Sustainability in MEO and GEO

Charles Law

Sustainability in MEO and GEO

Goal

Share operational experience related to sustainability at SES, in MEO and GEO orbits

HORIZON

Where Sustainable Space
Meets Sustainable Earth

We're doing the extraordinary in space to address some of the world's most pressing sustainable development challenges, in collaboration with customers, partners, and governments.

	Responsibility	Opportunity
SUSTAINABLE SPACE Lead, collaborate, and innovate for sustainable space.	Innovate to reduce our footprint from launch to decommissioning	Advocate best practice approaches to ensuring industry-wide responsible use of space.
CLIMATE ACTION Take bold climate action by setting targets and innovating for the planet.	Reduce GHG emissions across operations and our supply chain.	Provide solutions to combat environmental challenges through satellite connectivity.
DIVERSITY & INCLUSION Make the space industry more diverse and inclusive, starting with SES.	Build a more diverse and inclusive workforce across all levels of our business.	Increase diversity and inclusion in the space industry through targeted actions and investments.
CRITICAL HUMAN NEEDS Empower communities to thrive with services to support critical human needs.	Develop partnerships and innovate to increase access to education, health, and information services.	Expand reliable access to content and connectivity to build sustainable communities.

SES

SUSTAINABLE DEVELOPMENT GOALS

Sustainability in MEO and GEO

Overview

- **Satellite and Mission Design**
- **Responsible Operations**
- **Successful Disposal**
- **Life-cycle Assessment**

Sustainability in MEO and GEO

Satellite and Mission Design

- Reliability, testing, redundancy
- Launch
  - Reuse
  - Reentry, Disposal of Rocket body
- Design considering disposal
  - Propulsion system passivation

Sustainability in MEO and GEO

Responsible Operations

- **Tracking, orbit determination**
  - **GNSS or GPS in MEO and GEO**
  - **Tone-Ranging**
  - **PaCoRa or Time difference of arrival (TDOA)**
  - **Optical measurements**
  - **Data fusing and calibration**
- **Continuous Monitoring an Orbit Determination**

Sustainability in MEO and GEO

Responsible Operations

- **Maneuver predictions**
  - **Calibration**
  - **Covariance propagation**
- **Fuel predictions**
  - **Measurement accuracy and uncertainty modelling**
  - **Thermal gauging**
  - **High Probability of Successful Disposal requires including measurement errors**

Sustainability in MEO and GEO

Disposal Altitude

- Disposal Altitude GEO
  - IADC minimum perigee altitude: 235 km + (1000 * Cr*Area/Mass)
  - Ground station visibility: Altitude vs. Drift rate
  - Long term effective Solar Radiation Pressure Area
    - 0.5 to 0.6 Full Sun Area (using 19 re-orbited satellites)
- Disposal Altitude MEO: More than 135 km above
  - O3b operational latitude: 8065 km
  - No atmospheric re-entry possible
  - Outside operational orbit more than 100 years
  - Lunar resonance, long term eccentricity growth, suitable for high MEO and high inclination

