



Canadian Space Debris Activities Summary

Inter-Agency Debris Working Group
IADC 2024

Canadian Space Agency (CSA)



Canadian Space
Agency

Agence spatiale
canadienne

Canada

(Some of) Canada's space fleet

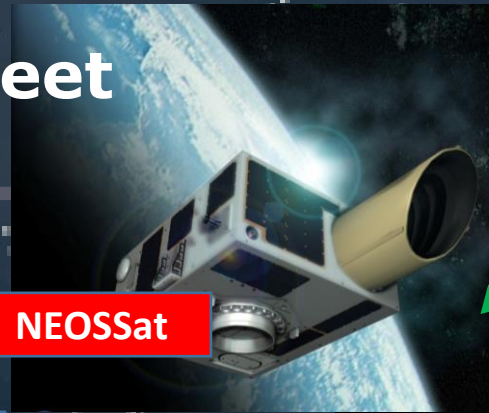


RADARSAT Constellation

RADARSAT-2

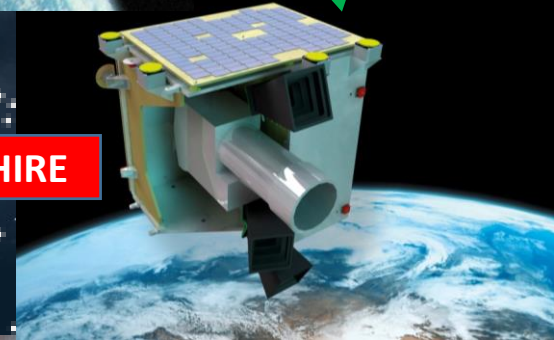


NEOSSat



On-orbit
SSA sensors

SAPPHIRE



CASSIOPE



SCISAT



New launches all commercial or academia;
No new de-orbits or mission failures;

Key Activities in Space Sustainability

- **Conjunction Risk Assessment & Mitigation System**
 - Over 100 satellites supported as a service
- **RCM:**
 - **Predicted ephemeris uploads 3x daily**
 - **RCM Collision Avoidance maneuvers**
 - Jan 2023
 - May 2023
 - Oct 2023
- **NEOSSat:**
 - **Predicted & definitive ephemeris uploads weekly**
 - **R&D observations**
- **SAPPHIRE:** contributing sensor to the US SSN

... for operators, by operators

Immediately following a conjunction data message notification, deliver necessary analysis to mission team to make decision on collision avoidance maneuver

- Automation engine around Matlab & STK
- User-friendly Excel and Text files delivered via email
- Configurable for additional missions with no overhead
- Hot backup servers to ensure system up-time

Over 100 missions now supported

0.49 11.69

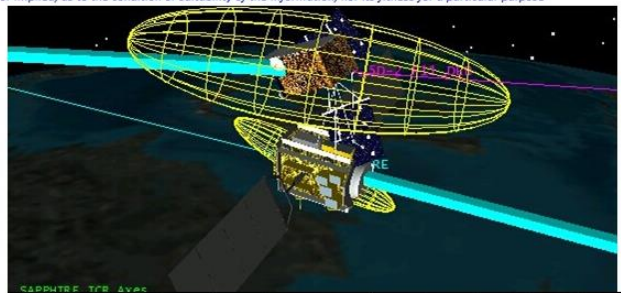
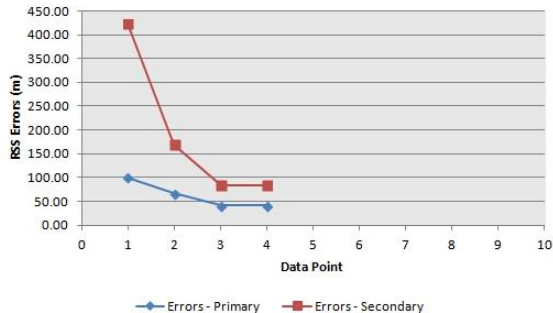
Configurable Parameters	Thresholds of Concern:
Error scaling:	Depth of Intrusion:
1 1 1	1
RSS Errors limit:	Probability of Collision:
1700	1.00E-04

