the window until it disappeared. McDivitt noted: "*Same here with me. I don't know where I am; up, down, sideways or anything else. I'd like to at least know the orientation…* [as] *we've been running into problems*." As McDivitt turned Gemini to pitch-up BEF, with the sun behind them, they still could not find the stars, only pitch black sky. McDivitt noted the reflections in his window, while over on his side, White was getting reflections off the dirty outside part of the window.

McDivitt: "*Half my window is black and the other had a little sun shining on it. Sun shining on the nose of the spacecraft so I've got to look past a lighted object. I don't see a star, and I never have seen stars in the daylight…* [It's] *much better at sunrise, when half the spacecraft is in dark and the other half is in light. I guess what we are saying is that ... D-9 cannot be done in the daylight.*"

White concurred, as it seemed there was no way either of them could find the stars in the daylight. Then McDivitt observed: "*My window's not in the light any more, and I still don't see the stars.*" He decided that he was in the correct position and should have been able to see both the stars in the daylight and the horizon at the same time, with the sun having moved off the nose of the spacecraft and on to the 'bottom'. But he still could not see any stars. Shortly afterwards, he updated the Capcom with the news that they could not find any stars in the daylight and that they would wait until they got back into the night period of the orbit and do more with the D-9 experiment there.

At GET 47:23, the Capcom asked McDivitt about the O_2 high usage rate readings. "*We don't think it's a problem*," the Capcom hastened to reassure the astronauts, before asking them to leave the Quantity Read Switch ON for several hours so that the experts on the ground could get a feel for what was going on the with subsystem on the spacecraft. Even if the rate continued the same as it had over the previous few hours, there was no suggestion that it would be a serious issue, but the controllers wanted to find a way of controlling the situation without it being a nuisance to use and to a point where the astronauts would not be concerned with it. The plan was to find a way to control the pressure build up in the Primary O_2 system without the need for the astronauts to relieve the cabin pressure every few minutes or every few hours. All this was explained to McDivitt, with the assurance that while it was a little bit higher than it had been, the level was nothing to worry about, with sufficient oxygen available for the expected duration of the mission. McDivitt had been doing some sums of his own on the data: "*I've been plotting, and it looks like we're going to end up with 7 or 8 percent remaining.*" The Capcom agreed, reaffirming their desire to keep the crew from constantly having to relieve the cabin pressure. "*Okay,*" McDivitt responded. "*Yes, I don't like that* [option] *either.*" At this point, the Flight Surgeon asked the Capcom to enquire whether either McDivitt or White had experienced any trouble either with drying around their eyes or a dry throat.

McDivitt: "*My throat is a little dry, and our eyes were bothering us about the end of the first day quite a bit, but that's cleared up now… Ed and I were just commenting that the weightlessness gives you a light-headed feeling... Ed was saying that his headache is gone. He had one earlier… and I don't have one yet, but I feel closer to having one now than I have had at any time. I think it's this darn 100 percent oxygen. I breathe it in and I don't think I've ever been this dry, [like] with the worst cold I ever had where I can't breathe though my nose and I sound like I've got a big deep cold. When I was sleeping it was burning my nose. I had a very hoarse sound to myself… I think because of this 100 percent oxygen where I kept assimilating, but I suspect maybe my ears and sinuses are always below ambient… I've got to pop my ears every hour or two* [and] *my mouth and throat are quite dry at this time.*"

At the Capcom console, Gus Grissom gave McDivitt a time hack at 14:45:00 GMT, and asked if there were any complaints so far in the mission.

McDivitt: "*No, except this thing* [Gemini] *isn't very big.*"

GET 47:32 (Orbit 32/Rev 30) – GET 49:00 (Orbit 33/Rev 31)

The focus of this orbit was the 30-minute operation of the D-9 experiment from GET 48:02 to GET 48:32, and preparatory work for the S-5 and S-6 *experiments. The S-5 experiment was operated between GET 48:50 and GET 49:00. The crew was again updated with regular landing opportunities.*

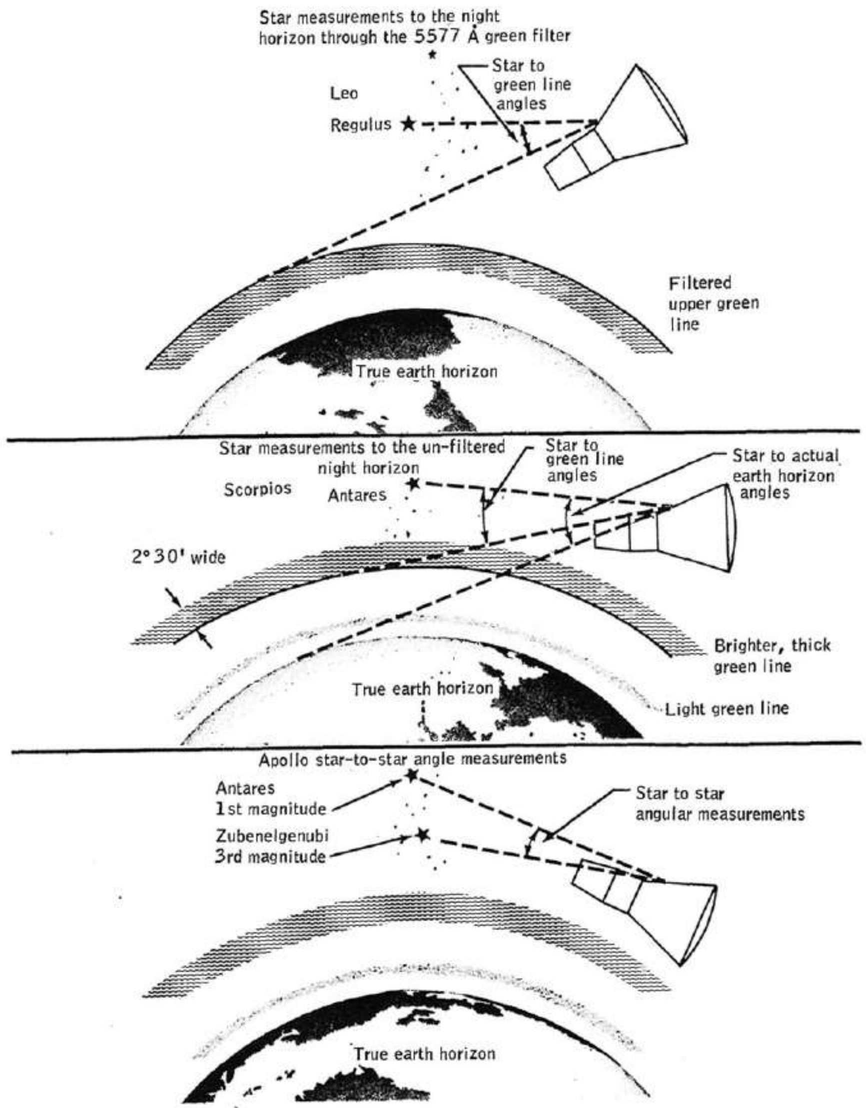
As the astronauts worked inside their confined spacecraft, they struggled to get the best views out of the small windows.

McDivitt: "The right side of my head is getting sore where I keep rubbing the hairs the wrong way when I try to turn my head inside my helmet so that I can look through the windows long ways. [Trying to] Get the best view I can through it."

Conducting stellar observations for the D-9 experiment, McDivitt commented on the gradual deterioration of the clarity through his single viewing window.

McDivitt: "I get the distinct impression that the upper part of my window is a lot dirtier than the lower part… I think the graduation of this goop that's all over it, whatever it is, looks like it's on about the zero-pitch line on up."

He stated at this point that he could see a star down below the zero-pitch level, and added that the difficulty "*might just be the peculiar way the reflections are coming back through the window.*"



Typical sextant measurements taken during the D-9 experiment.

Long before the Gemini 4 flight, the U.S. Air Force (USAF) had reviewed space navigation and guidance development programs and had found that most of the assigned techniques were automatic systems with no manual backup capability. Clearly, if any of these systems or the communications system failed in-flight, the astronauts would have no tools to assist with a safe return to Earth. To resolve this issue, the staff at the USAF Avionics Laboratory at Wright Patterson AFB, Ohio, developed an autonomous manual navigation and guidance technique, primarily as a backup to the automated systems, but capable of being incorporated with the primary systems. The objective of the D-9 experiment, therefore, was to collect data on "observable phenomena of spaceflight that could be used to solve the problem of autonomous navigation by the use of optical data and manual computations to calculate the position of the spacecraft." To test this objective, it was decided to fly a hand-held sextant on Gemini 4 (and later Gemini 7) to acquire the information required to establish a manual-optical technique of orbital space navigation.

At 12 minutes past the 48th hour of the mission, almost halfway through the flight, the Capcom in Carnarvon, Australia, reported: "*You're looking good here on the ground. How are you doing?*" McDivitt replied that they were doing fine and the Capcom advised: "*Okay. We don't have anything here for you. You have gone two full days, and we'll keep standing by here if you need anything.*" McDivitt reported that they were trying to take some star measurements, "*so we probably won't be talking too much*." That was borne out by the air-to-ground, with conversations between the two astronauts consisting of which constellation they were looking at, its position, and the type of filters and camera equipment being used, as well as comments on the flight planning for this type of activity.

White: "*We should spend the night side here doing… just taking pictures… taking sightings without a particular attitude. The object of the game is to nail a couple of ones right off the bat that you know of and use them… I think their* [flight planners/investigators] *kind of programming for us is no good. I think we'd do better if we make our own sighting… It takes definite attitude control to make these measurements* [of the star]. *You can't expect to make these measurements without using any fuel. It's such a small window, you have to pick up your star and bring it down to the horizon, keeping the horizon and the star in your field of view.*"

As Gemini 4 flew over the United States, McDivitt was asked to turn their computer back on to input updates and also to make a check of the main batteries. The Capcom then asked if the astronauts could "*try to see stars on the daylight side with the Earth shine not in view. Just forget the sextant; just get dark-adapted the best you can on the daylight side and see if you can pick out some stars*." McDivitt replied that they had already tried to do this but were unable to pick out any stars during the daylight side of the orbit. When asked by the Capcom what type of filters they were using, he noted they were satisfactory when used on the sextant and that "*we have some notes on that.*"

McDivitt again requested a chance to obtain ground imagery across the southwest United States, on a later orbit. "*I sure would like to get that out of the way,*" he added, as the Capcom said they would run it through the flight planners there at Mission Control and let him know. "*Okay,*" McDivitt replied. "*I think it would be foolhardy to run any more D-9 experiments in the daylight, because* *that is hopeless*." As they flew over Texas, the Capcom then advised them that the flight planners and investigators wanted them to take some weather pictures of the thunderstorms up north of Houston, but then relayed "*I guess you've already passed that now. Maybe you can get them next time around*." At this point, Ed White was taking some imagery, although McDivitt was not sure what pictures he was taking, suggesting that it was some terrain imagery.

The Capcom then read up the news to the crew, which mainly focused on what they were doing up on orbit and in particular about the satellite McDivitt had seen the previous day. Their conversation with their wives was also getting "*a big play*" in the media coverage of their flight. Grissom then briefly informed them that "*things in Vietnam have* [quietened] *down, and* [there was] *not too much going on over there right now,*" before moving on to the sports news.

McDivitt then asked if anyone had figured out what he had seen out over Hawaii and Guaymas the previous day. Grissom asked "*Have you figured it out? You saw it.*" McDivitt did not know. "*I took a picture of it, but the sun came across the window right after I saw it. I only* [saw it for about] *15 seconds*." Grissom admitted that he had not heard any more about it, but would look into it for him.

As far as could be determined, the only satellite McDivitt might have seen during Flight Day 2 would have been Pegasus. "*That's what I thought it might be, too,*" replied McDivitt. White then reported the battery levels at 9 amps and 22.5 volts and that the rest of the readings were nominal. The Capcom then gave the crew information on managing the O_2 levels.

Grissom: "*Next time you bleed down your primary oxygen pressure, bring it all the way down to about 800 psi* [55.2 bar]. *We can't find much else that we can do about the thing. Just bring it down lower so that you are working through a wider band. We don't think it's going to cause you any* [more problems]. *We think you can go way down in your pressure now without hurting anything, so if it gets to be a nuisance just bring it on down so that you don't have to watch it so close and be bothered with it too much.*"

A few minutes later, at GET 49:00, McDivitt was asked to provide more information on his satellite sighting, including an estimate of how far the satellite was from them.

McDivitt: "*I couldn't really tell. It looked like quite a large object, and it looked like it was closing on us rather rapidly. Distance is rather hard to judge.*

I'd say ten miles or so… That's just a guess. I really can't tell [the exact distance]. *I was close enough to see arms and cylindrical things sticking out*."

The Capcom replied that, as near as they could determine, there wasn't anything that close to them. Pegasus was about 1,200 miles (1,931 km) away, so if that was what he had spotted then McDivitt "*had pretty good eyeballs*." McDivitt replied that he had taken a picture of it. "*I just hope it comes out*," he commented, to which the Capcom replied, "*So do we*." McDivitt did not have the exact time that he had seen the satellite, but he had called in on the radio and thought that it ought to be on the tape. He had also put it on the voice recorder on board, so it would be possible to replay that later and look for it.

The Capcom then asked if McDivitt was using VOX (Voice Activated), because he was cutting out and clipping the last part of his sentences. He was not. He reported that he was using the continuous interphone PUSH TO TALK instead and suggested "*Maybe I have a weak thumb.*" McDivitt then asked permission to use the M-3 Exerciser more than planned, so that he could get more exercise than he had been. This was agreed, providing he reported exactly how much he was using the device, and Grissom then queried why he wanted to use the exerciser more, asking if he was feeling stiff, cramped or otherwise uncomfortable. McDivitt replied: "*Yes,* [I've'] *been in orbit two days and haven't moved around very much.*"

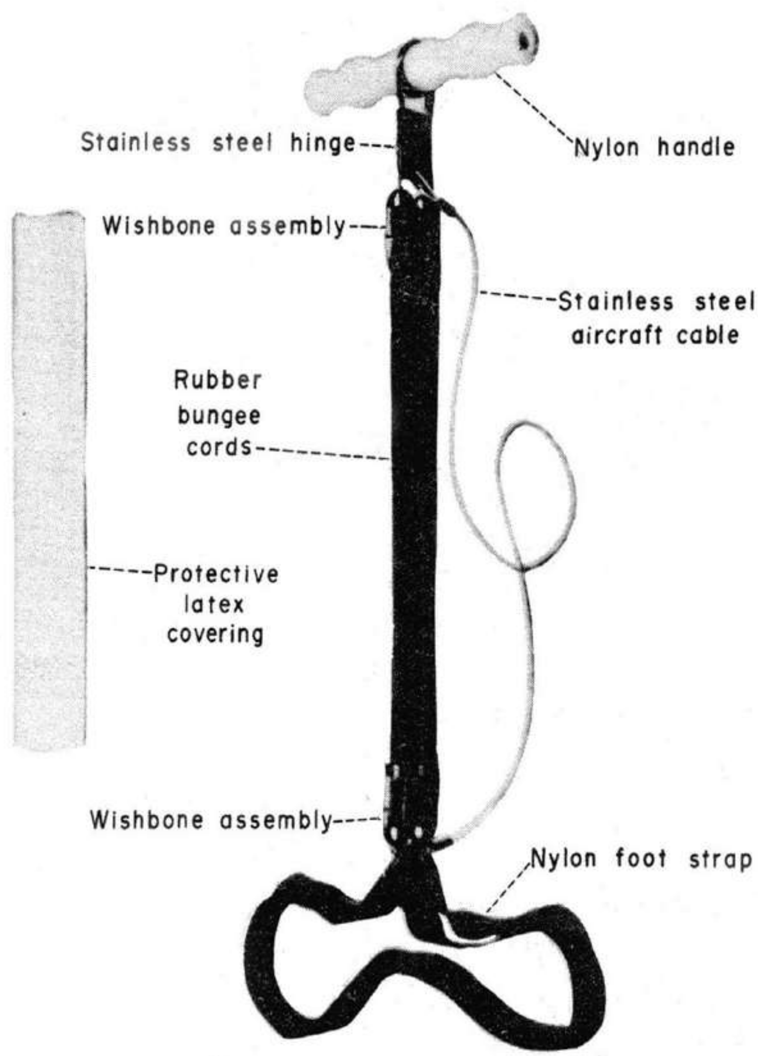
GET 49:02 (Orbit 33/Rev 32) – GET 50:30 (Orbit 34/Rev 32)

McDivitt's latest rest period came to an end at the beginning of this orbit, some 40 minutes before White started a 30-minute break. Work was completed on experiments S-5 and S-6, as well as another Apollo Landmark Investigation, updates to the onboard maps and a Type 2 medical data procedure for McDivitt.

As the 50th hour of their mission approached, while they were in contact with the Grand Canary station, McDivitt asked if they were passing directly over the site. He was told that they were passing well to the south of the Canaries and were over Cape Verde. "*Okay, I'll look down and see you*," McDivitt joked. "*I saw you standing outside waving.*" The Capcom then read up the data they required for the S-5 experiment over the U.S. on their next pass and for the fourth Apollo Landmark Investigation.

GET 50:35 (Orbit 35/Rev 33) – GET 52:03 (Orbit 35/Rev 33)

Tasks on this orbit for the two astronauts included further work on the S-5 experiment (for five minutes), updating the D-9 experiment and the start of another Apollo Landmark Investigation. There were also the usual updates to landing opportunities and playback of the onboard tape recorder.



M-3 In-flight Exerciser major components [original of poor quality].

The Capcom reminded the crew to update all their future Type 2 medical passes to Type 1, which would give them both more exercise. They were also asked about their quality of sleep at this point in the mission. White had been napping for about an hour, instead of the two hours he should have been resting, and McDivitt announced that they were going to rearrange their sleeping cycle a little. Neither man was getting an awful lot of rest, but as they were also not doing much physical activity, neither were they particularly tired. White was due to return to his sleep period after this current pass. McDivitt then updated the ground about the recent S-5 experiment pass that he had been wanting to complete over the United States for some time.

McDivitt: "*On that last pass, we took about 38 pictures on the Synoptic Terrain Photography, starting a little bit east of San Diego and until we ran into cloud coverage again. We picked up with intermittent pictures as soon as we started over the southern part of the United States, down around Alabama and Mississippi and on across to Florida. We got some very good pictures of the weather in that area, and then we got some pictures of the airfields around Jacksonville. We took a couple of pictures of the Cape. Probably one of the best pictures we got was one shooting back, and we got a whole weather formation along the coastline, starting with Florida and going all the way back to Texas. A very well defined line of weather, following closely to the coastline. Then we took some pictures of the weather formation in the State of Florida, around Cuba, and the island area, and into the Gulf… weather buildups, clouds, and we took a couple of pictures of the island, some very good pictures. We ended up taking 55 pictures.*"

At GET 50:58:03, McDivitt then reported spotting a second satellite out of the window.

McDivitt: "*Just saw a satellite, very high… spotted like a star* [from] *the ground when you see one go by. A long, long ways away. When I saw this satellite go by, we were pointed just about directly overhead. It looked like it was going from the left to the right… back towards the west, so it must have been going from south to north.*"

Ed White then commented on the fix to the vent valve on the ECS O_2. "*[This] was very cleverly fixed to take care of John's complaint* [referring to John Young, Pilot on Gemini 3[1]] *that it vented out of scale. Now, of course, it vents down into scale and causes quite a big problem, everyone knows, with the oxygen.*"

McDivitt: "*You might advise Houston that as far as we're concerned* [experiments] *S-5 and S-6 are complete. Do not do any more flight planning.*"

Capcom: "*Okay, we got that. Here's your apogee/perigee: 88.1, 148.7… and they say you got a real low decay rate.*"

McDivitt: "*It's a streamlined capsule.*"

Capcom: "*The fellow sitting next to you* [White] *is streamlined*."

White chipped in that he also thought the capsule was streamlined, with the Capcom replying: "*Your boss* [McDivitt] *says it's incredible*."

When asked to give a cabin humidity reading and a hatch temperature reading, they reported that they had just completed doing that a little earlier, "*about halfway around the night side.*"

McDivitt: "*The hatch temperature was 67 degrees* [F, 19.4 degrees C]*… cabin dry bulb was around 72 to 73 degrees F* [*22.2–22.7 degrees C*] *and wet bulb was around 60 degrees* [F, 15.5 degrees C]*… the relative humidity is about 61 percent*."

At GET 51:42, both of the astronauts' wives were back in Mission Control, and Ed White's two young children were with them. This time when they talked to their husbands, it was more formal. Pat White took the headset first and advised Ed to turn switches, which he did without changing the expression in his voice for between five to ten minutes. He knew who was broadcasting, and said the current Capcom was a great improvement over Gus Grissom. The wives told the two men to drink more water and try and get a good long sleep, as the Flight Surgeon was getting concerned over their devotion to the experiments over many hours without a good break. Ed White's children were patched into the conversation between their mom and dad and listened intently. Pat McDivitt then took over, repeating the request for them to drink more water, and that there was no static [argument] on the request. Jim McDivitt replied "*I'm not allowed to give you static at home, why should I do it up here?*"

GET 52:10 (Orbit 36/Rev 34) – GET 53:35 (Orbit 36/Rev 34)

A few minutes into this orbit, the Apollo Landmark Investigation was completed. This was followed by turning on the MSC-1 experiment and then a SPADATS tracking test over Antigua, where the ES sensor was switched on for 15 minutes followed by turning off the MSC-1 experiment. Other work included another M-3 exercise period and the D-9 and Apollo Landmark 4 (over Mexico, Big Bend , and Corpus Christi in Texas) experiments. McDivitt also completed a Type 1 medical data procedure.

When using the blue filter on the sextant, White had trouble finding the horizon for star tracking when he zeroed in on it, as it seemed to disappear, adding to their problems. However, the green filter cut out most of the airglow. White told the Capcom that he had decided to take off his helmet to use the sextant. McDivitt then told White that he had "*planned playing around a lot with the filters, just* [by] *themselves when you were sleeping.* [It was] *the next thing I was going to do. I was just going to get the sextant out and play with the filters and stuff.*" White then informed the Capcom that he wanted to detail his observations about using the sextant.

White: "*Its use in a cramped spacecraft is very difficult, particularly with the helmet on. I finally decided it was going to be useless with your helmet on to try to take the angles that the stars that were being called for required. So I took my helmet off. This gave me a little more flexibility in using it* [the sextant], *but still I was limited to angles of about 20 to 23 degrees, without maneuvering the spacecraft. What would happen if the star would be cut out by the upper part of the window? Now, by more frequent and liberal maneuvering of the spacecraft, you could maneuver it so that you have the long axis of the window in your tracking lane. We were somewhat limited by fuel and we didn't choose to maneuver in this manner. We used PULSE MODE, too, without a lot of maneuvers. The stars that were selected for that run were ones that had rather high angles to the horizon and, therefore, were very difficult to get. We finally decided to go ahead and get the stars a little closer to the horizon. I ran a couple on Canopus and a couple of others, as you'll notice. The blue filter seems to block out the horizon totally. I didn't have any horizon when I used that. Our horizon image probably is not as good where there is moonlight. The green filter, though, gave me what I would consider a little cleaner horizon than I had with no filter at all. I felt there was not a difficulty in making these measurements with either the green or clear filter. Still, the horizon is not very well defined and you have to kind of standardize yourself and measure on the same part of the horizon that you did before to get some type of standard measurement. To me, it was easier to measure with no filter to the top of the airglow. With the green filter* [attached, I used it] *to measure the bottom of the airglow.*"

McDivitt then updated the ground with the OAMS source temperature of 60 degrees F (15.5 degrees C) and pressure of a little under 2,000 psi (138 bar), with the quantity reading indicating 60.5 percent on the gauge. The ground then advised that the Adapter batteries were all reading fine at 2 to 2.5 amps at 24 volts, while the main batteries were recording 9 amps and 22.5 volts.

Mission Control was also hedging their bets about either preparing for a full mission or, depending on the state of the spacecraft and its power, a mission landing at the first opportunity on Orbit 48, for a flight of 3 days, 17 hours, 20 minutes and 18 seconds.

GET 53:55 (Orbit 37/Rev 35) – GET 55:15 (Orbit 38/Rev 35)

Both men took a meal break during this orbit. They also received updates for landing opportunities and their onboard maps. The sixth orbital navigation check was also completed.

Guaymas reported a map update to McDivitt, who had his helmet off but could still hear them through the headset (White was asleep at this point). He grabbed a pencil to copy down the data relayed up to him.

GET 55:20 (Orbit 38/Rev 36) – GET 56:45 (Orbit 39/Rev 36)

MSC-2 and -3 were turned on during this orbit and remained on for the next two orbits. As White began his latest rest period, McDivitt reported that they had no DCS map light available. He also completed a ten-minute S-6 experiment (GET 56:35 to GET 56:45).

GET 57:15 (Orbit 39/Rev 37) – GET 58:23 (Orbit 40/Rev 37)

As McDivitt took another meal break and prepared for another run on the S-6 experiment, the onboard tape was downlinked and landing opportunities data uplinked. He was updated on the tracking of the Pegasus satellite that was initially thought to be the object he had observed earlier in the flight. During their 58th hour, the Gemini 4 astronauts became the first to achieve one million miles (1.6 million km) on one spaceflight.

GET 58:55 (Orbit 40/Rev 38) – GET 60:00 (Orbit 41/Rev 38)

Early on this orbit, experiments MSC-2 and -3 were turned off after two orbits of gathering data. After his three-and-a-half-hour rest period, White took a meal break and then both astronauts participated in a briefing session. McDivitt also completed another Type 1 medical data procedure.

White was now awake and looking out of the window. “*Those are the Himalayas, I’m quite sure.* [I] *have seen Gordo’s* [Cooper, during MA-9 in 1963] *picture that he took. It was such a good one.*” At GET 59:23:14, White reported that McDivitt had seen another satellite. This one was much further away, which necessitated taking a picture with the 4x telescopic lens. When it came to White's side, the sun was right in the window and he could not see anything much. McDivitt said he had seen a white ball, and White confirmed that he had also seen part of one.

Capcom: [GET 59:26:49] "*Be advised. At 58 hours 10 minutes, about an hour ago, you surpassed the total lasted time for all the U.S. manned space flights. Our congratulations!*"

White: "*Roger. Understand; have surpassed total elapsed time of manned space flight of the United States…*"

McDivitt: "*This Gemini 4. I saw another satellite up here. It was 02:38 when I saw that thing and it was much further away than the other one I saw. I tried taking a picture of it. I think I might have it on our 200-mm lens… I'm afraid this one was way too far away to show any detail.*"

GET 60:15 (Orbit 41/Rev 39) – GET 61:30 (Orbit 42/Rev 39)

After work on the D-8 experiment, McDivitt began his latest rest period on this orbit, while White provided a Type 1 medical data procedure and recorded the latest landing opportunity updates.

White reported on a more mundane, but nevertheless important issue for them, early in the orbit.

White: "*Both Kleenex container zippers failed. They had split open from the bottom below the zipper so that the zipper could no longer be effective in the container.*"

Then, at GET 60:03, White reported an update of the food and water intake for both men and that McDivitt had used a defecation bag on the third day of the flight. In his biography, Chris Kraft later wrote that PAO Paul Haney had convinced him that a change-of-shift press briefing was the right thing to do. The Flight Director and some of those controllers responsible for that shift's major activities would be in attendance. "Sometimes the sessions were quick and easy," Kraft recalled, "sometimes they were brutal, with reporters pressing for intimate details of the astronauts' medical status, or finagling for a quote that would lead to a headline in tomorrow's paper." In his 2000 book, Gene Kranz recalled that these shift change press conferences "sometimes felt like interrogation sessions." According to Kraft, some reporters were unusually interested in the astronauts' bowel movements. Since the Gemini fecal interested in the astronauts'[1] bowel movements. Since the Gemini fecal containers bags were blue, Kraft recalled that “almost every day, somebody would ask for a ‘Blue-bag status’. It became a standard joke in Mission Control to deliver a ‘blue-bag’ report.” To his relief, Kraft discovered that this was not the sort of question asked by the best space reporters.

Footnotes

1 See Gemini Flies page 218–9.

David J. Shayler, *Gemini 4*, Springer Praxis Books
https://doi.org/10.1007/978-3-319-76675-1_11

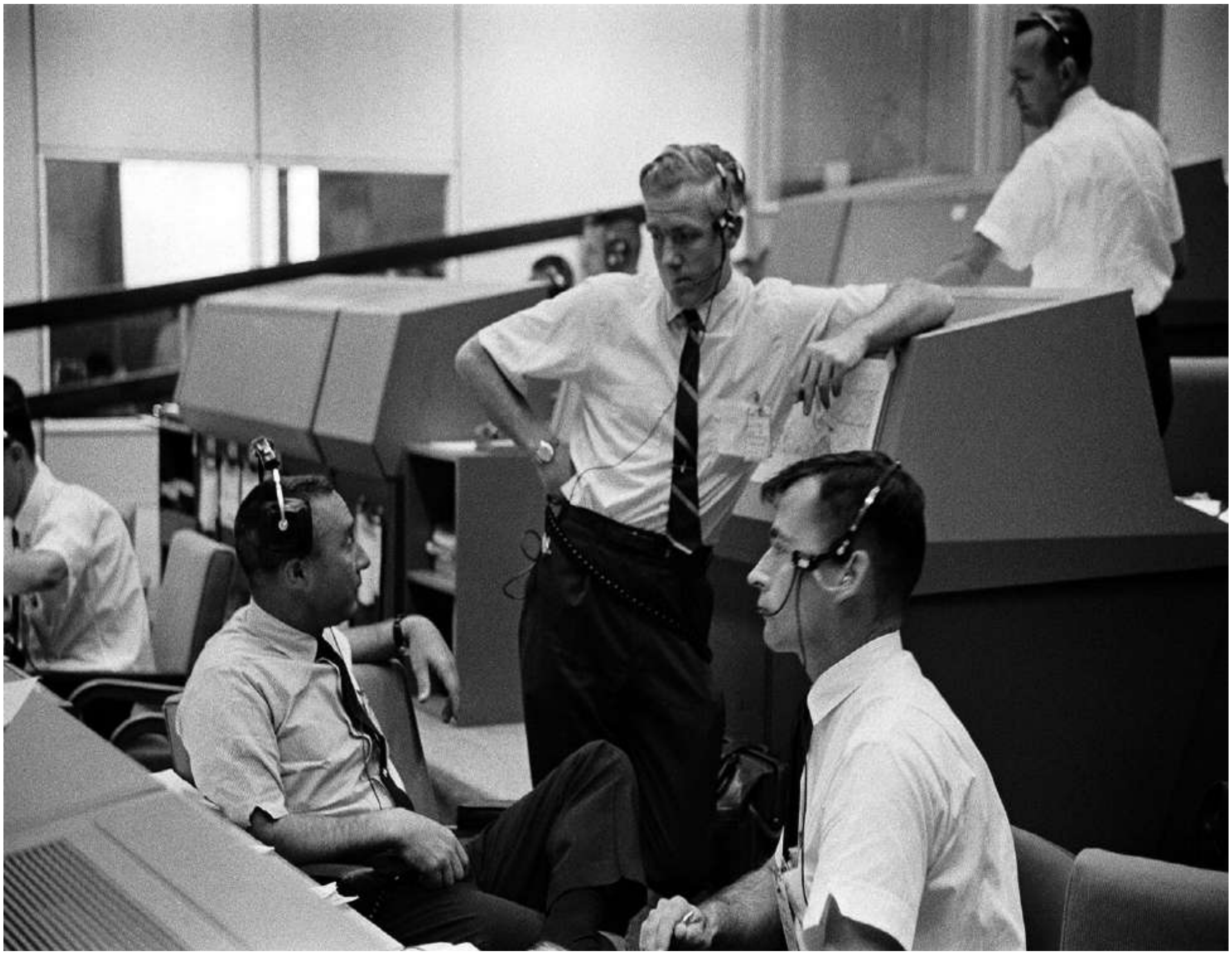
11. A computer malfunction

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

"Stale cigarette butts, cold coffee, and day-old pizza made up the scent of Mission Control… Every action worked to Mission Elapsed Time. Our bodies were the only laggards, responding to the need for food and rest on a schedule corresponding to a sun we couldn't see."
Gene Kranz (2000).

Orbit by orbit, hour by hour, the mission ticked away, with the astronauts progressing through the flight plan and adapting not only to working in Gemini but also to living inside its cramped confines. There were challenges for the ground controllers in the MCC as well. Stuck inside a windowless building for hours on end, they were free from the humid heat of a Houston summer day but not from the stresses of constantly monitoring their consoles to ensure that all was proceeding well. But there were moments of levity as well. At one point, the Blue Team Operations and Procedures Officer, Jim Timberland, called the control room to inform them that "if you need me, I'll be at [this] extension." Confused, the other person asked "Where's that?" Timberland replied "In the front elevator – stuck." Fortunately, he was not stuck there for long and was soon back at his console.



A quiet moment in Mission Control. Capcom Gus Grissom chats with Blue Team Flight Director John Hodge. Seated next to Grissom is his former Gemini 3 colleague John Young who accompanied Grissom during most of his shifts on the Capcom console, between them offering their experience of flying the first manned Gemini three months earlier to assist the current crew on orbit.

Flight Day Four, Sunday June 6

GET 62:00 (Orbit 42/Rev 40) – GET 63:05 (Orbit 43/Rev 40)

> *This orbit started with the crew unable to make contact with Ascension Island for an HF check. The orbit also saw the seventh orbital navigation check and more work on experiment D-9 (Run 2).*

Time is critical on any spaceflight, and that was especially true for these early, relatively short pioneering missions. It was hoped that the hardware would perform correctly for the intended duration of the mission, and that the crew would be able to accomplish all that was expected of them. For Gemini 4, with things going well, regular updates and changes were uplinked to the crew, occasionally at opportune times as happened during the D-9 Run 2 phase, where occasionally at opportune times as happened during the D-9 Run 2 phase, where the ground (in this case Capcom Roger Chaffee on the White Team in MCC Houston via the Kano tracking station in Nigeria) advised the crew that they were authorized to use maneuvering fuel to complete the task. Later, during another pass over the RKV, the Capcom asked the crew if they were ready to receive and copy down the data for an Apollo Landmark run as well as several other updates.

McDivitt: “*We* [are] *in the middle of Experiment D-9 right now. Can you hold them, or* [insert them in any] *late transmissions on the time schedule?*”

Capcom: “*If you can get through with your D-9 experiment in time, give me a call. We have about five-and-a-half minutes left in this pass.*”

McDivitt: “*Roger. I don’t anticipate that I’ll be done in time.*”

The new information would finally be passed up to the crew 30 minutes later, as they flew over the Kano station in Nigeria.

GET 63:25 (Orbit 43/Rev 41) – GET 64:40 (Orbit 44/Rev 41)

The D-9 Run 2 experiment was completed and an update to Apollo Landmark Investigations conducted.

GET 65:25 (Orbit 44/Rev 42) – GET 66:20 (Orbit 45/Rev 43)

Apollo Landmark Investigations were being conducted as McDivitt ended his latest rest period. This was followed by a joint meal break and a briefing period, before another session on the M-3 exerciser.

Once McDivitt had awoken, he updated his quality of sleep report to the Surgeon at Mission Control, advising that he had had about five-and-a-half hours of rest officially, of which only about “*four hours of it was pretty good sleep.*” The Surgeon then asked “*Did you use the waste collection system at all during the flight?*” This time it was White who replied. “*Boy, did we ever. We each used the defecation system one time and the urine system about four or five times, I guess.*” With the Gemini flying out of direct radio range McDivitt dictated his impressions of the fruit juice bags supplied for the long flight into the onboard tape recorder.

McDivitt: “*Okay… So far every orange juice bag, every bag that I have put water into that has had orange juice in it in any form, or pineapple, or* [fresh] *orange juice, has had a leaky water valve. Now, I have had only one other* *drippy bag so far and we are already about 60 some hours into the flight. But every single orange juice bag has had a leak in it. And Ed just came up with another leaky orange juice bag for himself. But this is Ed's first one.*"

Observing the world's weather was a fluid operation, as new weather systems could develop at short notice and offer new opportunities of interest for the meteorologists. Such targets were uplinked to the crew. At GET 66:25, the Houston Capcom updated the crew about significant weather opportunities for the S-6 experiment.

Capcom: "*Weather for S-6. Look for any clouds in the lee* [sheltered side] *of the Canaries and Madeira Island for oblique photographs. Location approximately 200 miles* [321.8 km] *south and 300 miles* [482.8 km] *north of the spacecraft position at time 09:51:00* [GMT] *for a total of five minutes,* [that's] *zero five minutes. It's highly desirable to get photographs of these clouds on successive passes over the same area.*"

When McDivitt queried whether they had adequate fuel to accomplish this, he was told that they had. Then the Capcom also enquired about the status of equipment stowage in preparation for re-entry the next day.

Capcom: "*Gemini 4, Houston. Can you give us any idea of whether you've got some of your gear stored? We're concerned about CG. Over.*"

With the intended dump overboard of unwanted EVA gear having been cancelled following the problems with the hatch, the added mass would be coming home with them and would affect both the planned CG (Center of Gravity) of the spacecraft during entry and the overall mass under the parachute during recovery. Therefore, Mission Control needed to know precisely what was being brought home and where it had been stored, so that they could calculate the revised mass of the vehicle and its amended CG.

