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TRISMAC

Trilateral Safety and Mission Assurance Conference 2024

24–26 June 2024
ESA-ESRIN | Frascati (RM), Italy

Thales Alenia Space activities and solutions to guarantee a sustainable and safe space

June, 24th 2024

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ThalesAlenia Space

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1 - Context

The evolution of space traffic, with the emergence of the constellations, has prompted the development of more stringent sustainability standards and regulations.

These new requirements impact a wide range of design and operations aspects to lead to safer spaceflights:

- ✓ proper preparation, assessment and execution of the End of Life disposal
- ✓ faster development and implementation of remediation activities (e.g. Active Debris Removal and In-Orbit Service)
- ✓ improvement of practices for collision avoidance and space traffic coordination
- ✓ management and reduction of the expected number of casualties during the re-entry of spacecraft to the Earth surface.

Activities performed by Thales Alenia Space in the field of Space Debris Mitigation and Space Traffic Coordination, both participating to international forums and to support satellite design and operations:

- ✓ Involvement in the review of ISO 24113, ECSS-U-AS-10C Rev. 2, ESA ESSB-ST-U-007 and French Space Operational Act (LOS)
- ✓ Review of the standard proposal on Space Traffic Coordination
- ✓ Contribution to European Commission Space Label and to the definition of an European Space Law
- ✓ Support to the ECSS Mirror Working Groups on Space Traffic Coordination and Space Debris Mitigation
- ✓ Real-time reliability monitoring of TAS Earth Observation constellations and application of life extension risk assessment techniques.

Examples of Space Debris Mitigation requirements and implemented solutions:

- Post mission disposal success rate → reliable design, RAMS criteria to support EoL decision
- Casualty risk → Controlled re-entry (SWOT satellite, Copernicus), Natural assisted re-entry (no chemical propulsion), Design for Demise
- Reduced re-entry duration → re-entry in less than 5 years rather than 25
- Design for removal → implementation of solutions to favor Active Debris Removal
- Conditions for mission extension → real-time monitoring of satellite health status to perform trend analyses and to determine any degrading conditions that could impact the spacecrafts' life.

Examples of Space Traffic Coordination requirements and their implementation on design and operations:

- Occurred failures → design improvement before launching new batch to avoid recurrent failures
- Increase EoL disposal success rate → EOL disposal mode implemented and tested before launch
- Reduced risk of collision with satellites, including ISS → disposal and passivation at low altitude
- COLlision Avoidance (COLA) capability above a given altitude → propulsion system implemented
- Dead on Arrival (DoA) and low altitude injection → satellite designed to meet longer mission duration and worse RAD environment
- Visual brightness → materials, design and/or operations to limit magnitude
- Rules of the road → priority to safety critical aspects

A new Earth Observation space program was developed in TAS in early 2000 under contract from the Italian Space Agency (ASI). The space segment is made up of a constellation of LEO satellites, that reached their EoL, for which a time-parametric model of the satellite reliability was developed to account for the constellation’s in-orbit field data at any time the observation is made.

To evaluate the possibility of satellites lifetime extension, TAS carried out a co-engineering activity and developed the FTA/FMECA Enhanced (FFE) technique based on the synergistic use of standard reliability analyses, mission and engineering assessments performed throughout the spacecraft in-orbit life. Satellites health status is continuously monitored to perform trend analyses and to determine any degrading conditions that could impact the spacecraft life.

The FFE technique is implemented in a dedicated tool and automatically provides different output data (KPIs). It is extremely flexible: it can be used for nominal mission monitoring, life extension/disposal risk assessment, and can be extended in terms of adding input data and providing additional outputs.

