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THE ADVANCEMENT OF KNOWLEDGE

Mars Buttfield-Addison

One Eye On The Sky: Why You Should Care About Space Junk

twitter.com/RoyalSocTas

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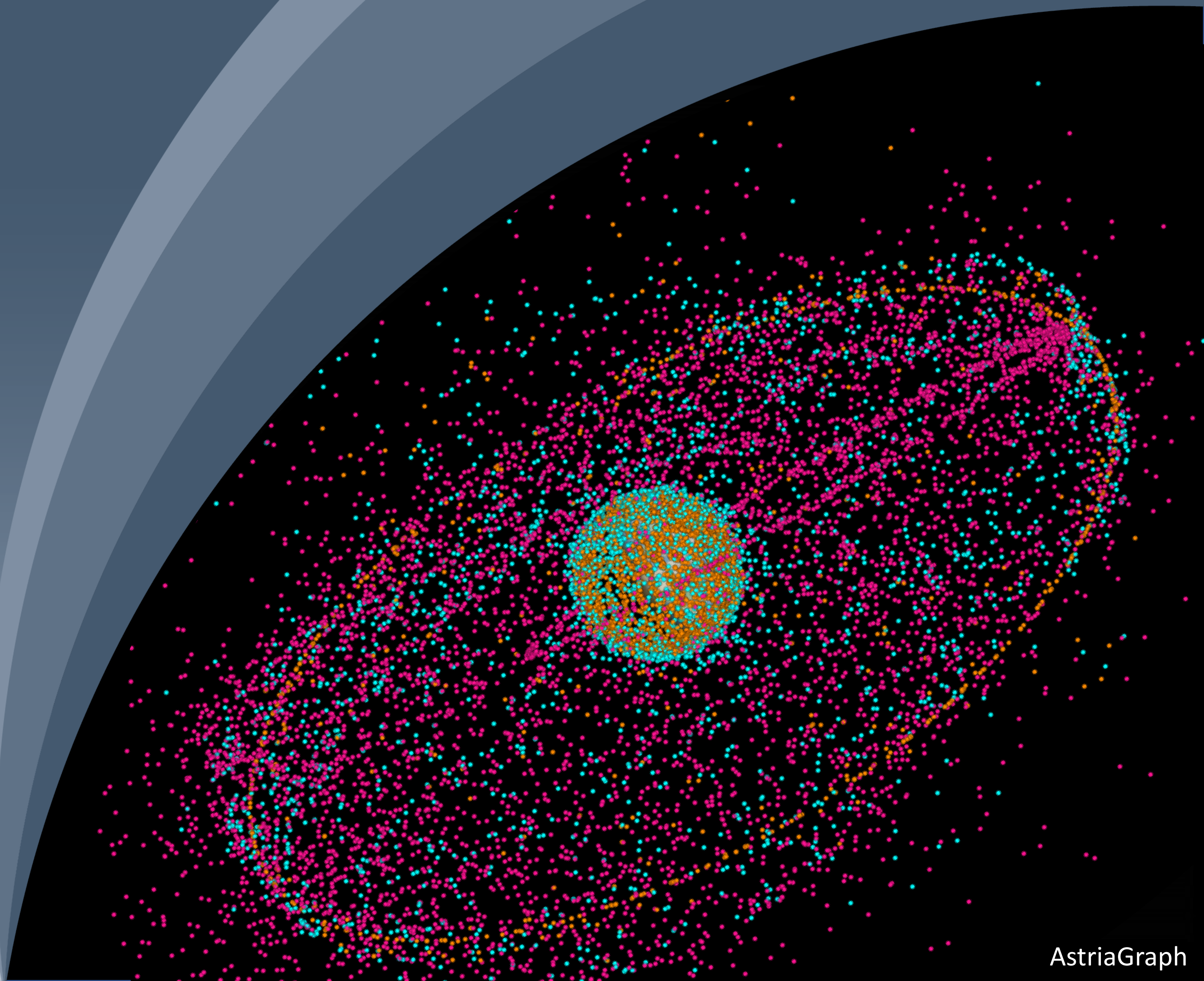
rst.org.au

4 September 2022



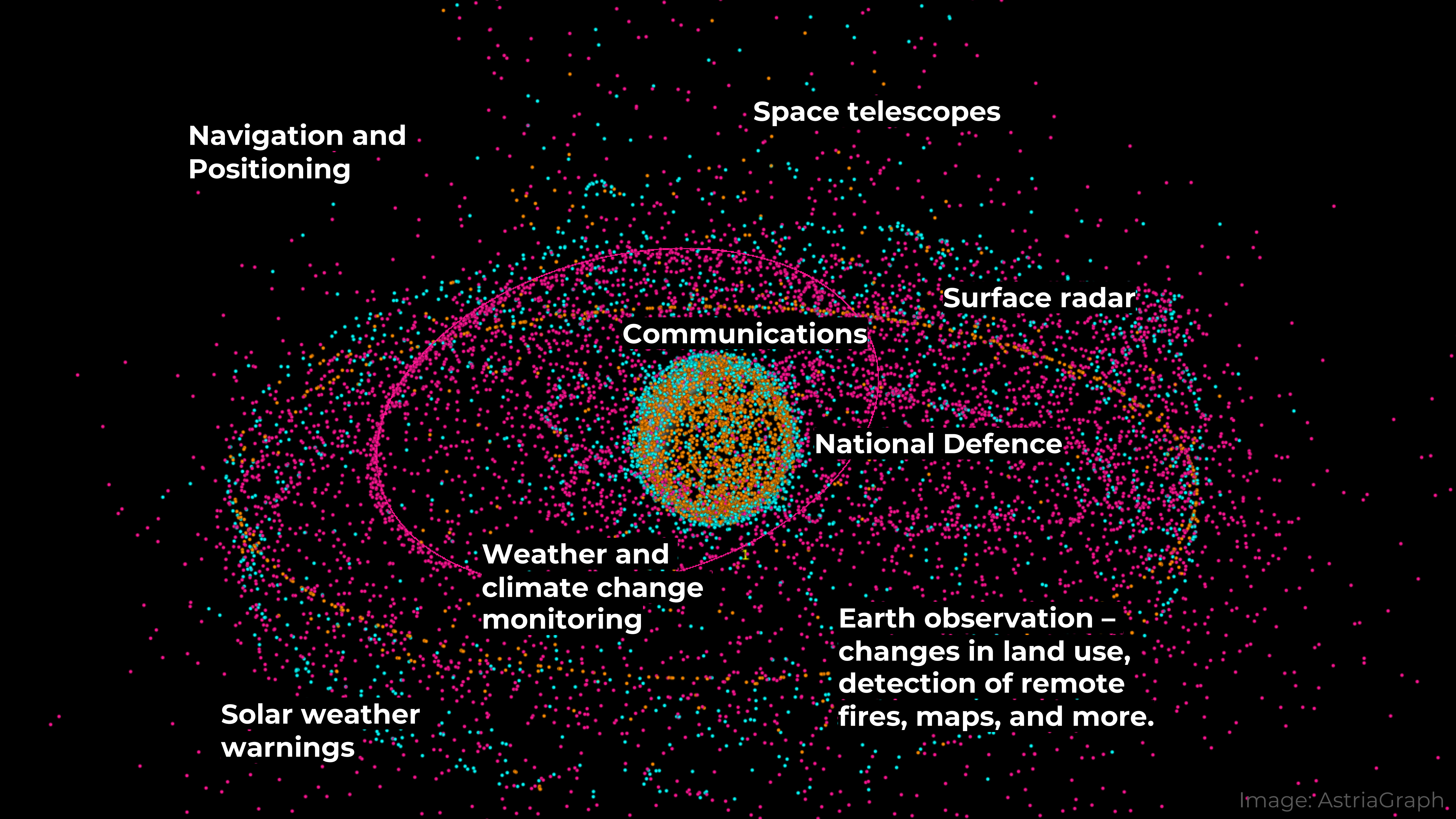
AstriaGraph

One Eye On The Sky

Why You Should Care About Space Junk

MARS BUTTFIELD-ADDISON @TheMartianLife
PhD Candidate, University of Tasmania & CSIRO Data61

Image: Alex Cherney


Navigation and Positioning
Space telescopes
Surface radar
Communications
National Defence
Weather and climate change monitoring
Earth observation – changes in land use, detection of remote fires, maps, and more.
Solar weather warnings
Image: AstriaGraph

How did we get here?

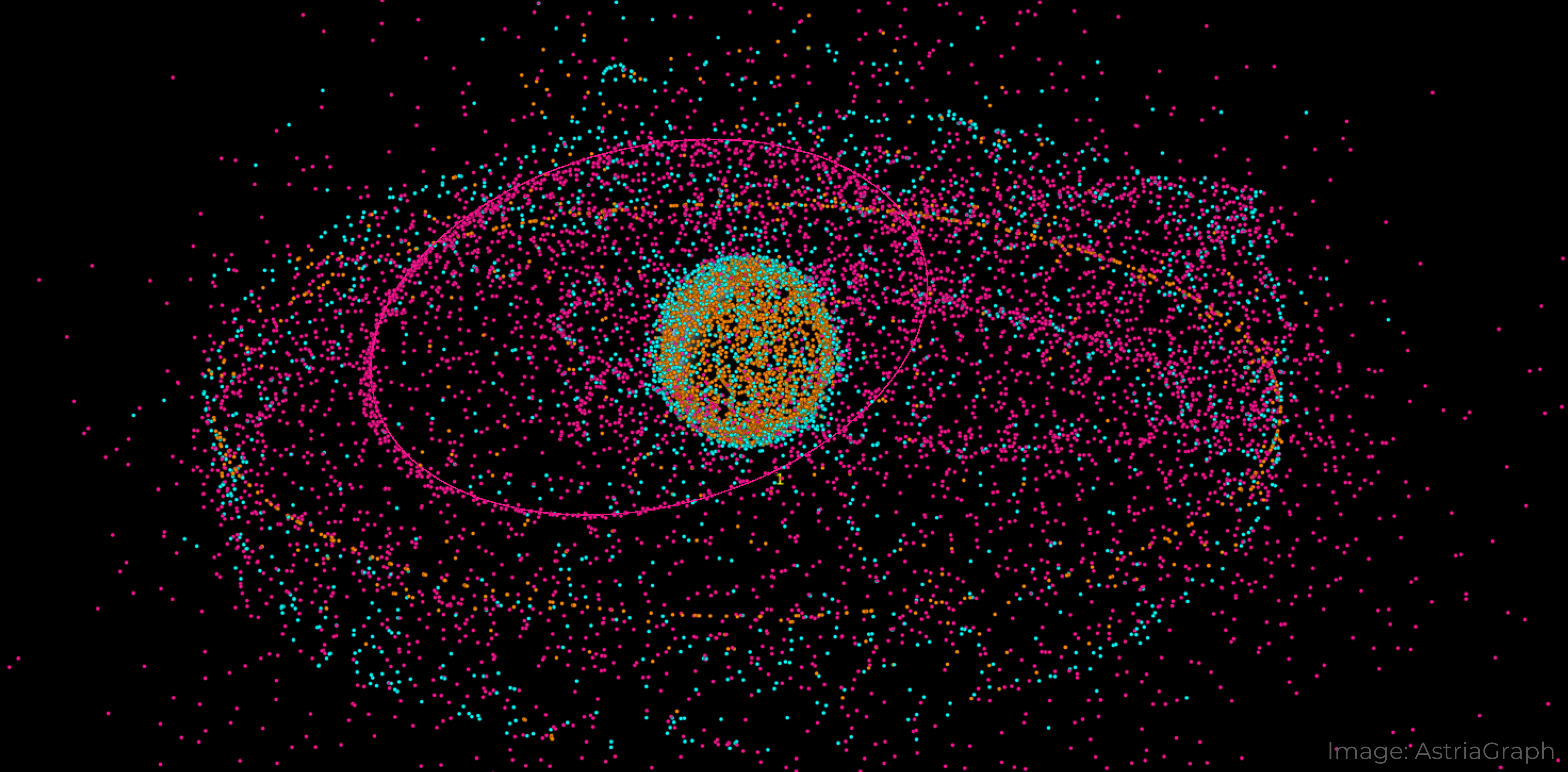


Image: AstriaGraph

1950

ANNÉE
GÉOPHYSIQUE
INTERNATIONALE
1957
1958
INTERNATIONAL
GEOPHYSICAL
YEAR

Silver Springs, Maryland

Sydney Chapman

Images: NAS (top), Terrain (left), Wiley (right)

