# The role of multilateral space diplomacy in preserving space security & sustainability

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22-51
WALL ST


SUN DIRECT
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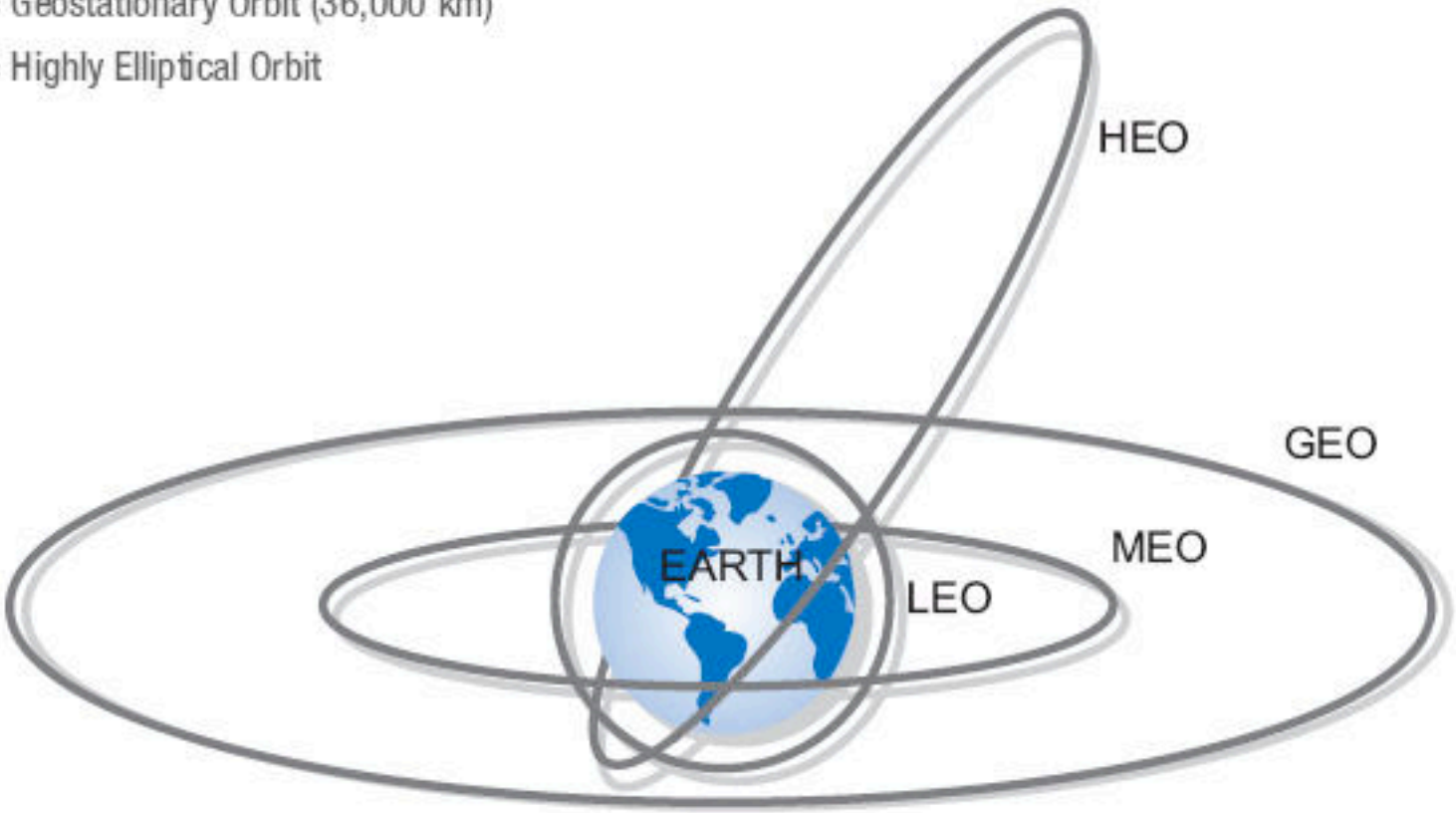
VIDEOCON

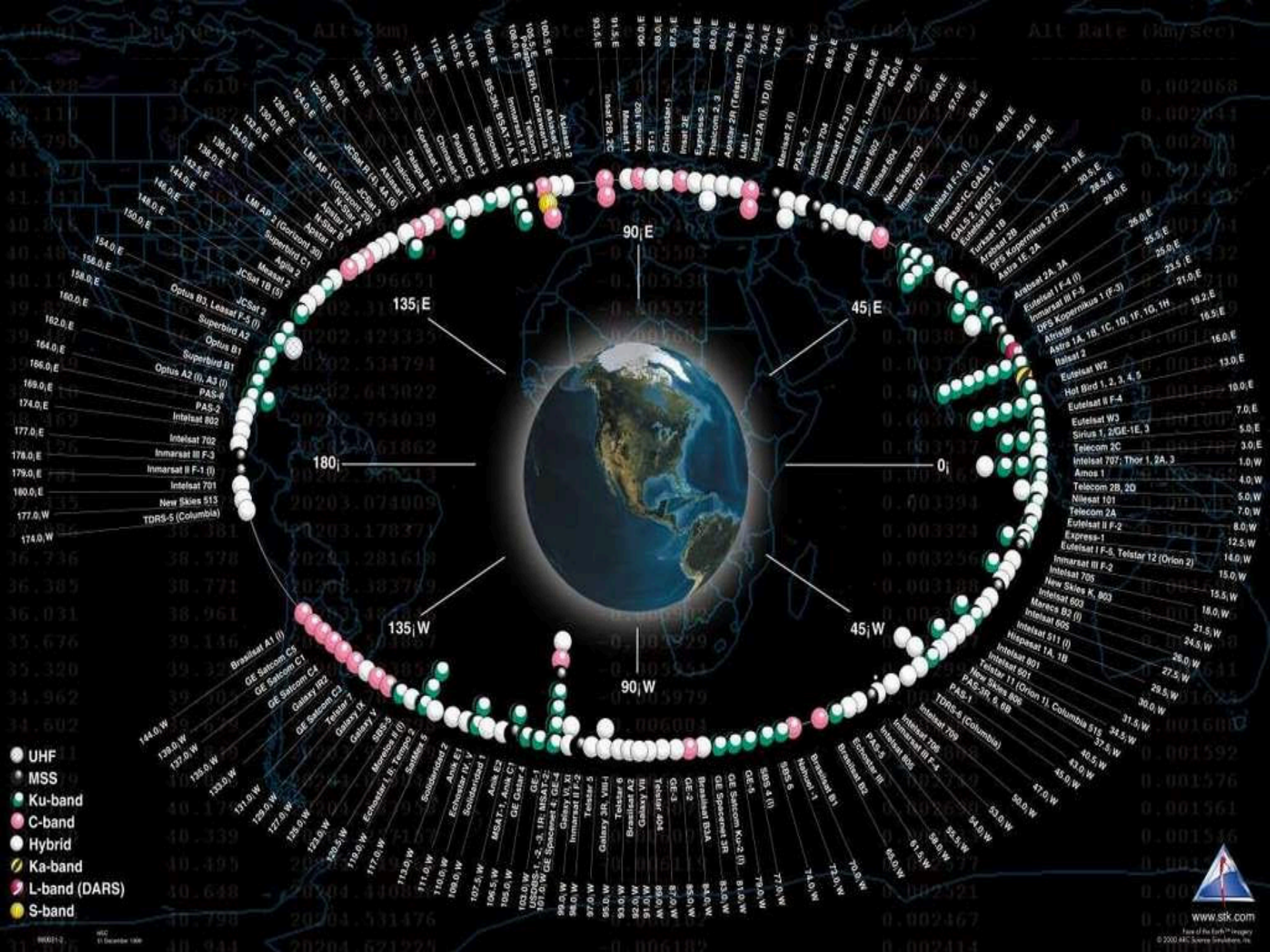
LEO = Low Earth Orbit (100-1,500 km)

MEO = Medium Earth Orbit (5,000-10,000 km)

GEO = Geostationary Orbit (36,000 km)

HEO = Highly Elliptical Orbit




90° E
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UHF
MSS
Ku-band
C-band
Hybrid
Ka-band
L-band (DARS)
S-band
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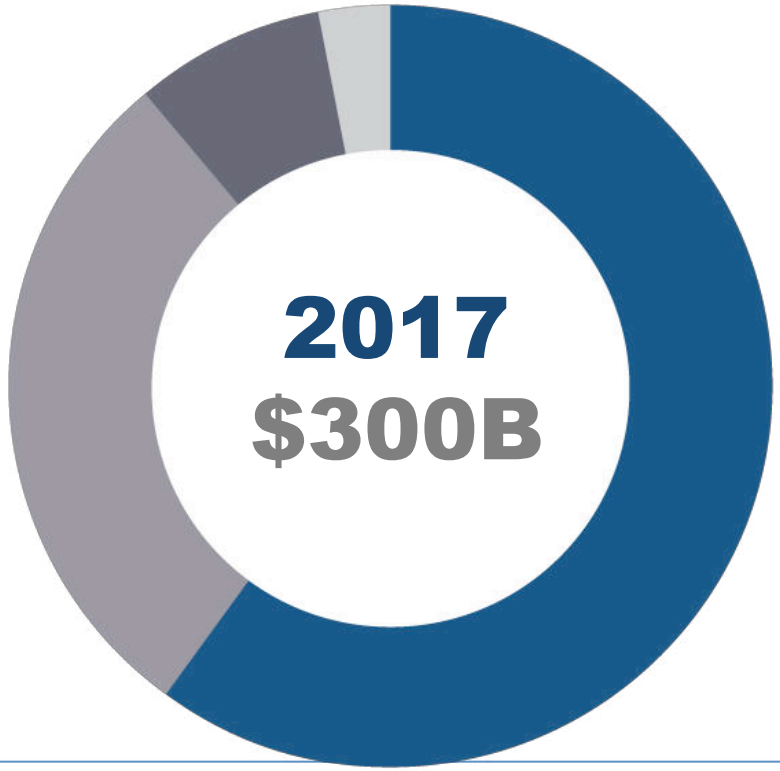
# Worldwide revenues


| 2001 | 2017 |
|---|---|
| SATELLITE SERVICES **50%** | SATELLITE SERVICES **60%** |
| GROUND EQUIPMENT **30%** | GROUND EQUIPMENT **29%** |
| SATELLITE MANUFACTURING **15%** | SATELLITE MANUFACTURING **8%** |
| LAUNCH INDUSTRY **5%** | LAUNCH INDUSTRY **3%** |

# Changing Space Domain

- Increasing number of actors
  - Over 1800 active satellites, over 25,000 trackable pieces of debris
  - Over 90 countries owning/operating satellites
    - 10 countries with independent access to space
    - 10 countries with capability to build > 1000 kg satellites

- Increasing uses of space
  - Rise of mega-constellations
  - Emergence of new kinds of activities on-orbit
  - Growing military uses of space
  - Growth of counterspace capabilities

# Hazards to space sustainability

**Natural Space Hazards**

- Space weather
- Meteors

**Anthropogenic Hazards**

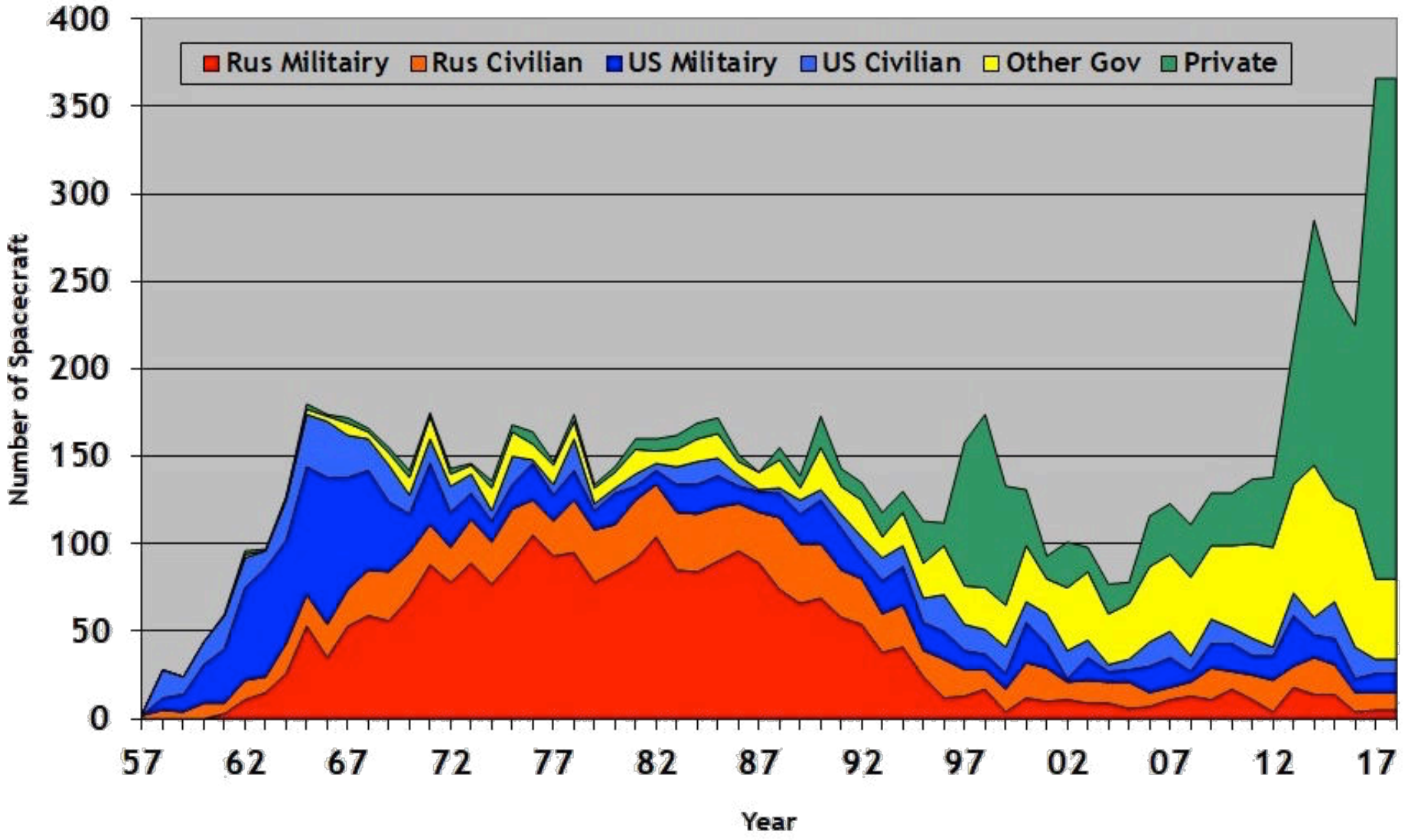
- Space Debris
- Congestion
- Frequency interference
- Irresponsible behaviors
- Counterspace activities

# Space Serving Development

- Space systems are now global utilities that provide critical modern infrastructure for the benefit all the nations and peoples on Earth.
- Space systems support human and environmental security in many areas, such as:
  - Natural, anthropogenic and humanitarian disasters
  - Food and water security
  - Health and education
- Space contributes to the achievement of the Millennium Development goals and is a critical contributor to sustainable development
- Space contributes to regional and international cooperation and in this way underpins peaceful human progress worldwide

Space is at the nexus of security, strategic stability, scientific and technological development, sovereignty and human progress.

# Launch Activity 1957 - 2017



# A changing space environment

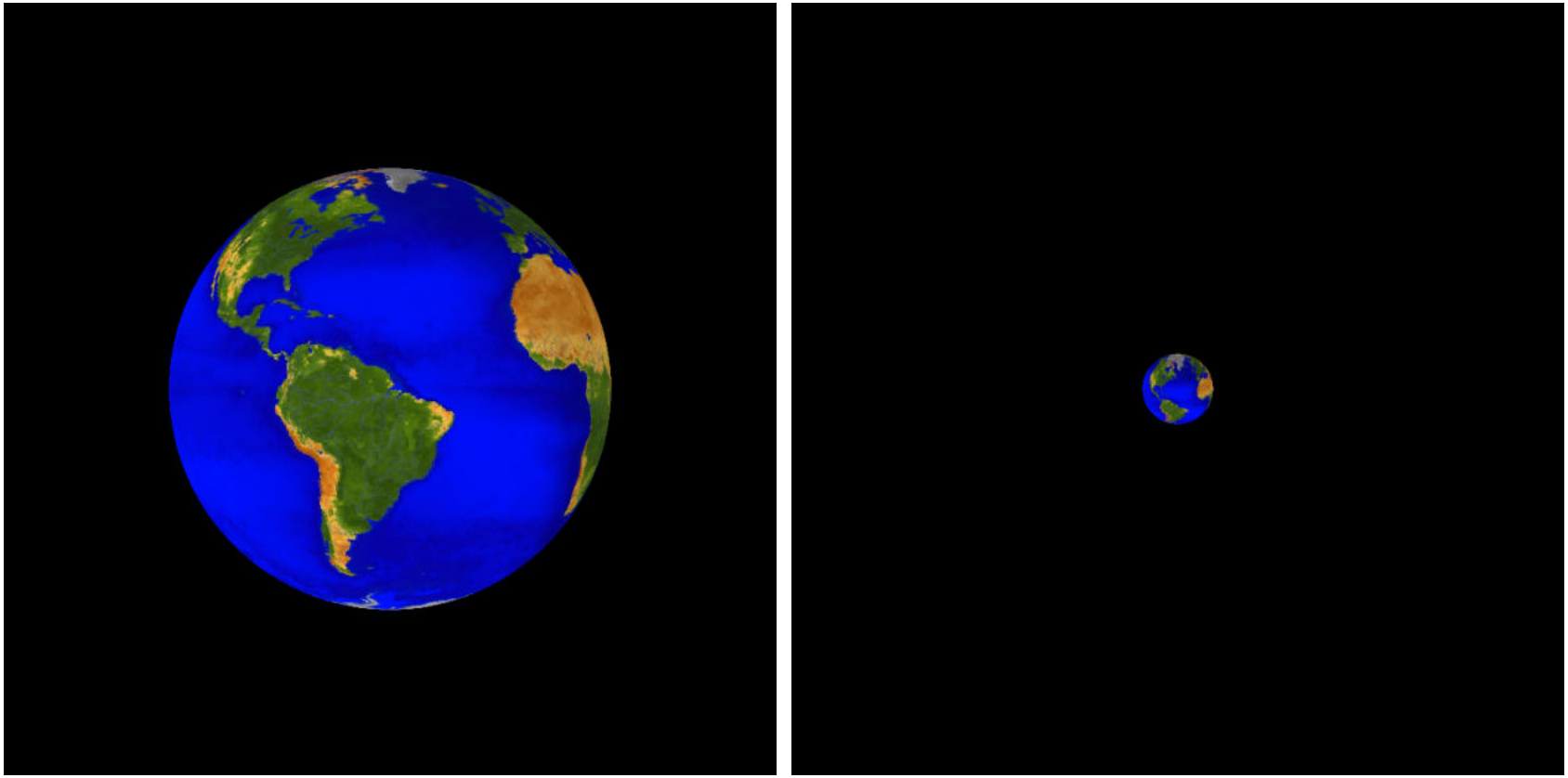
- Sustainability of space activities is threatened by
  - Debris (mission-related, deliberate or accidental, + collisions)
  - Interference (deliberate and unintentional)
  - Space weather events (affect space systems as well as their signals)
- Large number of emerging space actors
- Multiple stakeholder groups and dimensions
  - Each with own logic, concerns and interests, but …
  - … concern about sustainability of space activities is the common denominator

- Space is a global commons – and the only one that borders on every nation.
- No single country can avoid the sustainability issue by its own actions

Can be seen as part of the wider sustainability discussions relating to equitable and sustainable use of limited natural resources.

