CGMS FUTURE DIRECTION 2022+
POSITION PAPER THEME: SPACE SITUATIONAL AWARENESS

Lead: ESA

TOPIC DESCRIPTION AND RATIONALE FOR CGMS ENGAGEMENT

Orbital regions for operational missions are becoming increasingly congested. Over the last decade the number of active satellites in space has increased by a factor of seven from just over 1000 to over 7000. At the same time the number of debris is increasing, particularly in the LEO orbits increasingly used by operational space missions. At the end of 2022 the amount of tracked objects in space exceeded 30 000 (Figure 1). If efficient methods are not utilised, the probability of catastrophic collisions in orbit is predicted to increase significantly over the coming decades (Figure 2). Long term, this could lead to "Kessler Syndrome", the situation in which the density of objects in orbit is high enough that collisions between objects and debris create a cascade effect, each crash generating debris that then increases the likelihood of further collisions. At this point, certain low-Earth orbits will become entirely inhospitable.

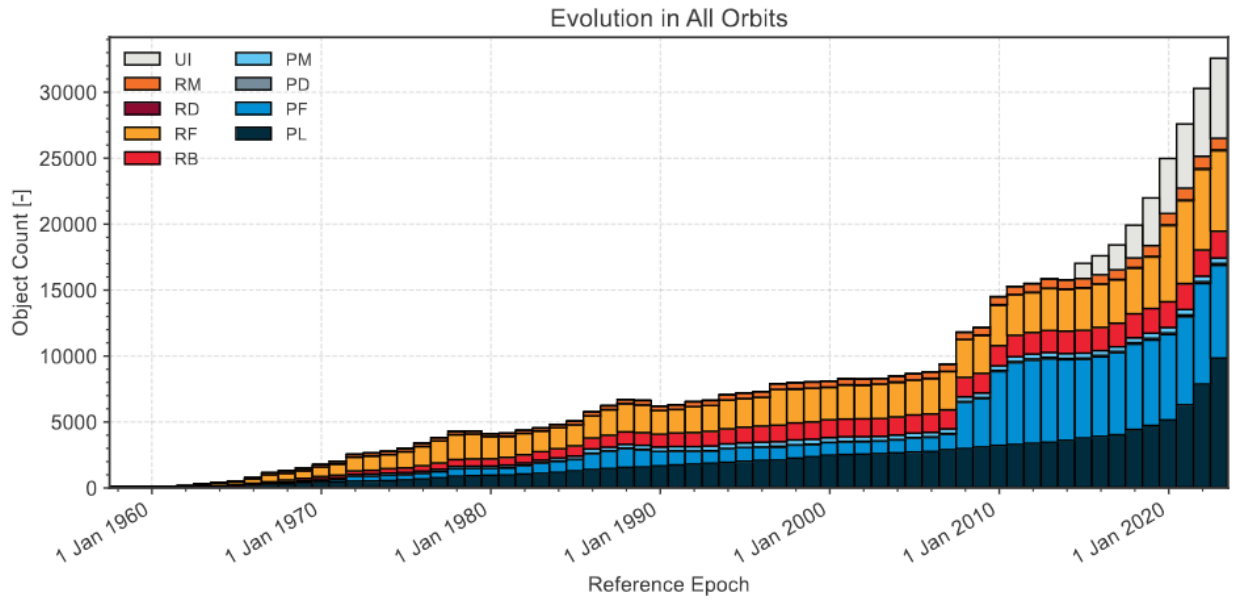

Figure 1. Evolution of number of objects in geocentric orbit by object class: PL = Payload, PF = Payload Fragmentation Debris, PD = Payload Debris, PM = Payload Mission Related Object, RB = Rocket Body, RF = Rocket Fragmentation Debris, RD = Rocket Debris, RM = Rocket Mission Related Object, UI = Unidentified (ESA'S ANNUAL SPACE ENVIRONMENT REPORT 2022, GEN-DB-LOG-00288-OPS-SD).