McDivitt: "*It looks like we're going to end up with VCM on the floor, and we're going to have the cable in Ed's lap. And we are going to have the gun stowed in the center food box where it was. We're going to have the camera equipment in the side food box.*"

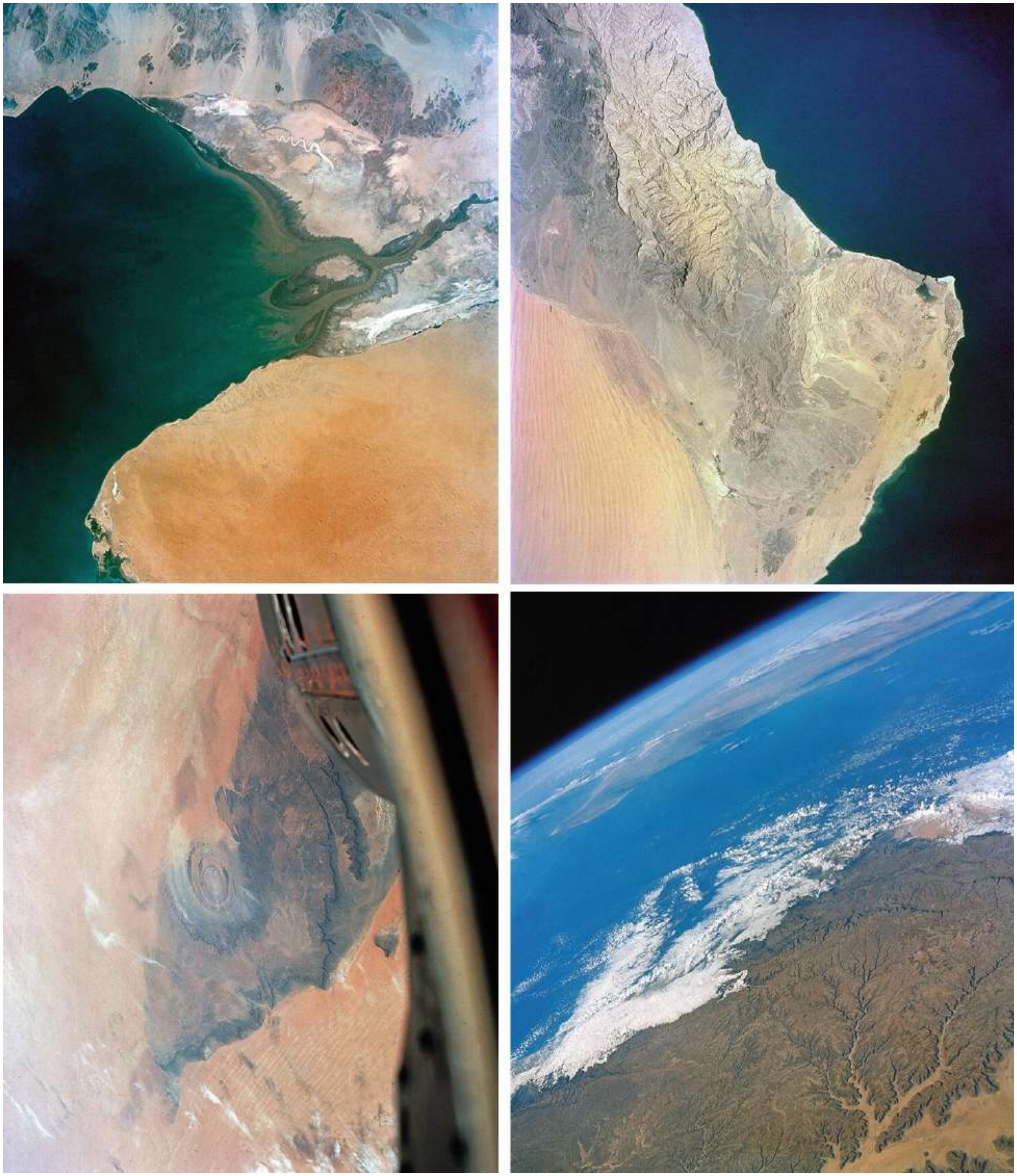
GET 66:30 (Orbit 45/Rev 43) – GET 67:55 (Orbit 46/Rev 43)

> *A 20-minute session on experiment S-6 was conducted early in the orbit, as well as activities involving turning the MSC-1 and MSC-10 experiments on. In addition to the now-regular updates for landing opportunities and onboard tape playback, this orbit saw the crew power up and align the platform and open the Acquisition air circuit breaker for five minutes.*

The crew then reported to the Capcom about their latest imagery.

White: *"I've taken a picture, a very good picture of the Cairo airport."*

McDivitt: *"I think that on this tracking task, using the world map and the small map of the Cairo–Alexandria area, we were able to pick up the airport at Cairo. However, I didn't see the airport until we were about 10 degrees from it, I would guess, or 15 degrees."*



Four images of Earth taken during the Gemini 4 mission. (top left) Experiment S-5 photograph showing the north end of the Gulf of California at the mouth of the Colorado River. (top right) The S-5 view of the southeast tip of the Arabian Peninsula, with the Gulf of Oman at upper right. Seif dunes (sand) can be seen lower left. (bottom left) S-5 image of the large Richat crater in northwest Africa. (bottom right) The Hahramaut Peninsula on the southern portion of the Arabian Peninsula. The Wadi Hahramaut is in the foreground with the Gulf of Aden (dark blue).

McDivitt went on to explain that this was the second time they had tried to capture the image. On the previous pass, he reported just seeing the area, successfully spotting Cairo and Alexandria but not picking out the airfield. On this second search over the area, he found the airfield straight away. Noting the technique for future missions, McDivitt suggested: "*I think [that] if you are going to take a picture of something like that, it might be worthwhile to pass over it one time, take a good look at it, and take the pictures next time around*."

Prior to settling down for his next sleep period, White reported an equipment failure to the ground. "*The rubber outside the prophylactic on the* [M-3] *exerciser broke*." He then settled down for his sleep period, but not for long. The Carnarvon Capcom informed McDivitt that in addition to operating experiment MSC-10, Houston also wanted them to turn on MSC-1 as well. He would therefore need to wake White up from his sleep period at the appropriate time, so that both astronauts would be able to accomplish the MSC-10 experiment.

McDivitt: "*Roger. I understand. We will get a flight plan update over the States. It looks like we're going to be pretty busy up here at that time. We'll be aligning the platform and doing MSC-10 at the same time.*"

The Capcom made a note to advise the ground team not to bother them too much during that period.

The objective of MSC-10 was to photograph the limb of the Earth on black-and-white film with a hand-held 70-mm Hasselblad camera, to evaluate guidance and navigation procedures planned for Apollo. Mounted closely in front of the focal plane were two color filter mosaics (red in the center and blue on the sides). The objective of the filters was to measure the excess elevation of the blue limb over the red by micro-densitometry. Ed White began the experiment at the end of the night pass of the orbit and rapidly shot groups of three photographs in five-minute intervals throughout the succeeding daylight pass, until the next sunset.

Later in the orbit, McDivitt reported more problems with the Hasselblad camera as he took photos through the window.

McDivitt: "*We haven't had much success with the photo-event indicator on the Hasselblad. [It] Puts the shutter in the – what do they call that thing? The shuttle doesn't fall properly…*"

White: [also unsure of the technical term for the failed component in the camera] "*The shuttle doesn't go down and the doors, or whatever they call* *them, don't open again*."

White: [A few minutes later] "*At this time, the event indicator worked all right. Looks like I got it adjusted so I can take the pictures with it, so the series from now on will be marked on the event… The timer, I think, hangs up to [the] magazine.*"

Ready to Come Home

GET 68:00 (Orbit 46/Rev 44) – GET 69:30 (Orbit 47/Rev 45)

> *This orbit featured sunset and moonset checks on the Horizon sensor, as well as an Apollo night orientation check. There were also several tape playbacks over different ground stations.*

Over Carnarvon, Australia, McDivitt was told to look out for the lights of Melbourne, though it was not certain he would see them as it was raining really heavily at the time.

McDivitt: "*Yes. Every time I go over Australia, all I ever see* [are] *thunderstorms… I see some lights shining through cloud down below me at this time… Okay. Very good. Tell them* [the citizens of Melbourne] *I thank them for lighting the night for me… Tell them next time, though, to get those clouds out of the way so I can see the city and not just the clouds.*"

Capcom: "*That's the same [way] I feel, I'm afraid.*"

Over Texas, the Houston Capcom asked for an update on the cabin humidity, and whether there was any noticeable water. McDivitt reported that the humidity had remained low at about 60 to 63 percent, there was no noticeable moisture, and that they had been working quite frequently with both their helmet faceplates open and with their gloves off, using the spacecraft's systems rather than their suit systems. They also reported that they had one magazine of unexposed Hasselblad film remaining and two magazines left for the 16-mm camera.

Backup Command Pilot Frank Borman was now at the Houston Capcom console, and a typical banter between colleagues ensued as the long mission drew towards it conclusion.

Borman: "*Are you two ready to come home yet?*"

McDivitt:

"*I'm sure getting tired of looking at* [White's] *ugly face. He needs a shave.*"

Borman: "*We're getting tired of hearing that silly voice too, McDivitt. How are you doing?*"

McDivitt: "*Well, I'm waiting until 12:58 so I can fire my thrusters again.*"

Borman: "*Ha ha! This is the most fun you've had in two days, I'll bet.*"

McDivitt: "*Yes, it's the first time I've fired the thrusters in two days.*"

Borman: "*Have at it, flight-time hogs!*" [referring to the monthly requirement to keep up their flying time proficiency to continue flying jets.]

McDivitt: "*Too bad this isn't next month. I have my requirements in* [this month] *already.*"

Borman: "*Hey, you know, I knew that White was a time hog Jim* [flying heavier aircraft on longer missions], *but I always thought you were a 55-minute mission man* [piloting faster jets on short sorties].

McDivitt then joked that the ground was making him stay "*up here until we burn out the fuel,*" with White adding "*I don't ever land with them* [the tanks] *full.*" The Capcom then let the men know that all was well at home. "*I saw both your wives yesterday. Everything is in good shape… We're thinking of extending the mission about a week.*" At that, McDivitt suggested that they had better send up some more food, to which the Capcom replied: "*Okay. Frank* [Borman] *said he would be on his way up as soon as he can make it.*" These short distractions from the flight plan were a welcome break from the routine of the drifting flight, as well as trying to keep track of where above the Earth they were, as evident in this exchange with McDivitt.

McDivitt: "*Houston, Gemini 4. Where am I?*"

Capcom: "*You don't know? It looks like you're just about southeast of the tip of Florida. Probably over Cuba.*"

McDivitt: "*I got it. I thought it was an island – turned out it was Florida.*"

Then it was back to work, with the Capcom requesting yet another update to the readings on the OAMS source pressure, temperature and quantity. McDivitt dutifully replied, informing the ground that at that time (GET 69:32:08), the quantity was fluctuating up and down, but a good average was 55 percent. White chipped in with readings of the source temperature of 70 degrees F (21.1 degrees

C) and pressure of 1,900 psi (131 bar). The Capcom then informed McDivitt that he had used about 15 pounds of OAMS, which confused him. "*I've used 15 out of 10?*" McDivitt asked. The Capcom affirmed this reading of 15 pounds, which was more than the ten pounds assigned for the checks, but McDivitt refuted the numbers and was told that this was just a rough guess and that he would get more accurate information after the Canaries pass.

It was Sunday morning in Houston and outside the Control Center it was pouring with rain, but despite the rumbles of thunder, daily life continued as normally as possible at the homes of Jim McDivitt and Ed White with the two dads 'out of town'. The families of both astronauts attended their local churches, with the rain letting up a little for their journeys there. Pat McDivitt and her children went to the auditorium of Webster's Junior High School, where St. Paul's Parish Catholic Church held morning mass and communion. A few miles away, Pat White took her children to the First Methodist Church in Seabrook [1]. With both astronauts facing the challenge of the first extended spaceflight in the American program, for the wives and families it was a different type of challenge, watching, listening and waiting for the mission to end. With the mission flying over the weekend, the children were home from school, so Pat McDivitt had taken her family out on nearby Clear Lake for a boating trip the previous day (June 5), filling the hours before splashdown two days hence. Meanwhile, Pat White was adding the growing collection of press cuttings to the scrapbook of letters and news reports on the flight that she had started on the day of launch. White's son kept accurate records of his father's adventure in space, referring to the orbital routes on the long strip-maps NASA had provided [2].

GET 69:38 (Orbit 47/Rev 45) – GET 70:55 (Orbit 47/Rev 45)

> *A Horizon sensor thruster check was followed by a Horizon sensor tracking check, and then a failure check on one of the attitude thrusters. At GET 70:12, the spacecraft was powered down and the MSC-1 experiment was turned off. Ed White completed a Type 1 medical procedure and another M-3 session was conducted.*

White was scheduled to have another Type 1 medical pass later in the orbit as they flew over Texas, but over Carnarvon, McDivitt suggested that as White had not slept for a while, it might be better to do the medical pass early and then let him sleep, rather than disturb him in the middle of his rest period. On the ground, Flight Surgeon Dr. Charles Berry concurred. White completed his exercise, and his blood pressure and temperature readings looked good. He informed the medics that he had not slept since his previous medical pass, apart from a brief 15-minute nap, but he had felt fine for the past couple of hours.

from a brief 15-minute nap, but he had felt fine for the past couple of hours. Once the medical data had been collected, White began his sleep period. In reviewing the medical information, Dr. Berry commented that he was seeing some of the best data yet, which was encouraging.

At this point, Gemini was pointing nose down and McDivitt asked if the ground wanted him to turn the spacecraft "*right side up*" in the pass over Cape Canaveral for a scheduled critical tape dump. This was confirmed. The Capcom at Carnarvon reported that he had managed a long night's sleep, to which McDivitt responded "*We've had a lot of short nights' sleep,*" though he reported feeling "*just dandy*" at this point in the flight and that he was having trouble getting White to settle down. The Capcom also advised the crew that any remaining MSC-10 films could be used for targets of opportunity of their own choice, while more opportunities for S-5 and S-6 imagery would be available over the Canaries and Africa on the next pass.

GET 71:05 (Orbit 48/Rev 46) – GET 72:35 (Orbit 49/Rev 46)

> *The status of experiments S-5 and S-6 was updated and a 'GO/NO GO' status check performed on the spacecraft. Ed White began another rest period, while McDivitt took a meal break and completed a Type 1 medical procedure.*

Back over Carnarvon one orbit later, McDivitt reported that White had finally gone to sleep 30 minutes beforehand, at about GET 71:21, and that he expected his colleague to sleep for the next five or six hours. Towards the end of the orbit, Grissom, on the Capcom console at Houston, passed up quite a bit of information to McDivitt.

Grissom: "*We would like for the* [astronaut] *who is asleep to leave his faceplate open and his gloves off. And then we would like for the* [other astronaut] *that is awake to take off his helmet and gloves and use the lightweight headset for communications if he can. And we would like for you to continue this way up to about three hours prior to retrofire.*"

McDivitt: "*We have been operating with the faceplate open and gloves off now for about the last twelve hours, but mostly in that situation we kept oversleeping. When we sleep, we generally close the visor and put the* [garbled] *cover to keep the light out of our eyes.*"

After he had reported that the humidity remained down at about 50 percent, the ground then informed McDivitt that they had decided there was more fuel left to play with than had been defined in the flight plan at this point in the mission play with than had been defined in the flight plan at this point in the mission. They requested that during the next eight hours, McDivitt should choose Horizon Scan Mode using the primary scanner, but should not control in yaw. If the scanner broke lock on the horizon, he was instructed not to attempt control in roll or pitch either. The plan was to see whether, should the scanner break lock, the system could re-acquire it without the astronauts' input. McDivitt then reminded Grissom that, for flight planning purposes, they had not been able to achieve much with the D-9 experiment, as they had not been using any fuel for it. He suggested saving some fuel to do that. Grissom told him to go ahead and use the D-9 fuel, then updated the next Apollo Landmark No. 2. McDivitt, with typical military astronaut efficiency, understood and affirmed the involved instructions first time.

Grissom: "*We would like you to be in attitude for that at 17:19 GMT. The landmark will be 16 miles* [25.7 km] *north of the track, and you should pitch down about minus 30 degrees at that time. And we would like for you to track this as close as possible and to get some pictures using the 16-mm camera, with 75-mm lenses with a nominal lens setting.*"

McDivitt: "*Apollo No. 2 at 17:19. Sixteen miles north of track. Pitch is down about 30 degrees and use the 75-mm lenses at that time.*"

A short time later, Grissom also relayed a message from Flight Director Chris Kraft, asking whether McDivitt was going to try to sleep with his helmet off next time.

McDivitt: "*I don't know. The sun really gets into your eyes, Gus. I don't think we'll try that. Ed had tried sleeping with his helmet faceplate up and then down and right now he just slipped it up. He's having tough time with the sun. I've tried it, and I can't do it.*"

Grissom then asked if they could just put a shade over anyway, to which McDivitt replied they could, before advising that White was currently asleep with his faceplate half open. The conversation between the astronaut on the ground and the one awake in space then focused upon the crew not keeping their faceplates closed, as the humidity was not increasing enough to warrant it. Grissom said that the ground was trying to get the data on what was happening inside the spacecraft, and suggested perhaps there was no humidity problem as they had first thought. McDivitt agreed, adding that White had not closed his faceplate fully for the previous 12 hours and that he had only closed his own when he slept, which he admitted was not for very long. As for the humidity in the spacecraft, McDivitt reported that the dry bulbs were running at 72 and 75 degrees F (22.2–23.9 degrees C), while the wet bulbs were between 60 and 64 degrees F (15.5–17.7 degrees C), with relative humidity standing around 60 percent. They could not see any visible moisture, nor was the blotting paper showing any. "*Unfortunately,*" McDivitt added, "*you covered up the* [spacecraft] *walls so that I can't take the temperature. But the worst temperature I can find is about 65* [degrees F, 18.3 degrees C]." The Surgeon then asked again if they had experienced any problems with their eyes drying.

McDivitt: "*Yes. I had a lot of trouble with my eyes at the end of the first day. I wasn't sure I was going to be able to hack it, but they have cleared up now. I think our little problem was taken care of by the suit heat exchanger. No problem at all* [now]*, though it was really bad between about 18 and 36 hours* [into the mission]."

At GET 72:34:38, the Capcom asked McDivitt to turn the spacecraft computer back on, which he did, reporting a few seconds later that the computer was ON and that the COMP LIGHT would be out in about ten seconds. The system was now ready to accept the update for landing on Orbit 48 at Site 1 if required, to be followed by a number of flight plan updates. Once this was completed, he turned the computer off again.

GET 72:45 (Orbit 49/Rev 47) – GET 74:10 (Orbit 59/Rev 48)

The eighth orbital navigation check was conducted on this orbit, as well as another Apollo Landmark Investigation. At GET 73:53, Guaymas gave a 'GO' for all spacecraft systems.

Over Carnarvon, the Capcom read up the morning news to McDivitt.

Capcom: "*Here's* [PAO Paul] *Haney's news release. It says in the morning paper that you are not going to go for five days* [and Bykovsky's record]. *This came up in a press conference last night and in an answer to this question Chris* [Kraft] *says it looked like we had the consumables to make it, but we had no plans to do so… Then, there is a nice story about Chris* [Kraft] *and the Control Center and your flight team and your families in the* [Houston] Chronicle *this morning… The rest of the news is Gemini 4.*"

Replying to a question from McDivitt about the operation of the new Mission

Control at Houston, the Capcom reported that it was “*working better than anybody had reason to expect*.” At this point, Houston Flight Director Kraft cut into the voice link.

Flight: “*Gemini 4, Houston Flight. We’re real pleased with the way the Control Center’s working down here Jim. The guys have done a great job and deserve a lot of credit. A tremendous flight!*”

McDivitt: “*Roger. Thank you. Glad to see its all working out*.”

At GET 74:10, McDivitt was again asked if he had the computer on, which he confirmed, having switched it on again just a couple of seconds previously.

GET 74:20 (Orbit 50/Rev 48) – GET 75:40 (Orbit51/Rev 48)

> *During this orbit, the onboard computer would not turn off. The orbit also saw the ninth orbit navigation check, a D-9 experiment and a thruster plume update.*

At GET 74:16, the Capcom reminded McDivitt to turn off the computer again in order to preserve the spacecraft’s power. Over Carnarvon, the Capcom asked McDivitt to find “*a long piece of paper*,” as he had a series of updates for him to take down. Before he did so, McDivitt reported a good battery check and then preceded to copy down the updates from the Capcom by hand. The process took nearly four minutes, including all the necessary confirmations of the nine sets of data. McDivitt got them all and complimented the Capcom on his precision in reading them up loud and clear. The Capcom informed the astronaut “*I’ve got a lot of wind!*” McDivitt then updated the ground about how well White had been sleeping through all the communications

McDivitt: “*Every once in a while he opens his eyes, but that’s the way you sleep up here. Sort of interrupted a lot… I’ve got my helmet on, but I’ve got the neck ring unfastened. The lightweight headset’s over on Ed’s side and I don’t want to bother him.*”

At GET 75:43, with White now awake again, the Capcom updated the crew regarding the Zodiacal Light experiment.

Capcom: “*They* [the investigators] *want to find out if they are going to get any fogging of the film from the attitude control thrusters. We’d like for you to use* *your 35-mm Contarex camera, and you can use either black-and-white film or color. And set it wide open at f/18 with the range set at eight feet.*"

The astronauts were then told to put the camera right up against one of the windows, but hold it so that the nose of the spacecraft was not in the field of view. They were then told to take two sets of photographs, with the spacecraft in PULSE MODE and pointed straight down at the 'black' Earth on the night side of the pass.

Capcom: "*And then give one pulse-up pitch and get a picture with the shutters of the camera open in the bulb position. And then as you come up through the horizon, get another picture, with the pitch-down pulse… again with the shutter wide open at that time. And then we want the same type of picture with pulse-up with the horizon view and with the black Earth in view, and a picture with pulse-down with the horizon view and the black Earth in view*."

Turn Your Computer Off

The astronauts were instructed to attempt this from the 51st orbit, starting at about 21:40 GMT. McDivitt then asked Grissom whether the next D-9 experiment was Apollo No. 4 or the other Air Force Run No. 4. Grissom confirmed that it was a planned Air Force Run. At GET 75:45:30, Grissom instructed McDivitt: "*You can turn your computer OFF now. We just checked your loading and it's all okay*." McDivitt did so, or so he thought.

McDivitt: [a minute later] "*Hey! I still have my Malfunction light and my Computer light ON, but the switch* [is] *OFF*."

Grissom: "*We show a Computer ON and no Malfunction light… What mode are you in on your computer now*?"

McDivitt: "*I just went from PRELAUNCH to CATCH-UP. That turned the Computer light OFF. Let's see if it comes back on now. Okay, it's back on. Now we'll turn the whole computer off and see what happens…*[McDivitt turned off the onboard computer and then reported]*… I still get the Computer Running light when I've switched it off.*"

Grissom: "*Hey, we still show the computer is on.*"

McDivitt: "*You say that you still show the computer is on?*"

Grissom: "*That's what we show here.*"

GET 75:55 (Orbit 51/Rev 49) – GET 77:12 (Orbit 52/Rev 49)

> *The crew performed an onboard check of the computer malfunction, updated the status of the D-9 experiment, performed another M-3 exercise period and received updates to the flight plan.*

With the uncertainty over what was happening with the computer, McDivitt was asked to cycle the system again, but he informed the ground that he had done so "*a bunch of times already*." After checking to see whether the ground could discern which mode the computer was in onboard the Gemini, McDivitt selected CATCH-UP mode to see if it would switch over, which was confirmed by the ground. McDivitt then asked for confirmation from the ground of the mode he was in. Grissom, at the Capcom console, replied: "*It shows you're in CATCH-UP and ON. That correct?*" But McDivitt was not seeing that at his end.

McDivitt: "Okay… my ON/OFF switch must have failed in the ON position… Why don't I just turn the IGS power OFF, let it go back to PRELAUNCH. Then just turn the IGS power on?"

The experts on the ground did not want him to do that yet, however, preferring to check the data they were seeing first. They told Grissom to advise McDivitt to leave the computer as it was for a few minutes. Grissom did so, adding "*We've got all the experts going through the books here.*" Ten minutes later, Grissom called again.

Grissom: "Hey. We're still thinking down here… We'd like for you to leave your computer running. Computer switch ON, your AC Power switch in ACME."

Communications with Gemini were becoming difficult, with Grissom having to repeat his message several times through the fading communications link before McDivitt finally acknowledged the instructions.

Later in the orbit, flying within range of the Carnarvon station, McDivitt was asked to recap what had happened earlier when he turned the switch to OFF position and to confirm whether or not he had seen a Malfunction light come ON. He reported that nothing had happened when switching the computer OFF and that there had been no Malfunction light at that point. The light came on when he switched the AC power from IGS to ACME. Then, as communications passed from Carnarvon to CSQ, he told the Capcom on the tracking ship that the

Computer light kept going on and off and that, occasionally, the Malfunction light was on. The CSQ Capcom asked whether the Malfunction light was on now.

McDivitt: "*Negative, but I've sure got a funny combination of switches. I've got the ACME Power ON, I've got the Computer ON, and my Computer light finally went off and finally my Malfunction light went off.*"

The Capcom asked when these lights had gone off.

McDivitt: "*When we put AC Power switch from IGS to ACME – this is not supposed to power the computer – the Computer light went OFF. When the Malfunction light came ON, then the Computer light came back ON again. Pretty soon both of them got dimmer… after three or four minutes. After we went to ACME power, the Computer light went out. The Malfunction light stayed on for about another four or five minutes, and finally it went out.*"

As the mission reached hour 77, just over an hour after encountering the problem with the computer, McDivitt asked the Hawaii Capcom how they were doing on their electrical power, receiving the response: "*Flight [Director] reports that you are doing great.*" This vote of confidence did not totally satisfy the astronaut, who then asked if that meant they were running above or below the predicted levels. The Capcom replied "*You have not used as much as predicted and should be well ahead. You're fat by approximately 160.*"

"*Understand,*" responded McDivitt, "*I've got 160 amps more than we had planned.*" Then he asked, quite naturally, "*Have they got my computer figured out yet?*" The Capcom replied: "*Negative on that, Gemini 4. They're working on it at the present time.*" Five minutes later, over California, the Capcom came back with an update.

Capcom: "*We'd like for you to bring your AC Power switch back to IGS and your Computer switch ON, and we'd like for you to watch for a rise in the ampage to make sure it came on… and we want you to leave this ON till you've just about finished your pass overhead. We want to check the computer memory.*"

A minute later, with Gemini 4 now over Guaymas, McDivitt reported "*I've got the Malfunction light ON now, and it won't go out.*" Guaymas did not seem to respond directly, instead informing him that they were standing by for the scheduled tape dump. McDivitt was naturally preoccupied with the computer issue and asked whether he had to instigate the tape dump himself, or whether it could be done by command from the ground. He was told that he had to do it. As he set the controls to do so, he once again reported that he could not get the Malfunction light on the computer to go out, but Guaymas merely advised him that they were still not receiving the tape dump. The astronaut then rechecked and confirmed that all the switches and circuit breakers were IN and that they should be receiving the data. He confirmed that he had placed the Telemetry switch to REAL-TIME and DUMP-TIME and shortly afterwards, the ground confirmed the tape dump had been successful.

The Capcom then suggested that McDivitt should check the Indicator Light Test Circuit Breaker over on his left panel, turning it OFF to see if that cleared the Malfunction light ON situation. Talking to Grissom in Houston again by this point, he said that he had already tried that and it had not turned the Malfunction light OFF. Grissom informed McDivitt that the memory seemed to be okay, but when McDivitt tried cycling the computer mode to CATCH-UP and back to PRELAUNCH, this seemed to make no difference.

GET 77:15 (Orbit 52/Rev 49) – GET 79:00 (Orbit 53/Rev 51)

A 65-minute session was completed with experiment D-9 and updates to the flight plan were sent to the crew. McDivitt completed a Type 1 medical procedure, an update for experiment D-8, and MSC-2 & -3 were then turned ON. This orbit also saw the tenth orbit navigation run.

While White worked on the experiment program, McDivitt was preoccupied with trying to understand the computer problem, talking with Grissom in Houston. McDivitt now had the Computer switch ON and the Power switch to IGS, and now tried switching the Computer switch OFF and then back ON again. He told Grissom that even doing that, the Malfunction light remained stubbornly illuminated. Grissom informed him that the earlier call about the computer memory was wrong and that the ground had in fact been unable to check the memory on that pass. Grissom then asked whether going to CATCH-UP and hitting the START COMP switch would work, followed by pressing the RESET button. After trying that, McDivitt reported that the Malfunction light went out but came back on again after a couple of seconds “*just like there’s a malfunction,*” he reasoned. All that hitting the START COMP switch had achieved was to turn the Computer light ON.

Working from information supplied by the computer specialists at MCC-Houston, Grissom now advised McDivitt to leave the Computer switch ON and put the AC Power switch to ACME, adding "*We will work on it. We'll give you an answer when we get one,*" leaving unspoken the possibility that they might not come up with one.

The flight continued, without an immediate answer to the computer problem. The crew could do little else other than to continue with their assigned tasks, which included further medical tests and reports on their meal and water intakes. Over Hawaii, they updated the start and end times of some of the experiments they had left to perform. Later, as they were flying over Guaymas, an update on the stowage issue was uplinked to the crew.

Capcom: "*Roger. All systems look GREEN. Flight would like you to think about where you plan storing the equipment* [for re-entry]. *They'd like to come up with a CG* [center of gravity]. *So in the next few hours, if you could, we'd like you to think about it and maybe tell us where you are going to put all those things* [prior to entry the next day]."

McDivitt: "*Okay. We've already thought about it. We thought about it quite early in the ball game. We're going to put the EVA pack back down in the wheel well* [McDivitt had automatically reverted to piloting terms, then amended his comment] – *the footwell on the right-hand side, bolted back down where it was for launch. We're going to take the cable and Ed's going to hold it between his legs, about level with the bottom of the seat. We're going to put the* [maneuvering] *gun back in our center food box. We're ready to put the film in the center food box. We're going to put the cameras in the left-hand food box… put the sextant in the middle food box… and all the refuse is going into the right-hand food box… and I think that takes care of it*."

The Command Pilot then added that the rubbish which did not fit into the right-hand food box would be stowed in either the left-hand food box or the side wall boxes where they had the film, while the sleeves from White's pressure suit and the extra thick garment on one of his suit legs would be stowed in McDivitt's footwell on the left. "*Sounds like you're kind of crowded up there,*" the Capcom commented. "*It's pretty deep,*" agreed McDivitt. "*I can just barely see out of the window,*" he only half-joked. The estimated weight (mass) of the refuse was given at about 3,000 pounds (1,360.7 kg), including the packages that the food had come in, the defecation bags, and a lot of waste paper.

Paul Haney, NASA Public Affairs Office, on console during the Gemini 4 mission. The PAO was the critical vocal link during the formal real-time air-to-ground commentary between the astronauts, the controllers on the ground, and the media and general public, informing, updating and explaining some of the activities, comments and actions as the flight progressed.

PAO Haney: “This is Gemini Control Houston, 78 hours and 11 minutes into the mission. Flight progressing nicely at this point. We still haven’t quite figured out what’s wrong with the Computer switch which had been acting up, but it is not of critical concern. Reviewing the electrical circuits involved [with the problem] and hope to have a solution shortly. This is Gemini Mission Control.”

GET 79:15 (Orbit 54/Rev 51) – GET 80:30 (Orbit 54/Rev 51)

Photos were taken of the plumes from the spacecraft thrusters. The computer troubleshooting continued, along with a platform power up. The S-6 *experiment was operated for 30 minutes.*

Over CSQ, as hour 80 of the flight approached, the Capcom gave the crew another update on the computer issue.

Capcom: "Houston requests we pass up the following information to you regarding the computer problem. They report that in ground testing on spacecraft GT-2 and GT-3, this same problem was encountered, and it apparently was caused by the computer being too cold. Houston requests you take the following action… Computer switch to OFF. AC Power switch to IGS. The Computer switch to ON. After about 20 minutes, start punching the Malfunction light to see if it will reset and extinguish. If the Malfunction light does not reset the first time, keep trying at intervals of 5 to 10 minutes."

If the computer did reset, McDivitt was told to leave it ON for the remainder of the mission. The aim was to warm up the computer and also recharge the Auxiliary Computer Power Unit (ACPU), which the experts at Mission Control assumed had probably run down by this time. Other than this issue, everything looked good onboard the spacecraft as the mission continued to clock up the orbits.

GET 80:33 (Orbit 54/Rev 52) – GET 81:55 (Orbit 55/Rev 52)

Experiments MSC-2 &-3 were performed, with the spacecraft orientated small end forward (SEF). A 23-minute session on the D-8 experiment was conducted.

On this pass, the Capcom reported that the indication on the ground equipment was that the computer on board Gemini 4 was showing Prelaunch Mode and a Malfunction indication. With McDivitt now asleep, White informed the ground that he had been unable to reset the computer, but was told that while the recovery of the computer might take a while, their other systems were looking good from the ground. This was confirmed by the astronaut up on Gemini. White was told during the next pass that it might take several orbits for the computer to come back online.

GET 82:00 (Orbit 55/Rev 52) – 83:25 (Orbit 56/Rev 53)

Work continued with experiments S-6 and D-8, while the MSC-2 & -3 experiments were turned OFF. Towards the end of the orbit, an experiment summary to date was reported by the crew.

Early on during this orbit, the Capcom advised that there were indications that the system was finally beginning to warm up and that they expected the computer would be back online before long. The ground also told White to look out for the Pegasus satellite, about 268 nautical miles (308.4 miles or 498.3 km) away from them and out on their horizon, as they neared the communication range of CSQ during their next pass.

The ground then informed White that they were showing approximately 950 psi (65.5 bar) on the oxygen and asked if he would turn the REPRESS to ON and run the primary oxygen down a little to about 850 psi (58.6 bar). However, with McDivitt asleep and without his gloves and helmet on, White said that he would prefer to delay that operation until the Command Pilot woke up, to which the ground concurred.

At the same time as White was trying to locate the aforementioned Pegasus satellite, there was another crucial tape dump scheduled. To accomplish the two tasks, White would have to maneuver the Gemini to a 45-degree pitch angle in an attempt to see the satellite and then quickly to 90 degrees for the tape dump, using his left hand to trigger the joystick on the central control panel. The first maneuver put the spacecraft facing exactly in the direction of the sun, resulting in a lot of reflections of debris just outside the window and making it difficult for White to see anything, let alone the satellite. When White told the ground that it would be difficult for him to be able to see the Pegasus in this attitude and then change to the new attitude in time for the tape dump, he was told to abandon looking for the satellite and concentrate on the important tape dump. Additionally, he was advised that the latest analysis of the fuel usage indications had revealed that they were going to have sufficient fuel to complete the flight and still have adequate reserves, although the Capcom added the cautionary comment that the crew should remain "*as judicious as possible with* [the fuel]" from now on.

After McDivitt awoke, the crew completed further D-9 runs, reporting the Apollo D-9 Run 4 as well as three D-9 Runs for the Air Force.

McDivitt: "*And the Air Force D-9 run; the way they're laid out is difficult to run. We got some runs though, in different order, and accomplished basically the information they wanted in D-9.*"

Capcom: [reading between the lines] "*You basically accomplished what the Air Force wanted. We'll analyze this in the flight plan and try to get you a final update for D-9.*"

GET 84:25 (Orbit 57/Rev 54) – GET 85:05 (Orbit 57/Rev 54)

Ed White completed a Type 1 medical procedure.

On this pass, the ground told White that they wanted to check the computer malfunction again and requested that he should depress and hold the switch for five seconds. He did so, but still the computer refused to cooperate.

GET 85:35 (Orbit 58/ Rev 55) – GET 85:40 (Orbit 58/Rev 55)

Kano station gave the crew the terminal re-entry information and the crew in turn gave the ground controllers an update on the D-9 experiment.

With Gemini 4 over Texas once more, the Capcom gave the crew the latest thinking on the computer issue, which had still not been resolved. It was looking increasingly likely that McDivitt would have to perform a manual entry at the end of the mission.

Capcom: "*We looked at all the possible possibilities down here. About the worst case we could come up with is the error miss distance – worst case 70 nautical miles* [80.5 miles or 129.6 km]. *What we would like to have you do is an OAMS retro maneuver; then we will have a manual retrofire, of course with no computer. We want a zero-lift, rolling re-entry. The reasons for the decision on the rolling versus a 90-90 bank are that there's less chance of dispersion. This will tend to equalize out. We feel we can have a faster recovery that way. Also, doing it that way we can get an IP prior to your blackout and you should pull 8-*g *on that re-entry*."

Capcom: [a short time later] "*We passed up this re-entry* [scenario] *so you two could talk it over and come back later on if you have any questions. For your information, the weather forecast [for the primary landing zone] looks like about three-to four-foot waves with 18 knots of wind. Visibility and ceiling will be good*."

The computer might have been malfunctioning, but the crew had trained for such failures, so Gemini 4 and her astronauts were about to come home as planned.

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12. Final orbits

David J. Shayler[1]

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"Listen, I just won't shave.
I'm so pretty now,
nobody will like me again."
Jim McDivitt, on the penultimate orbit of the mission.

Away from the headlines and listed objectives, eating became a very important part of the mission. The astronauts became hungry every four or five hours and felt completely run down, but upon eating a meal their energy returned. One definite problem on the flight was sleeping. Radio communications or thruster firings disturbed the astronaut trying to get some sleep. The planned four-hour rest cycle simply did not work and a better solution was found, namely a six-hour sleep period followed later by a two-hour nap. Another problem was the housekeeping within the cramped confines of Gemini, particularly once they had decided not to risk reopening the hatch on White's side to dispose of the unwanted EVA gear. Keeping the trash stowed was important so that the crew were not buried in detritus. But what emerged from all this, as another valuable 'first' on this flight, was the real-time flight planning.

The flight controllers on the ground and the astronauts in orbit had to deal with a significant amount of changes to the flight plan and address them in an orderly fashion. It was also found that operating two timing systems (Mission or Ground Elapsed Time used in flight planning, and the official mission time of GMT) not only complicated data transmission during the flight but was also confusing when interpreting the data to produce meaningful results after the mission. Addressing and highlighting such issues was one of the reasons for flying Gemini 4 for four days. As the mission reached its conclusion, the data from over 60 circuits of the Earth and nearly 98 hours in space was already being analyzed, and plans for the even longer upcoming missions were being reviewed.

Flight Day Five, Monday June 7

GET 86:05 (Orbit 58/Rev 55) – GET 86:25 (Orbit 58/Rev 55)

> *McDivitt conducted a Type 1 medical data procedure, and the D-9 experiment was activated.*

The extended flight of Gemini 4 was an important milestone in the development of long-duration spaceflight, and for developing a greater understanding of how the human body would adapt to spaceflight conditions over several days. In the mid-1960s, four days was still a relatively long time in orbit[1].

As the mission was orbiting over the RKV, the medical data collection was being monitored by Fred Kelly, the Flight Surgeon on the tracking ship.

Kelly: “*Gemini 4, this is RKV Surgeon. Would you give us the blood – there it goes. Blood pressure is going up… Alright Gemini 4. We have your blood pressure. Give me a mark on your exercise… Gemini 4, we have good blood pressure. Standing by for your food, water and sleep report…*”

McDivitt: “*This is the Command Pilot. I just finished about a five-and-a-half-hour nap, of which the last three hours of sleep were quite good. The first two-and-a-half were rather fitful. I’m in the process of eating meal two of day four and I haven’t had but about five swallows of water since I woke up, but I plan on having about another ten or fifteen before I finish, along with the meal.*”

At times, McDivitt was not all that complementary about the food provided. Clearly, this one was not his favorite choice of food on the flight.

McDivitt: “*The coating on the gingerbread wrappers. It tasted very waxy as it lined the inside of my mouth. It is something comparable to what was on the sandwiches. I put one inside my mouth after I had eaten a little bit* [and it] *feels like somebody spread lard all over your tongue.*”

Flight and Mission Director Christopher C. Kraft on duty during the mission [Courtesy Ed Hengeveld].

GET 87:00 (Orbit 59/Rev 56) – GET 88:20 (Orbit 60/ Rev 57)

The D-9 experiment run was completed and an update was given for the Apollo Landmark Investigations.

With White about to enter his last sleep period, the Capcom updated the crew on the forthcoming Apollo Landmark event. Later, the Capcom informed McDivitt that they wanted to perform a three-step check of the computer in all modes. The first step was to put 10 ft./sec (3.04 m/sec) in all the IVI windows and then he was to push MALFUNCTION RESET. Finally, the astronaut would press the START COMP switch and then look for an indication that the Computer Running light was illuminated. He had to do this in all modes. The Capcom then instructed him that, should he *not* get an indication that the computer was running, he was to perform a separate test, again checking in all modes. This time, McDivitt would have to turn the computer power OFF for two seconds, restart it, and press both the manual MALFUNCTION RESET switch and the

START COMP switch again. If he saw a Computer Running light in any of the modes, he was to discontinue the two-second power-off. McDivitt confirmed that he had understood the instructions, and then added: "*Okay. We've done these things already without any results, but I'll go ahead and go over them again*."

