

***LASER RANGING FOR THE PRECISION ORBIT
DETERMINATION AND REMOTE MANEUVER OF SPACE
DEBRIS***



Ben Greene

THE CRC FOR SPACE ENVIRONMENT MANAGEMENT

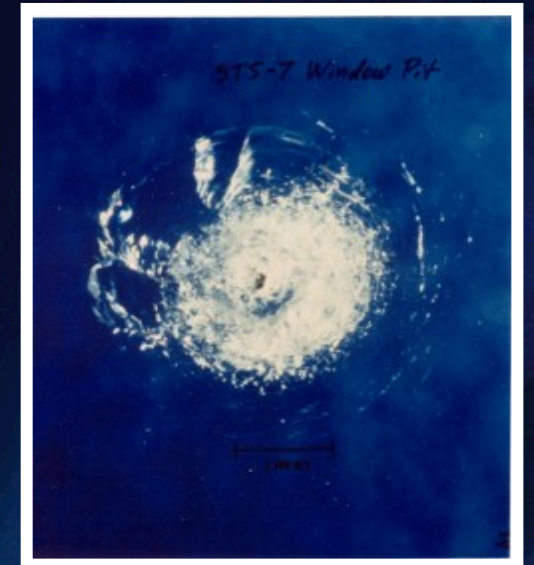
31 OCT 2014

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The Problem

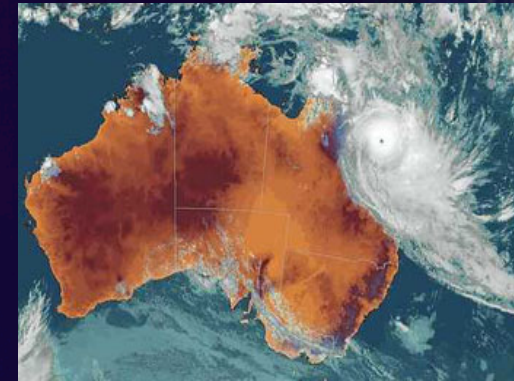
- 3,000+ operational satellites in orbit around Earth, worth about 1 trillion dollars and growing
- Also 300,000+ space debris objects, greater than 1 cm across, and up to 1 million smaller objects (objects include spent rocket casings, nuts and bolts and an astronaut's glove)
- A collision between one piece of debris and a satellite causes severe damage or destruction AND creates more debris.
- Space may be unusable within 20-30 years (Kessler syndrome)

Damage to space shuttle window caused by a fleck of paint



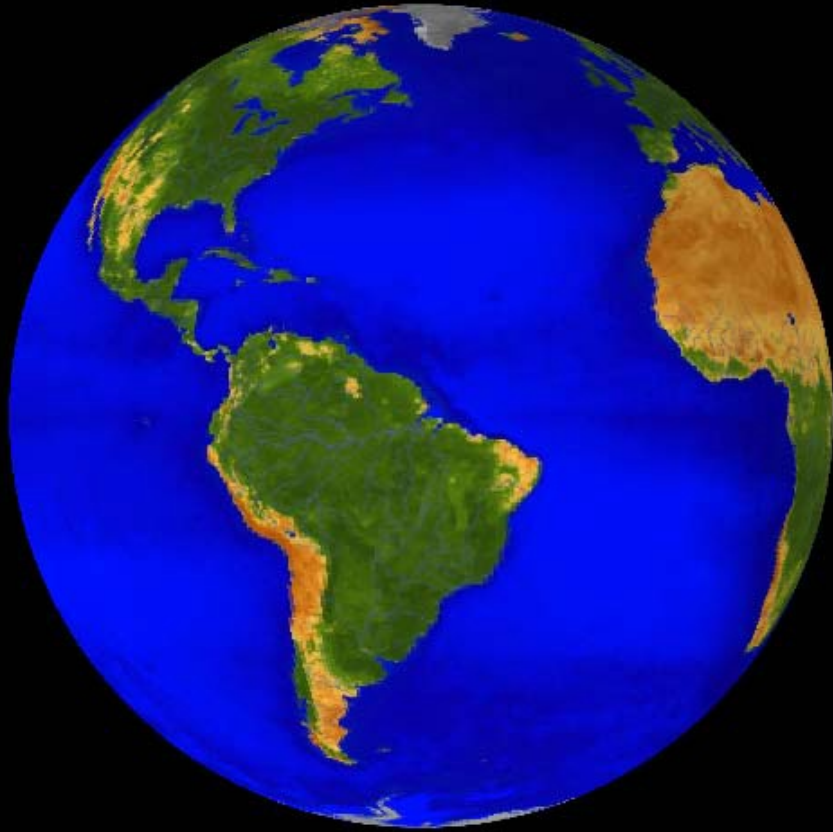
The Problem

Modern societies are now **fundamentally depend** on assured and secure access to space assets for many basic requirements



Space debris presents a devastating societal threat

The Orbital Debris Environment: Before 1957



Low Earth Orbit (LEO)

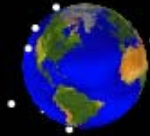


Geostationary Earth Orbit (GEO)

