



## System impact of additive manufacturing technologies design features

### Executive Summary Report

#### ESA STUDY CONTRACT REPORT

ESA Contract No: 4000113041/14/NL/MH	SUBJECT: System impact of Additive Manufacturing	CONTRACTOR: Thales Alenia Space
NAME OF ESA STUDY MANAGER: Laurent Pambagian DIV: Component Technology and Space Materials Division, TEC-QTM DIRECTORATE: D/TEC	ESA BUDGET HEADING: ESA's General Studies Programme	

Approval evidence is kept within the documentation management system.



The latest advances in the Additive Manufacturing technologies development lead to expand the application field. It is particularly well adapted to satellite which combine complex parts and small series production. Such technique provides additional freedom for design and opportunities of number of parts reduction, functions integration and development plan shortening for example.

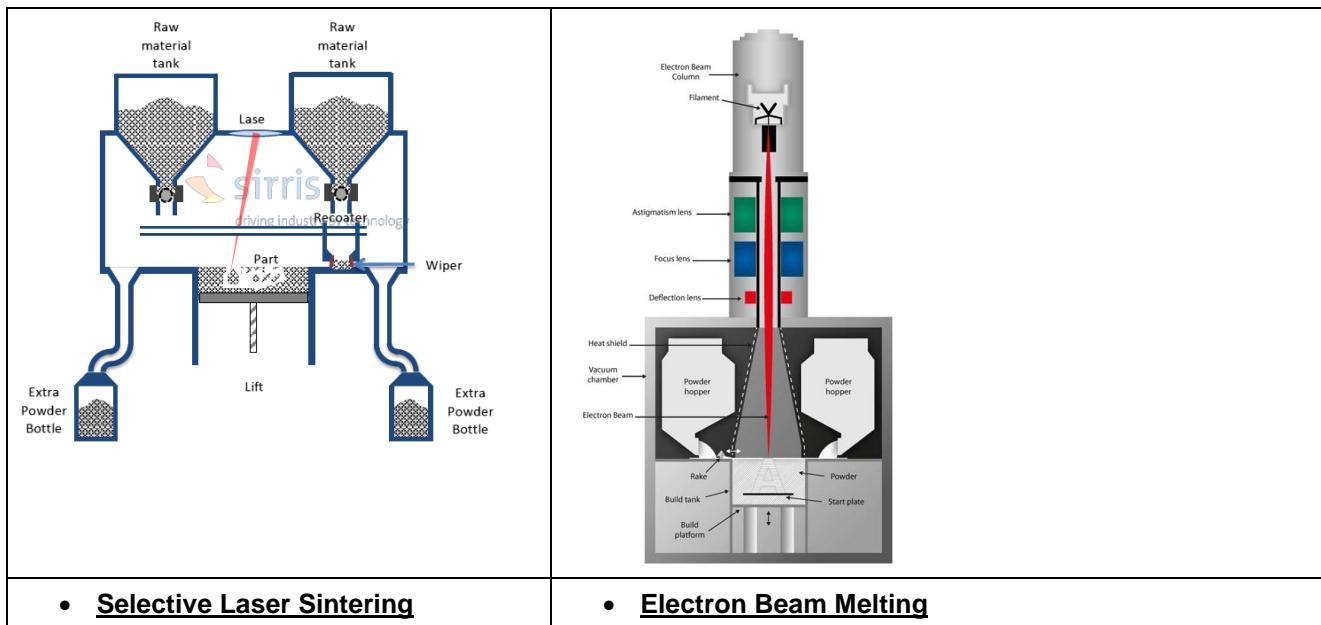
**The evaluation of the interest at satellite level was the purpose of this ESA phase 0 study “System impact of additive manufacturing”. With this initiative, ESA supports a top down analysis to interact with the on-going bottom up initiatives.**

The Thales Alenia Space consortium has shared their knowledge's and competences on the subject to propose a system approach to evaluate the interest of few applications in a multi-disciplinary innovative open-mind spirit.

The major hypothesis of the study, enforced in the SOW, was to consider AM technologies as achievable with no technical limitation (either size limitation nor TRL limitation).

In first step, high level screening of the most promising AM techniques (materials & processes) has been set with focus on material used in space programs and reflecting advantages for short term applications and put forward:

- **Titanium Alloys powder based processes**, with EBM & Laser sintering powder based process
- **Aluminium Alloys powder based processes** with Selected Laser sintering by powder based process
- **INVAR with related powder based processes**, promising for spacecraft optical applications





