ThalesAlenia Space
a Thales / Leonardo company

SYSTEM STUDIES FOR CIRCULAR ECONOMY IN SPACE

RECYCLING SPACE PLANT

ISAM DAYS - ESTEC

17TH OF SEPTEMBER 2025

THALES ALENIA SPACE OPEN

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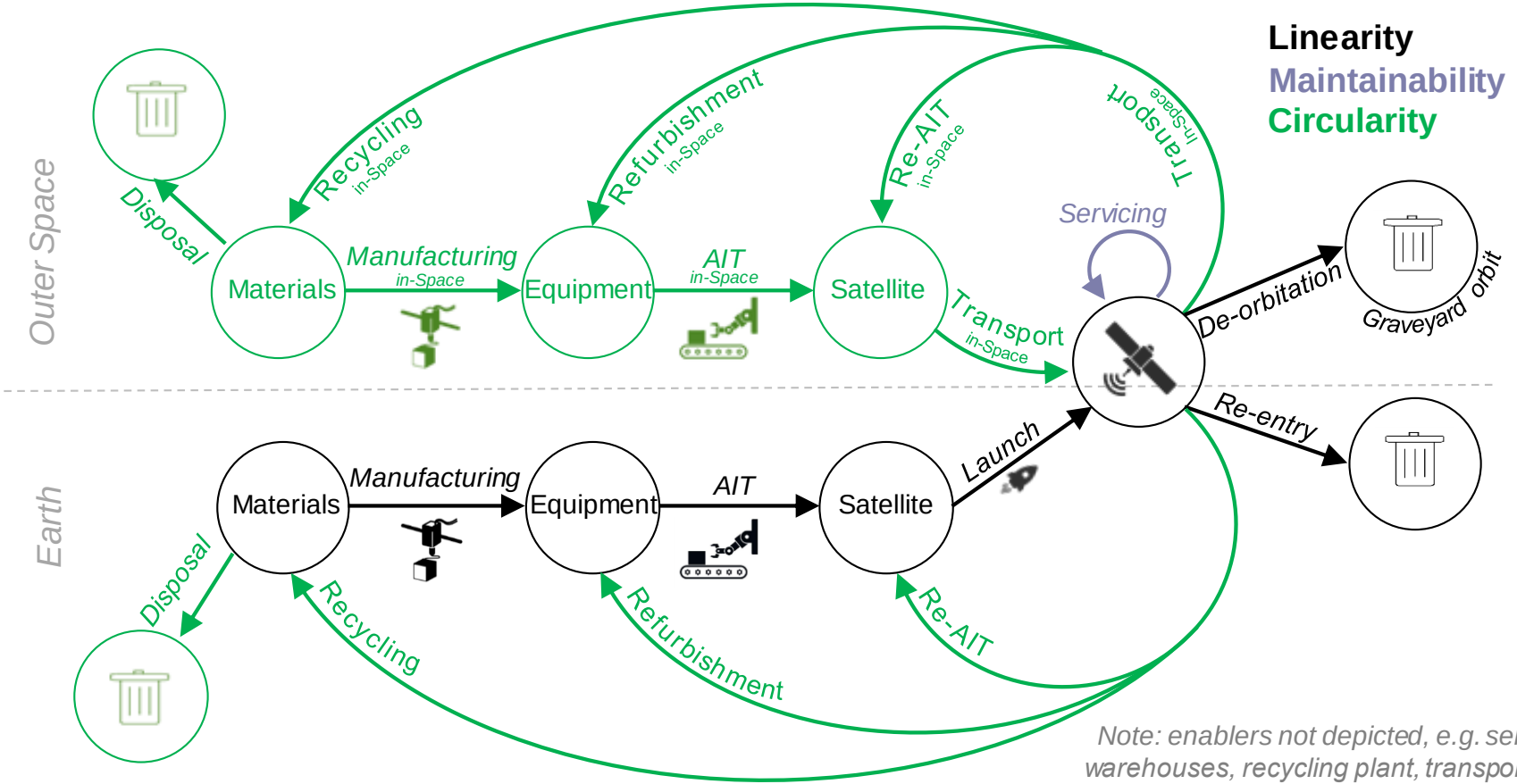
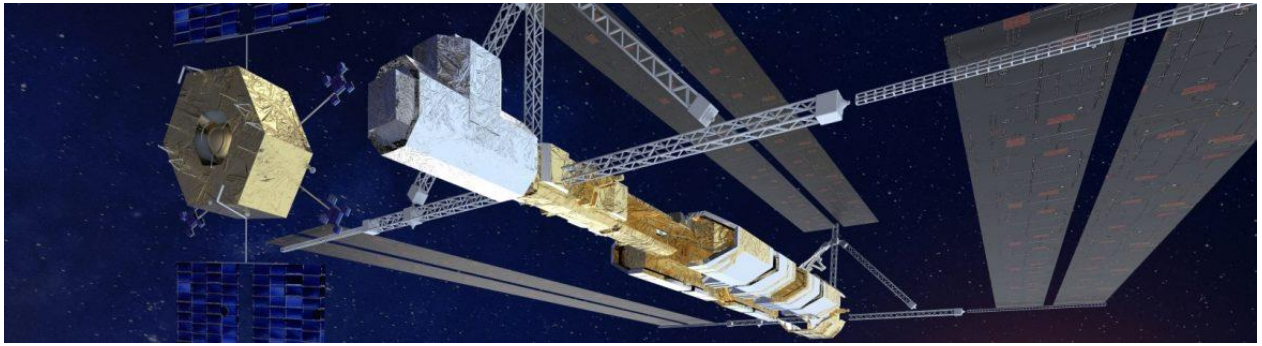
CIRCULAR ECONOMY: *A PRELIMINARY VISION*