1960



LEO

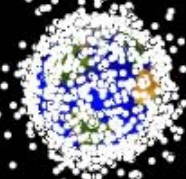


GEO

1970



LEO

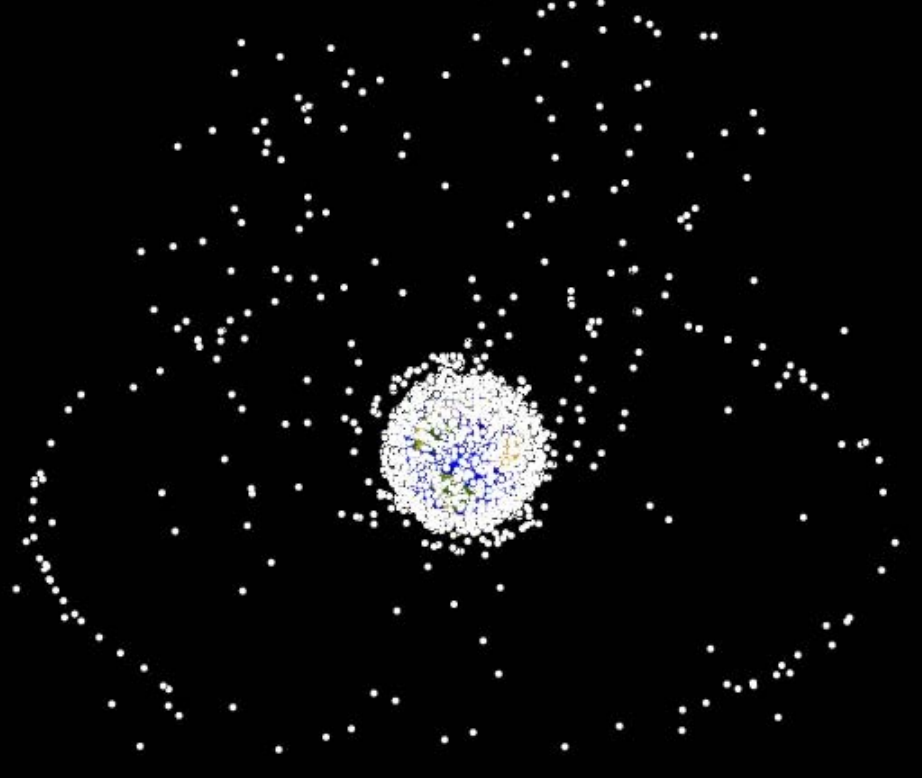


GEO

1980



LEO

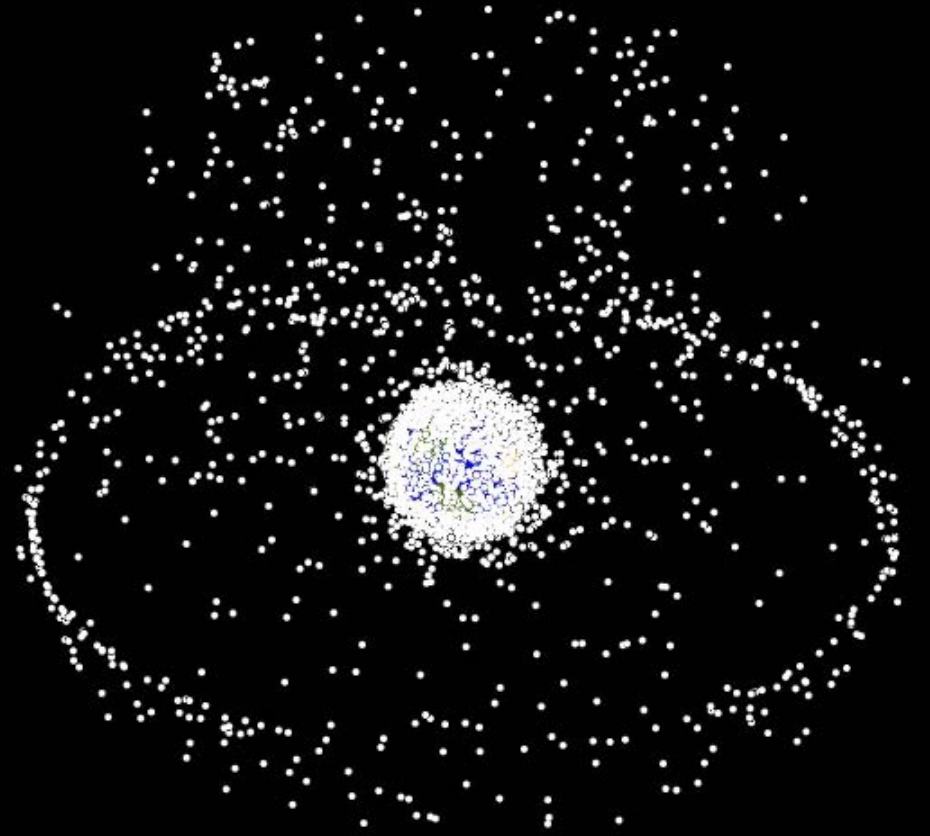


GEO

1990

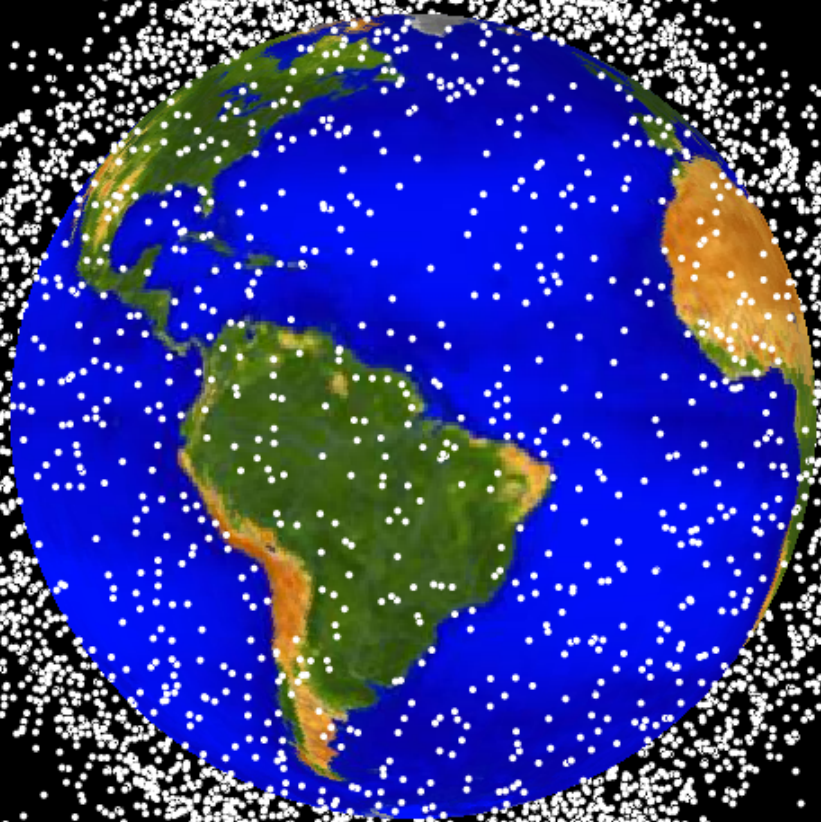