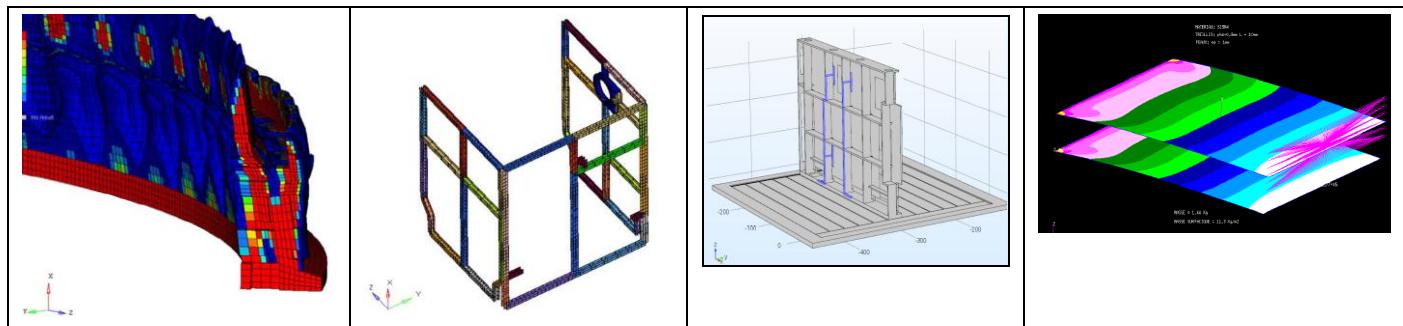
In second step, applications and equipment have been screened among 2 representative satellites with different mass, size and architecture characteristics: Sentinel 3 as typical recurrent LEO observation satellite and Euclid as specific interplanetary satellite in L2. Those two satellites have been selected to reveal potential different conclusion on AM system interest, and to offer extensive multiplicity of applications screening:

In third step, 4 applications were selected for further consideration and re-designed with AM technologies in accordance with the weighting of potential interest:

LVA Ring	structure with thermal control	PCDU	Optical bench



AM & Topologic optimization



In the last step, the re-designed solutions supported evaluation of benefits with regard to standard manufacturing process. The technical, schedule and cost elements produced will enable ESA to orientate their AM road map.

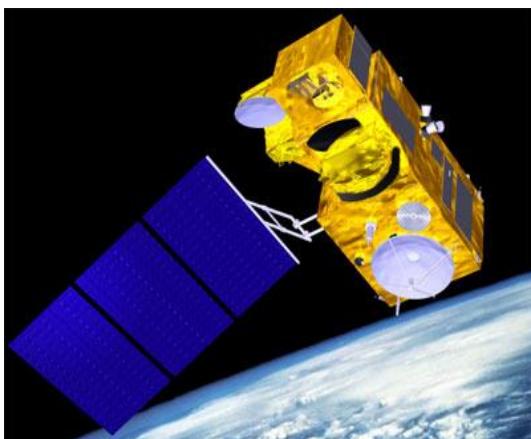
Main interests at satellite system level are identified:

- decrease of satellite dry mass, and consequently on launch mass thanks to snow ball effect
- significant improvement of lead time
- improvement to Space Debris Mitigation policy



- merging of functions with for example structure with embedded thermal
- improvement of integration time with possibility to manufacture several pieces in one piece

Evaluation is done for the 2 candidate satellites:



**Sentinel 3- like satellite**

- ➊ Total launch mass reduction is valued in the range of 4% to 7% .
- ➋ Satellite schedule duration slight improvement, not significant for a recurring satellite.

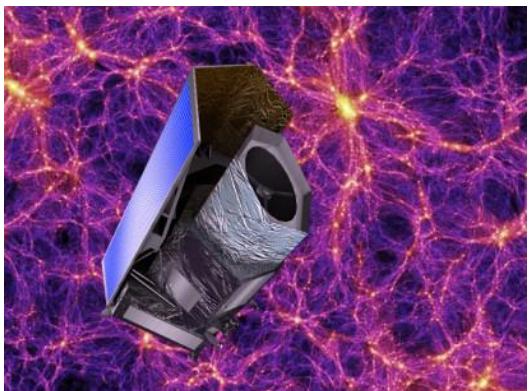
Typical LEO Satellite schedule is driven by avionics and payload. Additive Manufacturing allows to start some applications manufacturing later in the process with a consolidated satellite design wrt standard manufacturing process.

- ➌ Cost improvement is linked to risk diminution, integration process optimization and mainly derivative effect of mass reduction, through potential launcher range change.

For identical launcher capacity, satellite mass reduction allows to embark additional payload offering a higher mission cost efficiency.

Additive Manufacturing supports Space Debris Mitigation policy conformance improvement through two directions: reduction of surviving pieces and promotion of external panels separation earliest in the re-entry process.

- ➍ Application on small parts as supports is already on-going and under study for Sentinel future generation. Going forward would request higher TRL and consolidation of qualification approach.



**Euclid-like satellite**

- ➊ Total platform mass reduction is estimated up to 11%.
- ➋ No Satellite schedule duration improvement is identified, as critical path is presently payload development and electronics equipment.

For a future PFM satellite, Structural Thermal Model anticipation in early phase, taking benefit of Additive Manufacturing, is a promising axis to consolidate CDR design and to reduce risks.

- ➌ Cost improvement remains below 2% without taking into account any launcher adaptation.

Additive Manufacturing needs to be considered at preliminary design phase (A/B1) to take benefit of all design freedom capacities, which specially fits to one "single shot" scientific satellite.

- ➍ Some brackets have been identified as possible parts to be manufactured in ALM. Other applications require additional development time not in line with Euclid flight implementation.