> **Gemini 4's Computer Problem**
> Even the removal of the IGS power supply failed to shut down the computer correctly, and despite special tests, the astronauts had to continue the flight without it. This negated executing a computer-controlled (closed-loop) re-entry, with the crew completing a zero-lift re-entry instead. Failure analysis on the computer from Gemini 4 found that the turn-off anomaly was intermittent, with seven possible failure modes identified. Despite extensive – and expensive – post-flight tests, analysis of telemetry and voice recordings, and even the disassembly and individual analysis of components, the exact cause was never isolated. From the data available, it was surmised that the most probable cause was contamination of the ON/OFF switch. To ensure such a failure did not happen again, a manual shutdown sequence switch was installed to circumvent the entire failure mode.

GET 88:33 (Orbit 60/Rev 57) – GET 89:55 (Orbit 61/Rev 57)

An Apollo Landmark Investigation run was conducted and a session on the M-3 exerciser completed. The crew was also updated on an open-loop re-entry procedure, due to the computer malfunction.

Twenty minutes later over the Canary Islands, McDivitt reported on the results of the computer test.

McDivitt: "*Nothing happened when* [I] *went to IVIs… It's impossible to put anything through the MDIU. When you try to turn it off, you still got your Malfunction light back and nothing happened when you pressed the Start Comp… I'll tell you Canary, I think that computer died when we turned the power OFF with the switch stuck ON*."

Capcom: "*I think everybody else is thinking the same thing*."

At nearly 89 hours into the Mission, McDivitt reported on his Apollo Landmark tracking observations.

McDivitt: “I just made a run on Target 16-A. The airfield at Basra. It’s right at the Persian Gulf. I picked up the Gulf [at first, he explained, before adding] I pitched down then picked up the lake… northwest of the Persian Gulf. Basra, being right on the lakes, you can follow over and pick up the airfield right away. So I got the airfield out quite a ways before I got to the target, and then just started tracking on three targets. I was actually on the target by the time I was still 20 degrees from the vertical, I would guess, and tracked it out from the runway to about the 40-degree point past it, and I stopped tracking. I had the 75-mm lens on the 16-mm camera with the adapter on it to take pictures out the forward end and I had it running from the last experiment.”

McDivitt: [Some twenty minutes later] “*We saw Australia for the first time in daylight. First passed up Basra, then across India to Malaysia and across to Australia…* [I’ve] *seen an awful lot of North Africa…* [in] *daylight… know* [it] *quite well. I’ve just completed D-9 Apollo Landmark run on Target 14. I had a very good pickup. I had seen the target before*, [so] *I knew where it was. I got right on the thing about 30 degrees below the horizon and got on the area, and picked up the specific target at about 20 [or] 30 degrees from the vertical. Got on the target at about 30 degrees from the vertical and then tracked it to the vertical and then backed off… back up, straight on, and then back up…*”

The Capcom then requested a propellant quantity readout, which McDivitt reported back as about 48 percent. The ground also gave him a change to the next Apollo Landmark Investigation and then added “*We want to just advise you to use all the film. This is your last experiment. Use all the film you have at your option.*” The Capcom also advised that there was an increase in the lifetime of the aft thrusters on the spacecraft, which negated the requirement for a split burn. “*Very good*,” McDivitt replied, “*I was wondering what you were going to do about that.*” The Capcom admitted that they had been holding on to that information for a while to surprise him, then passed the comms over to backup Pilot Jim ‘Shaky’ Lovell, who was now at the Capcom console in Houston to discuss the re-entry with McDivitt.

Lovell: “*Gemini 4, this is Shaky here. Listen, what are your feelings on a rolling re-entry versus the 90-degree bank angle? We‘re recommending a rolling here.*”

McDivitt: “*Yes. It’s not very imaginative, but it gets the job done. So why don’t we go ahead with it?*”

Lovell: “*Roger. Here is the format which we’ll send up to you for a rolling re-*

entry. We'll give you the Delta V and Delta T for your OAMS burn. We'll give you the GMTRC. We'll give you a RET of .05-g*. And then you will also get the RET of drogue, of main and of landing. Your procedures will be at retro to go to full lift, heads down. At the RET of .05*-g*, you will go into a 15-degree roll rate. When you reach 100,000* [feet, or 100K]*… go to full lift. How does that sound to you Jim?*"

McDivitt: "*Okay that sounds good*."

Lovell then explained that the only difference between the two formats was that instead of the RET at 400,000 feet (121,920 m), there would be a .05-*g* RET when Gemini 4 started its roll. This would give a time angle into the atmosphere, a roll rate, and then full lift at 100,000 feet (30,480 m) again for the deployment of the drogue and main chutes. Lovell commented that the sequence was like the old Mercury days and McDivitt suggested that the Flight Directors were thinking of this, which was why he had said "*it was not very imaginative, but it gets the job done*." Lovell also said that he had a bet with McDivitt's wife that he would place Gemini 4 within five miles of the recovery carriers, and that he was trying to hold up his end of the agreement. The Capcom acknowledged that he, too, would hold his end up of the deal. Lovell then asked how McDivitt was feeling as the mission progressed towards its conclusion.

Lovell: "*Hey, listen, are you feeling pretty tired now, or are you pretty good?*"

McDivitt: "*No, I'm pretty sleepy and tired and I think that Ed probably is too… It's going to take us about three or four hours to get all of this stuff packed*."

Lovell: "*Righto. I understand you're kind of sleepy and tired. We're going to try to hold off the last couple of orbits just to prepare for re-entry. It looks like you're going to have good weather in the re-entry area* [and] *in the splash*[down] *area*."

GET 90:15 (Orbit 61/Rev 58) – GET 91:30 (Orbit 62/Rev 59)

An 18-minute Apollo Landmark Investigation session was completed during this orbit.

As this orbit started, McDivitt reminded the Assistant Flight Director Charles Harlan that they would be unable to read out any Delta V figures, and that it would be just the OAMS firing on time.

GET 91:40 (Orbit 62/Rev 59) – GET 93:03 (Orbit 63/Rev 60)

Another Type 1 medical data procedure was completed, and further playback of the onboard tape recorder was conducted over the ground tracking station as the mission reached its conclusion.

As the next orbit began, Ed Fendell, the Capcom at Carnarvon, reported: "*You're looking good here on the ground. How are you doing?*" McDivitt replied "*Everything is fine up here*." At GET 91:47, the Capcom informed the crew that Flight wanted to know if they were planning to sleep at this time. McDivitt confirmed that he still had another 10 or 15 minutes left of his sleep period. The Capcom then asked if they had been lowering the primary O_2 bottle pressure, as they had seen a slight rise in cabin pressure. McDivitt confirmed that they had, just a little bit. "*Not by dumping it, but just by letting it bleed into our cabin, bringing it up to about 5.3*."

A tired-looking Ed White inside Gemini 4 during the four-day mission.

With White now awake again, the Capcom asked how they were both bearing up to the flight, adding that they (the ground) were on standby if the crew needed anything at all. White replied that he was feeling "*great*" and that everything was "*in pretty good shape up here.*" The Capcom reported "*It's real fine* [down on the ground too]. *The weather has cleared up and everybody's happy*." It had finally stopped raining in Carnarvon.

Fendell: "*The young astronaut* [meaning Dave Scott] *did a rain dance.*"

White: "*That's supposed to* bring *rain isn't it?*"

Fendell: "*I don't know; the way he did the dance, you can't tell!*"

As well as the main Mission Control Center in Houston, this was also the first time the remote tracking stations around the world had handled a long-duration mission. To keep in touch with the spacecraft as it passed overhead, they had to cycle their shifts to coincide with the brief few orbits it was in range. As Gemini 4 drifted away to fly over other stations, or where there was minimal coverage, the ground teams could get some rest, leaving just a few key people on standby duty. Hamish Lindsay, author of *Tracking Apollo to the Moon* (Springer, 2001), gave an account of following Gemini 4 in his online essay. "We could be busy tracking through a group of seven station passes, say orbits 13 through 19, then we would go home to sleep for nine orbits and return to the station to support passes 28 through 34, and so on through the mission. It was a 14-hour day at work followed by a 10-hour break, sliding forward an hour each shift for the length of the mission. The passes would begin in the northeast with a short glimpse of the spacecraft for around a minute, peak overhead with longer passes of up to 12 minutes, and then fade out in the northwest with short passes again before it disappeared below the horizon to go through the whole cycle again [1].

Later, as Gemini 4 flew over Texas, the ground confirmed with White (as McDivitt was now asleep) that they were discussing the re-entry profile, and advised that they would send "*the final data up just as soon as we come up with the final answer… It looks like now, however, we're going to power up your platform about 45 minutes earlier than the flight plan calls for. It'll be an elapsed time of 95+19. That'll be over Carnarvon on the 61st Rev*." They then asked White "*Have you been using quite a bit of OAMS attitude control over the last orbit or so?*" White replied that he had "*stayed in PULSE-HORIZON SCAN the whole time as there has not been much in the way of attitude control* [performed].”

GET 93:15 (Orbit 63/Rev 60) – GET 94:33 (Orbit 64/ Rev 60)

This orbit began with a further workout on the M-3 exerciser by Ed White, which he followed by updating the onboard map at the end of McDivitt’s latest sleep period.

All systems continued to look good on the ground over the Canary Islands and again later over Carnarvon, where they were told to switch their Re-entry C-Beacon to the CONTINUOUS position and Antenna Selector to RE-ENTRY, and that they were to remain in those positions for the rest of the flight. This was followed by a map update. The countdown to the end of the mission had begun.

Over Texas, with McDivitt now awake again, he was advised that he would get general procedures for the re-entry from Grissom on the next pass. The general procedure he was to follow after retrofire was that he would roll the spacecraft to the normal position, head down, for full lift to 400K (400,000 feet, or 121,920 m). The ground would then give an attitude angle which he would have to hold all the way down to 400K. Then he would have to roll Gemini 4 at 15 degrees per second until the altimeter reached 100K and then return to full lift again until the deployment of the drogue chute.

McDivitt then gave the latest level readings, of propellant temperature at 65 degrees F (18.3 degrees C) and pressure between 1,700 and 1,745 psi (117.2 and 120.3 bar). It was pretty obvious that the computer was not going to work, but McDivitt was advised not to turn it off during entry anyway. He was also told that the weather in the recovery area looked very good. McDivitt then reminded the ground: “*I want to be recovered in a hurry!*” All he had to do was to hit the targeting spot and follow what was looking like an 8-*g* entry. “*Oh, that’s too much for an old man like me,*” he joked with Lovell, who retorted that he could “*hack it.*”

Suddenly, mid-way through a sentence, McDivitt let out an unexpected “*Oops! Stand by.*” That surprised Mission Control and John Young, who was now at the Capcom console, asked how they were doing.

McDivitt: “*Very good. We’re just taking a couple of pictures; that’s what the ‘oops’ was for.*”

Young: “*Oh! You had us shook up for a minute. Don’t do that, you’re giving us heart attacks down here.*”

McDivitt: “*Oh, come on John, it must have been a long night. If I were you,* *I'd be looking for a little excitement.*"

The Command Pilot was told that the prediction of their impact point would be more accurate following a zero-lift re-entry, and the recovery forces would move to the landing area about 15 minutes before they arrived. "*We think that's the safest and quickest way to get there.*" McDivitt agreed wholeheartedly, stating that it was a little old fashioned falling back on an old Mercury technique. He was told, jokingly, that if he hadn't "*fouled up the computer,*" then these adjustments would not have been necessary.

GET 94:42 (Orbit 64/Rev 61) – GET 96:00 (Orbit 65/Rev 61)

> *Both men completed another medical data procedure. They also installed the biomedical jumper leads plugs and powered up the spacecraft, aligned the platform and received a final update for landing at the primary site on Orbit 66/Revolution 63.*

At GET 95:20, the PAO noted that there was far more activity in Mission Control on this morning than there had been previously, as the minutes ticked away towards retrofire. In the final shift change, Lead Flight Director Chris Kraft and his Red Team took over from John Hodge and his Blue Team, though Hodge decided to stay on through the retro sequence.

At GET 96:09:26, McDivitt reported that he was starting to align the platform. When asked what control mode he had selected, he replied, "*Well, let's try RE-ENTRY RATE COMMAND. I was going to do that anyway, and then I decided we couldn't do it because we did not have the response, but since we don't need to, particularly* [garbled], *I'll use RE-ENTRY RATE COMMAND with gyros turned off.*" The Capcom then read up the weather report for the landing area on the next orbit: "*The weather in your recovery area is scattered clouds; you've got 10 knots of wind and four-foot waves. It could be better.*"

At GET 96:11, Houston Surgeon Dr. Charles Berry came online to update the crew regarding post-landing actions.

Berry: "Jim? Both of you are in real good shape at the present time and all the EKGs look just fine. Your water intake has come up real well and from my last computation here, both of you appear to be really well hydrated for the re-entry. I'd like to make sure that both of you feel completely rested. Is that affirmed?"

The insistence on taking sufficient water stemmed from the Gemini 3 mission, in which both Gus Grissom and John Young had been dehydrated at the end of their short flight. As a result, the astronauts on Gemini 4 had to report the amount of water they had taken regularly, so that the medics could keep track of their hydration. McDivitt confirmed that both men were a little tired but as rested as they could be, and that there was no need to take any medication prior to entry. Berry then ran though the blood pressure recording sequence for entry and post-landing.

Berry: “*You* [meaning McDivitt] *are not going to have the* [blood pressure] *adapter on until after you’re on the water*. *Ed already has it on, and we can tell from the data. He’s to get one blood pressure* [reading] *after retro, one on the chute before bridle* [two-point suspension], *one after bridle, and then both of you every 15 minutes in the water. The other thing is post-landing. We still, just to reconfirm, would like no more than one hour in the spacecraft. Get your suits off, at your discretion, if the spacecraft has no leak. The open hatch part is strictly your decision; it looks good in the recovery area at the present time for this. Remember the pumping exercises that we did at the time of the physical, and the feet up would be the preferable way*.”

As Gemini 4 was an important first test of a long-duration spaceflight (four days) on the human organism for the Americans, Chief Medical Officer Dr. Berry was eager to be on hand for the recovery of the crew in about four hours’ time. After he had spoken with McDivitt, he would leave Mission Control and be airlifted to the waiting recovery carrier in the Atlantic that afternoon, hopefully arriving shortly after the crew had been recovered to supervise the initial post-landing medical examinations.

As the final orbits ticked away, and preparations for re-entry began to dominate the crew’s activities and the focus of the ground teams, Chris Kraft asked McDivitt whether there was anything else they could do for the astronauts, or anything else McDivitt wanted. “*Yes. My computer*,” he quickly responded. Kraft wished he could indeed restore the computer to working order for entry, but passed up a message from John Young that the toughest part of the mission would come after they returned to the States. McDivitt joked that he had been resting his arm (presumably to deal with the waving, handshakes, salutes and autograph signings ahead of him), but he was also advised to rest his voice too (for all the debriefings and speeches). With a typically dry response, McDivitt said: “*Listen, I just won’t shave. I’m so pretty now, nobody will like me again* [without the four-day growth of beard]!”

After four days in the spacecraft, the internal aroma of the cabin was not pleasant and one that they were glad they wouldn't have to endure for much longer, as McDivitt indicated: "*I thought those fumes around 24 hours were bad! You ought to be up here now!*"

As they passed over Bermuda on the 62nd circuit, they began their final orbit of the Earth, with less than 90 minutes to go before completing their mission. At GET 96:17:51, the Capcom radioed: "*We'll be losing you in about two minutes here* [in Bermuda station]. *Hawaii will get your OAMS burn and Guaymas will count you down to retrofire*."

On board Gemini 4, after four long days, McDivitt and White were at last preparing to come home.

References

1. Gemini IV report, Hamish Lindsey, https//honeysucklecreek.net/other_stations/Carnarvon/GT4.html

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Footnotes

1 Prior to Gemini 4, only four people, all Soviet cosmonauts, had experienced spaceflight conditions for significantly longer than one day in space. They were Andrian Nikolayev (3d 22h), Pavel Popovich (2d 22h), Valery Bykovsky (4d 23h), and Valentina Tereshkova, the only female (2d 22h). In addition, cosmonauts Gherman Titov (1d 1h), Vladimir Komarov, Konstantin Feoktistov and Boris Yegorov (1d), and Pavel Belayev and Alexei Leonov (1d 2h) had also surpassed the 24-hour mark. The only American astronaut to have done so was Gordon Cooper (1d 10h).

David J. Shayler, *Gemini 4*, Springer Praxis Books
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13. "We're about ready to come down"

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

"That wasn't too bad.
Gemini 4's on the water
and we're floating fine. No leaks."
Gemini 4 Command Pilot Jim McDivitt's
comments to the Capcom following splashdown.

With the dawn of their fifth day of flight and the start of their fourth 24-hour period in orbit, Jim McDivitt and Ed White were in sight of the end of their record breaking mission. Before they could all celebrate, however, they were faced with the grueling de-orbit, re-entry and landing phase, followed by the recovery. No American astronaut had experienced this before after four days cooped up in their spacecraft. The mission may have been making the headlines but it was not over yet by any means. With the computer on but not working correctly, the planned computer-controlled re-entry could not be accomplished and instead, McDivitt would have to set Gemini 4 into a roll and follow a ballistic re-entry, similar to those flown during Project Mercury.

FLIGHT Day five: Monday June 7 – Re-entry Phase

> *PAO:* "This is Gemini Control, 96 hours and 39 minutes into the mission with the spacecraft going over the African continent for the last pass in this Gemini 4 flight."

GET 96:33 (Orbit 65/Rev 62) – GET 97:24 (Orbit 66/Rev 62)

The crew completed the pre-retro list and turned the MSC-1 experiment on for the final time. Carnarvon updated the information for the primary landing area and the OAMS translation was completed at GET 97:15. This was followed by the T_R -5 (minutes) checklist and T_R -1 (minute) checklists prior to starting the re-entry sequence.

At about 17 minutes into hour 96 of the mission, as the spacecraft flew over Bermuda towards the end of its penultimate orbit, McDivitt reported one final update of cabin humidity – which had actually been taken an hour previously – to Mission Control. The reading had been taken from the middle of the crew compartment and recorded 75 to 78 degrees F (23.9–25.5 degrees C) on the dry bulbs and 65 degrees F (18.3 degrees C) on the wet, revealing very little gain since the beginning of the flight four days earlier. This was encouraging for the much longer flights to come.

Soon afterwards, with about an hour and 20 minutes left in the mission, McDivitt told White that he was starting his suiting process. After four days in space, McDivitt initially had trouble finding his pressure suit gloves and was still debating whether he was going to put them on at this point. With White's help, he strapped himself firmly into his seat. After more than 96 hours of microgravity, he observed "*It seems funny to be sitting back down this low again.*"

Both astronauts then started stowing the loose items that surrounded them, placing the EVA maneuvering gun in a bag to contain it. The added clutter of the extra items they had planned to eject overboard after the EVA made it even more crowded in the already confined space within the Gemini crew compartment. Aware of the difficulties they might encounter if they had to eject during the landing phase, Ed White observed:

> *White:* "*Hey… we're* [not] *going to be surprised by ejecting – I don't believe so… We're hoping to see the chute or aren't we?* [McDivitt agreed] *If we don't, then we know right away that we've got to go* [meaning they eject]. *I'll plan on you pulling the handle though, and I'll just hold onto this strap.*"

In the post-flight debriefing, McDivitt commented that they had started their pre-retro preparation about three hours before the event. "At this time, we started stowing equipment and preparing the spacecraft and ourselves for the retrofire. I think we worked for probably 30 to 45 minutes without making a very big dent in the pile of junk that we had in the spacecraft. It was apparent to me at the time that we were going to have to go a lot faster than we were going or we'd still be up there stowing stuff away at retrofire time. So Ed and I then went into high gear, and we really started stuffing stuff away." **[** 1 **]** McDivitt explained that they put the film cassettes in the middle food box and the cameras, some of the refuse (including three defecation bags), the exerciser and other small things in the left-hand aft food box. Ed White added that they had "just everything out prior to this time. We hadn't really been able to stow anything. We used every piece of our equipment right up to the time we started our stowage." White also confirmed that for a while they were a little worried that they would not get it all stowed away in time. The increased pace worked, but as White recalled, the end of mission stowage was "not quite as thorough as we would like to have been." As with the earlier EVA preparations, it seemed that even with a detailed timeline worked out beforehand, the realities of spaceflight meant that doing a task during the mission was sometimes nothing like planning or training for it.

Apart from the EVA umbilical, everything was eventually stowed away. The astronauts had already decided that they were not going to stow the urine hose in its correct location, so that was put into the empty umbilical bag, along with the two meals they had left. McDivitt lodged the EVA suit sleeves, the blanket he had over his leg, and the launch day urine bags under his legs up against his seat. All of White's extra gear was stowed in the umbilical bag. Both trash bags bulged with dry trash and by the time they had finished, they had about 15 minutes to gather their thoughts before the pre-retro burn. By the time they were over Carnarvon, the last few things were still being stowed, but they had reached the point where McDivitt could at least fly the spacecraft.

McDivitt suggested that they ought to start thinking about going through the re-entry checklist. He ran through the egress-after-splashdown checklist verbally to get it fresh in their minds again, as it had been some time since they had practiced the process prior to the mission. An extract from the air-to-ground commentary from this point in the mission illustrates the routine, even mundane, nature of the tasks each crew has to perform prior to coming home.

> *McDivitt:* "*… and one splash curtain install, neck dam install, Cabin Air Recirculate handle UP. Left Snorkel handle UP, Cabin Vent handle UP... Verify the water seals are DOWN and closed. Attach the lanyard, left hatch open* [McDivitt's]. *Stow Command Pilot survival gear over right side of spaceship. Whole recovery loop… right side of the spacecraft. What you do* [meaning White] *is move to the left seat with your survival kit. Throw the Pilot's survival gear on the left hatch over*

the recovery loop. Inflate the Mae West; be sure it's on the right side of the spacecraft. Remove your survival gear from the left hatch and [then] *close and lock the hatch.*"

They were expecting that they would have help from the para-rescue divers and would transfer into an attached dinghy without a problem, as Air Force pilot McDivitt observed: "*That's the last thing in the world that I want to be doing out there – fooling around in the water.*" As an Air Force man himself, this was something with which White strongly agreed. As they progressed through the checklists, McDivitt observed:

McDivitt: "*Well, we're about ready to come down, Edward… It's been very pleasant on occasions, and unpleasant on other occasions, for the last four days.*"

White: "*I think we've had some exciting moments.*"

After stowing more gear, they progressed though the pre-retro checklist for real this time without skipping any steps, fully aware that they were preparing to come home.

White: "*ACME Bias Power on PRIMARY. Attitude Light switch breaker is ON, Altitude Indicator with FDI, MDU power is OFF.*"

The computer power should have been on at this point, but McDivitt corrected White, telling him to leave it in PRELAUNCH due to the problems encountered.

White: "*Platform aligned. Scanners PRIMARY. Rate Gyros PRIMARY. Equipment Stowed* [McDivitt noted that it was stowed as well as could be]. *Stowage vents are open. Drogue pins are out. Survival lanyards connected…*"

They tested the sequence lights and switch settings, with White calling out the sequence and McDivitt repeating the instruction to ensure he had interpreted the step correctly.

White: "*AMBER-GREEN – then RED, verify all your circuit breakers are CLOSED… verify attitude would indicate with FDI… Retro Power ARMED, Retro Power RCS PUSH… Retro Power OFF… OAMS Power*

OFF… Attitude Control RATE COMMAND. Test rings A and B [to see if both were still firing].”

McDivitt, now with his gloves on and noting that they were feeling tight, said that he hoped they got picked up early, as he “*didn’t want to get sea sick*.” They continued with the checklists, having set the recorders to RECORD to alleviate the need to keep pressing PUSH-TO-TALK as they had their hands full with other activities. Both men continued talking through the sequence over the next couple of hours. It is interesting to note that after so many hours in orbit using different timing systems on several clocks, they still closely scrutinized their countdown for certain events, with White counting down for McDivitt to initiate the maneuver or sequence. They also made sure, with all the updates that had been read up to them, that they chose the right one to work from.

During the various checks, McDivitt noted that the levels on his OAMS propellant gauge did not seem right.

McDivitt: “*There’s something about the amount of fuel that I have shown on my quantity gauge, and the amount for retrofire that we have here, that just doesn’t figure out*.”

The quantity should have been higher, indicating that they might burn short for re-entry. McDivitt commented that it looked like they were “*about 100–200 pounds* [45.3–90.9 kg] *showing. That doesn’t allow for any cushion. Well, if we burn out short, that means we are going to overshoot* [the landing area] *long*.” Thinking out of the box to resolve the problem, he reasoned “*So, we can adjust our retrofire time forward two seconds*.”

As the 97-hour mark was reached, Capcom Ed Fendell at Carnarvon came on line asking if they had completed the pre-retro checklist, which they confirmed. They also noted that the communications were not at their best this morning. Following a time hack from Mission Control, the Capcom reported that their RCS reading looked good. More times were read up to the crew for the fast-approaching end-of-mission event sequence.

Capcom: “*Begin blackout, 5+23* [meaning 5 minutes plus 23 seconds]. *End blackout, 9+21. 50K feet, 10+55. Main chute, 12+33. Splash, 17+10*,”

The Events Timer was set up as the check-off process continued. The Capcom asked if there was anything else the ground could do to help the two astronauts asked if there was anything else the ground could do to help the two astronauts in preparing for entry.

McDivitt: “*Negative. Well, I do still need my computer, but I can’t think of any way of bringing it up*.”

Capcom: “*I’ll buy you a new one*.”

Meanwhile, White informed everyone listening that he was going to go back and re-verify “*the whole stuff we’ve done*,” just to ensure that the numbers added up, while McDivitt announced: “*We’re going to have the most aligned platform in the world, or rather off it. We will be aligned for an hour. We’ll probably come out of the darkness facing sideways.*” White agreed that if they did that, it would be a shock. “*Hey Ed. You know we always said that we were going to make an open loop re-entry,*” McDivitt stated, “*I’m much happier that the computer failed and not the* [platform? This section of the transcript was garbled].”

Enduring the Endurance

Both astronauts were now beginning to show the signs of strain. McDivitt was completely fatigued and White confirmed that he no longer felt like pushing anymore. It was a funny feeling he could not quite put his finger on.

From Carnarvon on to the States in the orbit, the astronauts still continued to stow small items of equipment away, while also eating their final meal. White explained after the mission that he had pre-prepared one meal and put it aside so that he could eat it just prior to entry. “We finally decided,” McDivitt explained post-flight, “that [we’d] better [ensure] we were going to be ready for re-entry.”

McDivitt noted that the temperature was now down to 55 degrees F (12.8 degrees C) inside the crew compartment, adding, “*Boy I really smell that ammonia.*” White said that he could not, though he confessed that he wanted to tell McDivitt something.

McDivitt: “*It has something to do with wetting your pants does it?*” [White shook his head]

“*No? Right now this is the strongest I’ve ever smelled it. We really screwed up when we went with this padding here.*”

Ignoring his commander’s suspicions that he had a toilet issue, White said that he wanted to review a few items with him once again through retrofire, entry and landing.

McDivitt: *“We’ll probably get a countdown from the ground, too. We’ll have a multiplicity of countdowns.”*

White: *“None of which will probably agree in some respects.”*

As the clock ticked away, McDivitt wondered whether PAO Paul Haney down at Mission Control “*has the crowd worked up to frenzy*,” in anticipation of their entry, and mused on what was about to occur. “*Got some brilliant fireflies out there… Retrofire’s more fun than launch. You know nothing is going to stop it – it just counts down. In launch you have to be concerned about whether the gantry is going down.*” Both astronauts reflected on the loss of their computer and recalled similar problems on Gordon Cooper’s Mercury flight two years previously, knowing that this would be a tough re-entry. As they passed into range of the Hawaii tracking station, the Capcom asked if they were in the correct attitude for their OAMS burn. McDivitt confirmed that they were blunt end forward (BEF) with the nose slightly down, and were going through their checklists for the umpteenth time. White reminded McDivitt that he did not need to start the computer, to which McDivitt replied, “*I’ve got to wee-wee.*”

“As we started our pass across the States,” said McDivitt post-flight, “I started aligning the platform. We had the best aligned platform, although we didn’t really need an aligned platform since we didn’t have a closed-loop system. But we sure had the best aligned platform at retrofire the space business will ever see,” he reported proudly after the mission. After 20 minutes of alignment up on Gemini, he selected ORBIT-RATE and kept it there, then orientated Gemini with the small end forward (SEF) “because I wanted to see where I was going for a change,” he said after the mission. They had performed the pre-retro checkouts well in advance of the planned time.

Breaking a Mission Rule

In his 1999 Oral History, Jim McDivitt recalled the first breaking of a Mission Rule during Gemini 4. “As a matter of fact, as far as I know, the only Mission Rule that I can ever remember being broken was one on my flight, and [Flight Director] Chris Kraft did that, and it could’ve had some serious effects… On Gemini IV, we lost a computer; and the Mission Rule said that we would fly a 90-degree bank [multiple times] to make it a zero-lift re-entry. When the computer failed in flight, Chris wanted to do a rolling re-entry like they had done in Mercury. And we were up in space, and there was nothing wrong with the other concept, but he wanted to do that. Well, … there wasn’t wrong with the other concept, but he wanted to do that. Well… there wasn't any time to argue over that, so we did the rolling re-entry. Unfortunately, the instrumentation of the spacecraft only went to 20 degrees per second roll rate, and that's where it stopped… Well, you couldn't tell whether you were going 20 degrees per second, or 30, or 40, or 50. We had a broken thruster, which wound us up to probably 200 or 300 degrees per second on the way down. And while I could tell that we were going a little faster than 20 degrees per second, I couldn't tell what it was. Didn't have any instrumentation. It turned out that nothing really bad happened out of it, but it just went to show you that you really shouldn't change the Rules in-flight."

Re-entry Sequence

During the final, 66th orbit (62nd revolution), the pre-retrofire maneuver was initiated at GET 97:28:02, followed two minutes later by retrofire. At this point, White also took a blood pressure reading. At GET 97:40:47, the Retro Adapter separated. The blackout period ran from GET 97:44:59 to GET 97:49:14. The MSC-1 experiment was switched off at GET 97:45.

At the MCC PAO console, Paul Haney picked up the commentary just prior to the pre-retrofire maneuver.

> *PAO Haney:* "This is Gemini Control, Houston. We are 13 minutes from retrofire and only a minute or two from the pre-retro OAMS burn. Hawaii established contact with the spacecraft about a minute ago. We are standing by for whatever conversation might develop during this pre-retro burn. We really don't expect too much conversation."

"We're Home, Buddy"

Fifteen seconds from the start of the OAMS burn, McDivitt initiated the pressurization of the line and then the Capcom read out the countdown to start the burn.

> *Capcom:* "*5, 4, 3, 2, 1, MARK! Start burn*."

Up on Gemini, McDivitt initiated the OAMS burn. "*Attitudes are holding smoothly… grinding away*," he said. At two minutes, McDivitt reported that they had ten percent of fuel remaining. Thirty seconds later, the countdown to shut off the burn began at GET 97:30:37. The engines shut off, with White exclaiming "*Good show! How about that!*" McDivitt reported to the ground that the accuracy was within a degree and there was just three percent of fuel remaining. The Capcom replied, "*You looked good here on the ground.*" A few seconds later, the eight-minute mark to retrofire was reached.

> *PAO:* "This is Gemini Control. We have completed the OAMS burn over Hawaii."

Shown in the Mission Control Center during the recovery operations of the Gemini-Titan 4 mission are, from left to right, Bob Hart, Paul Haney, Al Alibrando and Terry White.

The PAO went on to explain to the audience listening around the world that the maneuvers should have expended about 130 pounds (58.9 kg) of fuel, leaving about 15 pounds (6.8 kg) in the primary tanks. The Equipment Section was to be ejected just prior to the retro maneuver over the Guaymas station, with McDivitt using the Re-entry Control System to control the attitude of his spacecraft as it plunged into the atmosphere (see sidebar *Re-entry*).

RE-entry
The Re-entry Control System (RCS) on Gemini featured two independent rings of 25-pound (111 N). thrusters, with eight on each ring. The fuel supply for this system (about 33 pounds [14.96 kg] of fuel) came from separate tanks. During retrofire, with Gemini now BEF, McDivitt orientated the spacecraft to pitch the nose down at 30 degrees, so that the astronauts were flying with their heads up and their backs to the direction of flight. Immediately after the completion of the burn, McDivitt rolled his spacecraft 180 degrees to face heads down, with the nose now pitched up but still BEF, aiming for an angle of 23 degrees off the horizon. He would then maintain that position until they reached 400,000 feet (121,920 m) above the surface of the Earth, where the Command Pilot would impart a roll rate of 15 degrees per second, similar to that used during Project Mercury.

McDivitt explained the sequence, instigated by White, after the mission. "[Ed] punched the SEP OMS. We heard the bang. He followed with a SEP ELECTRIC rather quickly afterward. We heard the bang. Then we waited a short time as we had planned and fired the SEP ADAPTER. Then there was a great big bang. The tendency is to punch those buttons 1, 2, 3. We decided… to go 1, 2, (pause) 3. That is exactly what we did, and there wasn't any doubt where the Equipment Adapter separated." White had no intention of looking around to check, and stated simply "I knew it was gone."

At GET 97:38:11, White explained to his commander "*All you have to do Jim, is fire* [the retros] *and fly her through* [the re-entry process]," though this was not as simple as he made it sound. A few seconds later, the squibs were armed in the Adapter Section. Then, at GET 97:39:20, the separation of the Adapter Section was confirmed, revealing the retro rockets which they then armed ready to fire to begin the long, and fairly memorable, journey home.

Capcom: [GET: 97:39:51] "*10, 9, 8, 7, 6, 5, 4, 3, 2, 1 – RETROFIRE!*"

Ed White thought that they had fired the engines somewhere over New Mexico or West Texas. McDivitt reported that the engines had fired in the sequence of 1, 3, 2 and 4. White mentioned that the engines had fired one second early, to which McDivitt commented, "*We're home buddy… All retros fired* *auto*." Then, to the Capcom, who had asked if all had indeed fired, he reported "*They seemed to be a second before your countdown. Attitude probably was within about a degree or so.*" Less than a minute later, the crew confirmed separation of the retro package.

McDivitt explained after the mission that "If the TRS was fast, I didn't want to punch off ahead [of time] and have the retro rockets go off early, but I figured that it wasn't in a hurry that much. But [in fact] it was much earlier… it was really going to make us short. So I decided that we'd go ahead and arm the auto-retro button at about three seconds, so that we weren't going to be any more than 15 to 20 miles short as a result of the retro rockets going off early." His logic was based on the realization that if something went wrong with the manual retrofire signal, they would still have the auto-fire signal and could get the retros fired. McDivitt reasoned that three seconds early would be far better than 15 or 20 seconds late in case they had to follow a non-nominal method of firing the retros. White added "I think I distrusted the system a tad more than Jim did, but I thought his logic was good. We had two systems working to fire the rockets. I was in full agreement."

They had deliberately saved fuel for four days to complete an OAMS retrofire. McDivitt thought that if that was the philosophy they adopted and they endured a lean period of fuel usage, "then we could afford another few miles of inaccuracy thrown in at an early retrofire if we got the redundancy that you would get from a double firing." After being in zero-g for so long, even the small increase in *g* forces seemed a lot.

"I maintained the attitude very well," explained McDivitt in the post-flight debriefing. "It was very easy, there were no deviations at all." White agreed: "I was sitting there watching it and enjoying it at that time, because the attitude was staying right on. It was as steady as a rock. You could see the decelerations and, looking out the window, I could detect any movement in attitude. I was looking right down on the ground several times during several of the retros, and I think you could detect motion very well. I didn't see any." McDivitt said he was very happy after the OAMS retrofire and the retro-rocket retrofires. "I figured that we had exactly what we were supposed to do, and I was positive we were going to come down on that cotton-picking carrier. I was really quite happy after that, because I don't think being in the simulator we ever had one that easy."

At the time, Jim McDivitt was well known as being one of the most antagonistic towards the OAMS retrofire procedure at MSC, as he believed it to be a fuel-wasting maneuver. Even after his Gemini 4 experience, he still believed this. "I'll still say one thing," he admitted during post-flight debriefings, "After I fired the OAMS retrofire and I knew I was going to come down, I was a lot more relaxed than I had been before I got there." He knew he had to tell Robert Gilruth that, but still believed that they could get by without it. It was nice to see it work, but McDivitt admitted he was "really sorry we didn't have a computer, because after those two things, which I thought were certainly as good as I could possibly do them, I felt sure that we could have landed on the carrier's deck if we just had a computer to tell us where to go. I would have liked to have tried the guidance," he lamented after the mission. "I worked hard enough on that re-entry guidance and I didn't get to use it."

> *PAO:* "This is Gemini Control. We have confirmed the retro sep. In our other ear we bring in [commentary on] lots of activity in the Atlantic Ocean as the [recovery] planes are establishing their call [signs] and are poised and waiting for Gemini 4 to splash down some 440 miles [707.9 km] east of the Cape. GHC, our White Sands [New Mexico] Station, is tracking the spacecraft right now. This radar data, and that from Eglin AFB in Florida, will help us establish with considerably finality the splashdown point."

The call signs for the recovery aircraft were passed up to the crew: *Sinclair 52, 54 and 64* (with *Sinclair 57* ready on standby) for the helicopters; *Inkpot 3* for the up-range search and rescue aircraft; and *Omnibus* for the local command aircraft. As the Gemini began to drop, White began taking his blood pressure reading. Then, at GET 97:43, McDivitt initiated the rolling entry. A minute later, the Retro Adapter separated and spun away from the spacecraft.

McDivitt said that they did not have any re-entry parameter updates after the retro burn, as there wasn't anything to update and they entered the blackout period pretty quickly. Just 2 minutes 38 seconds after retrofire, they passed 400,000 feet (121,920 m). "We got there in a hurry," noted McDivitt afterwards. "I thought that we'd retrofired a little early, so I wasn't in any great rush to start my rolling re-entry. I delayed [starting the roll] about another 30 or 40 seconds. The only reason I delayed was because I knew there wasn't any rush to get over, because if we were going to be any place, we were going to be short. I just wanted to get over and get in a good attitude. So I rolled the thing [Gemini] upside down [while] still in Rate Command. I held the lift vector up, heads down, until I got down to about 3 minutes and 15 seconds." With the onboard clock counting up, he received a three-minute time hack from the ground, then started to roll. "I put in about 15 degrees per second turn, then we turned off the roll gyro. I just left the thing rolling. I controlled the pitch and yaw inside the Rate dead band, which was ± 4 degrees, just as you would in Direct. I still had the Rate dead band to take care of any wild perturbations that we got into."

A minute out from the blackout period, both astronauts reported that they were feeling great. Meanwhile, they noticed the Adapter burning up in the atmosphere, as McDivitt, with a view looking behind them, reported: "*There goes the Adapter. It's burning. Look at us. We're making fire too*." He later figured out that the Retro Adapter had re-entered small end forward rather than blunt end forward, as he saw the spherical end of the retro-rockets, while White noticed the whip antennas sticking out from the side. "We were upside down," said McDivitt later. "It sure was a funny-looking sight and it was stable as a rock and very slow drifting behind us." In fact, McDivitt thought for a while that the separation velocities between the Gemini 4 Re-entry Module and the Adapter were too slow. "I thought it would come back and hit us," he stated post-flight, "but it just stayed out there, and we started our rolling re-entry there. We were coming on down and we were rolling around, and before I got any noticeable *g*s at all." McDivitt recalled watching the Retro Section behind them as they spun around. It started glowing a little, then a big spray came off it, turning it into a big orange mushroom falling behind them, with pieces melting and coming away. "That's when it really started falling behind us," he said.

