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Solar electric spacecraft for human Mars missions

Recent progress in the field of thin film photovoltaic cells and large deployable structures may allow to build fast solar electric spacecraft for human Mars exploration. At least in the short term, they may represent an interesting alternative to both chemical propulsion, which implies large initial mass in LEO – and hence large costs – and nuclear electric or nuclear thermal propulsion, which at present require large investments to achieve the required technological readiness. The performance of any electrically propelled spacecraft depends mainly on the mass/power ratio of its power generator, expressed in kg/kW by the parameter α. The value of α, at one astronomical unit (AU) from the sun, approximately doubles at Mars distances, mainly due to the reduction in solar illumination. In a Mars mission, this leads to a decrease of the overall performance of the spacecraft by approximately 15% with respect to a system with constant α i.e. NEP(nuclear electric propulsion). The main advantage of a planetary mission performed using electric propulsion is that the payload ratio increases monotonically with the increase of travel time (contrary to impulsive propulsion in which the payload ratio has a maximum and then decreases again) and thus makes the split-mission concept in which a robotic Mars cargo ship first preposition a habitable infrastructure on the planet before the crew travels there in a faster and lighter ship in a much more convenient manner. SEP is often considered a good choice for a robotic cargo spacecraft, while the crewed ship retains a traditional chemical propulsion. However, new technologies for solar arrays, based on the structures developed for solar sail spacecraft and on thin film PVA allow to maintain quite a low value of α, much lower than what can be realistically predicted in the short and medium term for nuclear generators. Very large, but nevertheless lightweight, solar arrays can thus propel also fast crewed spacecraft, reaching Mars in a time of about 6 or 7 months.

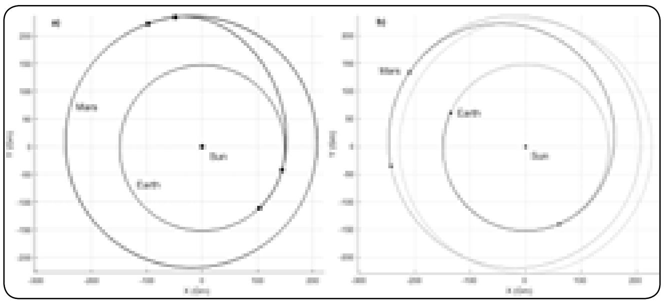

Figure 1: Trajectories of the a): passenger spacecraft and b): cargo spacecraft in the 2037 launch opportunity

Recent Publications

1. G Genta (2017) Next stop Mars - The Why, How, and When of Human Missions. Springer. ISBN: 978-3-319-44310 2.
2. Genta G and P F Maffione (2016) optimal low-thrust trajectories for nuclear and solar electric propulsion, Acta Astronautica. 118:251-261.
3. G Genta and P F Maffione (2017) Low thrust interplanetary transfers: second approximation computation of planetocentric phases. Advances in Aerospace Science and Technology. 1:100-107. ISBN 978-7-5159-1282-0.

4. G Genta and P F Maffione (2017) Comparison between different approaches to interplanetary mission design. International Journal of Signal Processing. 2:54-66.

Biography

Giancarlo Genta completed his Master Degree in Aeronautical Engineering, he is a Professor of Construction Machines at Polytechnic University of Turin, Italy. He is a Member of the Academy of Sciences of Torino and of International Academy of Astronautics (IAA). In 2013, he received the Yangel Medal for outstanding contributions to "The development of the international space sciences and technologies" and the Engineering Science Award of the International Academy of Astronautics for outstanding achievement in Engineering Science. Starting from 2012 he chaired two study groups of the IAA on human Mars and lunar exploration. He authored 95 papers, published in Italian, American and English journals, 276 papers presented to symposia and 26 books. He is also the Author of two science fiction novels, published in Italian, English and Ukrainian.

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