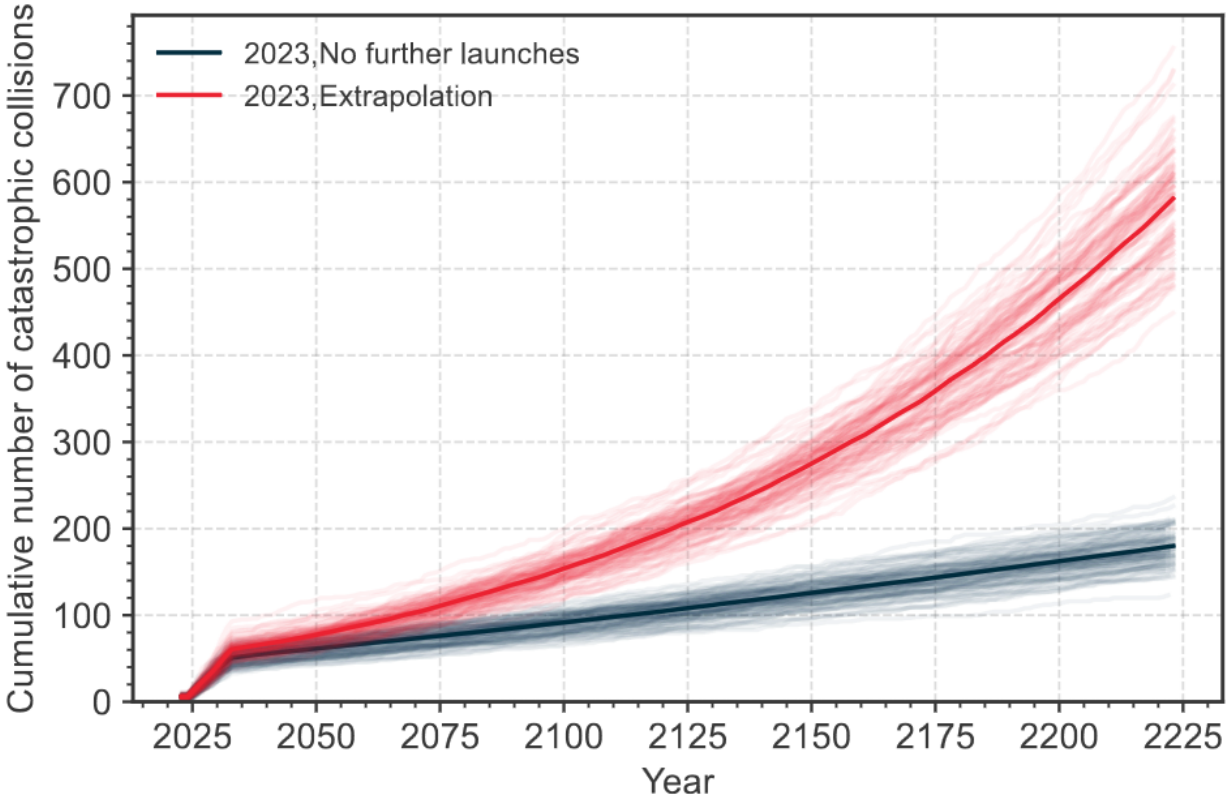

Figure 2. Number of cumulative collisions in LEOIADC in the simulated scenarios of long-term evolution of the environment class (ESA'S ANNUAL SPACE ENVIRONMENT REPORT 2022, GEN-DB-LOG-00288-OPS-SD).

Space Weather is both positive and negative factor in the domain of SSA and sustainable use of outer space. Expansion of Earth's upper atmosphere due to solar activity affects the atmospheric drag at orbits below 600 km and causing small debris to re-enter and burn in the atmosphere. At the same time space weather is a hazard to safe launch and operation of satellites and can contribute to creation of new debris when satellites malfunction or their control is completely lost. Space weather is also one of the main contributors to the uncertainty of the impact site in the case of uncontrolled re-entry of satellites.

How can CGMS support sustainable use of outer space and contribute to the efforts to mitigate existing space debris and, particularly, to reduce production of new debris to a sustainable level? CGMS Member Agencies are vital actors in establishing international collaboration to manage satellite orbits and avoid catastrophic collisions between space objects in the increasingly crowded orbital regimes.

A topic related to space sustainability is the analysis of the impacts of meteorological satellite launches (e.g., rocket exhaust) and re-entries, when satellites and pieces of space debris return to Earth's atmosphere depositing material there. Operational meteorological and space weather missions are only a small part of this re-entry of material, but CGMS would be in a good position to contribute to such analysis, potentially leading the way towards zero debris objective in the future.