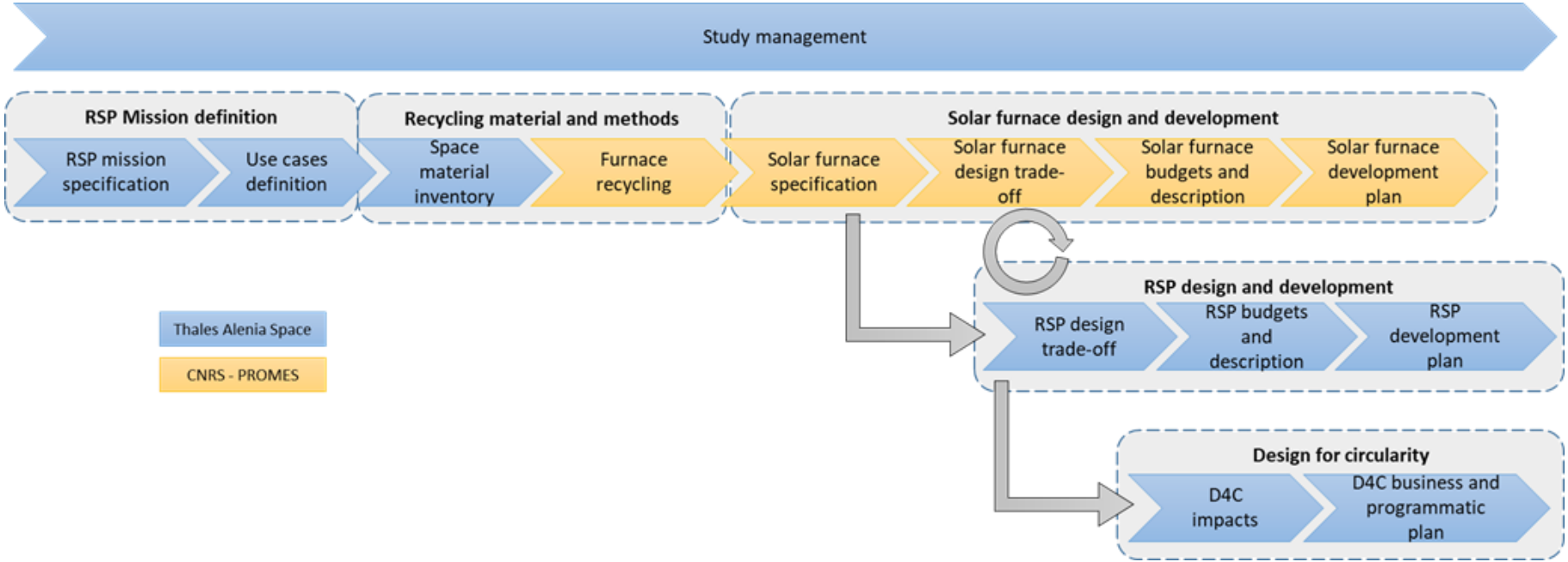
Note: enablers not depicted, e.g. servicer, warehouses, recycling plant, transporter,…

CONSORTIUM OBJECTIVES

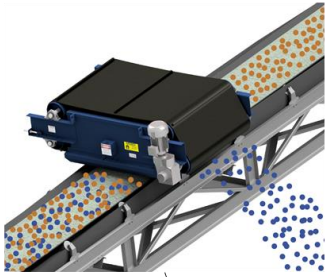


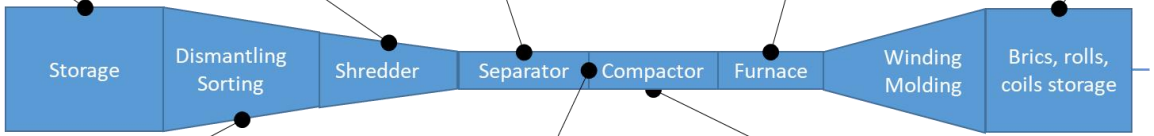
Propose a mission enabling orbital recycling capabilities to be used in a broader Design For Circularity space initiative.

