SECONDARY SCHOOLS' UNITED NATIONS SYMPOSIUM 2016

NASA: Apollo 13

Chair:
Zayd Omar

Vice Chair:
Caroline Wesley

Crisis Director:
Jeremie Ponak

Assistant Crisis Director:
Ryan Ramos

NOVEMBER 10-13, 2015 | MONTRÉAL, QUÉBEC

Days	Hr	Min	Sec	Sp.	
02	07	50	05	CC	Roger. We copy, and the TV show was great.
02	07	50	12	CMP	Okay, real fine. Okay, I' m going to maneuver to 060, 090, and 0.
02	07	52	58	CC	13, we' ve got one more item for you, when you get a chance. We' d like you to stir up your cryo tanks.
02	07	53	12	CMP	Okay. Stand by.
02	07	55	19	LMP	Okay, Houston --
02	07	55	20	CDR	I believe we' ve had a problem here.
02	07	55	28	CC	This is Houston. Say again please…
02	07	55	35	CDR	Houston, we' ve had a problem…
02	07	55	58	CC	Okay, stand by, 13. We' re looking at it

Dear delegates,

Above is the transcript of the past six minutes. Just around six and a half minutes ago, Apollo 13 and her crew were on live television. Now, we seem to be facing severe instrumentation error. Jim says, O_2 for tank 2 (oxygen tank 2), is showing zero. Whether this be an anomaly or a fact is yet to be determined. However, if it is true then it is not necessary to state further the gravity of the situation that we are in. Our boys are up there in space and they need all the help that they can get. Caroline Wesley and I have gathered you all here today because there is no one smarter or more knowledgeable of the mission. And we need to fix this fast. Time is of the utmost essence. Caroline and myself will be directing this committee personally and all that we care about right now is for you to figure out how we can fix that space ship.

Your Chair,

Zayd Omar

Introduction to Apollo 13:

Apollo 13 was the 13th installation of the Apollo Project, NASA's 13th manned spaceflight program. Slated to launch on the 11th of April, 1970, Apollo 13 was the third batch of U.S. astronauts who were supposed to land on the Moon. Just less than a year before, the July 16th, 1969, launch of Apollo 11, had allowed Neil Armstrong to be the first man on the Moon. The success of Apollo 11 and 12 meant that 13 was just another routine Moon mission. However, NASA quickly found out that when flying to space there is no room for complacency and every little detail is as important as the next.

The Mission:

Objectives: The Apollo 13 mission intended on exploring the Fra Mauro formation and was planned as a 10 day mission.

The Crew:

Commander	James A. Lovell, Jr
Command Module Pilot	John Swigert
Lunar Module Pilot	Fred W. Haise Jr

Apollo 13 was manned by James A. Lovell, John Swigert and Fred Haise Jr. Initially, Kenneth Mattingly II was supposed to be the pilot for the Command Module. However, when backup Lunar Module pilot Charlie Duke contracted rubella seven days before launch, both the prime crew and the backup crew were exposed. It was soon found out that Mattingly was the only person amongst the six backup and prime crew members who had not contracted Rubella as a child, and hence was not immune to the disease. Three days before launch the team physician, fearing that Mattingly faced increased risk of falling ill, grounded Mattingly, thus elevating backup Command Module pilot John Swigert into the main crew[1]. Mattingly, however, never did contract Rubella and eventually got his chance at space flight in the Apollo 15 mission the following year.