LEO

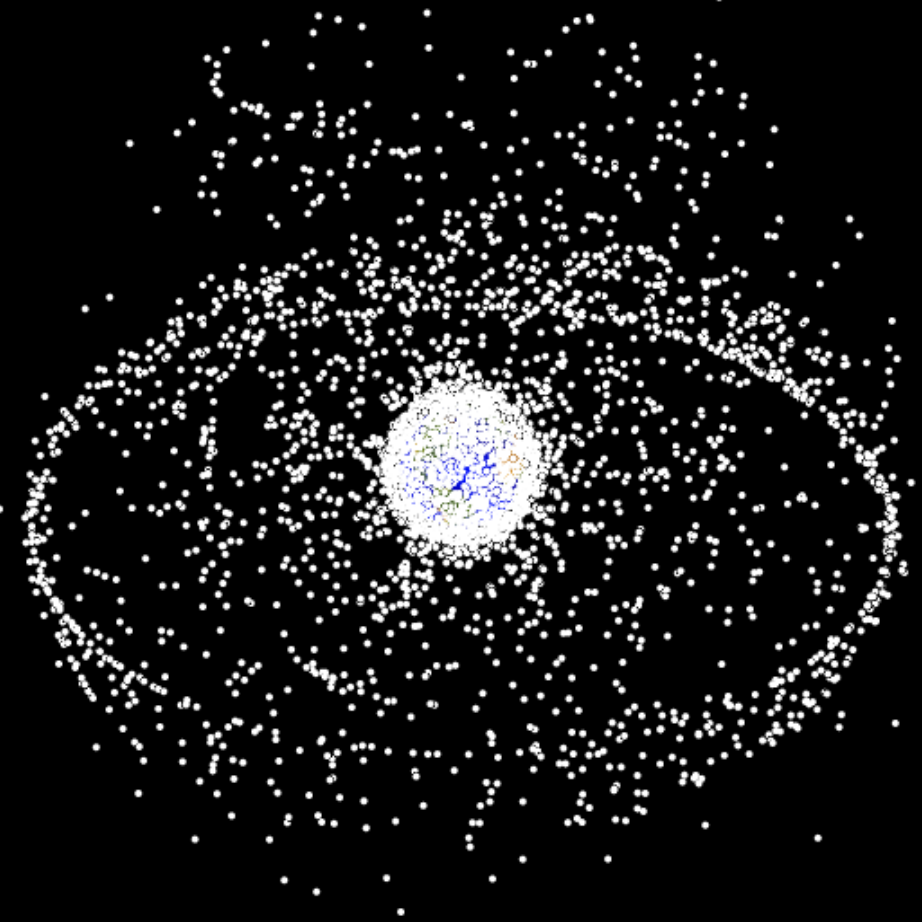


GEO

2000



LEO

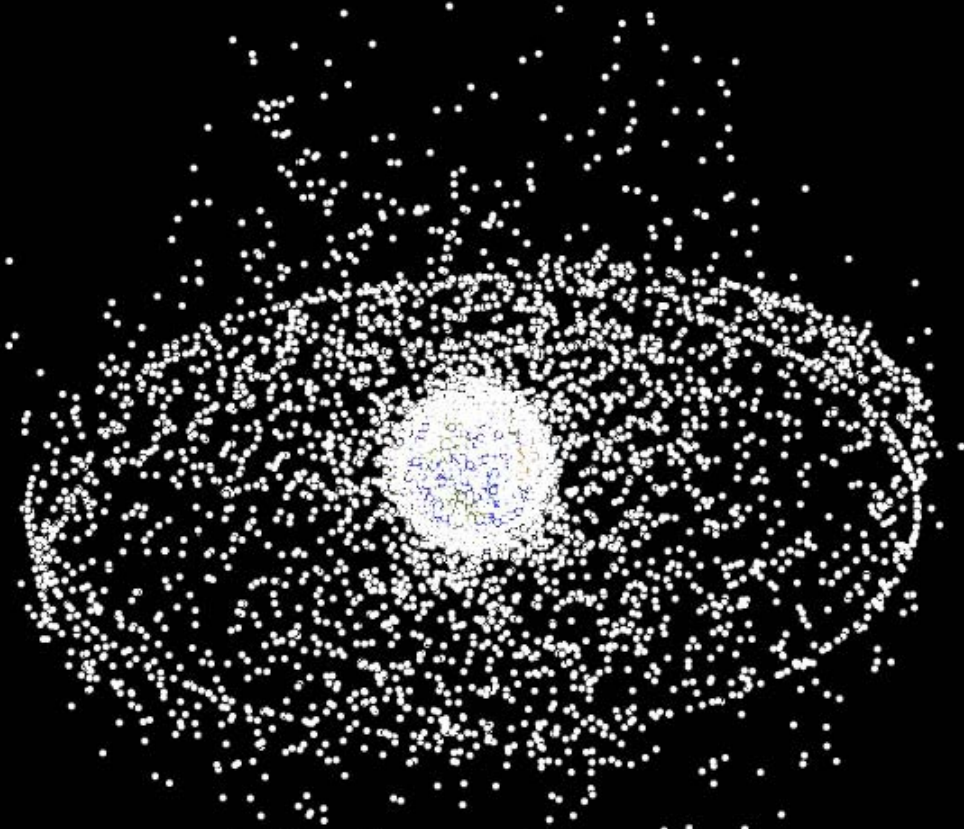


GEO

2013



LEO

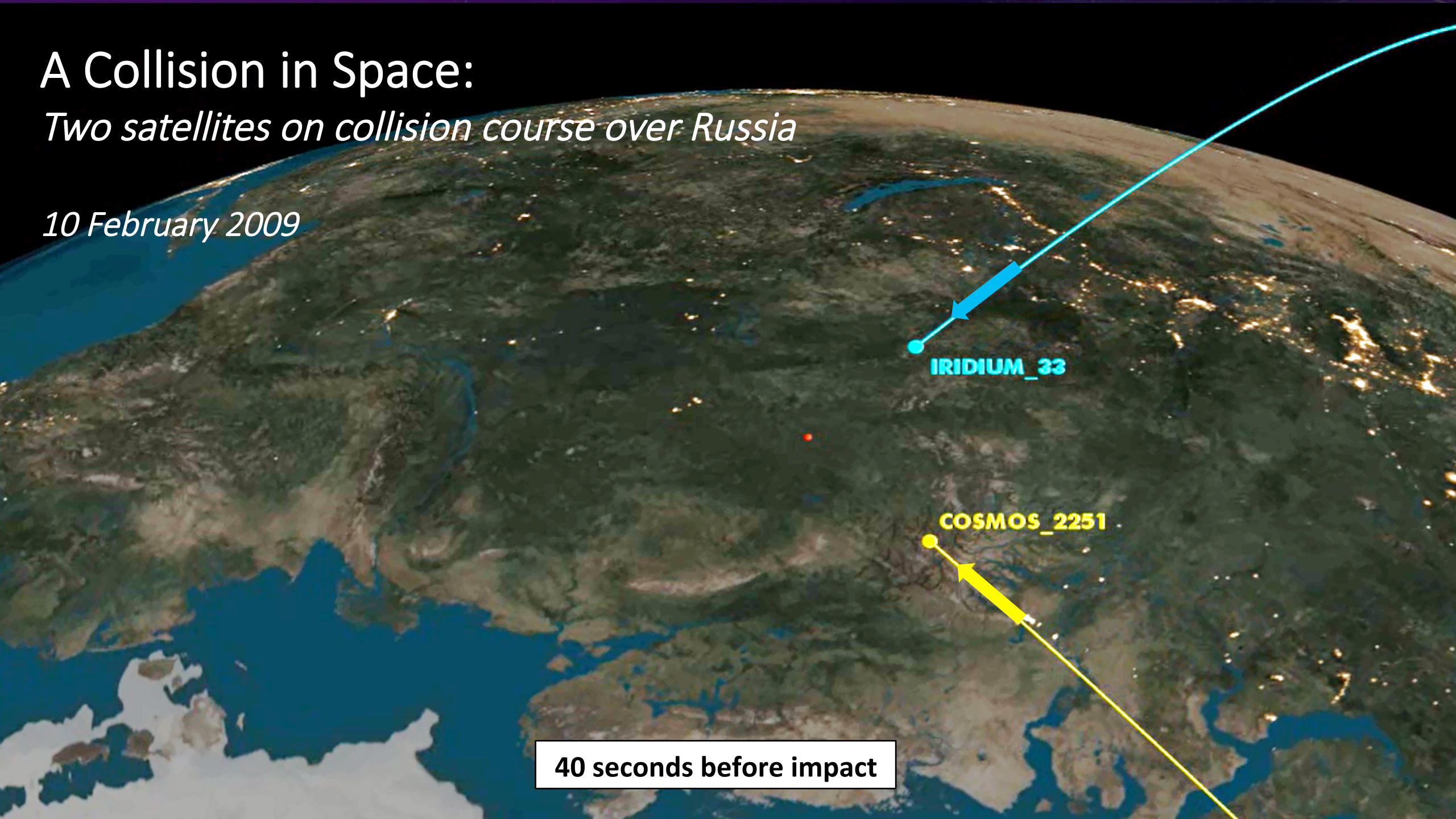


Less than 5% of the 300,000
debris objects >1 cm are shown.

GEO

A Collision in Space: *Two satellites on collision course over Russia*

10 February 2009



IRIDIUM_33

COSMOS_2251

40 seconds before impact

A Collision in Space:

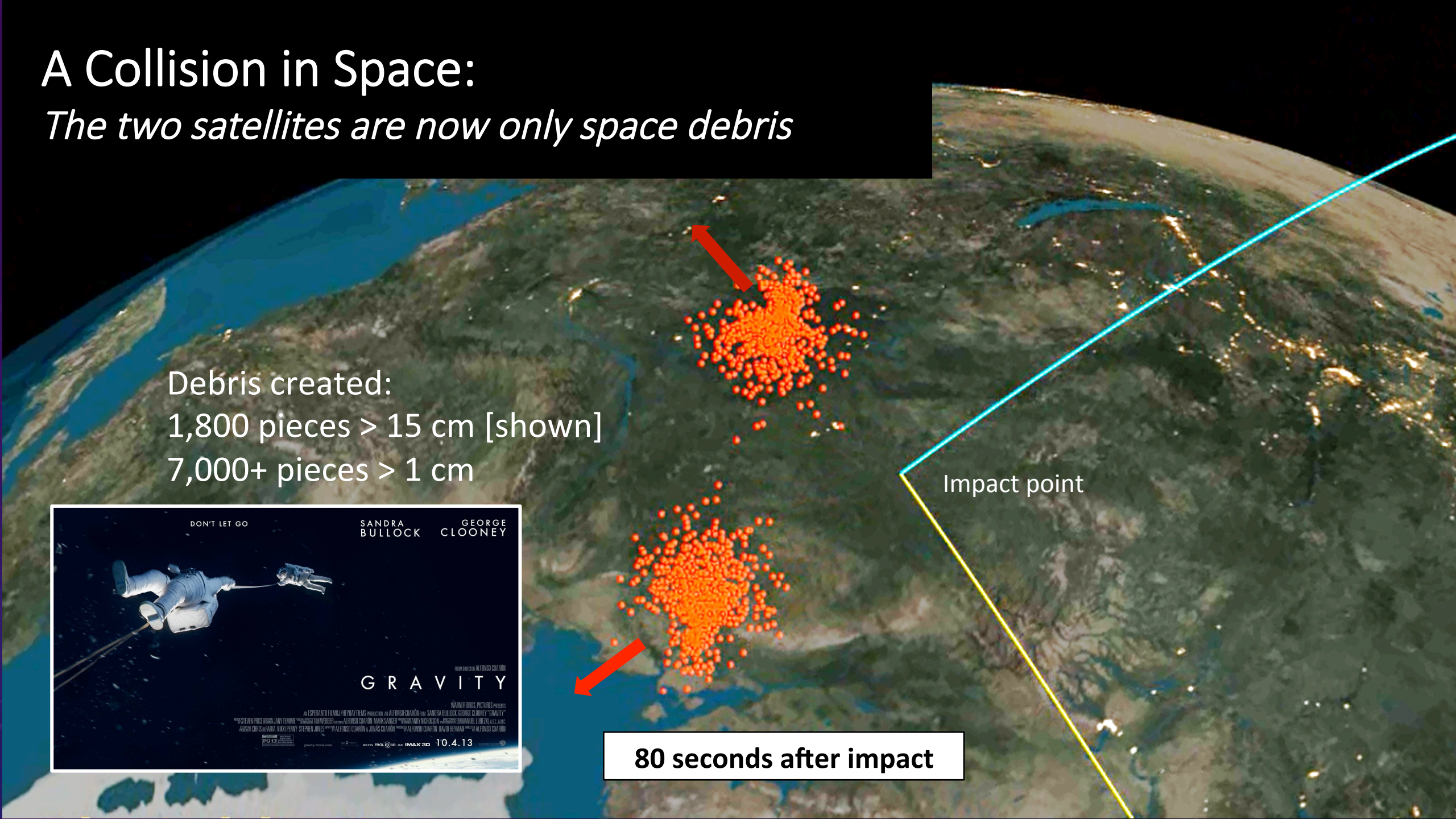
The two satellites are now only space debris