With the spacecraft enveloped in a pinkish-orange cast, as it streaked ever deeper into the Earth's atmosphere, White also reported that he could see two pump packages off to the left side, exactly as John Young had reported after his Gemini 3 re-entry. As the *g* forces built up, White noticed the state of Florida pass by his window far below. "*Okay, next thing to look for is 100K* [30,480 m]," he called out. "*Sit back and relax. We aren't going to do much about it from here out*." They thought that the pass over the Floridian peninsula was very low, joking that they should have filed a DD-175 Military Flight Plan form[1] for clearance as they swept high over Eglin AFB. As White joked later, "We had come though the control zone at Eglin, [and] they're kind of sensitive about low altitudes."

A Real Lifting Body

McDivitt agreed that the actual experience of re-entry was much better than in the centrifuge. "The first thing I saw was the orange or pinkish flame coming out. It looked like the flame was coming up around my side of the spacecraft," he recalled after the mission. White agreed that it looked like it was coming from about three points. "I saw the green fires down close to the left hand side, observing it coming up over the nose inside of the red fire and then it was all swirling around there," he added. Securely strapped inside Gemini 4, McDivitt and White were descending in a roll but with a relatively high lift-to-drag ratio, generating a lot of lift. Though the spacecraft was “stable as a rock,” it was certainly whipping around, as both pilots noted. McDivitt dampened it out a couple of times, but found he did not need to touch the pitch control after more than three or four inputs, or the yaw after more than six or seven times, as Gemini remained very stable as it plummeted towards the Earth. “What I was looking at,” said McDivitt, “was just a high portion of the sky. I could see the ground, then I could see the sky, and I really saw a lot of the country as we came rolling by.” White commented after the mission that the Gemini was “a real lifting body.” Initially, there was a lot of lift, and while it was dampened out by rolling around, it was difficult to tell. “You know you’re going to get some lift if you have an offset CG [center of gravity] but you could tell where it was going,” White explained after the mission.

Thirty seconds later came the first indications of *g* forces for four days. “*You know, it’s kind of nice to have some* g*s back again,*” McDivitt commented, to which White agreed. “*It’s making me dizzy going around in circles,*” McDivitt said, as Gemini 4 continued to roll in its trajectory. “*Look at the paint coming off my window*.” The *g* forces continued to build. They felt the *g* rise, but it took a while for it to increase significantly, which surprised both astronauts and had them thinking that “*the* g*-meter must be broken*.” McDivitt began to feel the increase, calling out levels up to seven. Having been told that they might reach 8-*g* as they descended, McDivitt recalled that “I thought that maybe 7.5-*g*, after being out there [in microgravity] for so long, would be tough, but I didn’t even have to breathe hard to get any air. I just lay there and relaxed and enjoyed the whole thing, and I really got a big kick out of that re-entry.”

White added that although they were pinned to their seats by the *g* forces, they continued chatting back and forth. “We talked through the whole *g*-load and I was watching outside and inside. I was looking out quite a bit of the time when things were going so smoothly, particularly the *g*-load. When you get to the high *g*s, you might as well look out, because you are not going to do anything about it, and I noticed no dimming of vision. Everything was clear as a bell, not a speck. I could see everything on the instrument panel, and I could see things outside very clearly. Once you get in that position and you get the high *g*s, you’re not going to do anything inside [the spacecraft].” McDivitt agreed that it was going so smoothly that he had looked out and enjoyed the scenery on the way down as well.

According to McDivitt, the control of Gemini was “like a dream,” with no oscillations and holding steady. “It was not like any failure simulation [we had] seen,” he added. “It was the easiest thing to control, easier than any simulation I’ve seen. Shoot, A baby could have done it.”

At GET 97:48:58, they reached the 100,000 feet (100K or 30,480 m) altitude mark. However, the altimeter on board Gemini 4 gave some strange readings as they descended. It remained at 96,700 feet (29,474 m) for some time, then began to drop to about 92,000 feet (28,041 m) and then started back up again to about 96,000 feet (29,260 m) before descending once again. This time it descended "*in a hurry*," as McDivitt observed, although he was sure they were still at around 100,000 feet (30,480 m). The Command Pilot waited until they reached the 3-*g* limit at around 80,000 to 90,000 feet (24,384–27,432 m) and then started slowing the roll rate, with the aim of reaching zero roll rate by the time they had descended to between 50,000 and 40,000 feet (15,240–12,192 m).

Ten seconds after they had reached 100,000 feet (30,480 m) altitude, the Houston Capcom called the crew to re-establish communications as Gemini 4 exited the blackout period, telling the crew that they should expect a recovery helicopter using the callsign "*Sinclair 52*." The PAO advised that the primary recovery aircraft carrier, USS *Wasp*, was in contact with the spacecraft via the HF circuit and that they had a received a loud and clear transmission from McDivitt.

Recovery Phase

The whole recovery force had constantly been updated on the progress of the flight during the mission. As the mission continued, its orbital ground tracks shifted and therefore the potential landing sites changes, requiring the recovery vessels to alter positions as necessary. As Gemini 4 started its 62nd and final circuit of the Earth, NASA informed the prime recovery ship USS *Wasp* (CVS-18) of the time the retro rockets would be fired for landing in area 63-1, the end-of-mission landing area in the Atlantic which the carrier was planned to support. Four minutes after retrofire, a CALREP (CALculated REovery Position) was received aboard the USS *Wasp.* Then, just seven minutes later, the Recovery Control Center at MCC-H reaffirmed the calculated landing position, offering the best estimate of the spacecraft's splashdown location.

Gemini 4 Recovery Fleet
The prime recovery carrier for Gemini 4 was the USS *Wasp* (CVS-18), on the first what would be five recovery missions. A global tracking and communication network and two ocean recovery forces – in case of an early abort – were readied, consisting of 10,300 men, 26 ships and 134 aircraft and helicopters, with planes on standby at a number of bases along Gemini 4's

ground track.

ATLANTIC
Destroyers: USS *Barry* (DD-993); USS *Blandy* (DD-943); USS *Charles S. Sperry* (DD-697); USS *Furse* (DD-882); USS *Hawkins* (DD-873); USS *Rich* (DD-820) and USS *Robert A. Owens* (DD-827)
Oiler: USS *Chukawan* (AO-100)
Salvage Ship: USS *Hoist* (ARS-40)
Minesweeper: USS *Nimble* (MSO-459);
Minesweeper: USS *Skill* (MSO-471)

PACIFIC
Destroyers: USS *Orleck* (DD-886); USS *Rupertis* (DD-851); USS *Leonard F. Mason* (DD-852) [which would play a more prominent role in the Gemini 8 mission the following year]; USS *Higbee* (DD-806)
Guided missile destroyer: USS *Goldsborough* (DDG-20)
Oiler: USS *Ponchatoula* (AO-148) [2]

During the re-entry, radar aboard the *USS Wasp* tracked Gemini 4 at a slant range of 330 nautical miles (379.76 miles or 611.16 km) through to landing. Upon receipt of the estimated landing times and locations, all the recovery forces headed to the predicted landing area 63-1. While the spacecraft was on main parachute, the recovery beacon signal emitted by Gemini was received by the up-range helicopter, which further refined the calculated landing time and position. At GET 97:56, just prior to splashdown, the first visual sighting of Gemini 4 since it had left the launch pad was reported by the "on-scene commander" aboard the Grumman S-2E tracker aircraft *Omnibus*. Recovery helicopters with para-rescue swimmers aboard were then dispatched to the scene.

The Gemini 4 Mission Report recorded the final milestones of America's sixth crew to return from orbit, the eighth to descend from space beneath a parachute.

GET 97:50 (Orbit 66/Rev 62) – GET 100:13

The recovery phase of the mission commenced with the deployment of the drogue parachute (GET 97:50:53), followed by the deployment of the pilot parachute (GET 97:52:11) which pulled out the main parachute a few seconds later. Then, prior to the move to two-point suspension, the post-main chute checkout had to be completed and White was scheduled to take another blood pressure reading. Following the change to two-point suspension the spacecraft pressure reading. Following the change to two-point suspension the spacecraft would fall slowly towards splashdown at GET 97:56:12 (13:13 EDT). The spacecraft would then be secured by the para-rescue divers and the crew hoisted into the helicopter for the return to the prime recovery vessel, followed about 90 minutes later by the now-empty Gemini 4.

McDivitt deployed the drogue chute at 40,000 feet (12,192 m). “That’s where things really got exciting,” he recalled during post-flight debriefing. At the deployment of the drogue, the spacecraft began oscillating at about 40 degrees. “When we put the drogue chute out, we were concerned about the thing destabilizing rather than stabilizing,” McDivitt recalled, “so I intended to put the drogue out and leave the control at Re-entry Rate Command. This I did, and we oscillated all over the sky.” White added that when the drogue came out, the sun was shining right in his window, though he could see the chute above them gyrating around wildly. McDivitt could not confirm whether the drogue had reefed or not, again due the sun as well as his restricted view thanks to the mess on his window. “All I could see was the shape of the drogue up there, and it was really fluttering around,” he said. He clearly thought that they had reached 40 degrees, perhaps even 60 degrees, in their oscillations under the drogue. “We were really getting tossed around,” he added. The oscillation had increased to such a rate that both astronauts were expecting the drogue chute to fall off at any minute. Neither had anticipated that action, but fortunately the chute held.

After the mission, McDivitt recalled what he had learned from Gus Grissom’s experiences during Gemini 3’s re-entry and landing. “I knew that Gus said that he had a pretty wild ride, and he thought the thing was destabilizing. He had a scheme where he just turned off the propellant valves to stop the propellant flow. That meant he had to wait about 10 to 15 seconds to get the propellant valves back open again to get the jets firing. Well, I wasn’t going to do that. I thought the thing to do was to turn off the electronics and see if the thing was going to become unstable… It didn’t get any worse. I watched it. I could see enough of it to tell that we weren’t becoming unstable.” At 28,000 feet (8,534 m), McDivitt pulled the handle to burn up all the fuel that he could get out of the manifolds, before they hit the water. When he put the control into Rate Command he turned off the propellant, careful not to let the thrusters fire for a long time which potentially could not only result in the loss of propellant, but also the destruction of the drogue chute. Fortunately, the oscillations subsided as they fell, with White deploying the snorkel on the vent valve somewhere between 28,000 and 27,000 feet (8,534–8,229 m). White said that at 16,000 feet (4,876 m), he was in a position to eject if they had to, to which McDivitt responded that he had hoped they would not need to.

> *McDivitt: “Roger, Cape Control. We’re just about ready to put the parachute out. Stand by… Okay parachute’s coming… I see it… It looks good, Ed, babe.*”

McDivitt later reported in the post-flight debriefing that he had deployed the main chute at 10,600 feet (3,230 m) and saw it go out “with a lot of crap and corruption flying off the nose.” It was a good deploy, but although it billowed as it should have, one edge suddenly collapsed about one-third back in. McDivitt was not unduly worried, as he had seen plenty of movies of this type of deployment, and the chute did indeed billow back out again.

From his position, White could not see the canopy initially with the sun shining directly through his window, but when Capcom Grissom noted that they should be on main chute, he replied enthusiastically, “*You’re not kidding!*” After main deployment, McDivitt quickly reminded White to take his blood pressure measurement. White had difficulty in getting the air out of the device, which frustrated him as he knew this was an important reading for the medics. In the post-flight account, McDivitt commented that he had told White to complete the pressure reading because they were going to two-point suspension at 5,000 feet (1,524 m), adding “He fooled around and fooled around… finally we got down to 5,000 feet [1,524 m] and I said ‘Ed, you’ve got about three or four more seconds and we’re going to two-point attitude’.” White acknowledged that he was being slow but could not work out why. Both men were aware of the dizziness of spinning during entry but were recovering well. McDivitt simply did not trust the altimeters, but White finally got a good blood pressure reading just in time.

At the two-point suspension maneuver, both men were anticipating the same sudden jolt that the Gemini 3 crew had experienced, and put their hands up against the windshield with their heads braced on their arms and to the side. On this flight however, the actual drop to two-point suspension was much smoother than the buffeting they had experienced on the drogue. White was firmly wedged in place with little movement, and McDivitt only noted a small movement forward and back. Neither were jolted anywhere near as severely as Gus Grissom or John Young had been on Gemini 3. They determined that they now had a far better operational procedure, bracing the head on the arm up against the window to prevent what had happened to Grissom and Young on *Molly Brown*.

“*Gemini 4 here*,” radioed McDivitt. “*We’re right side up. Two points on the parachute and everything fine.*” He was then advised that the recovery helicopter should be with them after about five to ten minutes in the water. "*Okay. Don't let them wait too long,*" McDivitt instructed, "*I want to get rescued in a hurry. Tell Doc Berry we got a blood pressure* [reading]."

As they descended under the main parachute, both men reported to Capcom Grissom that they were feeling great. White stated that he felt "*like a tiger.*" He also took yet another blood pressure check. When McDivitt began to call the recovery forces, he received a reply from the on-scene commander aboard *Omnibus* immediately. The two astronauts reported feeling warm in their suits, with cabin temperatures at 55 degrees F (12.8 degrees C) and their suits registering 70 degrees F (21.1 degrees C). McDivitt lamented "*Our poor spacecraft's all burned up.*" He reported the ejection of the R&R section, which had descended alongside them as they fell towards the ocean, as did the drogue and pilot chutes which floated right next to them for a long time until they lost sight of both after going to two-point suspension.

McDivitt had un-stowed his D-ring device at 35,000 feet (10,668 m), ready to activate the ejection seats if he needed to, although now they were in the two-point suspension configuration, it was too late to do so. As White explained after the mission, it would not have been a straightforward ejection if it had been initiated by McDivitt. "I'd come down with this bag of stuff [stowed gear] resting on my legs up against the bottom of the seat, and as we approached 35,000 feet (10,668 m) I pulled this up on to my lap and just held it. We had agreed that Jim would do the ejection if we had to, and I would just take the ride. I didn't un-stow my D-ring [and] I just sat there, That's why I made pretty sure that Jim got his [D-ring] out."

Preparing for splashdown, the astronauts turned off all the switches that were no longer required, as planned. This included the ones on the middle circuit breakers except for the last couple of rows, the IMU, the rate gyros, the horizon scanner and the switches on the central pedestal, but just the landing attitude circuit breaker over on the left side. They reminded themselves to activate the water seal and ensure that the snorkel was in the UP position when they hit the water. Both astronauts thought that the descent from 7,500 feet (2,286 m) down was much faster than on the simulator. At 300 feet (91.44 m), they were getting ready for arrival back on Earth, or rather the water, and recalled a comment from John Young on Gemini 3, who had questioned exactly how you prepared for such an arrival after a spaceflight. Remember, this was only the 16th time a human crew had ever completed this process, and only the eighth time on water (the six Vostok cosmonauts had all ejected from their re-entry capsules over land to return by personal parachute nearby, while the two Voskhod crews had endured a supposedly 'soft' landing by retro rockets).

Gemini 4's on the Water

At impact (GET 97:56:12), McDivitt estimated that the contact with the water was ten times harder than he had expected. He jettisoned the parachute, while White closed the inlet snorkel in the UP position to ensure that no fumes entered the closed spacecraft and then immediately checked for leaks. They did not detect any, but they could definitely smell something, probably the fumes from the heat of the spacecraft which was now cooling down in the ocean.

Satisfied that they could not detect any fumes inside, McDivitt opened the inlet snorkel. "Actually," White added, "shortly after we got on the water, I noticed an acrid smell that we were to have for the rest of the time we were out in the water. On the ECS systems, I could actually feel the relief [from the heat] that the pumps and the snorkel [in the open position] were giving us. It did provide some flow. I really didn't think that the heat was oppressively hot, to tell the truth… it was uncomfortably warm and very stuffy, [but] I would not say it was overbearingly hot. It wasn't as hot as I thought it was going to be in the spacecraft."

It was estimated that the splashdown was 230 miles (370 km) north of San Salvador and 390 miles (627.5 km) east of Cape Kennedy, at coordinates 27 degrees 44 minutes north latitude and 74 degrees 11 minutes west longitude. The altimeter recorded a negative height of -110 feet (-33.5 m) or so, prompting White to suggest that they should set it at the landing area instead of the lift-off setting. McDivitt did not think that would do any good, commenting "I would not trust that altimeter within a thousand feet." It was now time to go through their post-landing checklist and prepare for pickup, as the elation of what they had just achieved struck them both in their own particular ways. McDivitt explained later that it was one of the most emotional moments of his life.

> *White:* "*Gee, I feel great! Good job… let's clean every switch up in this mother.*"
>
> *McDivitt:* "*That wasn't too bad.* [To the Capcom] *Gemini 4's on the water and we're floating fine. No leaks.*"

In his 1999 NASA Oral History, McDivitt recalled the concerns over following a one-day mission in Mercury with a four-day mission in Gemini. "The medical profession was concerned about whether you could pump blood from your heart to your brain… when you're lying on your back. And so we had a lot of medical input that we didn't need, about 'Oh, they're going to die,' [and] 'Maybe we ought to put them in the spacecraft and let them sit there for four days and nights in the simulator, to see if we can separate the effect of confinement and the in the simulator, to see if we can separate the effect of confinement and the effect of weightlessness,' and a whole bunch of junk like that. Well, we would have died sitting in the simulator for four days because the seats weren't vertical. They were tilted. And it wouldn't have proved a thing anyway. But fortunately, Chuck [Dr. Charles A.] Berry, the NASA physician, and some of the cooler heads prevailed; and we just went ahead and flew. I do remember when we landed. We hit the water and we checked around for leaks.

"I said to Ed, 'How are you feeling?' He says, 'I'm feeling great. How are you feeling?' [I reply] 'I'm feeling great, too. Guess we aren't going to die!' As a matter of fact, the one concession that NASA made to these medical nitwits was to try to show us how to put our head down between our legs, because that way we'd get our head below our heart, and blood would flow to our brain normally. So, we went through the motions of trying to learn how to put our head down between our legs. But the fact is that the instrument panel was [in the way]. So, we went through the motions, but there was no practical way of doing that." [3]

After hitting the water with a "real wallop," as McDivitt put it, Gemini 4 began a 150-degree roll to the left and was being dragged backwards. The astronauts suddenly found themselves almost upside down and drifting backwards. From their vantage point, the CAG (Carrier Air Group) witnessed Gemini 4 'hit' from an altitude of about 100 feet down to the ocean. To the CAG, it appeared that Gemini hit the water and tilted up and over, apparently blunt end forward. McDivitt later said that they had tilted right over the top with a pitch-down maneuver of about 180 degrees, giving the astronauts the surprising sensation of moving backwards and upside down. Now in the water, things began to settle down. A little water sloshed over the windows, but at least they had finally turned the right way up.

Green dye was ejected from the spacecraft to help signal the landing area for the approaching aircraft. There were at least two helicopters in the area, and one of them soon reported a visual sighting of the spacecraft in the water, about five miles away. After switching their Rescue Beacon on, both astronauts began to notice the aroma inside the spacecraft now that air was bring drawn in from outside. "*It really stinks in here, doesn't it?*" remarked White. McDivitt thought that the worst part of their time out on the water was the smell. He estimated that it was the heatshield cooling, because he returned to the spacecraft later on the carrier deck and noticed the same smell. "This terrible, nauseating acrid smell was still all over the spacecraft, and it seemed to be worse at the heatshield, so I assume that [it] was heat we smelled inside."

After landing, they turned everything off that was not needed, so they could not read their gauges anymore, and began the post-landing checklist, although not read their gauges anymore, and began the post-landing checklist, although McDivitt did not take his helmet off and stow it at this point. McDivitt later commented during the post-flight debriefing on the control of the Gemini after landing. “Spacecraft control in the water is lousy,” he exclaimed. “I would take out the methods. The rates were terrible, uncontrollable!”

White spoke to Capcom Grissom, stating, “*There’s nothing you can do but pull us out.*” Clearly, both men wanted to get out of the spacecraft as soon as they could and had requested a helicopter pickup. The carrier was about 40 to 50 miles (64.3–80.4 km) away, but the rescue helicopter was already on the way to pick them up. Though it was hot inside the spacecraft, both astronauts felt that they could have endured being in there a while longer, but when told they could either have a helicopter pick up in 20 minutes or remain in the spacecraft for a carrier pickup after 40 minutes, it took Ed White only a moment to decide. As he revealed after the flight, McDivitt was busy plugging in a biomedical connector, so White answered the call. “I felt I knew my buddy well enough and made the decision that we’d take the helicopter pickup. I saw he was actually on the radio at the time, but he ‘roger-ed’ the decision. So we waited for the helicopter pickup.”

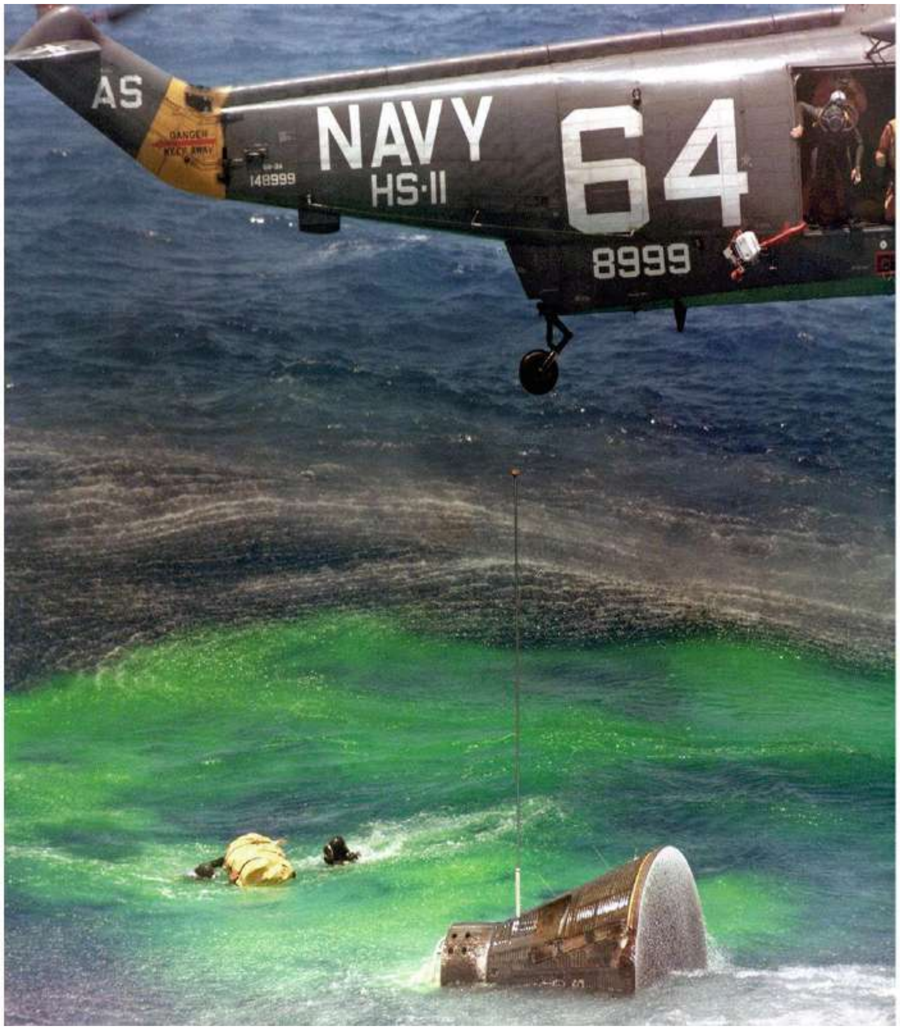
> *Capcom:* “*The Peek-a-Boo* [meaning the Flight Surgeon] *would like to know the condition of you two. Are you both in good shape? The doctors would like to know if you’re going to return in your spacesuits or not.*”

Both men reported that they were in excellent shape and would indeed remain in their suits for one more blood pressure reading and for the ride back to the carrier. McDivitt talked to the rescue crews on *Omnibus* and *Sinclair 64* via UHF, but communication with the MCC in Houston and on HF were difficult. Generally, they were both pleased with the communications with the recovery forces, hearing all the transmissions going back and forth. “We probably knew more about the recovery than anybody else around,” said McDivitt after the flight. As soon as they hit the water, *Omnibus* said “*I got them in sight, [and] I’m 48 miles* [77.2 km] *out,*” which McDivitt estimated was the distance from the USS *Wasp* to the helicopters, because he had heard the call that the helicopters were only 15 to 20 miles (24.1–31.1 km) away. “They were on our frequency and I could hear them dumping their swimmers into the water and standing by… throwing smoke bombs out and seeing the dye markers,” he recalled. “We had more activity than the Fourth of July.”

McDivitt later stated “We were in moderate seas, but I wasn’t about to open those hatches up and take the chance of any water getting in that spacecraft. So we elected to stay in the spacecraft until they got the collar on, and kept all the we elected to stay in the spacecraft until they got the collar on, and kept all the hatches battened down." White added "We… decided that the way we were to leave the spacecraft was in our suits, and we felt that rescue was coming pretty quick. We decided to go ahead and stay in our suits. I think this was a reasonable decision."

"We both took our gloves off to get the things out of the spacecraft that we wanted [with us]," added McDivitt. "I left my helmet on, and Ed left his helmet off. When we got ready to leave, we decided that we would put our gloves back on, take our helmets off and put our neck dams on, inflate our Mae West, and then get out. That's what we did."

Supporting the recovery of the astronauts and spacecraft were four helicopters and one fixed-wing aircraft. A Grumman S2E twin-engine airplane, designated *Omnibus*, was on the scene as 'commander' of the aerial recovery fleet and had established voice contact with the astronauts in the spacecraft. The primary recovery helicopter, designated *Sinclair 64*, was an SH3 twin-engine jet turbine. The pilot was Commander Clarence O. Fiske, who reported his visual sighting of the spacecraft and that it was "riding very nicely" in the water. Meanwhile, McDivitt had been in conversation with flight surgeon Dr. Howard Minnerson aboard the USS *Wasp*, who reported that he was most encouraged by the sound of McDivitt's voice. When he was informed that the swimmers were soon to be deployed to prepare the spacecraft for pick up, McDivitt reportedly replied "*Hurrah, Hurrah, we are going to the* Wasp."



The arrival of the para-rescue divers and "*Sinclair 64*," the primary rescue helicopter [Courtesy Ed Hengeveld].

The first swimmers (made up of members of the Navy's Underwater Demolition Team [UDT], the forerunner of the U.S. Navy Seals) were in the water just fourteen minutes after splashdown, and proceeded to deploy a life raft into which the astronauts would transfer for airlifting into the helicopter. Headed by Lt. (j.g.) Martin Every, this team had practiced all week for this moment, determined to effect a prompt recovery and aware of the threat from sharks, as one had apparently swum under Gemini 3 during the recovery of astronauts Grissom and Young three months earlier. Ed White was the first to have contact with one of the swimmers, who looked in through White's window "to see if we were alive," McDivitt surmised. After checking on the condition of the crew, obtaining an eyeball verification of how they looked and a verbal confirmation of how they felt, the swimmer reported that both astronauts looked in good shape, although they had emphasized that they were hungry.

At GET 98:16, the divers attached a floatation collar around the spacecraft to ensure the seaworthiness of the Gemini until it was picked up by the USS *Wasp* about 75 minutes later. McDivitt had declined to leave his spacecraft until he had assurances that the floatation collar was firmly attached and that at least one more blood pressure reading had been secured while in the spacecraft on the water. He was extremely pleased to see that floatation collar pumped up. “The best sign… was seeing that yellow thing [the floatation collar] around the spacecraft,” agreed White. “I guess [after that] I knew we were going to be able to file out pretty quick.”

The astronauts look off their helmets and put on the lightweight communications headsets. White had felt better with his helmet off, but McDivitt said “I felt much better with my helmet on and my visor closed because I didn’t like the smell of that stench in there.” McDivitt explained that they “did a lot of work when we first landed. We were fiddling all over and getting things out of boxes we wanted and stuff like that. We probably did more concentrated manual labor in those first five minutes after we got into the water than we had done at any other time during the flight, except trying to get the hatch closed.” White added “At this time, I was completely drenched with sweat. I said it was hot earlier, but with the combination of the suit and the warm climate that we were in, I was sweating pretty heavily. I looked over at Jim and he was pretty sweaty too.”

Getting Out of Gemini 4

Looking outside prior to opening the hatch, the astronauts could not visually detect any RCS fumes, the distinctively colored red and purple or yellow smoke, though they did see a little steam. McDivitt had great difficulty in looking though his dirty window, even trying to find the rescue helicopter, which was no more than 50 feet away right in front of them. He could see a little way out front, but could not see up at all. The Command Pilot stated after the mission that if they had not burned all the residual fuel on the way down, they would never have opened the hatch to get out while on the water and would have opted to wait for pickup by the USS *Wasp* because of the dangers of leaking fumes. The condition of the sea was just as had been predicted earlier, with swells of three or four feet, but three or four feet in Gemini was akin to 2,000-foot waves to an aircraft carrier, McDivitt noted. “We were bobbing around, but we had a lot of experience bobbing around before, so it was not that bad.” He also noted that their earlier training out in the Gulf of Mexico had made him feel confident when they were out there on the water all by themselves.

With Ed White already hoisted into the helicopter and the spacecraft hatches closed, Jim McDivitt waits his turn in the dinghy as the para-rescue divers secure the spacecraft for later retrieval.

The left hatch was opened, and at 42 minutes past the hour Jim McDivitt emerged, standing up on the seat to have a brief chat with the swimmers. He then briefly sat down again, presumably having stretched his legs to get accustomed to Earth's gravitational forces again after four days aloft. Wearing a pair of floatation wings, McDivitt moved across to the life raft, with White joining him a few moments later. Up in their helicopter, Commander Fiske and his co-pilot, Lt. Douglas C. Bullard, were signaled to move in to about 30 feet (9.1 m) above the raft ready to hoist up the astronauts one at a time into their helicopter for the trip back to the USS *Wasp* [2].

Had either astronaut been injured or needed medical attention, then they would have been hoisted horizontally up into the helicopter by means of a

Stokes Litter Basket, to be attended by a physician onboard the helicopter for the flight back to the carrier. Following the helmet strike incident on Gemini 3 (when the spacecraft pitched from single-to two-point suspension causing Grissom to hit his head and crack his helmet faceplate, fortunately without serious injury to the astronaut), it was decided that from Gemini 4, the helicopter physician should be trained to jump with the divers to provide immediate medical assistance should it be required. The problem with that idea on Gemini 4 was that the physician chosen was not a very good swimmer. The lead NASA flight surgeon was required to remain on the carrier and the assigned helicopter physician was not keen on the prospect of jumping into the ocean. Fortunately, he was not required to do so [5].

McDivitt recalled that after disconnecting his suit hoses, “I stood up in my seat, disconnected our survival landing gear, inflated both Mae Wests, snapped them together in the front and just jumped right over into the life raft. I landed right on my can [backside] just like I had planned to. It was so good to get out of there.” When White jumped out, he had not yet inflated his Mae West. “I was so happy to see that raft I jumped right over the side,” he said.

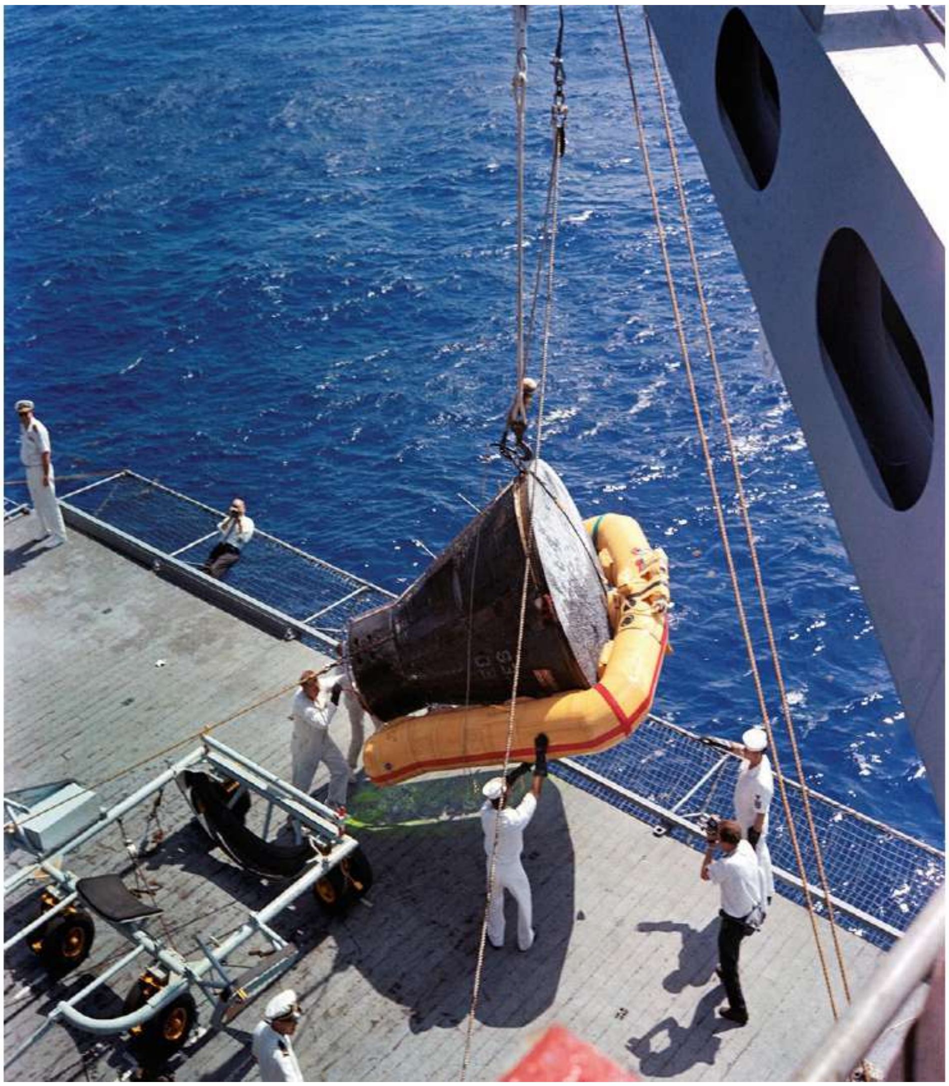
McDivitt did not want to be first up into the helicopter, so White took the “horse collar” sling and was hoisted out of the raft. When it came to McDivitt’s turn, he was unceremoniously dumped in the water briefly and was bumped against the side of the spacecraft’s heatshield, but he said that it was a good pickup up nevertheless. “Shoot, I was happy to be out there in that nice cold salt water blowing in my face,” he recalled. “I was dipping my hands in it and slinging it over my head.” Both men noted how stable the helicopter was on their ride, with McDivitt commenting “They got us picked up safe and sound.”

Looking tired after their four-day marathon, Jim McDivitt (right) and Ed White relax aboard a U.S. Navy helicopter on their way to the prime recovery carrier, the USS *Wasp* [Courtesy Ed Hengeveld].

At 50 minutes past the hour (and 34 minutes after splashdown), it was reported that both astronauts were safely aboard the helicopter. On the way back to the USS *Wasp*, some ten miles distant, a doctor gave each man a quick physical while they were still in their spacesuits, minus the helmets and gloves. He reported that they were in great shape.

Lost Parachutes

Meanwhile, the PAO in Mission Control commented that a second helicopter, which was to pick up the spacecraft's parachutes, had reported that apparently they had sunk. There was no confirmation that they had either abandoned the search or delayed it, however, with the PAO observing, "It's certainly not a search or delayed it, however, with the PAO observing, "It's certainly not a crucial item." Later, it was confirmed that the parachute was indeed lost. Usually, the parachutes remain very close to the spacecraft, though they can quickly float away when jettisoned. Several helicopters had remained on the scene searching for both the chutes and the Rendezvous and Recovery Section of the spacecraft. The recovery aircraft had been over the spacecraft almost immediately after it had splashed down and quickly reported sighting the main parachute in the water near to the spacecraft, but it had sunk by the time the swimmers had arrived. There were no traces of the Rendezvous and Recovery (R & R) Section and the smaller drogue parachute.



The empty Gemini 4 spacecraft is hoisted aboard the USS *Wasp* during recovery operations following the highly successful four-day mission [Courtesy Ed Hengeveld].

Staying Tuned in

Back in Mission Control Houston, with both astronauts safely on the helicopter, Mission Director Chris Kraft lit up his post-splashdown cigar and was puffing way merrily with a big cloud of smoke enveloping his head. As the PAO noted, “He’s a very happy man.”

> *PAO:* “This is Gemini Control. Here in the Control Center, there must be fully 50 people, project officials from the Gemini Office. Dr. [Robert] Gilruth, Director of the Manned Spacecraft Center, has just come in and shook Chris Kraft’s hand vigorously. They’re all smiles.”

With Gemini 4 having splashed down and the astronauts now safely recovered, the operational side of the mission was over. Outside Building 1 at the MSC, the Gemini Program and U.S. Stars and Stripes flags that had flown on Gemini 3 were lowered, until the next Gemini left the pad and entered orbit.

With the recovery now well underway, a member of the Flight Planning Department displayed a slide on the big screen monitor in Mission Control which read: “*End of the Flight Plan,*” together with a note that everyone should stay tuned ready for Gemini 5.

References

1. **GT-4 Flight Crew Debrief transcript,** NASA Program Gemini Working Paper No. 5038, section 4.4 Pre-retro preparation, p 4-101 to 4-105.

2. **Splashdown, NASA, the Navy & Space Flight Recovery**, Don Blair, Turner Publishing Company, 2010, pp. 38–39 and 162–4.

3. James A. McDivitt, NASA Oral History Project, June 29, 1999, pp. 12-41 to 12-42.

4. Information courtesy of Dr. Ross J. Smith, http://recovery_ships.rossjsmith.com/information/recovery_helo_pilots.html. Last accessed June 9, 2018.

5. **A recollection of Gemini from Forty Feet and Twenty Knots**, William R. Carpenter, M.D. and John B. Charles, PhD. NASA History News & Notes, Volume 32, Number 4, Fourth Quarter, 2015.

Footnotes

1 A DD-175 form provides the data required to process flight plans in accordance with appropriate air traffic service authorities. Though voluntary, failure to provide one could result in denial of flight plan processing.

2 Addendum for GEMINI FLIES and the recovery of Gemini 2 and 3. The Primary helicopter recovery pilot for the unmanned Gemini 2 mission was Lt. Donald Coolican; while the Gemini 3 helicopter pick-up crew were: Pilot Lt. Cdr. Warren H. Winchester; Co-Pilot Lt. jg [junior grade] J. R. Walker; 1st Crewman AX3 J. Kerivan; 2nd Crewman J. D. Hightower **[** 4 **]**

David J. Shayler, *Gemini 4*, Springer Praxis Books
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14. Post-flight

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

"You are symbols of a new world.
You are symbols of a new horizon.
You are symbols of a new potential, not just for yourself or your country but for three billion human beings everywhere."
President Lyndon B. Johnson's comments on awarding the NASA Exceptional Service Medal to Jim McDivitt and Ed White, The White House, Washington D.C., June 17, 1965.

It was estimated that about 90 percent of the ship's crew (approximately 3,100 of the complement of 3,448) were on the deck of the recovery aircraft carrier, the USS *Wasp* to witness the arrival of the Gemini 4 crew by helicopter[1].