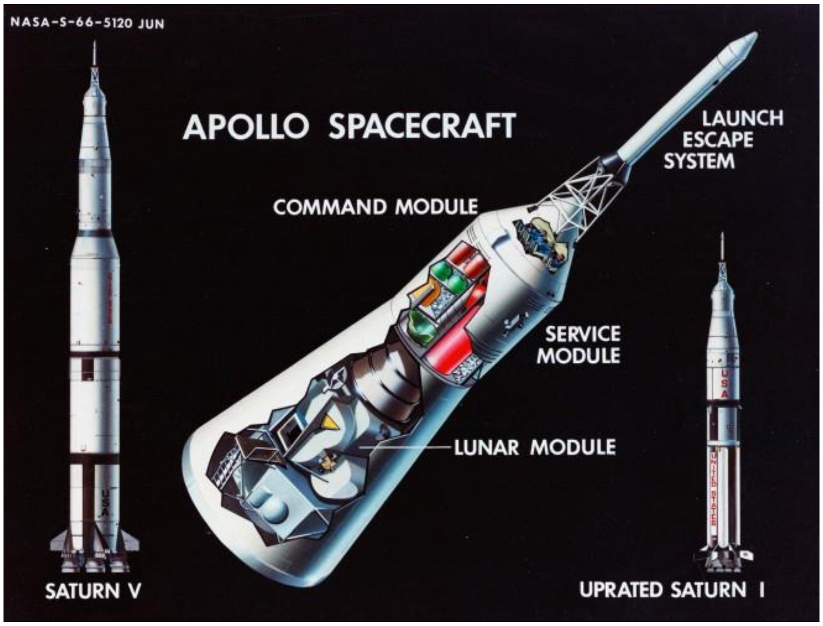
From left to right, the crew of Apollo 13: Lovell, Swigert and Haise

Source:https://upload.wikimedia.org/wikipedia/commons/thumb/1/17/Apollo_13_Prime_Crew.jpg/1280px-Apollo_13_Prime_Crew.jpg

[1] "Astronaut Bio: John L. Swigert". NASA. January 1983. Archived from the original on July 31, 2009. Retrieved August 21, 2009.

The Spacecraft:

Like the two successful Apollos 11 and 12, Apollo 13 used the Saturn-V rocket and the same Lunar Module design. The spaceship also consisted of the Command Module and the Service Module. Upon lift off, the Saturn V rockets would boost the spaceship into space and would eventually decouple putting Service Module, Lunar Module and Command Module in orbit. These three components would carry the astronauts to and from the Moon.



Source: http://www.wired.com/2012/06/apollo-lunar-orbit-rescue-1965/

Recreation of Apollo 11, Service Module, Command Module and Lunar Module before undocking

Source: http://talesofcuriosity.com/v/Apollo/i/comamndandlunar.jpg

Command Module:

The Command Module, named Odyssey for Apollo 13, lay in between the Service Module and the Lunar Module. The Command Module housed all the navigational and control panels essential for the flight, as well as the spaceship's computer. Along with this, it also acted as the cabin for the three-man crew. The other critical features of the Command Module were the heat shield and the three gyroscopes housed near the nose of the Command Module and the Carbon Dioxide scrubbers.

The heat shield was essential for reentry to Earth during the end of the mission, and without it the astronauts would forever be lost in space. During reentry into Earth, the Earth's gravity causes objects to accelerate to very high speeds. The high velocity combined with the Earth's atmosphere results in tremendous air resistance (friction) which results in very high temperatures. This is why most asteroids that come into Earth never make it down to the surface. By the time they reach the lower limits of the sky they have 'burnt up'. In the same way, without the heat shield the spaceship would burn up.

Navigational System:

The gyroscopes along with the spaceships navigational computer system formed the Primary Guidance, Navigation and Control System (PGNCS). On Earth, when moving, the frame of reference is the surface of the Earth. With respect to the surface of the Earth, one can go North, South, East or West. These describe longitudinal and latitudinal motions. Based on the motion taken by an observer, one's longitudinal and latitudinal position can very easily be determined, and the exact location of that individual/object may be stated. In addition to longitudinal and latitudinal motions, one can move up or down with respect to the surface of the Earth. This is measured by altitude. Gravity plays a very important role in helping us determine the 'down' position on Earth (towards the centre of the Earth).