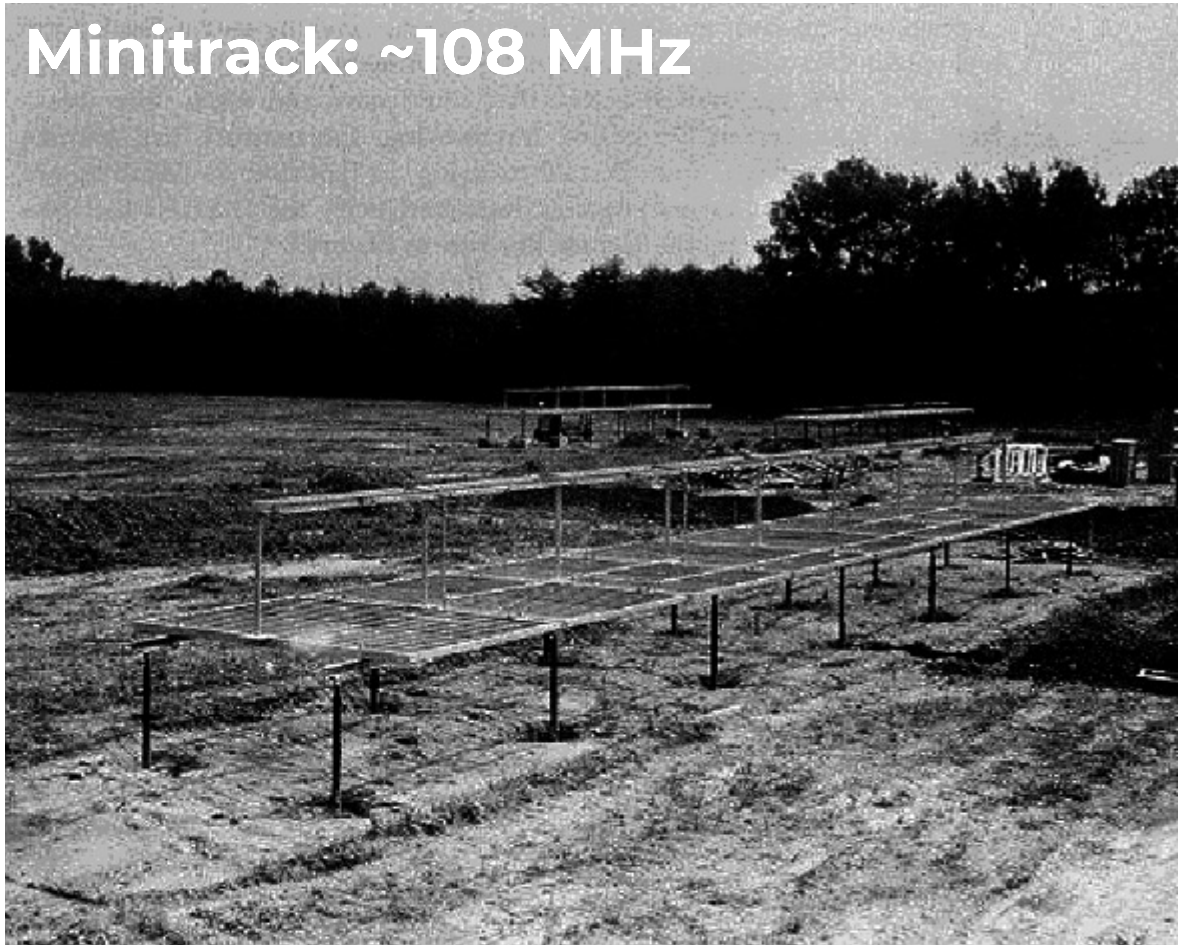
1956

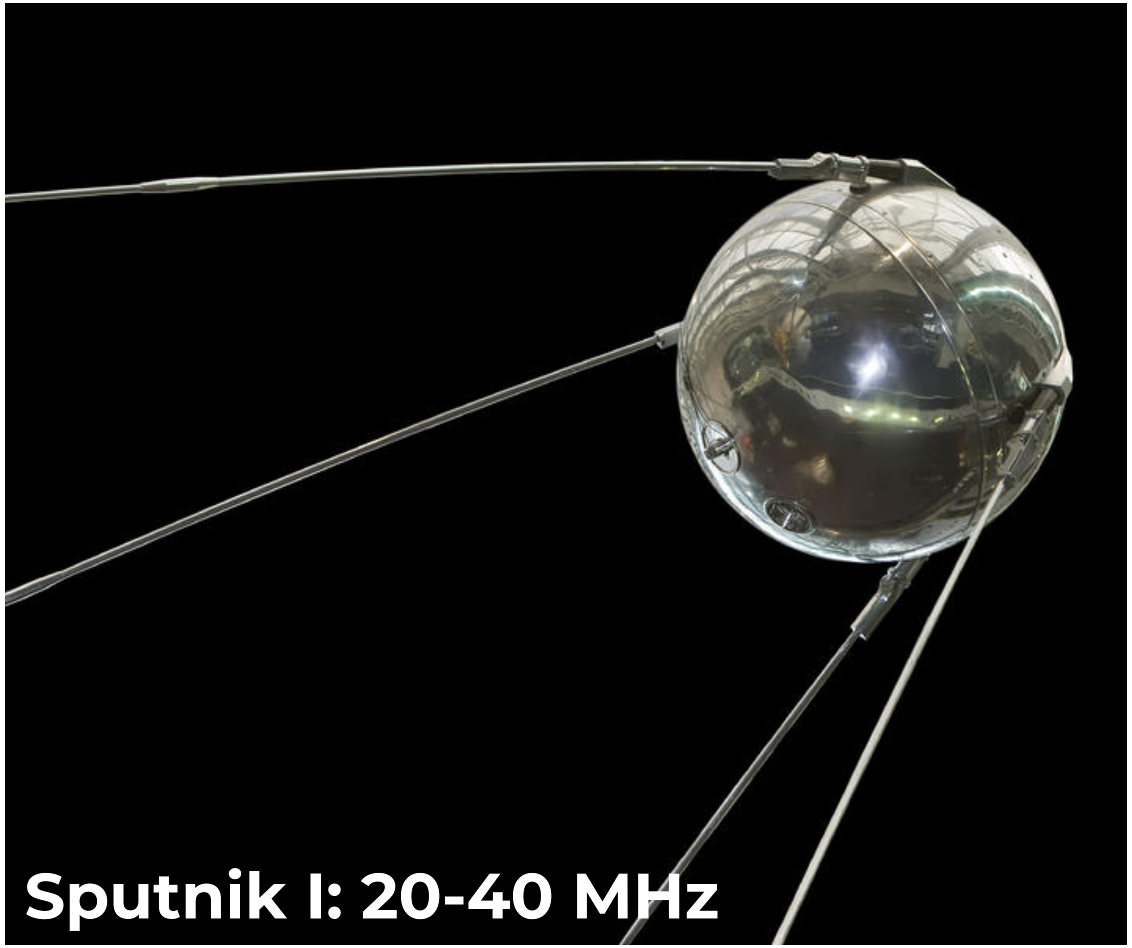
Comité Spécial de l’Année Géophysique Internationale (**CSAGI**)

CSAGI Conference, Barcelona

Images: ICSU (left), Observatori de l’Ebre (right)

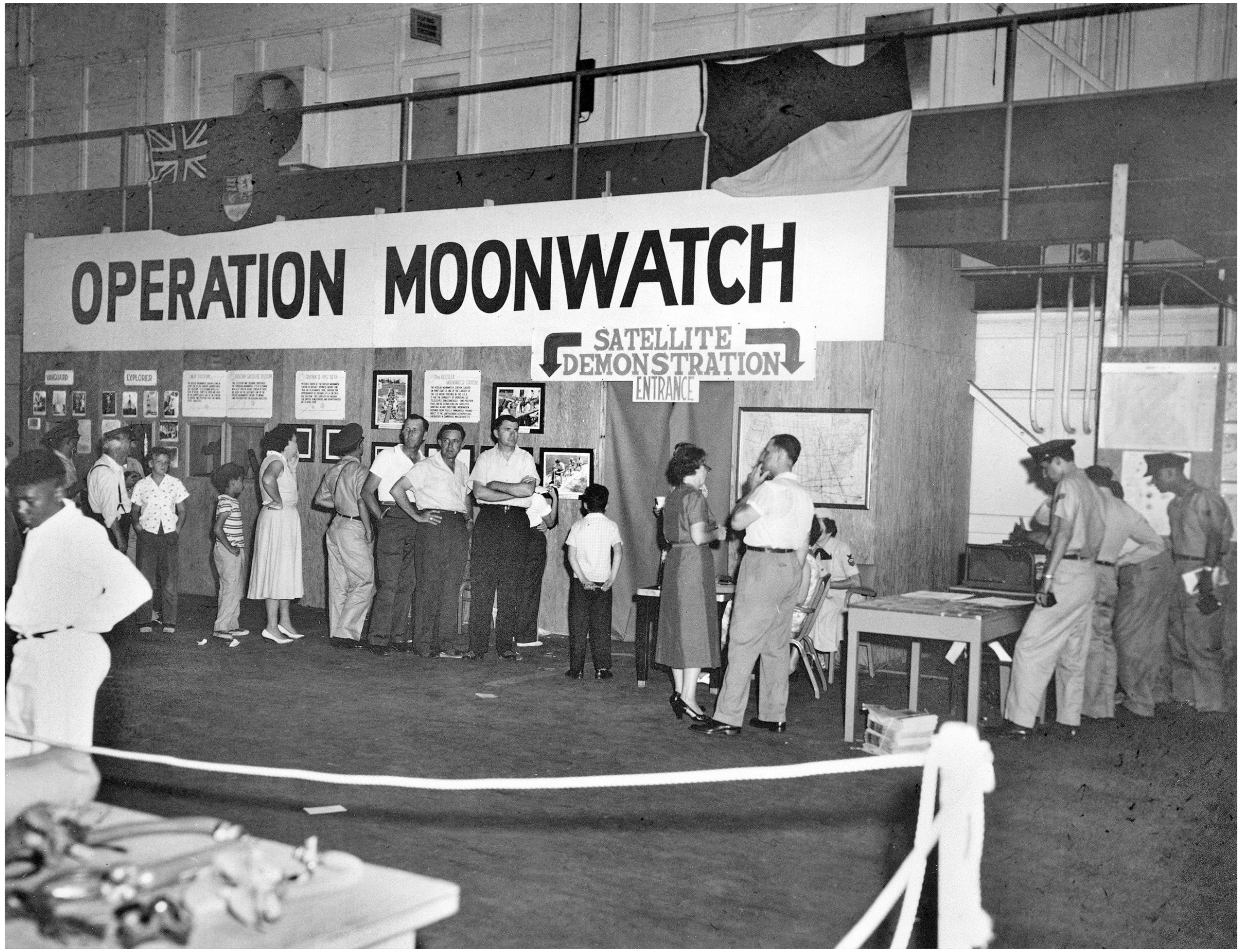
1957





Images: NASA (left), NSSDC (right)