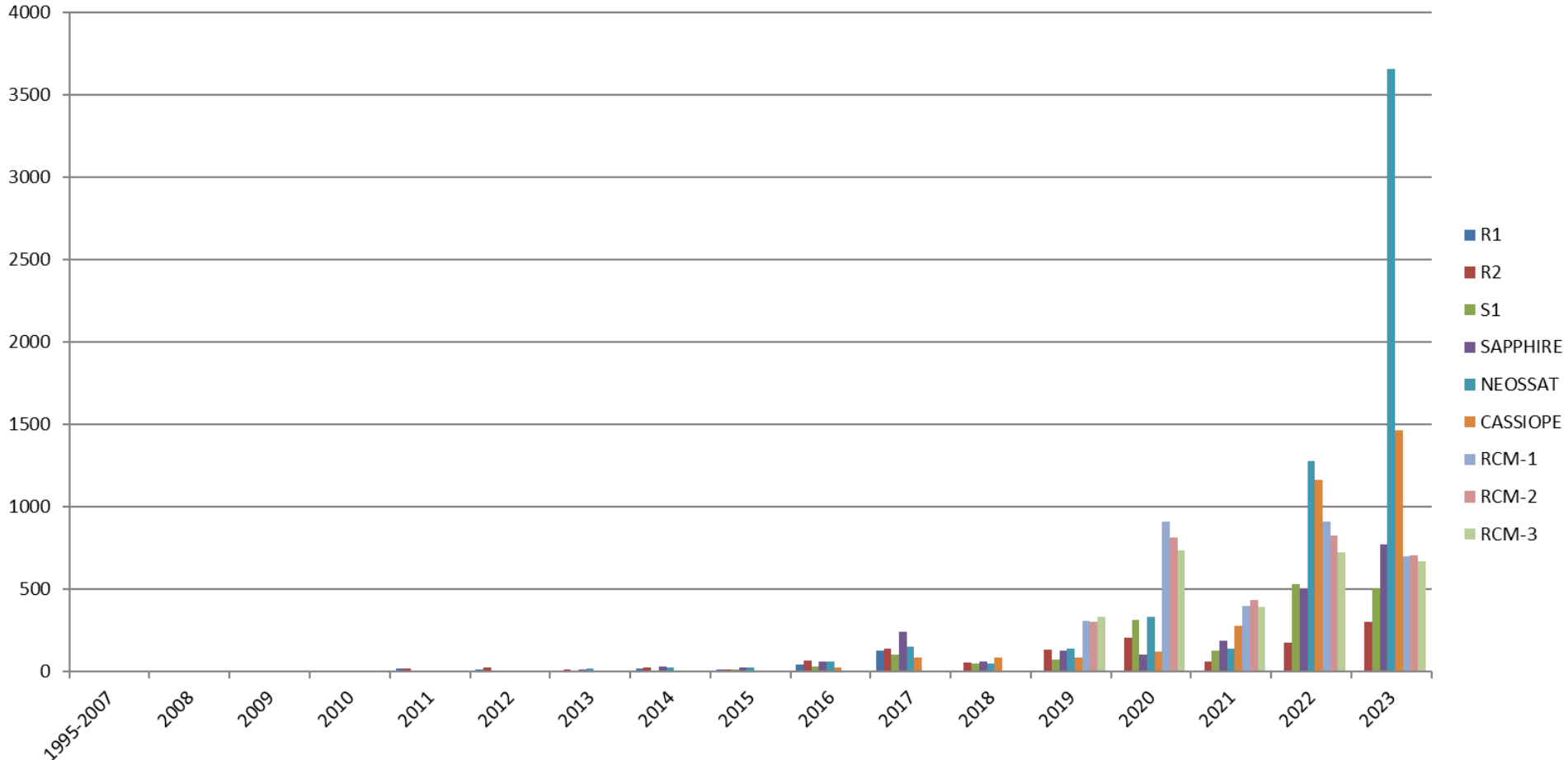
[illegible]

NO WARRANTIES: The enclosed information is provided "as is" and with no warranty, either express or implied, as to the condition or suitability of the information, nor its fitness for a particular purpose.

