

# Advances in Canada's Contributions to Space Situational Awareness

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STSC UN COPUOS  
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# Outline

This presentation will highlight Canada's interest in and contribution to three low-probability situations related to space that would produce significant consequences if they materialised in a negative way, collectively termed **Space Situational Awareness**:

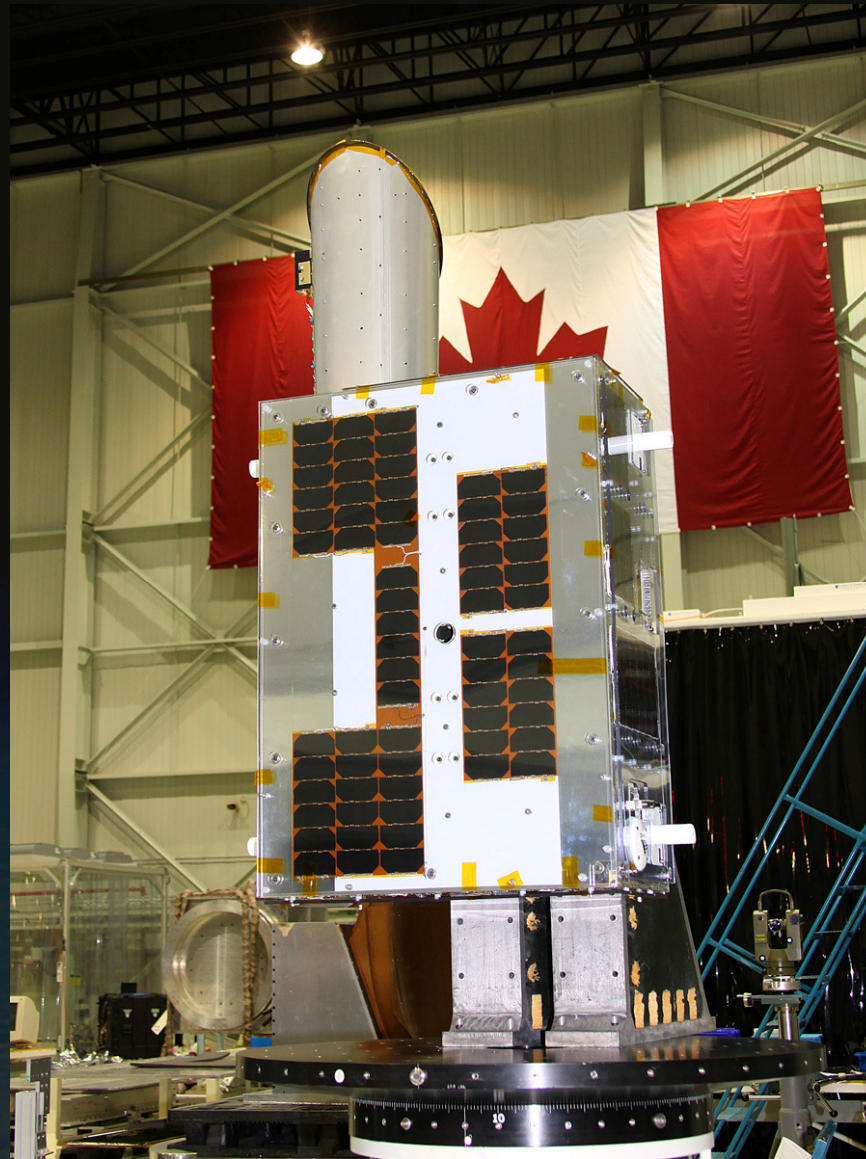
- **Near-Earth Objects (NEOs)**
- **Space Weather**
- **Space Debris**

# Near-Earth Objects

- Canada has been actively participating in the UN COPUOS AT-14 activity relating to Near Earth Objects that has stressed enhanced international coordination to deal with potential asteroid threats.
- It strongly supported the formal creation of the **International Asteroid Warning Network (IAWN)** led by the US as well as the **Space Mission Planning Advisory Group (SMPAG)** led by ESA.



# Near Earth Object Surveillance Satellite NEOSSat



# Near Earth Objects Surveillance Satellite

## NEOSSat



NESS (CSA)

Near Earth Space Surveillance → NESS

Asteroid, comet and meteor observation

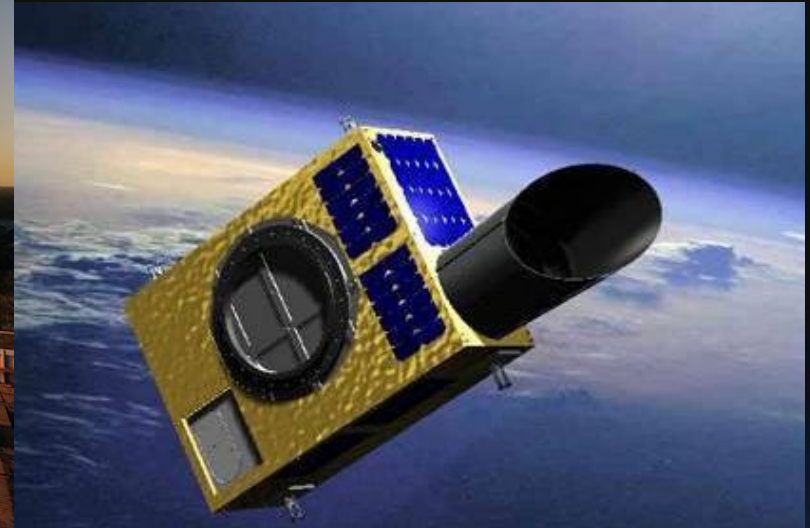


HEOSS (DND-DRDC)

High Earth Orbit Space Surveillance → HEOSS

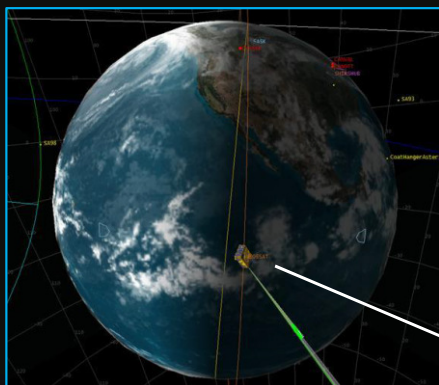
Satellite and debris tracking

Launched 25 February 2013

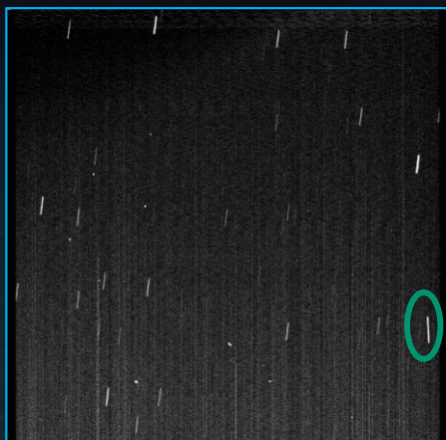




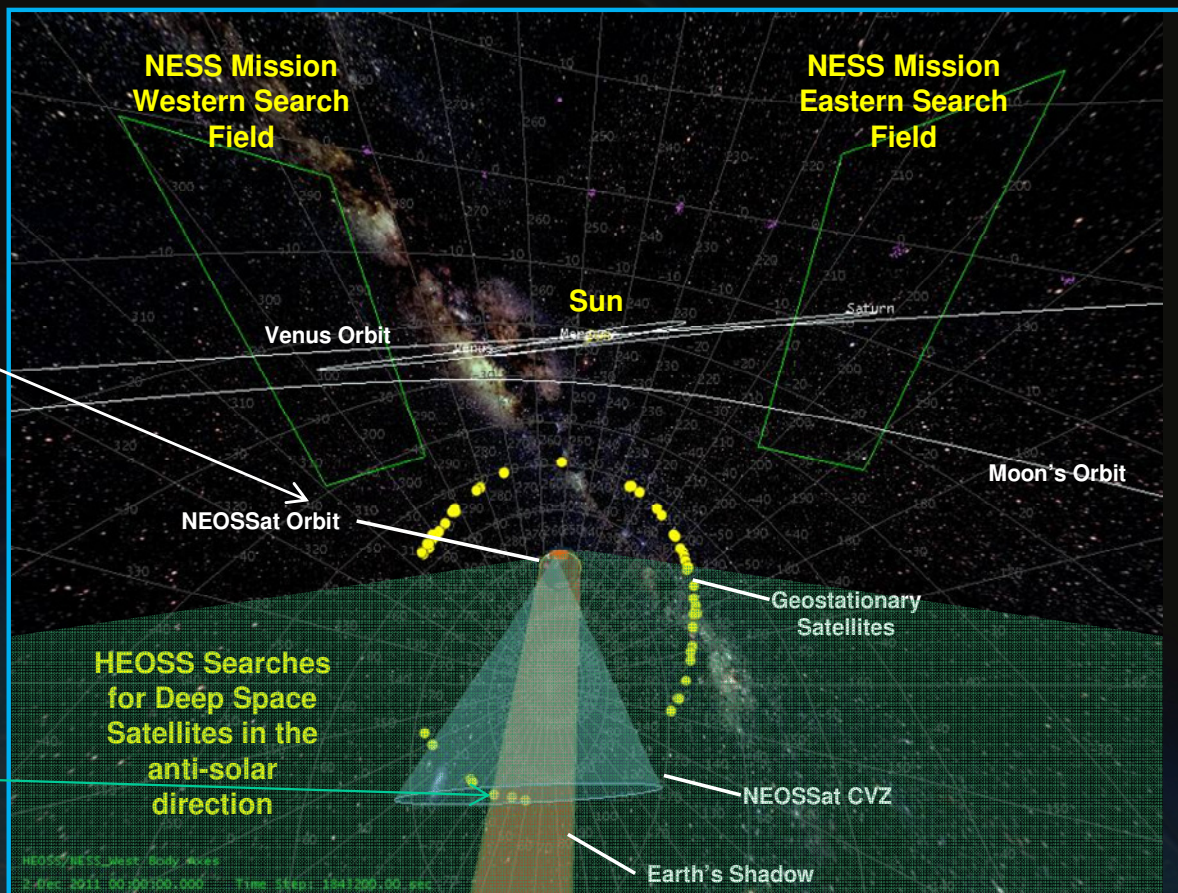
# STATUS: NEOSSat microsat check-out on-orbit progressing



730 km Sun-Synchronous Orbit



Engineering test image  
1<sup>st</sup> debris track



Space Surveillance Areas

# Space Weather

- Canada has had a long history in the study, observation, monitoring and understanding of space weather and its effects.
- Canada's first satellite – Alouette 1 – built in Canada and launched in 1962, was designed to study the Earth's ionosphere and to advance knowledge of “Space Weather”.