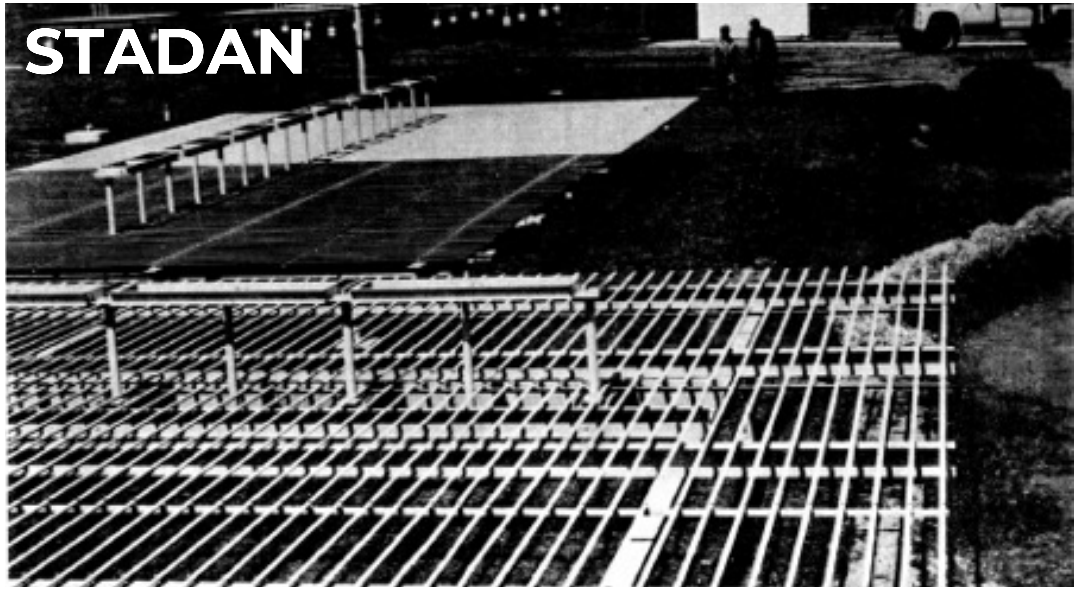
1958

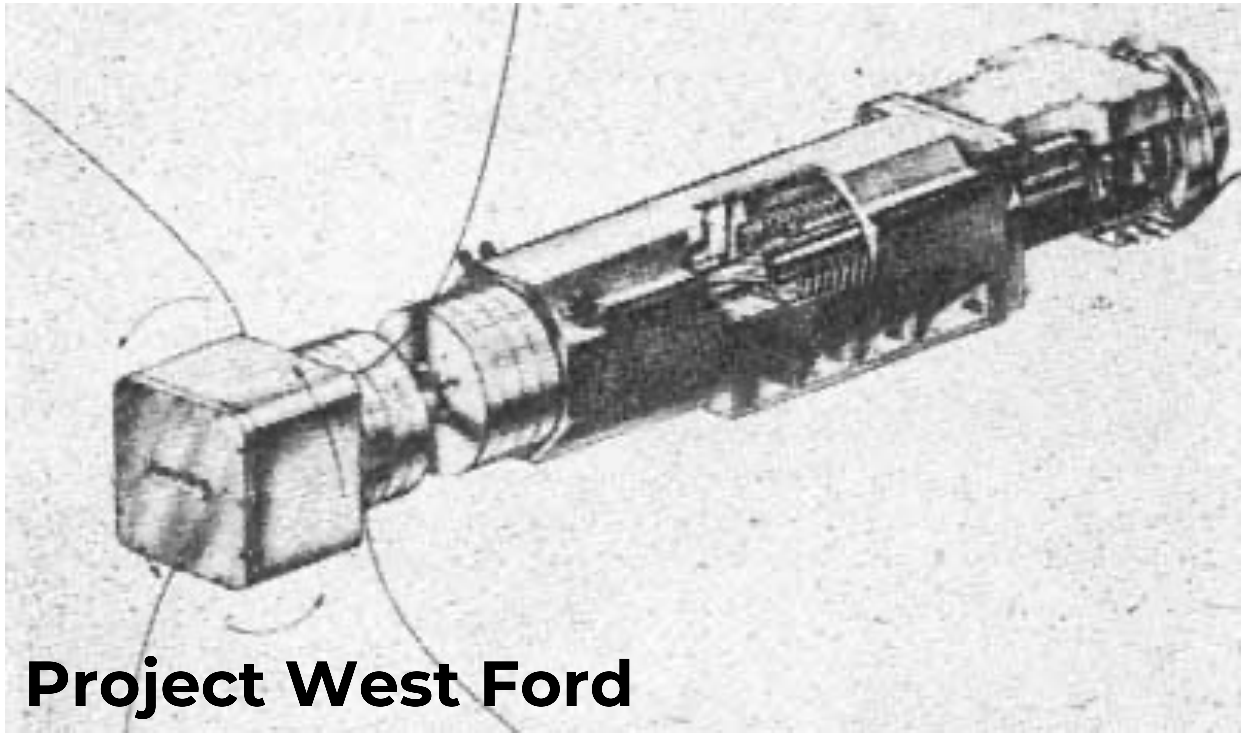



Vanguard I

Images: Smithsonian (left), NASA (right)