2 - SDM and STC: Real-time reliability monitoring of EO constellations

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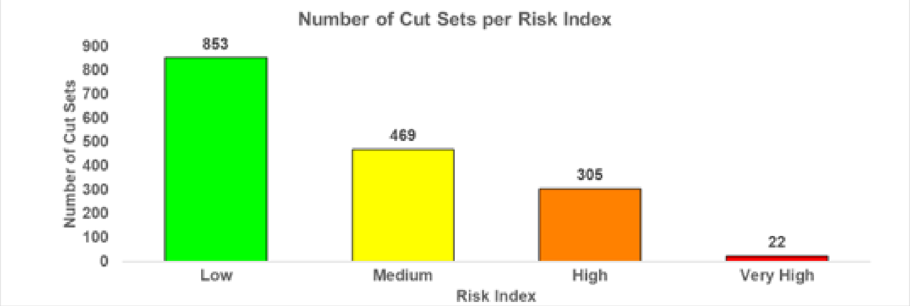
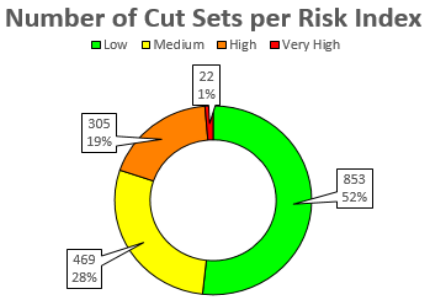
Telemetry set including failure data

Temperature data from the mission team





Probability of Successful Disposal	98,7%
Probability of Disposal Loss	1,3%
Probability to use a Degraded Disposal	1,1%

Extended Trend Analysis and prognosis ➔ Remaining Useful Life (RUL)

Reliability Design Data Reprocessing

CutSet list

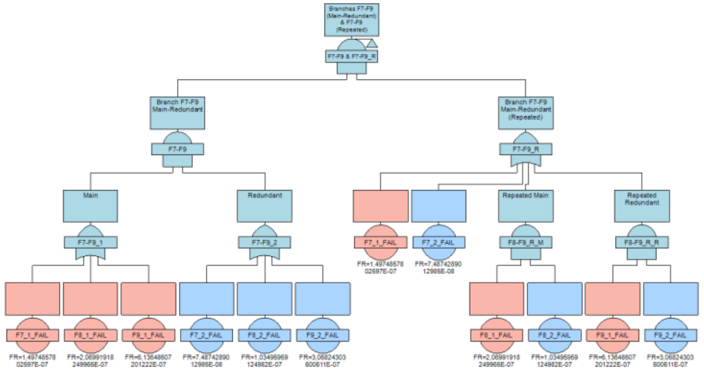
Computation of Outputs (KPIs)