Objects	Name	SSC #	Type	Country	Launch
	SAPPHIRE	39088	PAYLOAD	CA	2013-02-25
	DMSP_5D-2_F11_DEB	28317	DEBRIS	US	1991-11-28
TCA	2013/07/30 11:00				

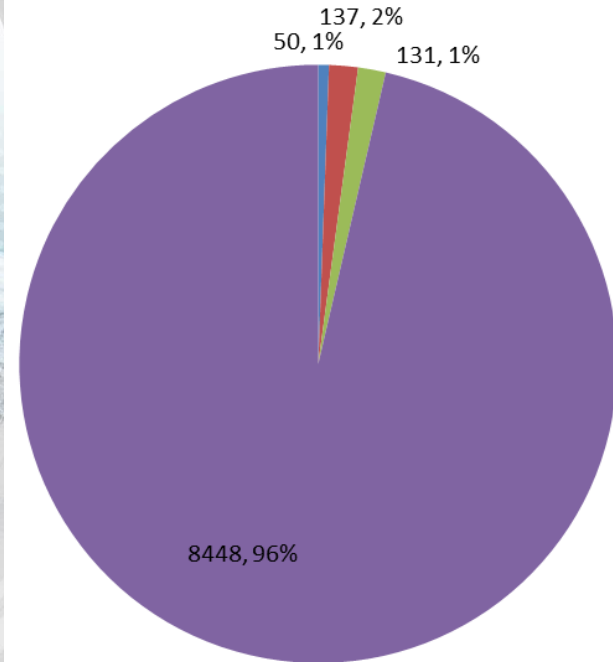
SAPPHIRE vs DMSP_5D-2_F11_DEB TCA
at 2013/07/30 11:00 (UTC)



