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Space Debris Mitigation – Implementation by DLR

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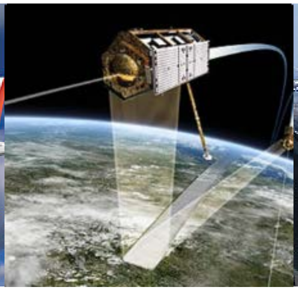
DLR

DLR - German Aerospace Center


Aerospace


Space


Transport


Energy


Space Administration

Project Administration

- Largest German research institution
- ~ 8.200 empolyees across 40 institutes and facilities at 20 sites
- Offices in Brussels, Paris, Tokyo and Washington
- Head of board: Dr. Pascale Ehrenfreund

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DLR Space Administration

- **National Space Agency Germany**
- **Preparation of German space planning** on behalf of the Federal Government
- **Representation of German space interests** in the international environment, especially with respect to ESA
- **Contracts and grants** for research and development tasks in the National Programme for Space and Innovation **–** from advice on funding decisions to technology transfer

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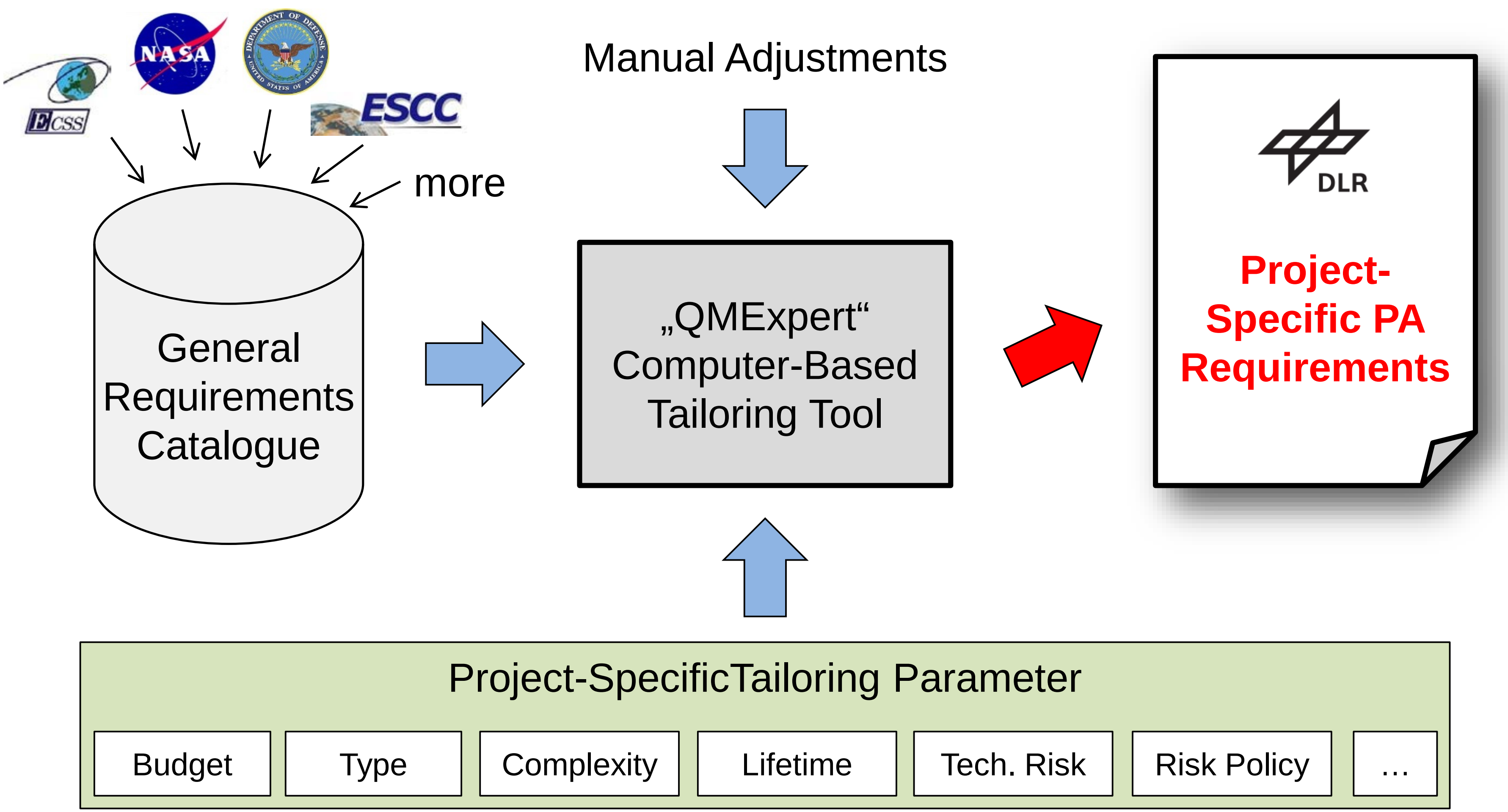
German Space Strategy – Sustainable Use of Space