WORK LOGIC

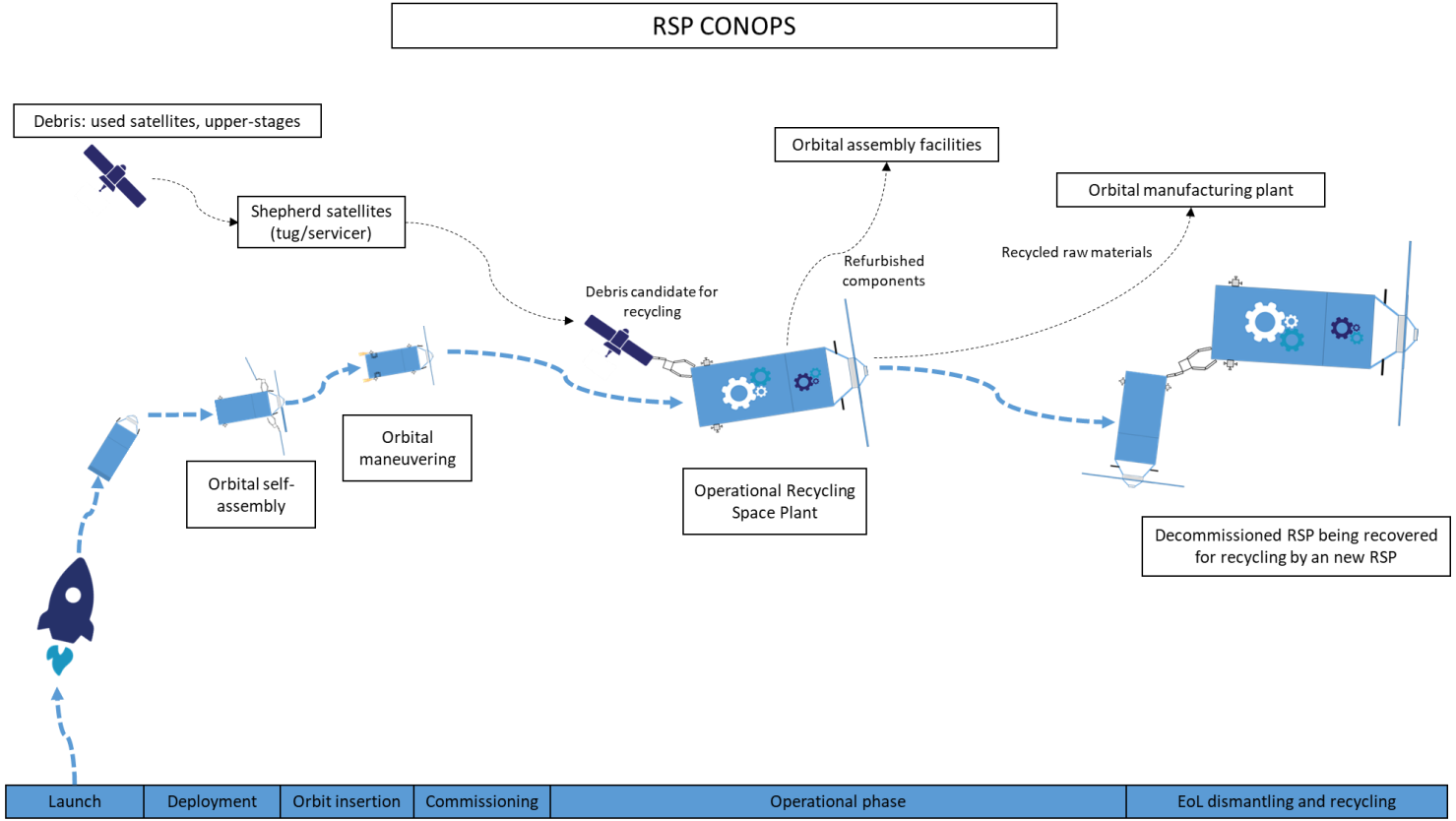


RECYCLING SPACE PLANT CONCEPT

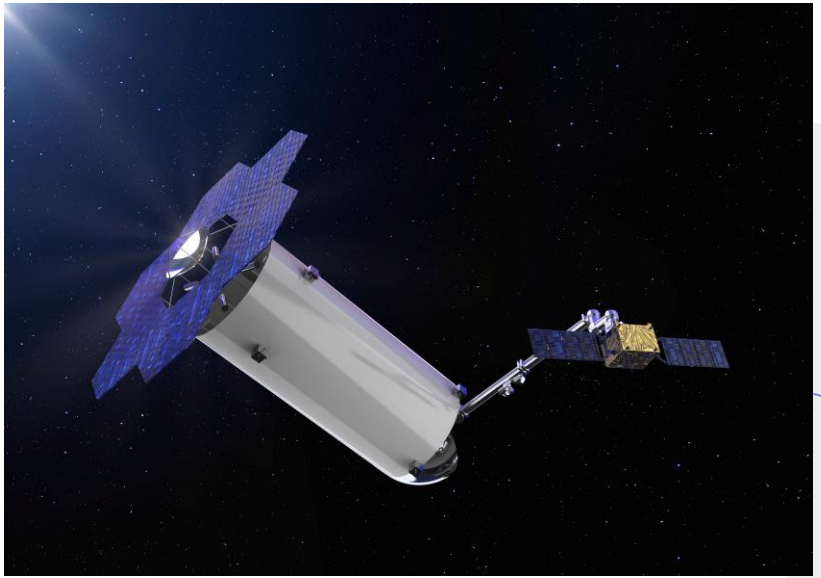


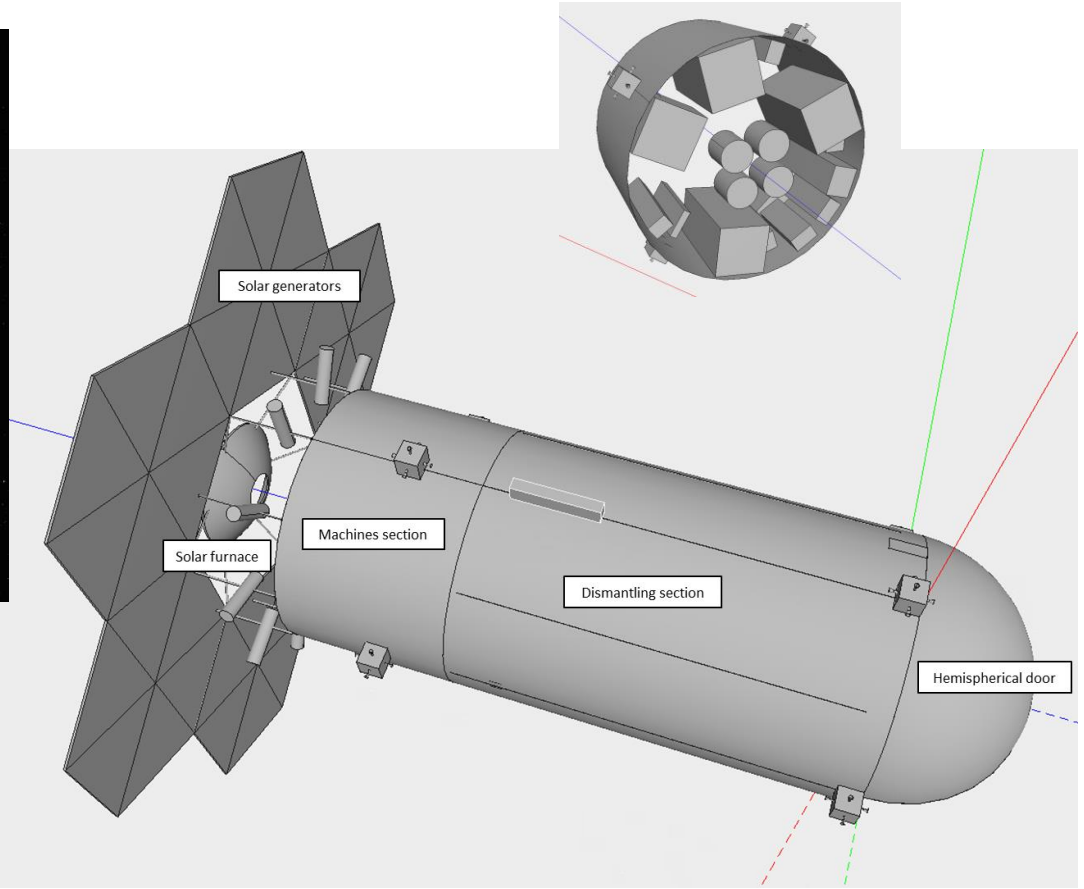


RSP CONOPS



PLATFORM DESCRIPTION





ATTITUDE & ORBIT

Orbit choice: SSO 6-18 LST @ 1400 km

- Lowest always sunny orbit
- A64 direct injection
- Sun power available permanently
- Minimizes battery needs and thermoelastics