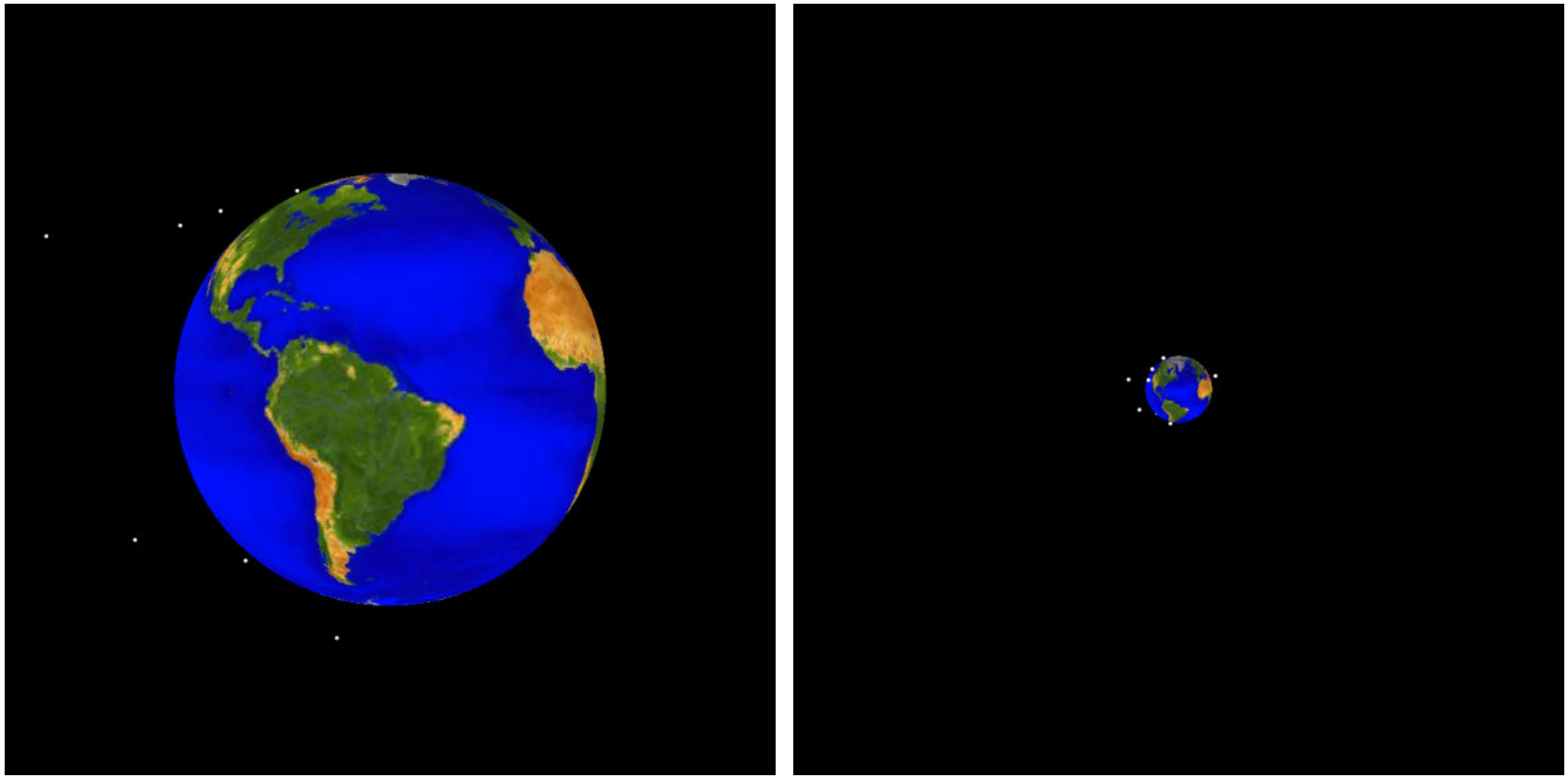
# Crowding of the Earth's orbital environment

Before 1957



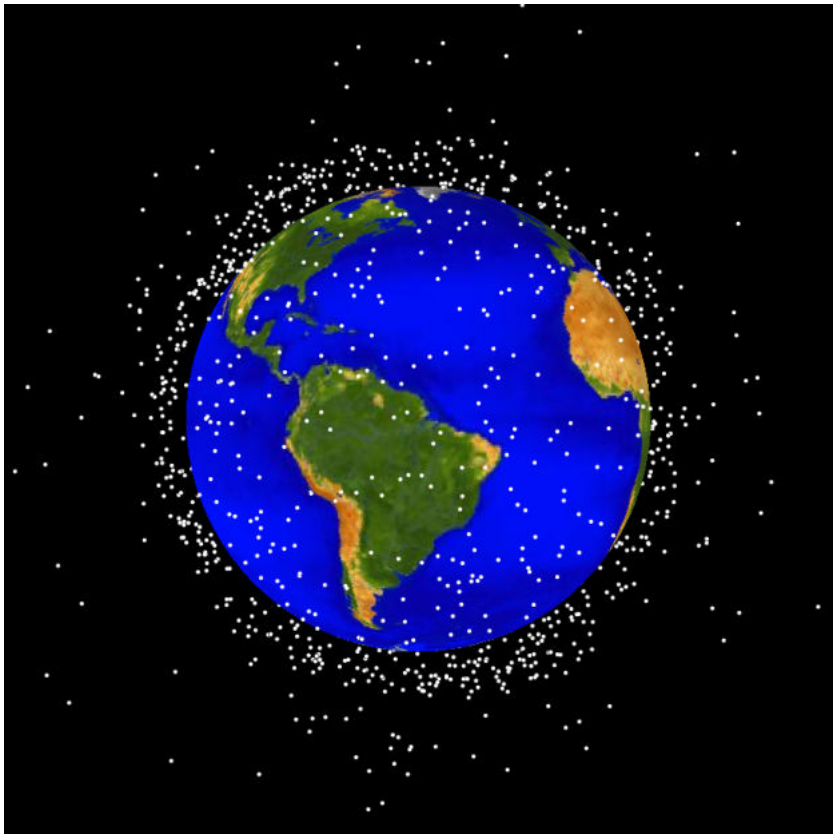
# Crowding of the Earth's orbital environment

