CONTRACT No. 21231/07/NL/CB

(Combined) Telecommunication and Earth Observation Mission options offered by Small Hall Effect Thrusters Propulsion

Abstract

The increasing number of European Earth Observation (EO) and Telecommunications programmes and missions has brought to the fore the need for an assessment of innovative concepts and technologies to cope with the requirements of LEO and GEO mission scenarios. To address this emerging need, ESA General Studies Programme funded a study on "**Combined Telecommunication and Earth Observation Mission driven Option For Small Hall Effect Thrusters (HET) Propulsion**" (ITT AO/1-5439/07/NL/HE, Ref. 1), which was awarded to Alta (Italy) and its subcontractors Deimos (Spain) and Snecma (France) at the beginning of 2008.

The main goal of the project was to identify the small-HET system concept suitable for the two most important applications for the European market in a medium term scenario: Earth Observation, Ref. 2, and small Telecommunication Platforms, Ref. 3. Possibly the system should also be applicable to the secondary scenarios of Science missions, Ref. 6-Ref.8, and University Satellites (microsatellites, Ref. 4, Ref. 5). The preliminary design of such a concept was also required.

As first task Deimos carried out a critical analysis of the mission requirements on the basis of past studies of the scenarios of interest, taking also considerable advantage of its participation to the ESA program on EP applications to the Remote Sensing. The primary output expected from Deimos activity was a matrix of small-HET systems performance requirements for the different mission classes.

In the meanwhile Alta carried out a review of worldwide existing HET technologies in the power range of interest (<1 kW) and provided ESA with a database file, collecting performance and dimensioning data for any identified thruster model. Alta also elaborated the "**Low Power Hall Thruster Simulator"** performance model and the corresponding numerical algorithm for thruster's performance prediction, comprising the lifetime. Model was validated with database.

Mission requirements were then cross-checked with thrusters' performance in order to identify for each scenario the suitable small-HET system options. At this purpose, Alta used the performance model for identifying such concepts, in terms of number of thruster units, discharge power, thrust level, total impulse. For each of the identified systems, Snecma carried out the conceptual design, on the basis of preliminary inputs about thruster characteristics such as number of thruster coils (except for all-permanents designs), operational discharge voltages and currents and cathode operation parameters (mass flow rate, power budgets). Another main input was the redundancy approach, which however is strongly dependent on the specific mission and could not be determined a priori. Then different solutions with respect to redundancy approach were presented. Main outputs from conceptual design were mass and power budgets, complexity (in terms of number of different component types) and cost level estimation for the gas feeding system and the Power Processing Unit.

A that point a trade off analysis was required among the different system concepts. The main aspects to take into account were:

- Multi-mission compatibility
- System complexity and cost estimates
- Heritage and perceived development risks

At the end of the trade-off and according to the Agency, it was possible to select a unique system for being further developed during the last phase of the project. The selected system consisted in a cluster of 1+

1(redundant) **HT400** thruster, having a nominal discharge power of 400 W. Such a system resulted suitable for drag compensation in EO missions with duration up to 5 years, S/C mass up to 1500 kg and orbit altitude as low as 450 km and for orbit control and additional maneuvers (orbit acquisition, repositioning, EOL disposal) in small telecoms up to 500 kg and operating life up to 15 years. In case of more demanding mission requirements, systems conceived for operating two or more thruster units in series or in parallel can be taken in consideration, with some penalization in system mass budget and complexity.

In the last phase of the project, the preliminary design of the selected HT400 thruster was carried out by Alta. It was decided to orient the design towards a solution for maximizing the versatility of the thruster in terms of operating power; this was recognized to potentially enlarge the range of applications and by consequence to decrease the development costs per mission. The operating and performance range of the conceived thruster was specified, as requested by ESA for mission study purposes:

Parameter	Min.	Nom.	Max.
Power, *W*	250	400	600
Thrust, *mN*	17	27	42
Specific impulse, *s*	770	1020	1250
Specific power, *W/mN*	15		
Total impulse, *Ns*	>2e5		
Weight, *kg*	2		

On the subsystem side, Snecma was required to study the general architecture of the propellant feeding system (tank excluded) and of the Power Processing Unit and to specify their requirements for future design activities. At the end, Snecma work went beyond: at least for the feeding system a preliminary design was elaborated. It is worth to note that both feeding system and Power Processing Unit had been conceived for potential operation at any point of the thruster envelope, in order to enlarge the versatility and then the multi-mission applicability to the entire system.

A development plan with ROM costs for the entire system was also provided at the end of the study. The technical outputs of this activity shall represent the starting point of successive ESA programs aiming to further develop the thruster unit and its subsystems.

Reference

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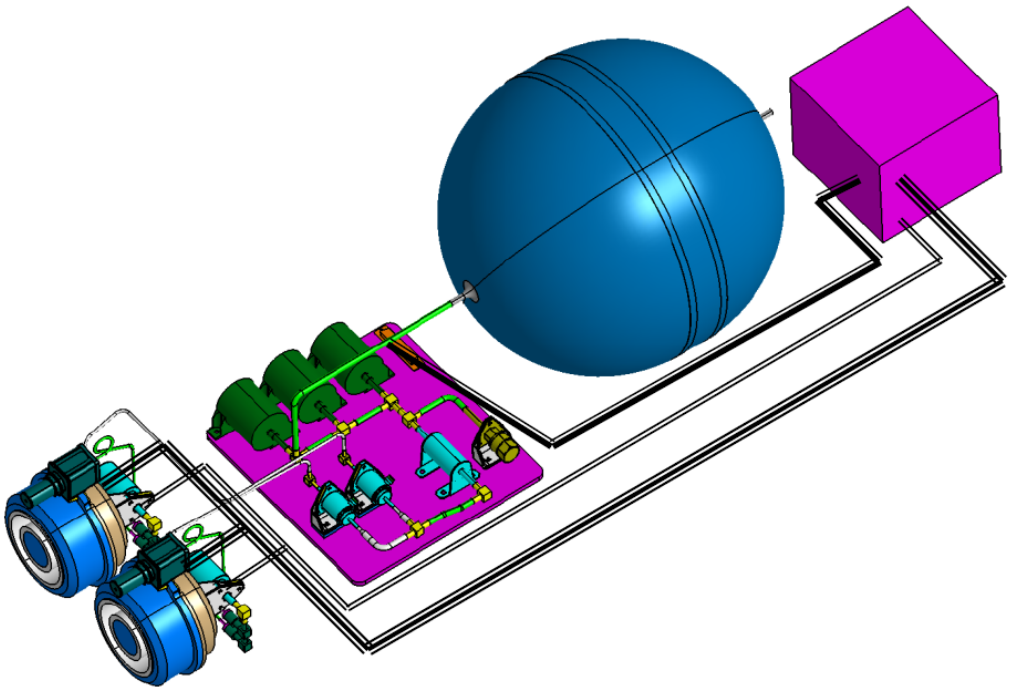

Figure HT400 EP system