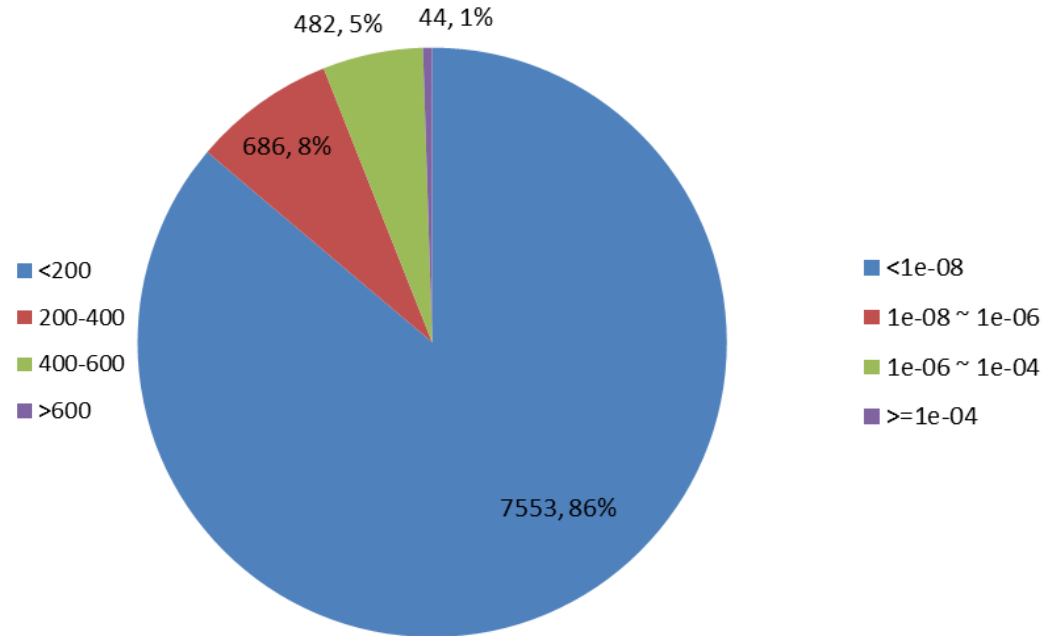


2023 Conjunction Events Breakdown

Miss Distance - 2023

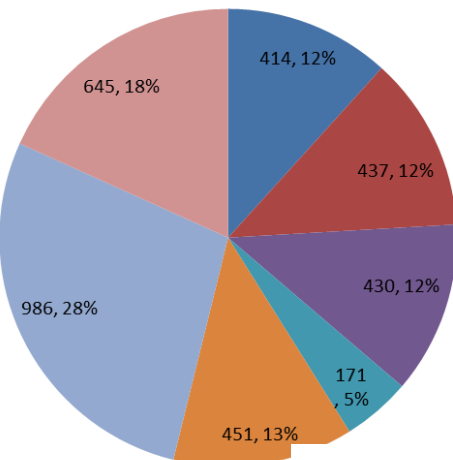


Probability of Collision

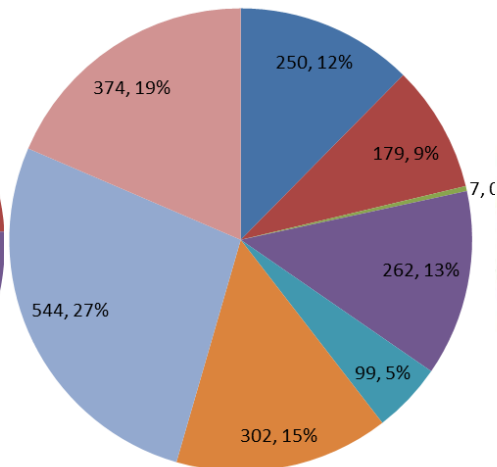


CRAMS Statistics – Evolution of LEO as seen by CSA CDMs

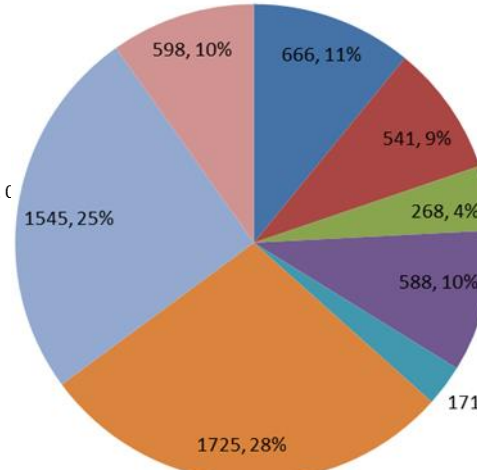
2020: 3534 events



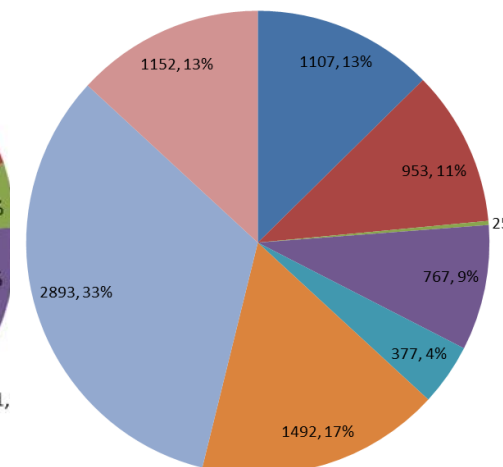
2021: 2017 events



2022: 6102 events



2023: 8766 events



FENGYUN_1C_DEB

COSMOS_2251_DEB &
IRIDIUM_33_DEB

COSMOS_1408_DEB

UNKNOWN

ROCKET BODIES

MEGA-CONSTELLATIONS

OTHER DEBRIS & COOLANT

OTHER SATELLITES

Notable points:

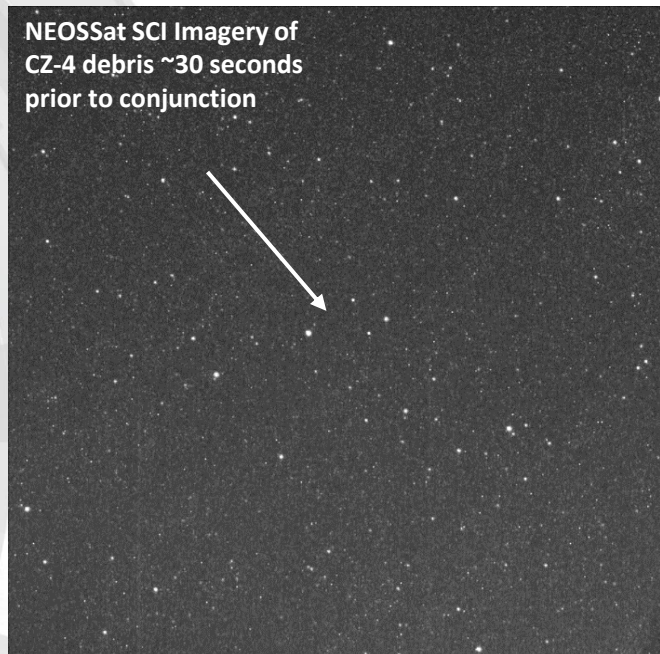
- Rocket bodies trending down... (more payloads/launch; better return practices)
- Mega-constellations trending up... (and more complex, due to new propulsion modes – operator ephemeris and interactions becoming more important than SP catalog in more and more cases)
- UNKNOWN / analyst satellites continue to be an important contributor to conjunction events