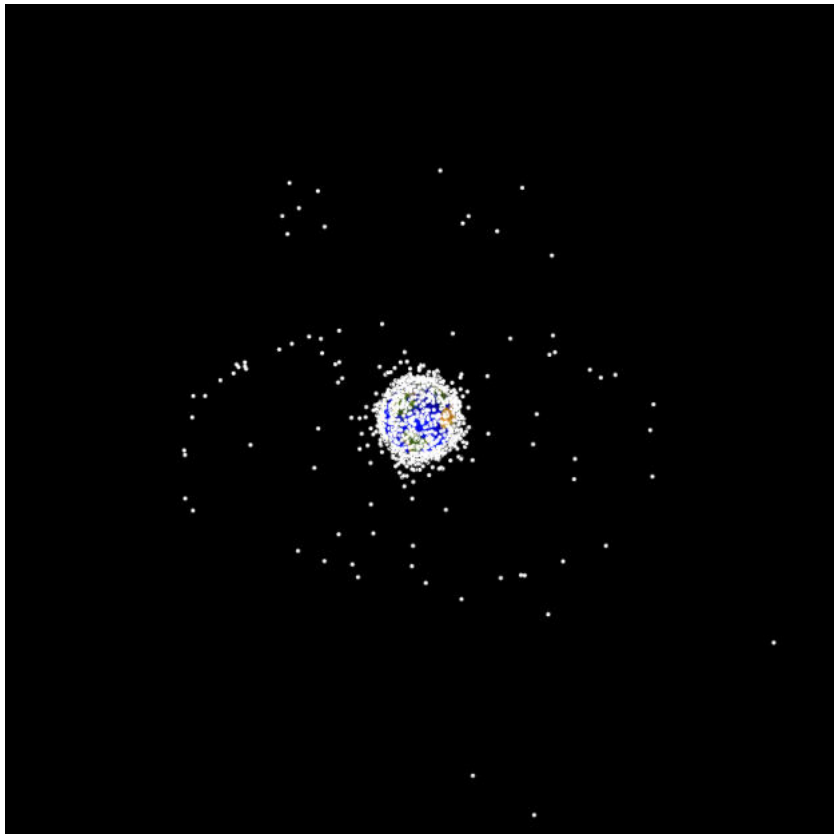
1960



# Crowding of the Earth's orbital environment

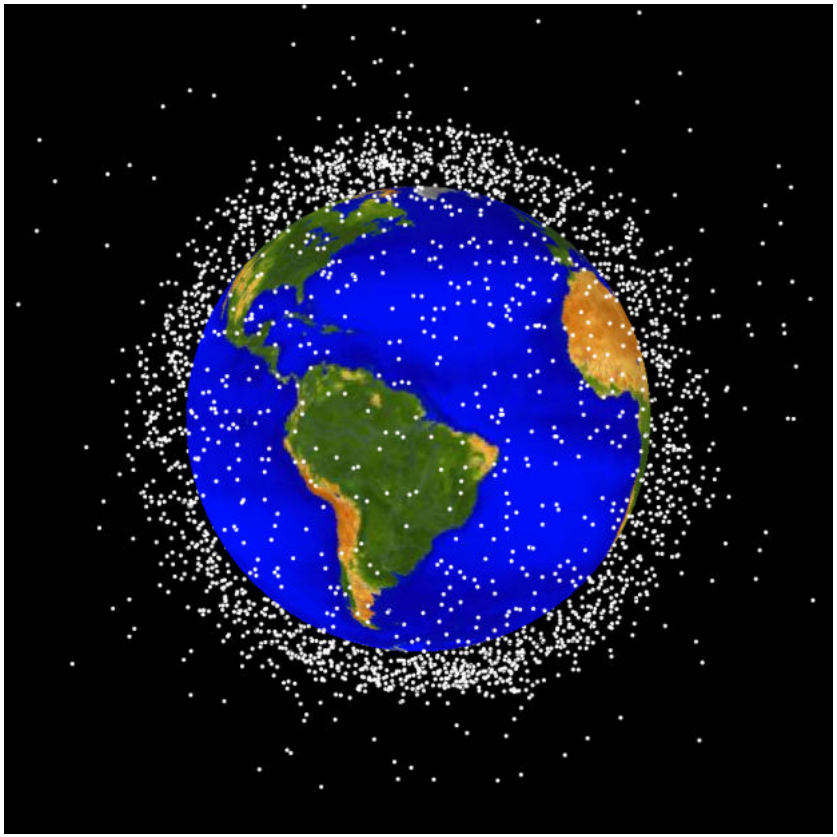
1970

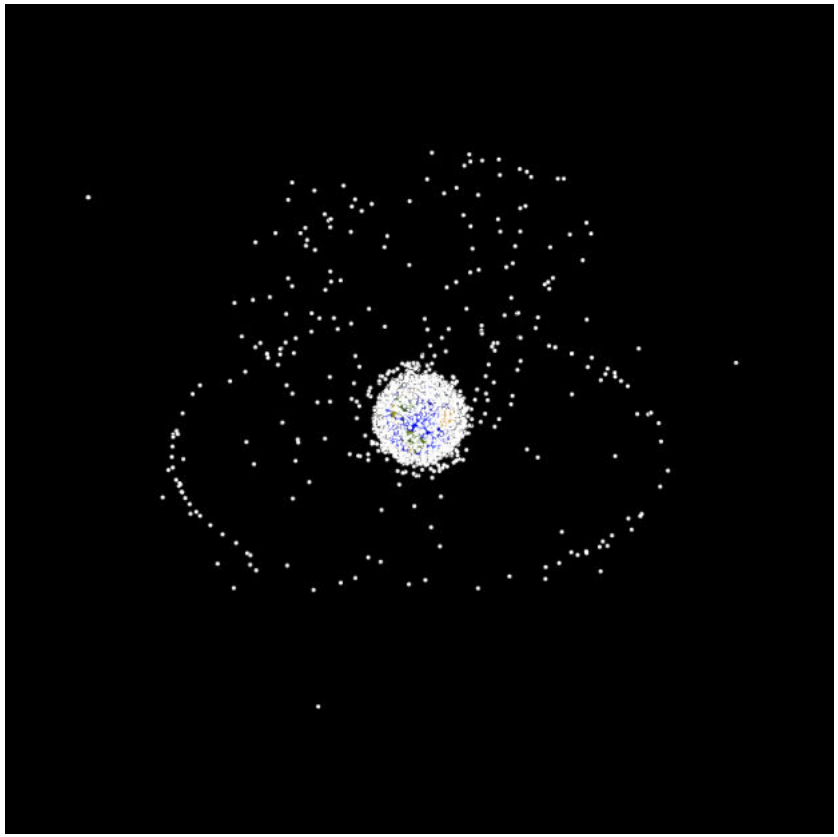




# Crowding of the Earth's orbital environment

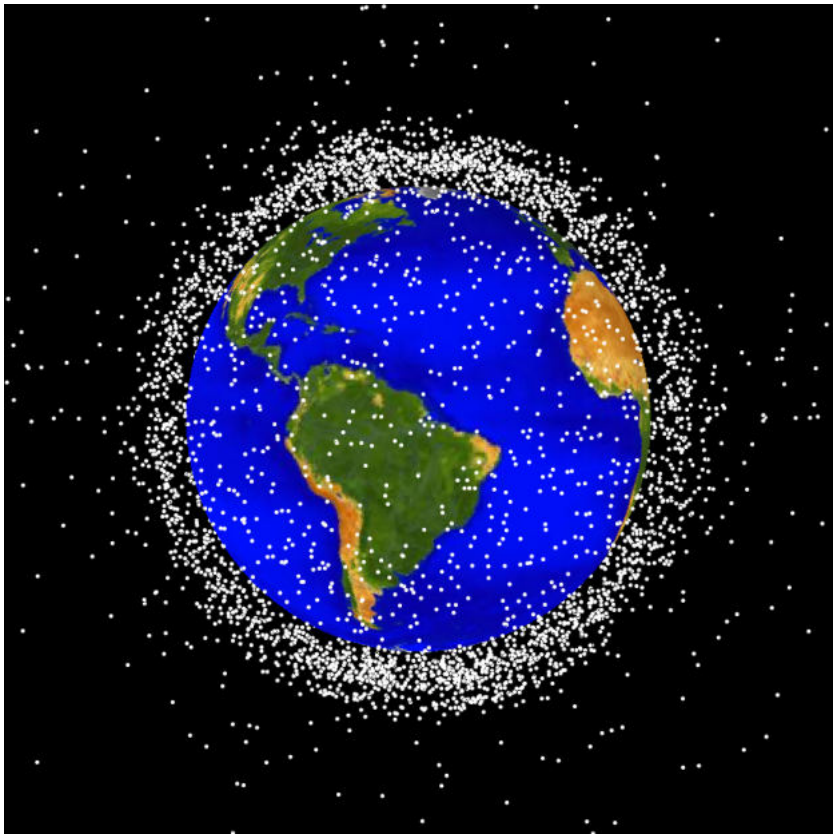
1980

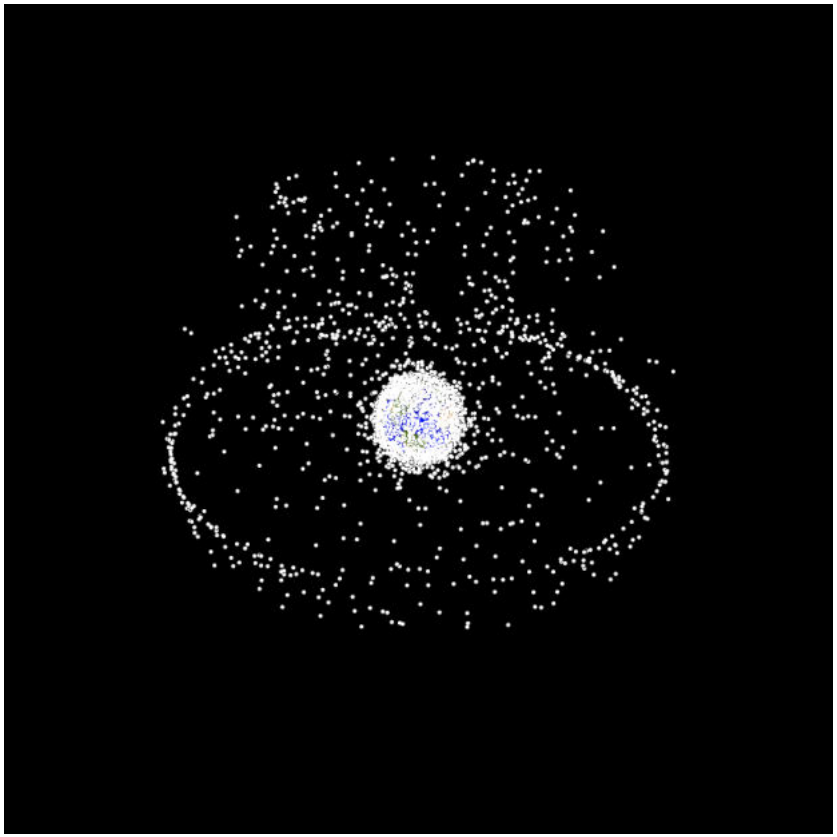




# Crowding of the Earth's orbital environment

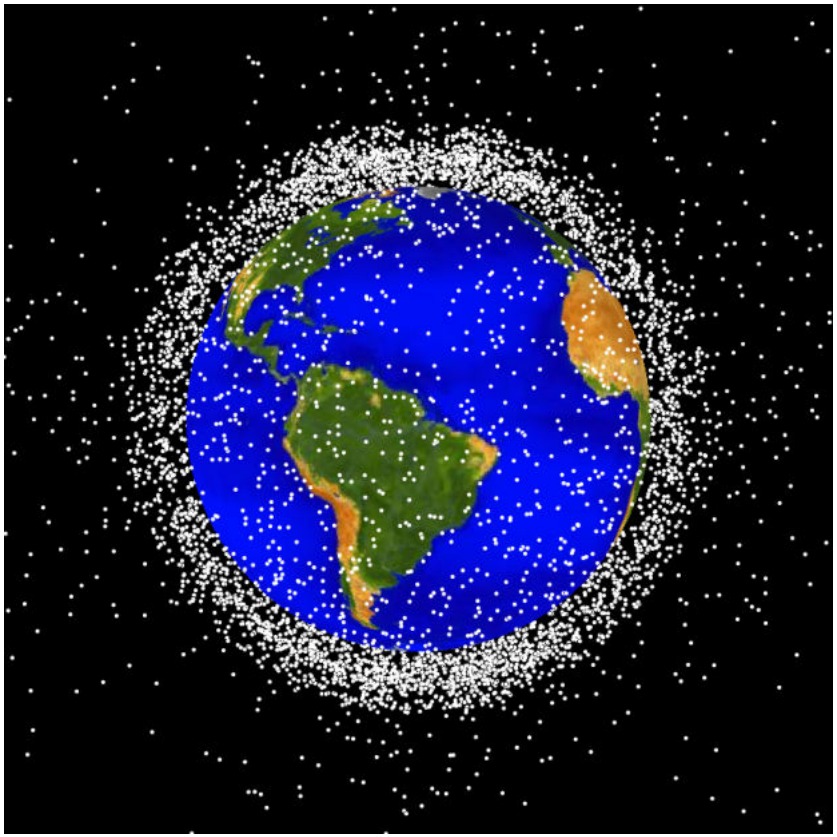
1990

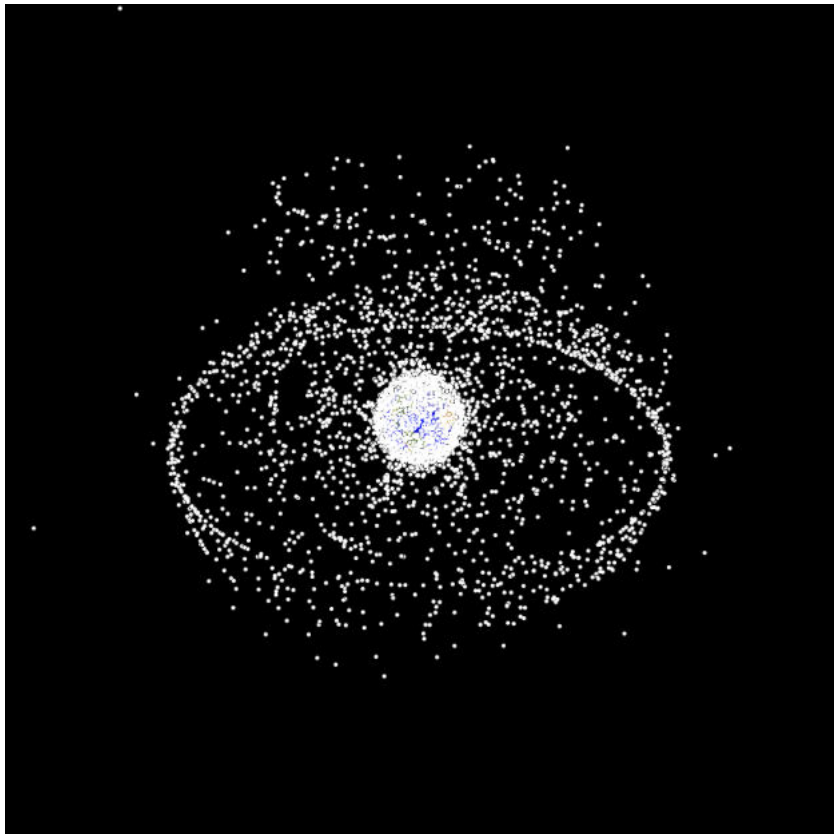




# Crowding of the Earth's orbital environment

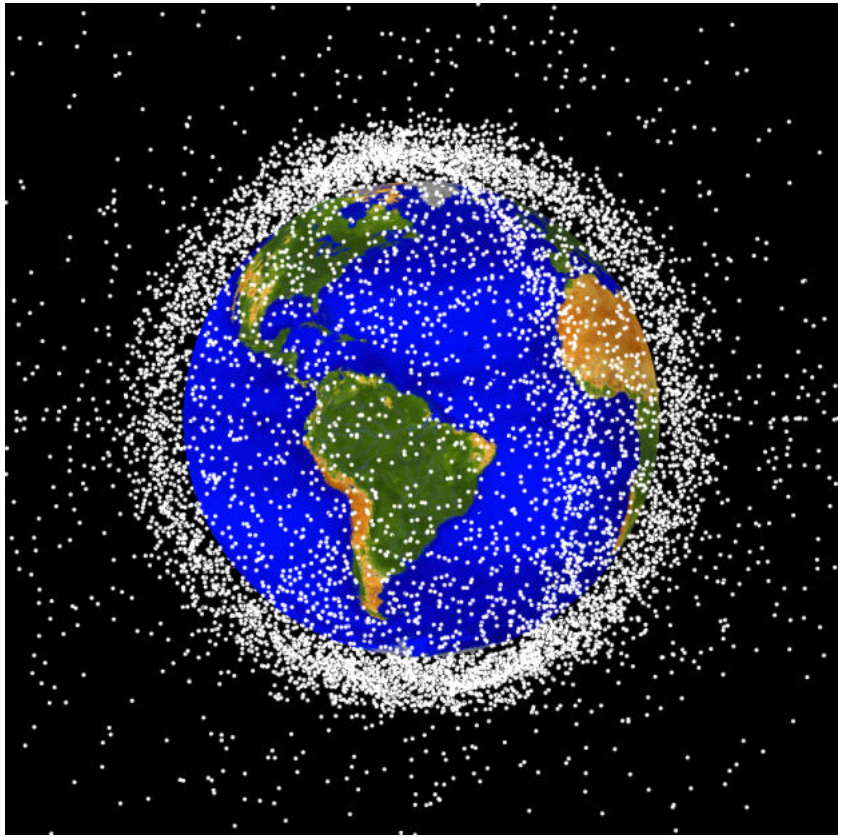
2000

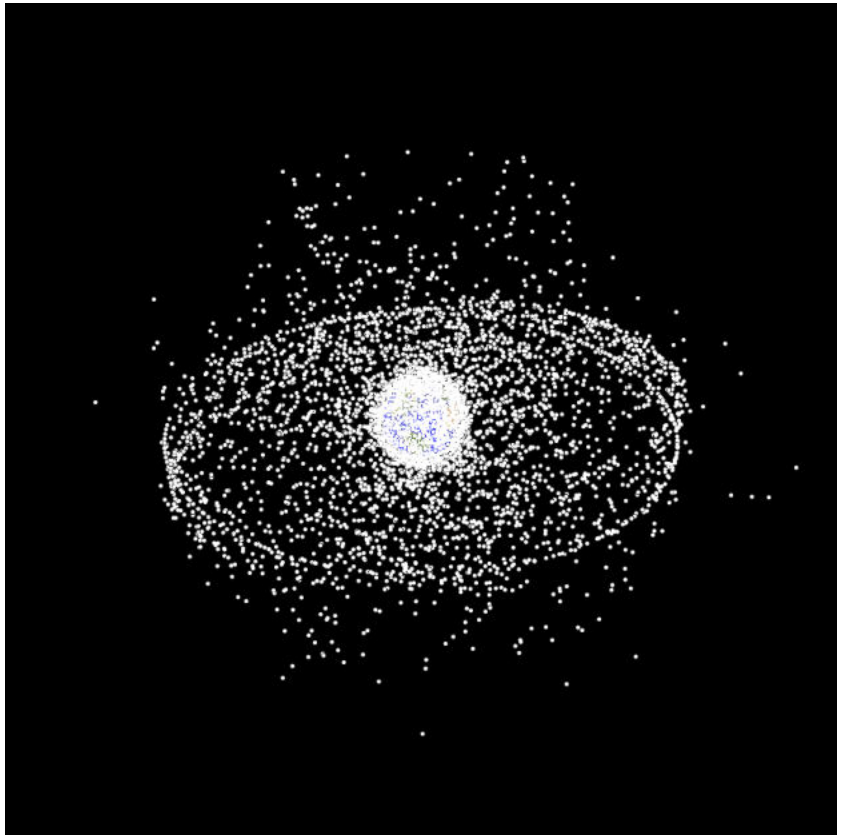




# Crowding of the Earth's orbital environment

2010

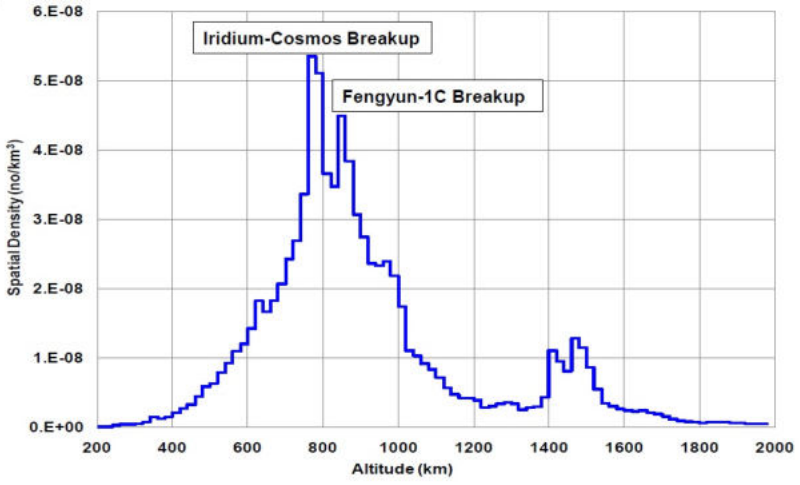




# The concern

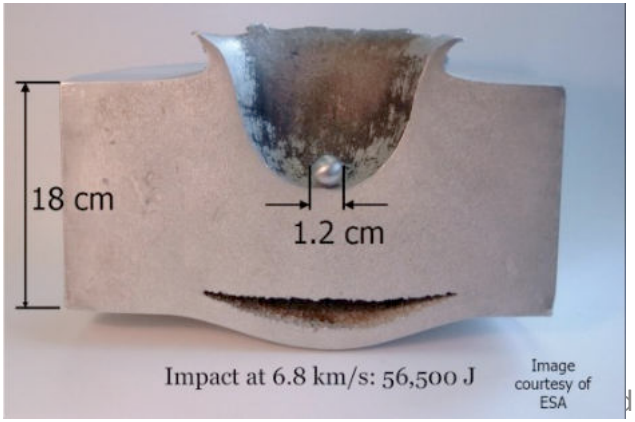
- The growing population of space objects in orbit may in time make activities in regions of near-Earth space hazardous and extremely expensive
- U.S. now tracks about 23,000 objects in Earth orbit
  - ~ 1,000 working satellites
  - ~ 22,000 debris pieces > 10 cm

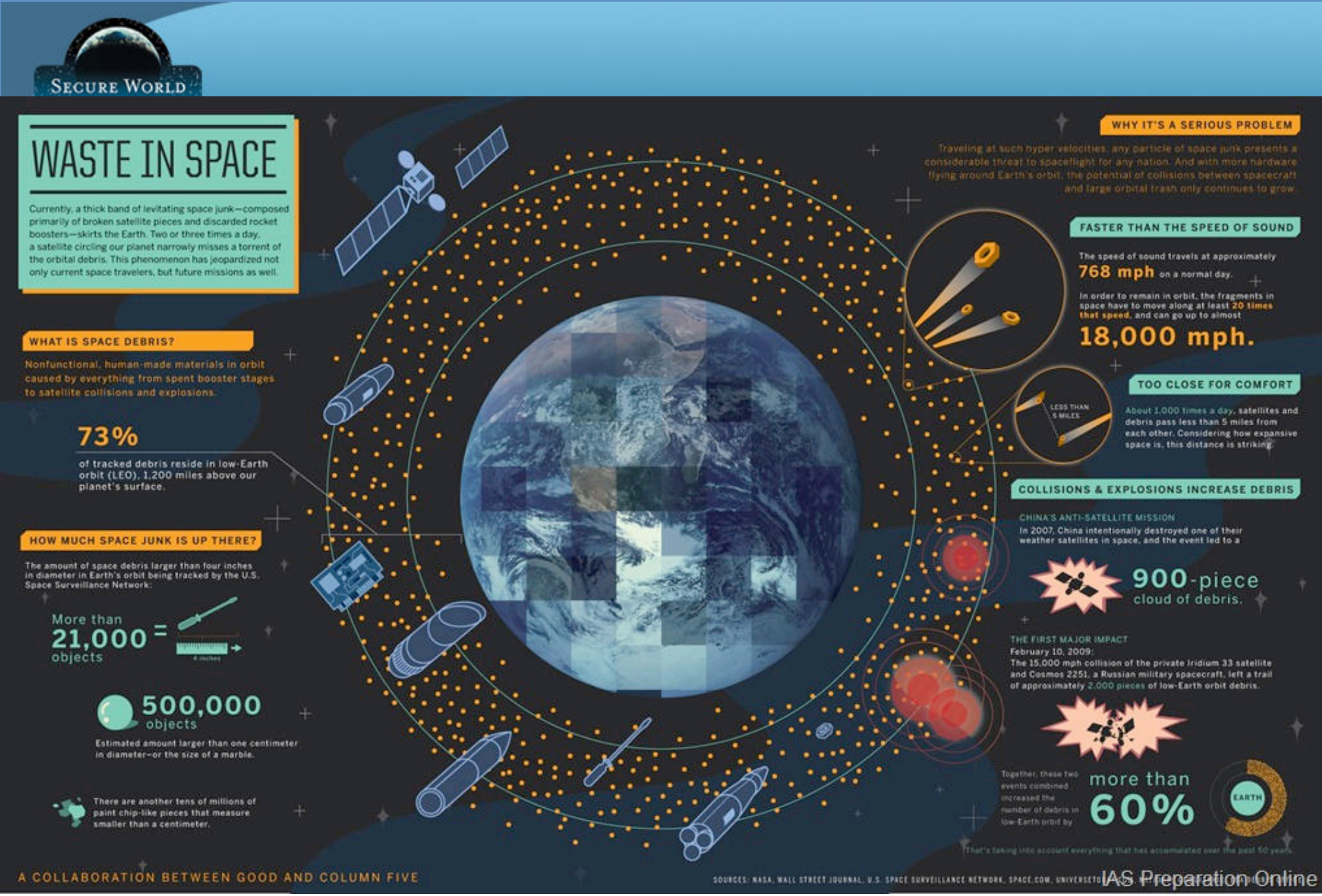
| Orbit | Operational Satellites |
|---|---|
| LEO | ~ 450 |
| MEO | ~ 55 |
| GEO | ~ 400 |



# But that's not all…

- Objects smaller than 10 cm are not consistently trackable
  - There may be as many as 500,000 objects of 1-10 cm size
  - Perhaps as many as 10s to 100s of millions < 1 cm
- No active collision avoidance is possible for such objects
- These objects can cripple or destroy spacecraft and endanger astronauts
- Total mass ~ 6300 tons