(left) The astronauts, arms around each other in celebration, confidently stride across the deck of the USS *Wasp*, even after four days in orbit. They were welcomed by members of the crew and NASA personnel. The astronauts are flanked by Captain J.W. Conger (left) commander of the *Wasp* and Rear Admiral W.M. McCormick, commander, Carrier Division 14, Atlantic Fleet [Courtesy Ed Hengeveld]. (right) Not quite believing the Red Carpet treatment from the navy ratings, these Air Force officers seem overwhelmed by their homecoming.

Post-Flight Activities

As the helicopter carrying the astronauts approached to within ten miles of the carrier, the red carpet was rolled out in preparation for the arrival of the VIPs. On the arrival deck was a Marine guard and a roped-off area, with naval dignitaries Rear Admiral William M. McCormick, commander, Carrier Division 14, Atlantic Fleet, and Captain James (‘Jim’) W. Conger, Commanding Officer, USS *Wasp*, standing by to greet the astronauts formally. Commander Fiske and co-pilot Lt. Bullard brought the helicopter in to land on the deck of the carrier at nine minutes past the hour, as a range of flags, including the NASA flag, the flag of the *Wasp*, the Marine Corps flag and the Stars and Stripes, were flying. As McDivitt and White stepped out, a huge round of applause sounded around the ship, with many of the sailors throwing their white hats in the air in celebration. While a band played in the background, both men were welcomed on board, saluted and then ushered onto a section of the deck covered in canvas with the greeting ‘WELCOME TO U.S.S. WASP’. They were then accompanied by Admiral McCormick and Captain Conger down the red carpet, between a double line of Marine Honor Guard, towards the medical area for a quick post-flight physical. They appeared to be in great condition after their four-day mission, with their arms slung around each other’s shoulders as they left the deck to go down below to the medical area and with McDivitt joking that he guessed the pair would end up in hospital. Observers noted that both were walking well after four days of weightlessness, but they needed a shave.

Admiral McCormick, the operations commander for the recovery, commented “They [the astronauts] said very little except they were very damned glad to be aboard.” [2]

Post-Flight News Conference

While the post-recovery events were underway in the Atlantic, over at the Manned Spacecraft Center in Houston, a post-flight news conference was arranged just thirty minutes after the crew was seen on the deck of the recovery carrier. The participants of this conference were:

- Dr. George E. Mueller, Associate Administrator for Manned Space Flight, NASA;
- Dr. Robert R. Gilruth, Director of the Manned Spacecraft Center;
- Major General Vincent G. Huston, Assistant DoD Manager for Manned Space Flight Operations;
- Christopher C. Kraft, Jr., Assistant Director of MSC for Flight Operations, who also served as Flight and Mission Director for Gemini 4;
- Charles W. Mathews, Gemini Program Manager, MSC; and
- Dr. Charles Berry, Chief of MSC Medical Operations.

Dr. Mueller noted the support of the industry-government-DoD team which had made the flight such a success, and spoke highly of the mission’s pair of world firsts: two men spending four days in space, and an EVA using a propulsive device for maneuvering (cosmonaut Alexei Leonov did not have such a device for his EVA). Dr. Gilruth also thanked the wider team, and in particular the Mission Control Center team. The other panelists also praised the team effort that had made the mission such a success. Then came the question and answer session.

The mission's duration sparked more medically-related questions in this conference and Dr. Berry indicated that although it was still too early after the mission for definitive results, the reports he had received from the recovery carrier, and the data at Mission Control, indicated that both astronauts were in excellent physical condition. "We have knocked down an awful lot of straw men," he added. "We had been told that we would have unconscious astronauts after four days of weightlessness. Well, they're not. We were told that the astronauts would experience vertigo [and] disorientation when they stepped out of the spacecraft. We hit that one on the head, [but] both men were bushed." He reported that McDivitt was found to have a few flecks of caked blood in his nostrils, caused by the dryness of the mucous membrane from the inhalation of pure oxygen for four days. Once the wider results arrived, Dr. Berry expected that they would prove there were no serious effects from flying four days of 'weightlessness'. Reports of a significant heat load in the spacecraft during re-entry were quickly refuted, as temperature readings taken inside the spacecraft when it was on the water registered 70 degrees F (21.1 degrees C). The mission had also clearly refuted the suggestion in some circles that a spacewalking astronaut would suffer from vertigo, preventing any EVA.

Charles Mathews replied to a question regarding the onboard computer problem and how it might affect the scheduling for Gemini 5. "I don't anticipate that type of problem would cause a delay. Of course we do have a failure analysis – we're taking immediate steps. We're already setting up a meeting with all the people involved to determine just how to handle the various guidance and control equipment that might be involved. I expect we'll find the answer fairly early for that case of failure. Failures in electrical equipment can generally be rectified quite rapidly." He went on to reveal that he had been surprised at just how well the spacecraft had performed during the four-day mission, reporting that all the temperature, pressure and fuel consumption figures were well within predictions and looked "about as steady as a rock." Chris Kraft then added "I think you ought to say… that the performance of the Environmental Control System was far above anything we've ever expected it to be. We never had any moisture problem in the spacecraft during the whole flight and the relative humidity stayed almost constant from lift-off to landing." [3]

All Aboard The USS *Wasp*

Monday June 7: USS *Wasp*

After the welcome ceremonies, the two astronauts underwent their first two hours of medical examinations. Dr. Howard Minners reported that both were in great shape, without underlying problems, and were "active, very talkative and cheerful."

From the time of their landing and for the next 66 hours, a range of post-flight medical data was gleaned from the two astronauts, mostly through clinical examinations. The planned medical recovery activities were similar to those conducted following Gemini 3, but this time a Medical Evaluation Team was sent to the prime recovery vessel.

Shortly after the astronauts arrived onboard the *Wasp*, about 90 minutes after splashdown, they underwent a detailed medical evaluation in the ship's sick bay, featuring over three hours (13:41–16:50 EST) of examinations including the first tilt-table procedures. This was followed, after about an hour and 40 minutes, by their first post-flight meal, consisting of a low calcium diet. Less than 30 minutes later, a second session of tilt-table procedures was completed (another hour and 45 minutes) and even more blood specimens taken.

A Proud Nation and a Grateful World

Later that afternoon, the astronauts held a telephone conversation with President Lyndon B. Johnson, who was at the White House in Washington D.C. The President told the two astronauts "Well done. We are all in this country very proud of you and the entire world is grateful for what you have done and particularly for your safe return. You have both written your names in history and our hearts. God bless you both and your very fine families." [4]

"Mr. President," Jim McDivitt replied, "you certainly make me proud saying something like that. As you know, this is one of the happiest days of my life."

President Johnson then enquired about what Ed White had done to McDivitt's windshield during the EVA. The pilot replied that there was nothing much he could do, as he was very close to the window and contact was unavoidable. The President reiterated the nation's relief at their safe return, adding "We're all very proud of you and we are looking forward to seeing you." He then invited both men to visit with him in Texas later in the week. "We'll see if we can get together down at the [Johnson's] ranch," as he had been saving "a little something for you."

The President then asked the astronauts to hold off on their domestic plans until they visited him in Texas. "I heard Major White's wife [Pat] say she until they visited him in Texas. "I heard Major White's wife [Pat] say she wanted to go to Colorado, but you tell her to just hold off that trip until you get up to the ranch. I'll have my military aide get in touch with you in a day or two and I hope we can make it." Naturally not wanting to disagree with their Commander-in-Chief, both men readily agreed. "Now, I just want to say this finally to the two of you. What you have done will never be forgotten. We can hope and we do pray that the time will come when… all nations will join together to explore space together and walk side by side for peace," Johnson said, foretelling events that would come to fruition over 30 years later with the International Space Station program. He then closed the conversation by noting that he would be in touch with them again through NASA Administrator James E. Webb and added "You two outstanding men have taken a long stride forward in mankind's progress, and everyone in this nation and, I think, in the free world, feels in your debt."

That evening, after a shower, both men were photographed with the ship's crew standing in the 'chow line' in the dining hall aboard the *Wasp*, where they enjoyed their first hearty meal in several days, consisting of steak, baked potatoes and vegetables, followed by a lemon pie dessert. Both men had spoken to their wives and reported they both felt great, with McDivitt especially proud of the fact that, unlike White, he had not been seasick out on the water. At 22:30 EST that evening, the crew finally turned in for a well-deserved first night's sleep on Earth (or at least on the ocean) for four days.

Post-Flight Inspection of Gemini 4

Once the crew was aboard the carrier, efforts on June 7 focused on retrieving the now-empty spacecraft. The USS *Wasp* was alongside Gemini 4 at GET 100:05, some two hours and nine minutes after it hit the water. The spacecraft was hoisted on deck seven or eight minutes later, with small quantities of the green dye still oozing from it. With Gemini 4 cooling down after its fiery re-entry, the pace over at Cape Kennedy was already picking up for the next mission, as work progressed that same day on readying the launch vehicle stages that had been erected at Pad 19 for Gemini 5. The new mission was scheduled for launch in August, barely ten weeks away.

Back on the *Wasp*, as soon as the Gemini 4 Re-entry Module had been safely installed on its support dolly, members of the recovery team began the post-landing procedures as directed under the Gemini Recovery Operations Manual. Some of the first items removed from the spacecraft included film, data recordings and other crew equipment, which were airlifted on special flights from the carrier to either Houston or the Cape. The equipment bays and the doors for the intended – but not fitted – landing skids were opened for the removal of equipment and then the empty bays were cleaned. The equipment removed included the troublesome computer, the Auxiliary Computer Power Unit (ACPU), the Inertial Guidance System (IGS), the static power supply, the gimbal power electronics, the inertial platform and the Inertial Measurement Unit (IMU) system electronics. Once cleaned, each item was packed in special containers and then flown to Patrick AFB Florida to be handed over to representatives of the Gemini Program Office for further inspections and tests.

The recovery team conducted a visual inspection of the Gemini 4 Re-entry Module and found no excessive heating or physical damage. Examination of the spacecraft also revealed that the heatshield did not have any hot spots and had burned evenly during the re-entry phase. There were certainly scars on the shield near the hoist loop, but it was determined that these had been caused by the equipment used by the swimmers to attach the hoists to the spacecraft during its retrieval from the ocean. During normal recovery operations, the hoist loop door was intended to open automatically when the parachutes were ejected. It did not do so on Gemini 4, despite the detonation of the pyrotechnics designed to open it. The door was manually removed by the swimmer and returned to the recovery personnel on the ship.

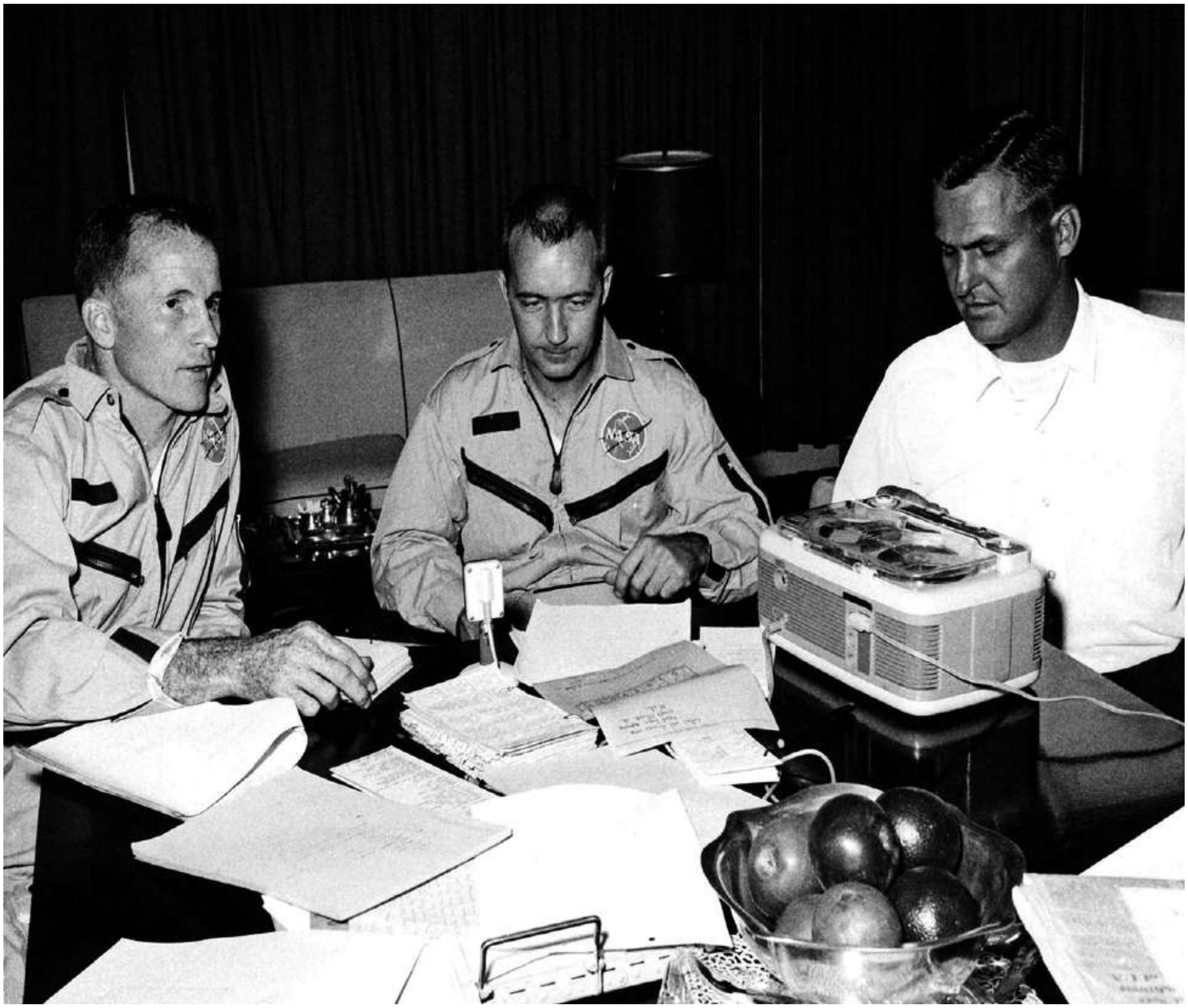
With three Gemini heatshields now recovered (Gemini 2, 3 and 4), the condition of the heatshield material after entry could be further analyzed. In comparing the heatshields from the three missions, it appeared that the Spacecraft 4 shield had received a similar heat stagnation point to that of Spacecraft 2. Initially, the Spacecraft 4 shield was gray and black all over. This was very different to the Spacecraft 3 shield, which had a distinctly white cast after landing. However, after a few days of ‘drying out’, the Spacecraft 4 shield also became very white.

The post-flight inspection recorded that “the spacecraft interior was exceptionally neat and all equipment was stowed,” which was a credit to both astronauts after four days in space despite their necessary rush to complete the task. Both the left and right observation windows were found to have moisture between the glass panes, except for a very small strip around the periphery of the windows. Small film deposits were recorded on the exterior surfaces of each window.

Both astronauts had exited the spacecraft through the left-hand hatch (McDivitt) after landing, so it was decided prior to commencing the post-retrieval procedures not to open the right-hand hatch that had given so much trouble before and after the EVA until the spacecraft had been returned to the Cape for further examination. However, when it was discovered that the right-hand biomedical recorder could not be removed without opening the hatch, that plan was abandoned. The right-hand hatch was torqued open to remove the recorder and then closed again, but not locked. The left-hand hatch was closed after the post-retrieval procedures had been completed.

On June 10, with the USS *Wasp* docked at Mayport Naval Station, Jacksonville, Florida, Gemini 4 was carefully offloaded onto its transport dolly. It was then taken to a remote and safe isolated area where its Re-entry Control System (RCS) could be deactivated. The RCS had to be decontaminated to a level less than 300 parts-per-million before the spacecraft could be returned to Cape Kennedy and transported through populated work areas for further post-flight examination.

A team of NASA and McDonnell engineers and technicians were flown to Mayport to complete the RCS deactivation and safing, with no reports of toxic vapors from any of the 16 thrusters. Unlike the deactivation procedures on Spacecraft 2[2], there were no problems with electrical components on Spacecraft 4. With deactivation work completed, Gemini 4 was airlifted by C-130 aircraft to the Cape, arriving on June 11. Once its safe condition was assured, Gemini 4 became accessible for immediate post-flight analysis.



With the recovery ceremonies completed, the crew got down to the formal debriefing and medical examinations aboard the carrier prior to their return to Florida [Courtesy Ed Hengeveld].

Tuesday June 8: USS *Wasp*

On June 8, the two astronauts awoke onboard the *Wasp* at 08:30 and breakfasted in preparation for a full day's program ahead of them. More in-depth medical tests were conducted, from 10:00 to 11:50, with a third tilt-table procedure completed and the medical debriefing begun. After lunch, another three-hour session of medical debriefings began at 13:00. After dinner, they began a fourth tilt-table session, which was completed prior to the crew going to bed at 22:00.

The tilt-table program used for the Gemini 4 astronauts was similar to that employed after Gemini 3, but with modifications to the saddle of the device. Instead of using the Stokes Litter[3], strain gauges were used around both legs to record any increases in leg circumference as part of the biomedical recording. At no time did the crew report any hypotension during recovery or post-flight procedures, and though the first tilt-table procedure recorded marked elevations in their heart rates in response to the heads-up tilt to 70 degrees for 15 minutes, their responses gradually returned to normal. The post-flight report stated "The cardiovascular response is believed to have occurred because of physiological alterations. Such alterations did not in any manner compromise the crew's ability to function in the in-flight or post-flight phases of this mission." [5]

Wednesday June 9: USS *Wasp*

Having woken at 06:00 on the second full day of their recovery, the two astronauts spent most of the morning in technical debriefings. As the mission had included the EVA, the attempted rendezvous and an extended duration, a significant number of items were discussed during this debriefing session. With regard to their medical condition, it was noted that neither astronaut reported experiencing any disorientation, breakoff phenomena or anything else untoward during the mission. Vision and ocular perception were reported to be normal, and most of their time on orbit had been taken up simply dealing with survival, performing the functions of life such as eating, drinking, excreting and sleeping, as well as stowing used or soiled items. During the afternoon, the crew participated in a fifth tilt-table session before finally retiring for the night at 23:00.

Thursday June 10: USS *Wasp*, then Houston

On Jim McDivitt's 35th birthday, the crew awoke at 05:40 and left the ship (now docked at Mayport) after breakfast at 07:15 to head home to Houston and their families. They were welcomed by a crowd of 3,000 as they left the ship. They later arrived at Ellington Air Force Base near the MSC. A large crowd of local residents and fellow workers at NASA were waiting to greet them, cheering the returning astronauts who had been away since May 23. That evening, the astronauts returned home for a few quiet hours with their close families and a chance to relive and explain some of their experiences and memories of the four-day adventure. Both men were clearly happy to be home and proud of what they had achieved, with White telling his family that he felt "red, white and blue all over." For McDivitt, it was a great way to celebrate his birthday. Later, back in the quiet of his home in Houston, he was tired but wanted to talk about the flight with his wife. Outside, it was dark, and looking up, he was aware of a strange impression. He told her: "You know, those stars look exactly the same down here as they do up there."

Crew Press Conference

The next day, June 11, McDivitt and White participated in a post-flight crew press conference at the MSC, four days after they had completed their mission. Also in attendance were Dr. Robert C. Seamans, Associate Administrator of NASA and Dr. Robert R. Gilruth, Director of MSC [6].

Seamans started by stressing that the Gemini program was a research and development effort to obtain as much information as possible about the space environment and spaceflight from each of the missions and that a great deal had indeed been learned from Gemini 4. The conference followed four main topics: the crew's experience of a long spaceflight; the problems associated with maneuvering in space; the EVA; and the wide variety of optical experiments. Seamans stressed that it was still too early to have analyzed all the data thoroughly, and also thanked the large support infrastructure around the mission.

The conference was then handed over to the astronauts, with each alternately describing different but distinct phases of their mission. McDivitt opened their presentation with a discussion on the launch phase and the first orbital operations with the second stage of the launch vehicle. Ed White then described his EVA and then McDivitt talked about the experiments, observations and exercises conducted over the four-day period. White concluded their presentation by explaining the activities connected with preparing and conducting the re-entry, recovery and post-recovery operations.

McDivitt also praised the larger team effort behind Gemini 4 in his opening remarks. "I feel [that it was] a tremendous NASA accomplishment, and the Manned Spacecraft Center really came into its own this time. We not only manned the program before flight from here [in Houston] but we directed it from here. There's not a single person in this auditorium or in this Center that should not feel that they are a very close part of the program and our flight. I can't really thank them enough… I also feel that it was a good industry team and a good Department of Defense backup on this and I can't thank those enough either. I always felt that we couldn't perform the mission till we got into space and this was a Martin function. They had promised us a good booster and they did [provide one]… Once we got there, it was [just] the spacecraft and Ed and I, and McDonnell Douglas provided the spacecraft that we needed."

Ed White added his own vote of thanks to the huge infrastructure behind Gemini 4. The very visible part of any manned flight into space is inevitably the flight crew, but there are always so many behind the scenes to make it all happen, as White acknowledged. "I think the theme that we want to stress on Gemini 4 is teamwork. I think this is the keynote on what we tried to do during our months of preparation and I know that [as far as] the rest of the members at our months of preparation and I know that [as far as] the rest of the members at the Center and the offices around the Center and the other industry that was supporting us [are concerned], this is what they were trying to do also. I think it went right down to the team of the Gemini 4 crew also.” He also acknowledged “the best backup pilots that two guys could have and I wanted to call attention to them here... Frank Borman and Jim Lovell.”

McDivitt then went on to describe the rendezvous phase with the Titan stage. On separation, he reported no tumble rates, but after turning around he noted that the booster had a tumble rate of between 10–20 degrees on all axes which gradually increased to 40–50 degrees, much higher than expected. It took more thrusts from the onboard maneuvering engines than he had estimated to stop the relative velocity between Gemini and the stage, and as he tried to align the platform it became apparent that the two vehicles were not in the same orbital plane, as the stage started falling away from them rapidly. Mindful that the late launch had shifted the operation closer to the period where they would be entering orbital darkness, McDivitt noted that he could see only one light on the stage as it tumbled instead of two, which made it more difficult to determine the range and rate “so we had a small problem on our hands,” he explained. As they approached Carnarvon he tried thrusting down towards the booster, unable to tell the rate at which the stage was separating from them or the range to reach it. When the booster emerged into sunlight, they found it had dropped much lower than they had estimated. Conscious of the amount of fuel being used as the booster continued to draw away from, them the attempt was terminated. “I hated to see it go,” he admitted, “but I knew the best thing was to stop the rendezvous and get to our extravehicular activities.” He admitted that despite these difficulties, a lot had been learned from this phase of their flight. “The big thing is that the overall mechanics in rendezvous positioning are a little more difficult than we had anticipated, but certainly not impossible.” He added that from the knowledge gained from the flight, “we can go on to many more successful rendezvous.”

Ed White then took up the account of the mission, talking about the EVA and showing a film of his exploits, which he narrated as it rolled. “This is actually when I’m coming out,” he began. “What I tried to do was actually fly with the gun and maneuver with the gun right out of the spacecraft, and when I departed the spacecraft this time there was no push off whatsoever from the spacecraft. The gun actually provided the impulse for me to leave the spacecraft [and was] actually providing the impulse for my maneuvers… At this time, I knew we had something with the gun because it was actually providing me with an opportunity to control myself where I wanted to go out there.” This was the main objective of the EVA, trying to add further information about tether dynamics to what was already known and to discover just how well an astronaut with a maneuvering device – and later just the tether – could control himself. He explained that he was more concerned with movement in pitch and yaw rather than roll as he evaluated moving from point A to point B, as pointing in the right direction was more important to future EVA operations.

With the film stopped at this point, White added a few more comments on his EVA. "Prior to going out, I thought 'What do you say to 194 million people when you are looking down at them from space?' This flashed through my head when I got out and I thought about it before they cautioned me that I was going to be on live radio, on live TV, and I honestly couldn't think of what I really should say. The solution became very obvious to me as I stepped out. I said 'They don't want me to talk to them from up here. They want to hear what we are doing up here while we are actually going through the mission.' So what you heard were two test pilots conducting their mission in the best manner possible... And the last thing I'd like to say is that the view from up there is just spectacular."

The astronauts thought that describing the orbit phase sequentially would be "almost a hopeless task," so instead they decided just to go over some of the things that had been learned from it. "The first thing that we learned," McDivitt reported, "was that the Gemini is a livable spacecraft for at least four days. We had an awful lot of equipment in the spacecraft [and] it took a lot of ingenuity or housekeeping to try and keep it all stowed. I think it took about three hours to decide what we were going to do with everything after we got it out, but we finally got it put away and we proceeded on with our experiments that we were going to perform. I think… the big thing that we found was [that] just eating and sleeping and staying alive up in space was just as big a task up there as it was down here. It took a lot of time to do this. We were able to take, I think, a lot of good photographs. The first few hours, possibly 20 or so hours, we were able to make certain observations, but the real productive part of our flight came later."

McDivitt alluded to the difference between detailed flight planning and real-time flight planning, which was tried for the first time on Gemini 4. This formed part of studies into long-duration missions rather than for a specific experiment, he explained. "You know, it's easy to start out with a flight plan that tells you exactly what you've got to do throughout the whole flight, and we had one like that. It told us exactly what we were going to do. I don't think we did [though], except for about the first five minutes during launch. Then after that we had to make decisions as we went along, and I think this is where a lot of pre-planning by the people on the ground… really paid off... I think we really made a step forward in the real-time flight planning.”

McDivitt reported on the difficulty of sleeping in the early stages of the flight due to the radio noise. “I think that Ed and I not only spent four days in orbit, we spent four days awake. It really wasn’t that bad, but I was a little sleepy…” Ed White added: “He wasn’t awake all of the time, I can guarantee you that, and neither was I.”

“But one thing we managed to prove,” McDivitt continued, “is that we could eat as much in space as we can on the ground… We did get all our experiments done and I think that we learned a lot from this orbit phase. As you know, our computer failed about 20 hours before retro… We never were able to get the computer back online, but people on the ground and Ed and I in the air discussed the technique we had to use to come down. We had gone through this many times before on the ground, so it wasn’t a big surprise once we all arrived at a mutually satisfactory agreement. I saw the retro rockets, it was just as smooth as could be. At retrofire, we had all four of our rockets just exactly the way [we] should have and it was very nice feeling. We knew we were coming down.

“One of the real major portions of this flight was the medical data that could be learned from four days of weightlessness. I know that there was a lot of controversy before the flight about whether or not we would be able to take care of ourselves when we landed, and although Ed and I were convinced that we would be, there were enough doubting Thomases... When I was over in Korea, I learned that the best way to survive was to get rescued early. I wanted to tell them to rescue me early. As a matter of fact, I think I called that out to Gus on the way down. He told me that he would have a helicopter over us in five minutes.”

Having detailed all the important elements of their mission, the first questions the astronauts were asked concerned the smeared window, but there was little to report at this stage. The astronauts said they had taken some pictures but they were still under evaluation. White was then asked about his reluctance to come back in at the end of the EVA.

“Well, I can tell you in all sincerity and honesty that I enjoyed the EVA very much,” replied White. “ I thought it was a wonderful opportunity to represent the people of our country in this endeavor and I can also tell you honestly, I was sorry to see it draw to a close. I suppose personally I was reluctant to come in, but when the word came out that this phase of the mission was over, I knew it was time to come in and this is when I started in.” There was a sequence of things he had to do before coming in, but he knew that when the Flight Director requested his return to the hatch, this phase of the mission was done. White was then asked if he had experienced any sensation of falling during the EVA.

"There was absolutely no sensation of falling [and] there was very little sensation of speed," he said.

The next question related to the lost EVA glove and the problem with the hatch closure. "The glove was a fairly interesting thing [to occur]," White observed. "I had planned to use my gloves initially, but we had also processed [that] the heat loads that those gloves were designed to protect me against would not be any problem initially, because we were just coming out of the night side. So I decided to go ahead and do the work I had to do outside the spacecraft with my gloves off. I thought I could do it more efficiently and quickly, so I took the gloves off, did the work I had to do and asked Jim [to] pass me out my left glove. He handed me out my left glove and I put it on. He asked me as I went out if I wanted my right glove and I said 'No, I'll use the gun and equipment. I think I can use it more effectively without the glove on my right hand.' I think this was the last that we had the opportunity to do much control on the glove because shortly thereafter, while I was out, I looked over my shoulder to my left and… there was my glove floating off into space. There just seems to be a bit of a flow out of the spacecraft of air from the Environmental Control System. The glove got caught in this flow and just drifted right out of the hatch and started drifting right off into space.

"You ask me in the last part of the question to relate the glove to the hatch problem that we had at the end. I think I can say it was a hatch malfunction at the end. We had planned several ways that we knew to close the hatch. The normal method of closing it was for me to hold onto a canvas strap and to use a large lever and ratchet to latch down. Well, when we got back in, I found out that the lever was turning free and it wasn't actually ratcheting the hatch down. We had [this] problem demonstrated to us before and we knew what the trouble was. It was one of the little levers that had to be fed so that the gears were set and would actually take up as you pull on the handle. I had to actually act as a little spring in there. I had to go back with my right hand to operate the lever, reach forward and operate the big handle. I had one more buddy with me, and he had to actually operate with me on the bar and the lanyard to apply the force to close the hatch. So I think if we had one period in this flight where teamwork really paid off, more so than any other time, this was the time it did, because as I pointed out, I actuated one lever with my left hand, the other with my right hand and Jim pulled like the devil on the handle. Between the two of us, we got into the proper sequence we knew we [needed] to get into to close the hatch, and this is the manner we closed the hatch.

"This didn't come as a bolt out of the blue. We were familiar with this mode of failure. We had a method of operations so that if this did occur, we knew what to do about it and this is exactly what we did do. I am not going say that my to do about it and this is exactly what we did do. I am not going say that my pulse didn’t go up when that handle turned freely because I’m already convicted. Chuck [Mathews] already has the data up here on the ground and he told me it went up a tad.”

McDivitt added that this was one of the reasons for such a long preparation time for the crew, to cover every eventuality they could prior to the flight, though he acknowledged that it was impossible to train for everything. White added a note about the immense teamwork of the ground staff and contractors, each adding their own contribution to the broader flight plan.

Turning to the longer duration, the next reporter asked whether, from their experience of four days in Gemini, they now thought it would be possible to spend 12 or 14 days in the spacecraft and work effectively, and whether either of them would be willing to fly that type of mission.

McDivitt replied “Yes, I think it would be possible for a man to do this. I think the things that we learned… are that we have got to rearrange our work rota cycle a little differently than what we had planned. I think if we start out like this, the man will be rested. I think there is enough room in the spacecraft to do this. We came back without a single pressure point on our body [from] our pressure suits. I think this was pretty interesting. If you saw, we didn’t have any effects of our weightlessness. Maybe a longer duration might, but I don’t think so. We’ve got to provide sufficient food and water and respect people in space the same way we do on the ground. I don’t think there should be any problems and I would be willing to do it.”

White added that after about 4–5 hours, if he hadn’t taken a meal, he felt like he slowed down a little, which was more pronounced than when he got hungry on Earth. After eating, his energy level “went right back up to the level that it had been prior to the time that I had run out of gas from lack of food. The point that I’m making is that we can go on long-duration flights, but I think we have to be sure that we provide adequate food… Food was very, very important.”

At this point, McDivitt was then asked about the ‘unidentified’ objects they reported seeing during the mission. “I saw three things that looked to me they were like satellites of the Earth,” he replied. He explained what he had seen, at what time in the mission, and that he had tried to take pictures. “The only one that I could even define the shape of at all was the first one and it looked like an upper stage of a booster. If I had to classify it as a known object, I would classify it as that. But I really didn’t see enough of it to say for sure what it was.”

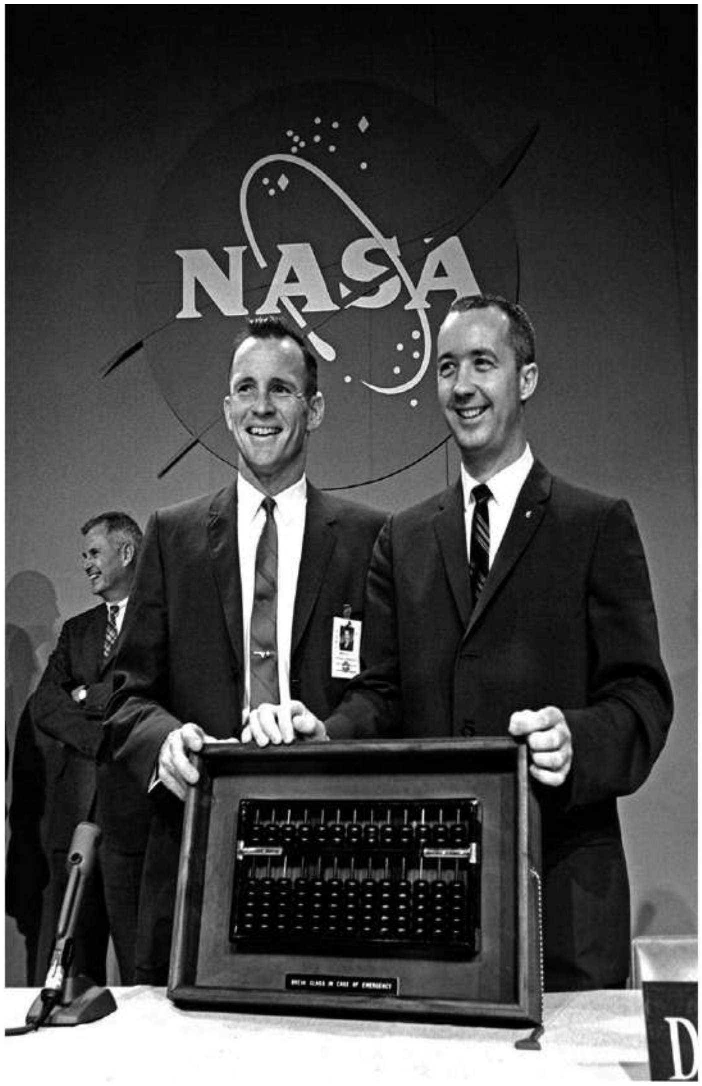
There had been a lot of discussion prior to the mission about how well a man in space could distinguish objects on Earth. The astronauts were asked what the smallest size objects were that they could pick out. White was quite surprised to find how much he could see with just the naked eye on orbit. “I could look at the find how much he could see with just the naked eye on orbit. "I could look at the cities both in the day and the night. I could see what I thought was much greater detail than I could [from] flying an aircraft at 40,000 feet. I also felt that I wasn't looking down and picking out the individual buildings or this type of thing. When you see a city, you see the outline and the details, and you can see the roads and the sea. You can see [where the ships are because] you could see the wake very clearly, and if you use your imagination, I suppose, you could almost see the ship, but I can't honestly say that I saw the ship… At night, I was quite impressed with the clarity. You could see the lights outlining the city when the atmosphere was clear. I went over a city in Australia, I believe it was Sydney, on one night [and] it was very, very clear. I looked down and it looked like almost fine strings of light where the street lights and the roads were lighted. It was like a spider web of lights, much clearer in detail than I could see in the normal night… I did specifically try to observe items. The area that I think I looked at closest was Texas. As I came over it, Jim called out and said 'I think we are over Texas' and then he said 'As a matter of fact, I believe we are over Houston.' At that time, I was in a position that I could look down and I saw the Gulf and… into the Clearway, Clear Lake. I could see the outline of the small lakes down there very clearly [but] I didn't take time to look for the Manned Spacecraft Center. I think if I had looked for the Center, taken the time to focus down there, I believe I could have seen objects of this size very clearly. The thing that impressed me was the clarity with which you could see objects down there. We looked down at roads, you could see airfields, you could see the runway outlines very clearly. I was very impressed with it."

Jim McDivitt added: "I think one thing that's very important was the contrast between the thing you are looking at and the surrounding terrain, and how long features tend to stand out better than square ones. If you saw an obstacle of a given width, if it was very long you would be able to see it. If it was the same length as it was wide, I don't think you would be able to see it nearly as well. Quite often, as we would go into the sunset or come out of a sunrise, we would get one window with the light shining on it and the other window facing the dark side, and you couldn't see a thing out of the light side window but out of the dark side you could see all of the stars. It was just like looking at two different worlds, like somebody had drawn a line right through the middle of the spacecraft. One side was in pitch darkness [and] you could see all the stars, and the other side you could see the horizon turning bright blue but no stars whatsoever. It was very interesting."

Next, the astronauts were asked about their time spent on the water after four days of microgravity and their activities in getting out of the spacecraft following splashdown. McDivitt replied "I didn't have any trouble. I following splashdown. McDivitt replied "I didn't have any trouble. I disconnected myself from the spacecraft after I had opened the hatch, which weighs a considerable amount, and disconnected all my leads. I had my neck dam on and my gloves on so my suit was watertight. I inflated my Mae West and I jumped over the back end into the life raft. So I wasn't having any trouble at all."

Then White responded to the question. "When we got down on the water, the best jump I made was out of the spacecraft and into the life raft. I didn't feel any discomfort. I had a wave of nausea for about 15 seconds while I was in the spacecraft, about 10 minutes after I landed [which he attributed to the movement of the spacecraft in the water]. In fact, I was quite surprised just how good I felt after that [nausea] was gone."

Following a few more questions related to the EVA, the press conference ended, but not before the two astronauts were presented with a 'gift' in the form of a 'computer', as their computer had broken during the flight. This was actually an abacus, the ancient Chinese device that could be used to complete mathematical calculations. But the day was not over for the astronauts, as an important guest was to visit the MSC that afternoon.



Following the official Gemini 4 post-flight crew press conference, reporters presented the astronauts with a humorous gift of an abacus, because of the computer problems during their flight [Courtesy Ed Hengeveld].

