68th International Astronautical Congress 2017

Paper ID: 38147
oral
student

SPACE PROPULSION SYMPOSIUM (C4)
New Missions Enabled by New Propulsion Technology and Systems (6)

Author: Ms. Martina Mammarella
Politecnico di Torino, Italy, martina.mammarella90@gmail.com

Mr. Christopher Andrea Paissoni
Politecnico di Torino, Italy, christopherpaissoni@gmail.com
Mr. Pietro Maria Vernicari
Politecnico di Torino, Italy, pietromaria.vernicari@studenti.polito.it
Dr. Nicole Viola
Politecnico di Torino, Italy, nicole.viola@polito.it
Mr. Jose Gonzalez del Amo
European Space Agency (ESA), The Netherlands, Jose.Gonzalez.del.Amo@esa.int
Mr. Giorgio Saccoccia
European Space Agency (ESA), The Netherlands, giorgio.saccoccia@esa.int

ELECTRIC PROPULSION FOR HIGH-POWER DEEP SPACE TRANSPORTATION SYSTEM: INVESTIGATION ON MUTUAL INFLUENCES AND PRELIMINARY SIZING

Abstract

With the utilization maturity reached by the International Space Station (ISS), the space community is working on moving the presence of humans beyond Low Earth Orbits (LEO), with Mars being the ultimate target. Accordingly, knowledge and technology must be improved for the Deep Space (DS) environment. A major focus is posed on a new powerful launch vehicle, able to deliver spacecraft into DS transfer, and a sustainable transportation system to connect Earth with DS infrastructures. The Moon represents one of the most probable intermediate steps along the journey to Mars. The main idea is to develop a DS Habitat in Cislunar environment. This infrastructure will require continuous refurbishment and replenishment using DS transfer vehicles. A candidate for this is an unmanned transfer vehicle, the Lunar Space Tug (LST), able to transfer large amount of logistic cargo from LEO environment to the Cislunar space. Focusing on the LST primary function of transferring a significant amount of cargo, the Propulsion Subsystem represents one of the most critical subsystem involved in the LST design. Two different classes of technologies can provide the required propulsion capabilities. On one side, Chemical Propulsion can provide high thrust levels, guaranteeing short transfer time and high reliability level thanks to its maturity, whereas its low specific impulse leads to large propellant mass requirements. Electric Propulsion, instead, provides higher specific impulse, allowing significant fuel saving, whereas the transfer time might increase considerably, requiring in any case a more challenging mission design in order to optimize the low-thrust trajectories involved. Because the payload to deliver is a nonpriority cargo, the transfer time can be relaxed, gaining in terms of propellant requirement and this design thread leads to consider an Electric Propulsion architecture. This paper presents a possible design of the Propulsion Subsystem of LST. A Hall Thruster cluster has been adopted to fulfill the thrust requirements, considering the whole operational lifetime along a 5-years mission. A mass model approach has been adopted for each of the main critical components of the Propulsion Subsystem. Analogous approach has been adopted for the design of the Attitude Control Subsystem, based on chemical thrusters for the rotational control of the LST, mainly during proximity operations. A trade-off analysis is performed to establish the best cluster architecture with respect to the mission and system requirements and constraints. Main results are presented and discussed, and main conclusions are drawn.