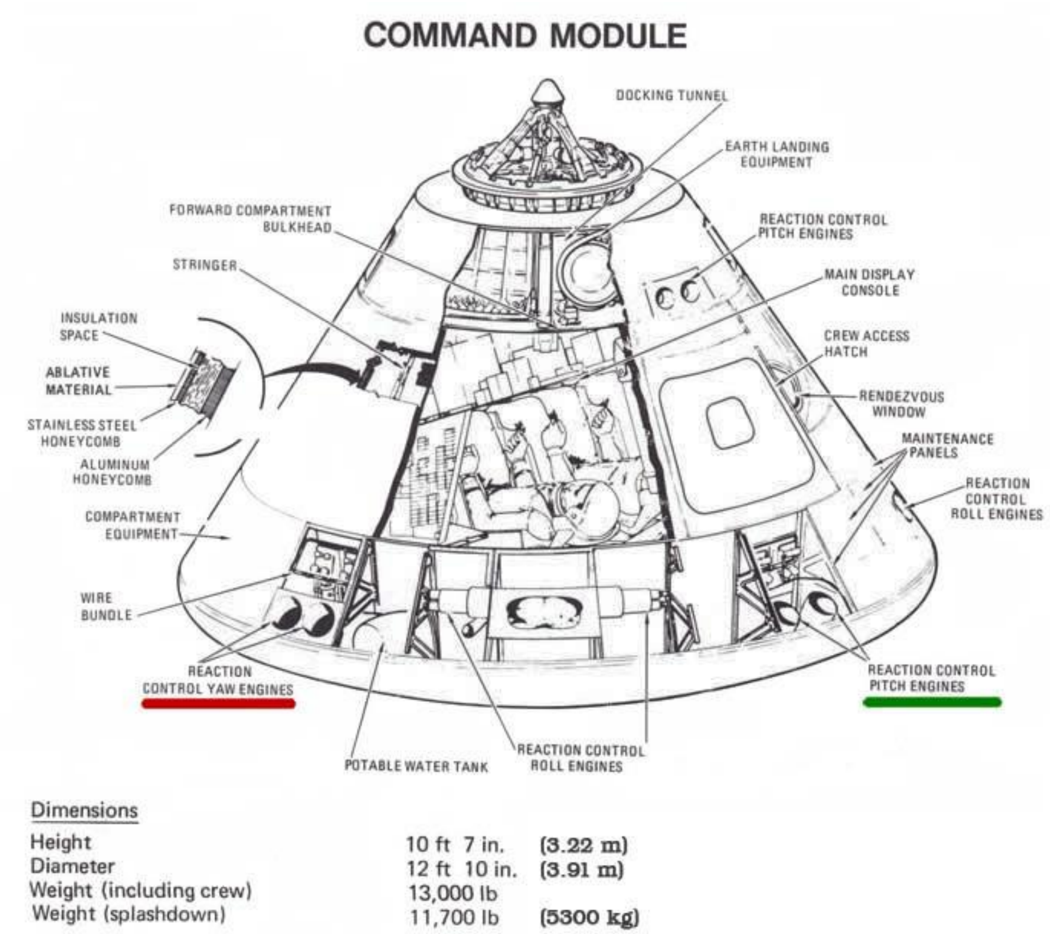
The ground forms an '*absolute*' frame of reference for objects moving on Earth. Everything else forms a '*relative*' frame of reference for a moving object. For example, imagine an empty field with a perfectly cylindrical tree at the centre which looks the same no matter which side you look at it from. Now if we start walking with our eyes fixed on the tree, we can walk towards the tree, walk away from the tree, walk to the left walk to the right, jump up or kneel down. Now imagine you take the following 3 steps: one step forward, one step right and another step forward. The way that the tree will appear after the above sequence of motion will always be the same regardless of whether the person starts his motion from the northern corner southern corner or any other corner of the field for that matter. So with reference to the tree, the position of the walker after the above sequence of motion is NOT UNIQUE. However, with respect to the latitude and longitude (i.e with respect to the ground), it does matter which corner of the field the observer starts walking from. And the hence motion with the ground as the frame of reference gives an absolute or UNIQUE location of that person.

In space, however, there is no absolute frame of reference, only relative ones. This means that there is no absolute up or down or North or South motion. With respect to the Moon, we can go closer to it, away from it, move up or down, move left or move right, and we would still not be able to uniquely determine our position in space. For example 30,000 km away from the Moon means that one can be that distance away from the Moon in any direction. Now, however, in addition to one's position with respect to the Moon, if we add one's position with respect to the Earth then we get what is seemingly a unique location. And that's how the PNGCS determines the location of the spaceship. The gyroscopes measure the rotational position of the spaceship, and using known constellation maps and the positions of other known celestial objects, the PNGCS computers can give an absolute location of the spaceship allowing astronauts to accurately navigate in space.