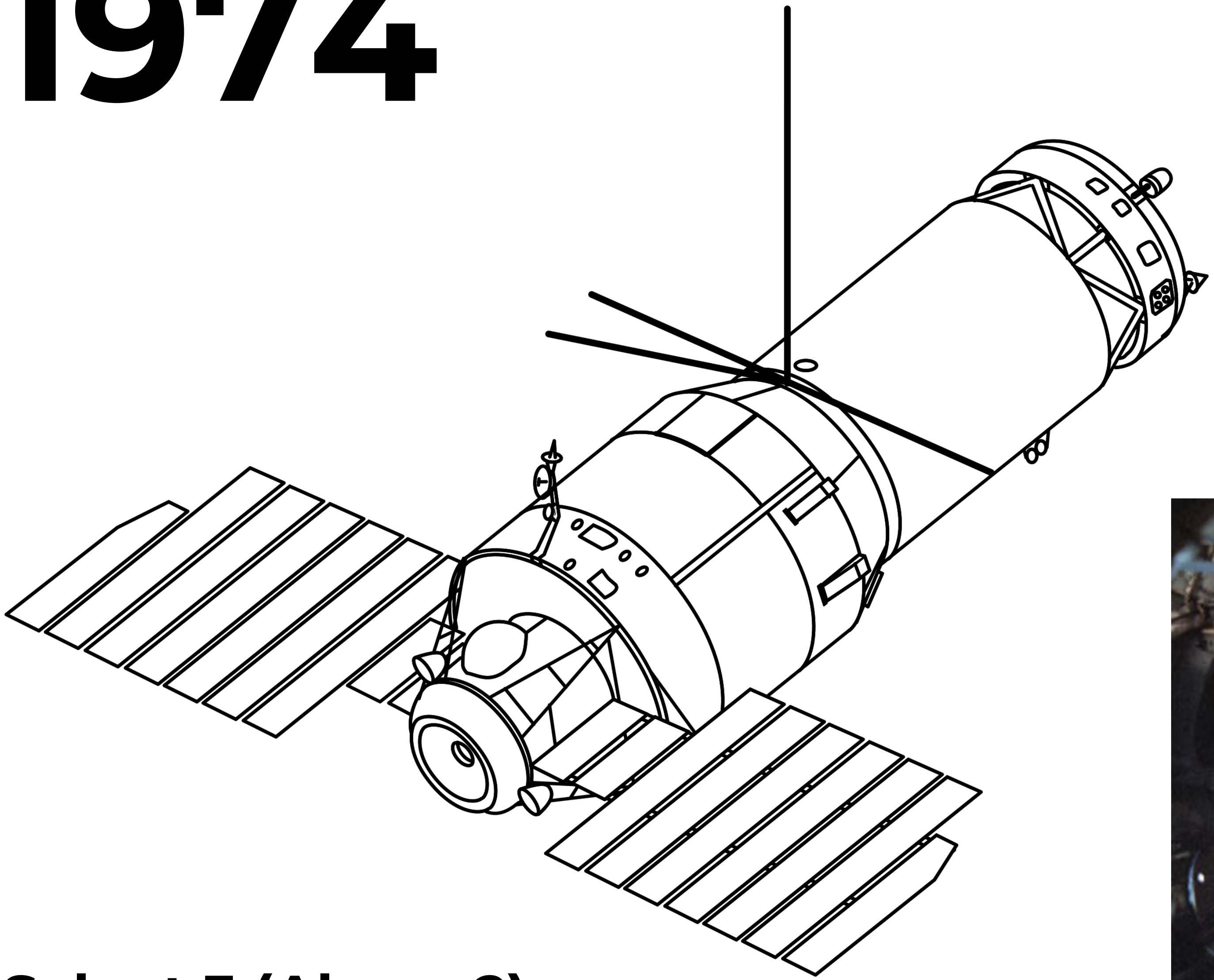
1961


STADAN


Project West Ford

Images: NASA

1974



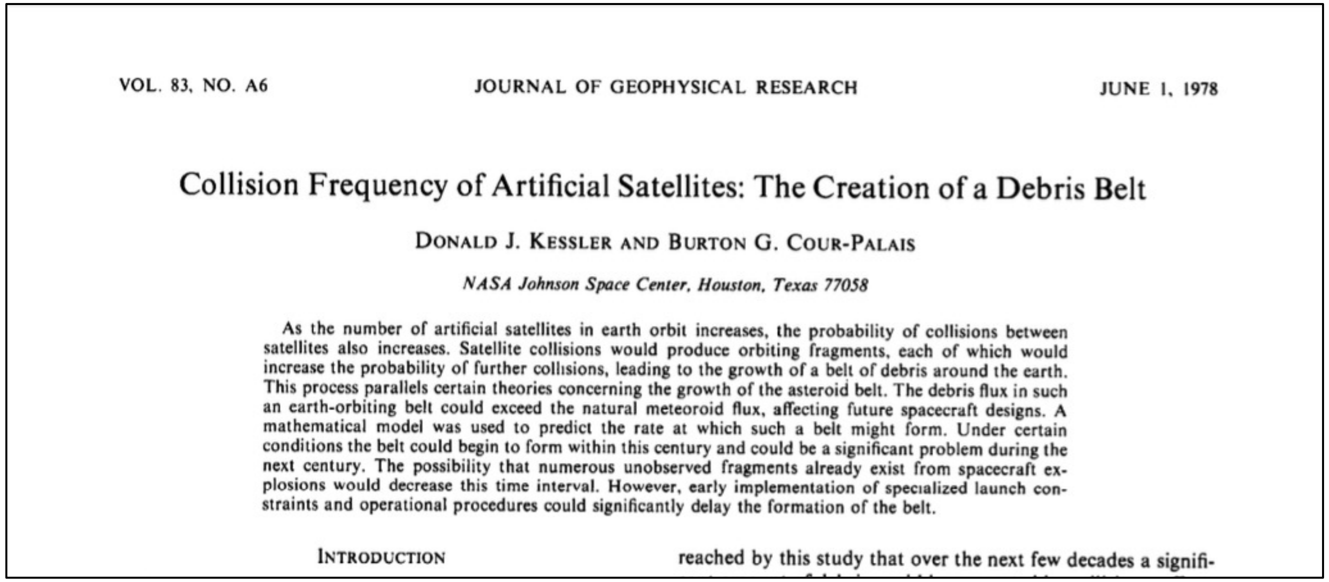
Salyut 3 (Almaz 2)

Images: NASA (left), Russian Ministry of Defence (top), Getty (bottom)

1975

Images: ESA

1978



VOL. 83, NO. A6 JOURNAL OF GEOPHYSICAL RESEARCH JUNE 1, 1978

Collision Frequency of Artificial Satellites: The Creation of a Debris Belt

DONALD J. KESSLER AND BURTON G. COUR-PALAIS

NASA Johnson Space Center, Houston, Texas 77058

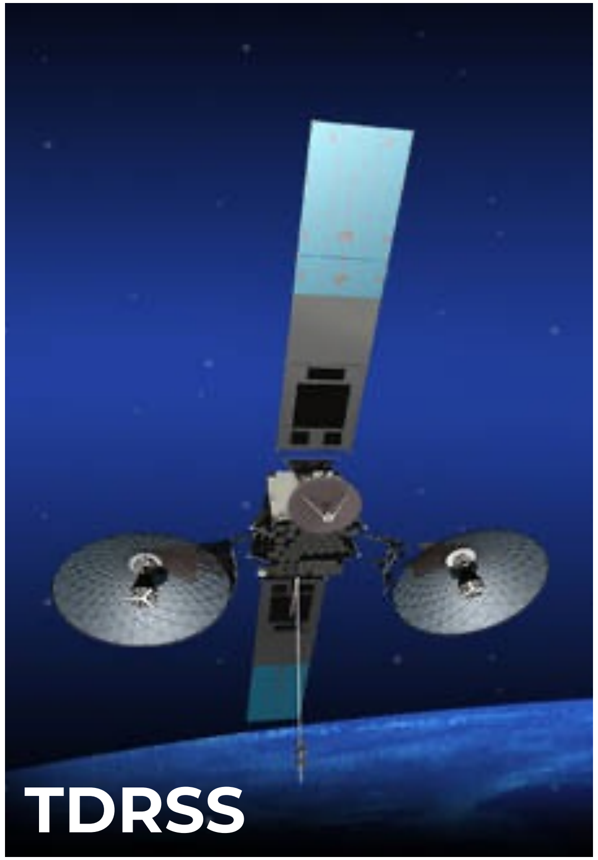
As the number of artificial satellites in earth orbit increases, the probability of collisions between satellites also increases. Satellite collisions would produce orbiting fragments, each of which would increase the probability of further collisions, leading to the growth of a belt of debris around the earth. This process parallels certain theories concerning the growth of the asteroid belt. The debris flux in such an earth-orbiting belt could exceed the natural meteoroid flux, affecting future spacecraft designs. A mathematical model was used to predict the rate at which such a belt might form. Under certain conditions the belt could begin to form within this century and could be a significant problem during the next century. The possibility that numerous unobserved fragments already exist from spacecraft explosions would decrease this time interval. However, early implementation of specialized launch constraints and operational procedures could significantly delay the formation of the belt.

INTRODUCTION

reached by this study that over the next few decades a signifi-

Images: Wiley (left), ESA (right)

1983



Images: NASA

1985

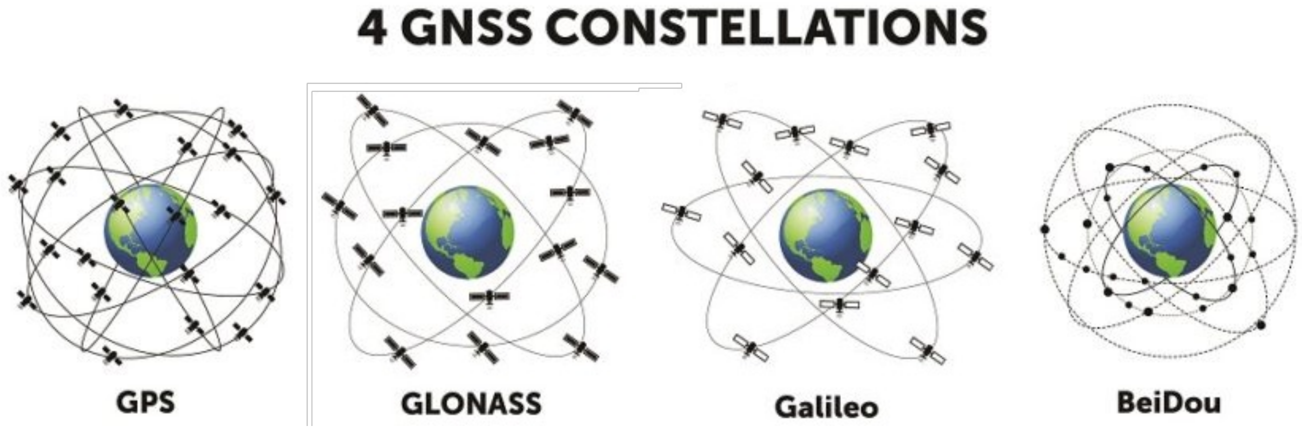
Celestial Eagle
285 pieces of debris

Images: US Air Force (left), Paul E. Reynolds (right)

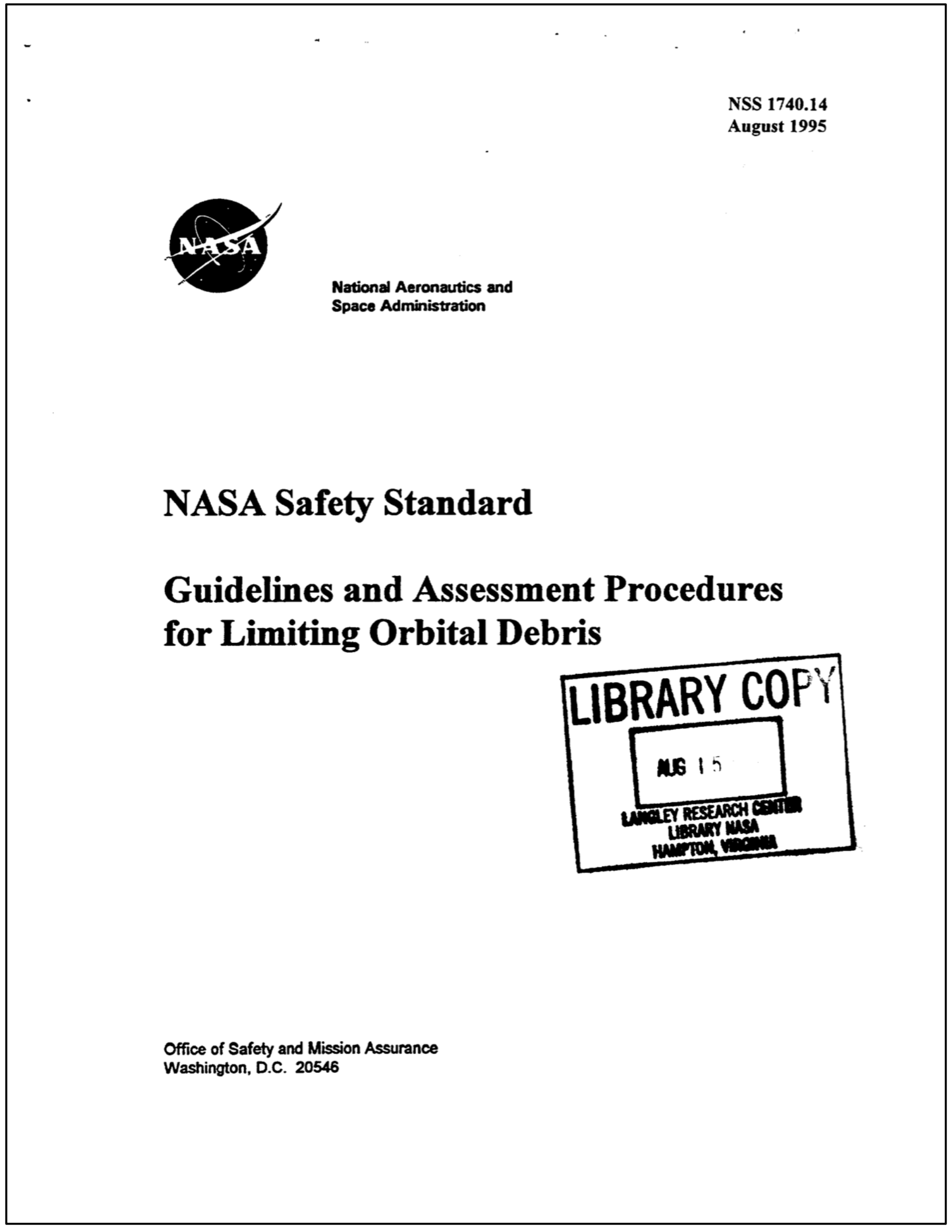
1995

ГЛОБАЛЬНАЯ НАВИГАЦИОННАЯ СПУТНИКОВАЯ СИСТЕМА

ГЛОНАСС



25 Sats | 24 Sats | 30 Sats | 25 Sats


NSS 1740.14
August 1995

National Aeronautics and
Space Administration

NASA Safety Standard

Guidelines and Assessment Procedures
for Limiting Orbital Debris

Office of Safety and Mission Assurance
Washington, D.C. 20546

Images: DDK (left), IAC (top), NASA (right)

2005

Latest update: 21-Dec-2004

ESA's Official Conference Organiser CONGREX

esa

SCOPE | CALL FOR PAPERS / ABSTRACT SUBMISSION | REGISTRATION & ACCOMMODATION | PRELIMINARY PROGRAMME
PRELIMINARY SCHEDULE | 23RD IADC MEETING | PROGRAMME COMMITTEE | CONTACT | VENUE

Fourth European Conference on Space Debris

18-20 April 2005

ESOC
Darmstadt, Germany

Organized by the European Space Agency (ESA)
Co-sponsored by ASI, BNSC, CNES, DLR, COSPAR, IAA

Cover illustration:
Observable debris population as of 8 October 1989, based on NASA/USSpaceCom data. Objects have been considerably enlarged in order to make them visible.

