

RECYCLING SPACE PLANT

EXECUTIVE SUMMARY

ESA Discovery Preparation and Technology Development

ESA Restricted Fixed Call for Proposals - RCP SYSTEM STUDIES FOR CIRCULAR ECONOMY IN SPACE Preparation Element of the Basic Activities

Originating from : Open Space Innovation Platform - OSIP - Campaign: System Studies for the Circular Economy in Space.

Affiliation(s): Thales Alenia Space (Prime), PROMES-CNRS (Sub)

Activity summary:

Consecutively to the OSIP – Campaign “System Studies for the Circular Economy in Space”, Thales Alenia Space proposed to develop its ideas exploring the ways to enable Design For Circularity initiative focusing on the definition of a design and concept of operations of a Recycling Space Plant involving a solar furnace for material melting.

1. Introduction

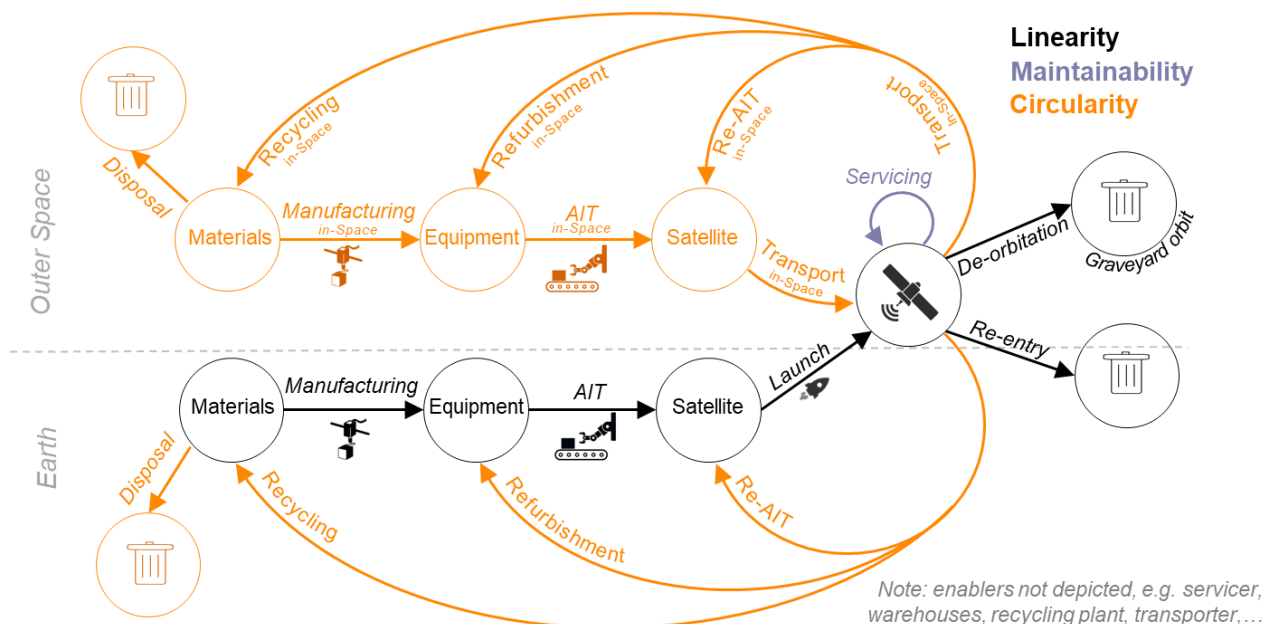
In the frame of the ESA campaign “System Studies for the Circular Economy in Space”, Thales Alenia Space proposed to develop its ideas exploring the ways to enable Design For Circularity initiative focusing on the definition of a mission design and concept of operations of a Recycling Space Plant involving a solar furnace for materials melting.

Therefore, Thales Alenia Space seized the opportunity to propose an advanced concept aiming to bring one of the key technologies to close the loop of the circularity: the orbital recycling, leading two complementary activities:

- Recycling Space Plant: to propose a preliminary design for a Recycling Space Plant system.
- Design For Circularity (D4C): to identify the materials and methods for on-orbit recycling as well as the impacts of D4C initiative in the broad space ecosystem.