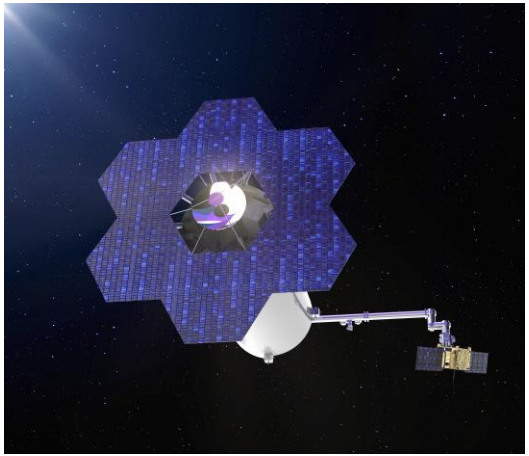
Frozen orbit

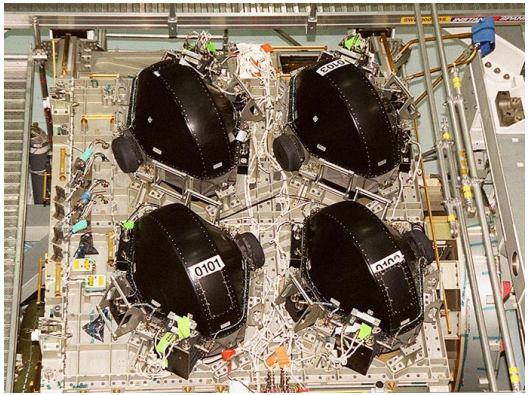
- Minimizes the orbit control
  - Small thruster pods (orbit insertion, SK and CAM)
  - Servicers and tugs boosts

Sun pointing performance required = 0.1 deg

Attitude control cascade:

- Spin stabilization
- Reaction control by 8 propulsion pods
- 4x CMG
- Vibration and shock absorbers
- Mirror stabilization





ISS CMG (NASA)

