ATOMIC OXYGEN MODELLING: ANALYSIS IMPLEMENTATION INTO SPACECRAFT DESIGN

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Background

- Density of atomic oxygen in atmosphere depends on:
  - Altitude and latitude
  - The solar activity
  - The magnetic activity,
  - Local time and season
- These data are derived from empirical atmosphere models. Most used ones are MSIS-86, MSIS-90, MSISE-00
- To assess the impact of AO on a spacecraft, the fluence of atmospheric particles is calculated
  - This fluence is the integration over time of the flux crossing the surface
  - The flux is the particle number multiplied by the average velocity
  - Erosion (cm) = fluence (atom/cm2) x Erosion yield (cm3/atom)
  - Erosion yield database is available from flight and experimental data

Modelling Atox analysis with ray-tracing (*)

OHB relies on Systema/Atomox that combines:

- The density of the atmosphere
  - Density is calculated from external models
  - The spacecraft orbit (attitude and Lattitude) is taken into account
  - Sun activity is taken into account in addition to the years of activity
- The velocity:
  - Velocity is the aerodynamic velocity vector and the thermal motion

$$\vec{v} = \vec{v}_{aero} + \vec{u}$$

  - The aerodynamic is the difference between the wind velocity and the spacecraft velocity
  - The thermal motion is the related to the density probability and the particle properties
- The spacecraft geometry:
  - The ray-tracing is used to calculate the reflexion of the Atomic Oxygen on different surface
  - This reflection depends on the spatial distribution of the Atomic Oxygen, its direction and velocity

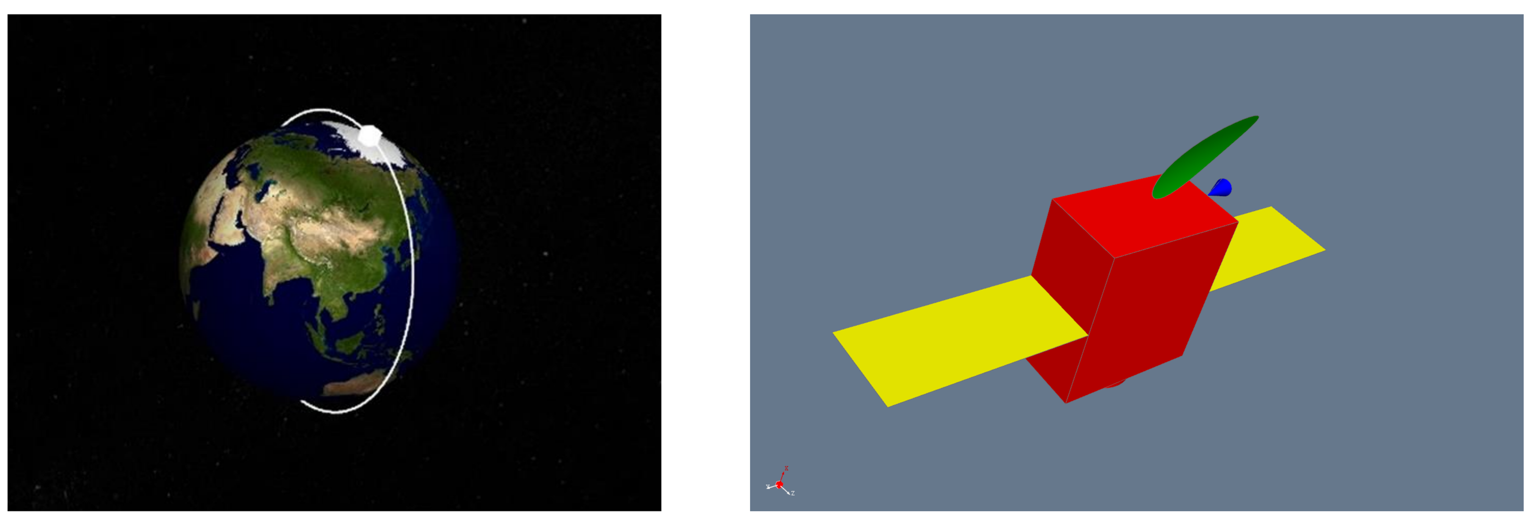


Fig. 1. Spacecraft orbit and geometry

Impact on spacecraft design

- Direct Impact

Items	Observation
Mirrors / Telescope Star trackers	Optical instrument: Transmission loss
OSR radiators	Absorptivity change
Solar array	Power Loss
MLI	Absorptivity change

- Thermal design is impacted.
  - The thermal team has to mitigate the impact of atomic oxygen
  - Update their thermal budget at EOL to see if the MLI is efficient
  - Choose MLI that is Atomic oxygen resistant
- Optical instrument design is impacted:
  - Choose a design that protect cavities
  - Assess EOL performance degradation due to mirror erosion
- Power design
  - Erosion of solar array cells need to power loss

