DEVELOPMENT OF A SIMULATION TOOL FOR THE PROPULSIVE SUBSYSTEM OF *ESMO* LUNAR MISSION.

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Introduction: The Moon is the main objective for next decade Space missions. Exploitation, scientific research, robotic and manned exploration are planned by the most important space agencies. This renewed interest involves both the main Space Players down to the academic level. The European Student Moon Orbiter (ESMO) is the first student mission to the Moon. Promoted and directed by ESA, ESMO represents a "*unique and inspirational opportunity for university students, providing them with valuable and challenging hands-on space project experience in order to fully prepare a well qualified workforce for future ESA missions, particularly those planned by the Exploration and Science programmes in the next decades*" [1].

The mini-satellite class ESMO Orbiter is launched as an auxiliary payload into a highly elliptical low inclination Geostationary Transfer Orbit (GTO) using the Ariane Support for Auxiliary Payloads (ASAP) by Ariane 5 or Soyuz from Kourou. An on-board bipropellant liquid thrusters system accomplishes the lunar transfer and the lunar orbit insertion. After Moon orbit injection several scientific objectives will be achieved during the minimum six months mission time [7].

The main objective of this paper is to describe the whole ESMO propulsion system control algorithm and the corresponding simulator [2], which will be used during mission Phases C, D and especially during mission operations.

More in details, the modelled Fuel Management System is in charge of the control of the entire propulsion system, regulating the propellant flow for the different orbital manoeuvres.

Fig. 1 : Structure of the simulation tool; each coloured block contains other subsystem components.

Design and structure: Orbiter propulsion system is constituted by four R6 thrusters working with MON-3 oxidizer and MMH fuel, contained in four spherical tanks. The propellant is pressurized by 300bar tank of nitrogen, used also as propellant for attitude control cold gas thrusters.

The model here presented includes piping devices - such as valves and filters - simulation in order to have a comprehensive control over the propulsive system behaviour.

Each component has been modelled, step-by-step, in order to follow a "close to reality" approach. Thus line losses, thermodynamic relations and other performance features were considered [3]. Matlab Simulink Simulation Tool is used for the model implementation, as shown in Fig. 1: any coloured block corresponds to another Simulink model, blue blocks for the tanks subsystem, green for the pressure transducers and pink for the thrusters (Fig. 2). The Propulsion System Simulator is connected to the main Orbiter simulator [4] in order to communicate the failure detection system outputs, such as thrust misalignments, leakages, measurement uncertainties and insufficient fuel level.

This highly challenging and demanding project, far over the common expectations for a preliminary design phase, has demonstrated to be complete and completely reliable [5] as well as suitable to be used as the primary mission control system.

Conclusions and further work: The Propulsion System Simulator has been tested and approved by ESA project manager.

Preliminary experimental tests on R6 thrusters conducted in ESA-ESTEC facilities were used to validate the simulator. More detailed functional and performance tests are going to be performed [6], followed by extensive model validation. The Simulator will be improved including dynamic figures for the thrusters, updated frequency and damping, in order to maximize reliability and minimize failure events.

Eventually, Propulsion System Simulator will then be integrated with other Orbiter subsystems models and tested before launch.

References:
[1] Walker R., The ESMO Mission: Education, Outreach and Science. [2] Pettinari A., Theoretical model and functioning test on ESMO propulsive system p.32, bachelor thesis (2009). [3] ESA, Design_Justification_File (2009). [4] ESA, Model_Specification_Document (2008). [5] Moro V., Mengaldo G., Moon Orbiter, Propulsion Issues (2008). [6] ESMO Functioning Test Pla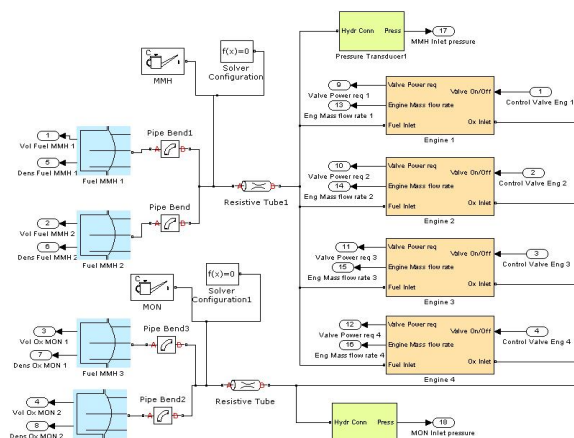n (2009). [7] ESMO_PhaseA_StudyReport p.18-19 (2008).