NEOSSat debris object measurements and reference data

- **NEOSSat observations of debris during conjunctions**
 - NEOSSat continues to observe space objects on very close (< 300 m) conjunction trajectories
 - Safest thing for NEOSSat is attempt imagery of the secondary object during a conjunction.
 - In this way we show our smallest cross sectional area to the oncoming object
- **NEOSSat Canadian Satellite Tasking List (CSTL)**
 - NEOSSat measurements continue to be collected weekly on objects attributed to Canada in the satellite catalog
 - Data continues to be used for R&D
- **NEOSSat GPS ephemeris**
 - Predicted and post-fit precision NEOSSat GPS orbit ephemeris data continues to be published on CSA open data portal
 - Data continues to be available from: https://data.asc-csa.gc.ca/users/OpenData_DonneesOuvertes/pub/NEOSSAT/Ephemeris/
 - Precision ephemeris is accurate to 1-2 meters. Can be used for moderate scale LEO sensor accuracy assessment
- **IADC observation campaigns**
 - **IT 38.2 “LEO Upper stage rocket bodies”**
 - NEOSSat collected observations on selected target list, integrated into the right
 - **IT 34.1 “Feasible options to study Molniya population of space debris”**
 - NEOSSat collected 305 observations (time, RA, DEC, Magnitude, XYZ observer) based on selected target list
 - **IT 37.1 “Preparation for a future beampark campaign”** (separate from NEOSSat)
 - Canada working to obtain funding for Algonquin Park 46 meter radar to participate
 - Minimum detectable size likely to be ~ 3 cm in LEO with Algonquin Park current transmit power