President Johnson Visits the MSC

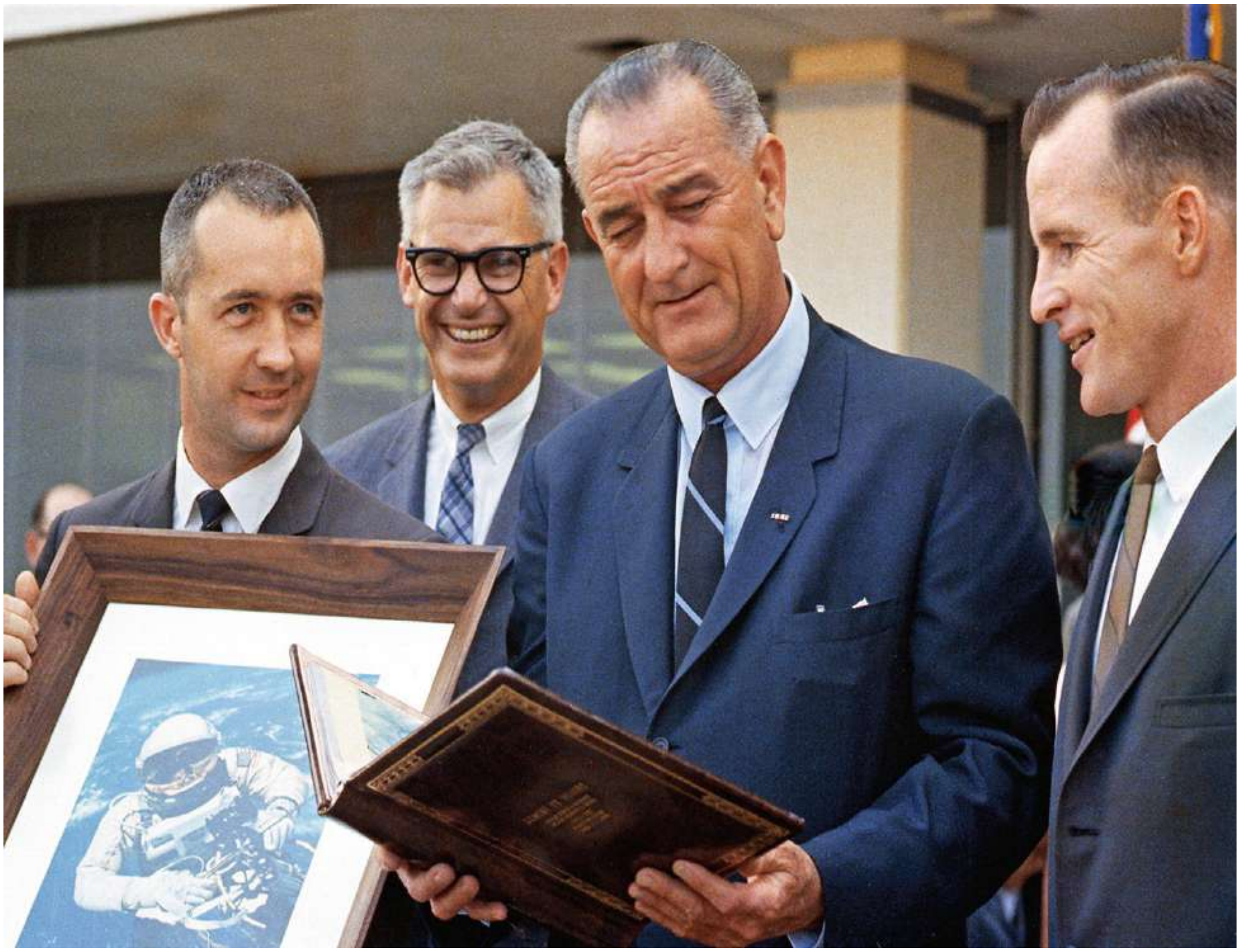
Friday June 11: Houston

Following the recovery of the astronauts on June 7, President Johnson had invited the crew, their wives and families to the 800-acre (324-hectare) ranch known as the ‘Texas White House’, close to Johnson City in the Texas hill country near San Antonio, to present them with a token of the country’s esteem and respect. However, it was reported that both astronauts felt such a ceremony would focus too much on them and not on the vast army of workers who made each flight possible. Therefore, the astronauts declined the invitation and would instead visit the White House in Washington with their families a few days later.

Instead, President Johnson decided to honor the staff of the relatively new Manned Spacecraft Center at Clear Lake, near Houston [7].

At the MSC, the President addressed a crowd estimated to be almost 5,000 employees of NASA and its contractors, standing outside Building 30 (Mission Control) in the humid 90 degree heat of a Texan afternoon. He praised the dedication shown in the success of America's most historic peacetime adventure and the personal modesty and humility each astronaut had shown on their return: "I have yet to meet a man who has not come down from space wanting to give more credit to all the men and women on the ground than he would accept for himself up there," the President proclaimed. He announced that he was nominating Air Force Majors McDivitt and White for promotion to the rank of Lieutenant Colonel "for their spectacular achievements on behalf of all the people of their country and the free world." In the same speech, the President announced that Mercury 9 astronaut Major Gordon Cooper, currently in training to Command Gemini 5 in two months' time, would be promoted to the rank of Lieutenant Colonel effective July 15, and that Mercury 4 and Gemini 3 astronaut Virgil 'Gus' Grissom was to be promoted to the same rank. President Johnson also noted that "the joy and the thrill and the exhilaration that Ed White experienced in his 'walk' from the Pacific Ocean to the Atlantic ran though the veins of us all. Our attitudes about space will never entirely be the same again."

The President added his hope that the promise of "this great adventure," which all those gathered at MSC shared "would not be lost upon mankind." He then went on to admit that "Only a few years ago, this great nation was unmistakably behind in space. Abroad and at home, some prophesied that America would remain behind, that our system had failed, that the brightness of our future had dimmed and would grow darker. But no such prophecies are heard today." Clearly targeting the recent successes in space by the Soviet Union, he commented that by "openly admitting failures, openly sharing and offering to share our success, America would proceed with the determination that burns in the hearts of men who love liberty… All that we have accomplished in space, all that we may accomplish in days and years to come, we stand ready to share for the benefit of all mankind." He closed by emphasizing a global effort for peace and a determination and the resources to see the labors through.



President Lyndon B. Johnson holds a Gemini 4 souvenir photo album presented to him during his visit to the MSC. Left to right: James A. McDivitt (holding a framed picture of White's EVA, also given to the President); Dr. Robert C. Seamans Jr., NASA Associate Administrator; President Johnson; and Edward H. White II [Courtesy Ed Hengeveld].

Saturday June 12 and Sunday June 13: Houston

The astronauts spent a quiet weekend relaxing with their families, having no official engagements until later on the Sunday, when McDivitt, White and their wives were guests of honor at a Houston Chamber of Commerce dinner. This was to be the start of a very busy week for the astronauts and their families. Having spent four days together inside the small Gemini crew compartment seeing no one but each other, the two astronauts were about to experience post-flight life as America's latest pioneering heroes.

Monday June 14: Chicago

The following day, while their children remained in Houston, the astronauts, their wives and parents flew to Chicago in a NASA aircraft. Waiting to greet them were a crowd of 2,000, mostly children, who burst into cheer when the two them were a crowd of 2,000, mostly children, who burst into cheer when the two astronauts emerged from the plane. There had been a demonstration planned to protest against the segregation in U.S. schools, but civil rights leaders postponed the march until after the celebrations for the Gemini 4 astronauts.

Following a brief greeting from the 38th Mayor of Chicago Richard J. Daley, the 33rd Governor of Illinois Otto Kerner and Vice President Hubert Humphrey, the astronauts and their entourage boarded a fleet of open-top cars for the drive down the Kennedy Expressway towards City Hall. “More than a million persons thronged the sidewalks, perched on lampposts and cheered and waved from every vantage point,” wrote Robert Wiedrich in the *Chicago Tribune* of June 15 [8]. Estimates gave a figure closer to two million, packed into the streets and waving from buildings and rooftops as the parade passed by. At several points, policemen locked arms to hold back the crowds, who were taking pictures and waving Stars and Stripes flags and homemade placards. The *Tribute* reporter wrote “It was incredible, and more, it was tumultuous. It was a genuine display of admiration as could be mustered for two young men who had demonstrated great courage in the vastness of outer space.”

All along the route, enthusiastic crowds waved and cheered the astronauts, their families and dignitaries, leading Vice President Humphrey to consider that McDivitt and White would be wonderful representatives at the International Air Show which had just opened in Paris, France. He later proposed the idea to President Johnson, who initially rejected it until he began to receive less-than-flattering reports from the U.S. pavilion at the Air Show and decided to re-examine the option [9].

As the convoy passed the Loop expressway, cars halted and drivers and passengers left their vehicles to cheer the parade as they passed. Other drivers sounded their horns in salute. Later at the Civic Hall, Ed White said “I just saw a display of plain Americanism. I saw the crowds on your streets and it didn’t matter if they were black, red or white. They were just Americans, feeling like Americans.” This got the audience to their feet, particularly when he concluded “I almost felt like cheering myself.”

In total, it was estimated that over two million people had indeed crowded the city to view the astronauts during the day. This had been the largest welcome in the history of the city, clearly surpassing the previous record crowd from July 1959, when Queen Elizabeth II of the United Kingdom had visited. Of course, this meant that progress was slow for the procession, which was forced to stop several times only to be cheered and greeted even more by the masses. At City Hall, Mayor Daley presented the astronauts with medallions and conferred on them Honorary Citizenship of the City of Chicago, together with NASA Deputy Administrator Dr. George Mueller and Gemini Program Manager Charles

Administrator Dr. George Mueller and Gemini Program Manager Charles Mathews. Despite a formal resolution honoring the event, everyone was so caught up with the celebrations that the council actually forgot to vote formally on the matter. As well as the astronauts, both their wives and their parents were also feted and introduced during the festivities.

Lunch was held at the Sherman House Hotel across the road from City Hall, and this was followed by a series of questions from youngsters in the Arie Crown Theatre, McCormick Place, who also viewed a 20-minute color film of the mission. As the author has personally experienced when facing open questions from a young audience, some of them can be tricky to answer. The two astronauts experienced this challenge themselves. In all, twenty questions were asked, but one of them in particular made the papers from that event. A 14-year-old female student asked if there were enough qualified men to handle the spaceflights. McDivitt naturally paused before answering, trying to be diplomatic, before stating “Any answer I give will get me in trouble, but yes I think there are enough qualified men to do the job.” When asked if the addition of women to the program would be beneficial, he reportedly replied “[that] could create a lot of problems,” trying to lighten the response. But though half the audience, the boys, raised a cheer, most of the girls remained silent, though no-one seemed offended by the off-the-cuff remark. McDivitt quickly added “There are a lot of women in the program. They don’t have to be ‘astronettes’. There are a lot of other things that can be done by women.” On the other side of the podium, Ed White could be seen smiling broadly as his commander tried to recover the situation.

The two astronauts walked down the sides of the rows of students, picking questions at random from hands raised. One questioner asked about the difference in the two suits worn by the astronauts. White said “I had a spacesuit with 20 layers of material so it could withstand temperatures from 200 degrees heat to minus 200 degrees. I also had felt in the suit. I was struck by a micrometeorite, but it did not go through.” White was also asked about the religious connotations of the medallions he had worn around his neck[4]. “It signified the great faith I had in the equipment, myself and my God. I felt it wasn’t necessary that an individual had to be a Catholic, a Methodist, or a Jew. What I had going for me was my great faith. The medals were a simple way to express it,” he replied.

Later, when the astronauts arrived at the Drake Hotel where they were staying overnight, they were greeted by a crowd of 2,000 and had to shake scores of hands of enthusiastic onlookers just to enter the hotel lobby. That evening there were no formal functions scheduled, so the astronauts and their families were free to make their own arrangements. The McDivitts stayed in the hotel and held a private dinner in the International Club for 25 members of the Chicago McDivitt clan, where they watched a WGN-TV show, *Salute to the Astronauts*, and later the first part of the Houston Astrojets vs. Chicago Cubs baseball game. Ed White and his wife dined in the Mid-America Club in the Prudential Building, together with NASA officials, while his parents remained in the Drake Hotel and dined quietly. The busy day ended with Mayor Daley joining the astronauts and their families to view a firework display from the rooftop of the Furniture Mart building. The day's events had touched both astronauts, with the crowds making an impression on McDivitt, reminding him "that we were just a speck in space, and when we came back, it was a large ocean and we were just a small speck in it." It reinforced his feeling of "how insignificant one man or two men are." White commented on the number of young people in the crowds. "These are the people who will be governing our country in the future," he said, hoping that the benefits from the space program would become most evident to them in future years [10].

Reassigning America's Position in Space

"The success of Gemini 4 should prompt a reassignment of the position of the United States in the perceived race to the Moon with the Soviets," according to the June 14, 1965 issue of *U.S. News and World Report*. The report suggested that the self-propelled EVA by White and McDivitt's ability to move the Gemini spacecraft in orbit had clearly "put the U.S. ahead in at least two key areas and gave the U.S. a fighting chance… to overtake the Russians in the race to the Moon." In addition, the military implication of the mission was not lost in their assessment. Having mastered spacecraft maneuverability, the report suggested that "the region just above the Earth – the inner space belt – could soon become vital to American security." [11]

In the *New York Times* editorial for June 14, Harry Schwartz pointed out the potential for significant cost savings if both the U.S. and USSR pooled their resources in the quest for the Moon and Mars, and that, from the experiences gained, this might "reduce the number of Gemini-type flights each would have to engage in." In this, he meant the number of flights that would be needed to master the techniques of orbital rendezvous, long-duration spaceflight and EVA, by perhaps "sending mixed crews [from the U.S. and USSR] on major missions. Such a move may alleviate the vast amount of resources and money being spent on the formation of armed space fleets," he wrote.

Tuesday June 15: University of Michigan, Ann Arbor, Michigan.

It was an early start for both families, as they left their hotel at 07:15 for O'Hare International Airport. They flew to Willow Run Airport, near Ypsilanti, Michigan, for another day of receptions and accolades, this time at the University of Michigan (U-M), Ann Arbor. Greeting the party were Governor Romney; Harlan Hatcher, President of the University; Dr. Melvin L. Niehuss, U-M Executive Vice President; Ann Arbor Mayor Wendell Hulcher; and a number of other notable persons [12]. Once again, a warm welcome greeted the astronauts, their wives and parents, as several hundred were waiting to greet them at the airport. From there, the motorcade went directly to the University stadium, witnessed by an estimated 30,000 people along the way, where both astronauts, former graduates of the University, received honorary Doctor of Astronautical Science degrees from Mr. Hatcher.

Yet another full program of speeches and receptions lay ahead of them, including the dedication of the NASA research laboratory at the University, for which the astronauts sported their full academic robes [13]. Such was the response to attend the event that the venue had to be changed to accommodate the growing audience. The honor bestowed on both astronauts was the first ever bestowed by any U.S. university at a public ceremony.

McDivitt told the audience at the ceremony that it was "really wonderful to be back in my home state of Michigan." Clearly choked with emotion, the astronaut added "The last few days of my life are days I will never forget. Today is nothing short of magnificent." Reflecting on the days when he was a student at the university, only a few years earlier, McDivitt said that he could only accept the honor on behalf of all those who worked behind the scenes in the space program. Ed White also recalled his days at the university in accepting his honor, reflecting on how strange the past few days had been, and how he was still trying to get used to being addressed as Colonel by those he met.

Later, the astronauts participated in the dedication of the new $1.75 m (1965$) U-M Space Research Building on the North campus, where the principle speaker was Dr. Floyd L. Thompson, Director of NASA's Langley Research Center. The new facility would house 67 space-related research projects, supported by contracts and a $6.2 m grant. Once again there was a good turnout, estimated at 1,000, to witness McDivitt and White formally cut the ribbon to open the facility.

At a luncheon for 525 in the Michigan Union building, attended by national, state and local officials as well as space officials and newsmen, they again showed the film of the flight. By now both men were in good humor, with McDivitt asking White to move to his right as he narrated so that McDivitt could view the footage. "I've never seen this from any other angle," McDivitt joked, referring to his restricted position inside Gemini 4 when viewing the event for real a few days earlier. As the film progressed to White standing in the hatchway at the start of the EVA, McDivitt joked “Actually, he would not get off and I’m shaking the spacecraft to get rid of him,” which raised laughter, with White adding “and I’m saying, ‘Don’t push! Don’t push!’” [14]

The astronauts then had a two-hour respite, before attending a reception at the U-M aeronautical and astronautical engineering department at the Barton Hill Country Club. While there, Ed White got a surprise as he was reunited with his ‘aunt’, Mrs. Robert Foley Smith, the wife of the publisher of the Dearborne Press and a long term friend of the astronaut’s family [15]. Robert F. Smith and Ed White’s father, Major General Edward H. White Snr., had been both roommates and classmates at West Point Military Academy in 1924. Coincidently, their sons, Ed White II and John D. Smith (at the time a major serving with the U.S. Army in Vietnam) were then also room and classmates at the same Academy in 1952. Mrs. Smith was the next best thing to a real aunt, as the young Ed White, his mother and siblings stayed at the Smiths’ summer cottage at Saugatuck during the WWII years, while his father, then a captain, flew “the Hump” in the China-India-Burma theater[5].

After the reception, the party returned to Willow Run Airport to take flights for the next stage of their post-flight tours, notably to San Antonio, Texas for White and his family, and to Jackson, Michigan for the McDivitts. White later sent a letter of thanks to the Mayor and citizens of Ann Arbor for their warm welcome, reflected in the commemorative ‘miniature corner lamppost’ both astronauts were presented with. During their visit, the northwest corner of the Intersection, in front of the College of Engineering Western Building and its ‘Engine Arch’, was renamed the “James McDivitt-Edward White Corner.” White recalled that particular corner in Ann Arbor from his youth, where he had “spent many hours in Ulrich’s bookstore and at the little coffee shops down the street.” [16]

On the day the Gemini astronauts toured Ann Arbor, the *New York Times* reported on a speech made by Dr. George E. Mueller, NASA’s Associate Administrator for Manned Spaceflight, at the National Space Club in Washington D.C. the previous evening [17]. Mueller emphasized that it would be an error of judgment to suggest that the U.S. had somehow overcome the lead in space built up over several years by the Soviet Union, and that it would take the United States “a great deal of effort” over a number of years to secure first place in space. He also noted that although the final medical reports on the mission would not be completed until August, the most important result from Gemini 4 had been the satisfactory condition of McDivitt and White upon their return to Earth.

Wednesday June 16: Jim McDivitt Home Town Visit, Jackson, Michigan

On their ninth wedding anniversary, Jim and Pat McDivitt traveled one-and-a-half miles on a parade in their honor, with the streets lined by well-wishers seven or eight deep to welcome the astronaut back to his home town of Jackson. It was estimated that the crowd numbered 125–150,000 people, the largest in Jackson's history, bearing signs such as 'Happy Anniversary' and 'By Gemini You Did It'. Streamers, confetti and balloons floated down, covering the cars, occupants, streets and crowds.

During luncheon with 1,500 guests, parade chairman John Elwood presented McDivitt with a gold windshield wiper to use "if another man walking in space should dirty your windshield." Clearly hoping to return to space soon, McDivitt replied "If I just had another spacecraft to use it on," noting that he was probably the only man in the world to have received a golden windshield wiper on his wedding anniversary [18].

In the afternoon, the family visited Jackson Junior College, from which McDivitt had graduated fifteen years earlier, to speak to the 120-strong graduation class of 1965 from both of Jackson's public high schools. The astronaut told them "From space successes, men everywhere can draw courage to attack other so-called problems. If men are ingenious enough to go to the Moon, he may be inspired to find the way to lasting world peace and the means to eliminate diseases, hunger, poverty and ignorance."

The stop at Jackson gave the McDivitts some family time. Due to all the post-flight debriefings and festivities, the wider McDivitt family had not had chance to catch up with their famous relation, but in Jackson they had that opportunity. His father, James Snr., commented that he now did not know whether to call his son Doctor, Colonel or Jim, but his mother, Margaret, reminded him that "he is still little Jimmy to me." James McDivitt Senior said it would take about three weeks for them to rest up after all the celebrations, and added "Anyone who thinks it isn't a grind to have an astronaut as a son is crazy. Don't even try it. The schedule changes every half-hour." [19] Little did McDivitt and his wife know that his father's comment about a constantly changing schedule would be a prophetic one, as they headed for Washington D.C.

Wednesday June 16: Ed White Home Town Visit, San Antonio, Texas

With City and State officials in attendance, including Mayor Walter W. McAllister Snr., there was a red carpet welcome for the Whites as they arrived in San Antonio for a six-hour whirlwind visit. An estimated crowd of 150–170,000 greeted and cheered the astronaut, his wife, children and parents, who were accompanied by VP Hubert Humphrey. The crowd enthusiastically displayed banners along the 15-mile route from the airport to downtown San Antonio and the historic site of the Alamo Mission. Once more showered in a rain of confetti and streamers, and immensely proud of his Texan heritage, especially of having the honor of being the first Texan in space, Ed White commented that during his EVA, he had "stepped lightly over Texas."

He said that it was "wonderful to be back in San Antonio, which gave me a good start when I was launched [meaning born] at Fort Sam Houston and started me on my way." Reflecting on the support of the nation for the space program, White said that the astronauts were merely representatives of all Americans, without whom events such as those accomplished on Gemini 4 would not have been possible. "Without you, we can't go," he explained [20].

Later, the Whites attended a sold-out dinner in the Valletta Assembly Hall, where once again the astronaut proudly showed the film of his daring exploits. Showered with praise and honors, it was a memorable day for the popular Ed White, who stopped several times to shake hands with onlookers and supporters.

In yet another packed day, the astronaut and his family also visited Fort Sam Houston and Brooks AFB, where he returned to the School of Aerospace Medicine, the site of the medicals he had undergone for entry into the astronaut program three years previously. As the day's festivities ended, the family then flew via Langley AFB to Washington D.C., as guests of President Johnson [21].

A Maturing NASA

On the same day the astronauts were visiting their home towns, NASA Administrator Jim Webb was testifying to a Senate Appropriations Committee Subcommittee hearing on the NASA FY 1966 budget. Webb stated that the first two manned Gemini missions had verified the overall system for manned flights, had demonstrated the capability of the Gemini spacecraft and the capability of an astronaut to operate outside of his spacecraft, and had proven the ground network of launch tracking, communications and control. In addition, they had provided initial tests of systems and procedures intended to be used in forthcoming rendezvous and docking missions. "They also served as an orbiting laboratory, with several experiments included on both flights," he said.

As the Gemini 4 astronauts headed for Washington, Congress sanctioned President Johnson's $5.2 billion space authorization bill, of which over half was

President Johnson's $5.2 billion space authorization bill, of which over half was planned for project Apollo and the effort to land Americans on the Moon by 1970.

Writing in the *Washington Evening Star*, William Hines noted a new "Coming of Age in Houston" and that there was a "new, mature outlook at NASA." [22] There was a conscious effort to deglamorize, but not depersonalize the astronauts, and an attempt to focus more on the mission and not the celebratory status of the crew, starting with Gemini 4. According to Hines, this was partly due to not giving the Gemini 4 spacecraft a personality by naming the vessel, as the Gemini 3 crew had done with *Molly Brown*. Another factor was the astronauts' decision not to attend the Presidential ranch so soon after their mission, deciding instead to continue their debriefing and go on a number of public tours before visiting the President in the White House a full ten days after they had splashed down at the end of their mission.

Hines wrote "The determination of NASA to rid itself of what's been called the 'Hollywood syndrome' and handle spaceflights as transcendental news events instead of tawdry theatrical productions did not come easily, or without prodding from the outside. But once the decisions had been made not to try any longer to fool all the people all the time, a new era in the public's understanding of space dawned." Not that the astronauts, flight controllers or space workers would term their activities as "tawdry theatrical productions" or even "transcendental news events," but there was certainly a change in the presentation of post-flight reporting, even though the astronauts' heavily edited so-called 'personal stories' were still being serialized in *Life* magazine.

The following day (June 17), James Webb gave a briefing to President Johnson and the Cabinet in session on the success of the two previous Gemini missions and the future plans for the series. Webb said that Gemini 3 and Gemini 4 had "proved the design and confirmed the results of ground tests," which in turn had increased confidence in the overall Gemini system to a point where NASA had advanced the Gemini objective of rendezvous and docking to the second half of the year (1965).

Christopher Columbuses of the 20th Century

Thursday June 17: Washington D.C.

At the White House, where it was planned that the astronauts and their families would stay overnight, President Johnson proclaimed that their flight had "closed the gap in manned spaceflight," without naming the Soviets directly but clearly indicating that the United States no longer trailed in manned flight achievements. Though breaking records was not a priority at NASA, the one target the Soviets

Though breaking records was not a priority at NASA, the one target the Soviets held that many at NASA desired to surpass was the five-day flight of Valery Bykovsky in Vostok 5. This was soon to be challenged by Gemini 5 in two months' time, under the objective of simulating a week-long Apollo lunar flight. Matching the achievement of Bykovsky's colleague Valentina Tereshkova in Vostok 6 (by sending the first American female into space) was quietly overlooked as there were no female astronauts in the program, something that would take another 13 years to rectify and a further five years to reach fruition, with the 1983 Shuttle flight by Sally Ride.

After bestowing praise on the current direction of NASA under the leadership of Jim Webb, the President stated "In terms of our national goals of leadership in space, it can be said that the brilliant performance of both spacecraft and crew on the flight of Gemini 4, together with the progress on our Apollo program, clearly indicate that the United States of America has closed the gap in manned spaceflight. But I believe Gemini 4 has done more than that. Your successful mission has raised hopes – at home and abroad – that the day may now be much nearer when the entire world can enjoy the benefits of close cooperation among all nations in exploring and using space for the common good and for the peaceful interest of all mankind." The President also recalled the message the astronauts had received from Major Yuri A. Gagarin shortly after they landed, who had expressed hope that all spaceflights may serve the world and benefit all mankind, and noted how America very much welcomed that expression.

The President called the astronauts "the Christopher Columbuses of the 20th Century." Without wishing to place too much pressure on McDivitt and White, the President called them "symbols of a new world. You are symbols of a new horizon… of a new potential, not just for yourself or your country but for three billion human beings everywhere." This type of endorsement, which is now known as 'spin', metaphorically rocketed the previously unknown McDivitt, White and the rest of the Astronaut Corps straight into the world's spotlight, for which many were unprepared having come from the classified, secretive nature of the military at the height of the Cold War. This was a very different playing field and one which NASA initially found difficult to prepare the individual astronauts for. For the astronauts and their families, dealing with life and celebrity status after a spaceflight was something of a culture shock [23].

The visit to the White House was followed by yet another motorcade, this time up Pennsylvania Avenue to visit both Houses of Congress. Here, the astronauts were presented with flags which had flown in front of the East and West wings of the Capitol during their flight. That evening, the astronauts were honored guests at a State Department dinner. They once again showed the 20-

honored guests at a State Department dinner. They once again showed the 20 minute film of their mission, this time to an assembly of foreign diplomats and prior to President Johnson's arrival from the White House to give another planned speech.

Gagarin steals the show in Paris

As the events in Washington D.C. were taking place, on the other side of the Atlantic, the 26th International Air Show at Le Bourget, Paris, was underway. It had begun on June 10, the day the astronauts had flown home from Florida to Houston, and the Soviets were stealing the show. They were exhibiting the Ilyushin IL-62, a 186-passenger jet airliner powered by four huge 23,100-pound-thrust (102,754 N) engines; the M-110 crane helicopter, which had reportedly set a new world record the previous month by lifting 25 tons over 8,000 feet (2,438 m) into the air; the Antonov An-225, the world's largest aircraft; and an artist's sketch of the proposed Tupolev Tu-144 supersonic aircraft. And then there was the world's first man in space, cosmonaut Yuri A. Gagarin, and his Vostok spacecraft.

For the past week, President Johnson had been unhappily hearing reports and comments coming out of Paris about a lackluster American pavilion overshadowed by the highly popular Soviet hall, with Yuri Gagarin smiling and shaking hands with anyone who met him and handing out Vostok lapel pins. For several days, Johnson simmered as he tried to come up with a plan to upstage the Soviets. The solution seemed simple enough to him, recalling Vice President Humphrey's idea of dispatching astronauts to the Air Show. Why not send the Gemini 4 astronauts and their wives to capitalize on the success of their flight and the interest shown in the successful EVA, and steal the Soviet thunder?

During the State Department reception for the Gemini 4 astronauts, Johnson telephoned his old friend, NASA Administrator and fellow Texan Jim Webb, who was attending the reception, to propose the idea of sending the party to France on the Presidential plane, known as Air Force One, early the next morning. Webb was not convinced, worried that French President Charles de Gaulle would not take kindly to an uninvited visit of such prominence by American astronauts as the Air Show was a high-profile French event, even if it did have an 'international' flavor. Webb was also worried that the event might be seen as a publicity gimmick by the Americans, in light of Gagarin's presence, and would perhaps ruin the good publicity that the flight and the spacewalk had established in America and around the world. According to author Michael R. Beschloss, however, LBJ had an "almost childlike penchant for surprises" and told Webb "We don't give a damn." He wanted to put on a big show for the

United States [24]. Johnson was clearly under pressure from events in Vietnam and wanted to use the effect that the flight of Gemini 4 had had on Americans back home, with the public “standing in line [for] blocks to see our boys.” Johnson told Webb “We’re in such bad shape in the world. We ought to [use] everything we can,” citing the dozens of casualties being recorded over in Vietnam, which Johnson was ultimately responsible for as Commander-in-Chief.

Webb was still hesitant, stating that the astronauts needed to complete their debriefing before the next mission and that they were really tired after the flight and from the post-flight celebrations to date. But it was Webb’s next comment, “The Russians have upstaged us on almost everything,” which baulked Johnson. The President replied “They’ll keep upstaging us if we just put on a buffet supper in our own State Department, Jim.” Johnson then related the tragic news of the loss of a supersonic USAF B-578 Hustler jet that had crashed on landing at Le Bourget on July 15, as it arrived from Torrejon Air Base in Spain to participate in the Paris Air Show. The pilot, Lt. Col. Charles Q. Hobbs, USAF, was killed and two crewmembers injured. Johnson stated that he wanted to show the world some of the good that America was doing. There was an Asian-African conference pending and, according to Johnson, “They’re denouncing the hell out of us, and the UN is trying to screw us up.” Johnson told Webb that they could take Air Force One, which had room for everyone to stretch out and get some sleep. He told Webb to stop debating with him and that he would be over at the reception shortly.

Meanwhile, the astronauts were showing their film at the State Department dinner, but if they and their wives had thought they would be having a nice evening in the White House to relax before heading back to Houston, their President was about to announce that he had other plans for them.

“I am seldom accused of being at a loss for words,” announced President Johnson to the distinguished guests, “but I am sure all of you agree that there are no words that are really adequate to describe what we have just seen on that screen. I should like to say to you gentlemen [addressing the two astronauts] that if I had seen your films before I saw you last week in Houston, I might have made you full Colonels. It is so unusually fitting that we could view these films tonight in the company of our diplomats and their families… from every corner of the globe.” The President once again emphasized the need for peaceful exploration of space and for peace on Earth, and that there was no need for arms races or indeed for Moon races in a combined effort towards peace on Earth. “We of the United States are quite proud of this accomplishment by these fine young men and by all who are part of our space exploration team.” The President then dropped his bombshell, revealing his plans for sending the astronauts and their wives to France.

“This may not make me too popular with your families,” he explained, “but I am going to ask you tonight – in the very next few hours – to take the Presidential plane and travel outside this country again. Many people in many lands are thrilled by what you have done… I want you to join our delegation… at the Paris Air Show and share with them the excitement and thrills of your experience.” Vice President Hubert Humphrey and his wife, and NASA Administrator Jim Webb and his wife, would join them as representatives of the United States and the President emphasized that they would be travelling straight from this function. “You won’t travel quite as fast or nearly as far, but I hope you will enjoy your mission.” At this, Jim McDivitt and Ed White glanced at each other, amazed at what they had just heard. They would be off to Europe in a few hours [25]. Johnson hoped that in the current mood of negativity towards America, such a visit would provide a boost of good publicity for a change, if successful. With the Presidential seal of approval, the organization of the trip that would begin in the early hours of the following morning moved into high gear, with passports to be organized and documents to be secured.

In his book, former Air Force One pilot Jim Cross recalled that none of the trips he had flown or organized under President Johnson were routine. “His pace and personality made each flight indelible [on the memory],” Cross wrote, “and last minute changes were never unexpected. The human commotion was worse than any atmospheric turbulence.” Cross later recalled that this was one of his most memorable and enjoyable trips in Air Force One [26]. One of the first issues to overcome was more domestic than diplomatic, however. Upon hearing the news that they were to be sent to Paris that night, both Pat McDivitt and Pat White explained that they had nothing to wear, having planned for just a short trip to Washington. With the trip to Paris coming at short notice, and in the middle of the night, they had no time to shop. The First Lady, Ladybird Johnson, came up with a solution, in that her two daughters, Lynda Bird and Luci, had plenty of clothes back at the White House. The astronauts’ wives therefore returned to the private quarters in the White House and were duly kitted out for an impromptu trip to Paris [27].

Americans In Paris Meet a cosmonaut

Friday June 18: Washington to Paris

With passports and documents in hand, extra clothes borrowed and packed for the wives, but with the children staying in Washington, the party (which also included Gemini Program Manager Charles Mathews) left the White House lawn by helicopter in the middle of the night heading for Andrews AFB. Their children waved their goodbyes, chaperoned by the President's daughters dressed in their night clothes. Another astronaut would take the children back home the following day. It was all very surreal to the two astronauts and their wives.

Air Force One (a Boeing VC-137), piloted by Jim Cross, departed Andrews AFB at 04:00 EDT and crossed the Atlantic heading for France, with the passengers trying to get as much rest as possible but not really succeeding. The flight landed at Le Bourget Airport at 15:55 local time (10:55 EDT). They were met at Le Bourget by an estimated crowd of 15,000 people, despite the short notice of the visit. In his book, Cross wrote that he deliberately taxied Air Force One to park right next to the huge Soviet Antonov AN-225, which he described as his attempt at Cold War one-upmanship [28]. French President Charles de Gaulle was reportedly a little miffed that there had been so little warning of the visit (less than 12 hours) and was not at the airport to meet the astronauts and the delegation in person. Instead, he dispatched French Foreign Minister Maurice Couve de Murville as his personal representative, and sent an official from the French armed services as well. At the time, De Gaulle was on a speaking tour in the provinces, but he hoped to meet with the astronauts on the Sunday prior to their return to the United States[6] [29].

Following their arrival, the astronauts and the American officials met with top French air industry officials, including Bruno Vallieres, President of the French aerospace industry association, and attended a packed press conference at the airport before heading off to their hotel for a good night's rest.

Saturday June 19: Paris Air Show

The next day, the two astronauts toured the exhibits and aircraft displays at the show. Initially, the Russians had refused any suggestions that the astronauts would meet with Yuri Gagarin, but at the aerospace industry association luncheon, French Prime Minister Georges Pompidou had seated the astronauts side by side with the cosmonaut and soon all three were shaking hands and smiling broadly for the cameras as they were swamped by autograph seekers. McDivitt commented that this was "harder work than piloting Gemini 4 around the world." [30] The astronauts worked hard during their brief trip, with Cross calling them "real troopers" as both had really bad colds. They gave lectures, posed for pictures with Gagarin, appeared on French TV, and received so many phone calls during a radio show that the Paris telephone exchange promptly shut down, unable to cope. When asked if they were ready for another spaceflight, preferably to the Moon, McDivitt replied "We flew once together and would like to make our next flight together to the Moon." Ed White nodded in agreement.

Soviet cosmonaut and first man in space Yuri A. Gagarin (front left) shakes hands with NASA's Gemini 4 astronauts Edward H. White II and James A. McDivitt at the Paris Air Show in June 1965. Also shown in the picture are U.S. Vice President Hubert H. Humphrey (seated) and French Premier Georges Pompidou (standing).

In 1968, shortly after the tragic death of Gagarin on March 27 in an aircraft accident, McDivitt commented on his historic meeting with the world's first space explorer in Paris three years earlier. "We talked about pilot stuff, about how we'd hoped we'd get another flight. He seemed [like] just another pilot, down-to-earth, casual and friendly. It's like any exploration. You're not pitting yourself against an individual but against nature. There's competition sure, and everybody wants to be first, but we're all in the same business. We've seen things and had experiences which are similar – even photographs don't show it all, the continents spread out down there, or how you feel. So you think of another man who's been there and, well, there's a camaraderie." [31]

Sunday June 20: Return to the United States

On June 20, the Americans once again boarded Air Force One for the trip home, confident that they had done a good job on such short notice. On Monday, June 21, astronauts Jim McDivitt and Ed White reported for duty back at MSC, ready for new assignments, as their wives and families slowly returned to a 'normal' lifestyle. Preparations for the next mission began to occupy the headlines.

A Partial Recovery?

American aircraft manufacturers participating at Le Bourget felt that the U.S. had actually let the Soviet Union "steal the show," but had recovered lost ground with the last-minute appearance of McDivitt and White. They certainly gave the Russians some real competition, drawing large crowds wherever they appeared and prompting the French newspapers to pass the verdict that their last-minute appearance was "a partial recovery for the United States." McDivitt and White also seemed to have made an impression on Yuri Gagarin. Following his visit to the Paris Air Show, Gagarin said in a Soviet newspaper interview that he regretted not having a longer meeting with the two astronauts [32]. The world's media also reported that the Soviet Union had seemed to dominate the Paris International Show until the arrival of McDivitt and White.

In a report from one American exhibitor at the Paris Air Show, E.J. Stecker of Holex Inc., the general feeling was that initially "the Russians made us look like idiots." [33] Stecker conceded that "when White, McDivitt and the Vice President finally arrived, it was a triumphant tour surrounded by Secret Service, press, public relations and photographers… [but the] great unwashed public, including the exhibitors, were generally ignored and forgotten." [34] Clearly, there was more work to do.

MSC Technical Symposium

Discussion of the mission and its achievements was soon being shared outside the more formal post-flight debriefings and press conferences. On June 28, a two-hour technical symposium was organized to discuss the results of Gemini 4 and the Pegasus satellite program. Held in the Building 1 Auditorium, the symposium was open to MSC employees and contractor staff with appropriate security clearance and badging. The program included a presentation on the

Pegasus spacecraft by Dr. W. G. Johnson of the MSFC, followed by a second paper discussing the results from that program by Dr. Ernst Stuhlinger, also of the MSFC. This was followed by two papers on aspects of the Gemini 4 mission. The first covered the extravehicular spacesuit and was given by James V. Correale of the Crew Systems Division at the MSC. The second, by Harold J. Johnson of the Flight Crew Support Division, focused on the Hand-Held Maneuvering Unit. The session closed with a film about GT-4 entitled "*Astronaut White's Excursion in Space*."

The Wind-Down

With the major public tours completed, the formal phase of Gemini 4 was over and the focus now switched to post-flight analysis of the data and results. For the program, efforts were already turning towards final preparations for the next mission, Gemini 5, an even longer flight.

June

On June 10, three days after splashing down in the Atlantic, the computer that should have controlled the landing of Gemini 4 was returned to IBM for a series of tests designed to determine the cause of its failure [35]. Two weeks later, on June 22, it was reported that in the tests conducted under simulated orbital conditions to determine whether the problem experienced on Gemini 4 was in the Inertial Guidance System, the computer had worked well [36].

In a constantly evolving program, NASA announced management changes for future Gemini missions on June 25 [37]. Robert F. Thompson, formerly Chief of the Landing and Recovery Division, MSC, would now assume the role of Mission Director for the forthcoming Gemini missions, assigned to the Mission Operations Directorate, Office of Manned Spaceflight, NASA Headquarters, Washington D.C. He would take overall responsibility for the direction of each mission, while Christopher Kraft would continue his regular role as Flight Director for the Gemini missions. Just ten days later, on July 4, Thompson turned down his new position for personal reasons and elected to remain in his current role. For the interim, Chris Kraft would serve in the dual roles of Mission and Flight Director for Gemini missions [38]. That same day, it was announced that members of the Gemini 4 extravehicular activity (EVA) development team had received a Group Achievement Award, presented by MSC Director Robert R. Gilruth, for their work in developing the EVA capabilities demonstrated during the Gemini 4 mission [39].

Confidence in the program was high after Gemini 4, as Gemini 5 moved closer to launch and planning for the missions beyond that continued. NASA Administrator James E. Webb announced on June 26 that the third manned Gemini mission would attempt a record eight-day flight, which was the duration estimated for Apollo to reach the Moon, conduct a short exploration of its surface and return to Earth. Webb also indicated that NASA was about to select a new group of scientist-astronauts within a week. In fact, the six scientists for the Apollo program were identified in the nation's press on June 27. They were to be announced officially on June 29, but this was moved forward to June 28 after the press began to run the story. Their training schedule would mean that none of the new astronauts would be eligible to fly on Gemini, but would instead be prepared to fly either on crews assigned to later Apollo missions after the initial landings, or on extended missions on the Orbital Workshop Program that was under development[7].