CHALLENGES/OPPORTUNITIES FOR CGMS

- Safe launch and operation of missions requires increasing amount of SSA information requiring CGMS Member Agencies to engage to
    - Space Traffic Coordination (STC),
    - Space Weather status, nowcasts and forecast information for safe operations.
- Space sustainability is mandatory to maintain safe access to space and CGMS Member Agencies should take measures:
    - Avoidance of generating new debris by robust design of satellites for reducing number of failures in orbit, safe operation throughout the mission, and safe and quick passivation and disposal at end of life (including consideration of third-party disposal services as an alternative to self-disposal designs),
    - Utilising safely disposable materials in launch vehicles and satellites including fuels, coatings, etc., minimising the risk of re-entries,
    - Design satellites for in-orbit servicing for extended lifetime to reduce the need of launches and to achieve a zero debris footprint.
- Long term target should be satellites design for reuse and recycling of the launched material to facilitate circular economy in space.

To further refine this description/rationale, recommend we begin by:

- Developing a shared understanding of the range of CGMS Member Agencies' views and current practices relating to SSA including STC and Space Weather,
- Collecting CGMS Members Agencies' needs for SSA (STC and space weather) services,
- Defining service development prospects and how CGMS can support them.

SHORT-, MEDIUM- AND LONG-TERM GOALS FOR CGMS:

Space Traffic Coordination

- Review of CGMS Member Agencies' satellite operations for the needs of STC services for collision avoidance and re-entry prediction (builds upon CGMS-50-WGI-WP-02)
- Perform a gap analysis between the needs and the available/used STC services[1],
- Carry out an assessment of service development prospects and how CGMS can support them,
- Prepare a proposal for the best practices to support improvement of STC services towards the CGMS Member Agencies' needs,
- Engage with UN-COPUOS to achieve global standardised approach for STC based on CGMS proposal.

Space weather

- CGMS Space Weather Coordination Group (SWCG) already exists and contributes, for example, to:
    - CGMS baseline for space weather monitoring, HLPP and WMO gap analysis,
    - Cross calibration of space weather sensors,
    - Planning of specific observations (e.g. RO),

[1] In this context STC services are considered to include, for example, space assets and debris tracking inputs, conjunction filtering and assessment for specific objects, operator ephemeris sharing facilities and operator to operator hotline contact database. In the future STC services may include also automated conjunction analysis and avoidance systems and services.

  - Sharing national and agency plans for space weather observations,
  - User access to space weather data (Task group established in 2022).
- Potential new space weather goals within the SSA Theme would be:
  - Produce a report of space weather observation requirements by improved STC services and space sustainability,
  - Identification of synergies with other CGMS Themes (e.g. Future Observing Space Infrastructures, Future Information Technologies, …)

Space sustainability

- Arrange a meeting where Space Sustainability Rating (SSR) and similar metrics supporting event consequence analyses are presented to all CGMS Member Agencies,
- Carry out a pilot project where some operational missions (e.g. one existing and one under planning) are evaluated using selected metrics and produce a report,
- Arrange a presentation of objectives and prospects of "zero debris policy" to all CGMS Member Agencies,
- Carry out assessment of impacts of such policy on operational missions including private sector (including missions for data buy by CGMS member Agencies),
- Prepare a CGMS best practices document for long term space sustainability.

Four pillars of transversal action for zero debris approach.

IMPACT ON CGMS ACTIVITIES

- Need to consider medium- and long-term impacts on planning and implementation of operational space missions to space sustainability regarding public image (positive impact should be expected) and cost (potentially negative impact, at least until technology has been matured and standardised),
- Consider benefits from improved STC and space weather services to satellite operators in CGMS Member Agencies,
- Better understanding of global STC impacts on operational missions can be envisioned,

- Synergies with other Themes/areas of CGMS.

IMPLICATIONS ON CGMS STRUCTURE AND KEY DOCUMENTS

- Update/include in HLPP as appropriate,
- Development/Publication of best practices documents,
- Publication of study and pilot project reports.

IMPACT ON EXTERNAL INTERFACES

- WMO Expert Team on Space Weather (ET-SWx) is defining space weather observation needs including the needs for STC services. CGMS is represented in the WMO ET-SWx and should contribute to all SSA related aspects of the Expert Team
- Space sustainability is a regular item in UN COPUOS STSC. The SSA effort with CGMS needs to target establishing a position paper that is presented in the STSC.

ADDITIONAL QUESTIONS/PROPOSALS

- What the concrete impact on CGMS duties and functions?
- How would the proper SSA data sharing question be quaranteed?

INITIAL LIST OF REFERENCE DOCS

- Guidelines for the Long-term Sustainability of Outer Space Activities
- UN Space Debris Mitigation Guidelines
- European Code of Conduct
- ESA'S Annual Space Environment Report
- Report from the CGMS WGI Task Group on Space Debris and Collision Avoidance (CGMS-50-WGI-WP-02)
- Space Operations Sustainability (SOS) Working Group report