# Space Weather Effects

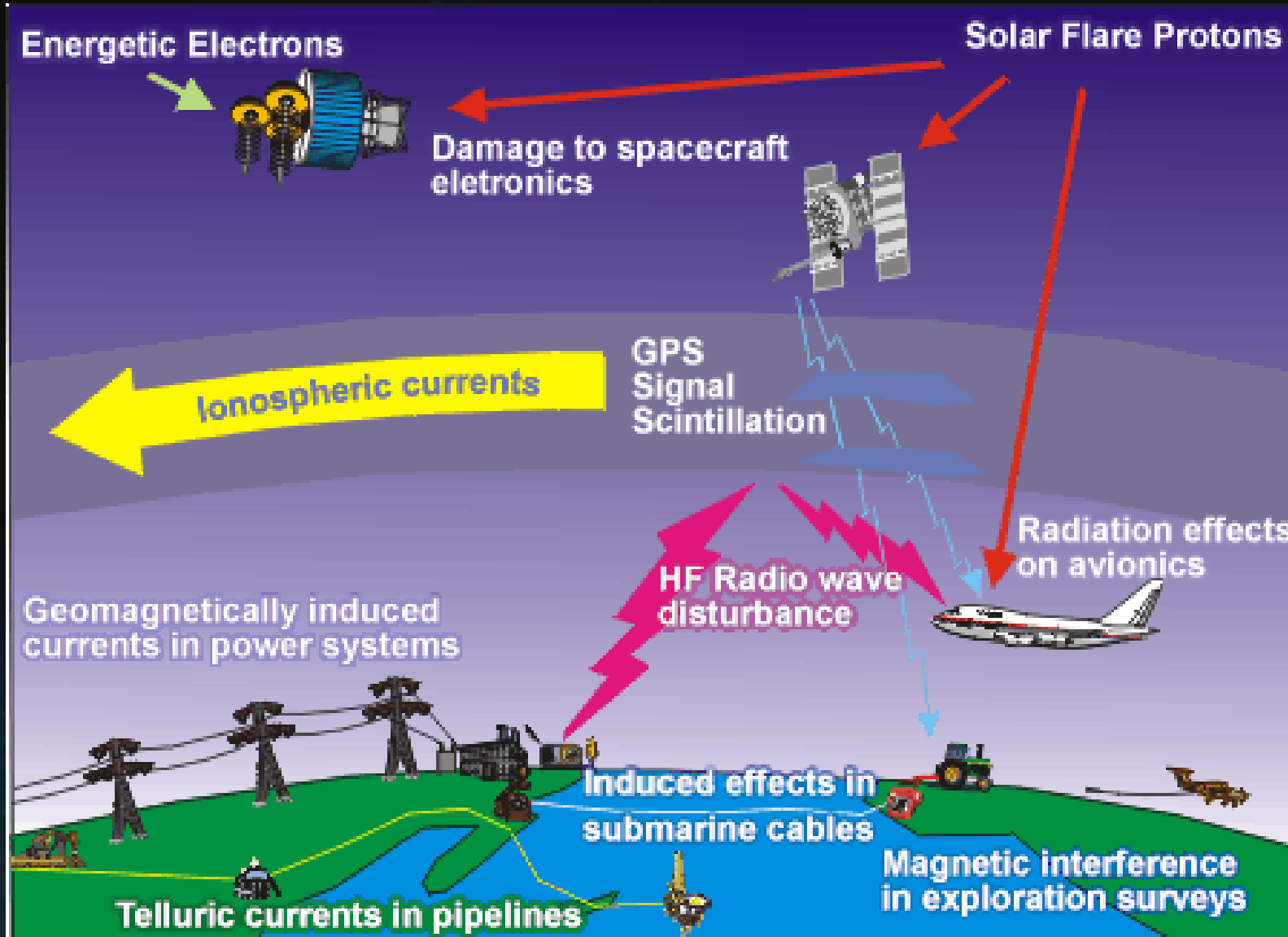


Image courtesy of [spaceweather.ca](http://spaceweather.ca)

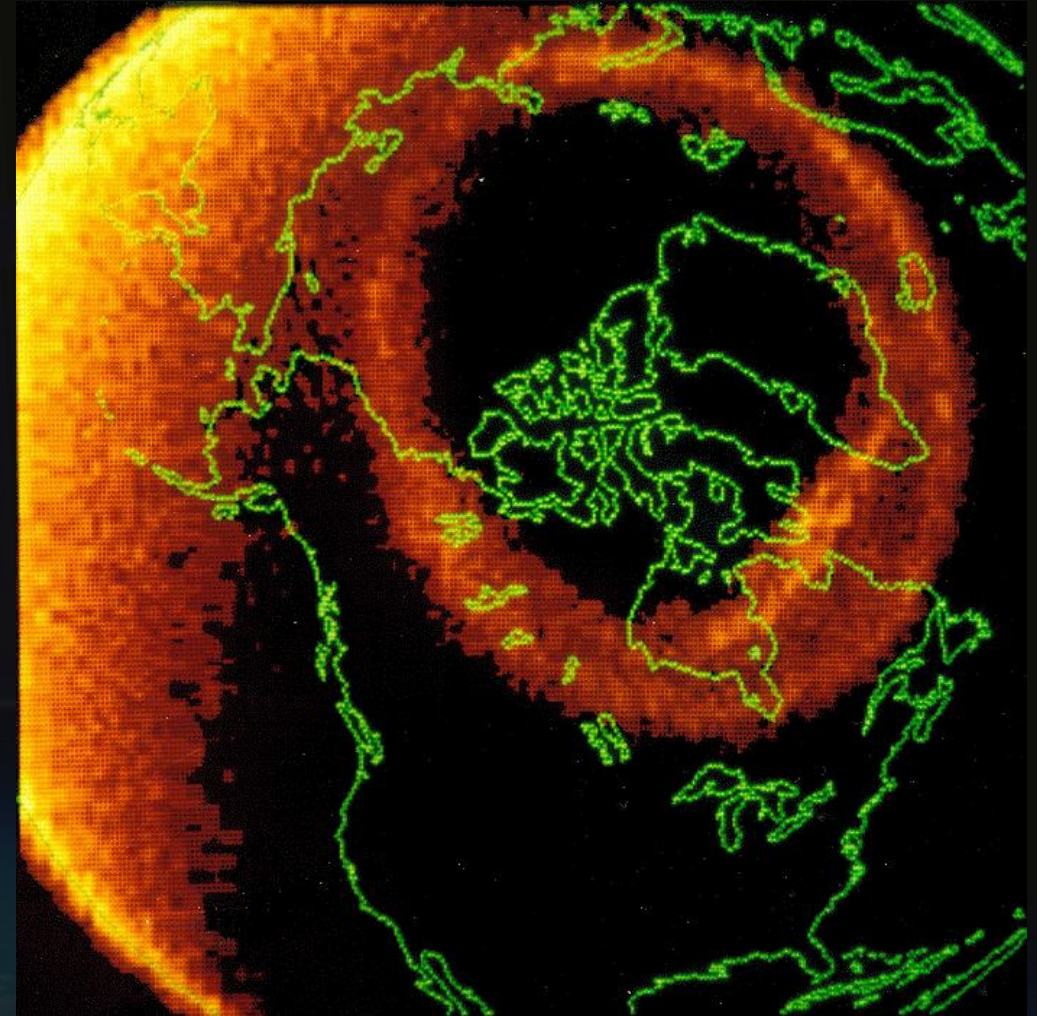
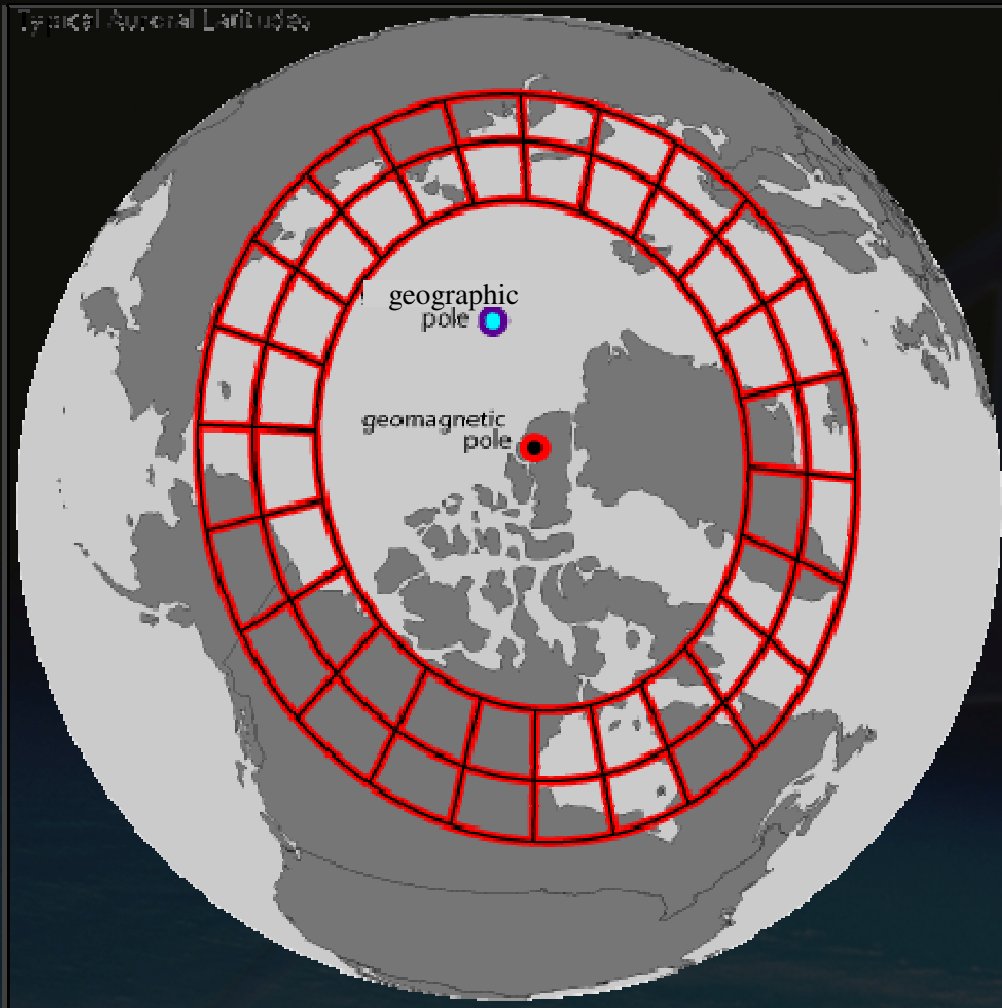


# Space Weather

- Space Weather is a constant threat to Canada due to its geographic location.
- One of the most studied space weather events was the March 1989 severe geomagnetic storm that shut down the Hydro-Québec grid affecting 6 million people for 9 hours causing a direct cost of over 2 billion dollars.

