Technische Universität Braunschweig

Describing the Sustainability of the Space Debris Environment

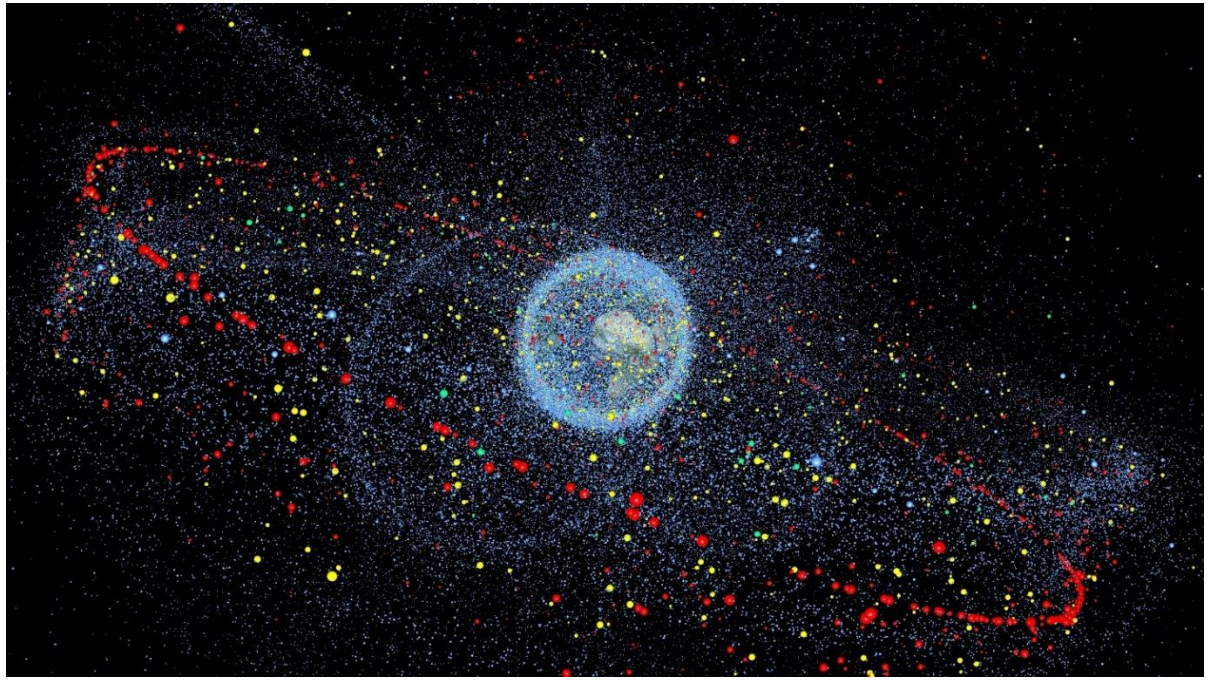
04.03.2021

Kerstin Soggeberg, Lorenz Böttcher

Institute of Space Systems

Motivation

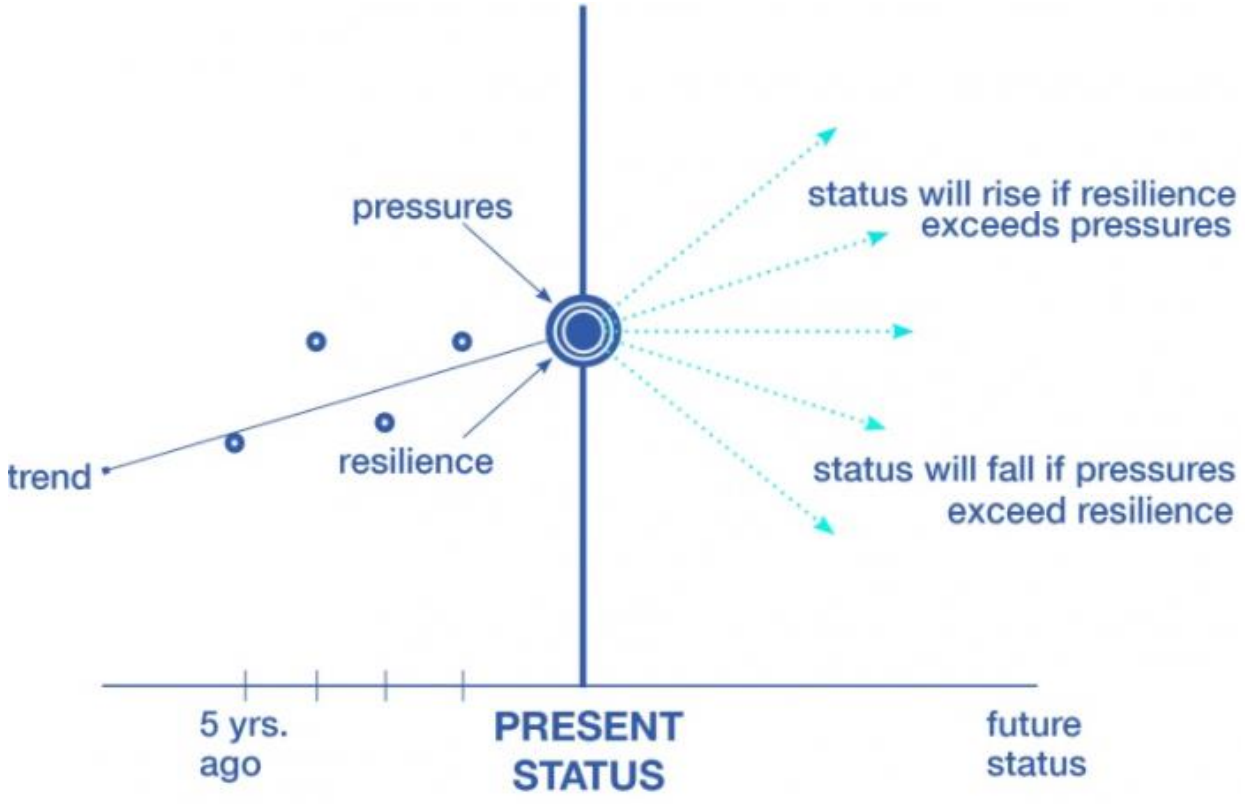
- As widely known: increasing number of objects in space
- For a reasonable discussion on „Sustainable Space“ a quantification is needed
- Already existing: many different indices to describe the space debris environment
- Possible Problems:
  - Relate to different baselines (e.g. single objects)
  - No weighting factors
  - Small number of indicators



▲ Space Debris Environment
[Source: IRAS]

Idea of the own Index

- Orientation on „Ocean Health Index“
- Includes not only present status, but also past and future status
- Built up from different Goals → easy to expand later
- Each Goal gets own weighting factor → individual emphasis possible



▲ Concept of Ocean Health Index
[Source: http://www.oceanhealthindex.org/methodology]

Idea of the own Index

$$Index = \sum \alpha_i \cdot G_i$$

Goal: Present Status (50 %) + Future Status (50 %)

- Trend (67 %)
- Pressures (16.5 %)
- Resilience (16.5 %)

Goals:
1. Spatial Density
2. Added Mass
3. Removed Mass
4. Fragmentationevents

Pressures:
1. Fragmentations
   a) Catastrophic Collisions
   b) Non-Catastrophic Collisions
   c) Explosions
2. Launches

Resilience Factors:
1. Post Mission Disposal
2. Active Debris Removal
3. Collisionavoidance
4. Passivation