To test the accuracy of a Command Module PNGCS, the Command Module is also fitted with a small telescope and a sextant. The astronauts used these to manually check whether the PNGCS has the spaceship pointing in the right direction.

Carbon Dioxide Scrubbers:

The lack of oxygen in space means that spaceships have to carry their own oxygen to support life. As the astronauts breathe in this oxygen, they produce carbon dioxide gas, which at high concentration becomes lethal. To prevent the buildup of dangerous levels of carbon dioxide gas, the Command Module is fitted with lithium hydroxide scrubbers, which absorb the carbon dioxide from the spaceship. These scrubbers on the Command Module were cube shaped. The Command Module had been fitted with enough scrubbers to support a crew for around 10 days.



Source: http://www.aulis.com/command_module.htm

<u>The Service Module:</u>

The Service Module lay behind the Command Module. It housed the many essential things needed to complete the mission. The Service Module contained fuel cells, solar panels and a tank for liquid Hydrogen and two tanks of liquid Oxygen, amongst other things. The oxygen and hydrogen tanks were the fuel that propelled the rocket forward. The reaction between oxygen and hydrogen also provided the water needed for the Astronauts to survive, and power needed for the Command Module.

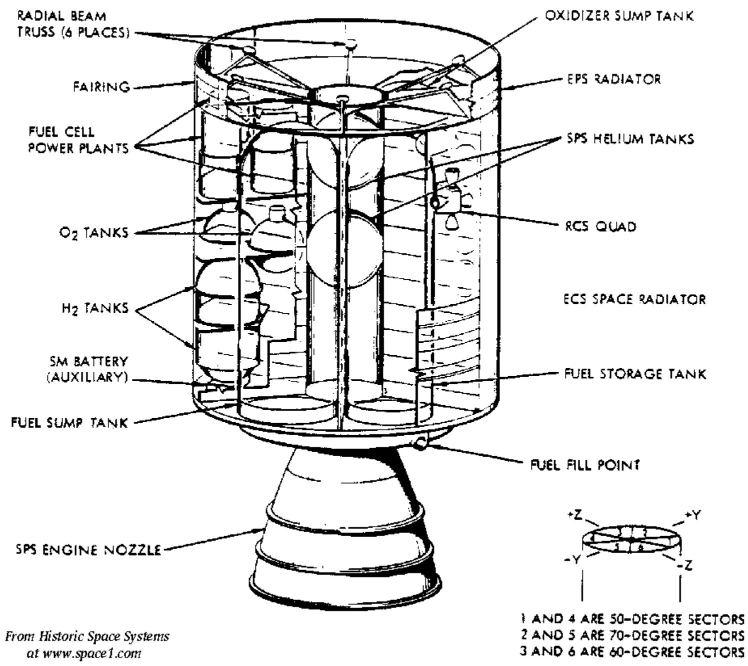
The Service Module was designed to be attached to the Command Module until reentry. During reentry, the Service Module provided an additional protection to the Command Module and would burn up after re-entry.

To measure the amount of fuel (oxygen and hydrogen) left in the tanks, each of the tanks for oxygen and hydrogen were fitted with sensors and meters that relayed this information back to the panels on the Command Module. The oxygen and hydrogen are liquefied by cooling them to extremely low temperatures, and then keeping them in pressurized tanks. The problem with this type of liquefied fuel, particularly for oxygen, is that the temperature inside the tanks is not uniform. The temperature of the liquid oxygen at the top of the tank is higher than the temperature of the oxygen at the bottom of the tank. This results in a phenomenon called **'Thermal Stratification'**[2], and causes the oxygen to stratify (separate) into different layers based on temperature in the tank. As a result of this stratification, accurately measuring the level of fuel in the tanks becomes difficult. To counteract this phenomenon and get reliable measures of the level of fuel stored, the oxygen tanks have a motorized fan built into them. Every now and then the Astronauts would turn on these fans stirring up the contents inside the tanks and **'destratify'** the fuel.