- Released by the **Federal Government** in 2010
- **Foundation** for governmental space activities in Germany
- Space activities shall be consistently aligned with the **idea of sustainability**:
  - Space debris mitigation
  - Protection of space systems
  - Establishment/Evolution of national and international regulatory frameworks

Structure of the German Space Programme

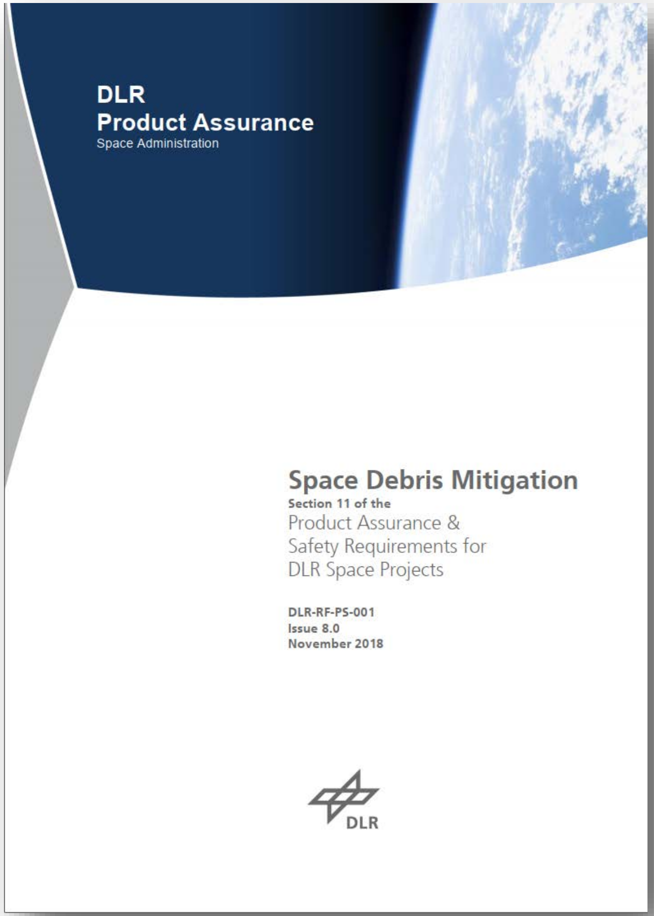
	ESA	NP	DLR	Other
	ESA programmes, EUMETSAT	National programme	DLR / Helmholtz Association (HGF) R&D programmes	EU, BMBF programmes, German Research Foundation (DFG), universities, Fraunhofer Society (FhG), HGF, Max Planck Society (MPG), public bodies, industry
Application	Communications Navigation Earth observation			
Technology	Space transport Space station Technology of space systems			
Research	Research under space conditions Space exploration			

Requirements Tailoring for Projects within National Space Programme



Space Debris Mitigation Standards for DLR Space Projects

- Established in 2009, last updated in 2018
- Requirements are consistent with **CoC** as well as with **IADC** and **UN guidelines**
- **Applicable for all space projects** within DLR National Programme
- **DLR monitors the implementation/ verification** of the requirements and decides on possible waivers



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Major Mitigation Measures Requested by DLR (1/2)

- Limiting the **generation of debris** associated with space operations
- Limiting the **probability of impact** with other objects in orbit
- Limiting the **consequences of impact** by existing orbital debris or meteoroids
- Limiting the **debris hazard posed by tether systems**
- **Depleting onboard energy** sources after completion of mission
- Limiting **orbital lifetime** of space systems after mission completion in or passing through LEO protected region

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Major Mitigation Measures Requested by DLR (2/2)

- Limiting the **human casualty** risk from space system components surviving reentry
- **Protection of human health** and life due to generated space debris
- **Transferring** a GEO space system that has completed its mission into higher orbit
- **Reducing the time** during which the orbital stage left in GTO can interfere with GEO

Space Debris Mitigation Assessment

- Each programme/project shall conduct a **formal assessment** for the potential to generate orbital debris
- The assessments shall be documented in form of **Space Debris Mitigation Assessment Reports** (SDMARs).
- Each SDMAR shall follow a defined format and include the content indicated at requirements
- The SDMARs are considered as **design documents** and are basically final when Flight Readiness Review (FRR) was carried out