*Ref.: Extreme space weather: impacts on engineered systems and infrastructure, Royal Academy of Engineering, February 2013*

# Canada's unique vantage point



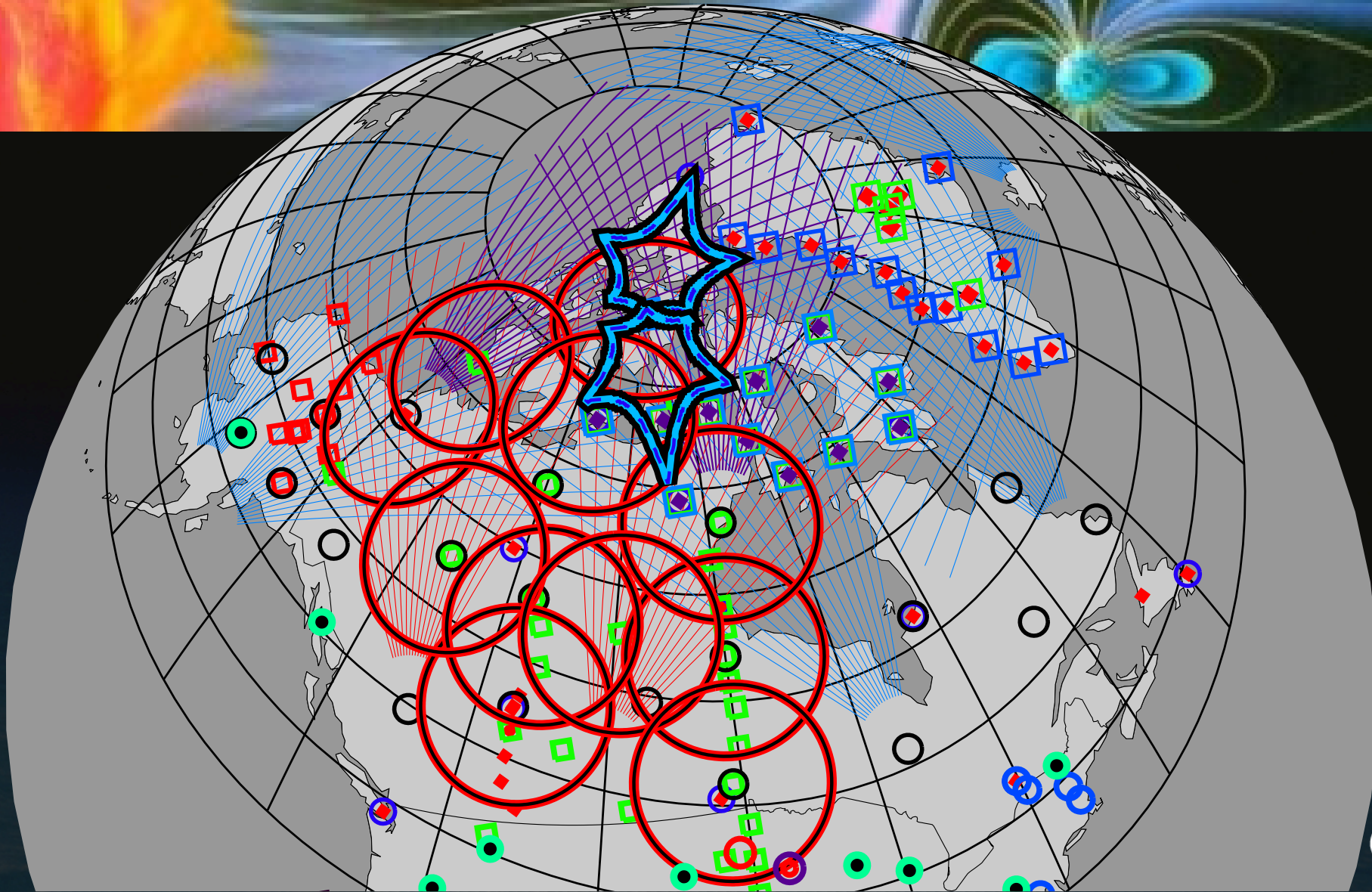


# CSA supported projects

- GO Canada
- NASA THEMIS
- e-POP on CASSIOPE
- ESA Swarm



# Geospace Observatory (GO) Canada

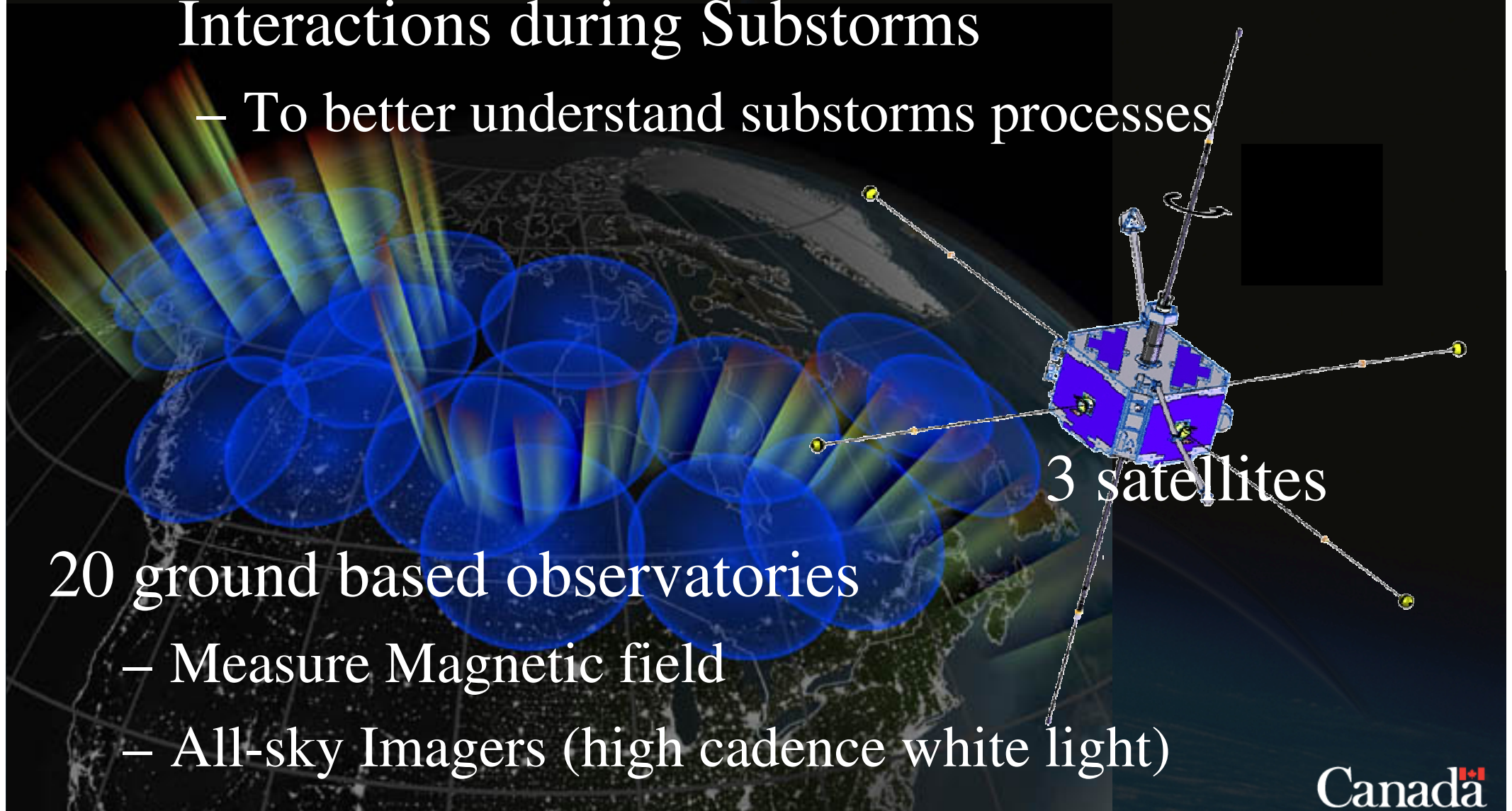




# THEMIS Mission

## Time History of Events and Macroscale Interactions during Substorms

– To better understand substorms processes



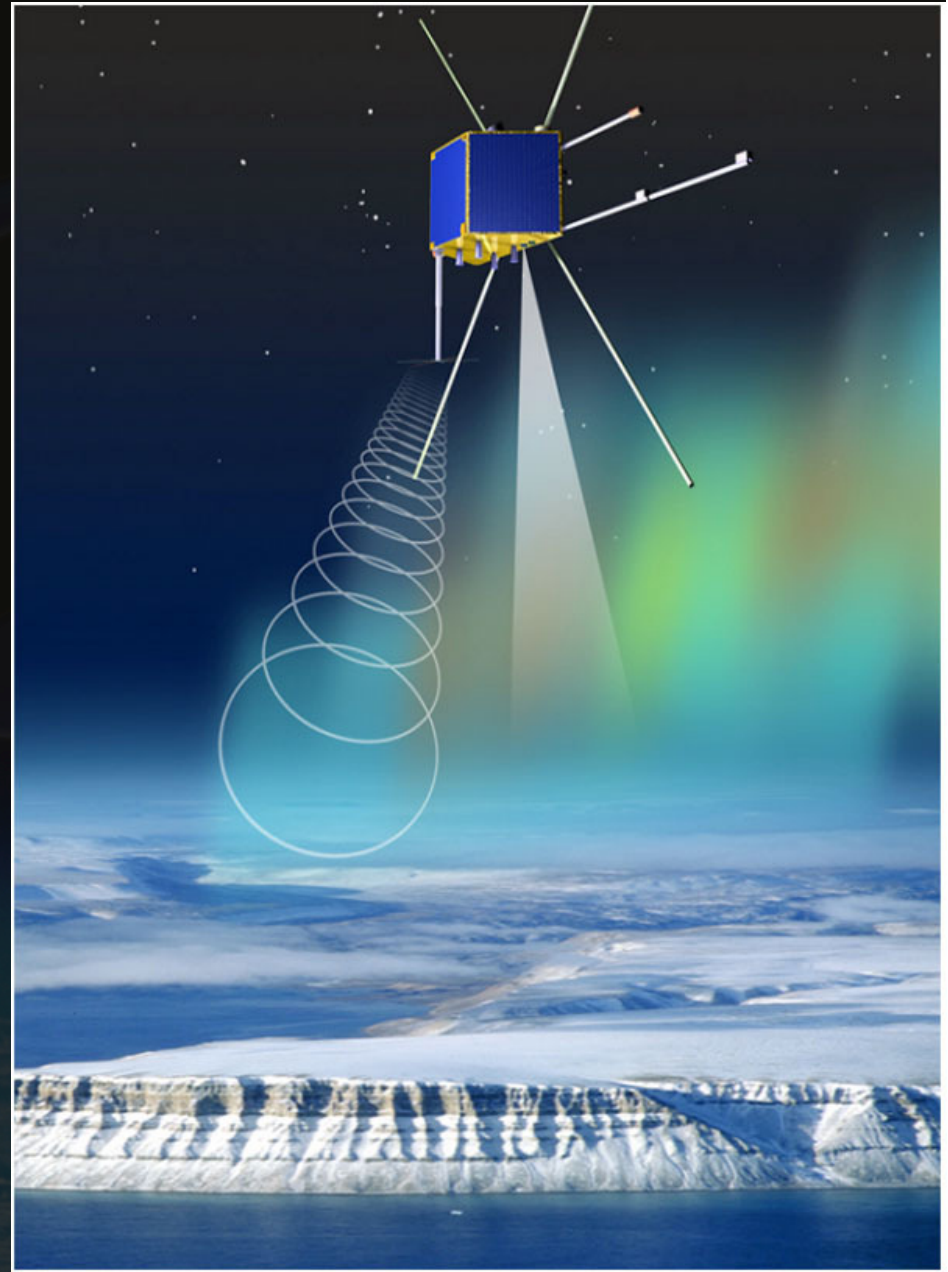
20 ground based observatories

– Measure Magnetic field

– All-sky Imagers (high cadence white light)

# e-POP on CASSIOPE

- Launched 29 September 2013
- To study near-Earth Space (350-1500 km)
- 8 Instruments from Canada and int'l partners to study ionosphere and plasma outflow
- Interactions with GO Canada instruments





# ESA Swarm mission

- Canada provides Electric field instruments
  - Required for precise measurements of the magnetic field
- Launched 22 November 2013
- Canada's contribution will lead to a better understanding of the ionosphere



# Natural Resources Canada

- Operates an array of Fluxgate Magnetometers and Riometers throughout Canada
- Operates the **Space Weather Forecasting Centre**
  - <http://spaceweather.ca>
- Member of the **International Space Environment Service**



# Space Weather

- Canada is a co-lead of the Expert Group on Space Weather of the UN COPUOS STSC **Working Group on the Long-Term Sustainability of Outer Space Activities.**
- Canada is charter member and member of the Steering Group of the **International Living With a Star (ILWS)** program.

# Space Debris



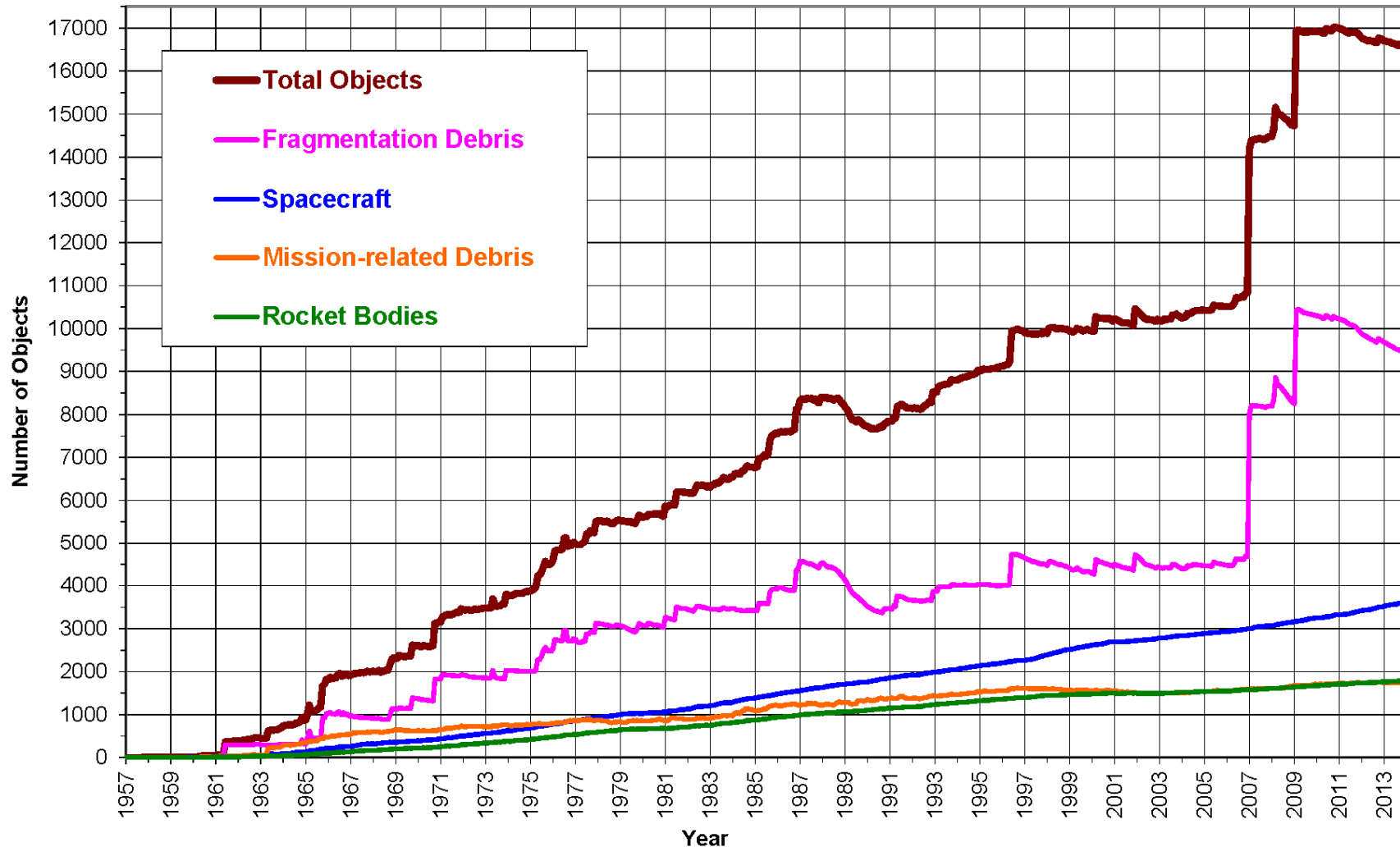
Ariane helium tank,  
Brazil, February 2012