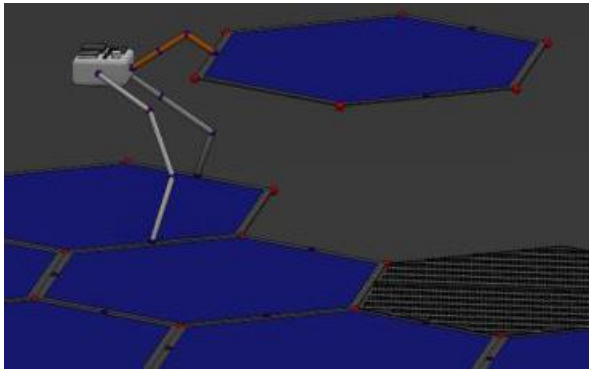
ROBOTICS

1x heavy duty robotic arm (1/2 Canadarm 2)

4x internal robotic arms

2x external walking robots

Canadarm 2 (NASA)

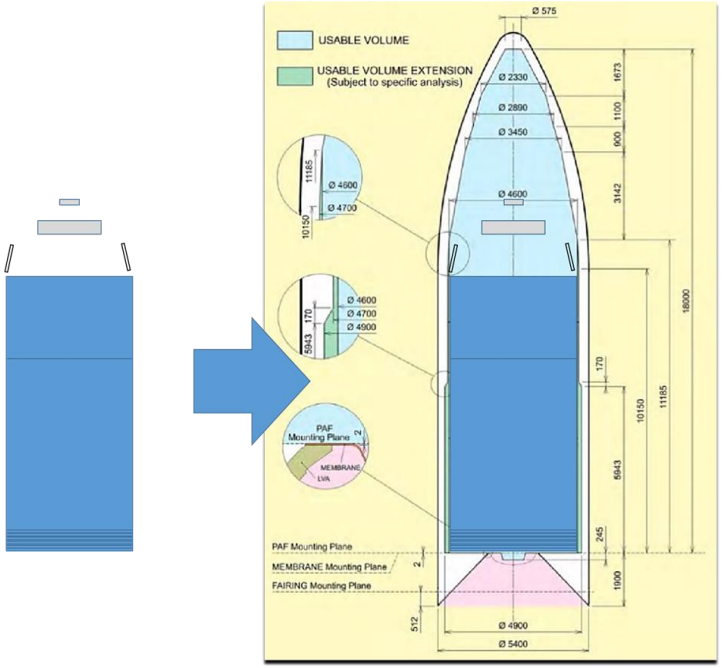


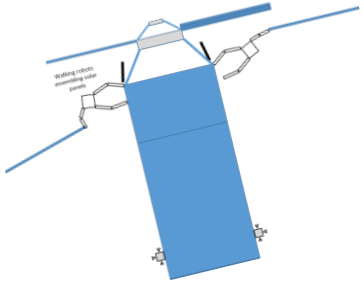
External walking robot
(ASCEND study)

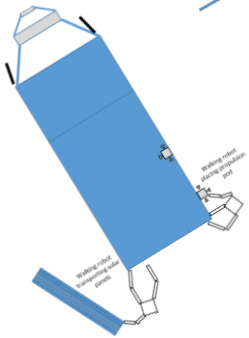
LAUNCH

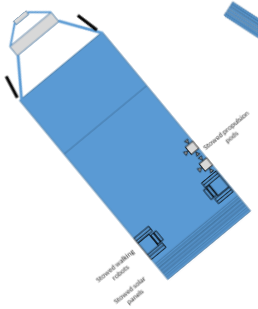
Stowed equipment inside dismantling section:

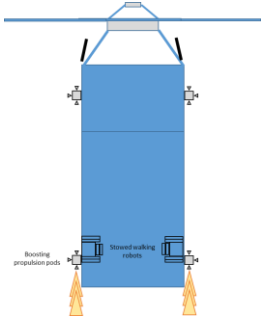
- (1+2) robots + 4x robotic arms
- 6x Hexagonal solar panels
- 8x Propulsion pods