The Service Module contained enough hydrogen and oxygen to support a 10-day flight. This included breathable oxygen, consumable water, power for electronic systems and propulsion. In addition to this, the Service Module was fitted with 3 power cells which help power the Command Module during the crucial process of re-entry when all other sources of power become inactive. These

[2] http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5138753

3 power cells provide around 120 ampere hours of power, just enough needed during the process of reentry.



Source:

http://space1.com/Spacecraft_Data/Handbook_Illustrations/Apollo/Service_Module_Cut/service_module_cut.html

Lunar Module:

The Lunar Module, named Aquarius, was designed for a two-man crew for a mission to the Moon that would last approximately one and a half days. The Lunar Module consisted of two stages, an ascent stage and a descent stage. On its journey to the Moon, the Lunar Module would be docked to the Command and Service Module (CSM) and then when in Lunar Orbit, the assigned crew would transfer into the Lunar Module, undock it from the orbiting CSM. They would then use the descent stage to propel it out of Lunar Orbit and down onto the surface of the Moon. After the Lunar mission was over, the two-man crew would strip the Lunar Module of all non-essential items, in an effort to reduce mass, and fire the ascent stage of the module which would jettison the crew back into Lunar orbit, where they would re-dock with the CSM. Once the crew had transferred back into the CSM, the Lunar Module would be discarded, and the crew and the CSM would be headed back to Earth. Eventually, the gravitational pull of the Moon would pull the Lunar Module back to the surface, which would become the final resting place of the Lunar Module.

Unlike the CSM, which used rocket fuel as a source of power, the Lunar Module was fitted with batteries for both the ascent and descent stage. Also, unlike the CSM, the Lunar Module was designed for astronauts to exit the ship. This meant that Lunar Module needed to have enough oxygen to support full decompression when the door was opened for the astronauts to exit the vehicle and also recompress back to normal pressure when the astronauts came back in. Just like in the CSM, to reduce the levels of carbon dioxide, the Lunar Module was fitted with lithium hydroxide scrubbers. However, unlike in the CSM, the scrubbers in the Lunar Module were spherical in shape and not cubic.

The Descent Stage of the Lunar Module was designed with a large scale propulsion engine known as the Descent Propulsion System, DPS. This was used to propel the Lunar Module out of Lunar orbit after undocking from the CSM on the journey to the surface of the Moon. After landing on the surface of the Moon, to return back to the Command Module, the Ascent Stage booster would jettison the astronauts back the to CSM, leaving behind the Descent Stage on the Moon.

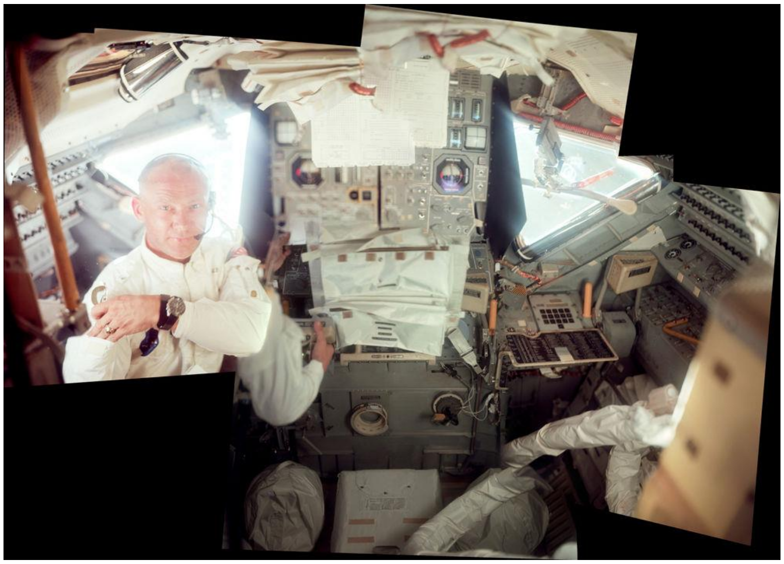
The Lunar Module was fitted with the exact same system of gyroscopes and PGNCS as in the CSM. In addition, the Lunar Module was also fitted with a backup navigational system in the event of a failure of the PNGCS. Known as the Abort Guidance System, AGS, it was not as accurate as the PNGCS in navigating. As a result, the Lunar Module was also fitted with a telescopic unit, so that astronauts could satisfactorily navigate through space. The AGS also consumed significantly less power than PNGCS.