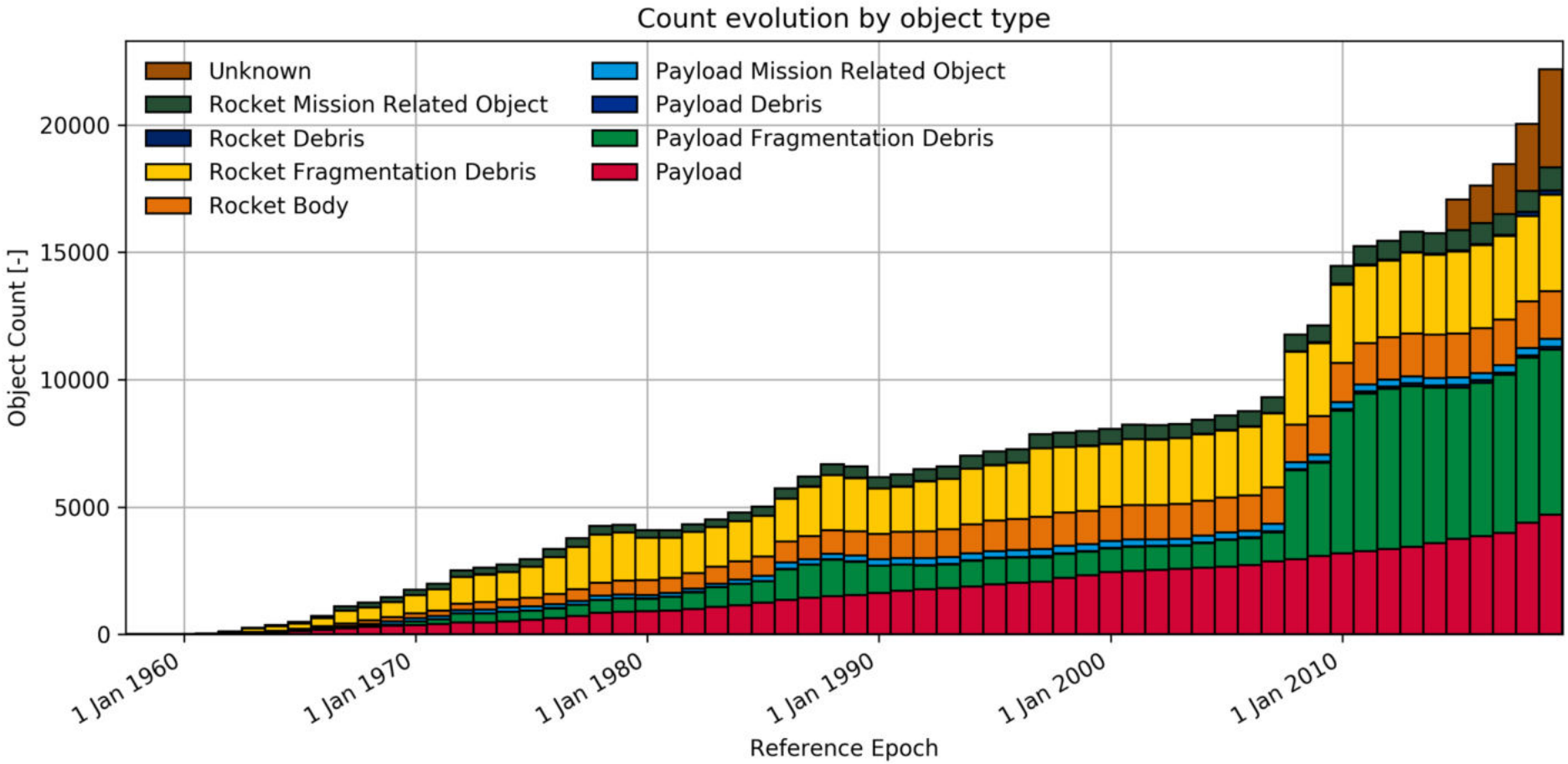




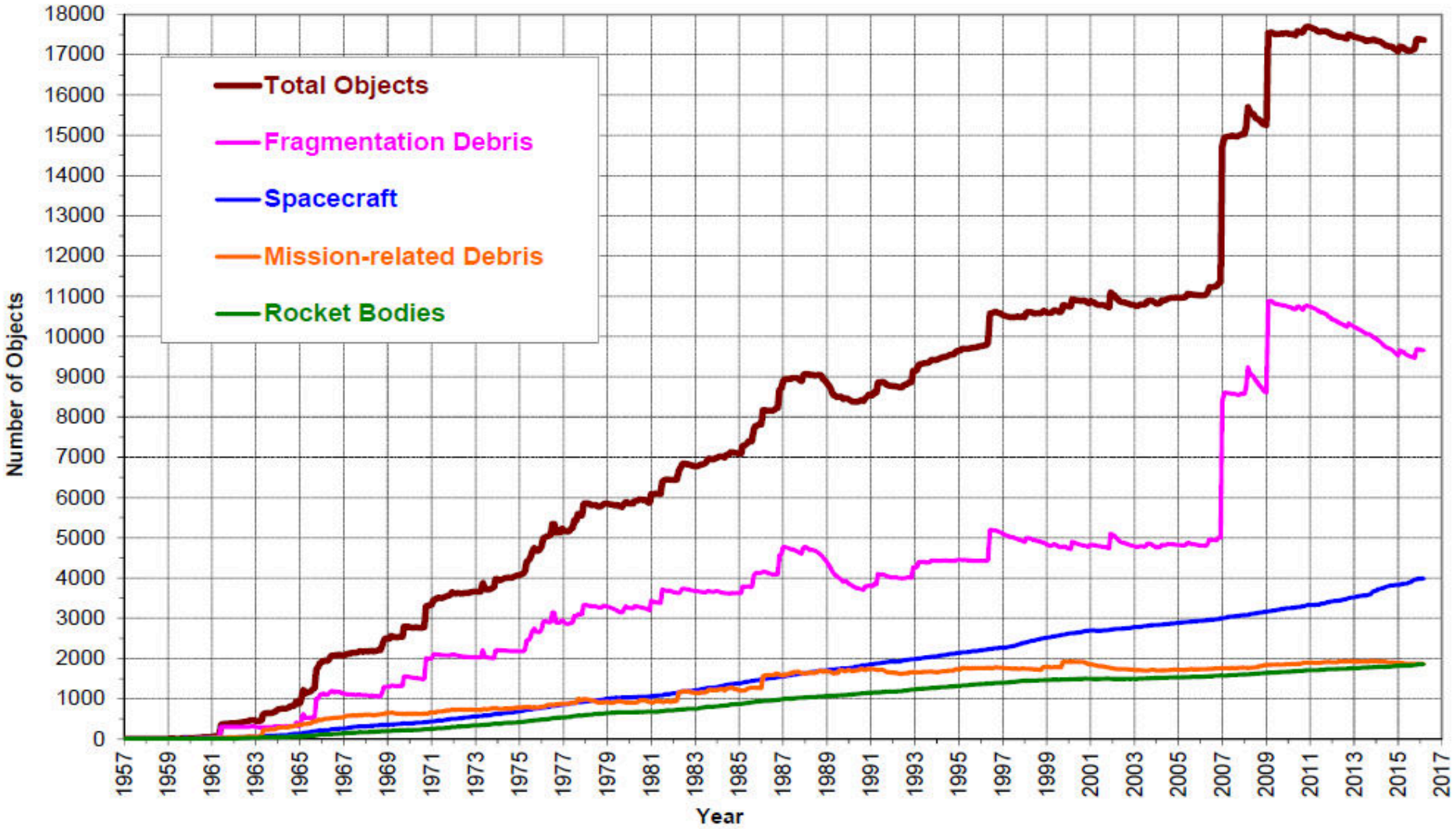
# Sources of debris

- Defunct spacecraft
- Mission debris
- Rocket bodies
- Fragmentation debris
  - Explosions
  - Degradation
- Collisions
- Deliberate debris creation
  - ASAT tests

# Debris evolution by type

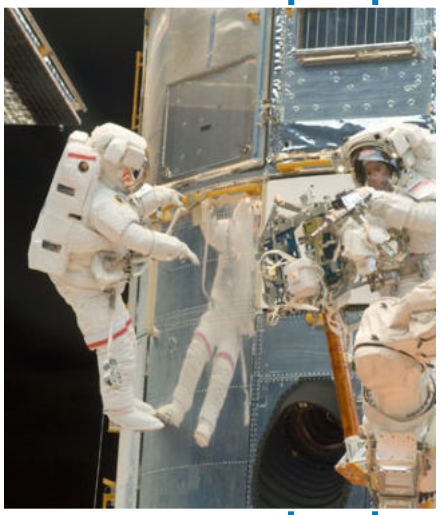


# Trackable debris population




Courtesy of NASA OD Program Office

# Space Shuttle vulnerabilities

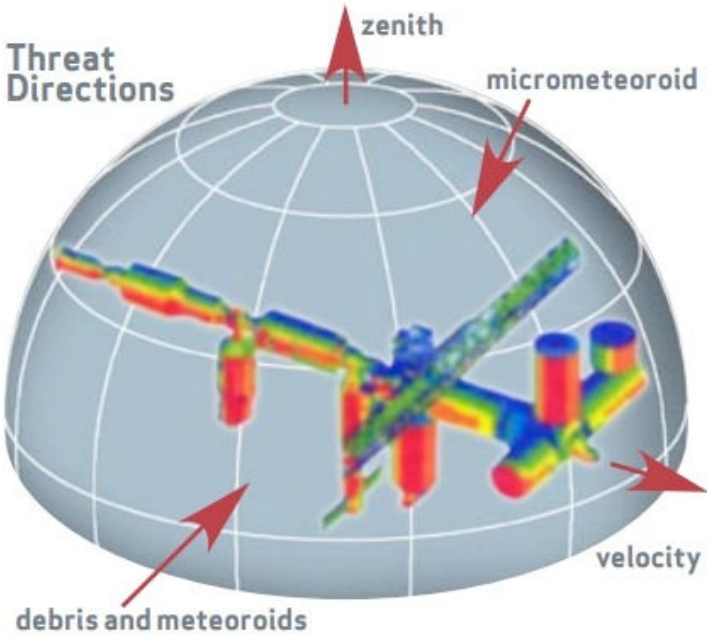





Source: NASA OD Program Office

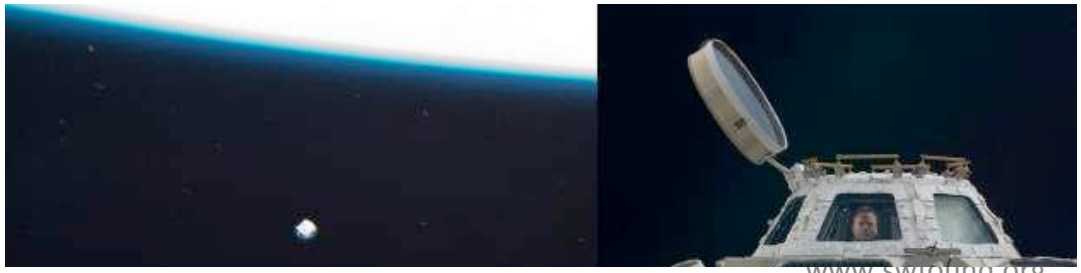
# International Space Station vulnerabilities

- Passive shielding
  - Most shielded spacecraft ever flown
  - Total shielding mass ≈ 23,400 kg
  - Launch cost ($10k/lb) ≈ $515 million




- Collision avoidance manoeuvres
  - 16 manoeuvres since 1999
  - 5 since 2011

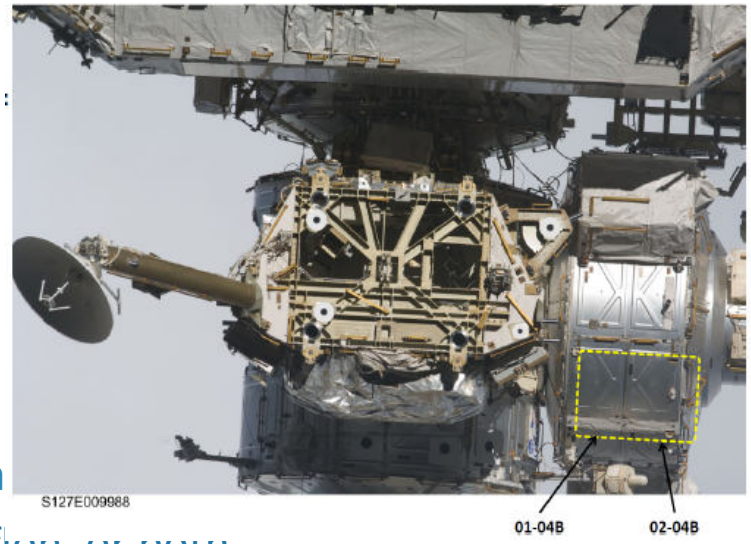
- Risk tolerances
  - <24% probability of penetration (10 yr)
  - <5% probability of catastrophic failure (10 yr)



10 June 2012 MMOD hit on ISS Cupola

# Small particle impacts on ISS

- Two debris shields from an airlock returned to Earth after nearly 9 years in orbit

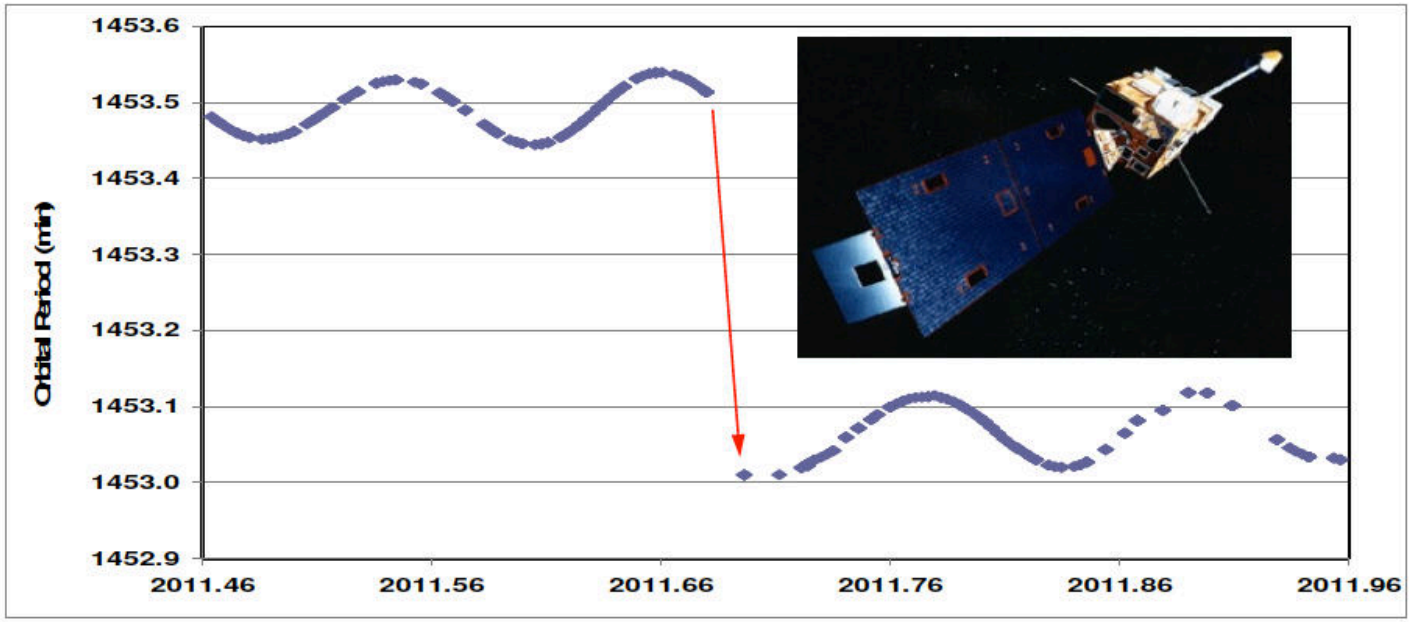



- Analysis at JSC showed
  - 58 craters with diameter > 0.3mm
    - Largest crater had a diameter of 1.8 mm a
    - Six craters contained residues of silica, teflon, or both
    - Might be evidence of secondary debris from impacts on the ISS solar arrays

Courtesy Nicholas Johnson, NASA

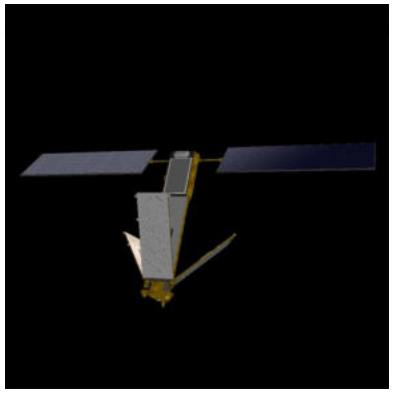
# GOES 10 Anomaly

- On 5 Sept 2011, nearly 2 years after GOES 10 had been decommissioned and placed in a disposal orbit above GEO, its perigee decreased abruptly by 20 km.
- Collision with a small object is a possible explanation

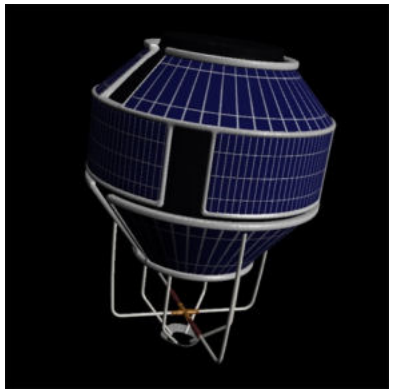


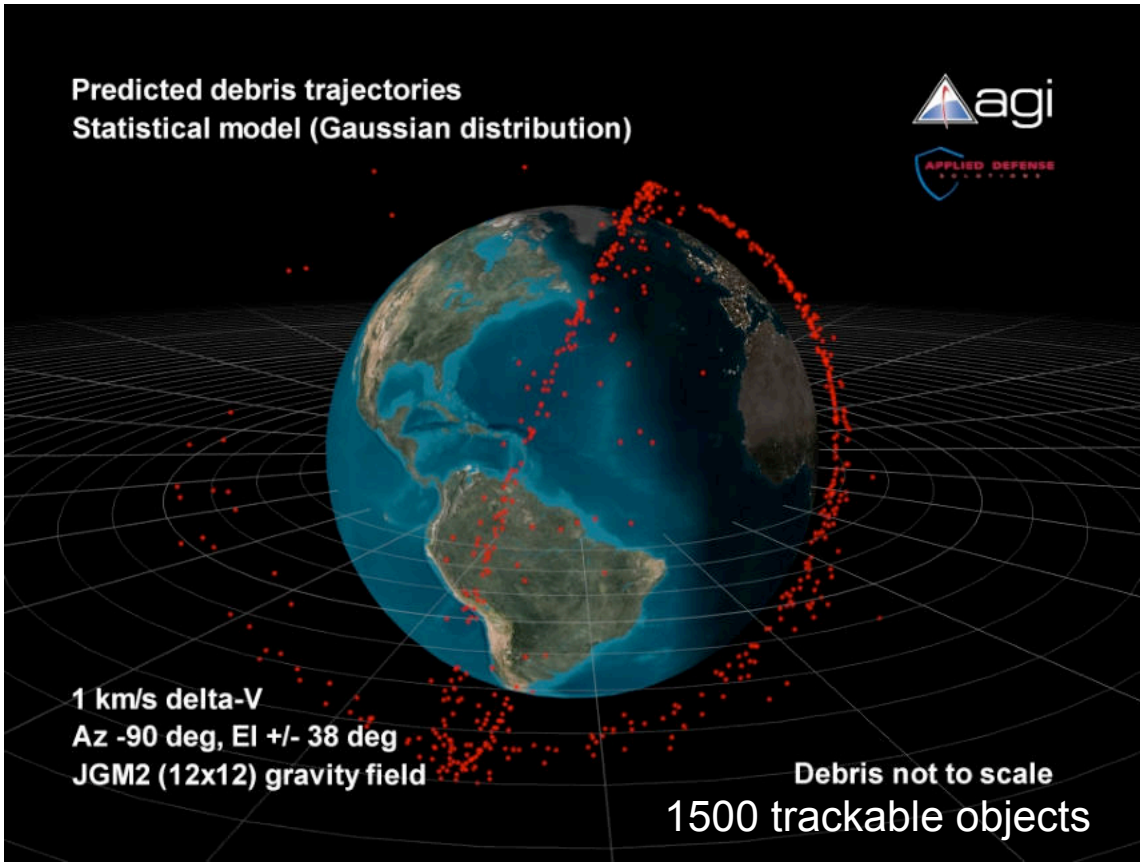
# Cosmos – Iridium collision: 10 Feb 2009

Iridium



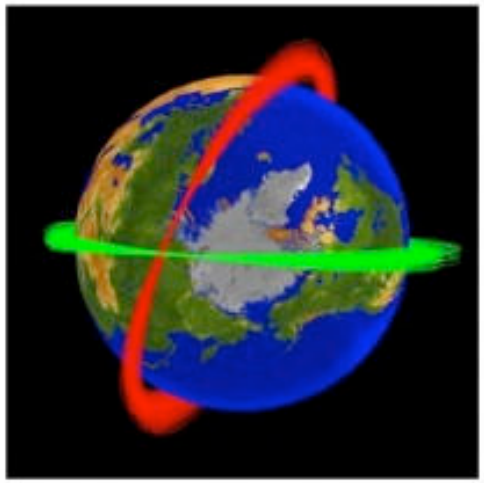
Cosmos 2251



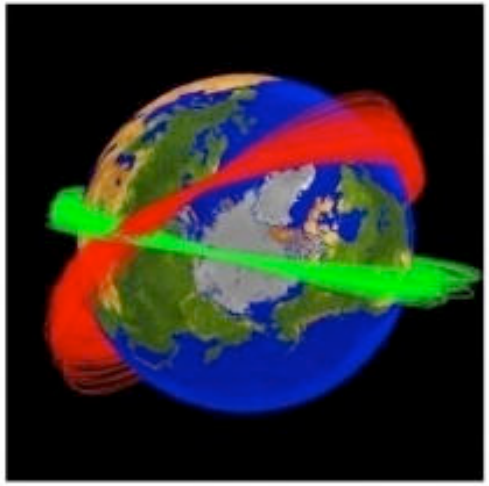



We do not have in place the capacity and systems to prevent another similar collision!