Debris created:
1,800 pieces > 15 cm [shown]
7,000+ pieces > 1 cm

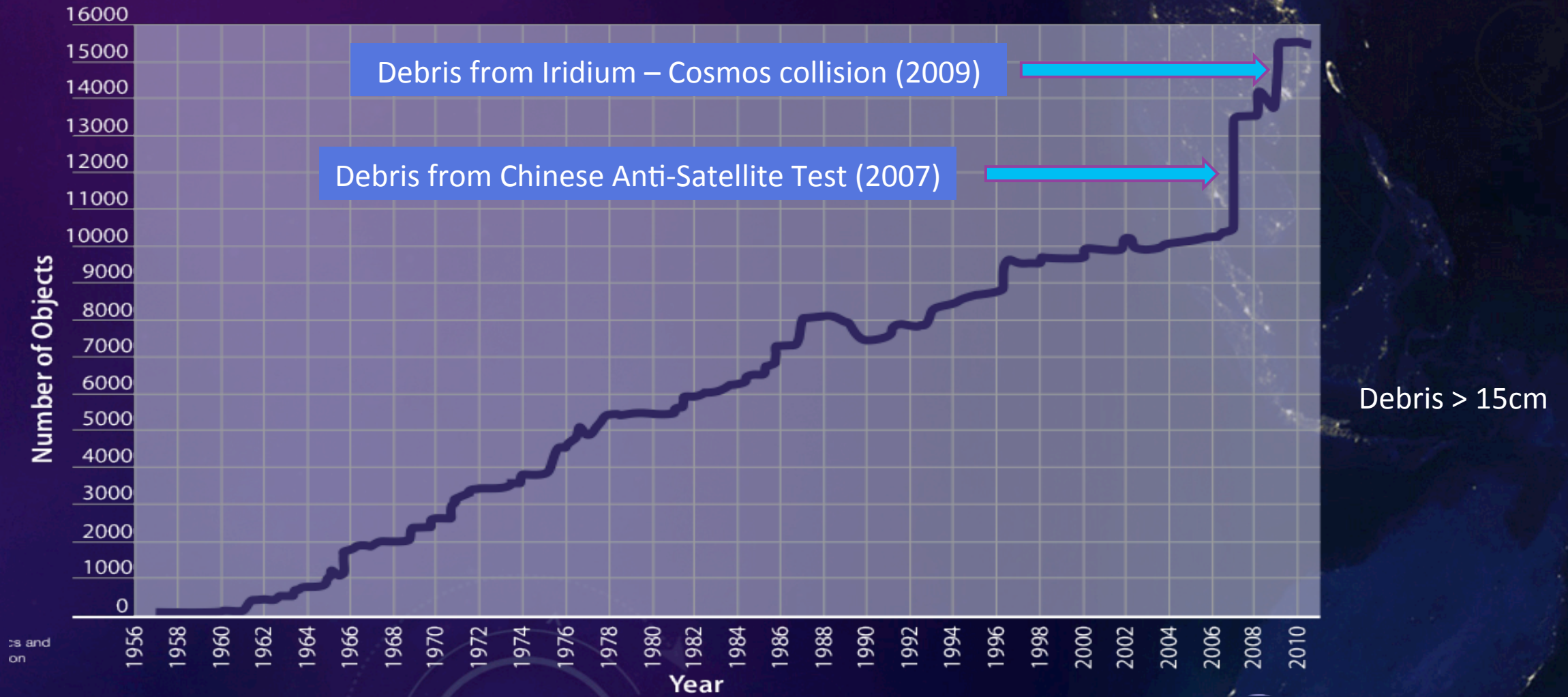


Impact point

80 seconds after impact



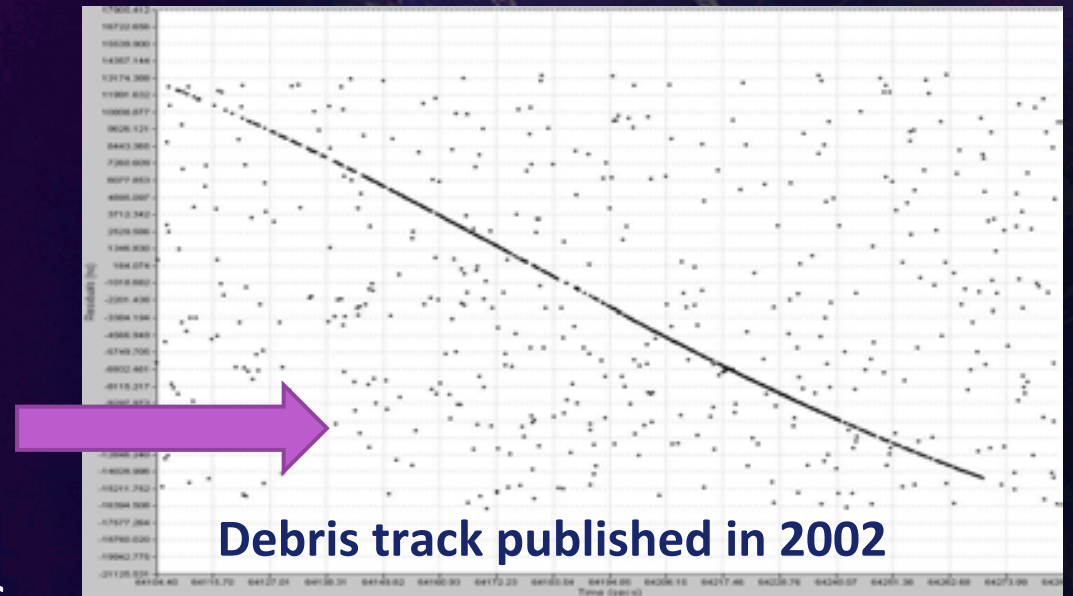
Large Debris Objects in LEO



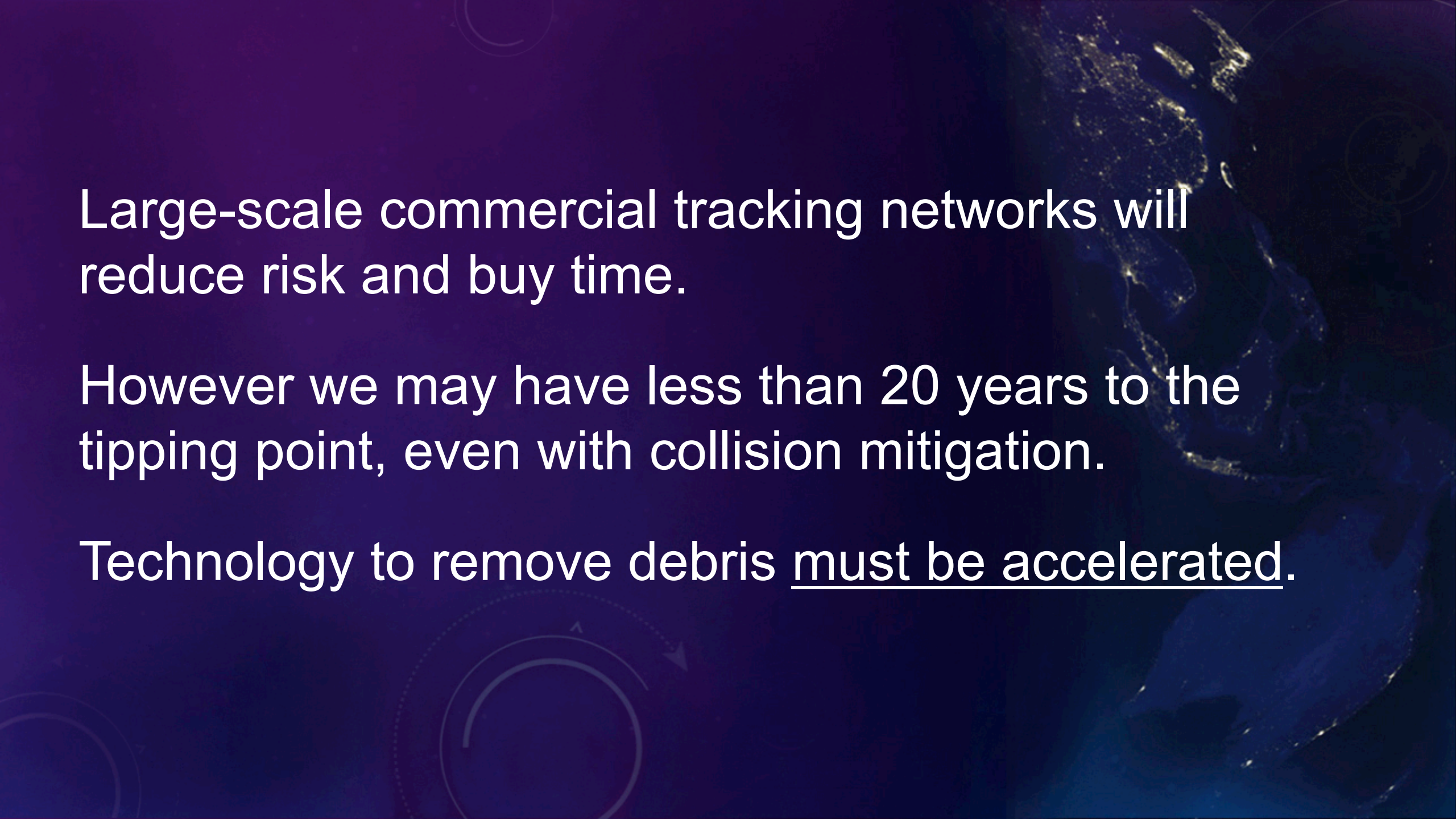
Debris is now increasing through collisions in space

Optical Space Tracking in EOS

- 1997-1998 Technology demonstrators
- 1999-2002 Laser tracking of 15 cm debris
- 2003-2004 Total loss of facility to wildfires
- 2005-2009 Upgrades to 5 cm and entire catalogue, at all altitudes
- 2010-2013 Automation, cost, scaling and interoperability factors
- 2014-2018 Network for collision mitigation [announced August 2014]



Breakthroughs in optical tracking allow the technology to deploy for collision mitigation and provide a platform for debris removal technologies



Large-scale commercial tracking networks will reduce risk and buy time.