Open questions

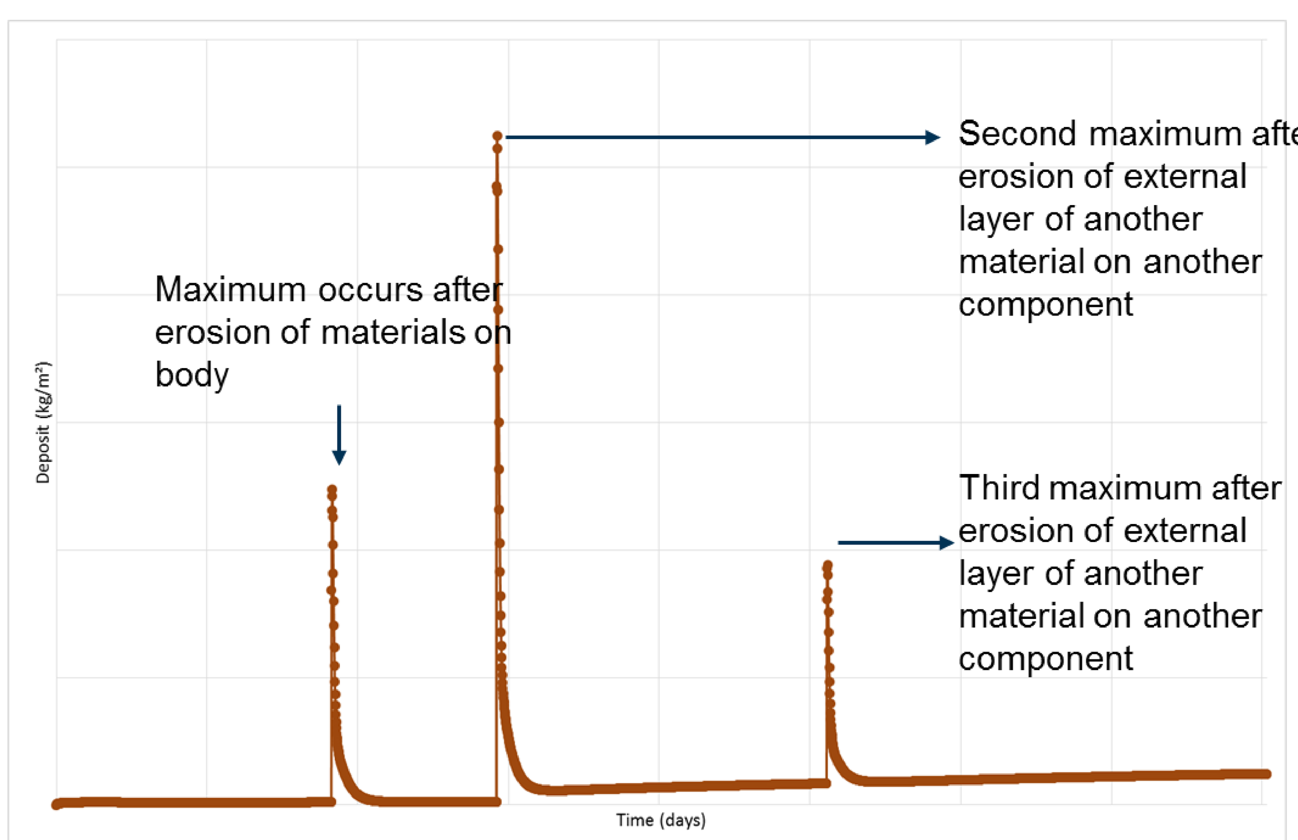
- Failure spacecraft cases due to Atomic Oxygen impingement can happen
- To avoid this, atomic oxygen analysis should be carried out during the spacecraft design.
- The physical phenomena is understood but the numerical modelling depends on the quality of the inputs.
- Erosion Yield database not existent at European level.
- Cross effects are still unknown:
  - For example: the atomic oxygen has a „cleaning effect“
    => Not completely true
  - The sputtered materials can deposit on other part of the spacecraft
    => Contamination also changes materials properties
  - Interactions between Silicone and Atomic Oxygen: merged in one layer? SiOx?
    => Atomic Oxygen is not cleaning the contamination from the silicone but merge with it
- Further synergies?
  - Atomic Oxygen + UV Radiation (?)
  - Atomic Oxygen + Plume (?)
  - Outgassing + Atomic Oxygen:
    - Proposition of modelling (see after)

Synergies with outgassing? Modelling proposition

ATOX Analysis is performed before the outgassing analysis:

- Outgassing starts when the external layer of the material is completely eroded
- Table of eroded thickness is then used as starting time of the outgassing process
- Assumption is the outgassing molecules are stuck under the external material layer
- The maximum of erosion is spotted on the nodes of the spacecraft

Object	Thickness eroded layer (cm)	Time to completely erode (years)
Solar array	5E-03	5
Star trackers baffle	3E-03	2
Body	4E-03	Never
Antenna	7E-03	3



(*): Systema/Atomox by Airbus DS Toulouse