Deadline for Submission of Abstracts has been extended till 22 December 2004!

Preliminary Announcement

PURPOSE

Since 1957, more than 4000 space launches have led to a current population of approximately 13000 trackable objects (i.e. larger than 10 cm) in near-Earth space. Only about 600 - 700 of these are operational spacecraft. The remainder is space debris, i.e. objects which no longer serve any useful purpose. About half of the trackable objects are fragments from explosions, or from the breakup of satellites or rocket bodies. In addition, there is also a much greater number of objects in orbit that cannot be tracked because of their small size.

Due to the high relative velocities in orbit, centimetre-sized debris can seriously damage or even destroy an operational spacecraft. Current design and operational practices need to be reviewed and adapted in order to avoid an irreversible degradation of near-Earth space and other important regions in space such as the geostationary ring.

The purpose of the Fourth European Conference on Space Debris is to provide a forum for the presentation of results from research on space debris, to assist in defining future directions for research, to identify methods of debris control, reduction and protection, and to discuss policy issues, regulations and legal aspects.

The Conference will also promote the technical understanding and support discussions which are ongoing on a worldwide level, such as within the Inter-Agency Space Debris Coordination Committee (IADC) and at the Scientific and Technical Subcommittee of UNCOPUOS.

The present event follows previous European Conferences on Space Debris of 1993, 1997 and 2001, which have found wide interest. Maintaining continuity in the technical themes will allow the monitoring of progress in the various disciplines since then.

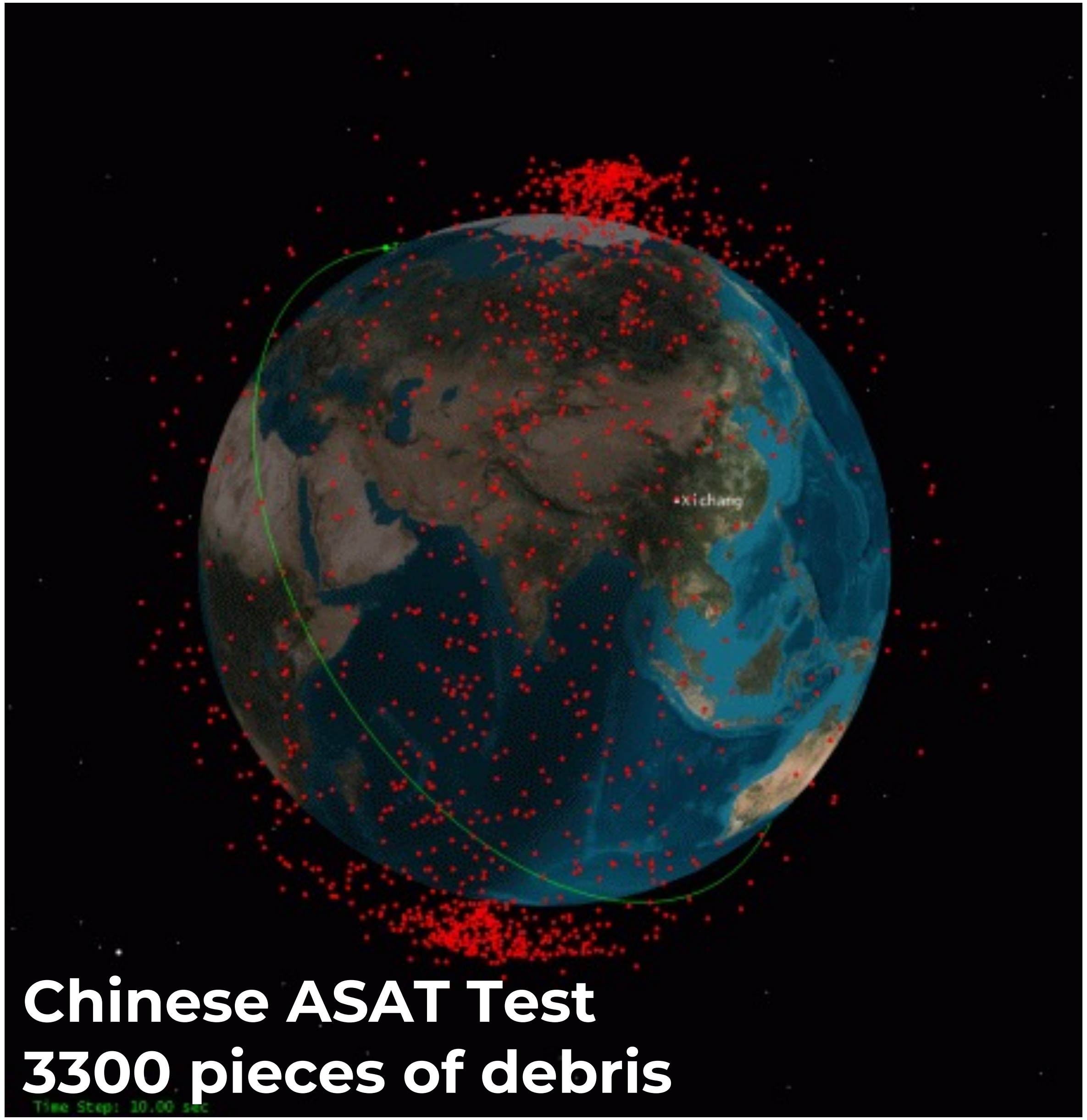
Images: ESA

2006

Images: US Navy)

2007

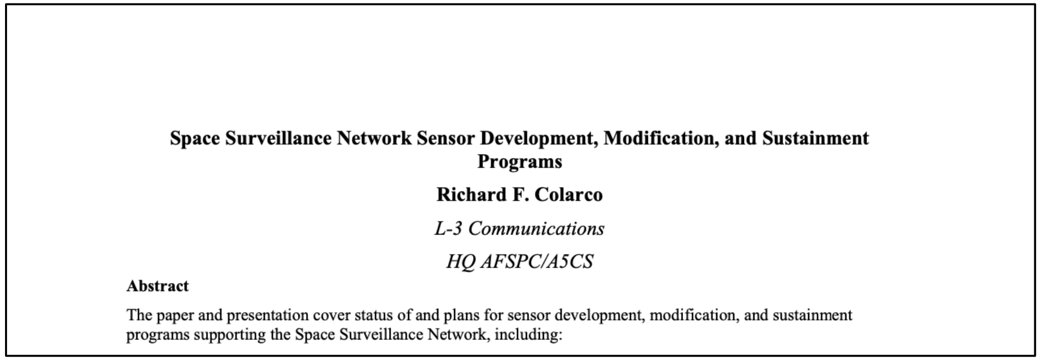
GlobalStar
48 useless satellites



Chinese ASAT Test
3300 pieces of debris

Images: GlobalStar (left), CelesTrak (right)

2009



Space Surveillance Network Sensor Development, Modification, and Sustainment Programs