However we may have less than 20 years to the tipping point, even with collision mitigation.

Technology to remove debris must be accelerated.

1. What is a CRC [Cooperative Research Centre]?

SEM CRC is an international PPP involving governments, universities and industry. Led by industry, but funded by government and operating under statute as a quasi-government agency

2. CRC Lifetime?

5 years plus extensions, subject to progress [typically 10 years]

3. Funding?

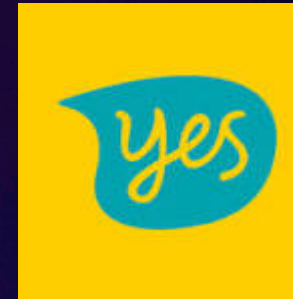
A\$60M over 5 years, plus priority access to \$100M of new infrastructure

A proposal to form a CRC for space debris, based on a \$20M contribution from EOS, was implemented, and funded to \$60M from 1 Oct 2014. The CRC is called the “Space Environment Research Centre” and is a non-profit agency legally prohibited from ever passing any benefits to members.

CRC

Participation

1. EOS Space Systems [AUS]
2. Lockheed Martin Corporation & NASA [USA]
3. Australian National University [AUS]
4. National Institute of Information and Communications Technology [Japan]
5. RMIT University [AUS]
6. Optus [AUS]



Participants leverage synergies from many existing international research efforts and embed links to space users in all segments

1. Tracking

We will research accurate, low-cost optical-tracking sensors and management strategies which may enable affordable monitoring of 100% of the threat

2. Orbits

We will improve orbit determination technology to extend the tracking interval to at least 2 days and reduce the future cost of debris tracking infrastructure



CRC Space Laser tracking Facilities

3. Collisions

Improve collision avoidance prediction at least 10-fold

We will make collision avoidance maneuver cost-effective

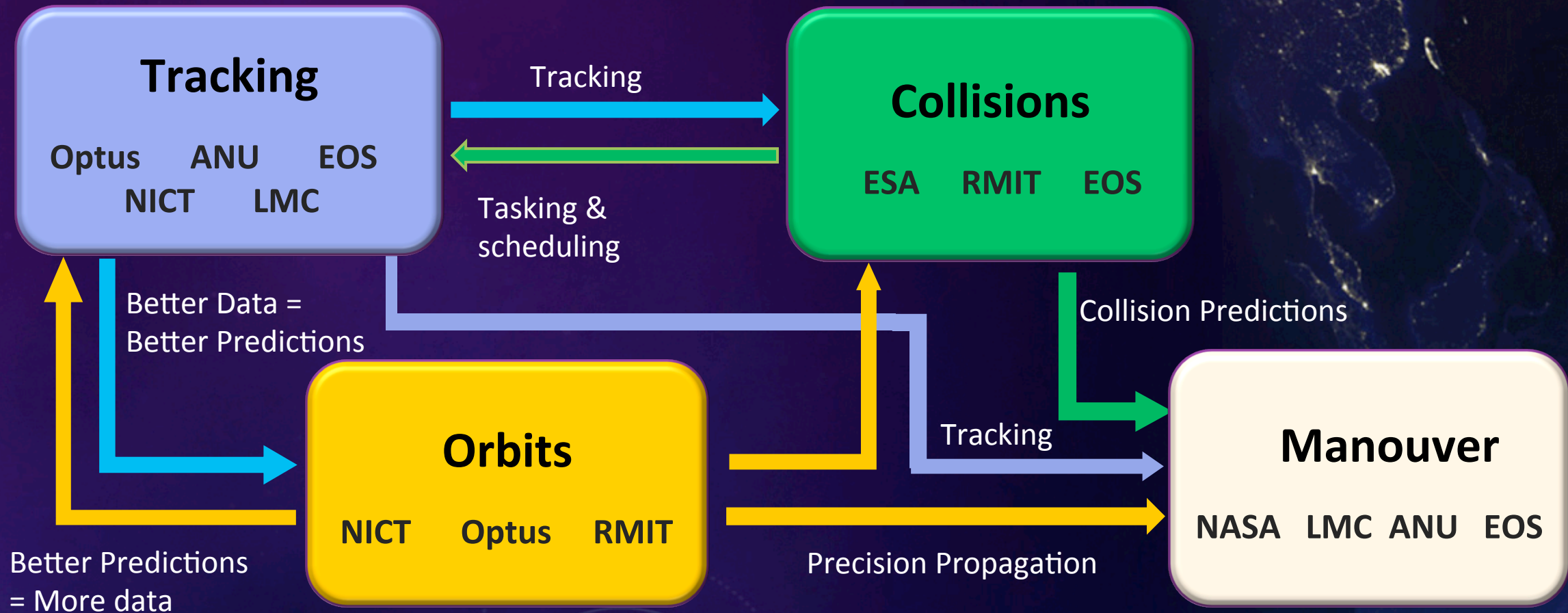
4. Maneuver

Develop a practical demonstration to modify the orbits of space debris from Earth using CW lasers

We can already maneuver many satellites to avoid collisions, but we now need to maneuver debris to limit debris growth



Research Program Relationships



Programs 1-3 delay Kessler and support Program 4 which removes debris

Forecast Research Results

Tracking

Optus ANU EOS
NICT LMC

- Better accuracy
- New Sensors
- New techniques
- Characterization
- GEO active track
- Utilize historical data

Orbits

NICT Optus RMIT

- New algorithms
- Improved atmospheric density models
- Better propagation accuracy
- Embedded reliability data for operators

