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ADVANDED PROPULSION FOR FAST LUNAR MISSIONS

Abstract

The Moon is the closest celestial body and can be reached easily and in a relatively short time using chemical propulsion, as was demonstrated half a century ago by the Apollo missions. The introduction of reusable launchers and other innovations mostly caused by the entering of private enterprises in the space transportation market promise to reduce the cost of reaching our satellite and to make it easier to build lunar infrastructure and to develop a lunar economy, of which lunar tourism will be an important part. All this can be done without advances in propulsion, except for improvements and cost reduction of chemical rockets. While these developments will be under way, advanced propulsion will be developed mostly for human planetary missions, which on the contrary lie beyond (or in the case of Mars at the border of) the possibilities of chemical propulsion. The first possibility is Nuclear Thermal propulsion (NTP), which can allow to reduce the time to reach the Moon from the usual 4-4.5 days to about 3 days, with at the same time a reduction of the initial mass in low Earth orbit (IMLEO). Perhaps it is not worth while to develop NTP for this application, but if it will be made available to reach Mars, it would be useful to build a fast lunar reusable nuclear shuttle. All other advances in propulsion are linked with low thrust devices, which are intrinsically more suitable for interplanetary than for lunar missions, in which all the travel must be performed in a gravitational field much stronger than the interplanetary field. A low thrust lunar trajectory is made of a multi-turn geocentric spiral, patched to a selenocentric spiral with possibly a coasting arc in between. With the thruster and power generator performance expected for near and medium term NEP and SEP devices the minimum travel time is at least 10 days, with many hours (or days) spent in the Van Allen radiation belts. This means that SEP and NEP (and even more solar sails) are unsuitable for human lunar missions, while allowing to build cargo spacecraft allowing to carry to the Moon large payloads in an economical and efficient way in times of a few months. Thigs may be different if power generator with a very low specific mass are built, or above all is the studies on Direct Fusion Drive (DFD) technology prove to be successful. A DFD spacecraft will allow to reach the Moon in two days or less, an interesting perspective for human transportation to the lunar bases and other touristic infrastructures on our satellite. The present paper shows a number of examples of lunar missions performed with different types of advanced propulsion, showing that it will be possible to improve human transportation to the Moon only when large advances in propulsion will be achieved. As a final consideration it will be shown that even in the unlikely case in which the ideas about propellantless propulsion will prove to be more than just dreams, the constraints about the specific mass of the generator will remain and limitations similar to those seen for NEP or SEP will still remain .