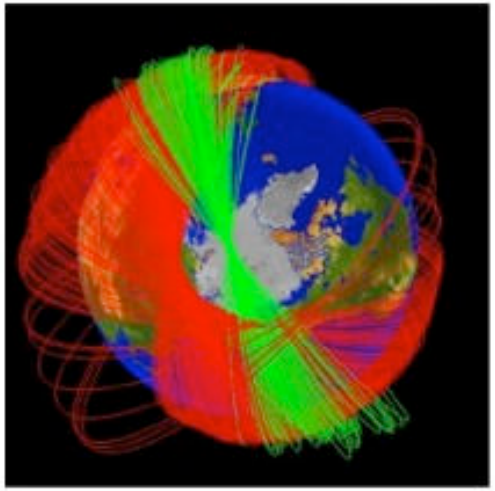
# Spread of debris orbital planes



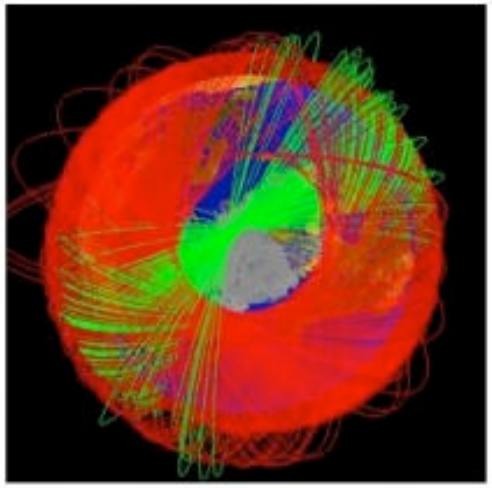
7 days



30 days



6 Months



1 Year

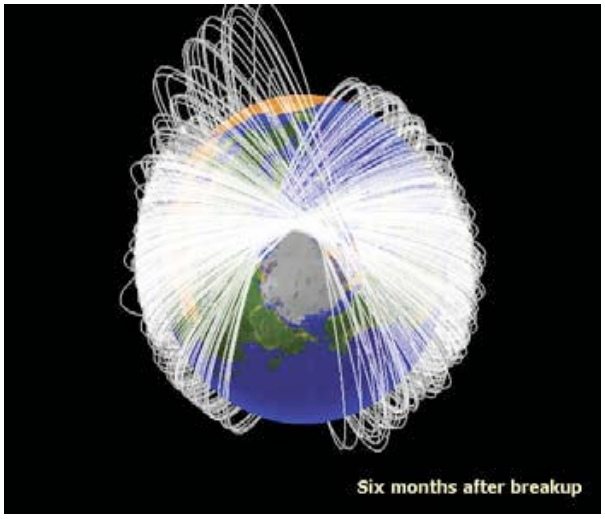
# Destruction of FY-1C: 11 Jan 2007

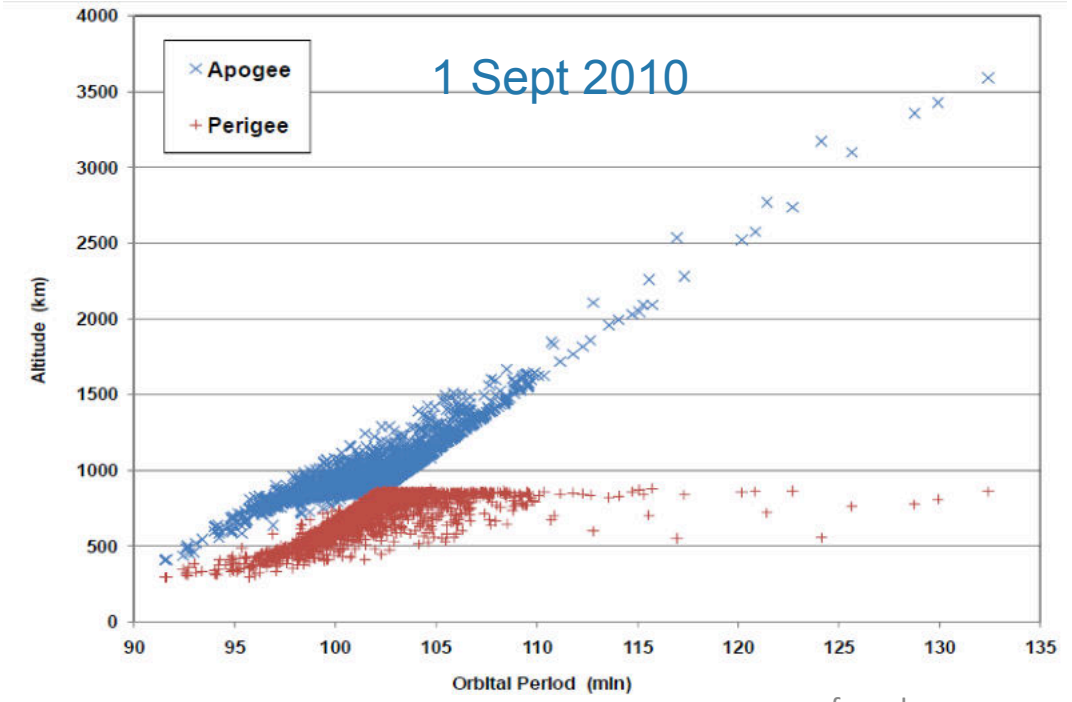
- Direct ascent kinetic destruction of inactive Chinese Feng Yun 1C (FY-1C) weather satellite.
- The satellite was in a polar orbit, at an altitude of 865 km, and was struck when it passed over the Xichang Space Centre in Sichuan province.
- 2377 trackable fragments created > 10 cm
  - Perhaps ~150,000 too small to track
- Instantaneous 23% increase in the trackable debris population

Similar tests were conducted by the USSR and USA in the 1970s and 1980s

# Destruction of FY-1C: 11 Jan 2007

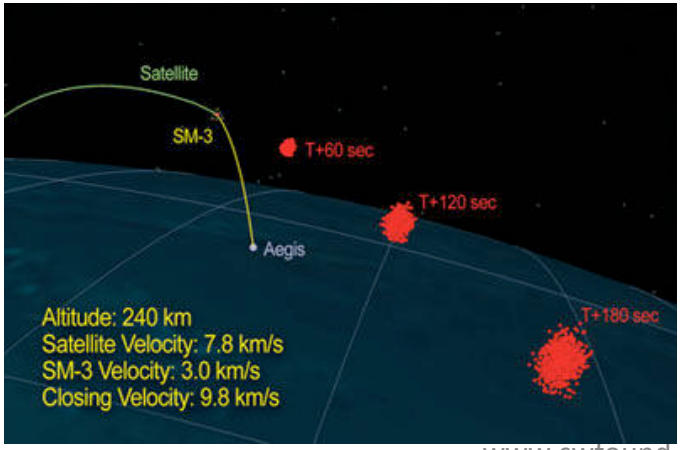
- Debris dispersed in range 200 km to 3500 km orbits.
- 2/3 of all active or inactive satellites in Earth orbit pass through this orbital region, including the ISS



# Destruction of USA-193: Feb 2008

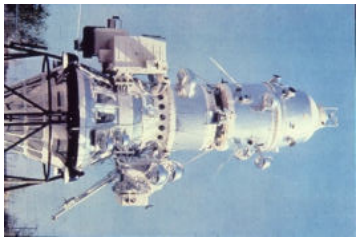
- The ailing US national security satellite USA 193 was expected to re-enter some time in 2008, with hydrazine fuel in its tanks.
- The US government decided to destroy the satellite shortly prior to re-entry at an altitude of 250km.
- The debris fell from orbit within 8 months of the event.



# Space debris - reentry

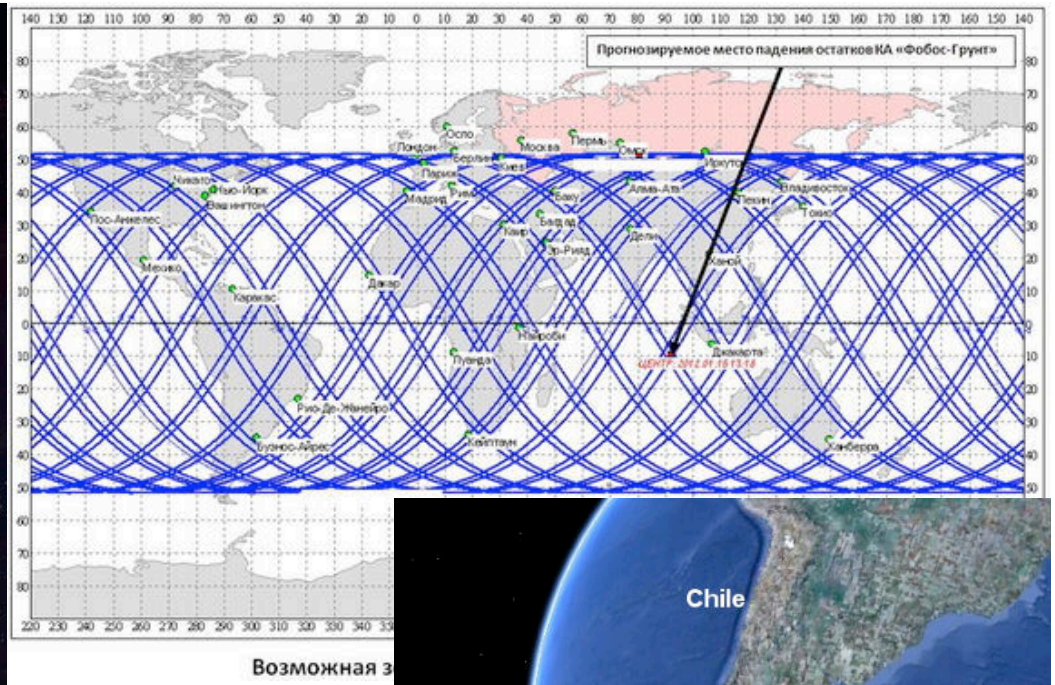
## *SOME EXAMPLES*

- On January 24, 1978 the Soviet military satellite Cosmos 954 crashed in Northwest Canada.
- It had a nuclear reactor on board.
- Radioactive debris scattered over 800 km area of Canada.



On April 27, 2000 a USA Delta II 2nd stage reentered over South Africa. The propellant tank landed 37 km NE of Cape Town.
A pressurisation sphere and rocket nozzle were also recovered.

# Phobos-Grunt reentry – 15 Jan 2012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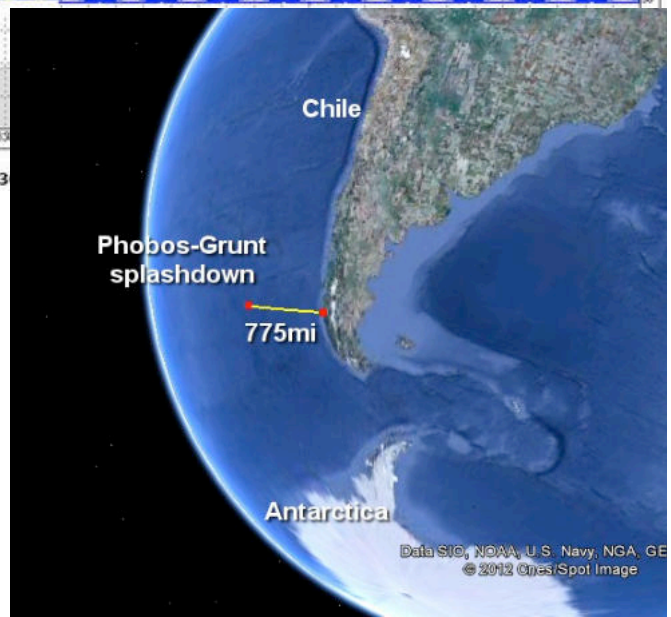
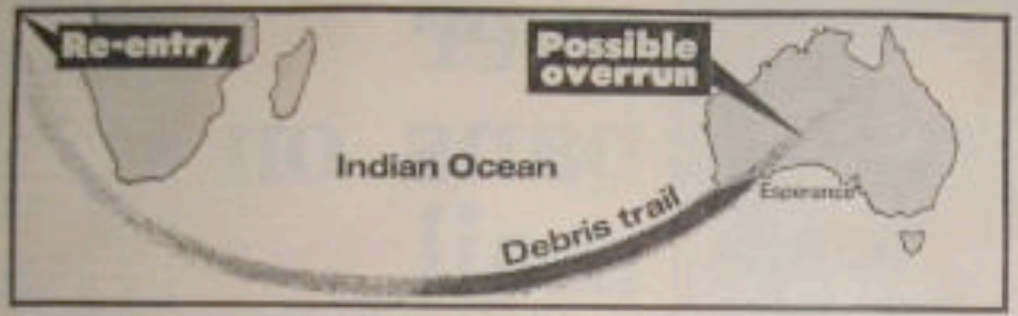


SPECIAL EDITION

POLICE VIEW OF MIGRANTS

— Page 3

The Sydney Morning Herald




Skylab's dying sweep across the Indian Ocean and into Western Australia

3 AM NEWS

# SKYLAB HITS WEST AUST

By BEN SANDILANDS, in Sydney, RICHARD MACEY, in Canberra, and MIKE STERCHI, in Washington

**The dying US spaceship Skylab crashed to earth in a huge ball of flame near the West Australian town of Esperance at 2.38 am today, Sydney time.**

Skylab

As far as was known, there was no damage to life or property.

It was not known if the wreckage fell into the sea or on to land near the remote coastal town.

"It was beautiful. There was a huge glare which lit up the sky," said Constable P. Giles, of Esperance police.

"We heard the rumbling followed by an explosion. It shook the windows and the sky was lit up like an exploding sky rocket.

"It must have been the metal parts breaking up, everyone is outside watching it."

TV camera catches image on tape

Flights grounded

Oil traces

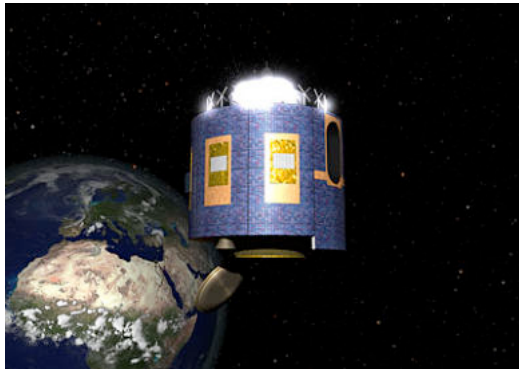
# Union clash looms over PM's threat to use new law

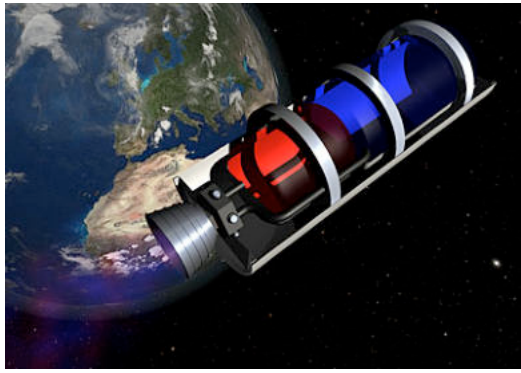
Telecom technicians and public service unions three days a direct challenge yesterday to a threat by the Prime Minister

Tomorrow

# Space debris mitigation measures

- Voluntary measures have been adopted by the leading space agencies to reduce introduction and proliferation of debris.
- **IADC Debris Mitigation Guidelines (adopted by UN)**
  - No intentional production of debris
  - Designing to minimise space debris production during normal operations & fragmentation due to strikes
  - Employ launchers that do not pollute the LEO environment
  - End of service disposal
    - Intentional de-orbiting & breakup for LEO s/c
    - Transfer to graveyard orbit for GEO s/c (235 km higher)
  - Active passivation of the spacecraft
    - Draining of all power, fuel and energy sources

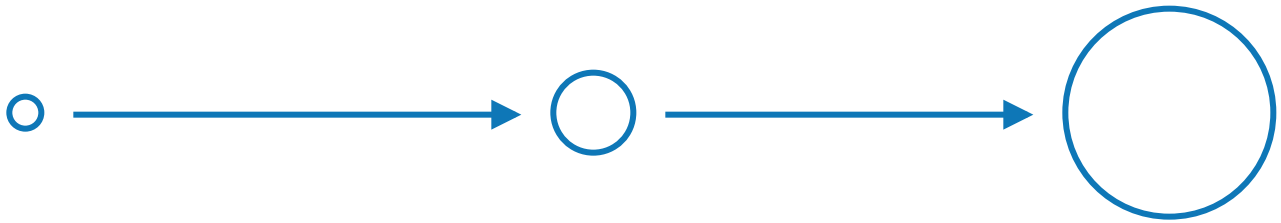




IMPLEMENTATION OF SDMGs WILL RETARD BUT NOT STOP OR REVERSE DEBRIS GROWTH

# Dealing with meteoroid/debris risk

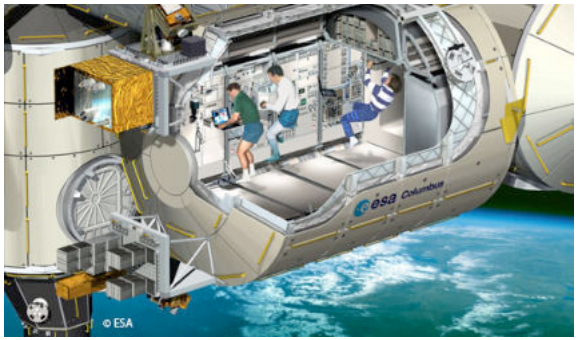
| NON-TRACKABLE<br>Probabilistic risk MODELS<br>“TAKE THE HIT” | TRACKABLE<br>PrEDICTABLE EVENTS<br>“GET OUT OF THE WAY” |
|---|---|