Delta 1 stage, Zimbabwe, July 2013

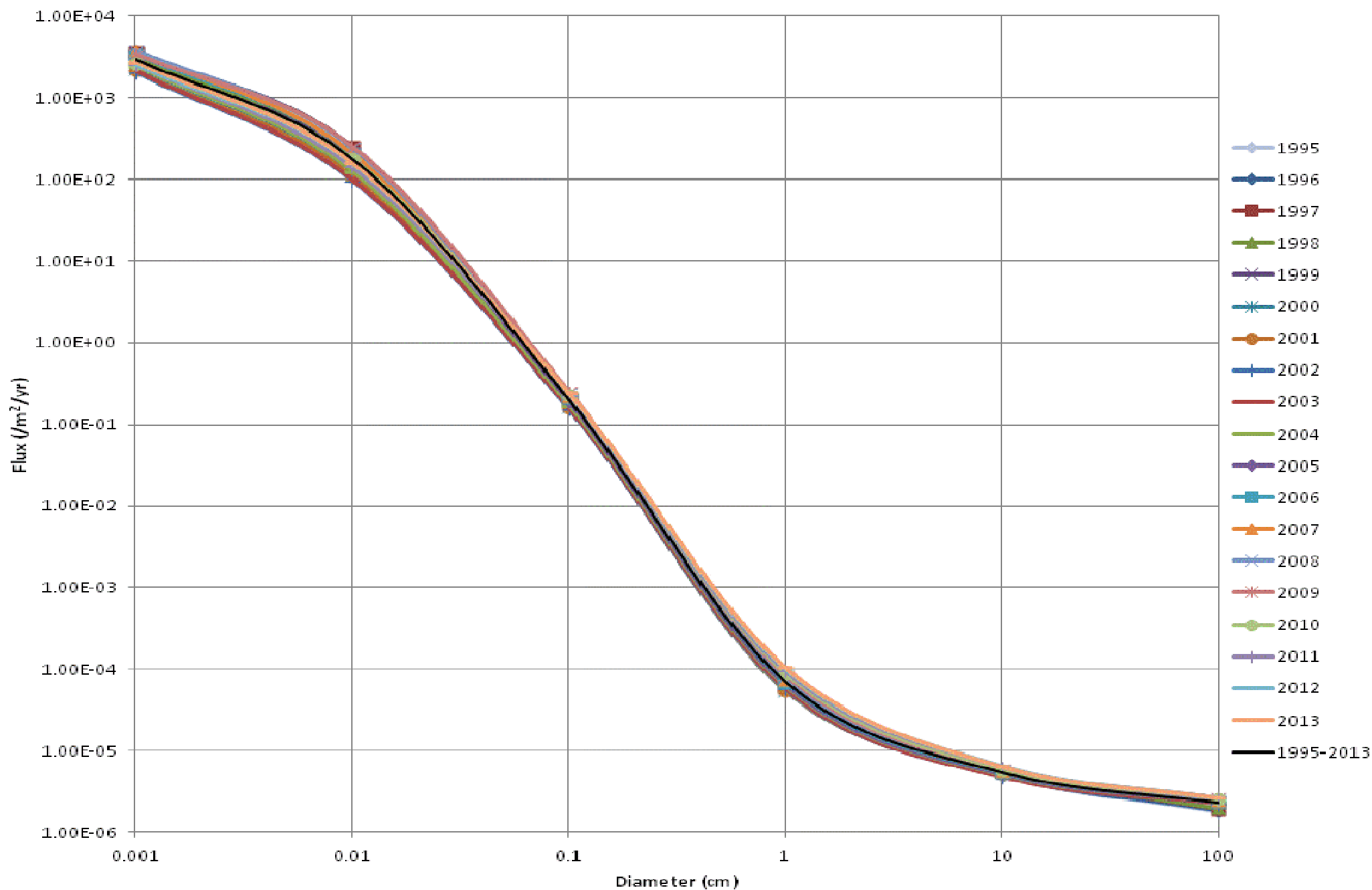
# Space Debris

Monthly Number of Objects in Earth Orbit by Object Type (excluding STS)