Collisions

ESA RMIT EOS

- Satellite Object Catalogue
- Sensor tasking
- Data quality management
- Conjunction analysis
- Threat Warning

Manouver

NASA LMC ANU EOS

- Beam propagation
- Beam shaping and focussing
- Manouver debris
- Delay or avert Kessler Syndrome

The research programs will each have a strong impact on the development of collision mitigation technology

SERC Resources

\$60M over 5 years is not much funding:

- **World best practice is our starting point**

World leaders are in the CRC, bringing current programs

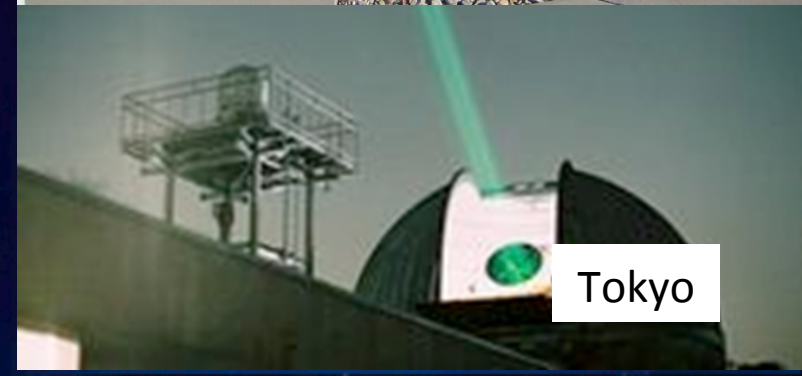
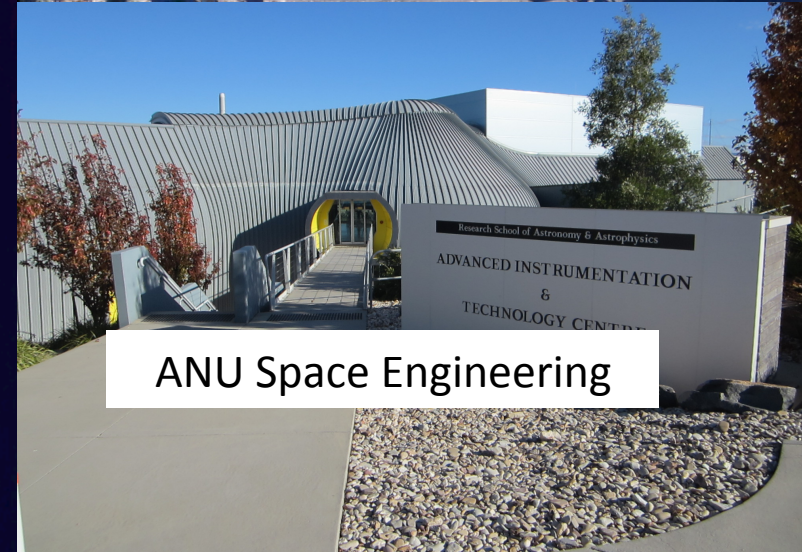
- **\$100M+ in new facility investment is available to CRC**

Facilities at Mt Stromlo (\$30M) & Tokyo (\$30M) as well as major facilities with other partners are now available

- **Multi-lateral collaboration is achieved efficiently**

Private sector management implemented for research

The CRC already has the infrastructure access it needs



SERC Resource Requirements

- **Program managers**

These are initially provided by members from current staff

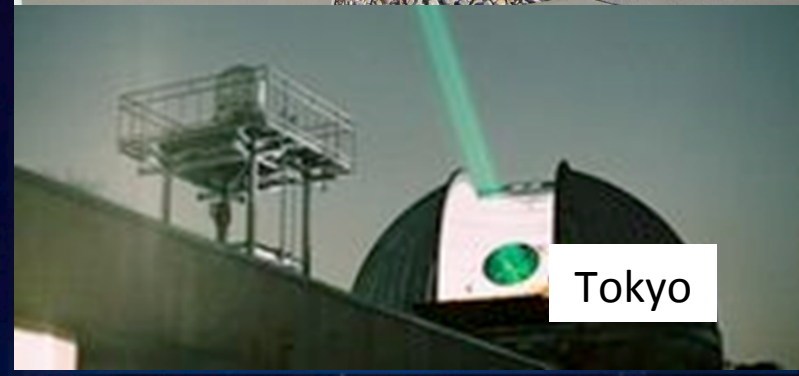
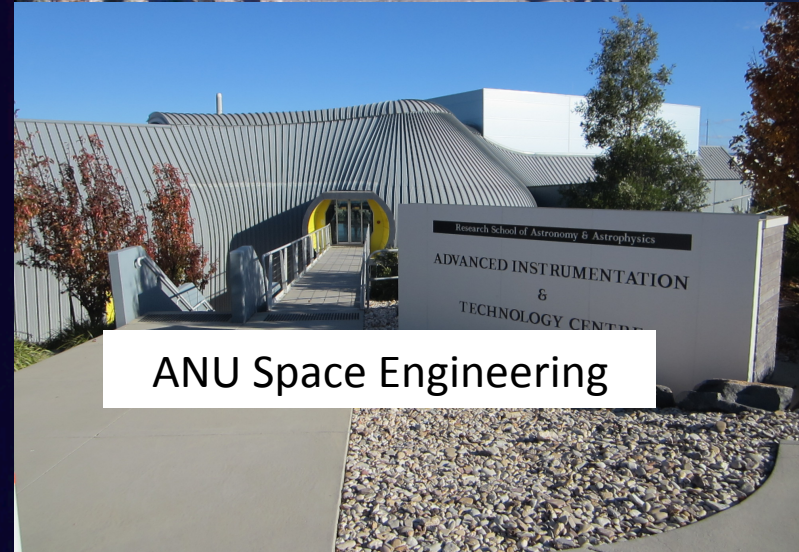
- **Post-doctoral Fellows and PhD students**

Around 10 vacancies are now available with more in 2015/16

- **Research Scientists**

Affiliation with major universities allows sabbaticals

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