A Risk Analysis of CONASENSE Satellite Systems Threats

Dr. Homayoun Nikookar

Netherlands Defence Academy (NLDA),
Faculty of Military Sciences,
Den Helder, The Netherlands

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- CONASENSE Satellite Systems provide space-based capabilities with a wide range of applications:

  Communications, navigation, targeting, mapping, remote sensing, surveillance and meteorological tracking, prediction and other services

- With this ever growing applications threats become more serious to Conasense satellites

ORBIT	ALTITUDE	APPLICATION
Low Earth Orbit (LEO)	up to 2000 km	Communications, Internet,Intelligence- Surveillance and Reconnaissance (ISR)
Medium Earth Orbit (MEO)	2000 to 35000 km	Communications, Positioning- Navigation- Timing
Geo Earth Orbit (GEO)	approximately 36000 km	Communications, ISR

CONASENSE Satellite systems threats

Atmospheric threats:

- Thunderstorms (charged particles and currents present in the thunderclouds)
- volcanic activities, Lava, ash clouds

Outside Earth Atmosphere:

- conditions on the sun, solar flare, solar wind
- space debris, smaller sized meteorites and asteroids, man-made debris like decommissioned satellites

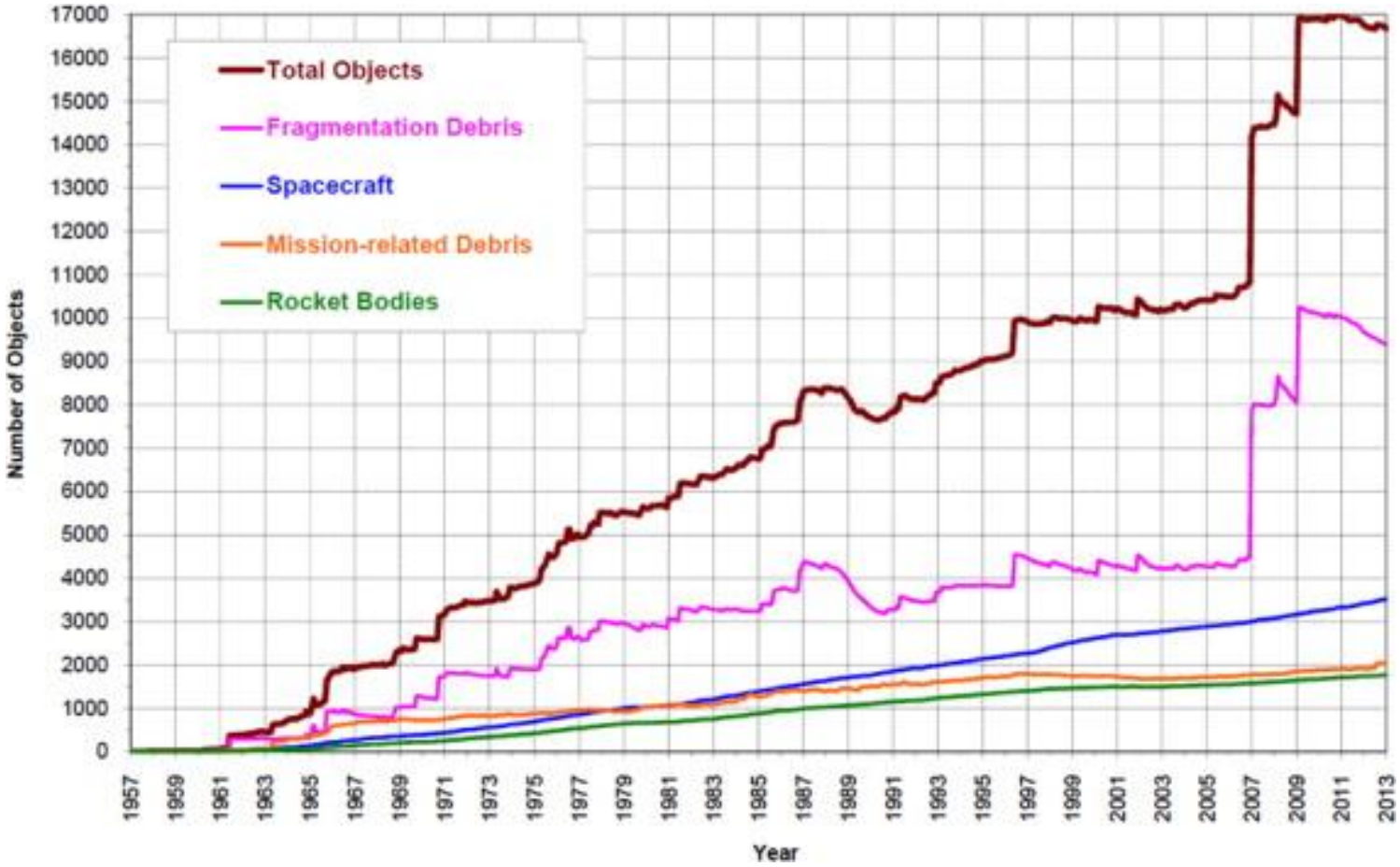

Fig. 1: Objects in earth's orbit over the years. The two step increases in 2007 and 2009 result from fragments from the FY-1C ASAT test and Iridium 33/Cosmos 2251 collisions, respectively.