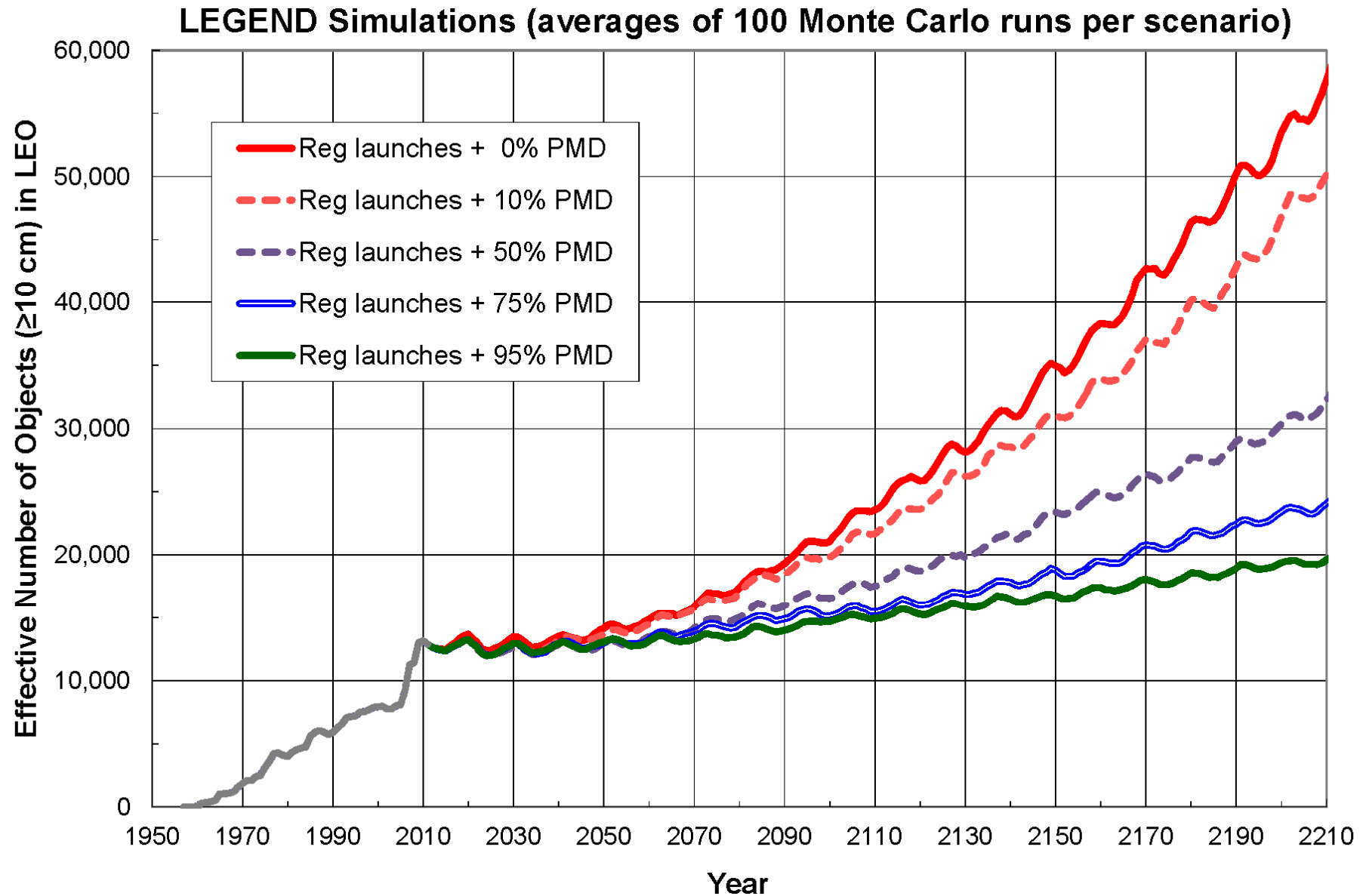




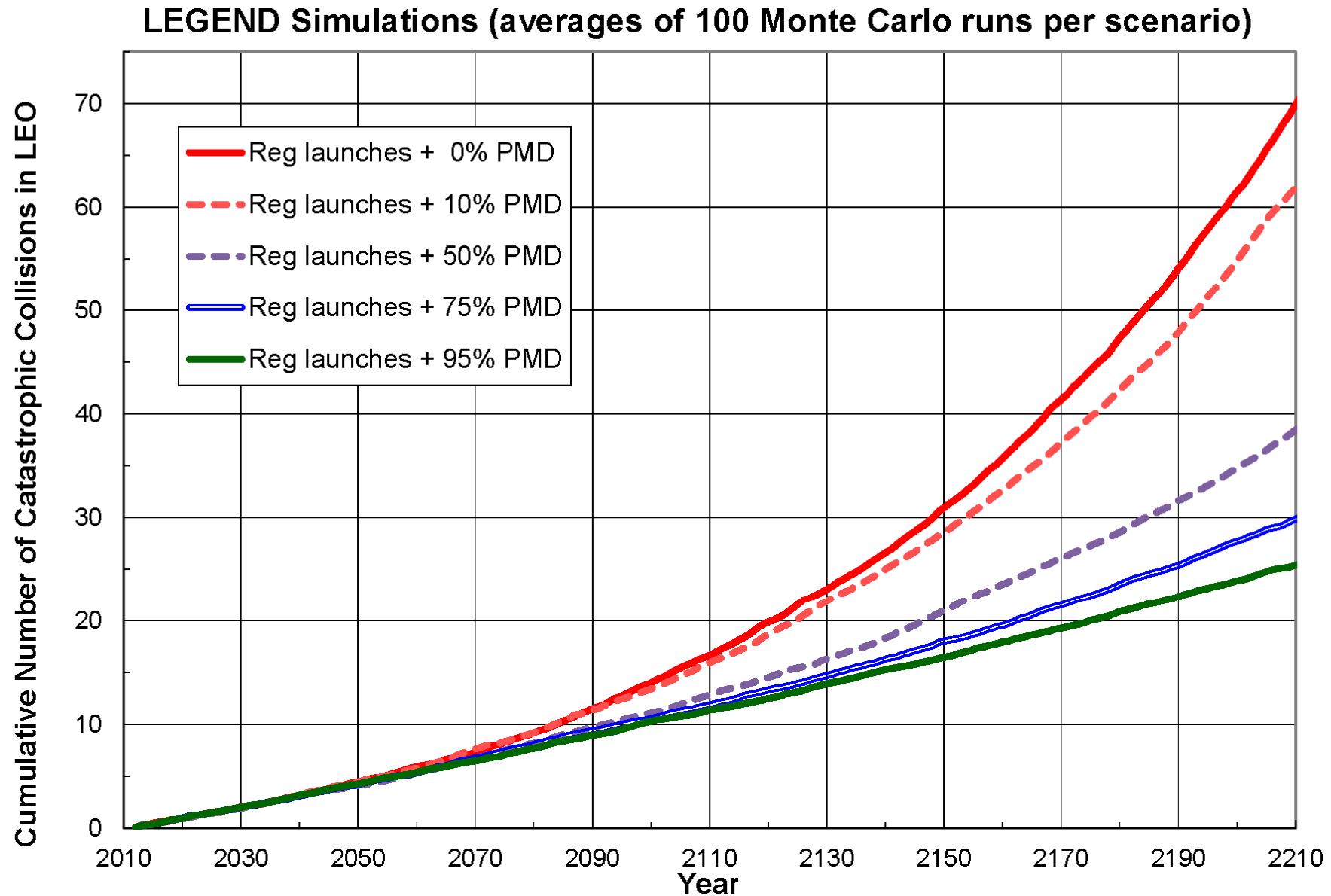
# MMMOD Flux VS Diameter



# Space Debris

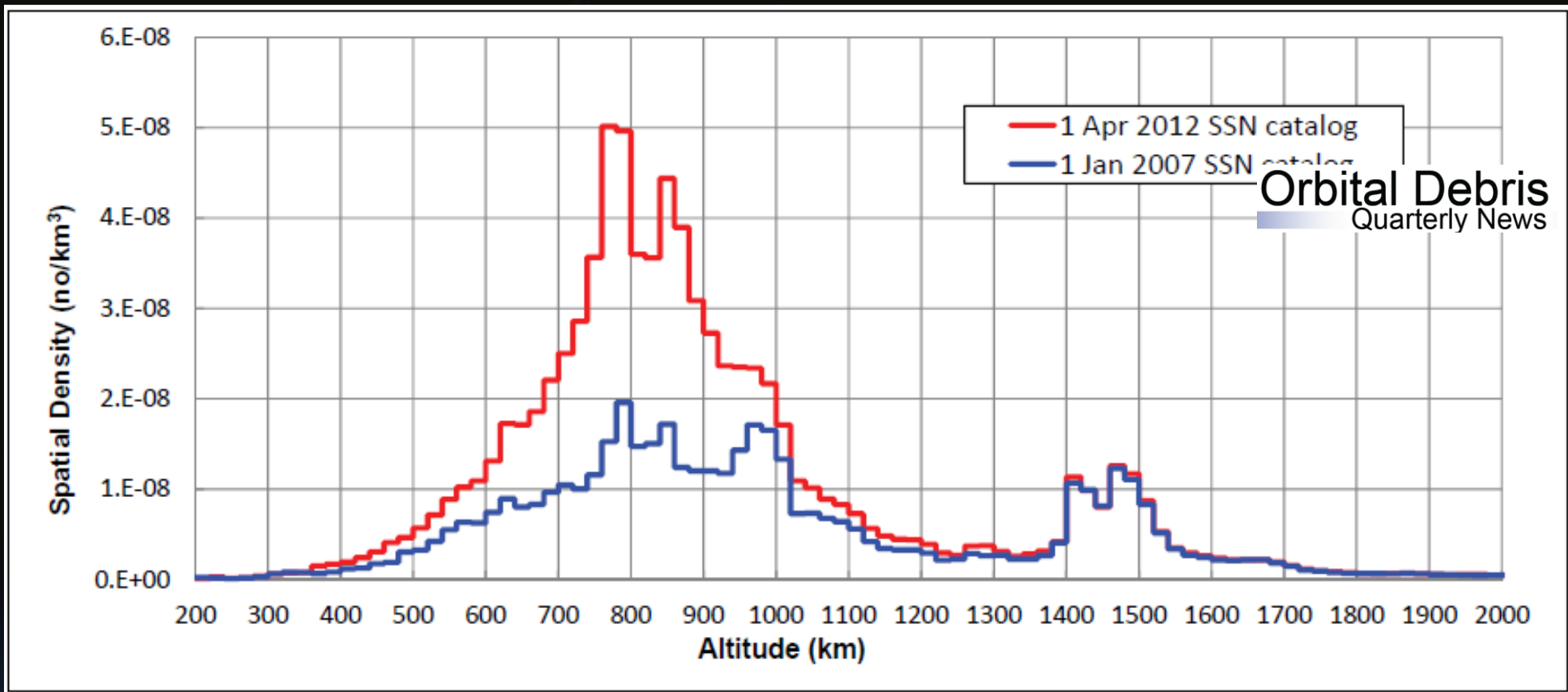


# Space Debris





# The Problem



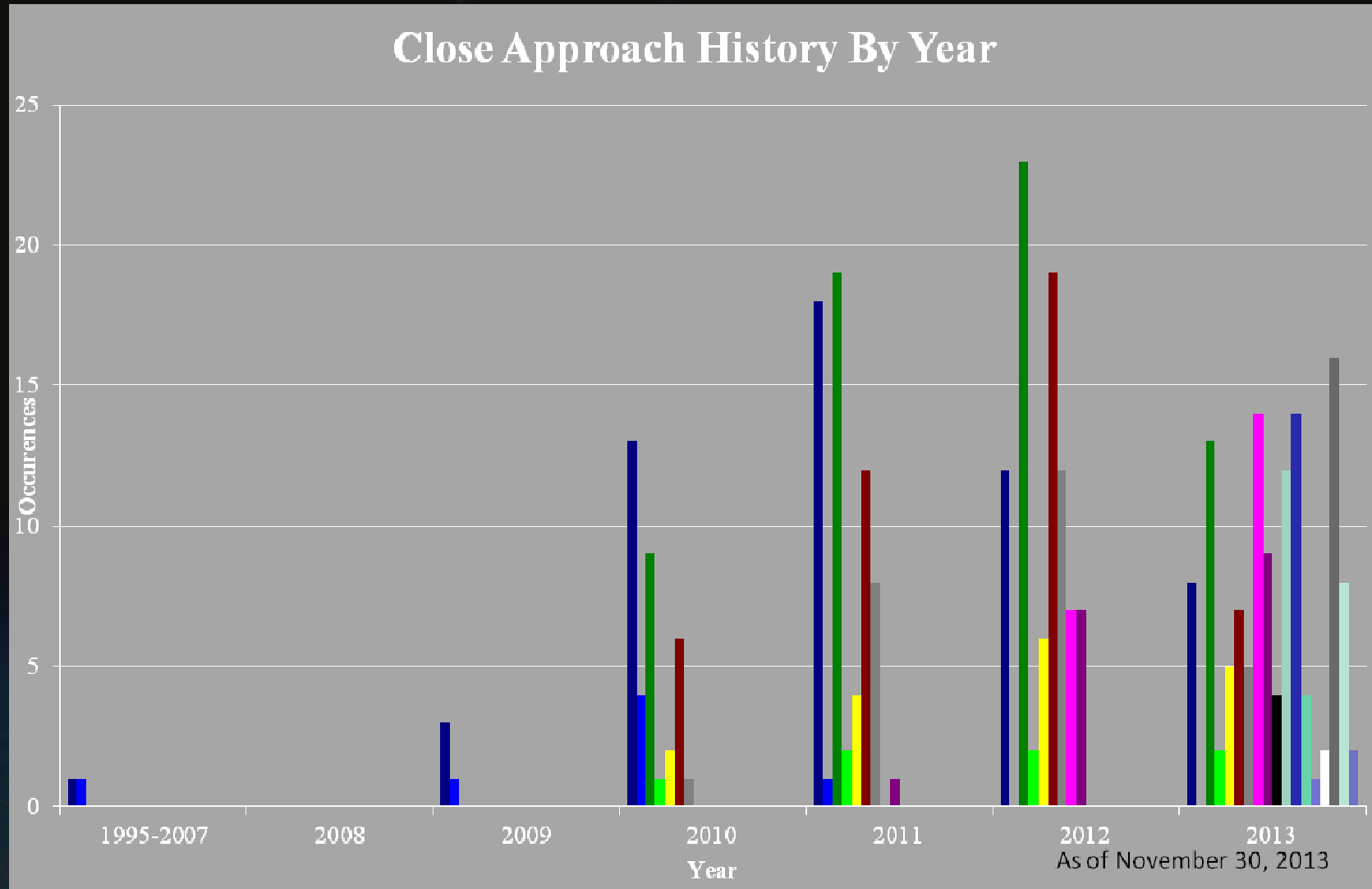
RADARSAT-2 is in polar orbit at ~790 km altitude, SCISAT-1 ~650km, MOST ~ 800km, CANX ~600-800km, EV1 817km, EV6 695km, NEOSSAT ~700km, CASSIOPE ~300kmx1500km, RCM ~600km

# Missions Supported

- RADARSAT-1
- RADARSAT-2
- SCISAT
- MOST
- CANX-2
- CANX-6
- ExactView EV-1
- ExactView EV-6
- NEOSSAT
- Sapphire
- CASSIOPE
- RAPIDEYE-1 to RAPIDEYE-5
- Coming soon: M3MSAT, RCM, ...



# CSA Close Approach Experience





# Space Debris Centre of Expertise

- There are several aspects to space debris:
  - the **monitoring** and **measurement** of debris;
  - **protection** against debris;
  - **mitigation** measures to avoid collision with debris; reduction and removal of debris;
  - guidelines to **prevent** the creation of debris; and, the **safe disposal** of space assets, all in a context of international cooperation and security.
- Since 2011, Canada has been actively engaged on most of these fronts, building inter alia a unique Canadian expertise in threat assessment and mitigation.

# Near Earth Objects Surveillance Satellite

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**HEOSS (DND-DRDC)**

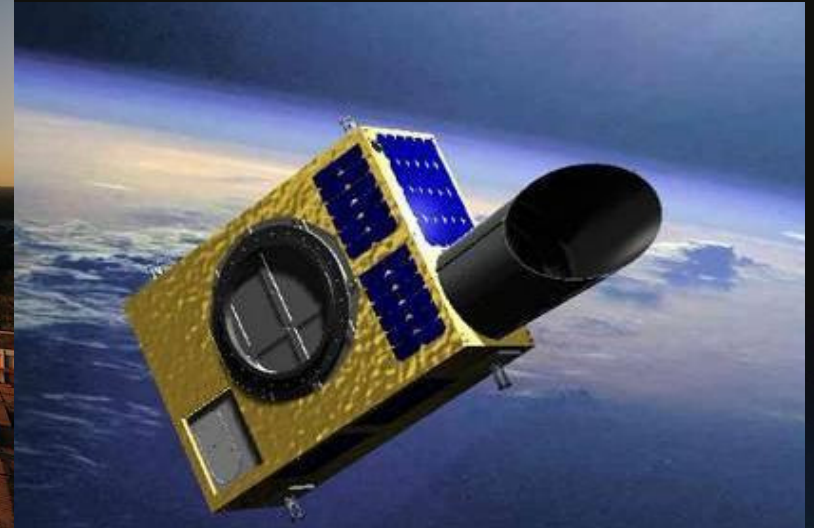
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PSLV C-20