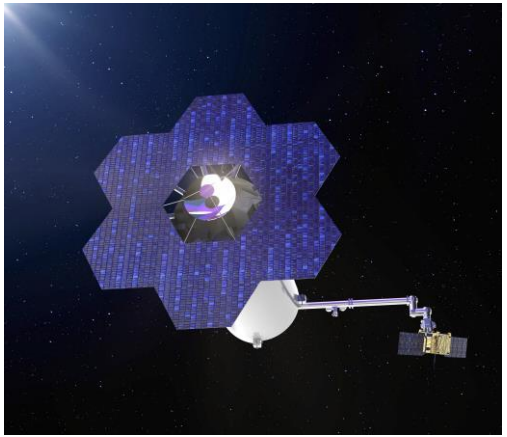




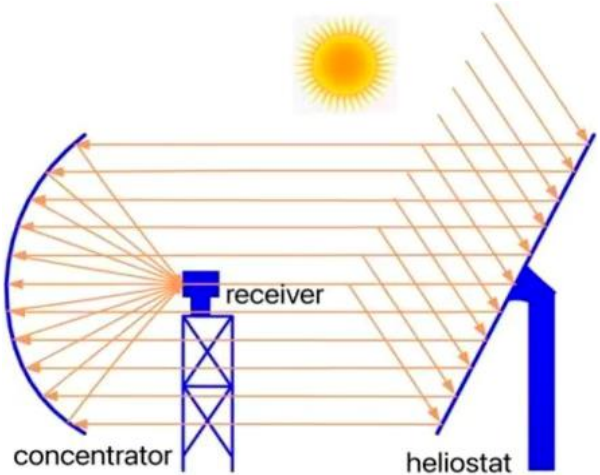








SOLAR FURNACE



MATERIALS

Targeted processing rate = 100 tons per year per RSP

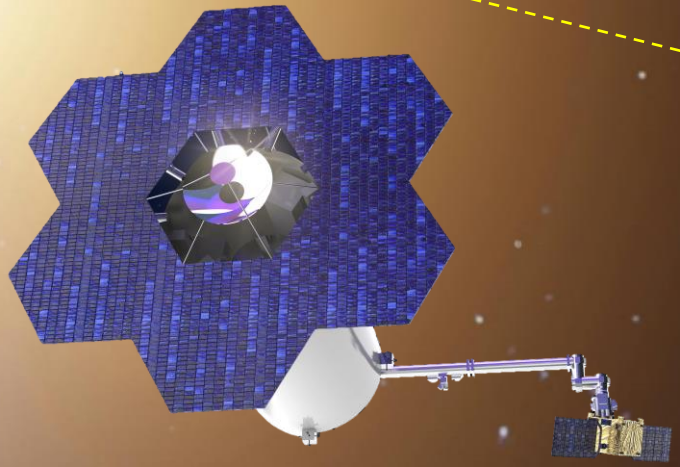
	Mass (%)	Melting point (°C)	Power needed for targeted rate (kW)
Aluminium	37,7	660	**3,36**
Copper wire	3,1	1083	**2,20**
Copper & nickel alloy	1,5	1100	**2,44**
Plated silver	0,1	962	**1,16**
Stainless steel	12,5	1420	**3,28**
Titanium	11,3	1660	**4,42**
Ti6Alv	7,7	1660	**4,17**
GaAs	0,9	1240	**1,73**
Electronic components	13,1	-	-
CFRP	5,2	-	-
Quartz	2,0	1710	**9,83**
Cobalt	0,2	1495	**2,91**
Aluminium PET film	0,9	660	**3,36**
Extruded PTFE insulation	1,3	-	-
Extruded PFA jacket	1,3	-	-
Li Ion cells	0,9	-	-
EPDM rubber	0,4	-	-
Resin	0,1	-	-

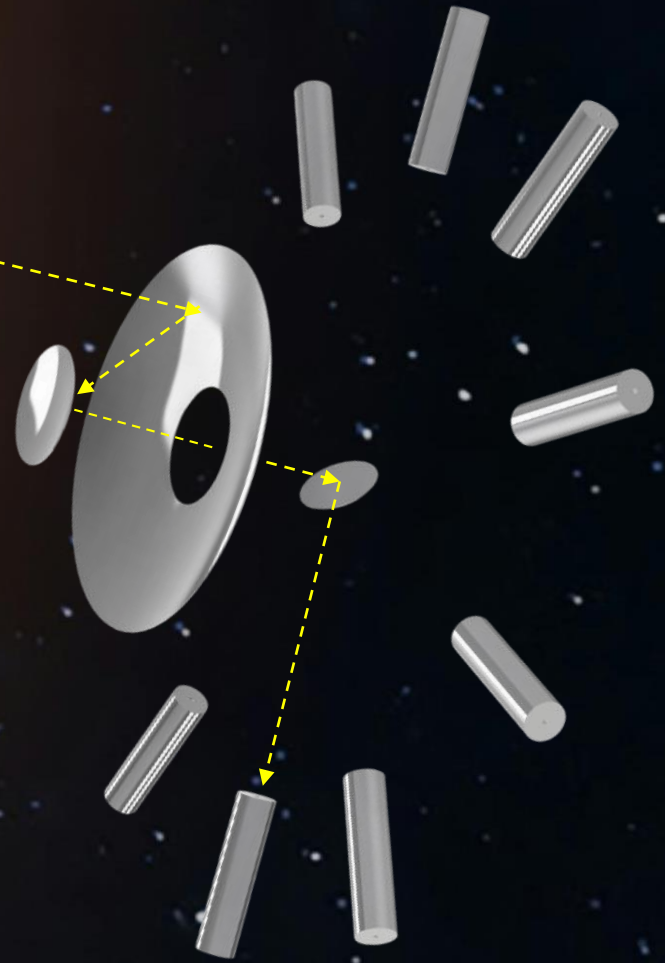
Table 1. Observation satellite's material list and mass contribution

ALUMINUM = BEST CANDIDATE

- LOW MELTING POINT (660°C)
- LOW MELTING POWER (3,36KW)
- HIGHER MASS AVAILABLE (37,7%)
- HIGH RECYCLABILITY (75% OF ALUMINUM EVER PRODUCED IS STILL IN USE)
- WELL-KNOWN AND ROBOTIZED RECYCLING PROCESS
- UNDER VACUUM TREATMENT DATA AVAILABLE