July

With his assignment on Gemini 4 completed, Ed White received a new assignment and 'promotion' on July 1, as backup Command Pilot for the Gemini 7 mission. Named with him as Pilot was Michael Collins from the 1963 astronaut group. The pair would support Command Pilot Frank Borman and Pilot Jim Lovell, who had been named as prime crew for a mission that was expected to last up to 14 days. Borman and Lovell had been the backup crew to Gemini 4, with Lovell training with White for the EVA, and the latter's experiences from Gemini 4 would be useful in supporting the much longer flight of Gemini 7. With this assignment, White was also in line for assignment as the Command Pilot for Gemini 10 in 1966, under Deke Slayton's system of back up one mission, miss the next two and fly the third. However, Slayton had other plans for White after Gemini 7, as he was to join Gus Grissom and Roger Chaffee as the prime crew for the first manned Apollo mission – Apollo 1. That crew was formally named to the flight on March 21, 1966.

Following Gemini 4, Jim McDivitt served as a Capcom for Gemini 5, and once that assignment was over, six or eight weeks after coming back from Gemini 4, he went over to Apollo and took over as Astronaut Office representative for overall engineering issues on that program. In September 1965, he was named Apollo Branch Chief in the Astronaut Office, until December when he was replaced by Grissom. Once again, Slayton had a far more important role for McDivitt in the early Apollo program, and his experience was a factor in his selection to command the first manned test flight of the Apollo Lunar Module in Earth orbit, a demanding rendezvous and docking mission (originally identified as Apollo 3). In March 1966, he and his crew were named backup for Apollo 1, until November when they were reassigned following the cancellation of the Block I Apollo 2 mission that duplicated Apollo 1. Instead, McDivitt was to command the new Block II Apollo 2 and test the LM in Earth orbit. This mission was to occupy his crew's attention for the next three years.

In 1967, Ed White was tragically killed along with Gus Grissom and Roger Chaffee in the Apollo 1 pad fire on January 27. America's first spacewalker was buried with full military honors at West Point Academy on January 31. The Apollo 1 tragedy forced all flights to be suspended and an inquiry held to determine its cause and suggest improvements to the program. During this difficult period, McDivitt and his crew of David R. ('Dave') Scott and Russell L. ('Rusty') Schweickart continued to follow the development of the LM and continued with generic Apollo training for the re-designated Apollo 8, the second manned Apollo planned for 1968. Then, in August 1968, with the LM falling behind schedule, it was decided to exchange the missions of the second and third crews. The third Apollo crew, Frank Borman, Jim Lovell and Bill Anders, would now fly Apollo 8 around the Moon at Christmas but without the LM. McDivitt would command Apollo 9 in early 1969 to test the LM in Earth orbit. That mission was successfully flown between March 3–13, 1969 and qualified the LM for manned operations. It was a critical step for Apollo in the quest for the Moon.

Under consideration for the command of an Apollo lunar landing crew (some reports suggest that it may have been Apollo 13) and having also been approached to head up the USAF MOL program, McDivitt instead decided to take a managerial role at NASA MSC. On June 25, 1969 (after MOL had been cancelled), he became Manager for Lunar Landing Operations, APO. When that position was deleted in September 1969, he was named Manager of the Apollo Spacecraft Program Office on September 25, until June 1972. On September 1, 1972, Jim McDivitt resigned from NASA and retired from the USAF with the rank of Brigadier General, to enter the private corporate world. Over the next three decades, he held a variety of executive positions before finally retiring in 2009.

Spacewalks or Space Rendezvous?

The mission of Gemini 4 had met with varying degrees of success. Firstly, the EVA by White was generally judged to have been successful and the imagery provided great public relations copy. The rendezvous with the Titan had not gone so well, however, and this was a disappointment as the procedure was critical to Apollo reaching the Moon via the Lunar Orbit Rendezvous (LOR) mode chosen back in 1962. As a result, NASA management decided that further rendezvous practice needed a higher priority than the more ambitious step-by-step EVAs planned for the next three missions. By the end of June, NASA management were seriously considering cancelling the EVAs planned for Gemini 5, 6 and 7. On July 2, the Gemini Program Office took the critical decision to form a group specifically to look at future EVA planning in the program, creating the Gemini Extravehicular Planning Group (GEPG) with the aim of reviewing and re-planning the EVA objectives set for Gemini 8 through 12.

On July 7, Paul Haney, the NASA PAO at MSC, confirmed that EVA was no longer part of the flight plans for Gemini 5, 6 or 7, with the recommendations from the GEPG passed to Charles Mathews on July 19. The next opportunity for an astronaut to leave his spacecraft in orbit would be during Gemini 8, manifested for the spring of 1966 [40].

On July 10, Ron Simpson of the MSC Guidance and Control Branch gave details of the probable reasons why Gemini 4's crew could not achieve rendezvous with the Titan second stage, based on evaluations of rendezvous simulations after the mission using data provided from the flight. The evaluation suggested that:

- Visual rendezvous required an extended period of ground-based practice and training.
- If the spacecraft and target were over 4,500 feet apart (1,371.6 m), then without radar the rendezvous maneuver is nearly impossible.
- It took far more fuel in the exercise than had previously been estimated [41].

Though the rendezvous on Gemini 4 may not have gone exactly to plan, 134 million miles away, the unmanned Mariner 4 flew by Mars, its closest approach within 5,500 miles (8,849.5 km) of the surface on July 14. The probe took 21 images as it flew by the Red Planet. On July 15, the day the 21 images from Mariner 4 were publicly released, astronauts Jim McDivitt and Ed White received the USAF Astronaut Wings from General John P. McConnell, USAF Chief of Staff, in a ceremony at the Pentagon, Washington D.C.[8]

Although the proposed Gemini circumlunar flight had not officially been approved, the idea of sending a two-man Gemini spacecraft on a six-day circumlunar flight around the Moon was receiving serious study at the Martin Company and Aerojet General. According to Kenneth S. Kleinknecht, the Deputy Manager of the Gemini Project Office at MSC, the study envisaged a Titan II-C rocket with two upper stages that would place one of these Transstages in orbit. Then, a Gemini launched on a Titan II would rendezvous and dock with the Trans-stage for maneuverability and propulsion during its trip to the Moon and back. “We are always studying possible future missions for Gemini,” said Kleinknecht [42]. Sadly, none of these plans for extending the life of Gemini operations ever matured into actual programs.

August

On August 3, the Gemini 4 spacecraft arrived at the New York World Fair, to be put on public display in the U.S. Space Park starting the following day [43]. The Hand-Held Maneuvering Unit used by White on the EVA was sent to the Smithsonian Institute, Washington D.C. on August 13, 1965 [44].

During the month, a modified Gemini EVA suit was used in underwater operations in Virginia to demonstrate the ability to use space-developed hardware and procedures here on Earth, an early example of what has become known as ‘space spin-off technology’ that is widely used today. In this case, an identical pressure suit to that worn by Ed White during his EVA was donned by George C. Wiswell Jr., founder and head of Marine Construction Inc., for a repair job some 200 feet (60.96 m) underwater at the American Electric Power Co. Smith Mountain Dam, near Roanoke, Virginia. Wiswell was the head of a team of divers who lived in a pressurized tank at the bottom of the dam and used a pressurized diving bell to make the repairs using the D.C Clark “Aquanaut suit.” It was possible for each diver to work for four hours a day at these depths in the suit, instead of the 20 minutes or so of work each day that could be done using conventional methods [45].

At the Cape, Gemini 5 was waiting in the wings, planned to double the duration of Gemini 4 to just over one week. Recording the missions of Gemini is not a straightforward case of covering each flight on its own, as each mission affected those to come in the program. Just as Gemini 1, 2 and 3 helped define the plans for a four-day Gemini 4 mission, so the results from that mission contributed to the plans for long-duration flights proposed for Gemini 5 and 7, as well as for the rendezvous missions beyond that. With such a short time between these early missions, the experiences from each flight had to be incorporated quickly into the next in order to develop the Gemini program and, in turn, benefit Apollo. At least, that was the desire and plan. It did not exactly work out that way, as was tragically revealed in 1967 and will be explored in the later books in this series covering the Gemini missions flown during 1966, as the program gave way for Apollo.

A significant amount of information had been gathered during Gemini 4, and with only a few weeks to analyze the data, the lessons learned from the four-day mission had a direct and immediate impact on the preparations and expectations for the next one. That story is explored in the next title in this series, *Gemini 5: Eight days in space or bust.*

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45. New York Times, August 9, 1965.

Footnotes

1 This was not the first time the *Wasp* had supported the recovery of an American astronaut from the ocean at the end of their mission. In May 1963, she had served off Bermuda as the backup recovery ship for Gordon Cooper's Mercury Atlas-9 mission, but was not called upon to retrieve the astronaut who had landed as planned in the Pacific. This time, however, the *Wasp* would play a more prominent role. She had sailed from her homeport of Boston on February 8, 1965, for fleet exercises in the Caribbean prior to her temporary assignment to recover the Gemini 4 crew [1].

2 There had been unexpected RCS thruster activity while the empty Gemini 2 spacecraft was in the water.

3 The Stokes Litter, or basket, is a metal or plastic litter used to restrain a patient while being transported across difficult terrain. It is primarily used in recovering injured patients during rescue by helicopter, or transport through narrow passages or down stairs. The device was originally designed by Charles F. Stokes, Surgeon General of the Navy, and was patented in 1905.

4 White wore a Star of David, a Christian cross, and St Christopher medal.

5 "The Hump" was the name given to the eastern end of the Himalayan Mountains by allied pilots flying transport planes from India to China to resupply the front line troops.

6 Vice President Humphrey did indeed met with De Gaulle, but no evidence could be found that the astronauts did so, nor visited the Presidential Palace, before they returned to the United States. The author would welcome any clarification to update his records.

7 The six were Owen K. Garriott; Edward G. Gibson; Duane E. Graveline; Lt. Cdr. Joseph P. Kerwin USN; Frank Curtis Michel; and Harrison H. Schmitt. Graveline left for personal reasons in August, while Garriott

Frank Curtis Michel; and Harrison H. Schmitt. Graveline left for personal reasons in August, while Garriott, Gibson and Schmitt were sent to jet pilot school. That left Kerwin and Michel, who had already qualified to fly jets during their military service, to assume a number of technical roles in Houston for a year prior to the group joining the 1966 pilot-astronaut selection for formal academic and survival training.

8 At the same ceremony, Air Force X-15 test pilot Captain Joe H. Engle also received the USAF Astronaut Wings for his achievements in the X-15 program, having flown the vehicle above the 50-mile (80.4 km) altitude to the threshold of ‘space’. Ten months later, in April 1966, Engle would be selected in the group of 19 pilots chosen as NASA’s fifth group of astronauts – See: *The Last of NASA’s Original Pilot Astronauts, Expanding the Space Frontier in the Late Sixties*, David J. Shayler & Colin Burgess, Springer Praxis, 2017.

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15. A significant contribution

David J. Shayler[1]

(1) Astronautical Historian, Astro Info Service Ltd., Halesowen, UK

"Gemini 4 was a great adventure for both of us.
The thing that I liked about Gemini 4 was that
we didn't know what we were doing!
In those days, every time a flight went up
we discovered new and wonderful things."
Jim McDivitt, Command Pilot Gemini 4,
comments from a 2005 interview.

In evaluating Gemini 4, the official reports summarized the mission's achievements and setbacks. Overall, the performance of the spacecraft, the launch vehicle, the flight crew and the mission support team were listed as "satisfactory," with all bar two of the objectives assigned to the mission successfully achieved. The exceptions were: the close-up station-keeping exercise, which meant that the subsequent rendezvous with the second stage of the Titan launch vehicle was not attempted; and the lifting re-entry maneuver, which was omitted due to a malfunction in the Inertial Guidance System. The post-flight report went on to state:

> "The flight contributed significantly to the knowledge concerning manned spaceflight, especially in the areas of long-duration flight, crew performance, and extra-vehicular activity. The Gemini 4 spacecraft systems demonstrated the capability to support a crew on flights of up to four days."

Summing Up Gemini 4

The official report drew up 20 separate conclusions and 45 recommendations going forward [1]. These points are summarized below under specific headings.

Crew Training

Operational and Experimental Equipment

As the full suite of operational and experimental equipment intended for crew use was not available during training, the crew was unable to complete full training on those items prior to the mission. Post-flight recommendations also suggested that more effort should be made to ensure that up-to-date flight equipment was installed in the mission simulators and trainers, so that the crew station and stowage provisions were the same as those in the current spacecraft being flown. In addition, the training aids and simulators should, at minimum, duplicate exactly – or indeed feature greater loads than – the flight equipment planned for EVA training, and that EVA training should be conducted with suit pressures at 4.5 psi differential.

Launch Vehicle and Launch Facilities

Launch Complex 19

It was recommended that further action should be taken to ensure that the malfunction of the launch vehicle erector and the problems with the umbilical disconnects did not reoccur.

Payload Capacity

The Titan launch vehicle assigned to the Gemini 4 mission performed well and successfully inserted the spacecraft into a nominal orbit. However, the launch vehicle's achieved payload capacity was approximately 270 pounds (122.5 kg) greater than the predicted nominal. As a result, it was recommended that the methods used to determine the payload capability of the Gemini-Titan launch vehicle should be re-evaluated, to achieve greater accuracy.

Monitoring Displays

A suggestion was made to improve the readability of the displays for the launch vehicle tank pressure gauges.

Countdown

The Cape Capcom should be the only person talking to the crew during the period of terminal countdown, i.e., between T-3 minutes and T-0, or lift-off.

Spacecraft

Spacecraft

Crew Hatch

The difficulties encountered by Ed White following the EVA were found to be the result of a fault in the hatch latching mechanism. Though the lanyard was used to pull the hatch closed, it was not designed to keep it closed. It was recommended that the Gemini hatch mechanism must be modified or redesigned to prevent a malfunction of the type experienced on Gemini 4, ideally before performing any further EVA activities. It was also recommended that the lanyard connected to the EVA hatch should be strengthened. There were no plans to open the left-hand/Command Pilot hatch during orbital operations. Prior to any future EVA, the hatch closing device had to be redesigned "to act as a satisfactory method for holding the door [hatch] closed in case of failure in the normal latching device."

Spacecraft Hoist Door Flap

It was suggested that the door designed to cover the spacecraft hoist (which was used at the end of the mission to retrieve the spacecraft from the ocean and which failed to operate correctly during the Gemini 4 recovery phase) should be tested as close to the launch as possible to ensure it worked.

Ejection Seats

The method of safing the ejector seat drogue mortars should be simplified and a positive means found to protect the ejection seat aneroid barometers from corrosion during longer missions.

Windows

Both astronauts suffered from the sun shining directly into their eyes during the mission, so recommendations were proposed to consider providing filters for the cabin windows.

Spacecraft Systems

Propulsion

Generally, the spacecraft propulsion system operated satisfactorily, except for one nine-minute period during the station-keeping exercise early in the mission. During that time, one thruster chamber assembly in the OAMS did not operate and a failure in the electrical control circuit prevented a thruster in the Re-entry Control System from operating. Neither of these malfunctions significantly affected the control of the spacecraft.

Voice Communications

The voice communications during this mission were summarized as "not entirely satisfactory." There were periods where the system worked normally, but problems were sometimes found in the operational procedures being used or in the maintenance of the ground stations. It was also found that the High Frequency (HF) mode did not provide an acceptable backup system to the Ultra-High Frequency (UHF) mode as had been expected. Recommendations were put forward to determine the changes required to make the communication system acceptable for manned spaceflight, with emphasis given to the poor HF performance experienced on Gemini 4. It was also suggested that the lightweight headset should be replaced by one which would not give discomfort and would "stay in proper mechanical adjustment." Recommendations were also put forward to have the ground team provide more information to the crew on consumables and expendables on their vehicle.

Computer

A malfunction in the Inertial Guidance System (IGS) prevented a nominal computer shutdown. Following a number of power down attempts, the computer suffered an uncontrolled voltage decay which seriously affected its internal memory. As a result, the computer could not be used to support the re-entry phase. Among the recommendations made after the flight, there was a request to improve the reliability of the power sequencing of both the IGS and the onboard computer.

Optical Sight

The required intensity for the reticle of the optical sight was recommended for further investigation, and corrective action would need to be taken to improve the device.

Displays and Controls

It was suggested, based on the astronauts' request, that an independent and separate ON/OFF control should be made available for the voice tape recorder. It was also proposed that a digital display of Ground Elapsed Time (GET) in hours, minutes and seconds, from zero to 99 hours, should be made available to the astronauts, again based upon a request by the Gemini 4 crew. It was also recommended that the intensity of the cabin lighting should be increased, and that Velcro should be installed on all cabin wall spaces and made readily accessible to both flight crew members. The altimeter setting for the recovery phase should also be determined and relayed to the crew prior to re-entry.

Crew Equipment and Provisions

Flight Planning

Despite meticulous planning prior to the mission, the crew did not have sufficient time to prepare for many of the tasks which took place during the first orbits. These included station-keeping, platform alignment and preparing for the EVA. The first few hours of the mission were completed in a continual rush, while the latter stages of the mission were more paced. Real-time flight planning was found not to be too difficult and it was suggested that this method should be employed where necessary during the mission. It was also suggested that in future, a scheduled meeting between the appropriate NASA and MAC (McDonnell Aircraft Company) engineers and the flight crew should be scheduled as close as one week prior to the planned launch, in order to review crew system operation procedures and to reduce the possibility of last minute changes which the crew would have no time to prepare for. It was also suggested that future mission planning and operations should be conducted using GET to simplify the process.

Orbital Navigation

Assuming the availability of map updates provided by the ground, or using crew observations of the terrain to update the orbital plots, it was possible to conduct useful orbital navigation. In addition, with adequate training on maps and photograph studies prior to the mission, the crew could have some confidence in gaining familiarity with the terrain, rapid landmark identification and significant landmark tracking.

Star Sightings

The star-to-horizon sightings from the Gemini spacecraft were found to be much more difficult than anticipated, especially during the daytime pass.

Crew Health

Toxic Contamination

Both astronauts suffered irritation and inflammation of their eyes, nose and throat from a “toxic substance.” This was assumed to have been caused by outgassing from the water absorbent material or its additives in the spacecraft. This source of irritation was to be investigated, identified and eliminated.

Waste Management

Waste Management
Apart from a few minor problems, the waste management system performed satisfactorily throughout the mission.

Duration
The long-duration aspect of the flight (four days) and the added EVA demonstration did not have any adverse physical effects on either astronaut. However, it was recommended that the rest cycle should be revised to incorporate a six-hour sleep period and a two-hour nap period.

Medical
For the second time on Gemini, the crew had difficulty in fitting the blood pressure bulbs into the ports. It was recommended that they should be modified to provide a good fit and to ensure that they would continue to operate correctly during the mission without deterioration, to avoid making the operation more difficult for the crewmember. An expanded exercise program was also recommended for future flights. A further suggestion was to exchange the existing comprehensive physical at T-2 days with the shorter one at T-10 days, so that the more comprehensive examination was held ten days prior to the planned flight and the shorter examination just two days prior to launch. Stricter measures also needed to be put in place to prevent accidental exposure of the crew to communicable diseases.

Habitability

Food and Drink
Gemini 4 had carried sufficient food for the two men over the four-day mission, and most was deemed suitable for orbital use. However, the leaky bags containing the re-hydratable orange drink and the crumbly toast and peanut bars would require re-evaluation before being flown again. Recommendations were made to review the consistency of the foodstuffs and the packaging. During the mission, the plunger on the water dispenser was found to be bending and this needed to be addressed and corrected to prevent it happening on a future flight. It was also suggested that a quantity monitoring system should be provided for the drinking water supply. For future flights, it was suggested that the daily food portions per man carried onboard should be at least equal to that flown on Gemini 4, and that a greater variety of dehydrated smoked meats should be developed.

Crew Station

The design of the crew station was deemed suitable for missions up to four days. The next flight would test its suitability for double that duration, but for planned rendezvous and docking missions, four days would be adequate. This gave confidence that the primary objective of rendezvous and docking operations in preparation for Apollo would be feasible on later four-day Gemini missions intended to focus on those techniques.

Pressure Suits

Both the crew station and the G-4C space suits were deemed suitable for orbital missions of four days or longer, subject to a number of minor changes. The fingertip lights, with protective covers on the bulb, should be standard on all future Gemini pressure suits, and should be positioned between the fingertip and the first joint. The over-visors on the pressure suit helmets were to be redesigned to make it easier to raise and lower the visor with just one hand and hold it in the desired position. The redefined visor should be a single unit, with both visual and physical protection on one visor. The urine receptacle should be modified to prevent leaks.

Sleeping

The astronauts reported difficulty sleeping and were disturbed in their sleep periods, mainly due to the audio volume and the fact that the headsets could not be fully turned off, but also because of the ambient light and associated noises that occur during nominal operations on the spacecraft. Recommendations here included allowing each astronaut to turn off the audio in their headsets and reducing cabin ambient lighting level to provide a better sleep environment.

Mission Phases

Rendezvous

Based upon the difficulties encountered during Gemini 4, it was recommended that any future target vehicle should be fitted with a proper light pattern to provide suitable depth perception during night passes.

On July 1, it was reported that a “repeat performance” of the rendezvous attempt was to be simulated in the MSC Guidance and Control Laboratory later in the month. Engineers at the laboratory would duplicate the Gemini 4 rendezvous maneuvers using a Virtual Image Simulator and a trio of computers [2]. This simulator was being used to present 3-D representations of the Apollo lunar landing for astronaut training. In the Gemini rendezvous simulations, the Titan booster was to be represented by a 30 x 10 ft. (9.14 x 3.04 m) rectangle against a black background. Jim McDivitt was not expected to be present for the simulations, but a number of pilots and astronauts were expected to participate in runs. Each run would take about 70 minutes, with the ‘pilot’ seated in a mock-up Gemini capsule having the same field of view as from the spacecraft in orbit, and using attitude and translational control handles for maneuvering.

Each run was to start after the simulated spacecraft separated from its booster to about 400 feet (121.9 m). The pilot would then try to perform station-keeping maneuvers up to 3,000 feet (914.4 m) from the ‘booster’, then turn around and thrust back to the Titan stage again to try to duplicate what had occurred on Gemini 4. The plan for Gemini 4 after the first rendezvous was for McDivitt to separate to 21.8 miles (35 km) and then perform a terminal rendezvous, but as half the available fuel had been used in attempting the station-keeping exercise, the second rendezvous was cancelled. Ron Simpson explained that several other computer studies of the Gemini 4 rendezvous orbital mechanics had been run by the division for the purpose of upgrading the simulations, not only for forthcoming Gemini rendezvous missions, but also in planning Apollo lunar orbital rendezvous maneuvers.

Extra-Vehicular Activities

Gemini 4 proved that EVA could be completed as a routine part of a manned spaceflight. The three-dimensional spacecraft offered Pilot Ed White valuable visual references during his spacewalk, and the Hand-Held Maneuvering Unit (HHMU) was proven to be an effective method of controlling the astronaut’s position and attitude in free space – while the fuel lasted.

Following White’s experiences without the use of the HHMU, a further study was suggested to determine the best places to attach a tether to the spacecraft when maneuvering with the tether line. In addition, it was recommended that adequate handholds should be installed on the outside of the spacecraft for using during future EVAs. Interestingly, no mention was made of providing footholds at this time.

Experiments

Initial data indicated that all eleven assigned experiments conducted during Gemini 4 were successful (see below).

Re-entry

Despite the loss of the spacecraft’s computer, the re-entry of Gemini 4 was completed satisfactorily. The vehicle remained stable and its oscillation had been controlled following deployment of the drogue parachute. In future, it was recommended that re-entry should be conducted in Re-entry Rate COMMAND mode, with all the gyros activated in order to prevent divergence or excess rate magnitudes.

Gemini 4 Experiment Program

The increased flight duration dramatically expanded the time available for the experiments carried on Gemini 4. There is insufficient room available here to discuss all the experiment results from this flight in depth, so the reader is directed to the references and bibliography to explore these results in more detail. Brief summaries of results, with crew participation notes for these experiments, are given below [3].

MSC-1 (M-403) Electrostatic Charge.
Following the flight plan, or as directed by the ground, the sensor was turned on or off as required.

Results: The results from this experiment were a surprise, compared to what had been expected. The electric field readings were extremely large compared to the predicted short discharge times. This prediction was based on measurements of potential from previous satellites and projections of what might be expected from a vehicle in the ionosphere. There was no data to suggest that there had been an instrument malfunction or an electrical failure, so studies were conducted to determine whether something else other than the surface of Gemini 4 itself was generating the readings. Post-flight tests revealed that the instrument responded to radiated radio-frequency energy and to streams of charged particles on the face of the sensor unit. As the experiment was to fly again on Gemini 5, comparison data could be gathered to determine the anomalies encountered on Gemini 4.

MSC-2 (M-404) Proton-electron Spectrometer and MSC-3 (M-405) Tri-Axis Fluxgate Magnetometer.
This experiment was also activated according to the flight plan or as directed by Mission Control. The astronauts reported that some indication that the boom for the experiment had extended would have helped, as they had no way to determine whether that was the case and both this and MSC-1 depended upon it.

Results: Both experiments were performed at the same time during the mission as the spacecraft flew through the South Atlantic Anomaly between South America and Africa, which contained the required intensity of protons and electrons. Strong directional variations recorded during the 7th and 23rd/24th orbits (7th and 22nd revolutions) around Earth were caused by the spacecraft tumbling while in free drift. Data recorded on the 53rd/54th orbit (51st revolution), during which the spacecraft was held with pitch, yaw and roll as close to zero as possible, compared with the theoretical predictions before the flight. Small errors could be attributed to stray magnetic fields from the spacecraft.

MSC-10 (M-411) Two-color (red/blue) Earth's Limb Photography.
This was a follow-on experiment to the photography carried out on the earlier Mercury flights and it was hoped that this reflight of the experiment would answer some of the questions raised from those missions. Nine-and-a-half runs were completed during Gemini 4. Unfortunately, the event indicator failed to trip the camera shutter and was removed.

Results: Initial inspection of the images suggested that limb profiles in blue were not as sharp as those in red and that the most useful images were those taken shortly after sunrise. Further studies would be required on this experiment if the process was to be adopted as a guidance and navigation aid during Apollo.

M-3 (M-003) Flight Exerciser.
The crew used this device as scheduled and even after the outer thin rubber layer of the device broke at GET 67:30, the effectiveness of the device was not diminished. McDivitt thought he was not getting sufficient time on the device and requested additional sessions, eventually completing seven periods of exercise compared to White's ten. The crew reported no interference with other activities when using this device, but both astronauts felt that their capacity and desire to continue the strenuous exercise decreased as the flight progressed. In fact, the astronauts performed more frequent leg and back stretches – as well as tensing their leg and stomach muscles – than actually using the exerciser.

Results: From the data collected during the mission, the response of the cardiovascular system to a calibrated workload was seen to be relatively constant for each individual, at least for missions up to four days. The crew demonstrated their ability to perform mild to moderate amounts of work under spaceflight conditions. A variation of the Harvard Step Test was used as an indicator of their physical fitness, with no decrease in physical condition of either crewmember apparent during the four-day mission.

M-4 (M-004) Inflight Phonocardiogram.
There were no crew activities associated with this experiment, as the recording procedures for both the electrocardiogram and phonocardiogram were entirely passive.

passive.

Results: Heart sounds were relatively constant for both men and did not increase as flight time increased. As expected, the greatest heart rates were recorded at lift-off, during re-entry and for White during the EVA.

M-6 (M-006)Bone Demineralization [Non-Flight Investigation].
This study, based on radiographic bone densitometry, was performed on both Gemini 4 crewmembers before and following the spaceflight. Radiographs were taken of each crewmember, from the "lateral aspect of one foot and from the posterior-anterior aspect of one hand." These were obtained during medical examinations at the Cape nine and three days prior to lift-off, as well as on the morning of the launch. Further readings were taken immediately after recovery onboard the USS *Wasp* and again at the MSC at 16 and 50 days following the mission.

Results: This was the first experiment to measure changes in skeletal mass during spaceflight, opening a new avenue of investigation. Results were compared to previous bed-rest and dietary calcium intake studies. It was known that exercise did have an effect in reducing bone-mass loss, and the potential influences of stress were also under study. Bone-mass losses were experienced by both astronauts after Gemini 4, and in some areas these losses were greater than that previously recorded from bed-rest subjects. This was an early study, and the reports indicated that more data, from a larger number of subjects, would be required to interpret the results fully. However, it was clear even from this one set of data that "for every anatomic site investigated, densitometric values underwent a negative change in four days, and the change was greater than the losses incurred by healthy men in bed-rest during the same period of time and on the same dietary level of calcium." One important finding from this study on Gemini 4, however, was that "the absorption losses from bone are recoverable within comparatively short time periods."

S-5 (S-005) Synoptic terrain.
Conducted as scheduled, these experiments obtained a wealth of terrain and weather photography, despite one magazine jamming and most of its frames being lost.

Results: Using a hand-held Hasselblad 500C camera with a Zeiss Planer f/2.8 lens and haze filter, the crew exposed five magazines' worth (60 frames per magazine) of 70-mm Ektachrome film. This yielded about 100 pictures that were useful for studies of Earth terrain. The images were mostly of excellent quality with respect to their exposure, resolution and orientation, reflecting the training the astronauts had completed prior to the mission. Fuel and power restrictions prevented the crew from orientating Gemini 4 vertically (nose down towards Earth) for a direct forward view of Earth below, the preferred orientation for this experiment. Nevertheless, a series of 39 overlapping, portrait-orientation images were taken on the 33rd orbit (32nd revolution) covering an area from the Pacific coast of Mexico to central Texas. Throughout the mission, priority was given to photography of East Africa, the Arabian Peninsula, Mexico and the southwest United States. The resolution of these images was also studied. Examinations of cultural features of known dimensions on enlarged prints enabled estimations of ground resolution to be made. The maximum ground resolution was estimated to be between 30 and 40 feet. The film record included:

- **Magazine 8, Roll 3:** 54 terrain images of Northern Mexico, southwest United States (continuous coverage), Florida and the Bahamas Islands (intermittent coverage). The exceptional quality of these images included considerable off-shore detail.
- **Magazine 9 Roll 4:** 23 pictures from North Africa (18 images were considered good), the Persian Gulf and southeast United States (which were poor).
- **Magazine 16, Roll 5:** 17 images, including Mexico (2 pictures), the Arabian peninsula (which were very good) and adjacent area, and a picture of Mauritania (showing the Richat Structure).
- **Magazine 7 Roll 2:** 10 images, five of which were of the Bahamas Island (showing underwater topography), and the rest of the Arabian peninsula.
- **Magazine 6 Roll 1:** 10 pictures of northwest Africa (good coverage in seven images of the Nile river and surrounding area), and a single image of Iraq, India and Pakistan **[** 4].

S-6 (S-006) Weather Photography.
This was a data-gathering experiment designed to acquire a set of pictures covering a broad range of meteorological phenomena, specifically various cloud systems.

Results: About 100 cloud formation and other meteorological information images of interest were taken during the four-day flight. The varied and day-to-day recording of certain weather patterns was of such interest that the plan was to continue this experiment on subsequent Gemini missions.

D-8 (D-008) Radiation.
No problems were encountered during the operation of this experiment.

Results: Apart from the South Atlantic Anomaly, the principle contributor was cosmic radiation, with the average radiation dose rate obtained every 3.2 seconds on each orbit. The maximum and minimum dose levels were collected from the lowest or highest readings taken during a period of one minute for each orbit. The data obtained would be used in projections for longer missions with similar shielding configurations. The average dose rate for the all orbits that did not pass through the Anomaly was 0.15 millirads per hour and it was determined that the total radiation dosage during the four-day flight was approximately 15.0 millirads. Assuming a 90-minute orbit, the total accumulated dose was calculated at about 0.23 millirads per orbit, with about 3.5 millirads being recorded as a daily average inside the crew compartment. “Such radiation levels are very low and constituted a permissible exposure dose for extended periods at Gemini operating altitudes,” according to the official post-flight experiment reports.

During the EVA, with the right hand hatch open, the exposed dosimeters did not record significantly higher radiation than the unexposed dosimeters, indicating a total absence of softer (trapped) corpuscular radiation in the region of space where White was performing his EVA. However, dose-rate data within the South Atlantic Anomaly increased significantly by three orders of magnitude, and were recorded over nine orbits between the 7th and 54th orbits from a peak of 125 millirads (orbit 7) to only 20 millirads (orbit 51). The transit time for most orbits that only grazed the Anomaly was less than seven minutes, and about 12 minutes for those which passed through the Anomaly.

D-9 (D-009) Simple Navigation with the Sextant.

When the crew unstowed the sextant, the light in the readout dial failed, which decreased the speed at which readings could be taken. The crew soon determined that trying to take star-to-horizon measurements in the daytime was not feasible, but orientating Gemini 4 to block out the sun allowed stars to be viewed during sunrise and sunset. During the night runs, the initial stars selected were at such a great angle that it was impossible to measure with the sextant through the small Gemini window. The problem lay not only in the limitations of the window but also the available room inside the spacecraft. Other stars were later selected at between 20 and 25 degrees, but even here, the astronaut had to remove his spacesuit helmet to capture an adequate reading. The crew found that during the night, the horizon was not well defined and it was difficult to take precise measurements. The clear filter and the green filter provided usable horizons, but the blue filter was not suitable for night-time viewing. The astronauts found that the photo event indicator required a large ‘throw’ to activate and it was therefore not considered to be an accurate or satisfactory timing device. The crew therefore determined that taking star-to-horizon measurements was not a simple task, but predetermined constellations were easily identified and the launch vehicle lights were visible when in range during day and night passes. They suggested that while the stars were not visible during the day pass, they might be if the eye was dark-adapted and a shaded window was used.

Results: There were 160 scheduled star-to-horizon measurements with the 5577-angstrom green emission line at night. There was no evaluation of the blue filter or blue-haze horizon during the day-passes. A total of 45 star-to-horizon sightings were accomplished to the natural night horizon and to the 5577-angstrom green emission line, with and without a filter. The green emission line was more defined when using a filter, and measurements were made to the top, middle and bottom of this layer, though useful navigational measurements could not be made due to the failure of the timing device external to this instrument. Due to the cancellation of the rendezvous with the Titan stage, the scheduled star-to-stage sightings were not performed. However, 47 of the 50 planned the star-to-star maneuvers were accomplished.

Apollo Sextant.
While there were no star-to-stage measurements taken, it was determined that if they had attempted this, the crew would again have encountered the limits to suitable angles though the small Gemini window. The number of sightings taken and other navigational-related data recorded during Gemini 4 were:

- Air Force sightings (star-to-horizon) – 45
- Apollo sightings (star-to-star) – 47
- Useful horizons (natural Earth and 5577Å emission line) – 2
    - Air Force – 11
    - Apollo – 6
- Maximum sighting angle obtained
    - Air Force – approximately 30 degrees
    - Apollo – approximately 21 degrees
- Number of green horizon layers observed – 2
- Thickness of 5577Å layer – approximately 2 degrees 40 minutes
- Star transit time
    - Through green layer – 49.5 seconds
    - First sighting to top of green layer – 3 minutes 23 seconds

- Type of data recording – written and voice tape
- Type of sighting time – manual and photo event timer.

Relative Humidity Sensor Check.

Both dry-and wet-bulb temperatures were taken throughout the four-day flight. Data indicated that the relative humidity remained around 62 percent through the flight, which was much less than had been predicted preflight. The crew had no problems in using the sensor to obtained the measurements, but was unable to obtain a satisfactory wall temperature as the spacecraft's inner surfaces were covered with water-absorbent padding ('wallpaper').

Apollo Landmark Identification.

The astronauts found that it was possible to acquire and track prominent landmarks or features. If the area was familiar and the landmarks contrasted, it was possible to obtain good tracking from 20 degrees to 30 degrees before the vertical. The astronauts' preflight studies of maps, and the ability to make several passes over the same area during the mission, made more rapid landmark identification possible. However, the crew reported that any amount of cloudiness greatly complicated the tracking task and landmark identification became more difficult. A good method of tracking was to use PULSE control. The crew did report that the charts provided for the mission were simply not detailed enough for their needs and that the most desirable aid for this would be aerial photographs.

HF Transmission-reception Check.

These checks were completed as scheduled, but yielded a very low degree of success.

Orbital Navigation Check.

The crew completed only a limited number of orbital navigational checks. Conversely, they completed a considerable amount of orbital navigations with the orbital plotter, which was similar to the checks. Little difficulty was encountered in observing terrain features and updating the orbital plot.

Apollo Yaw Orientation Check.

This test was performed during the night-time pass, the most difficult time to do so. The crew found that it was not difficult to orientate Gemini even at night, so daytime checks were omitted in an attempt to save fuel. The best technique for the night-time checks was to pitch the nose of Gemini down towards the Earth, so that the astronauts could observe the movement of the ground and clouds and therefore determine flight direction in order to orientate the spacecraft into retrofire attitude. The decision to use DIRECT mode sparingly also saved fuel, and the required orientation was achieved in just 2 minutes 20 seconds. The attitude was correct in pitch and roll, but was 18 degrees off in yaw. If fuel conservation was not an issue, it was estimated that this maneuver could be performed in approximately 1 minute 30 seconds. Despite this, the astronauts reported that attaining accurate yaw orientation during a night pass by just using stars was a difficult task.

One Attitude Thruster Failure Check.
The crew found that this task was not difficult as long as the roll Thrust Chamber Assemblies (TCA) in the other axes were available. It was possible to damp out the tumble rates and establish the desired yaw rate. They found that this check compared very closely to tests they had performed prefight in the simulator.

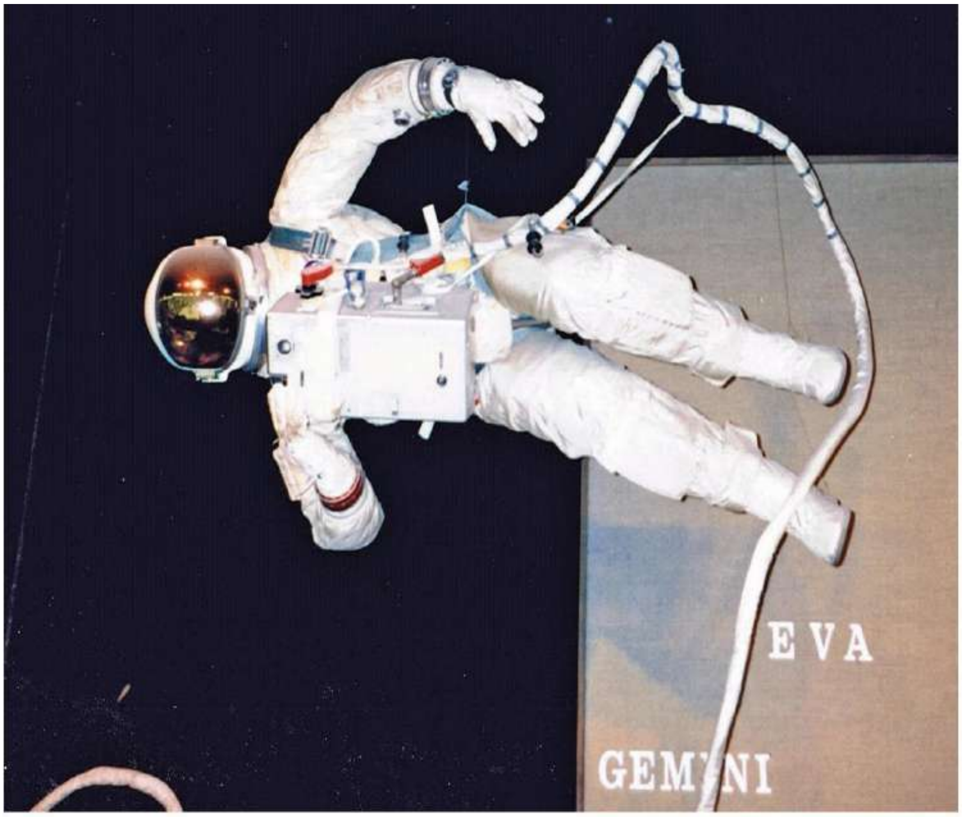
Horizon Sensor Track Check.
This task was performed as scheduled, but the last two runs with pitch and roll were omitted as the sensor was performing well. The crew did report that the sensor operating range was considerably broader than they had expected.