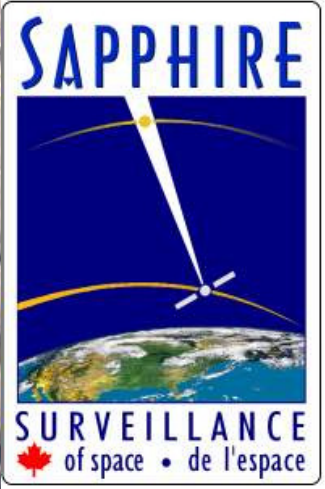
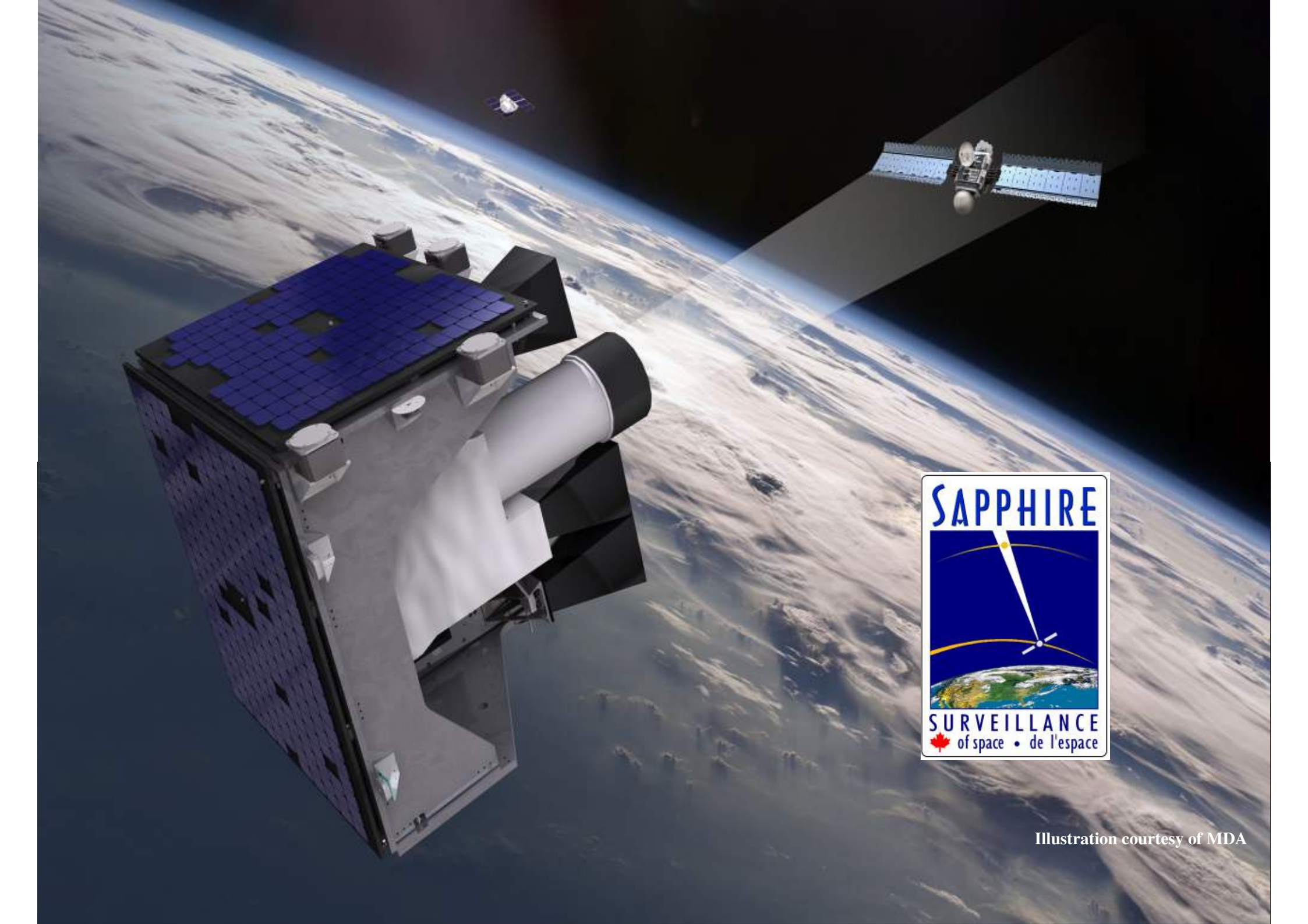


Illustration courtesy of MDA

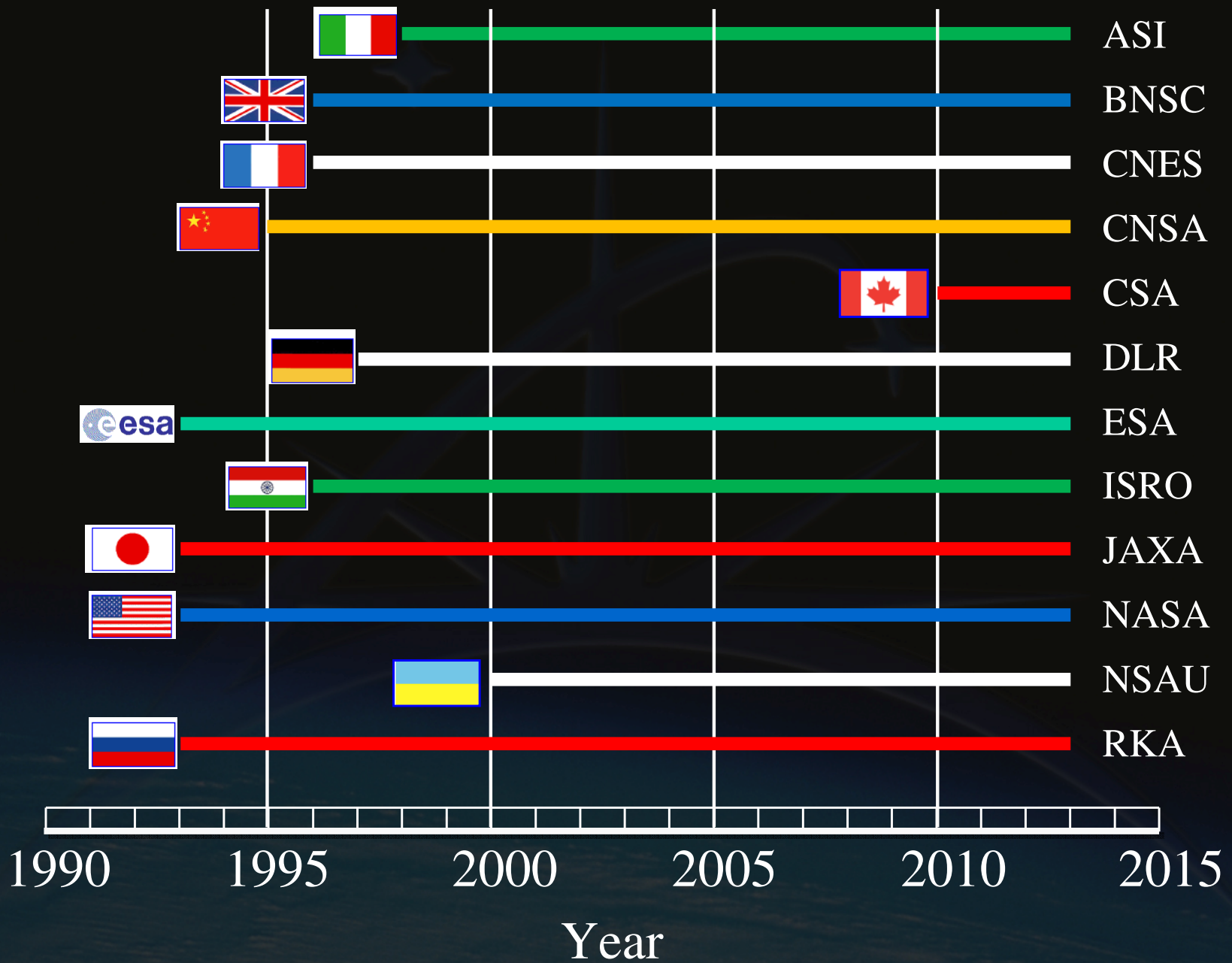


# SAPPHIRE

- SAPPHIRE was launched on 25 February 2013
- Launch and Early Orbit Phase (LEOP) Successfully completed 29 May
- Initial Operational Capability (IOC) signed 10 September
- Full Operational Capability (FOC) announced on 22 November 2013 and officially declared a contributing sensor to the U.S. Space Surveillance Network.
- Begins a 5-year operational mission monitoring space objects orbiting between 6,000 and 40,000 km altitude

# IADC

- Canada is latest member of International Space Debris Coordination Committee (IADC) (joined in 2010).