data coming from suppliers or elaborated with the mission team

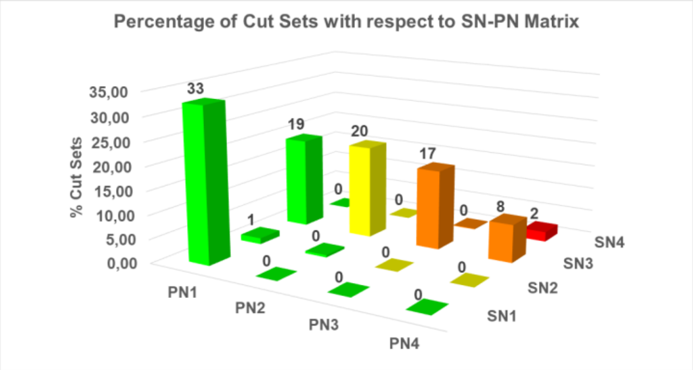
update of the Failure Rate values

$$\lambda = f(T, RUL)$$

FTA on Commercial Software



Fault tree representing systems and sub systems



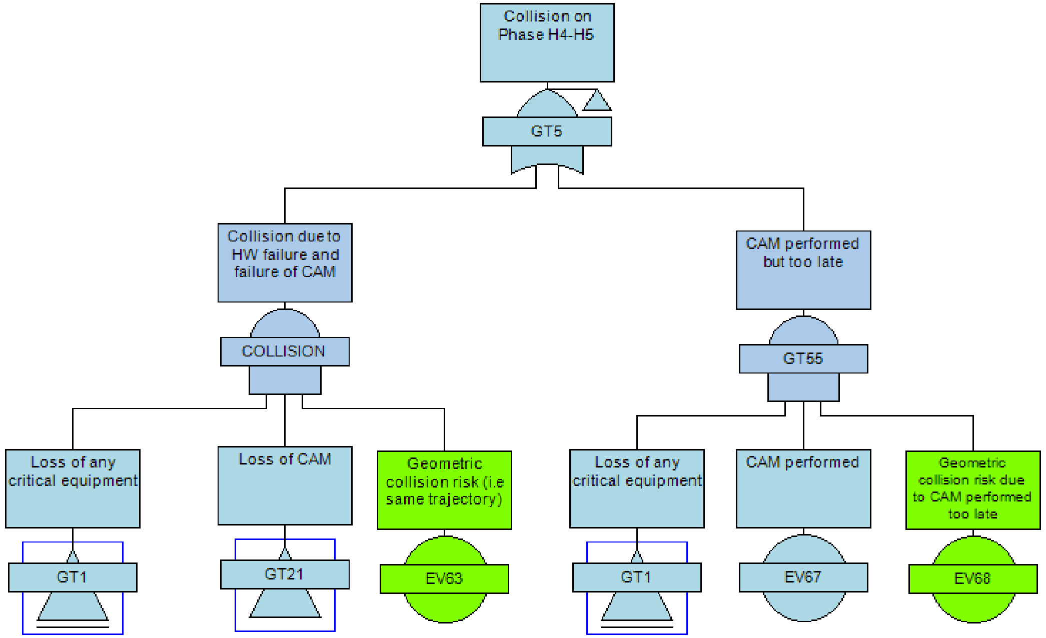
Activities performed by Thales Alenia Space in the field of Close Proximity Operations and In-Orbit Servicing:

- ✓ EU EROSS (European Robotic Orbital Support Services) study: to demonstrate approach and capture/docking capabilities with vision-based algorithms, ORU (Orbital Replacement Unit) transfer and refuelling.
- ✓ ESA Safe Rendezvous and Close Proximity Operations study: to define V&V methodology, verify and validate safety guidelines/requirements for CPO and apply these methodologies on a use case.
- ✓ ASI IOS LEO demonstrator: to perform target relocation and disposal, including providing refueling and ORU replacement, and to validate the technologies and operations necessary to assist and refurbish other satellites.

Use case - EROSS:

The probability of unintentional contact between space objects as a result of close proximity operations, or formation flying, in Earth orbit, shall be below **10^{-4}** (ESSB-ST-U-007 Issue 1 §5.3.3.4).

Collision risk assessment:



Fault Tree Analysis (FTA) conducted on the Close Rendezvous phase

Use case - IOS:

Alternative disposal approach in case of un-responsive satellite:

- ✓ In-Orbit Servicing (IOS) is an ASI project, a Low Earth Orbit demonstrator whose purpose is to validate the technologies and operations needed to assist and refurbish other satellites.
- ✓ Its development is driven by a consortium of Italian space companies.
- ✓ The IOS demonstrator will be launched containing an on-board target, whose scope is to detach from the servicer and simulate the client satellite of future applications.
- ✓ The servicer will then perform several rendezvous with the target, in both cooperative and non-cooperative (tumbling) relative approaches.
- ✓ The main objective is to be able to perform relocation and disposal of the target, while also providing refueling and ORU replacement.

New risks for a sustainable and safe space due to:

- ✓ Increase of traffic in space (large constellations), in addition to the population of debris
- ✓ New actors with no/limited experience in satellite design and mission operations
- ✓ Innovative and complex operations

↓

Need for a better coordination of space operations and common international requirements in addition to classical Space Debris Mitigation and Remediation topics

Thales Alenia Space is developing and implementing solutions to guarantee a sustainable and safe space