2. Project Background

Thales Alenia Space has been working for more than a decade on large space systems and more recently has been involved in CleanSpace and Zero Debris initiatives. Then even if a new domain to foster, Circular Economy in Space is the logic continuation of these initiatives.



Thales Alenia Space Circular Economy preliminary vision

In this study, Thales Alenia Space is proposing an innovative idea to allow on-orbit recycling by leveraging on its experience in large space infrastructures and logistics concepts, but also on its expertise in satellites manufacturing and space debris as a future orbital resource.

The idea is to conceive a Recycling Space Plant able to process used satellites and make them new raw materials for on orbit manufacturing. Of course the state of the art is very low for this new topic and only a few concepts have been studied so far. However the Consortium's approach was pragmatic and innovative, for example by learning from ground recycling plants.

3. Methodology

The activity was led by Thales Alenia Space Observation and Science Domain in France, more specifically by the Future Satellite Systems Department. Thales Alenia Space teams have been working on large space infrastructures and on orbit manufacturing, assembly and recycling for several ESA, EC and CNES studies. It was supported by PROMES Laboratory of CNRS, which will brought its expertise in solar furnaces employment for research on materials and space applications.

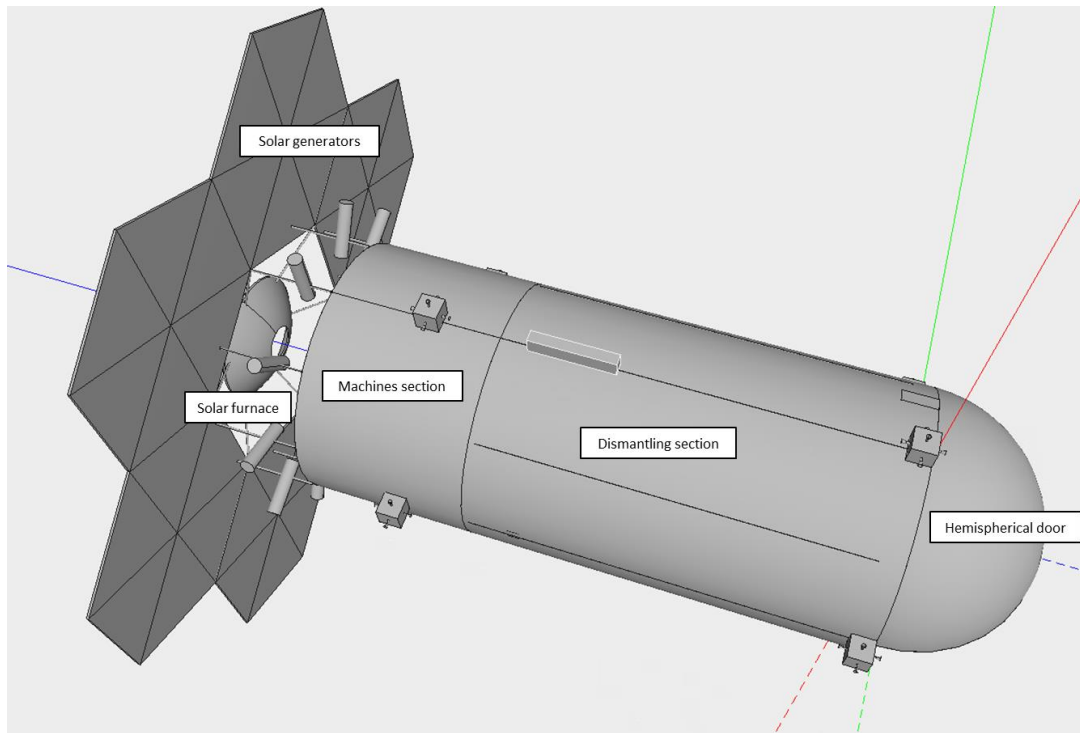
After a preliminary mission definition, an analysis of the recycling methods was led. Then were led the solar furnace and Recycling Space Plant designs activities, in parallel, allowing the RSP design to be fed by and iterate with solar furnace design. Finally the Design For Circularity analysis activities were led in parallel at the end of the study.

PROMES laboratory also led dedicated modelling and experiments with solar furnace and materials samples in order to validate the hypotheses.