Requested Project Documentation

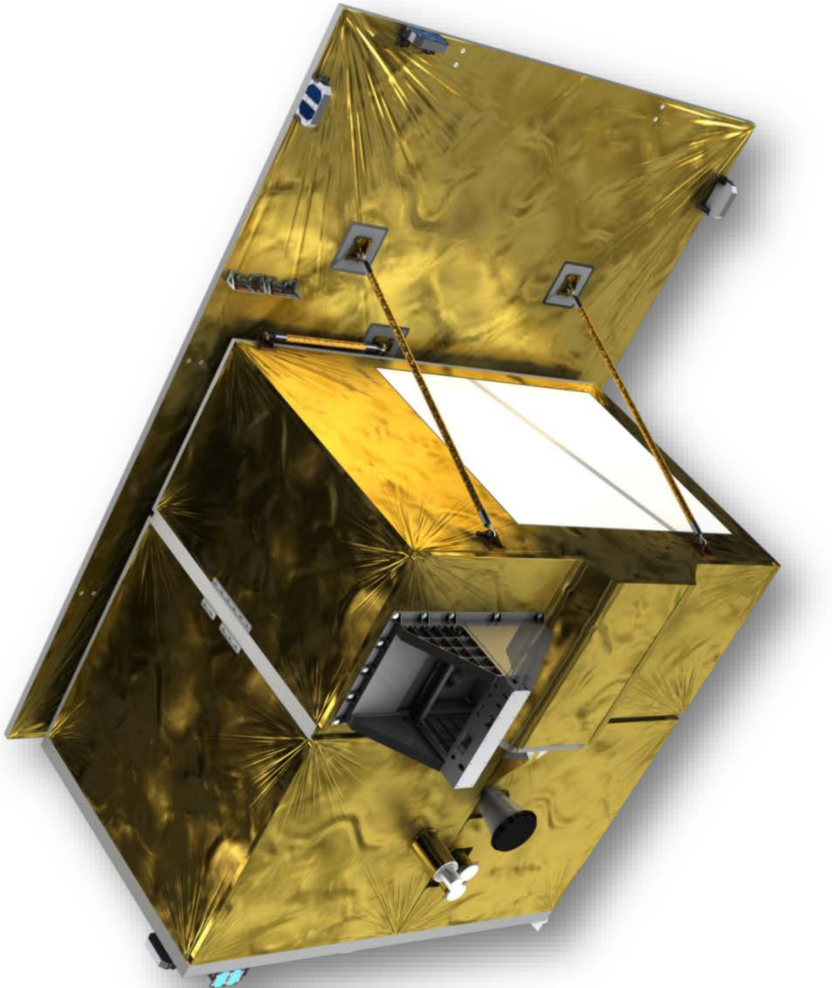
Document	Scope
SDM Declaration	Brief summary of all design measures and ops procedures relevant for limiting space debris generation
End of Mission Plan (EOMP)	Decommisioning and disposal of spacecraft including passivation, identification of milestones affecting the EOM, EOMP shall be evaluated/updated through whole mission lifetime
SDMAR-1	Debris released during normal operations
SDMAR-2	Spacecraft accidential breakups and potential for explosions
SDMAR-3	Spacecraft potential for on-orbit collisions
SDMAR-4	Spacecraft postmission disposal plans and procedures
SDMAR-5	Spacecraft re-entry hazards

Methodology and Tools

- In principle, use of state-of-the-art methods and tools is required in our space projects
- However, no specific tools are provided by DLR or required to perform e.g. residual orbital lifetime estimations after EOL or re-entry risk analyses
- The SDM documentation is reviewed at least during all major project reviews (PRR, PDR, CDR, FRR)

Example: EnMAP Earth Observation Satellite

Prime Contractor	OHB System AG
Mass	~ 1000 kg
Operational time	2020 – 2025
Orbit	Sun-synchronous, perigee altitude 634 km
Thruster for orbit maintenance	2 x 1 N, hydrazin
Spectral range	420 – 2450 nm
Spectral sampling	6.5 – 10 nm
Ground sampling	30 m
Swath width	30 km
Objective	Accurate, quantitative measurements of the state and evolution of ecosystems



The project is funded under the DLR Space Administration with resources from the German Federal Ministry for Economic Affairs and Energy (support code 50 EP 0801) and contributions from DLR, OHB System AG, and GFZ.