Apollo 11 Lunar Module

Source: http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1969-059C

Separation of Ascent Stage and Descent stage in Lunar Module

Source: http://science.ksc.nasa.gov/mirrors/images/images/pao/AS11/10075186.jpg



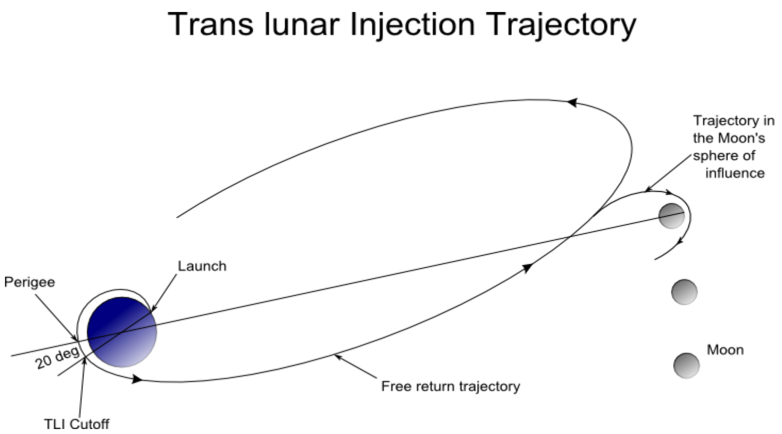
Buzz Aldrin in the Lunar Module- Eagle, used for Apollo 11.

Source:http://www.popsci.com/sites/popsci.com/files/styles/large_1x_/public/import/2013

/images/2013/12/AS11%20Aldrin%20NASA%3AHancock.jpg?itok=_uHdV_vM

Trajectory:

The trajectory of the rocket is set for a Moon landing. The free return trajectory, which is the return of the spaceship back towards Earth due to the Earth's gravity, would result in the spaceship missing the Earth by 2500 miles. Due to this, a circumlunar trajectory will be need to be used with course corrections in order to get the spaceship back to Earth.



Source: http://history.nasa.gov/afj/launchwindow/figs/Fig%205.png

Notes for the Delegates:

This committee will be focused on getting the astronauts to complete their mission. We will start around two days into the mission and then carry on from there. This background guide is designed to familiarize you with the different components of the spaceship that will be needed during this mission so that you can guide the astronauts and help them overcome any obstacle that may appear. Also, watching the movie Apollo 13 will help you prepare for this committee. Although the events are over-dramatized, it does serve as an exciting and informative movie.

List of Acronyms:

AGS: Abort Guidance System

CM: Command Module

CSM: Command Service Module

DPS: Descent Propulsion Stage

LM: Lunar Module

PGNCS: Primary Guidance, Navigational and Control System

SM: Service Module

Character List:

Prime Crew

1. Jim Lovell – Commander

2. Jack Swigert – Command Module Pilot

3. Fred Haise – Lunar Module Pilot

Backup Crew

4. John Young – Commander

5. Charles Duke - Lunar Module Pilot

6. Ken Mattingly (Removed from prime crew 2 days before launch) – Command Module Pilot

Support Crew

7. Vance Brand

8. Jack Lousma

9. Joseph Kerwin

Flight Directors

10. Gene Kranz

11. Glynn Lunney

12. Milt Windler

13. Gerry Griffin

Others

14. John Aaron – Flight Controller

15. Thomas Paine – NASA Administrator

16. George Low – Deputy Administrator

17. Edgar Cortright – NASA Langley Research Center Director

18. Deke Slayton – NASA Director of Flight Crew Operations

19. Sy Liebergot – Mission Controller

20. Tom Stafford – Chief of the Astronaut Office

21. Robert Lauder -NASA PR Director

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6. The Recipe for Apollo 13’s Disaster, Amy Shiera Teitel, Popular Science, Jan 27, 2014.