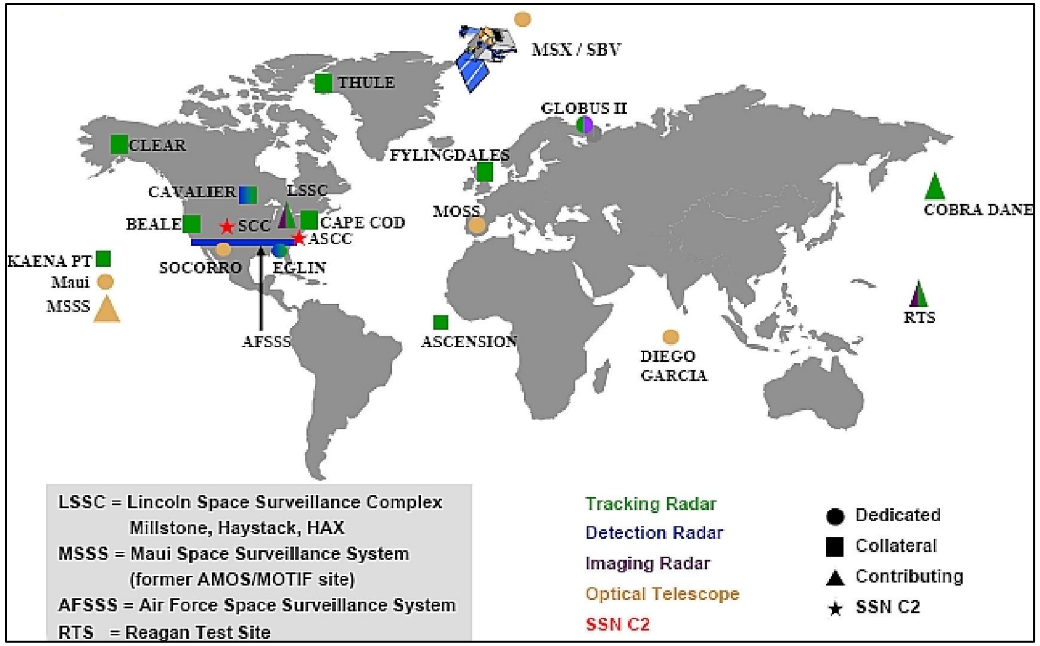
Richard F. Colarco

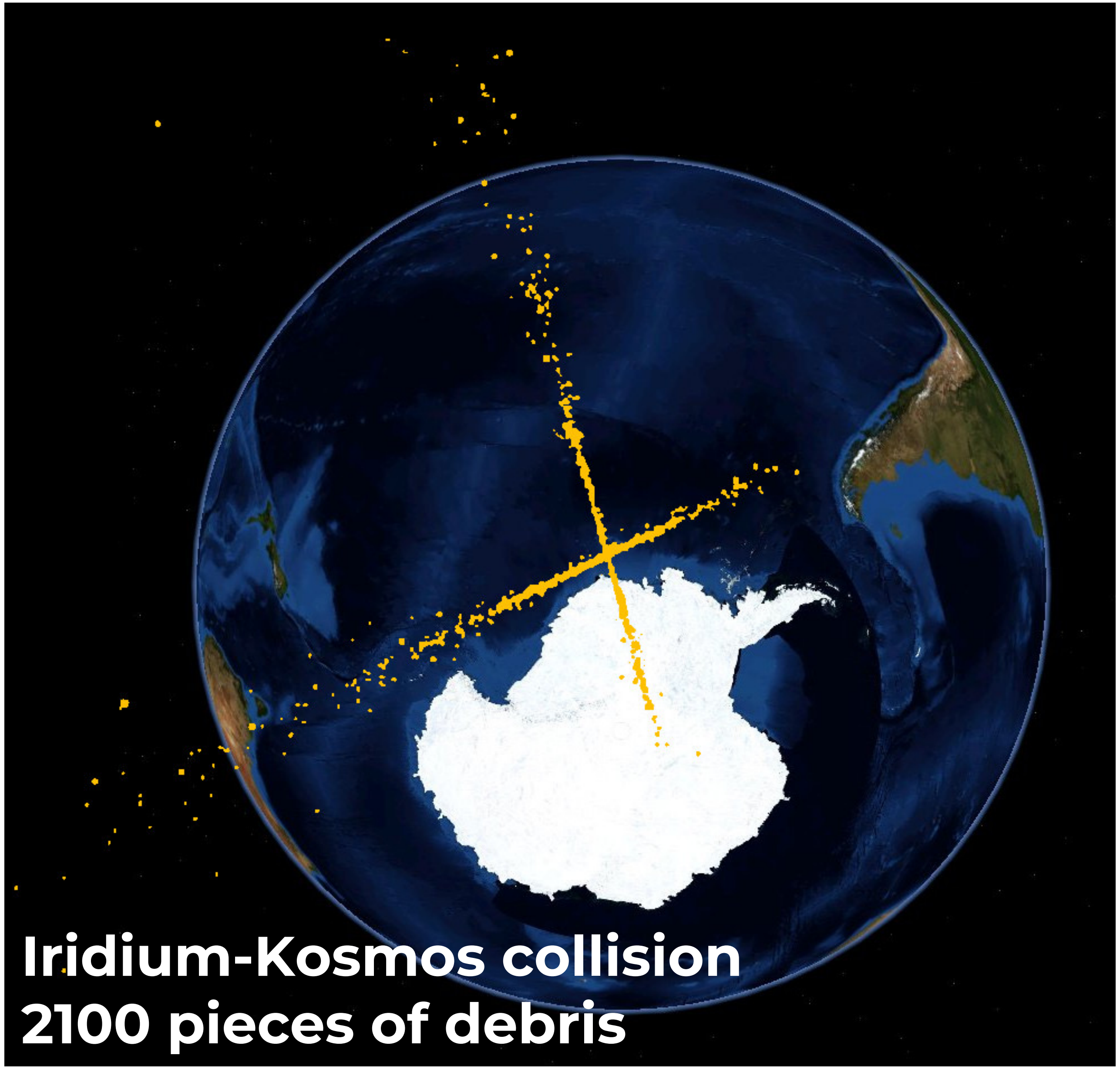
L-3 Communications

HQ AFSPC/A5CS

Abstract

The paper and presentation cover status of and plans for sensor development, modification, and sustainment programs supporting the Space Surveillance Network, including:

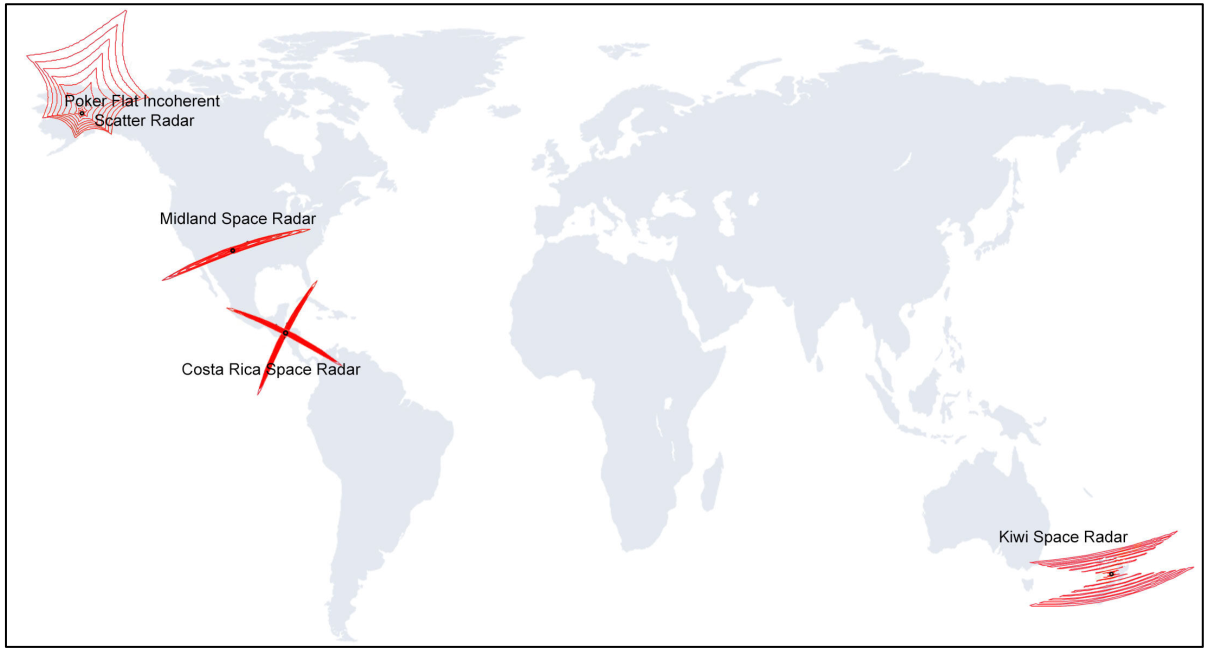


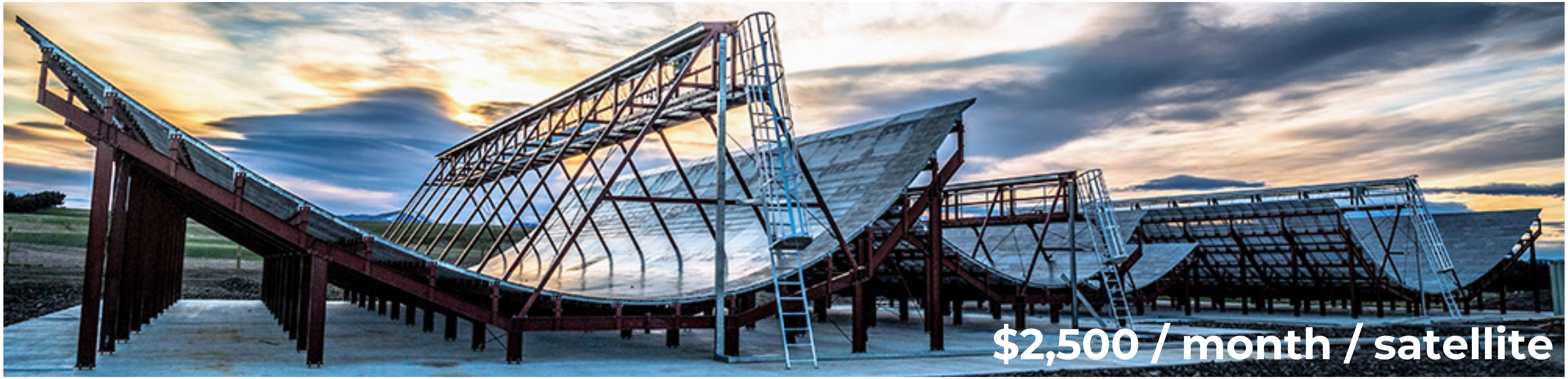


Images: US Air Force (left top), ESA (left bottom), Astronautics (right)