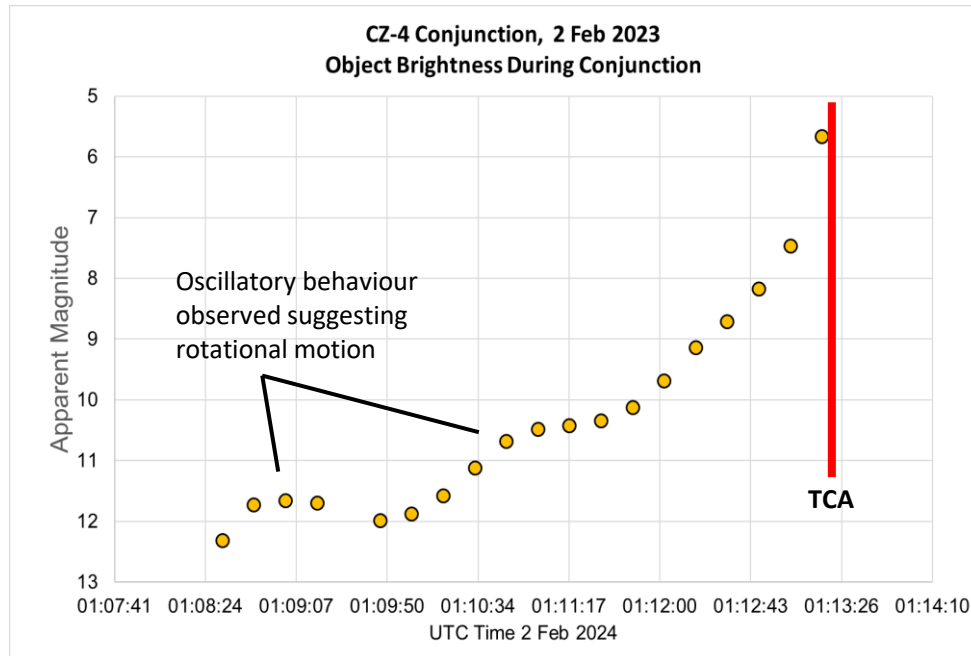
NEOSSat recent measurement activities

NON CLASSIFIÉ / UNCLASSIFIED



- **CZ-4 Conjunction (Feb 2023)**

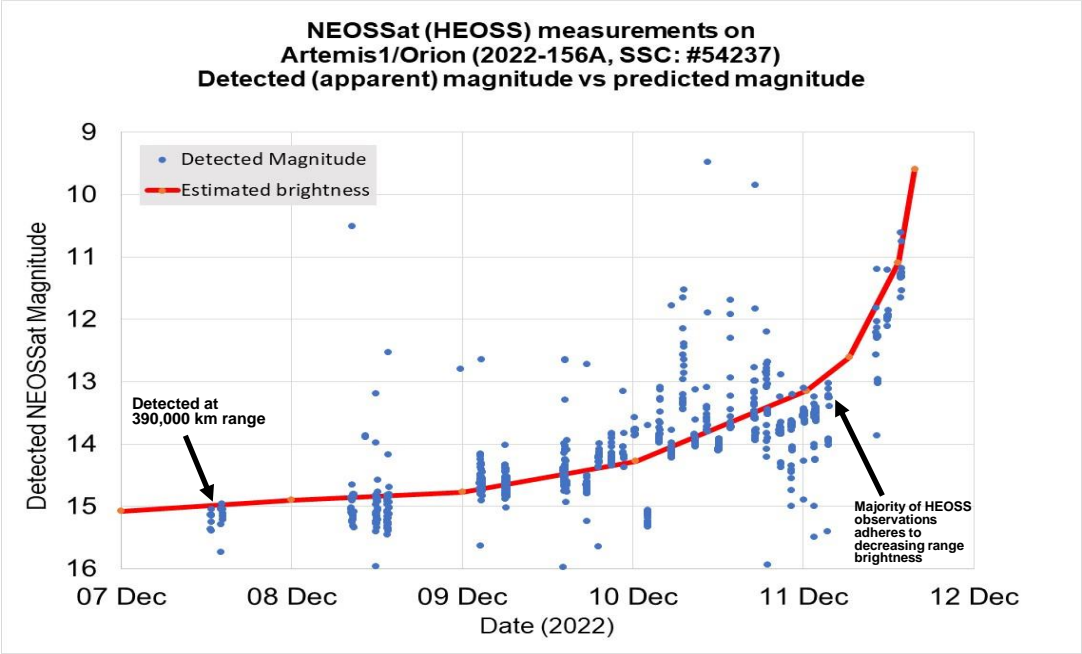
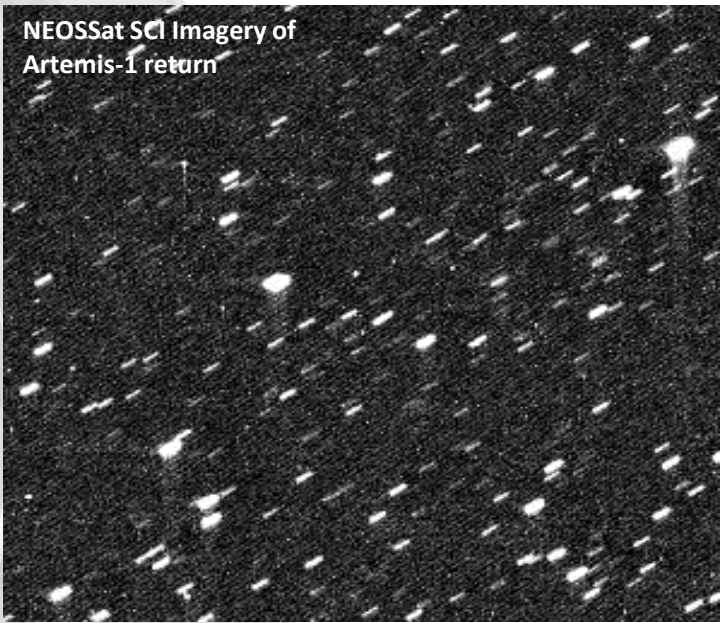
- NEOSSat tracked CZ-4 debris (#20887) just prior to its conjunction with NEOSSat
- TCA: Feb 2 2023 1:13:22.6 UT
- Miss distance: 30 meters
- CDM provided by 18th SDS and CSA CRAMS to CSA satellite operations



- **NEOSSat measurements**

- Measured object: M_v 5.6 -12.4
- Object detected during the terminal phase pass of the conjunction.
- ***Rotational behaviour in light curve observed during its approach to NEOSSat***
- Analysis ongoing to determine actual miss distance

New measurement activities – Artemis 1 return (Dec 2022)