www.enmap.org

EnMAP Mission Characteristics and Disposal Concept

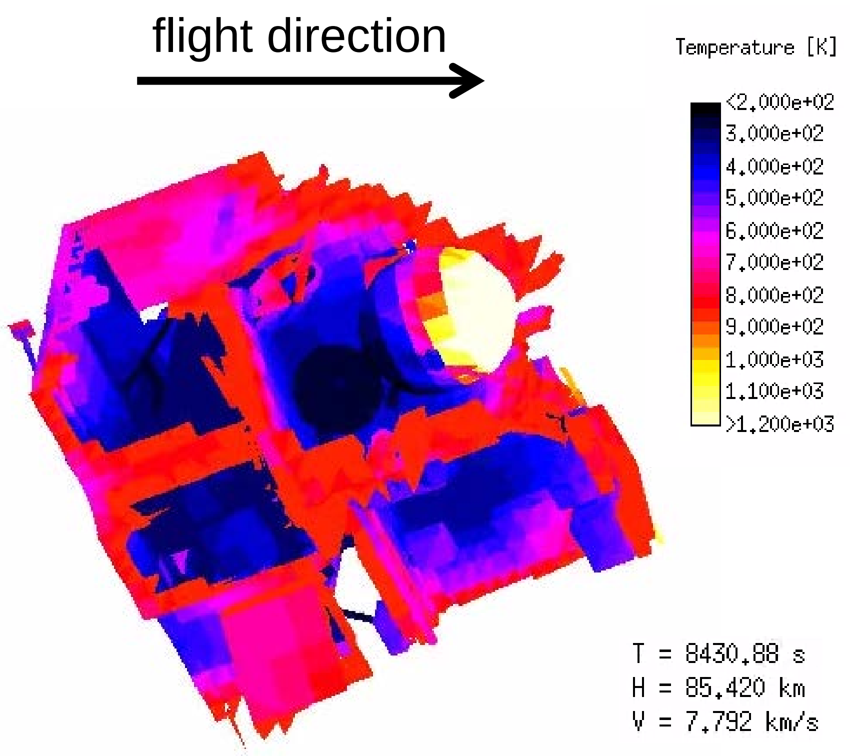
- **Launch planned in 2020**
- **Operational phase of 5 years**
- **Disposal manoeuvre** planned to lower perigee altitude to ≤ 500 km
  - ~ 1/3 of the total propellant mass will be used in this manoeuvre
- **Active collision avoidance** implemented in mission operations
  - Δv = 4 m/s of 2 kg hydrazine foreseen in propellant budget
  - Currently, budget includes an additional margin of Δv = 6 m/s
- No controlled re-entry feasible

EnMAP Collision Avoidance Analysis

- Performed 2014 by the **ESA Space Debris Office** HSO-GR
- Results:
  - The baseline for the EnMAP disposal orbit (perigee = 500km) has **enough margin for a decay within 25 years**
  - Even under conservative assumptions **EnMAP complies with collision risk propability requirements** (object > 10 cm) of < 0.001
  - **Active Collision Avoidance is necessary** with reasonable ACPL of 0.0001

EnMAP Re-Entry and Casualty Risk Analysis

- Performed 2014 by HTG Hyperschall Technologie Göttingen GmbH, Germany using the tool **SCARAB**
- 3 cases with different initial orientations analysed
- < 20 surviving fragments
- Weighted casualty area ~ 5.6 m²
- Weighted casualty risk < 1:13.400



Summary

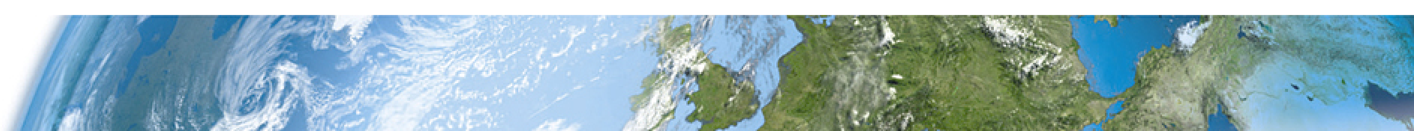
- DLR Space Administration is **principal and funding agency** for the German space programme

- German space activities shall be consistently aligned with the **idea of sustainability**

- DLR established **Space Debris Mitigation Standards** for space projects in 2009

- Each project shall create **Space Debris Mitigation Assessment Reports** (SDMARs)

- **SDMARs are reviewed by DLR during major project reviews** and are considered final after Flight Acceptance Review (FRR)



Thank you for your attention!