Results

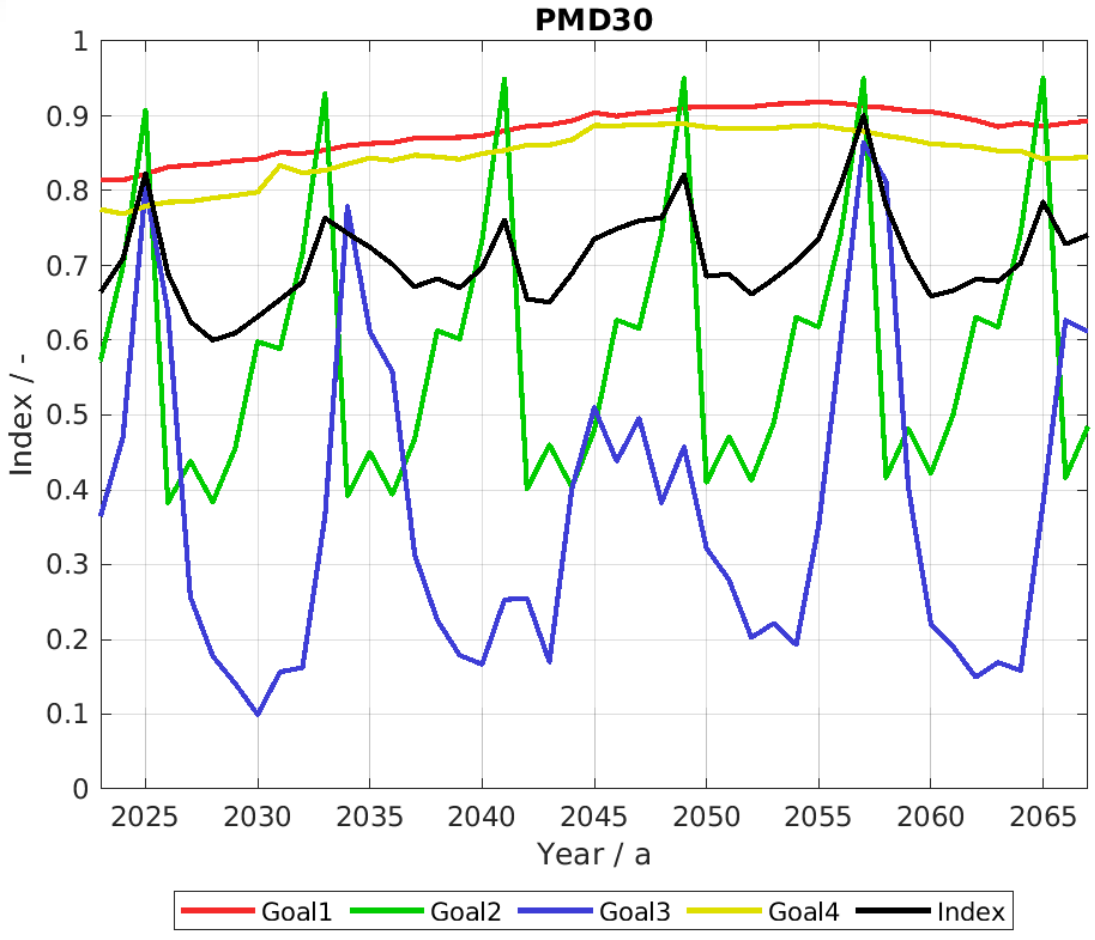
Background:

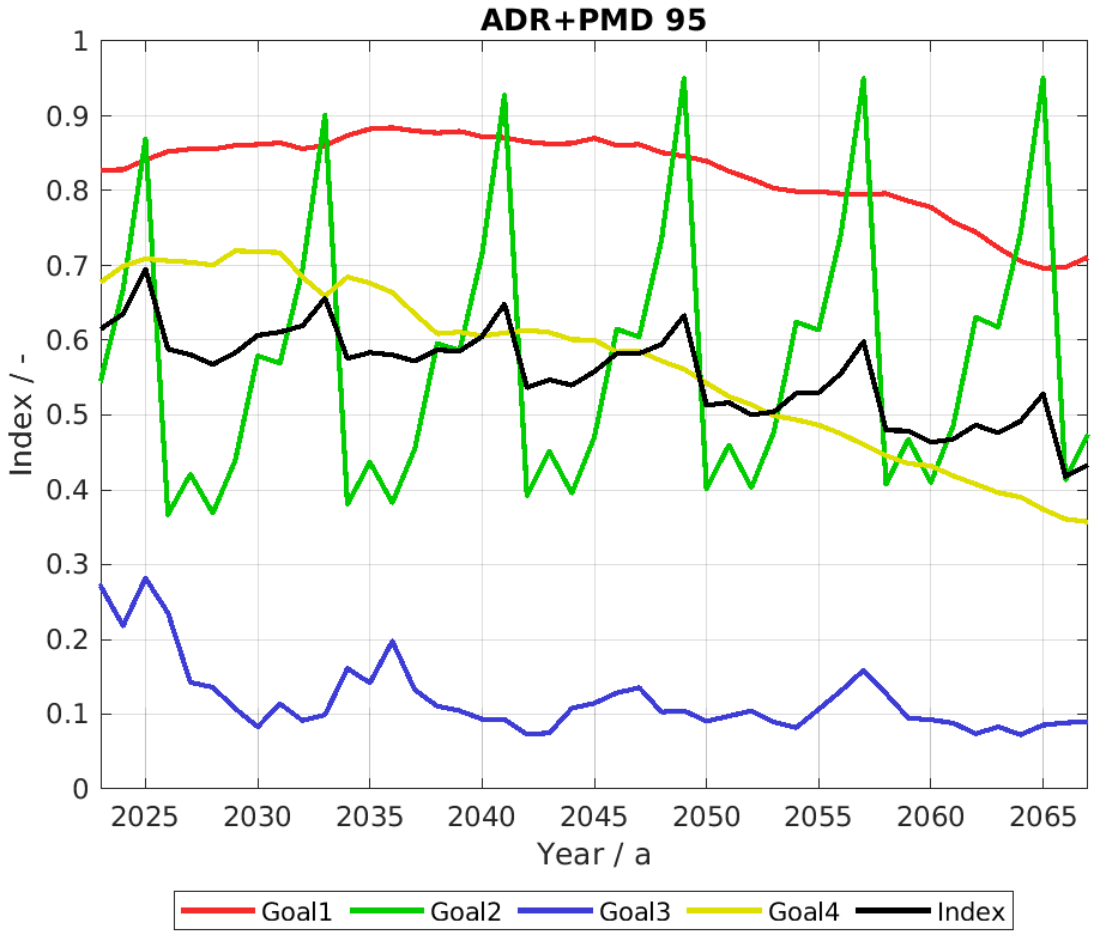
- MASTER Population from 2018
- Repeating launch-cycle from 2010 to 2017 (IADC launch-cycle)
- No explosions
- Simulation duration of 50 years
- Minimum diameter of 10 cm
- Simulation with LUCA2 (IRAS in-house tool)
- 50 Monte Carlo Runs per scenario (e.g. variation of solar activity)

Scenarios:

- Mainly variation of PMD:
  - 0 %
  - 30 %
  - 90 %
- No activity (no PMD, no ADR, no Launches)
- Best case: 95 % PMD + 10 ADR maneuvers per year + 100 % Collisionavoidance