OPTICAL SYSTEM





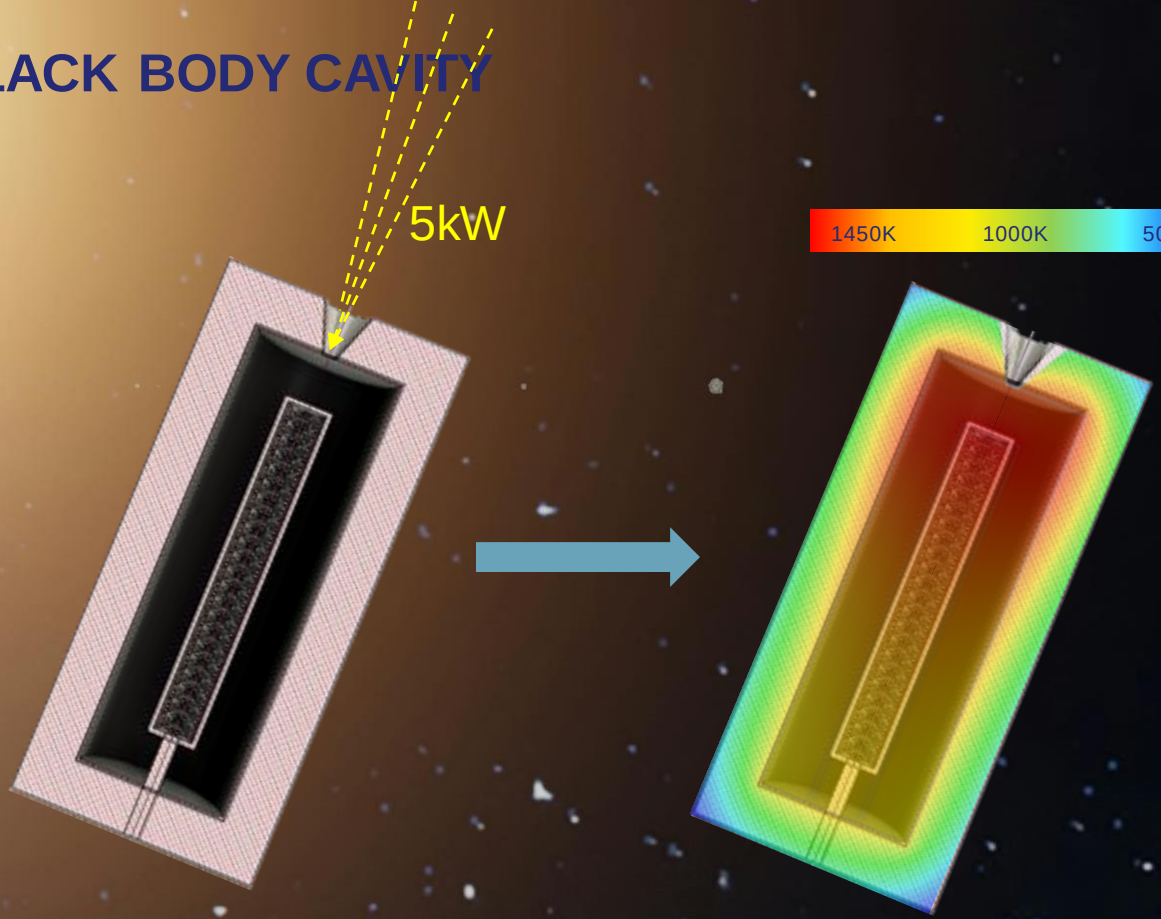
5kW at focal point

2,38m parabola

0,55m rotary reflector

5L reactors corona

BLACK BODY CAVITY

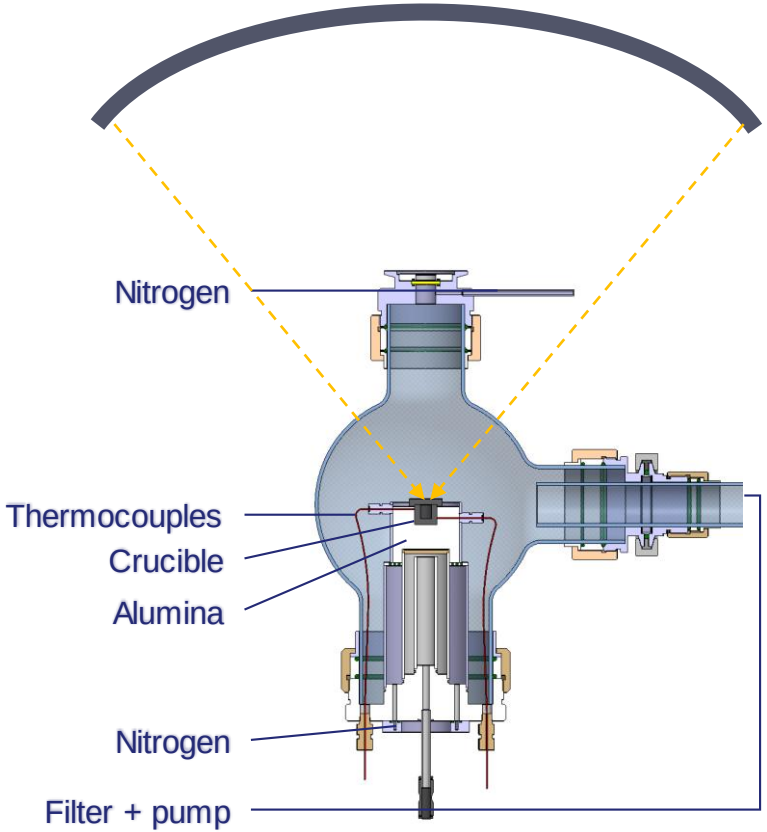


ALUMINUM

Melting point : 933K

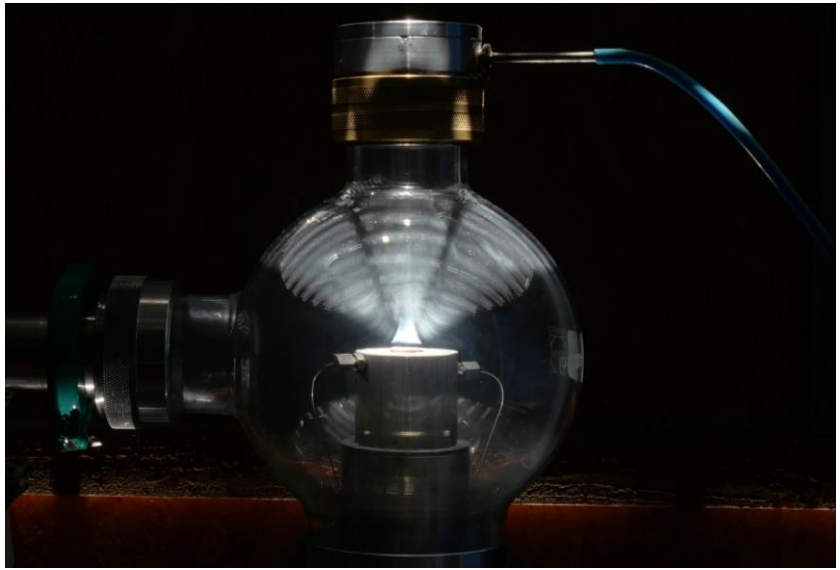
Boiling point : 1775K

EXPERIMENT

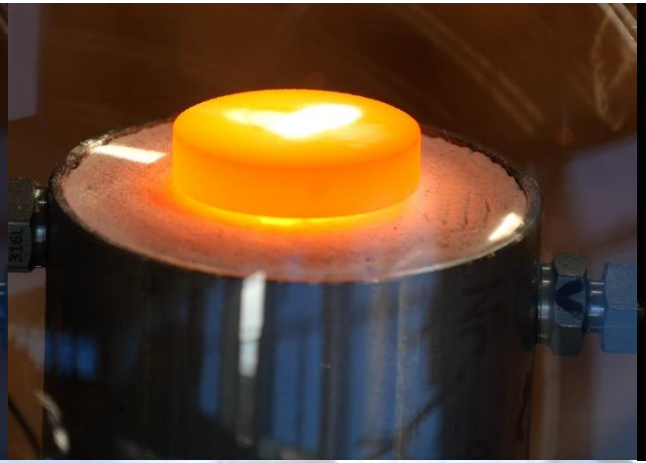


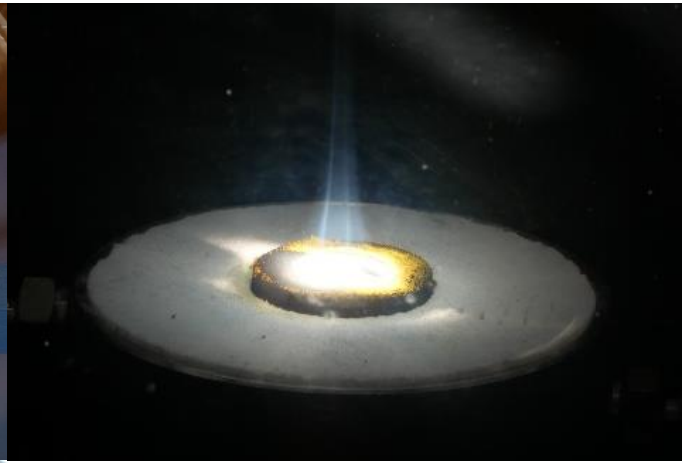
EXPERIMENTAL SETUP

- 0,1mBar pressure
- 30 n.L/h of nitrogen
- 1kW parabola
- 1cm3 graphite crucible
- 5cm alumina insulation
- 0,33-1,33g aluminum scraps



EXPERIMENT





RESULTS

- +1100°C reached with 750kW
- Direct and indirect heating success
- Oxidization (sorting and cleaning importance)
- Shape impact

CDF SESSION AT ESTEC

Phase 0 fruitful but mission too ambitious

→ Awarded a « RAPID CDF » session at ESTEC

→ ESA asked for mission descoping

→ Smaller demonstration mission

→ Each subsystem and mission aspect supported by ESA experts

→ Fast moving and very constructive experience

Results:

1.2 t S/C mission demonstrating critical technologies

CONCLUSION

Innovative yet realistic mission concept

- Platform definition and budgets
- Mission CONOPS
- Techno locks

Orbital Solar Furnace concept

- Solar Furnace definition and budgets
- Simulations and experiments

Roadmap and business plan

- Exploration of new paradigms of space circularity
- Development and business plans

Connecting opportunities

- Discussions with leading recycling and operators companies
- Cross fertilization meeting contacts

Rewarding CDF session!

- Supportive ESA CDF/experts team
- New mission ideas and perspectives