2015

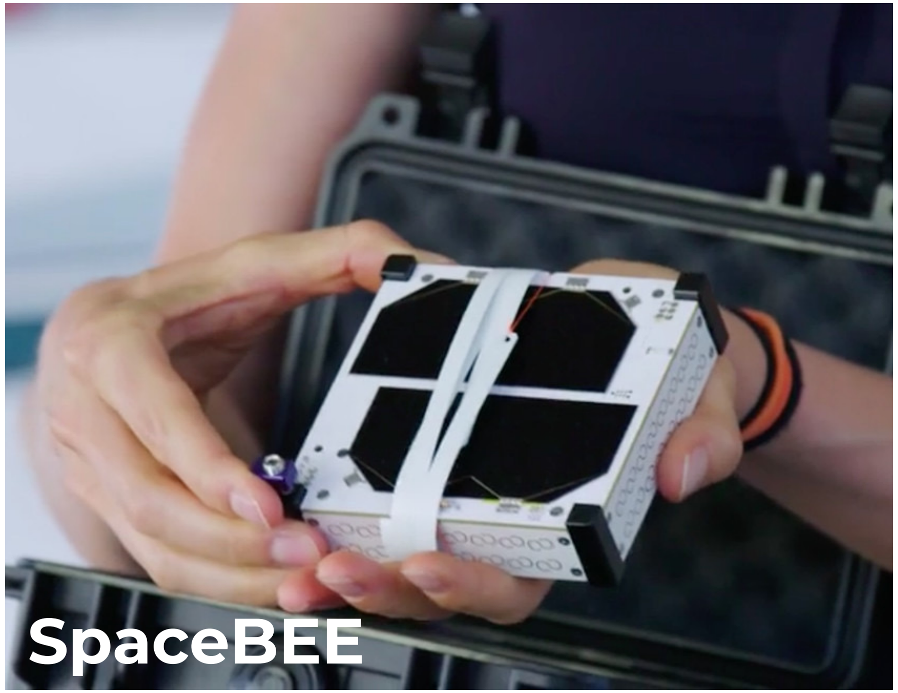
LEO LABS





Images: LeoLabs

2018



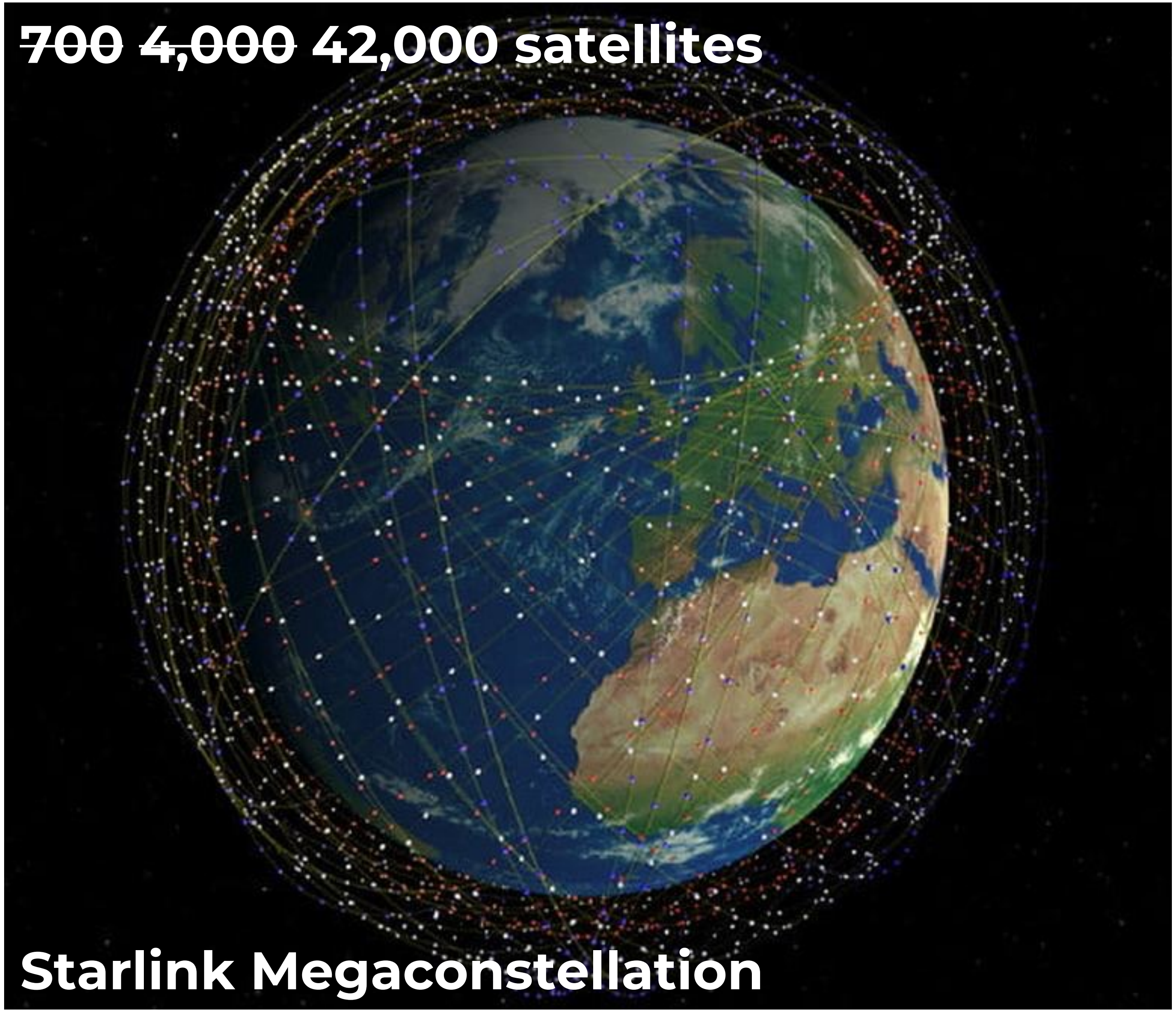


Image: Swarm Technologies (left), SpaceX (right)

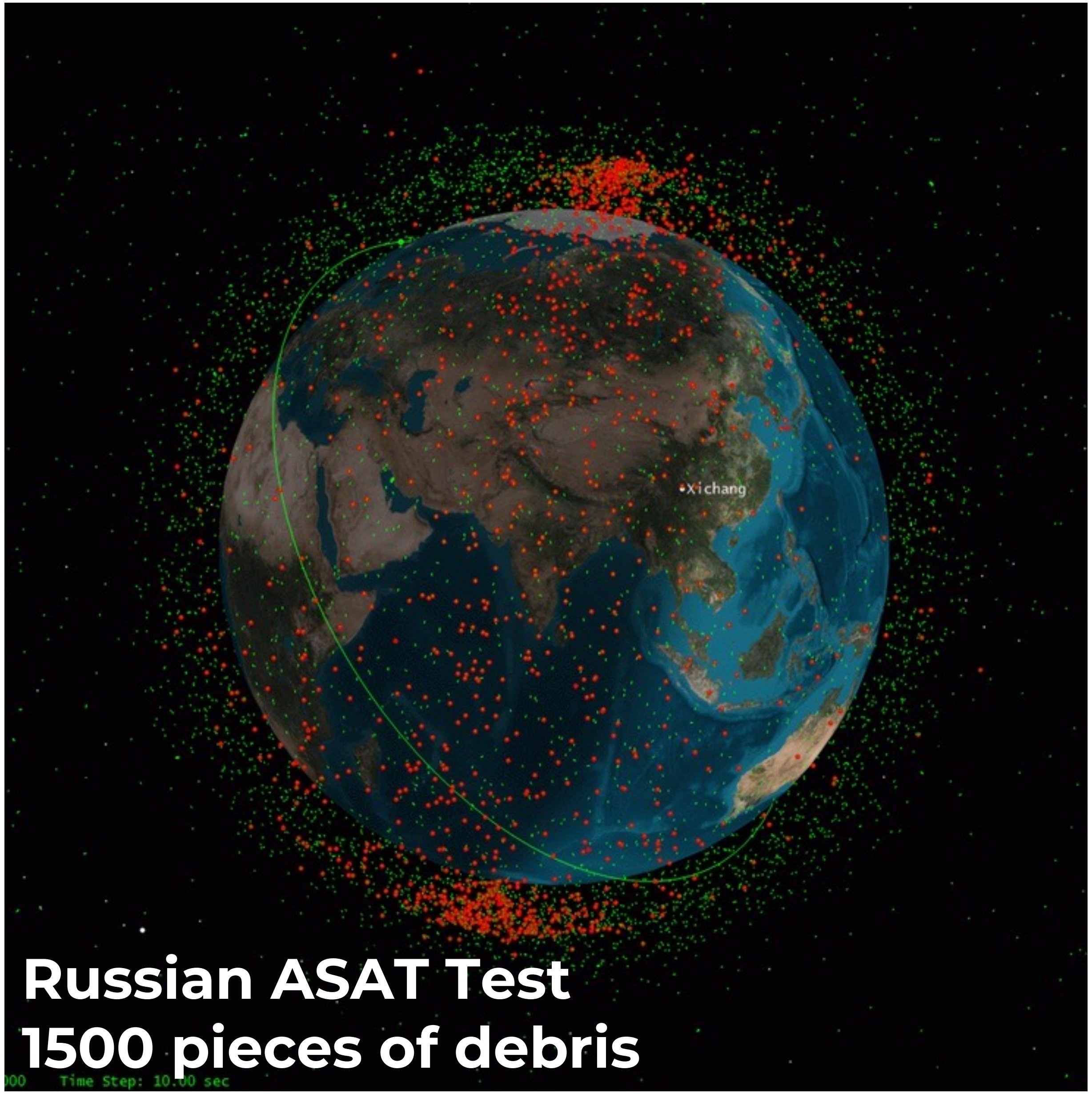
2019

Image: Lockheed Martin (left), Ministry of Defence (GODL-India, right)

2020

Images: OneWeb (left), Mars Buttfield-Addison (right)