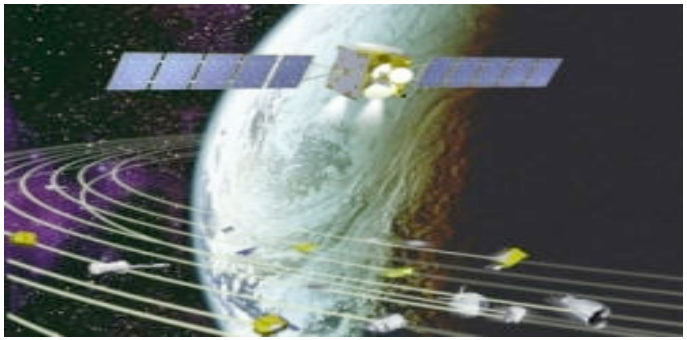


MMOD <1 cm
Passive shielding

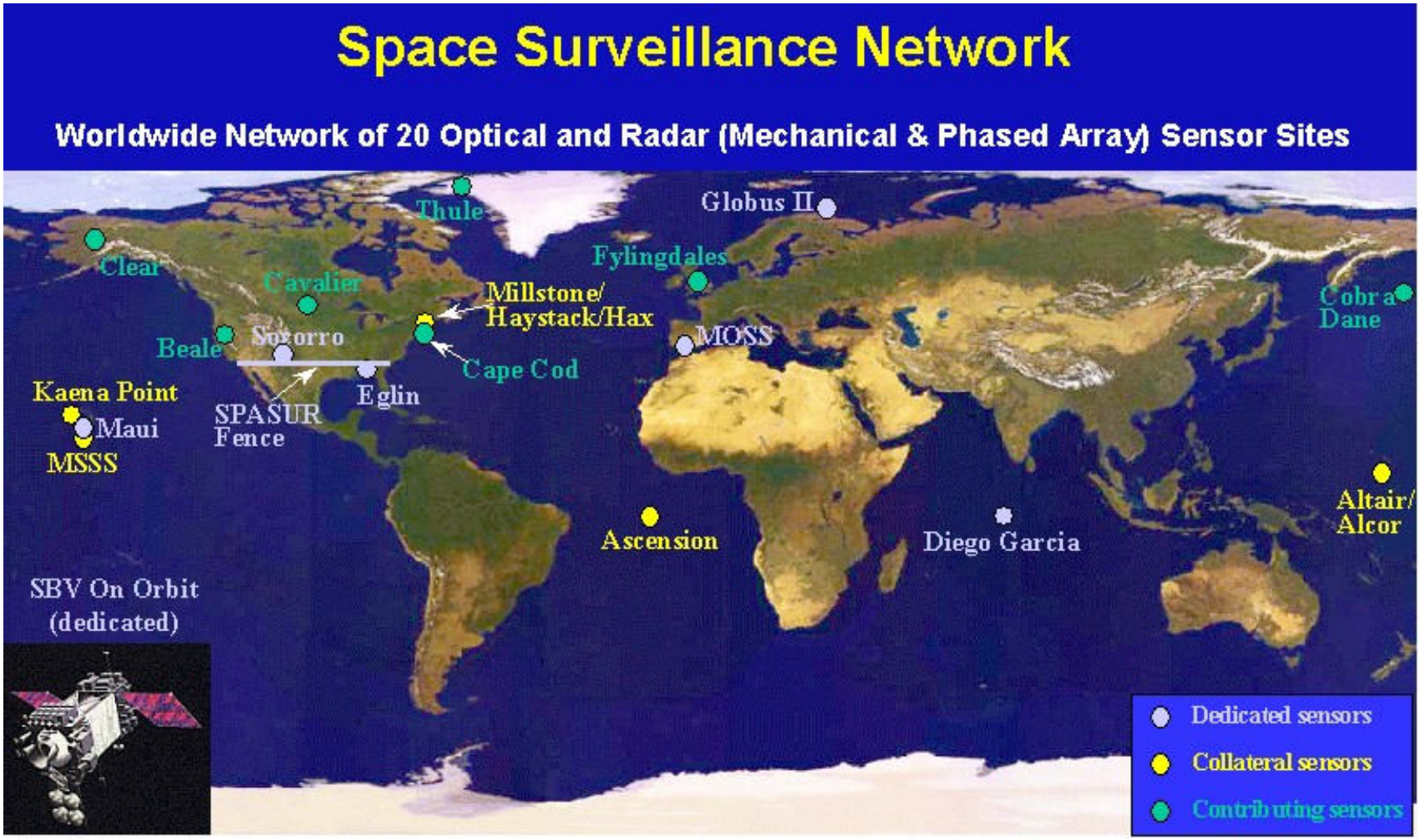
1 cm < MMOD < 10 cm
Passive shielding

MMOD > 10 cm
Collision avoidance manoeuvre

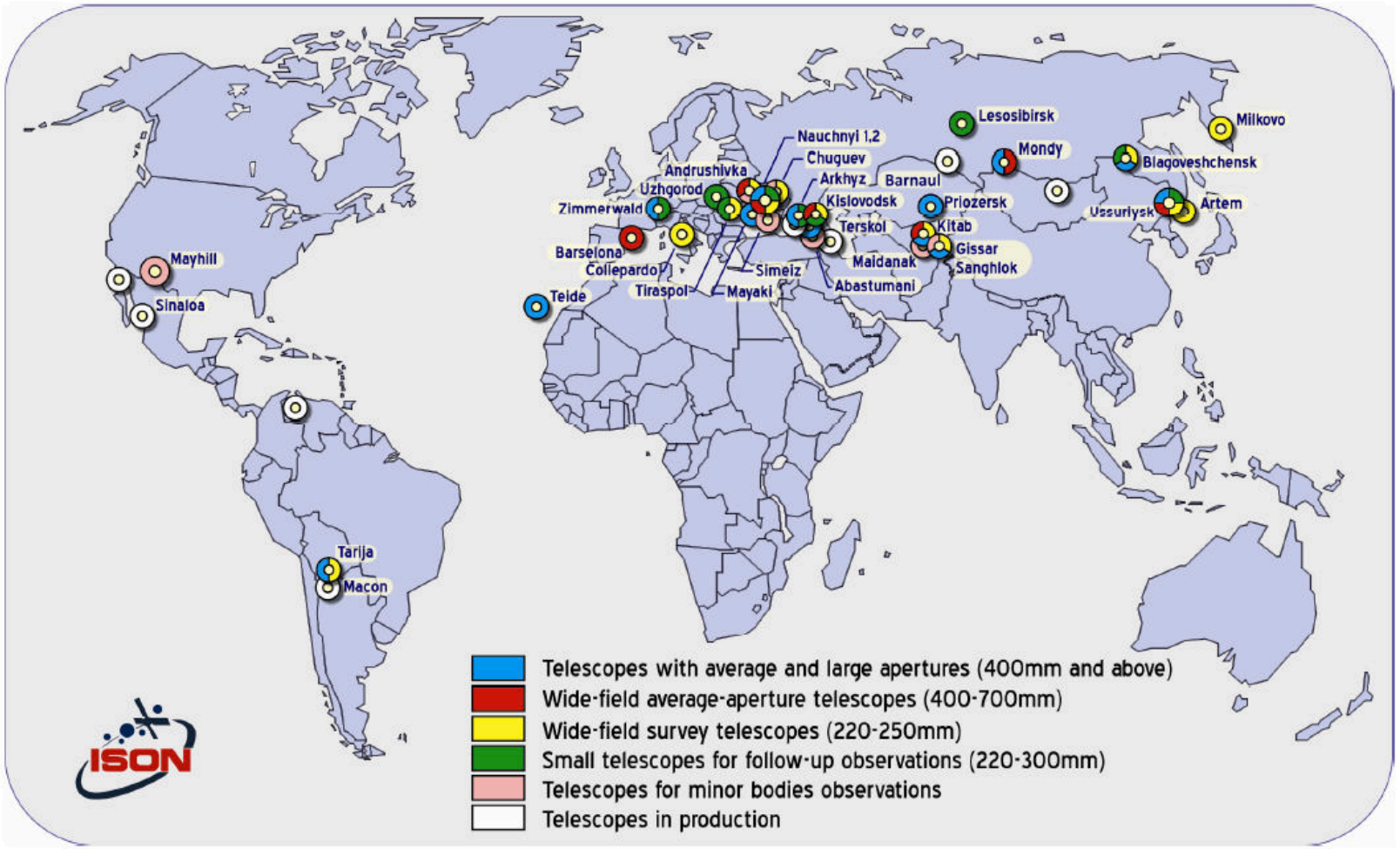


# SSA Networks - SSN

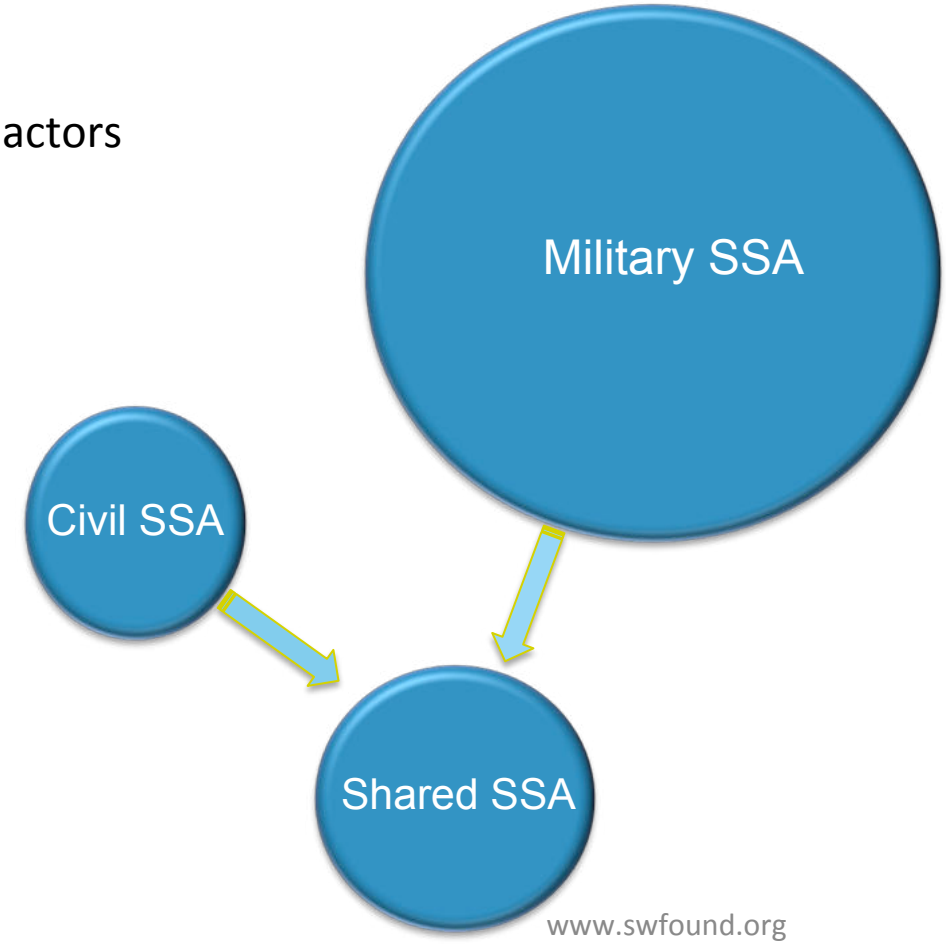


# SSA Networks - ISON

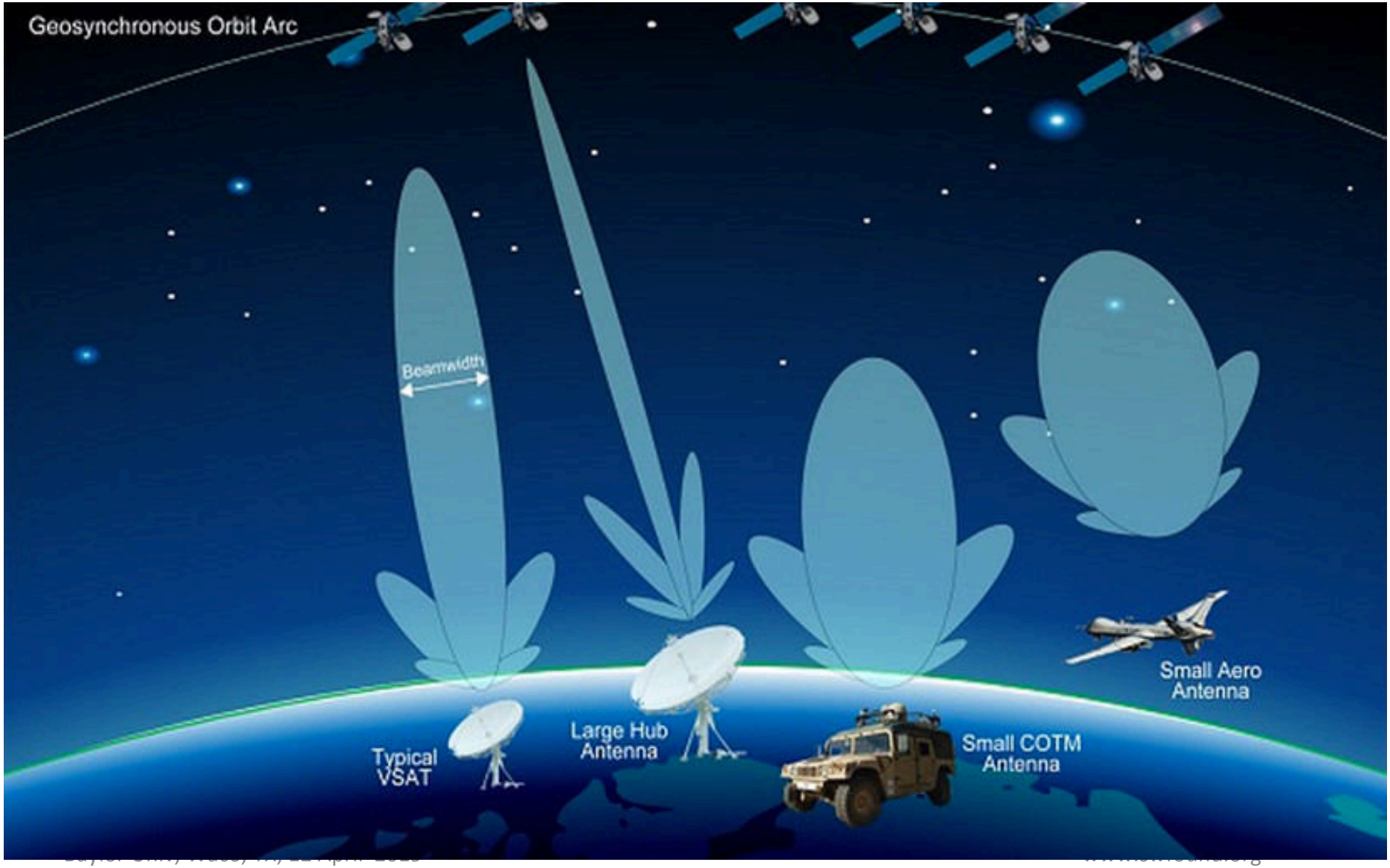


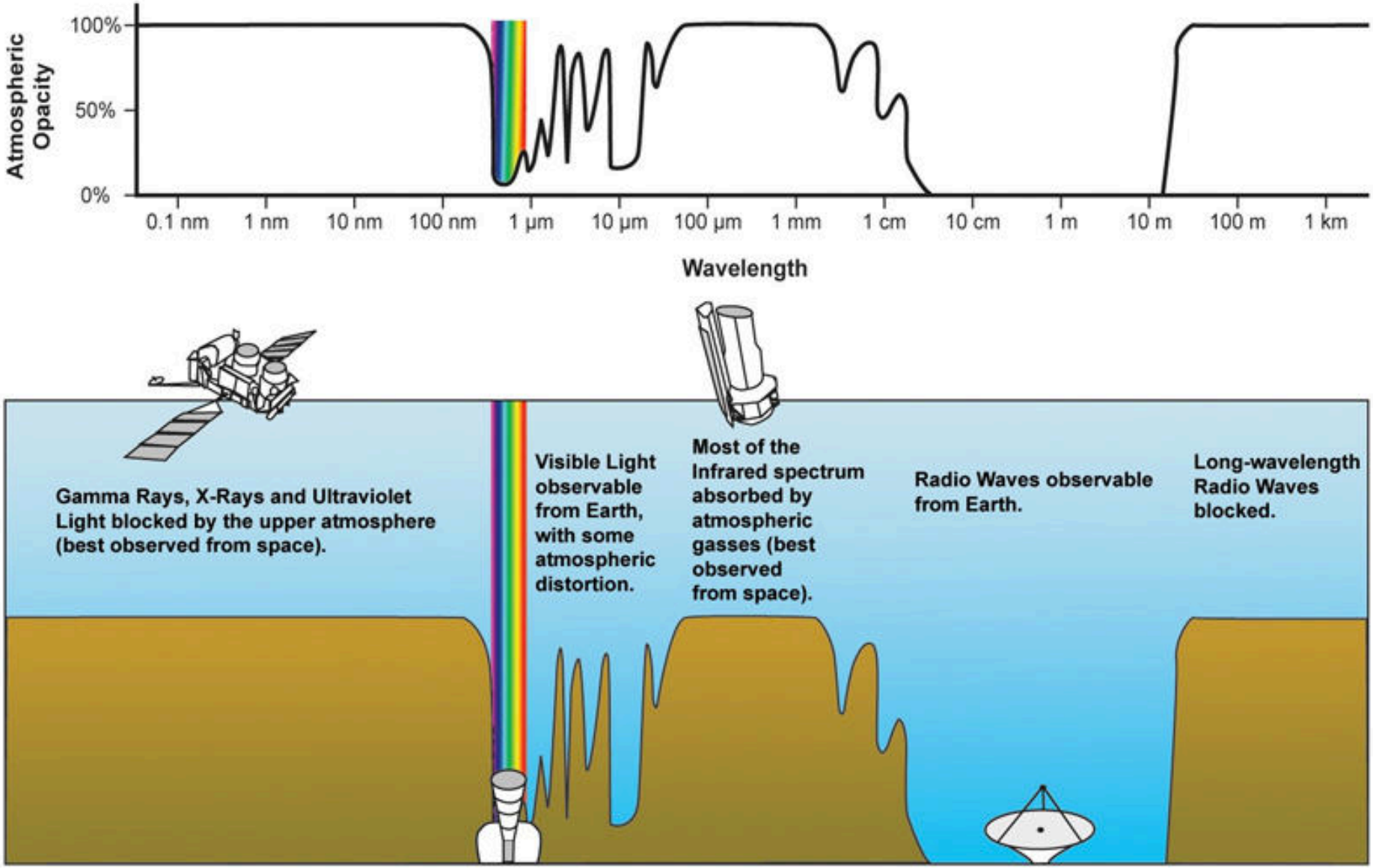
# SSA – Broadening the SSA base

- Currently, almost all SSA is done for ***military purposes***
- Emerging recognition of the need for
  - Civil SSA to support safety
  - Sharing of SSA between
    - Government and commercial actors
    - With other governments
    - With the public



# Radiofrequency interference




Atmospheric Opacity
100%
50%
0%
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1 km
Wavelength
Gamma Rays, X-Rays and Ultraviolet Light blocked by the upper atmosphere (best observed from space).
Visible Light observable from Earth, with some atmospheric distortion.
Most of the Infrared spectrum absorbed by atmospheric gasses (best observed from space).
Radio Waves observable from Earth.
Long-wavelength Radio Waves blocked.

# Some multilateral space security & space sustainability initiatives

# Space Sustainability & Space Security

- **Space Sustainability** is about using outer space in such a way that all humanity will be able to continue to use it in future for peaceful purposes and for societal benefit.
- Driven by the realisation that the Earth's orbital environment and EM spectrum are limited natural resources.
  - Concerned with ensuing that the benefits of space will continue to be accessible to future generations.
  - Raises issues about equitable and responsible access to and use of space resources.
  - Seen in the context of wider sustainability discussions.

- **Space Security** is about ensuring the continuity of space services and the integrity and resilience of space systems against natural and anthropogenic risks & threats.

Concern of all beneficiaries of space applications, including those not active in the space environment, and focuses on development on Earth.