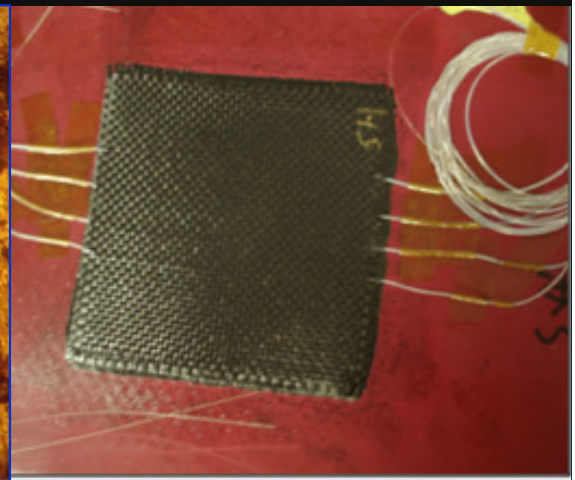
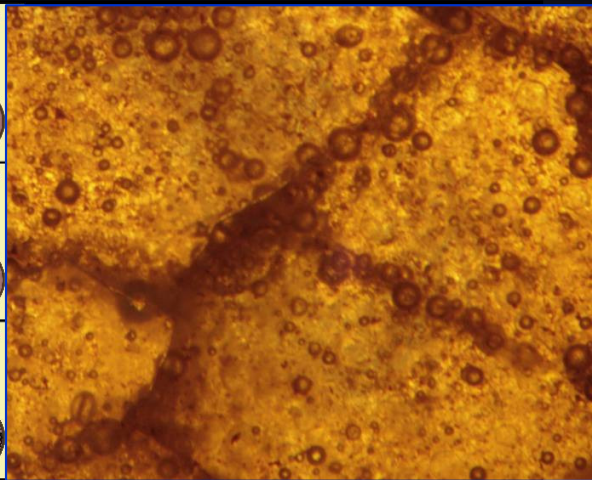
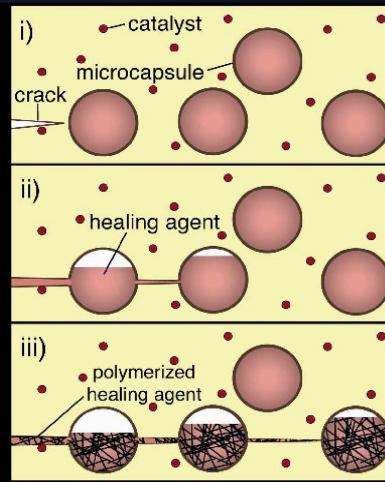
# Re-Entry Analysis

- Re-entry time and impact location prediction for an uncontrolled one is a difficult task
  - The attitude evolution of the object and its drag coefficient is a significant source of uncertainty
  - Computation of atmospheric density is another source due to modelling and space weather predictability issues
  - A mean error of 20% may still be expected after executing about 16 re-entry campaigns to calibrate models
- Inclination gives the path. Location is TBD until a few hours/minutes before impact
- CSA has participated in the last GOCE re-entry campaign led by ESA

# Smart Materials/Smart Structures for MMOD Protection

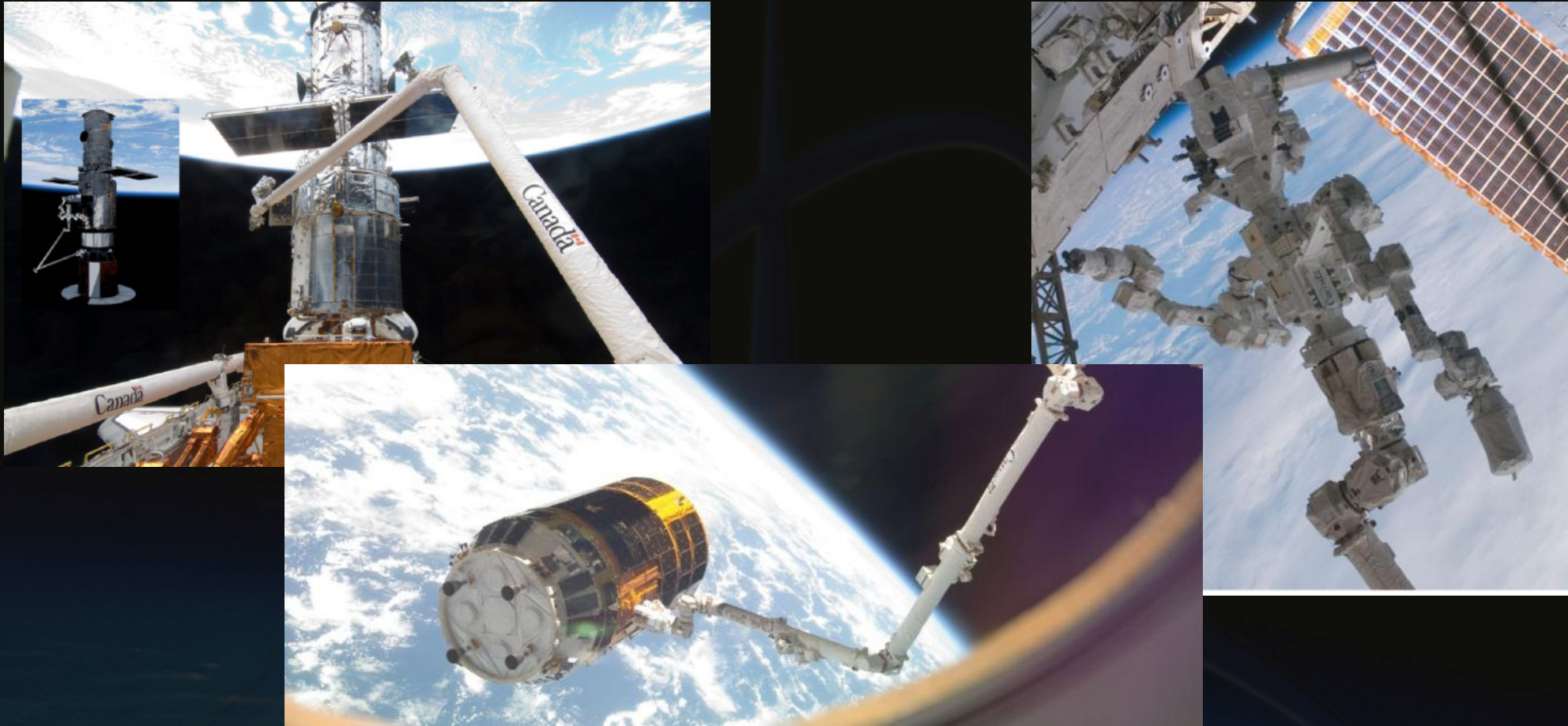
CSA Project with Industry (MPB) and University (Concordia) On Carbon Reinforced Composite Panels with:

- Embedded self-healing resin micro-capsules working in space environment (extreme vacuum and temperature range)
- Embedded optical FBG fibers for MMOD damage monitoring





# ADR based on Operations System Heritage In Space Robotics



CSA has delivered 3 state-of-the-art robotic systems for operational use in Low Earth Orbit: the STS (US-Shuttle) Canadarm, the ISS Canadarm2 and Dextre.

Demonstrating the following on-orbit capabilities: Assembly, Inspection, Payload handling, Capture and Berthing, Cooperative Servicing, EVA Support, Robotic Servicing, Change-out of On-orbit Replaceable Units (ORUs)



# Orbital Debris Remediation Concept Studies

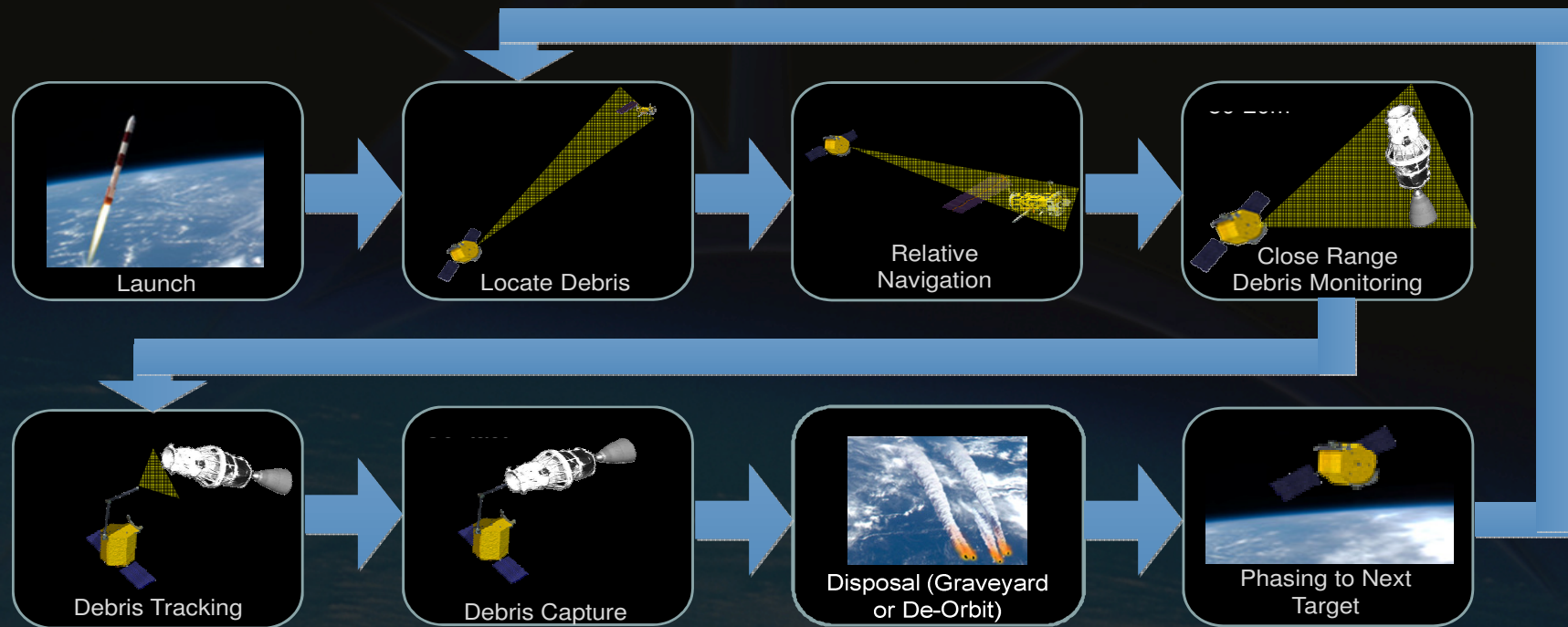
Two CSA funded Space Exploration concept studies examine use of space robotics to contribute to remediation of large debris :

[http://www.asc-csa.gc.ca/eng/media/news\\_releases/2011/1027.asp](http://www.asc-csa.gc.ca/eng/media/news_releases/2011/1027.asp)

Start: October 2011. End: March 2012

*Clear Sky Team:* MDA, Bristol Aerospace, UTIAS, Cyber & Space Telecom Inc, Mafic

*MODEL Team:* COMDEV, Neptec, NGC Aerospace Ltd, ESI Automation and Robotics



# Space Debris Compendium

The development of a **Space Debris Compendium** listing Space Debris Mitigation Standards adopted by States and International Organisations is a national initiative of Canada and the Czech Republic supported by the German Aerospace Agency (DLR) and ESA for tabling at the COPUOS Legal Subcommittee in March 2014.

Thank you  
Merci