Horizon Scanner Check.
This check was run at sunset and moonset. For the sunset checks, the sensor IGNORE light would illuminate as the sun passed through the point directly in front of the sensor. The Moon, however, did not cause any erratic operation in this mode. It was found that neither the forward-firing thrusters nor the three-axis attitude inputs affected the operation of the sensor, as the scanner ignition light did not illuminate. It was determined that the horizon sensor mode was generally satisfactory.

Zodiacal Light Check.
This experiment was conducted as planned and scheduled.

Where Has All the Hardware Gone?
In 1967, NASA transferred the Gemini 4 Re-entry Module to the Smithsonian National Air and Space Museum (NASM), Washington D.C. for display. Currently (2018), Gemini 4 is within the Boeing Milestones of Flight Hall. The HHMU is also at the NASM, while in 2009 the left-hand hatch

(McDivitt's) was reported to be on display at the Cradle of Aviation, Long Island City, New York.



(above) A manikin of a Gemini astronaut (representing Ed White) on EVA, displayed at the Visitor Center, Building 2 Auditorium, NASA Johnson Space Center, Houston, Texas in August 1988 [©AIS Archive, photographed by the author]. (below) A representation of the Gemini HHMU, also on display at the Visitor Center at that time [©AIS Archive, photographed by the author].

Ed White's suit remained on display inside Gemini 4 for decades before being removed in 2006, together with McDivitt's, for preservation. Before her retirement Amanda Young, Curator of the NASM spacesuit collection, explained to Robert Pearlman of CollectSpace, that both the Gemini 4 spacesuits were "my biggest curatorial dilemmas." [5] Light damage due to being in the display case for so long meant that the outer cover layer was deteriorating. Replacement cover layers on both White's and McDivitt's suit, together with the U.S. flags, NASA 'meatball' logo and name tags, were added to the original inner layers. The team at the suit preservation facility at the NASM do a fantastic job at maintaining 'Spacesuits in the National Collection' for future generations to view these items of spaceflight history for as long as possible [6].

The Legacy of Gemini 4

Gemini 4 was the first 'operational mission' of the series, but could also be considered as the fourth test flight. This was the first time that the Americans had flown for significantly longer than a single day in Earth orbit and despite some small, niggling problems, the mission was a huge success. It was also a confidence booster, not only for future Gemini missions but also for Apollo and U.S. manned spaceflight capabilities.

The difficulties encountered in conducting the rendezvous with the spent Titan stage gave a good indication of the challenges that still needed to be overcome prior to attempting a rendezvous with an Agena, but it also provided good real-time in-flight experience of an important skill that had to be mastered, to make Apollo a success in its chosen mode for reaching the Moon and for long term human spaceflight operations.

The short EVA by Ed White was also an outstanding success but again revealed potential difficulties, in maintaining attitude and position. This would have to be addressed prior to attempting more extensive excursions. The EVA also uncovered the need to supply adequate fuel in maneuvering devices and not to restrict the hands, keeping both free to operate equipment. Retaining line of sight during the EVA between the spacewalking astronaut and the one in charge of controlling the spacecraft was another key area of concern.

The habitability of the spacecraft was a challenge over four days, but was possible, and the reliability of the equipment and systems suggested that longer missions could succeed, although some issues (such as the computer failure) remained to be overcome.

As a public relations exercise, Gemini 4 was a huge boost for both NASA's

As a public relations exercise, Gemini 4 was a huge boost for both NASA's morale and that of America as a whole, as it emerged from the shadow of Soviet space success. The flight of McDivitt and White captured the nation and the outside world at a time when America most needed it. The images of Ed White on EVA were spread across the world, on books and magazine covers, stamps and posters. Even today, these images are easily recognizable and attributable to the flight of Gemini 4. They remain as iconic to the space program of the 1960s as the first images from the Moon landings.

Gemini 4 also served as a testbed for a wide variety of experiments and new pieces of equipment, demonstrating the usefulness of long-duration flight in evaluating these instruments and the capabilities of the Gemini spacecraft to support their operation.

Another key event from Gemini 4 was the first operational use of the new Mission Control in Houston. This is probably as important a legacy from this mission as the EVA and the station-keeping exercise, with each aspect relevant to today's space program 50 years later. On the International Space Station, regular orbital maneuvers are conducted, EVA occurs at frequent intervals and the whole thing is controlled from MCC-H, among other locations.

One other element to this mission which marked a change was in the liaison between the source of the news (NASA) and the media. In marked contrast to the early Mercury program, where NASA was criticized for giving out too much information, or where the media created sensationalized headlines because they didn't have enough information, the feedback from Gemini 4 was one of "responsible reporting and accurate judgment and evaluation by trained newsmen." [7] Despite the fears of some controllers, in advance of regular press conferences at the change of each shift, there was an awareness of the responsibility to the public in reporting what the astronauts were doing. Allowing access to the air-to-ground commentary helped the general audience to understand the successes and difficulties encountered during the mission and offered the opportunity for the media to deliver responsible and accurate accounts of events without the need to sensationalize.

One Down… One Ready to Go…

Gemini 4 still featured in the news on June 7, 1965, four days after it had left Launch Pad 19 and the very day it would splash down in the Atlantic Ocean. That same day would also see darker reports from the U.S. military command in South Vietnam, which announced that its troops would fight alongside Vietnamese forces, thereby guaranteeing an escalation in that conflict. Back at Cape Kennedy that day, attention turned to the next space mission, as the launch vehicle intended for Gemini 5 was erected on Pad 19. Exactly one month later, on July 7, the Gemini 5 spacecraft was mechanically mated to its launch vehicle for a series of tests in preparation for its launch the following month. After years of preparation and months of delays, activities at the Gemini launch pad were getting decidedly busier. Around the Cape, as the halfway point in the program approached, it was about to get even more frantic, with three more missions – two long-duration flights and the first Gemini-Agena docking – remaining before the end of the year. The first of these, Gemini 5, was to attempt to double the duration record just attained by Gemini 4 to eight days, and in doing so give more confidence that Apollo could reach the Moon by 1970, as America looked for more positive news to detract from the negative reports coming from southeast Asia.

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1. Gemini Program Mission Report, Gemini IV, MSC-G-R-65-3, June 1965, specifically Section 9.0 Conclusions & Section 10.0 Recommendations.

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4. Terrain Photography on the Gemini IV Mission: Preliminary Report by Paul D. Lowman Jr., NASA Goddard Space Flight Center; James A. McDivitt and Edward H. White II, NASA Manned Space Flight Center, NASA Technical Note TN D-3982, June 1967.

5. Collect Space http://www.collectspace.com/ubb/Forum41/HTML/000283.html last accessed July 27, 2018.

6. **U.S. Space Gear: Outfitting the Astronaut**, Lillian D. Kozloski, Smithsonian, 1994, pp. 169–185.

7. *Free Exchange Gave True Picture*, California Desert Sun, June 8, 1965

Appendix 1: Gemini 4 Mission Timeline (Abbreviated)

PRE-LAUNCH JUNE 3, 1965				
	04:10 EST			Crew awakened
				Physical examination
				Breakfast
	05:22 EST			Left crew quarters
	05:35 EST			Arrived Pad 16 suiting trailer
	07.00 EST			Left Pad 16 for Pad 19
	07:08 EST			Arrived Pad 19
	07:12 EST			Crew inserted in spacecraft
	09:00 EST			1 hour 16 minute hold at T-35 minutes due to difficulties with lowering launch vehicle erector
			GET min:sec	**EVENT**
ASCENT PHASE JUNE 3, 1965				
			0:00.00	LIFT-OFF (pad disconnect separation) 10:16 EST (15:15:59.562 GMT)
			2:32.43	BECO (Stage I engine shutdown)
			2:32.43	Stage II engine ignition (signal)
			2:33.14	Stage separation begins
			5:33.75	SECO (second stage engine shutdown)
			6:04.71	OAMS Separation manoeuver start
			6:05.55	Spacecraft separation
			6:09.56	OAMS Separation manoeuver ends
FLIGHT DAY ONE (FD1) JUNE 3				
Flight Control Team	**REVOLUTION**	**ORBIT**	**GET hr:min**	**EVENT** **NOTE: Events are listed to the closest approximate time based upon the post-flight mission report**
Red Shift FD Kraft	1	1/2	0:10	Platform alignment
			0:10	Commence station keep attempt with GLV Stage II
	2	2/3	0:50	Aborted rendezvous with Titan second stage
			2:30	Blood pressure (McDivitt)
			2:50	Delayed EVA for one orbit
	3	3/4	3:05	Medical data (White)
			4:10	Blood pressure (McDivitt)
			4:25	EVA start (White)
	4	4/5	4:55	EVA end
			5:20	Meal break (both)
	5	5/6	7:20	Blood pressure (McDivitt)
			7:30	Rest period begins (White)

			7:45	Experiments MSC-2 & -3 ON; experiment MSC-1 ON
White Shift FD Kranz			7:50	Update experiment D-8
	6	6/7	8:30	Experiment M-3
			9:10	Meal break (McDivitt)
	7	7/8	10:10	Experiment MSC-1 OFF
			11:10	Rest period ends (White)
	8	8/9	11:20	Experiment D-8
			11:25	Rest period begins (McDivitt)
			11:50	Experiment MSC-2 & -3 OFF
			12:00	Experiment S-6
			12:00	Typhoon Babe
	9	9/10		
	FLIGHT DAY TWO (FD2) JUNE 4			
Blue Shift FD Hodge	10	10/11	14:55	Orbit navigation check Run 1 (no fuel)
			15:40	Rest period ends (McDivitt)
	11	11/12	16:00	Meal break (McDivitt)
	12	12/13	17:45	Experiment S-6 (no fuel)
			18:30	Meal break (both)
			18:45	Experiment M-3
	13	13/14	20:30	Rest period starts (McDivitt)
	14	14/15	21:05	Orbit navigation check Run 2 (no fuel)
Red Shift FD Kraft	15	16/17	22:35	Apollo Landmark Investigation – run 1 (no fuel)
			22:55	Meal break (White)
	16	17/18	24:25	Experiment M-3
	17	18/19	25:55	HF test at sunset
			26:05	Medical data procedure 2 (McDivitt)
			26:15	HF test at night
	18	19/20	27:10	HF test in daylight
			27:55	HF test at sunrise
	19	20/21	28:55	Experiment M-3
			29:05	Rest period (White)
White Shift FD Kranz			30:00	McDivitt sights satellite with arms
	20	21/22	30:10	Meal break (McDivitt)
			31:35	Experiments MSC-2 & -3 ON
			31:40	Orbit navigation check Run 3
	21	22/23	32:40	Rest period (McDivitt)
			33:00	Experiment S-6
			33:15	Experiment MSC-1 ON
	22	23/24	33:30	Spacecraft blunt end forward for experiments MSC-2 & -3
			33:45	Experiment D-8
			33:45	Experiment MSC-1 OFF
			34:40	Meal break (White)
	23	24/25	34:55	Experiment D-8
			35:25	Experiments MSC-2 & -3 OFF
			35:55	Meal break (McDivitt)

	24	25/26	36:30	Rest period (White)
			36:55	Orbit navigation check Run 4 (no fuel)
	FLIGHT DAY THREE (FD3) JUNE 5			
Blue Shift FD Hodge	25	26/27	38:30	Experiment S-6 (no fuel)
			39:30	Blood pressure (McDivitt)
	26	27/28		
	27	28/29	41:30	Meal break (both)
			42:00	Rest period (McDivitt)
	28	29/30	43:05	Apollo Landmark Investigation
			43:10	Experiment S-5
			43:10	Experiment S-6
	29	30/31	44:20	Experiment S-6
			45:00	Meal break (White)
			45:15	Experiment M-3
	30	31/32		
Red Shift FD Kraft	31	32/33	48:00	Experiment D-9
			45:50	Experiment S-5
	32	33/34	49:15	Experiment S-6
			49:40	Rest period (White)
			50:25	Orbit navigation check Run 5
	33	34/35	50:35	Experiment S-5
			51:50	Apollo Landmark Investigation
	34	36/37	52:10	Experiment MSC-1 ON
			52:15	SPADATS tracking
			52:20	Experiment MSC-1 OFF
			52:30	Experiment D-9
			52:35	Apollo 4
White Shift FD Kranz	35	37/38	53:55	Meal break (both)
			55:15	Orbit navigation check Run 6
	36	38/39	55:20	Experiments MSC-2 & -3 ON
			55:30	Rest period (White)
			56:35	Experiment S-6
	37	39/40	57:15	Meal break (McDivitt)
	38	40/41	58:55	Experiment MSC-2 & -3 OFF
			59:00	Meal break (White)
	39	41/42	60:15	Experiment D-8
			60:15	Rest period (McDivitt)
	FLIGHT DAY FOUR (FD4) JUNE 6			
Blue Shift FD Hodge	40	42/43	62:10	Orbit navigation check Run 7
			62:45	Experiment D-9 Run 2
	41	43/44		
	42	44/45	65:20	Apollo Landmark Investigation
			65:45	Meal break (both)
	43	45/46	66:40	Experiment S-6
			67:40	Experiment MSC-1 ON
	44	46/47	67:50	Acquisition aid circuit breaker – OPEN (5 minutes)
			67:55	Experiment MSC-10

			68:20	Horizon sensor ON
			68:35	Horizon sensor sunset check
			69:00	Horizon sensor moonset check
			69:15	Apollo night orientation check
Red Shift FD Kraft	45	47/48	69:45	Horizon sensor thruster check
			69:50	Horizon sensor tracking check
			70:00	One attitude thruster failure check
			70:10	Power down spacecraft
			70:10	Experiment MSC-1 OFF
			70:35	Experiment M-3
	46	48/49	71:15	Rest period (White)
			71:45	Check spacecraft for GO/NO-GO
			72:00	Meal break (McDivitt)
	47	49/50	72:55	Orbit navigation check Run 8
			73:55	All Systems - GO
			74:00	Apollo Landmark Investigation
	48	50/51	74:20	Report computer would not turn off
			75:30	Orbit navigation check Run 9
	49	51/52	76:35	Experiment M-3
			76:40	Spacecraft checks on computer malfunction
White Shift FD Kranz	50	52/53	77:35	Experiment D-9
			78:20	Meal break (both)
			78:50	Experiments MSC-2 & -3 ON
			79:00	Orbit navigation check Run 10
	51	53/54	79:15	Thruster plume photos
			79:55	Computer troubleshooting
			80:00	Platform power-up
			80:00	Experiment S-6
			80:00	Rest period (McDivitt)
	52	54/55	80:35	Experiment D-8
			80:30	Experiment MSC-2 & -3 ON small end forward
	53	55/56	82:00	Meal break (White)
			82:03	Experiment S-6
			82:05	Experiment D-8
			82:25	Experiment MSC-2 & -3 OFF
			83:20	Experiment summary from spacecraft
	54	57/58		
	FLIGHT DAY FIVE (FD5) JUNE 7			
Blue Shift FD Hodge	55	58/59	86:25	Experiment D-9
	56	59/60	87:00	Rest period (White)
	57	60/61	89:05	Apollo Landmark Investigation
			89:15	Experiment M-3
			89:25	Meal break (McDivitt)
	58	61/62	90:15	Apollo Landmark Investigation
	59	62/63	92:30	Rest period (McDivitt)
	60	63/64	93:25	Experiment M-3

			93:50	Re-entry C-band cont.
Red Shift FD Kraft	61	64/65	94:50	Biomedical jumper [leads] plugs installed
			95:45	Experiment M-3
			95:55	Power-up spacecraft & align platform
	62	65/66	96:30	Pre-retro list
			96:40	Experiment MSC-1 ON
			97:15	OAMS translation
	RE-ENTRY PHASE JUNE 7			
	62	65/66	97:28:02	Initiate pre-retrofire maneuver
			97:40:01	Retrofire
			97:40:47	Retro Adapter separation
			97:44:59	Blackout begins
			97:45:??	Experiment MSC-1 OFF
			97:49:14	Blackout ends
	RECOVERY PHASE JUNE 7			
			97:50:53	Deployment of drogue parachute
			97:52:11	Deployment of pilot parachute
				Deployment of main parachute
			97:55:??	Post-main checklist
				2-point suspension
			97:56:12	Landing (14:28 EST)
			98:26:00	Recovery of crew by helicopter
			98:53:00	Crew on deck of USS *Wasp* prime recovery vessel
			100:13:00	Recovery of spacecraft

GEMINI 4 POST-FLIGHT ACTIVITIES	
Date	**Event**
June 7	Initial post-flight medicals on USS *Wasp*
June 8	Medical debriefing & tests on USS *Wasp*
June 9	Technical debriefing on USS *Wasp*
June 10	Departed USS *Wasp* for Ellington AFB, Texas; then MSC
June 11	Houston crew post-flight press conference, MSC Houston, Texas; President Johnson visits MSC
June	Spent most of the weekend with their families

June 12	Spent most of the weekend with their families
June 13	Crew honored guests at Houston Chamber of Commerce evening dinner
June 14	Ticker-tape parade and ceremonies, Chicago
June 15	Crew awarded honorary Dr. of Astronautical Sciences degrees, University of Michigan, Ann Arbor, Michigan
June 16	McDivitt feted at Jackson, Michigan (home town)
	White feted at San Antonio, Texas (home town)
June 17	Flew to Washington D.C. for ceremonies at the White House.
	Motorcade up Pennsylvania Avenue to the Capitol
	Visited Congress
	State Department dinner
	Guests with families
June 18	Travelled by Presidential plane to Paris Air Show, France
June 19	Met cosmonaut Yuri Gagarin at the Paris Air Show
June 20	Returned to United States
June 21	McDivitt & White reported for duty back at MSC, Houston

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Appendix 2: The Gemini 4 Experiments

For clarity, each of the experiments assigned to Gemini 4 is listed separately here as a quick-look reference, in support of their descriptions and operations in the main text.

The experiments flown on the second manned Gemini mission were intended, according to the official mission report, “to extend man’s knowledge of space and to develop further the ability to sustain life in the space environment . ” These investigations utilized the first significant increase in orbital duration on a U.S. manned spaceflight and pioneered a broad program of research that would be conducted on the remaining missions in the program.

The previous longest American spaceflight, two years earlier, had been the 34-hour, 22-orbit mission of Gordon Cooper in Mercury-Atlas 9 (*Faith 7*). The leap to a four-day (98-hour) 62-orbit sojourn by Jim McDivitt and Ed White offered the first real opportunity for prolonged experiment activity. Without the additional flight objectives of rendezvous and docking that would occupy the later crews, Gemini 4, the first of three planned long-duration missions, also presented the best opportunity to insert experiments into the flight plan, to occupy the crew's time and to gain the maximum from the time on-orbit.

The Experiments

The late addition of the full-exit ExtraVehicular Activity (EVA) into the flight plan resulted in the removal of two experiments from this flight (D-1, Basic Object Photography and D-6, Surface Photography). These two investigations were rescheduled for a later Gemini mission.

Of the eleven experiments assigned to Gemini 4, three were of a medical nature (M), four were engineering studies (MSC), two were Department of Defense experiments (D) and two were scientific investigations (S).

Department of Defence (D)

Basic Object Photography (D-1) and Surface Photography (D-6)

Deleted due to late inclusion of EVA and reassigned to a later flight.

Radiation in Spacecraft (D-8)

The objective of D-8 was to gather reliable data on the absorbed and total radiation doses entering the crew compartment of Gemini. This was highly relevant to future planning for manned space missions.

D-8 consisted of two active current mode ionization chambers, five small passive dosimeter packets, three telemetry channels and an electrical power cable for each ionization chamber. Potable tissue-equivalent ionization chambers were to measure the dose levels during the South Atlantic Anomaly revolutions and when the spacecraft passed through regions of the inner Van Allen radiation belt. Experiment equipment interfaces with the spacecraft consisted of attaching the ionization chambers and the dosimeter packets inside the cabin, providing electrical power connections and the wiring for telemetry output.

Simple Navigation (D-9)

The objective of D-9 was to prove the feasibility of spacecraft navigation by manual means during flight. Star and horizon sightings and measurements were to be made using a handheld space sextant. The goal was to simplify orbital determination mathematics, so that orientation and the size and shape of the orbit could be obtained with the sextant and an analog computer. The experiment hardware consisted only of the handheld sextant and the experiment's interface with spacecraft consisted solely of provision for stowing the sextant within the cabin.

Engineering (MSC)

The first three experiments under Engineering were all conducted on behalf of the Radiation and Fields Branch of the Advanced Spacecraft Technology Division, Manned Spacecraft Center, and were sponsored by the Office of Manned Space Flight. The fourth experiment, two-color Earth's limb photography, was conducted on behalf of the Instrumentation Laboratory Department of Aeronautics and Astronautics, Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts, and was also sponsored by the NASA Office of Manned Space Flight.

Electrostatic Charge (MSC-1)

Though Gemini 4 was to approach its spent second stage booster, the techniques of true rendezvous and docking would not be attempted until later in the program. There were many hurdles to overcome, even prior to developing the techniques to be used during the Apollo program. One of these centered upon the detection and measurement of any electrostatic charges on the surface of a spacecraft. It was known that natural charging mechanisms and charged particles could be ejected from rocket engines, causing electrostatic potential, so it was imperative to investigate this prior to sending a Gemini to link up physically with an Agena. This was the objective of the MSC-1 experiment on Gemini 4.

There was a real danger from the differences in potential between vehicles during docking. Damage could be inflicted on the structure of the spacecraft or its electronic equipment, and it could even ignite the pyrotechnics aboard the vehicle. By gathering data on the known difference in electrical potential between the spacecraft (its potential) and its ability to store an electrical charge (its capacitance), it would be possible to calculate the net charge on the spacecraft and the energy available for an electrical discharge of a second spacecraft of known potential.

During Gemini 4, an electrostatic potential meter was used to measure the cumulative surface charge on the spacecraft. The data gathered throughout the period of extensive attitude maneuvering and also during retrofire was telemetered to ground stations. Ed White was assigned to activate the experiment by flipping a switch inside the cabin, recording the ON and OFF times into the onboard voice recorder for later comparison with the telemetered data.

Weighing just 1.8 pounds, the electrostatic potential meter consisted of a

Weighing just 1.8 pounds, the electrostatic potential meter consisted of a sensor unit and an electronics unit and was located in the Adapter Section of the spacecraft. The sensor unit was placed so that its face was flush with the outer surface of the spacecraft to gather electrical signals proportional to the spacecraft potential. The data obtained from the sensor was then processed by the electronics unit and adapted to the telemetry systems before transmission to the ground by the tape recorder/receiver system.

Proton-Electron Spectrometer (MSC-2)

The second engineering experiment flown on Gemini 4 was designed to measure the radiation environment immediately outside the spacecraft. By collating such data with radiation measurements made within the spacecraft, it would be possible to predict the radiation levels on future missions and the potential risk to the flight crew. Once again, Ed White was tasked with switching the experiment ON and OFF and recording the times he activated or deactivated the device on the voice recorder.

The proton-electron spectrometer, with a mass of about 12.5 pounds, was located in the spacecraft Adapter Section, with the face of the sensor pointing to the rear of the spacecraft. The spectrometer measured the number and energy of electrons and protons, again telemetering its findings to the ground.

The experiment was operated while the spacecraft was flying through the region known as the South Atlantic (geomagnetic) Anomaly. This is defined by the coordinates 30 degrees east and 60 degrees west longitude, and 15 degrees south and 55 degrees south latitude. It is here that the Van Allen radiation belt dips closest to the Earth due to the irregular strength of the Earth’s magnetic field.

Tri-Axis Magnetometer (MSC-3)

This experiment operated at the same time and in the same region as the spectrometer experiment, and once more Ed White was its primary operator, this time with two switches. One of the switches activated the boom and was a one-time action as the boom was not retracted. The second switch operated both the spectrometer and magnetometer experiments. The data the instrument obtained was telemetered to the ground stations.

The objective of this experiment, whose data was used to collate the radiation measurements from the spectrometer experiment, was to monitor the detection and amplitude of the Earth’s magnetic field with respect to the spacecraft. The spectrometer was unable to determine the directional distribution of the trapped radiation at the altitude Gemini 4 flew. In addition, that altitude data was insufficient to determine the relative orientation of the planet’s geomagnetic field during periods of drifting flight. Therefore, both types of measurement were necessary to correlate the desired radiation measurements. For this experiment, a 3.5-pound, tri-axis flux-gate magnetometer, consisting of an electronics unit and sensors, was located in the equipment Adapter Section, positioned so that the sensors faced aft. These sensors were located on a boom which could be extended (but not retracted) beyond the end of the Adapter.

Operating in the same region and at the same time as the spectrometer, the sensors on the magnetometer measured vector components of the magnetic field. Measuring each component enabled referencing of the direction of each field line to the spacecraft and spectrometer experiment. Once the field line direction and the pitch angle for the charged particles were known, estimations of the data from the spectrometer could be related to the total charged particle strikes on the spacecraft.

Two-Color Earth's Limb Photography (MSC-10)

This was a continuation of an experiment flown during Project Mercury, involving photography of the Earth's limb, the planet's outer edge of brightness, to determine the excess elevation of the blue limb over the red. Following the mission, the photographs were analyzed and measurements used to determine whether the elevation of the Earth's limb might be a valuable and reliable aid for future manned spaceflight guidance and navigation sightings.

Once Gemini had been orientated along its orbital track, no further attitude maneuvering was required as each sequence of images was taken. Ed White used a handheld Hasselblad camera with black-and-white film and a special filter mosaic, allowing each picture to be taken particularly through the red and partly thought the blue filters. Each frame was filtered centrally through the red filter, with the blue filter used on each side of the frame. The one-pound film magazine was specially modified to include a two-color mount just in front of the film plane.

Operationally, White conducted the experiment during the day-side portion of an orbit. He would aim the camera at the horizon directly in front of him and along the spacecraft's line of flight. Then, as the sunlit Earth's limb became visible, White would take three photographs in succession, followed five minutes later by another group of three pictures. This enabled nine or more such groups to be taken during the day-side portion of an orbit, when the sunlit limb was visible. Between taking the groups of photos, White was free to do other tasks, but it was important not to remove the experiment film magazine from the camera and he could not alter the camera settings. If he was interrupted, he was able to try again on a subsequent day-side orbit pass, but was unable to remove the film magazine until they had completed the experiment. As the magazine held approximately 36 frames, this allowed up to nine exposures of unrelated phenomena to be taken during the experiment.

Scientific (S)

The ability to take high-quality images of the Earth has been one of the highlights of space programs since the 1960s. Supplementing the images taken of well-mapped areas on the ground via aerial imagery, space imagery has become a standard for the interpretation of pictures of remote and largely unknown areas on Earth. Of course, space photography of the Earth, its features and phenomena, offers a far greater perspective than could ever be achieved by aerial photography, with broader coverage, greater speeds and the rapid repetition of imaging over the same area. It also offers far greater applications in many areas, such as a wide range of uses in oceanography, meteorology, agriculture, topography and hydrology. Images of the geology of Earth provide references for comparable features on the Moon and other planets, while detailed topographical mapping of the planet provides up-to-date and more detailed maps (with a scale at the time of Gemini 4 in 1965 of 1:1,000,000). Space imagery taken for the field of hydrology offers estimates of the amount of snowfall in particular regions and what the expected run-off of this would be in the spring, helping with flood prevention and control. Finally, space-based oceanography images can reveal the distribution and temperature of ocean currents, or the location of ice to warn shipping. Imagery from space was also showing possibilities for forestry management at the time of Gemini 4 (noting changes in definition), as well as supplementing TV photography from Earth satellites with film of greater resolution.

Fifty years after the flight of Gemini 4, the idea of imagery from space is very familiar, with the fields of interest greatly expanded and many missions and satellites focusing upon the topic. Management of the results will continue to be of interest in the decades ahead. However, in the summer of 1965, the flight of Gemini 4 became the first mission to explore the real potential of Earth photography from space – and from manned spacecraft in particular – following on from the rudimentary images acquired by earlier manned spaceflights. From this mission, and the subsequent Gemini flights, humans began to look at Earth in a different way, with the spectacular images of our home planet revealed to the general public for the first time.

Synoptic Terrain Photography (S-5)

In addition to taking high-quality images of significant land masses to expand the world's database, a secondary objective for the mission was to obtain expand the world's database, a secondary objective for the mission was to obtain high-quality pictures of areas of Earth that were yet to be mapped in detail, in support of specific scientific studies. By studying these photos, scientists – and specifically, geologists – were hoping to uncover additional clues that might help to answer questions on continental drift, the structure of Earth's mantle and the overall structure of the planet's continents.

On Gemini 4, the United States was naturally the primary target, followed by the Arabian Peninsula, east Africa and other areas in the African continent. Though this imagery was of Earth, there was a connection to the studies of the Moon (and planets) and a link to the approaching Apollo lunar program. Images of rift valleys would better help to understand similar features found on the Moon. On Earth, rift valleys extend from Turkey, through Syria, Jordan and the Red Sea area, and on to eastern African as far south as Mozambique. This type of research offered a greater understanding of the Earth's crust and mantle, as well as the possibility of understanding how the rilles on the Moon were formed.

Another area of study for the crew of Gemini 4 was the phenomenon of seif dunes, which are windblown sand dunes found particularly in the Sahara desert, that can be several hundreds of feet high and extend for hundreds of miles in length. These were of particular interest at the time of Gemini 4, as there was scientific speculation that the apparent 'canals' or 'channels' on Mars might be a type of seif dune. From the images obtained during Gemini 4, scientists were expecting to achieve better interpretation of the images from the subsequent flyby of Mars by Marnier 4 the following month. It was also hoped that the Gemini 4 imagery would help to provide a better interpretation of imagery of Mars from Earth-based telescopes.

To obtain the maximum from the experiment, the images were taken, ideally, during the period of maximum daylight (or 09:00–15:00 local time). The crew was directed to photograph subjects of opportunity (which meant interesting areas of land mass) if the cloud cover was at 50 percent over the primary target. To obtain the required images, the crew used a modified Swedish 70-mm Hasselblad camera (Model 500C), with a magazine capacity of 55 frames per roll. To take the images, the nose of Gemini was tilted down for five to ten minutes, with photographs taken every six seconds of a 100-mile-wide area. These images could later be merged to form a continent-wide swath as a continuous photographic strip.

The principle investigator for this experiment was Dr. Paul D. Lowman Jr., a geologist at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

Synoptic Weather Photography (S-6)

According to the mission press kit, this experiment was "designed to make use of man's ability to photograph cloud systems selectively, in color and in greater detail than can be obtained from the current TIROS [Television and Infrared Observation Satellite] meteorology satellite."

During the Gemini 4 mission, the astronauts were to photograph a variety of cloud systems using the 70-mm Hasselblad camera and Ektachrome film, similar to that used in the terrain photography experiment. As with the Earth imagery, the purpose of this experiment was to augment the imagery obtained from meteorology satellites to expand the knowledge of the world's weather systems. Though the meteorology satellites supplied imagery in areas where few, if any, other objectives existed, they were still relatively poor quality, grainy black-and-white TV transmissions compared to today's standards, covering large areas from over 400 miles altitude. With Gemini 4 flying at about 100 miles and using color still cameras, more detailed images could be obtained.

The primary objectives for the S-6 experiment, starting with Gemini 4 but also flown on subsequent flights, was to revisit some of the cloud patterns identified from the TIROS pictures that were not fully understood. These included cellular patterns, cloud bands radiating from a point, apparent shadows of indistinguishable high clouds on low cloud decks, and small vortices sometimes found in the lee of mountainous islands. Gemini 4 was also tasked with obtaining pictures of a variety of storms systems, such as weather fronts, squall lines, or topical disturbances, so that their structure could be better understood, and with photographing several sets of views of the same areas on subsequent passes, to document how various weather phenomena moved and developed.

The experimenters were Kenneth M. Nagler and Stanley D. Soules, both of the Weather Bureau's National Weather Satellite Center (NWSC). Nagler had a dual-role on GT-4, as an experimenter for the weather photography effort and as Head of the Spaceflight Meteorology Group which provided NASA's forecast support for its manned spaceflight programs. Soules had been with the Meteorological Satellite Laboratory, which had previously prepared photographic experiments conducted by Astronauts Wally Schirra and Gordon Cooper on their Mercury flights. For the Gemini 4 experiments, Earth and its cloud systems would be viewed in different portions of the visual and infrared spectra. The experiment mentor was Capt. Robert D. Mercer, USAF, assigned to NASA MSC.

Medical (M)

The Space Medicine Division of the NASA Office of Manned Space Flight sponsored the medical experiments on the mission. Medical checks were based upon voice communications and telemetry. From this data, the doctors were able to evaluate the general health and state of mind of each crewmember, as well as their blood pressure and oral temperature.

In-flight Exerciser (M-3)

One of the objectives of Gemini was to investigate the effects of long-duration spaceflight on the human body, and to help understand the countermeasures required to keep the astronaut fit to accomplish a range of tasks. One such countermeasure was the bungee cord in-flight exerciser used to evaluate a crewmember's condition during physical exercise and determine their work tolerance. While the Gemini spacecraft was larger than the earlier Mercury capsule, the confines of the vehicle were still restrictive for attempting such exercises. It would be almost a decade later before the Americans had sufficient room aboard a spacecraft (the Skylab Orbital Workshop) to be able to evaluate exercise and work capacity in space fully.

The four-day mission of Gemini 4 offered a greater opportunity for NASA to investigate an astronaut's capacity to complete physical work in orbit than they had been able to with the shorter, more confined Mercury missions. The same type of elasticated bungee cord was used, but whereas it had been attached to the 'floor' of Mercury, the Gemini astronauts were able to hold the elasticated cord by means of foot loops. McDivitt and White would pull on the bungee cord once per second for a full minute at various times throughout their orbital flight. Each 'pull' required 60 pounds (27.2 kg) of force to stretch the cord to its limit of 12 inches (30 cm). Prior to and immediately following each exercise period, the astronaut's respiratory rate and blood pressure would be recorded and then monitored, to determine how long it took for both to return to pre-work levels and obtain an indication of the general condition of each astronaut.

In-flight Phonocardiogram (M-4)

To monitor heart muscle deterioration during spaceflight, this experiment featured the use of a microphone on the astronaut's chest to monitor the sound of the heart and record it on the biomedical recorder. This data was then compared with an electrocardiogram to determine the time interval between heart contractions.

Bone Demineralization (M-6)

For several years, studies of the loss of bone calcium had been conducted with patients who were confined to bed or who had been in casts for a long period of time. Using this clinical experience as database, similar studies were conducted on spaceflight crews through the technique of bone density X-rays, to determine whether demineralization had taken place and, if so, to what extent. For this mission, each astronaut's heel bone and the end zone on the fifth finger of the right hand were studied.

Cardiovascular Effects of Spaceflight

This experiment examined the effects of prolonged weightlessness on the human cardiovascular system. This continued the work conducted during Project Mercury and on Gemini 3, in which measurements were taken before, during and after a head-up tilt of 80 degrees from the horizontal. By the time of the Gemini 4 mission, this was considered to be an operational procedure and was no longer classed as an experiment, but it is listed here with the medical investigations.

For this program, pre-and post-flight blood pressure, blood vessel, pulse rate and electrocardiogram measurements were taken on each astronaut. The procedure required no in-flight measurements. From the captured data, it was possible to determine any changes in the cardiovascular and blood volume due to heat stress, the effects of being in a confined environment, dehydration, fatigue and the possible effects of weightlessness.

After the mission, both astronauts were picked up by helicopter and taken to the prime recovery carrier. When they arrived on the carrier's flight deck, they left the helicopter and stood on the ship's deck before retiring to the ship's medical facility. There, they underwent the tilt-table tests and a more comprehensive medical examination. Had they chosen to remain with their spacecraft and be hoisted aboard the recovery vessel, portable biomedical recorders would have been attached to each astronaut before they exited the spacecraft, together with blood pressure and electrocardiogram measurements recorded automatically before, during and shortly after they left the vehicle.

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About the Author

Spaceflight historian David J. Shayler, F.B.I.S. (Fellow of the British Interplanetary Society or – as Dave likes to call it – Future Briton In Space!), was born in England in 1955. His lifelong interest in space exploration began by drawing rockets aged 5, but it was not until the launch of Apollo 8 to the Moon in December 1968 that his interest in human space exploration became a passion. He fondly recalls staying up all night with his grandfather to watch the Apollo 11 moonwalk. Dave joined the British Interplanetary Society as a Member in January 1976, becoming an Associate Fellow in 1983 and Fellow in 1984. He was elected to the Council of the BIS in 2013. His first articles were published by the British Interplanetary Society in the late 1970s and in 1982, he created Astro Info Service (www.astroinfoservice.co.uk) to focus his research efforts.

Dave's first book was published in 1987 and has been followed by more than 20 other titles, featuring works on both the American and Russian space programs, and topics including spacewalking, women in space and the human exploration of Mars. Dave's authorized biography of Skylab 4 astronaut Jerry Carr was published in 2008.

In 1989, Dave applied as a cosmonaut candidate for the U.K. Project Juno program in cooperation with the Soviet Union (now Russia). The mission was to spend seven days in space aboard the space station Mir. Dave did not reach the final selection but progressed further than he expected. The mission was flown by Helen Sharman in May 1991.

Visiting one site where American spaceflight history was made. The author tours Building 30, Mission Control Center at JSC in August 1988 [©AIS Archive].

In support of his research, Dave has visited NASA field centers in Houston and Florida in the United States and the Yuri Gagarin Cosmonaut Training Center in Russia. During these trips, Dave was able to conduct in-depth research, interview many space explorers and workers, tour training facilities and handle real space hardware. He also gained a valuable insight into the activities of a space explorer and the realities of not only flying and living in space, but also what goes into preparing for a mission and planning future programs.

Dave is a friend of many former astronauts and cosmonauts, some of whom have accompanied him on visits to schools across the U.K. For over 30 years, Dave has delivered space-themed presentations and workshops to children and social groups across the U.K. This program is intended to help the younger generation develop an interest in science and technology and the world around them, in addition to informing the general public and interested individuals about the history and development of human space exploration.

Dave lives in the West Midlands region of the U.K. and enjoys spending

Dave lives in the West Midlands region of the U.K. and enjoys spending time with his wife Bel and their young and very large white German Shepherd called Shado, as well as indulging in his love of cooking, fine wines and classical music. His other interests are in reading, especially military history, specifically about the Napoleonic Wars, visiting historical sites and landmarks and following Formula 1 motor racing.

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