# Who are the actors?

- In terms of international space law States bear international responsibility for all space activities
  - Article VI, Outer Space Treaty (1967)

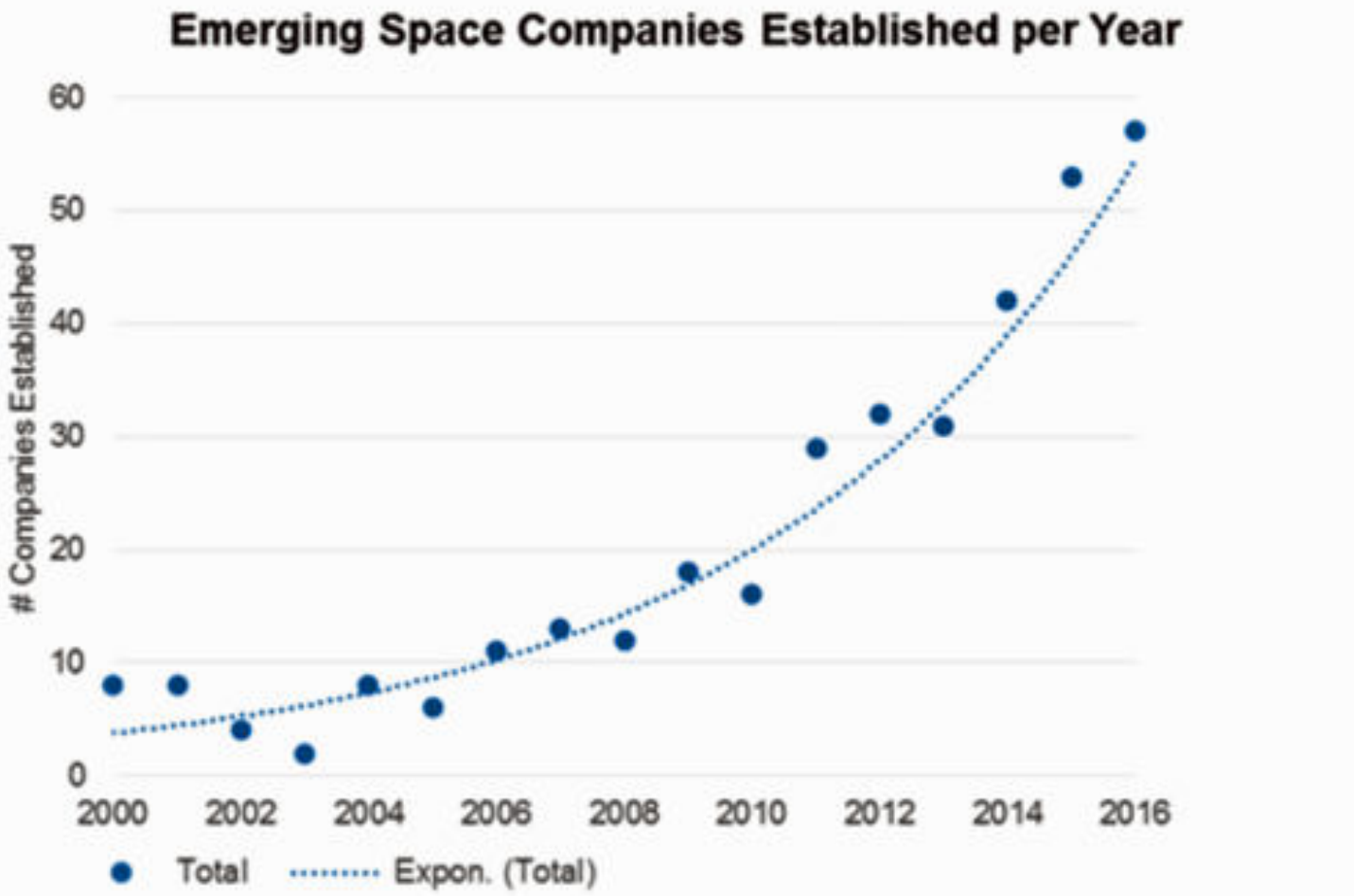
- In practical terms, space activities are carried out by:
  - State entities
    - Space agencies and other national civilian agencies
    - Military
  - Non-State actors
    - Academic and research institutions
    - Private sector, especially commercial sat. operators
    - Civil society organisations

Number increasing gradually

Number increasing more rapidly

Need to incorporate non-State contributions to inter-governmental discussions

# New space actors




Source: Northern Sky Research

# Space in the UN system

**VIENNA**

- UN COPUOS
- UNOOSA – Secretariat + Pgm Space Apps
- UNSPACE – Inter-agency Coordination

**GENEVA**

- Conference on Disarmament (CD)
- UNIDIR
- ITU

**NEW YORK**

- UN General Assembly

# UN COPUOS - overview

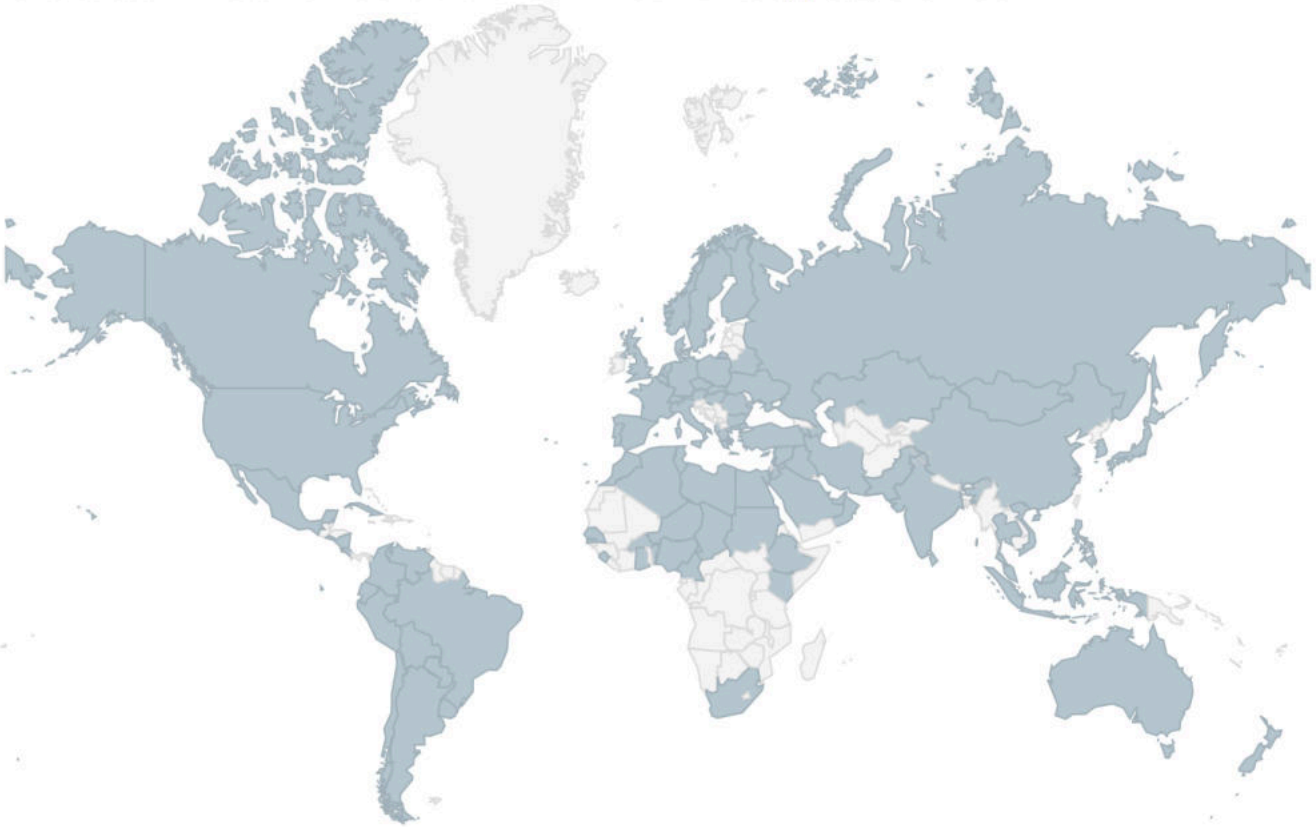
- UN COPUOS (Committee on the Peaceful Uses of Outer Space) is the primary international forum for the development of laws and principles governing activities in outer space.

- A standing committee of the UN, founded in 1959 by 24 Member States.
  - Currently 92 Member States and a large number of permanent observers
  - The technical work of COPUOS is carried out by two subcommittees
    - Legal Subcommittee (LSC)
    - Scientific and Technical Subcommittee (STSC)
  - Decisions are reached by consensus
  - Secretariat is the UN Office for Outer Space Affairs (UN Centre Vienna)

# UN COPUOS Member States

## Members of the Committee on the Peaceful Uses of Outer Space

In 1959, the United Nations General Assembly established the permanent Committee on the Peaceful Uses of Outer Space with 24 members. Since then, it has grown to 92 members - one of the largest Committees in the United Nations. In addition to States, a number of international organizations, including both intergovernmental and non-governmental organizations, have observer status with COPUOS and its Subcommittees. For the evolution of Committee Members, please click here.



Source: www. unoosa.org

# What COPUOS has done for space

- Five Treaties on Outer Space
- Legal Principles Governing Activities of States, Remote Sensing, Nuclear Power Sources, Direct TV Broadcasting and International Cooperation
- 130 Gen Assembly resolutions & recommendations on outer space matters
- Three UN Space Conferences (1968, 1982, 1999) & UNISPACE+50 in 2018
- UN Programme on Space Applications
  - Many capacity-building workshops each year
  - Regional Centers for Space Science & Technology Education
  - SPIDER (Disaster Management)
  - International Committee on GNSS

Activities relating to space security/sustainability

- UN COPUOS Space Debris Mitigation Guidelines
- UN COPUOS/IAEA Safety Framework for Nuclear Power Source Applications in Outer Space.
- WG on Long-Term Sustainability of Outer Space Activities of the STSC

# Treaties governing space activities

- Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the "Outer Space Treaty") 1967;
- Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (the "Rescue Agreement") 1968;
- Convention on International Liability for Damage Caused by Space Objects (the "Liability Convention")1972;
- Convention on Registration of Objects Launched into Outer Space (the "Registration Convention") 1976;

- Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (the "Moon Agreement") 1984.

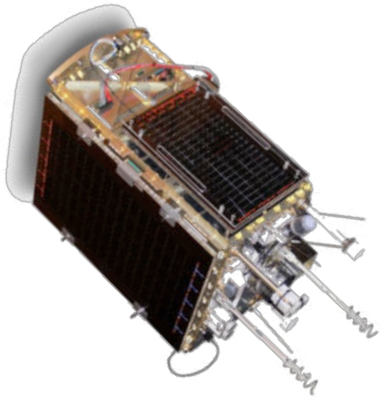
In recent years, tendency to non-binding decisions, rather than treaties.
(Non-binding does not mean non-legal)

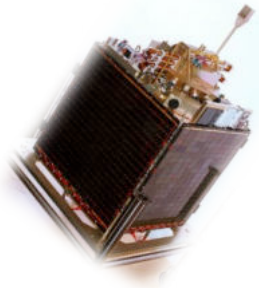
- What's new
- Office for Outer Space Affairs
- Meetings Calendar
- Committee on the Peaceful Uses of Outer Space
- Programme on Space Applications
- UN-SPIDER
- International Committee on GNSS
- Regional Centres for Space Science and Technology Education
- Space Law

- Register of Space Objects
  - Registration Convention
  - Registration Submissions
    - Notifications by States & Organizations
      - Algeria
      - Argentina
      - Australia
      - Austria
      - Azerbaijan
      - Belarus
      - Brazil
      - Canada
      - Chile
      - China
      - Czech Republic
      - Democratic People's Republic of Korea
      - Denmark
      - Egypt
      - France
      - Germany
      - Greece
      - Hungary
      - India

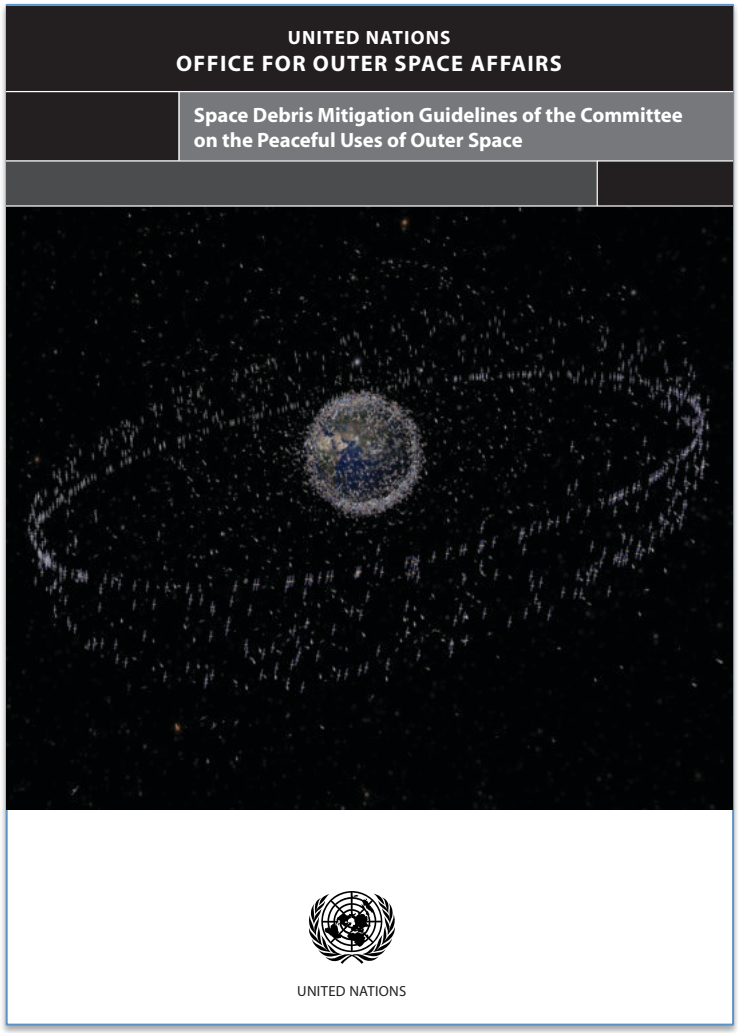
## Convention on Registration of Objects Launched into Outer Space: Reports

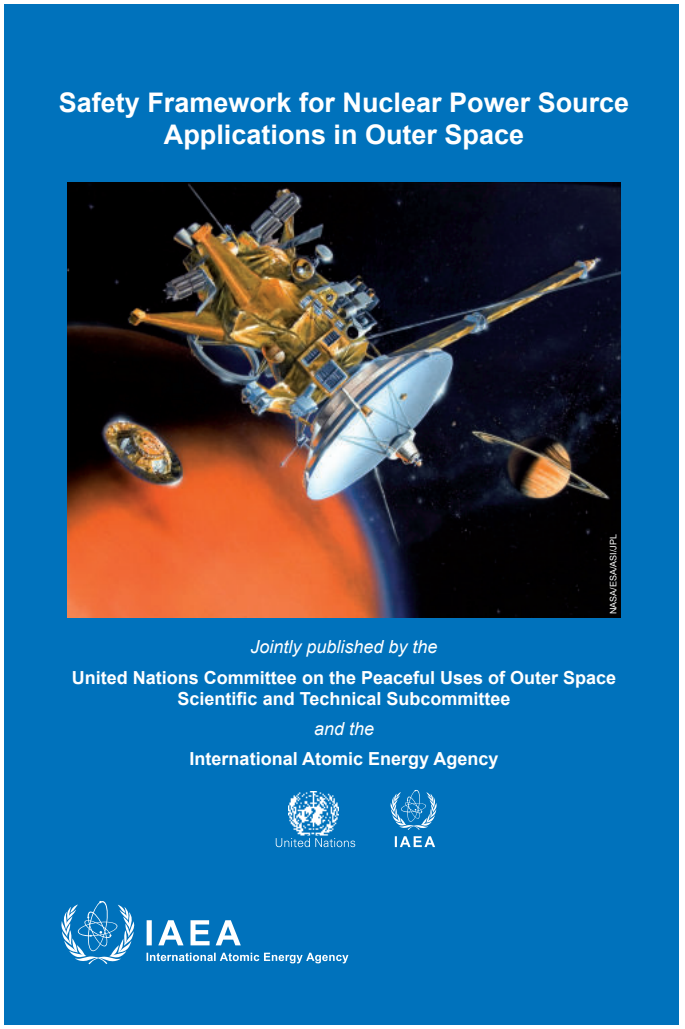
| | |
|---|---|
| Document Symbol: | ST/SG/SER.E/687 |
| Notifying State/Organization: | South Africa |
| Main Title: | Information Furnished in Conformity with the Convention on Registration of Objects Launched into Outer Space |
| Sub Title: | Note verbale dated 9 September 2013 from the Permanent Mission of South Africa to the United Nations (Vienna) addressed to the Secretary-General |
| Remarks: | Registration information for SUNSAT (international designator 1999-008C) and SumbandilaSat (international designator 2009-049F) |
| Available Format: | Adobe PDF |
| Available Languages: | • Arabic<br>• Chinese<br>• English<br>• French<br>• Russian<br>• Spanish |





# Soft law (voluntary) instruments



# UN GGE on TCBMs

- UN Group of Govt Experts on Transparency and Confidence Building Measures (TCBMs) for Outer Space Activities
- UN General Assembly Resolution A/Res/65/68 of 2010
- 15 Experts selected for geographical balance & knowledge
- The GGE conducted a study on outer space transparency and confidence-building measure
  - making use of relevant reports of the UN Secretary-General
  - without prejudice to the substantive discussions on the prevention of an arms race in outer space within the framework of the CD
  - Report adopted by General Assembly at its sixty-eighth session (in 2013) A/68/189 (Sponsored by China, Russia and USA)

- TCBMS are meant to be voluntary and not legally binding

# UN GGE on PAROS

- For many years the UN General Assembly has been passing a resolution on the Prevention of an Arms Race in Outer Space (PAROS)

- In 2018, the UN established a third GGE related to space, this time with a focus on PAROS.

- The GGE was mandated to consider what might be the elements of a possible future binding treaty on PAROS.

- In March 2019 the GGE's mandate ended and the Group was not able to agree on a report.

# International Code of Conduct

- Proposed by EU
- Principles
  - freedom for all to use outer space for peaceful purposes
  - preservation of the security and integrity of space objects in orbit
  - due consideration for the legitimate security and defence interests of States
- All-encompassing in scope (civil & military uses of space)

- Focuses on establishing norms of behaviour and proscribing irresponsible behaviours
- Not legally-binding, a political commitment
- EU seeks to promote broad participation in this initiative
- The ICOC initaitive has been dormant since July 2015

# Conference on Disarmament (CD)

- Some States believe that conflict in outer space would have such terrible consequences that they would like to ban the use of weapons in space through a legally binding treaty
  - However, there are definitional problems
- CD has discussed Prevention of an Arms Race in Outer Space (PAROS) for a number of years
- However, CD is deadlocked because States cannot agree on its agenda, so there has been no progress on PAROS
- In 2008 China and Russia introduced draft Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects (PPWT)
- PPWT has support of many States, but not all, because of definitional issued and verification concerns of the PPWT

# UN COPUOS Space Sustainability WG

- Working Group on Long-Term Sustainability of Outer Space Activities worked from 2010 – 2018.