Sustainability in MEO and GEO

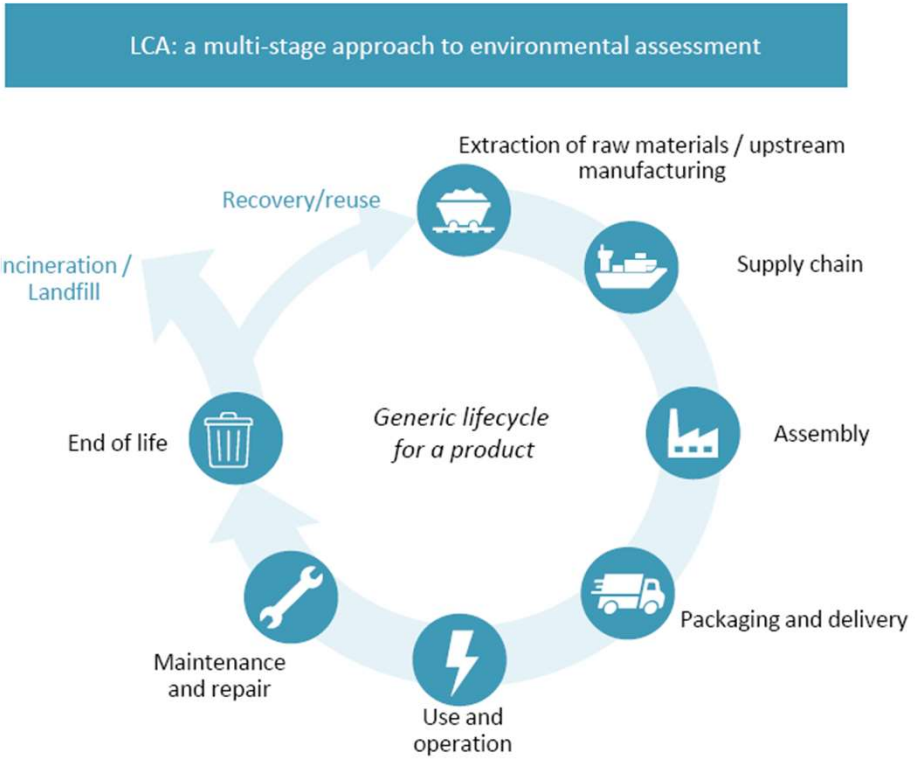
Disposal Venting and Passivation

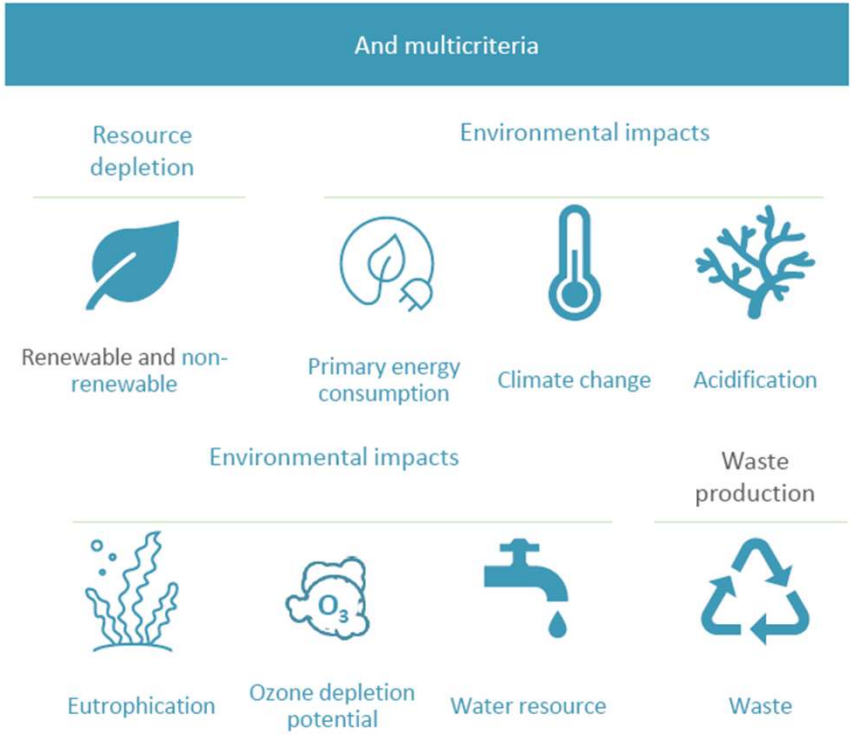
- Propellant venting effects on disposal orbit
  - Unbalanced firing directions
    - Possibly reducing perigee
  - Transition from bi-prop to single flow
    - Intermittent thrust
    - Temperature control
- Probability of successful disposal
  - Fuel end-of-life
  - Disposal when redundancy is lost. Single point failure to re-orbit

Sustainability in MEO and GEO

Life-cycle Assessment

- **Environmental Impact**





Sustainability in MEO and GEO

Let's work together to act responsibly and take care of our global neighborhood so space can continue to benefit future generations