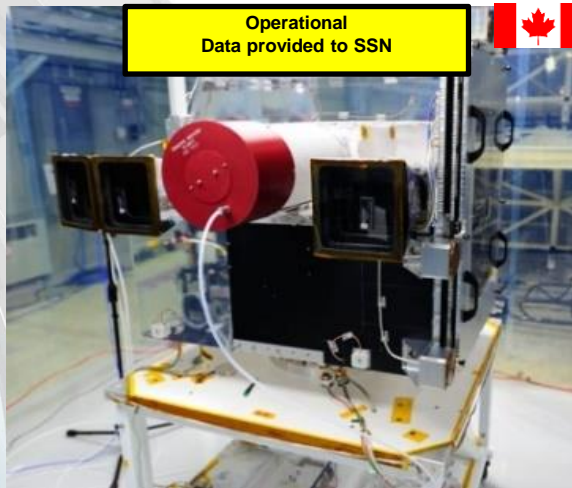


- **Cislunar tracking of Artemis-1 Return**

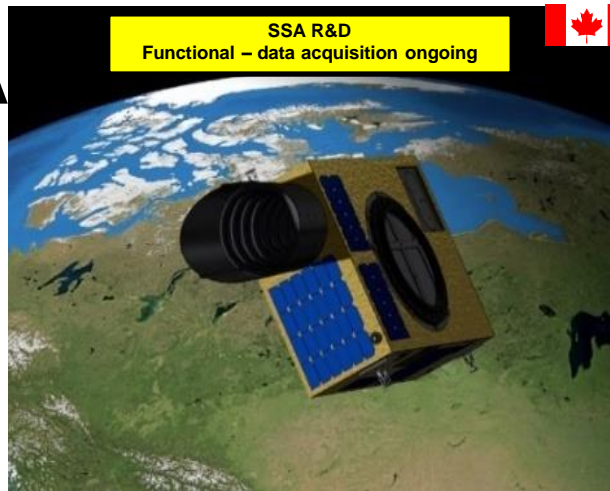
- NEOSSat performed observations of Artemis-1 during its return trajectory to Earth
 - Object surprisingly bright and easily detected at ~400,000 km range

- Some oscillatory light curve behaviour noted. Likely due to Artemis-1 attitude control adjustments
- Optical observations were consistent with NASA OEM ephemeris but it was found that full orbit observability could not be achieved.
 - Lack of ranging measurements complicates the orbit estimation process, especially for objects “falling” back to Earth from lunar distances.

Operational
Data provided to SSN



SSA R&D
Functional – data acquisition ongoing



SSA R&D



New mount / telescope /
camera updates in progress

• Sapphire (DND)

- Owner: Dept of National Defence
- Mission: operational space surveillance
- Bus: Surrey SSTL 150
- Payload: 15cm V-band anistigmat
- Sensitivity: Mv 16
- Tracking Accuracy: < 3 arcseconds
- Orbit: 785 km dawn-dusk
- Tasking: 22 Wing North Bay/ CanSpOC
- Operator: MDA (Richmond, BC)

■ NEOSSat (DND/CSA)

- Owner: Canadian DND / CSA
- Mission: SSA R&D, Asteroid astronomy
- Bus: MOST bus lineage
- Payload: 15cm V-band Maksutov
- Sensitivity: Mv 16
- Tracking Accuracy: 2.4 arcseconds
- Orbit: 785 km dawn-dusk
- Tasking: DRDC Ottawa, Select observers
- Operator: CSA, St Hubert, QC

■ Ground-Based Optical Space Surveillance Observatory (SSO) (1 of 3 shown)

- Owner: Defence R&D Canada Ottawa
- Mission: Space Surveillance, SSA R&D
- Located: Suffield, AB, Ottawa, ON, Valcartier, QC
- Instrument: 35cm V-band, EMCCD/Conventional CCD
- Sensitivity: Mv 16
- Tracking Accuracy: 1.5 arcseconds

Future Activities

- **New Canadian Missions:**

- QEYSSat
- WildFireSat
- HAWCSat
- RADARSAT+
- Redwing (DRDC)
- Surveillance of Space 2 (DND)

CRAMS Evolution:

- Drag-based collision avoidance analysis
- Electric propulsion support

Other Engagements

- **Regulatory review in progress**
- **UN-COPUOS**
- **Inter-Agency Operations Advisory Group**
- **ITU/WRC**