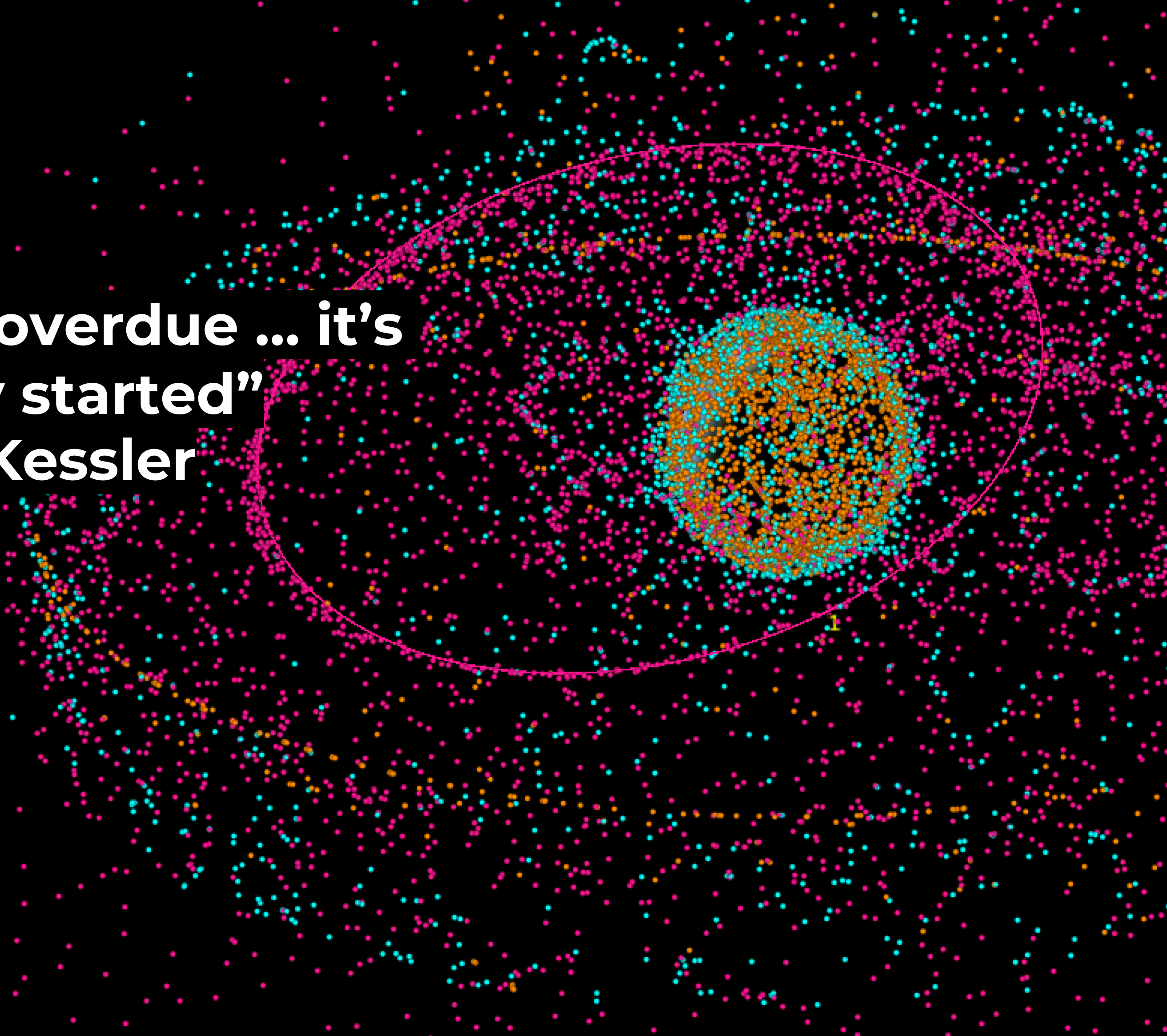
2021

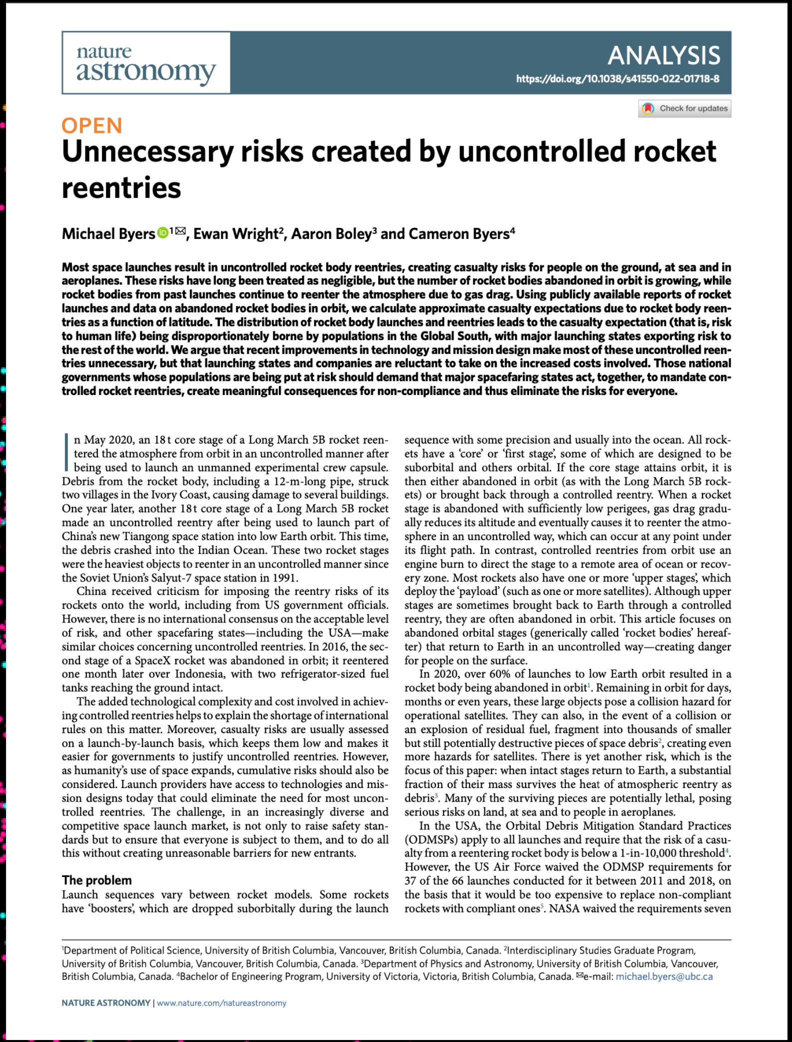


Images: OneWeb (left), Mars Buttfield-Addison (right)

2022

“we’re overdue … it’s already started”
—Don Kessler





nature astronomy

ANALYSIS

https://doi.org/10.1038/s41550-022-01718-8

Check for updates

OPEN

Unnecessary risks created by uncontrolled rocket reentries

Michael Byers[1✉], Ewan Wright[2], Aaron Boley[3] and Cameron Byers[4]

Most space launches result in uncontrolled rocket body reentries, creating casualty risks for people on the ground, at sea and in aeroplanes. These risks have long been treated as negligible, but the number of rocket bodies abandoned in orbit is growing, while rocket bodies from past launches continue to reenter the atmosphere due to gas drag. Using publicly available reports of rocket launches and data on abandoned rocket bodies in orbit, we calculate approximate casualty expectations due to rocket body reentries as a function of latitude. The distribution of rocket body launches and reentries leads to the casualty expectation (that is, risk to human life) being disproportionately borne by populations in the Global South, with major launching states exporting risk to the rest of the world. We argue that recent improvements in technology and mission design make most of these uncontrolled reentries unnecessary, but that launching states and companies are reluctant to take on the increased costs involved. Those national governments whose populations are being put at risk should demand that major spacefaring states act, together, to mandate controlled rocket reentries, create meaningful consequences for non-compliance and thus eliminate the risks for everyone.

In May 2020, an 18 t core stage of a Long March 5B rocket reentered the atmosphere from orbit in an uncontrolled manner after being used to launch an unmanned experimental crew capsule. Debris from the rocket body, including a 12-m-long pipe, struck two villages in the Ivory Coast, causing damage to several buildings. One year later, another 18 t core stage of a Long March 5B rocket made an uncontrolled reentry after being used to launch part of China’s new Tiangong space station into low Earth orbit. This time, the debris crashed into the Indian Ocean. These two rocket stages were the heaviest objects to reenter in an uncontrolled manner since the Soviet Union’s Salyut-7 space station in 1991.

China received criticism for imposing the reentry risks of its rockets onto the world, including from US government officials. However, there is no international consensus on the acceptable level of risk, and other spacefaring states—including the USA—make similar choices concerning uncontrolled reentries. In 2016, the second stage of a SpaceX rocket was abandoned in orbit; it reentered one month later over Indonesia, with two refrigerator-sized fuel tanks reaching the ground intact.

The added technological complexity and cost involved in achieving controlled reentries helps to explain the shortage of international rules on this matter. Moreover, casualty risks are usually assessed on a launch-by-launch basis, which keeps them low and makes it easier for governments to justify uncontrolled reentries. However, as humanity’s use of space expands, cumulative risks should also be considered. Launch providers have access to technologies and mission designs today that could eliminate the need for most uncontrolled reentries. The challenge, in an increasingly diverse and competitive space launch market, is not only to raise safety standards but to ensure that everyone is subject to them, and to do all this without creating unreasonable barriers for new entrants.

The problem

Launch sequences vary between rocket models. Some rockets have ‘boosters’, which are dropped suborbitally during the launch sequence with some precision and usually into the ocean. All rockets have a ‘core’ or ‘first stage’, some of which are designed to be suborbital and others orbital. If the core stage attains orbit, it is then either abandoned in orbit (as with the Long March 5B rockets) or brought back through a controlled reentry. When a rocket stage is abandoned with sufficiently low perigees, gas drag gradually reduces its altitude and eventually causes it to reenter the atmosphere in an uncontrolled way, which can occur at any point under its flight path. In contrast, controlled reentries from orbit use an engine burn to direct the stage to a remote area of ocean or recovery zone. Most rockets also have one or more ‘upper stages’, which deploy the ‘payload’ (such as one or more satellites). Although upper stages are sometimes brought back to Earth through a controlled reentry, they are often abandoned in orbit. This article focuses on abandoned orbital stages (generically called ‘rocket bodies’ hereafter) that return to Earth in an uncontrolled way—creating danger for people on the surface.

In 2020, over 60% of launches to low Earth orbit resulted in a rocket body being abandoned in orbit[1]. Remaining in orbit for days, months or even years, these large objects pose a collision hazard for operational satellites. They can also, in the event of a collision or an explosion of residual fuel, fragment into thousands of smaller but still potentially destructive pieces of space debris[2], creating even more hazards for satellites. There is yet another risk, which is the focus of this paper: when intact stages return to Earth, a substantial fraction of their mass survives the heat of atmospheric reentry as debris[3]. Many of the surviving pieces are potentially lethal, posing serious risks on land, at sea and to people in aeroplanes.

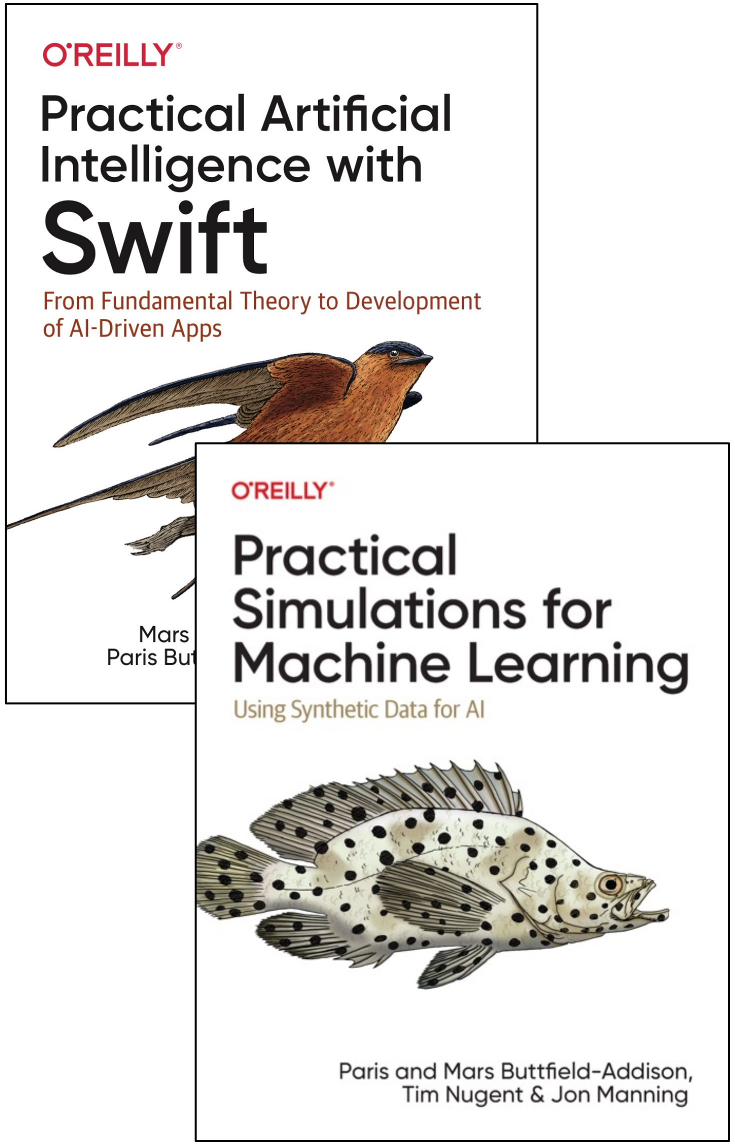
In the USA, the Orbital Debris Mitigation Standard Practices (ODMSPs) apply to all launches and require that the risk of a casualty from a reentering rocket body is below a 1-in-10,000 threshold[4]. However, the US Air Force waived the ODMSP requirements for 37 of the 66 launches conducted for it between 2011 and 2018, on the basis that it would be too expensive to replace non-compliant rockets with compliant ones[5]. NASA waived the requirements seven

[1]Department of Political Science, University of British Columbia, Vancouver, British Columbia, Canada. [2]Interdisciplinary Studies Graduate Program, University of British Columbia, Vancouver, British Columbia, Canada. [3]Department of Physics and Astronomy, University of British Columbia, Vancouver, British Columbia, Canada. [4]Bachelor of Engineering Program, University of Victoria, Victoria, British Columbia, Canada. ✉e-mail: michael.byers@ubc.ca

Image: AstriaGraph (main), Byers et al. (inset).

Mars Buttfield-Addison

- **PhD Candidate, Developer and Tutor**, University of Tasmania
- **Author**, O'Reilly Media
- **Telescope Observer**, AuScope
- **Collaborator**, Secret Lab
- **Conference Organiser**, AUC
- **Software Developer, Speaker, Tutor and creator of STEM educational materials**, Freelance (as TheMartianLife)
- **Programmer**, [unannounced big project]
- Many other things...



THE ROYAL SOCIETY OF TASMANIA

THE ADVANCEMENT OF KNOWLEDGE

Thank you for joining us

We hope you enjoyed this lecture

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