Source: https://www.researchgate.net/figure/Monthly-number-of-objects-in-the-Earth-orbit-cataloged-by-the-US-Space-Surveillance_fig3_264863542

Hostile threats

anti-satellite weapons:

- Nuclear,
- non-nuclear (Kinetic Energy Warfare-KEW)
- non-dedicated space weapons (Cyber)

Cyber threats do not damage the physical satellite but destroy the Command Control and disable the satellites' operations.

ground- space, space-space, space-air, space-ground and air-space.

Use of Artificial intelligence (AI)

Use of AI in the prediction of space weather

Collecting data from Earth's orbital sensors like telescopes and satellites. Conversion of this data to usable information

AI can be used as a protective manner against cyber threats in specifically the Satellites' Ground Control Stations

As Conasense satellite systems become more complex integration between systems gets harder. AI can be used as a central managing and integration tool for all systems, which allows different complex systems to integrate.

Risk Analysis

Risk Matrix: values a threat into a risk factor, based on the consequence and the likelihood of the threat.

$$Risk = (Consequence \text{ of threat}).(Likelihood \text{ of threat})$$

extreme	Risk≥15
high	7 ≤ Risk ≤ 14
moderate	4 ≤ Risk ≤ 6
low	1≤Risk ≤ 3

Likelihood		Consequence: Negligible 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
	5 Almost certain	Moderate 5	High 10	Extreme 15	Extreme 20	Extreme 25
	4 Likely	Moderate 4	High 8	High 12	Extreme 16	Extreme 20
	3 Possible	Low 3	Moderate 6	High 9	High 12	Extreme 15
	2 Unlikely	Low 2	Moderate 4	Moderate 6	High 8	High 10
	1 Rare	Low 1	Low 2	Low 3	Moderate 4	Moderate 5

Risk Matrix

Threat	Satellite system's component	Frequency of threat	Destructive capability of threat	Total risk
Earth's Atmospheric threats	- GCS - Channel	Almost certain (5)	Minor (2)	High (10)
Space weather threats	- Channel - Satellite	Possible (3)	Major (4)	High (12)
Nuclear threats	- GCS - Channel - Satellite	Rare (1)	Catastrophic (5)	Moderate (5)
KEW's threats	- GCS - Channel - Satellite	Rare (1)	Major (4)	Moderate (4)
Non-dedicated threats	- GCS - Satellite	Likely (4)	Major (4)	Extreme (16)

GCS:Ground Control Station
KEW: Kinetic Enegry Weapon

Risk Matrix with protective measures

Threat	Satellite system's component	Frequency of threat	Destructive capability of threat	Total risk
Earth's Atmospheric threats	- GCS - Channel	Almost certain (5)	Negligible (1)	Moderate (5)
Space weather threats	- Channel - Satellite	Possible (3)	Minor (2)	Moderate (6)
Nuclear threats	- GCS - Channel - Satellite	Rare (1)	Catastrophic (5)	Moderate (5)
KEW's threats	- GCS - Channel - Satellite	Rare (1)	Moderate (3)	Low (3)
Non-dedicated (Cyber) threats	- GCS - Satellite	Possible (3)	Moderate (3)	High (9)

GCS:Ground Control Station
KEW: Kinetic Enegry Weapon

Comparison of risk analyses

Threat	Total risk without protective measures	Total risk with protective measures
Earth's Atmospheric threats	High (10)	Moderate (5)
Space weather threats	High (12)	Moderate (6)
Nuclear threats	Moderate (5)	Moderate (5)
KEW's threats	Moderate (4)	Low (3)
Non-dedicated (Cyber) threats	Extreme (16)	High (9)

Conclusion:

- For CONASENSE satellite systems different **varieties of threats** and countermeasures were discussed.
- The threats are divided into two general groups: **naturally occurring threats and man-made threats.**
- Naturally occurring threats consist among other things of **Earth's weather effects but also space weather like solar flares and meteorite showers**.
- Man-made threats are divided into **nuclear weaponry, kinetic-energy weaponry and cyber threats.**
- A **risk analysis** was carried out with the help of a risk matrix to gain an insight into the resulting risk for each threat, before and after specific countermeasures.
- **Total Risk of Cyber threats** was found to be the **largest.**
- The influence of **artificial intelligence** and its role in protective and defensive measures against **cyber attacks** was included.