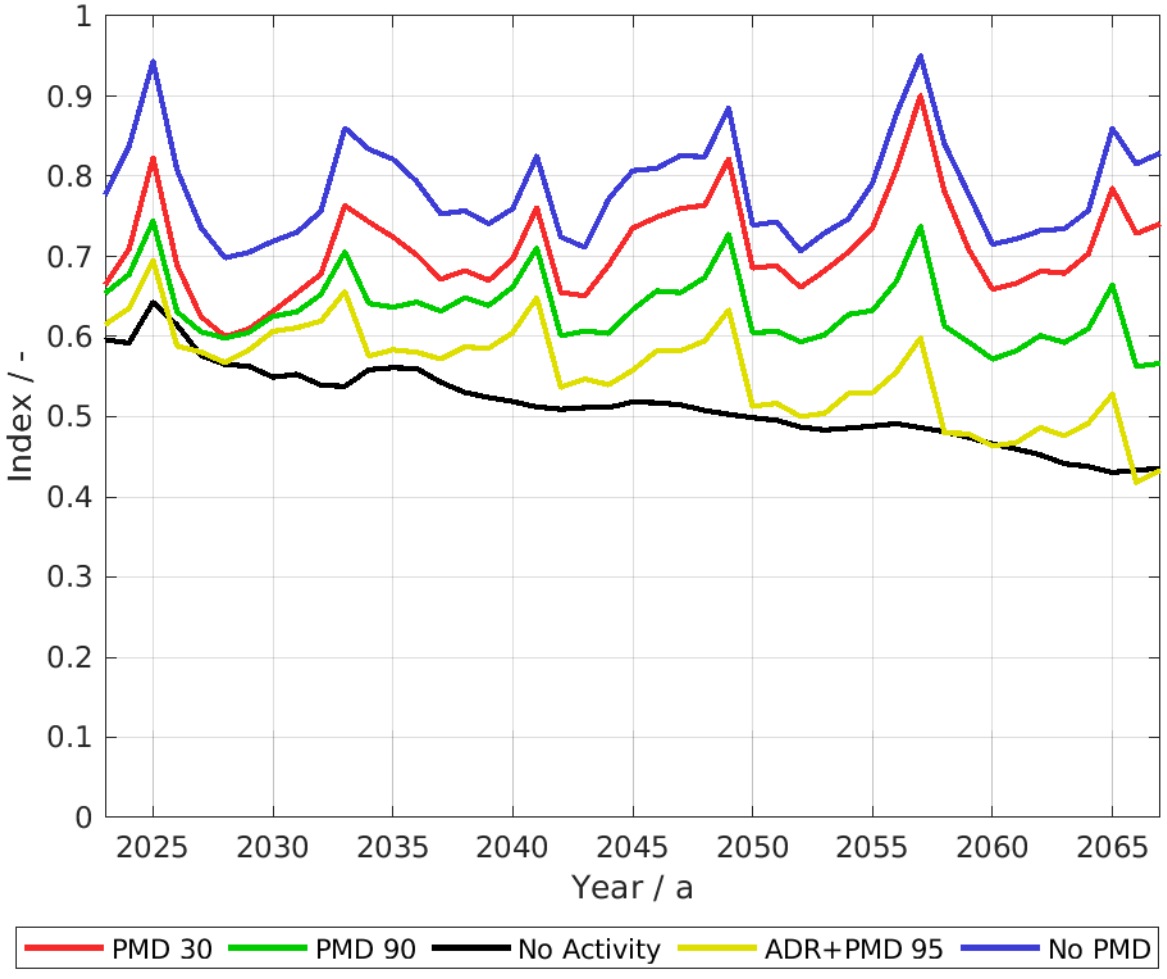
Results





Goal 1: Spatial Density | Goal 2: Added Mass | Goal 3: Removed Mass | Goal 4: Fragmentations

Results



Conclusion:

- This index could be a good way for quantification of space debris environment
- Normalized
- Scenario based (more intuitive)

Thank you for the attention!

Questions?

- This work has been supported by the German Federal Ministry for Economic Affairs and Energy within the framework of the research project “ERNA: Ermittlung von Raumfahrtszenarien für eine nachhaltige Weltraumschrottumgebung“ (50 LZ 1801).
- Project management agency was the German Aerospace Center (DLR).

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

aufgrund eines Beschlusses des Deutschen Bundestages

DLR