- Four expert groups were established to develop the draft guidelines ("Track 1.5" process)
  - **Expert Group A: Sustainable space utilization supporting sustainable development on Earth**
    **CO-CHAIRS: FILIPE DUARTE SANTOS (PORTUGAL), ENRIQUE PACHECO CABRERA (MEXICO)**
  - **Expert Group B: Space Debris, Space Operations and Tools to Support Collaborative Space Situational Awareness**
    **CO-CHAIRS: RICHARD BUENNEKE (USA), CLAUDIO PORTELLI (ITALY)**
  - **Expert Group C: Space Weather**
    **co-CHAIRS: TAKAHIRO OBARA (JAPAN), IAN MANN (CANADA)**
  - **Expert Group D: Regulatory Regimes and Guidance for Actors In the Space Arena**
    **CO-CHAIRS: SERGIO MARCHISIO (ITALY), ANTHONY WICHT (AUSTRALIA)**

- Produced 21 consensus-based guidelines for safe and sustainable space activities
- Guidelines are voluntary – not binding
  - "Non-binding" does not mean "non-legal"

# LTS GUIDELIENS AND SPACE TRAFFIC MANAGEMENT

- COPUOS is not discussing STM per se

- COPUOS is discussing norms of behavior that create a foundation for a future STM
  - Treaties & Principles
  - Space Debris Mitigation Guidelines
  - Guidelines for Long-Term Sustainability (LTS) of Outer Space Activities

**LTS GUIDELINES THAT ARE FOUNDATIONAL OR IMPORTANT FOR STM**

| POLICY & REGULATORY | GUIDELINE |
|---|---|
| Adoption of national legislation | A.1, A.2 |
| Supervise national space activities | A.3 |
| Rational use of orbit/spectrum resource | A.4 |
| Enhance registration practice | A.5 |

# UN COPUOS AND STM

| SAFETY OF SPACE OPERATIONS | GUIDELINE |
|---|---|
| – Exchange of contact information & info on objects/events | B.1 |
| – Improve accuracy of orbital data on space objects and enhance sharing of orbital information on space objects | B.2 |
| – Collect & share debris information | B.3 |
| – Conjunction assessment during all orbital phases | B.4 |
| – Pre-launch conjunction assessment | B.5 |
| – Share Space weather forecasts, data & models | B.6, B.7 |
| – Design for trackability | B.8 |
| – Precautions in use of lasers | B.10 |

# What are the thorny issues?

- The most contentious draft guidelines are those that address:
  - The exclusively peaceful uses of outer space
  - Refraining from actions directed at foreign space objects that would not be acceptable if applied to one's own space objects
  - Interference with the operation of foreign space objects through unauthorized access to their on-board hardware and software
  - Intentional modifications of the natural space environment
  - Active removal of space objects from orbit
  - Destruction, in exceptional circumstances, of space objects
  - Non-registered space objects

# What are the thorny issues?

HOWEVER – Substantive issues apart, there are also two fundamentally different views on the process to finalise the guidelines:

1. "Conveyor-belt" or phased approach of negotiating and delivering guidelines in packages as they are agreed

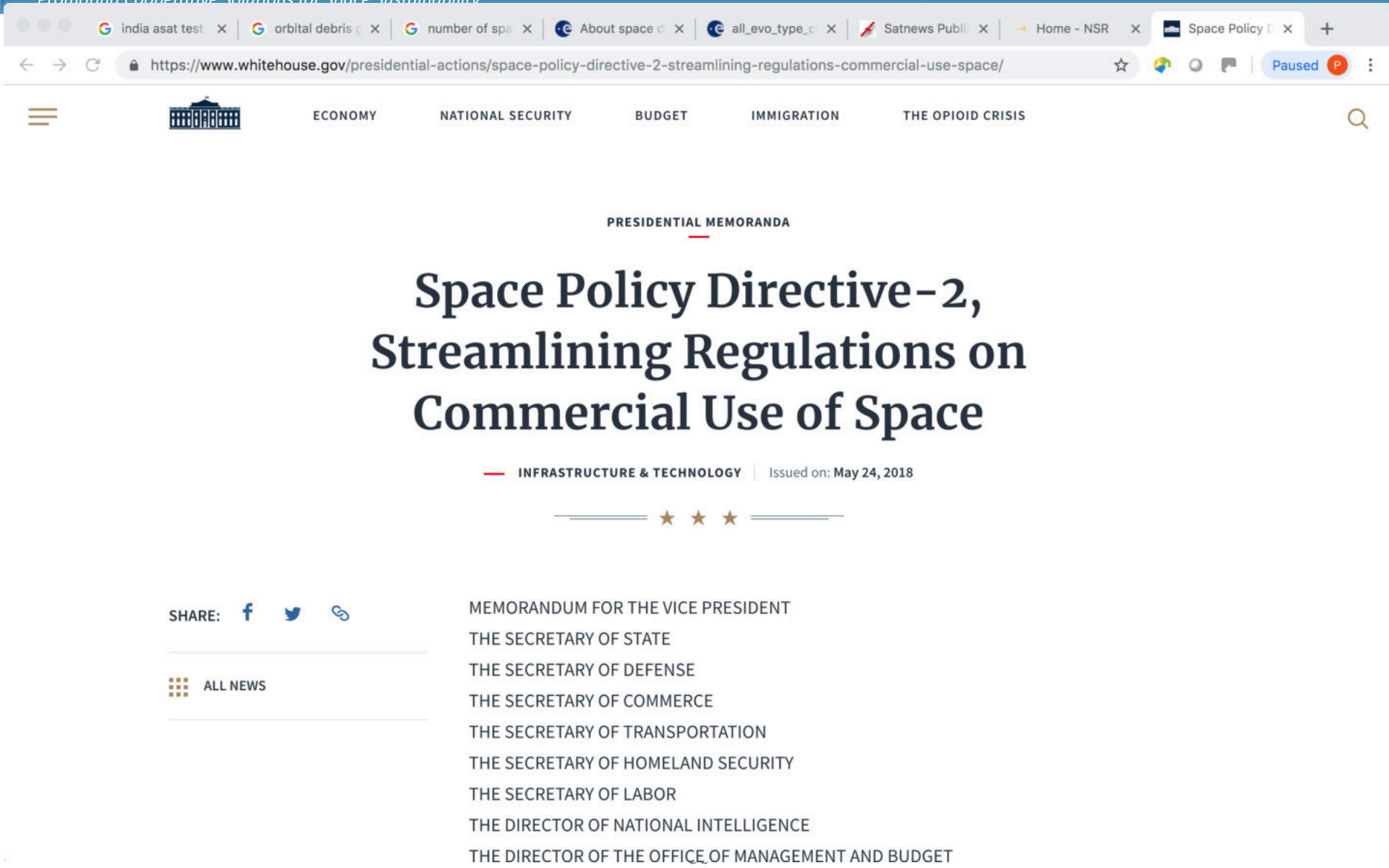
   →Favoured by many states that want to demonstrate the substantial progress that is being made in COPUOS.

2. "Nothing is agreed until everything is agreed" approach.

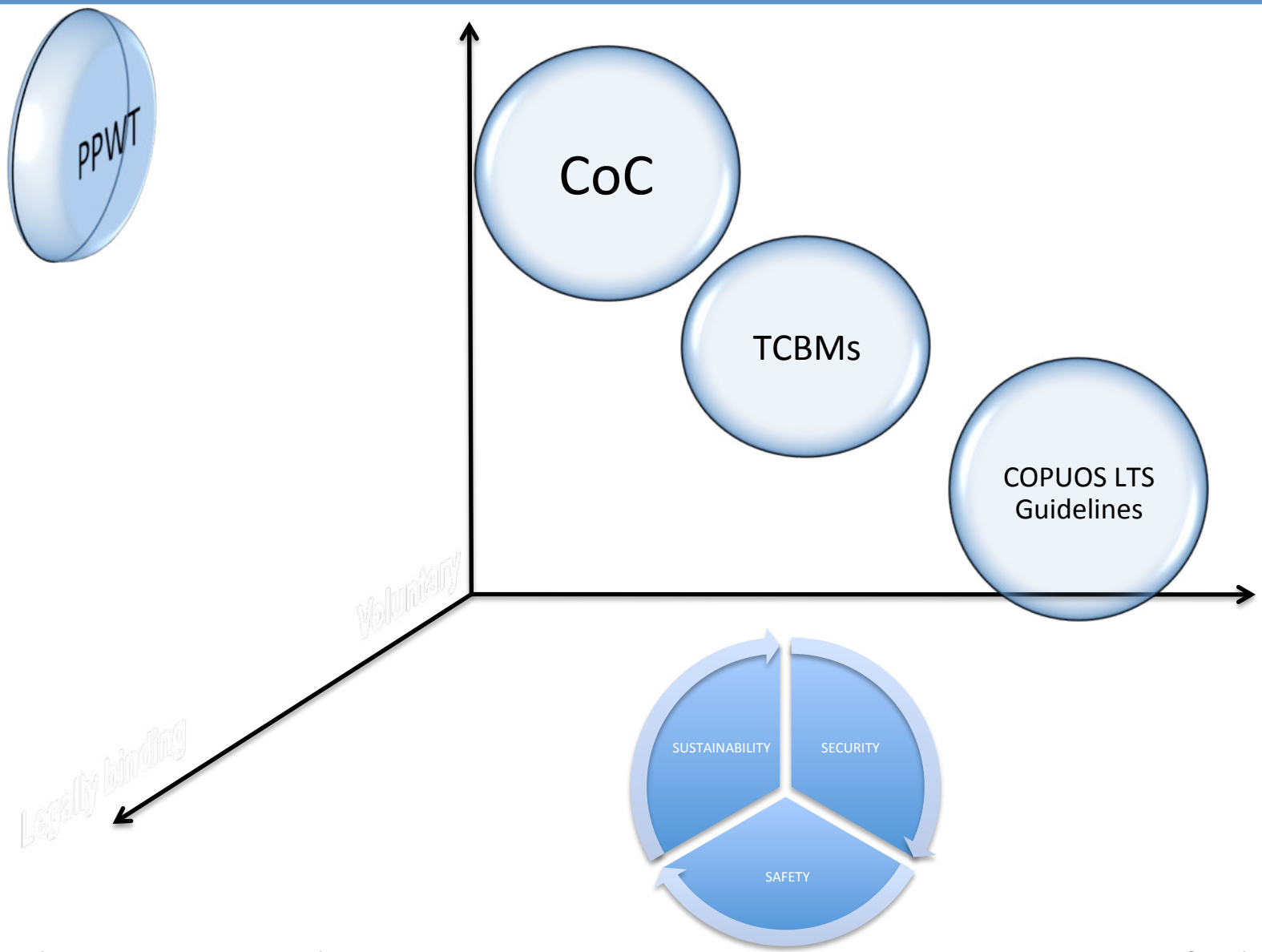
   → Favoured by States that want to be sure that their proposals will not be "left behind"

Reconciling these different approaches will be the major challenge for the upcoming session of COPUOS in June 2017.

# Commercial space regulation



# How do these initiatives relate to each other?



# The future

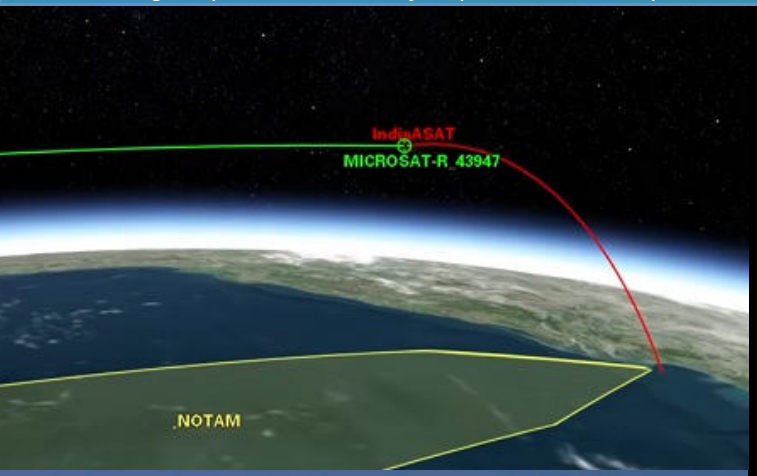
- Era of multi-functional, multi-layered orbital constellations
- The UN process is necessary but not sufficient effort to ensure space sustainability

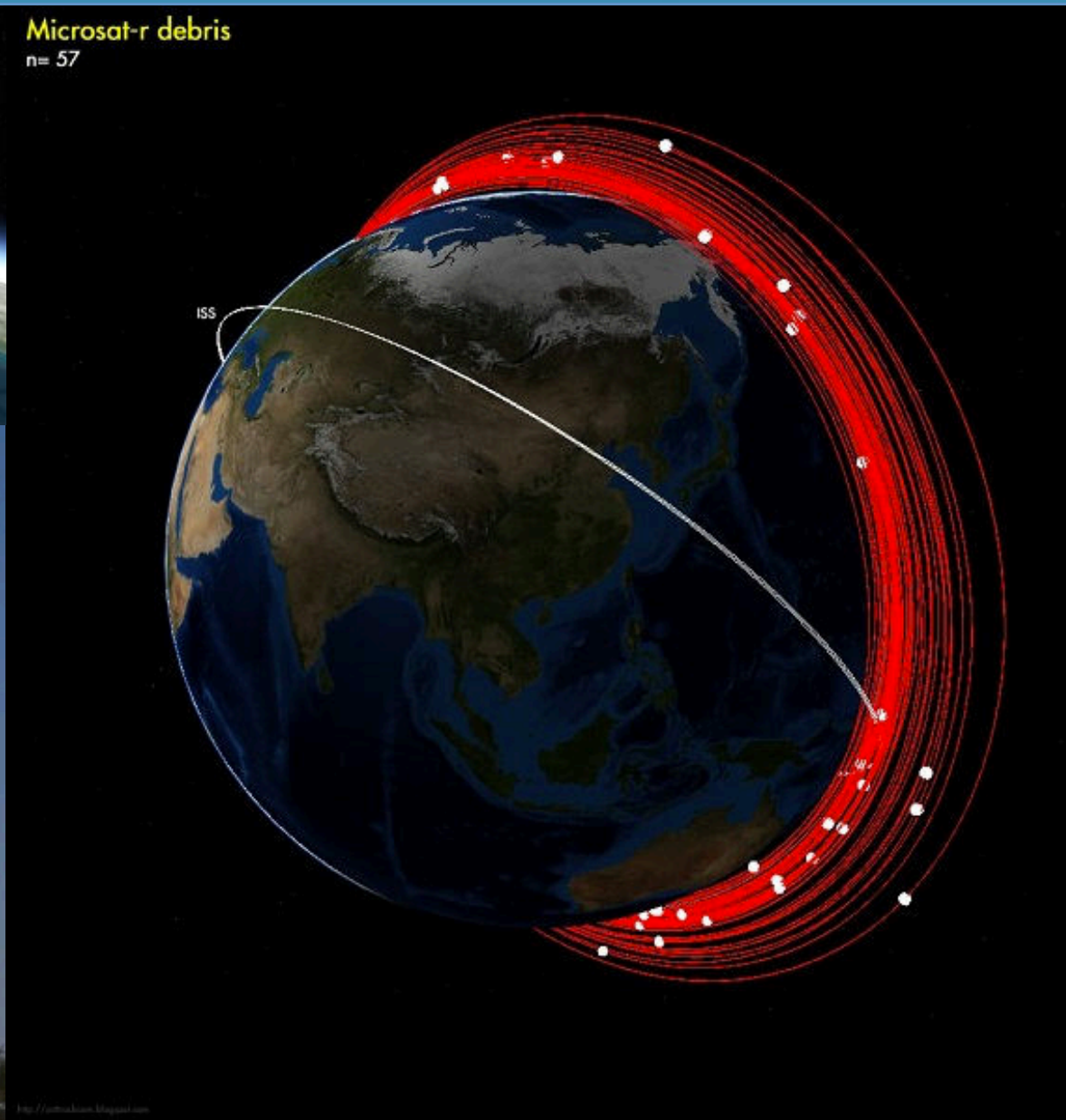
- National regulators
  - Authorisation & supervision (spectrum, orbits, registration)
  - Coordination
  - Industry stimulus
- Launch providers
  - Gatekeeping function
  - Registration
- Smallsat community (govt, academic & industry)
  - Technical and operational standards
  - Norms of behaviour
- Space traffic management
  - SSA information sharing (Rules & procedures)
  - Conjunction assessment

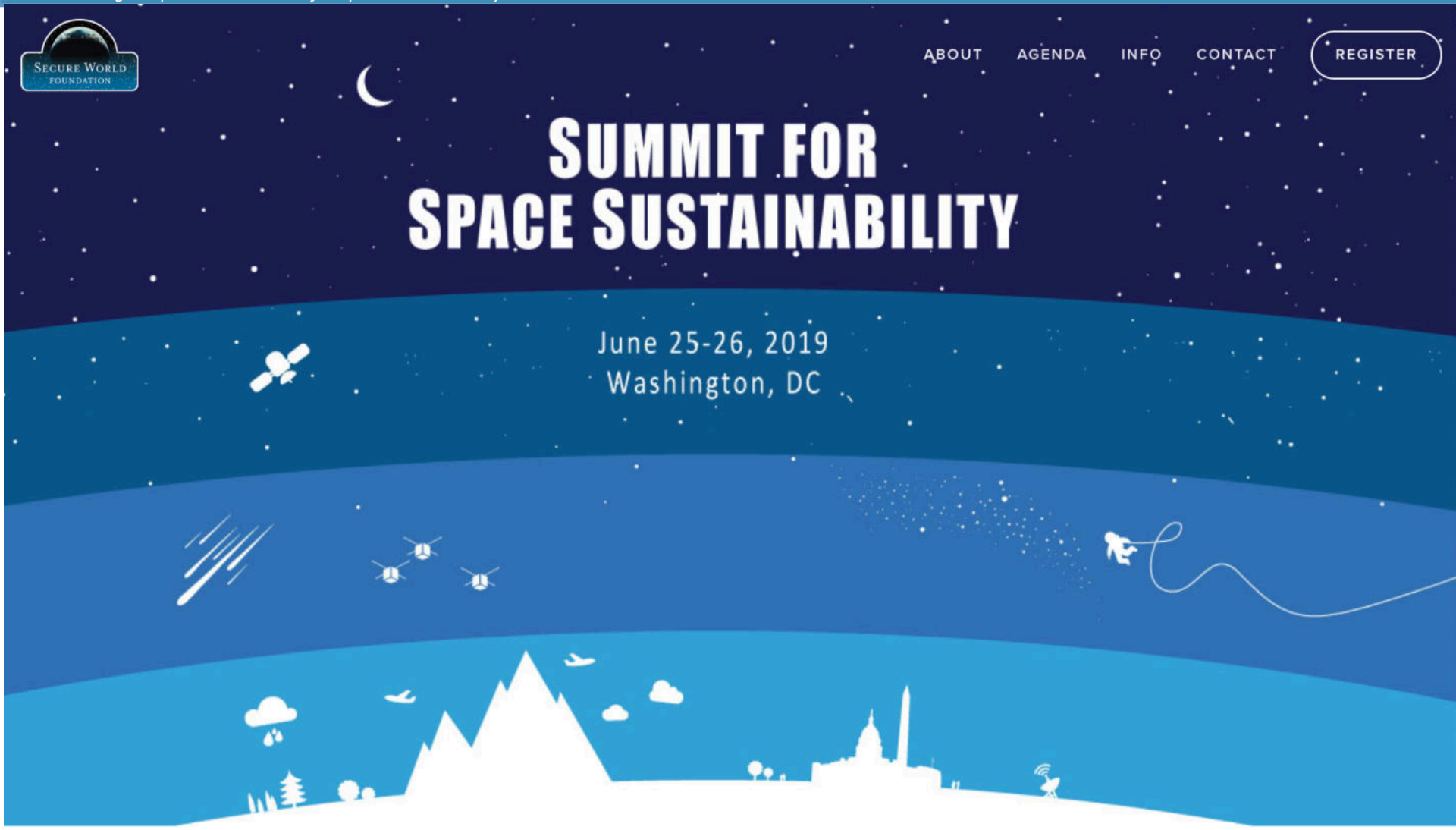
SECURE WORLD FOUNDATION

*Promoting Cooperative Solutions for Space Sustainability*

# The March 2019 Indian ASAT test

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June 25-26, 2019
Washington, DC


Thank you