4. Key Findings

The most significant findings of the activity are:

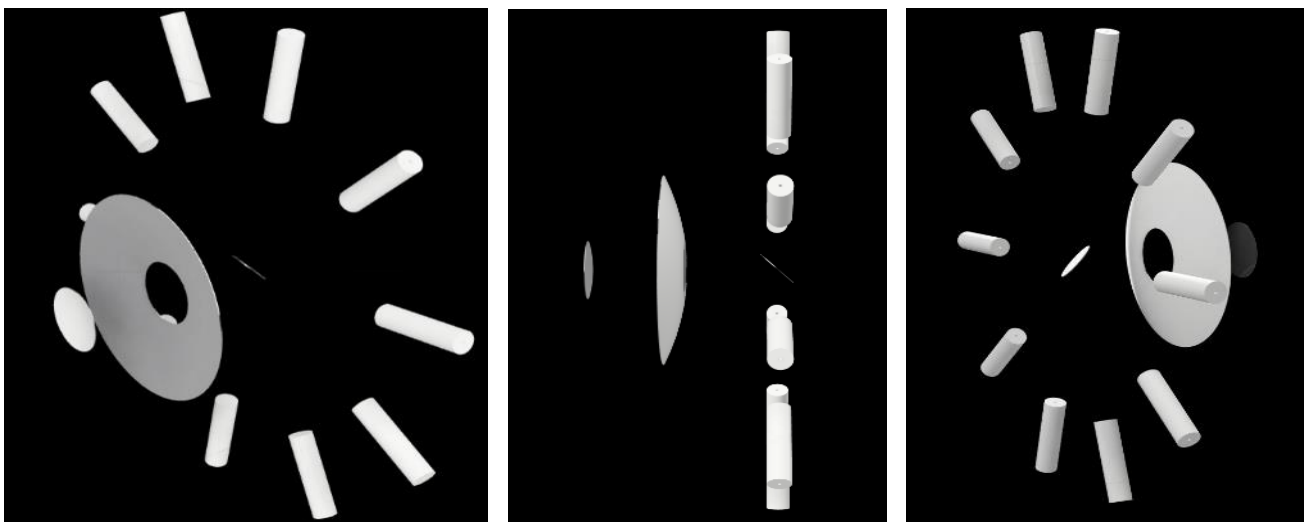
An original recycling space plant platform concept:



A self-deployable from a single Ariane 6 launch platform able to process large space debris, including upper stages, and hosting a solar furnace.

A space solar furnace design:

Composed of a solar concentrator and multiple crucibles compatible with the space environment.



Experimental validation



Validating the preliminary space solar furnace design hypotheses made, and allowing to align modelling made with thermal/fluid mechanics ANSYS Fluent software.

5. Conclusion

It was a great opportunity for Thales Alenia Space to propose and study an advanced concept of orbital recycling mission and Thales Alenia Space thanks ESA Team for proposing and managing the campaign: System Studies for the Circular Economy in Space. Innovative yet realistic orbital concept has been proposed in that frame resulting in a quite compact platform based on many technologies existing on Earth.

Moreover it was interesting to present and compare our concepts and missions with other circularity campaign's Consortiums, highlighting the fact that our mission dealing with space recycling was complementary with other concepts presented. In particular, it allowed us to identify, with Kinetik Space team, many synergies with their Robofab project. So that Thales Alenia Space and Kinetik Space project teams intend to merge their respective missions and concepts in the future steps given by ESA to this space circularity initiative.

6. Future Work

ThalesAlenia Space suggests the following next steps to develop the circular space economy:

1. Organize a CDF session together with ThalesAlenia Space and KinetikSpace Robofab consortiums, in order to merge our missions and concepts since many synergies were found.
2. Organize a 6 to 9 months pre-phase A study, in 2025 in order to consolidate the concepts of the recycling space plant
3. Start in 2026 a phase A, to demonstrate the adequacy and feasibility of the proposed architecture with respect to the specifications. During this phase, the industrial organization would be consolidated, identifying which are the technological partners to team with in order to launch parallel TRL raising initiatives through, for example ESA GSTP.
4. ThalesAlenia Space is also seeking opportunities to explore the potential of orbital recycling in a dedicated thesis by 2026.