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Nuclear Application for Economic Space Exploration

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1. Introduction

In the beginning of the space exploration, end of 50s, beginning of the 60s, electric energy was guaranteed using batteries, or solar panels, or RTGs. These components fulfilled the electrical requirements because of the short term of the missions or because of the low power demands. With these constrains in mind, the Human Species occupied the Earth orbit, sent men to the Moon, and explored the inner and the outer planets of the Solar System. It started in the tenths of We (*e* means electric) and it grew to hundreds of We [1]. As for instance SNAP 3B of 2.7 We (1961); to the APOLLOs 12-17 from 1969 to 1972, using SNAP 27 >70 We; to the Pioneer 10 and 11, (1972 and 1973), using SNAP 19, 4 units each of 40 We; to the Voyager 1 and 2 (1977) MHWRTG, 3 units each of 158 We; to the New Horizons (2006) GPHSRTG, 1 unit of 247.7 We [1]; and finally the 2 Mars Science Laboratory Rovers: Curiosity (Launched 2011 and Landed 2012) and Perseverance (Launched 2020 and Landed 2021), with the MMRTG, 1 unit each of 110 We[2]. All of those are RTGs. The great example of Solar panels is the International Space Station - ISS, 75 kWe [3]. As we advance into the Twenty First century the requirements and demands for the space exploration are gradually increasing. And, despite all these advances, it is steel necessary to push the envelop for exploration even further. And that requires more firm energy in the range of the hundreds of kWe and even of tenths of MWe. And that means Nuclear Fission Reactors. This power level is being considered for the free navigation of the Cislunar space volume. The Cislunar space is a volume that includes a little further than the Moons' orbit. It has excellent stable positions for space station installation, as for instance the stable Lagrange points. The Dark side of the moon is an excellent local for radio astronomy once it is protected from the Earth's radio noise itself. And those are just scientific advantages. The material advantage of the Moon's surface for instance is the deposit, spread throughout the whole surface in the form of He3, deposited by the Sun bombardment of this material for over 4 billion years. The importance of He3 is readily recognized by the people who works with nuclear Fusion, Deuterium + He3 is an aneutronic Fusion reaction with lower energy threshold occurrence. In recent years Water was found in ice form in deep craters where the Sun light never reaches. Water is not just for drinking it generates hydrogen (H2) that may be used as rocket fuel and oxygen (O2) for breathing. Finding Water in space is like finding gold on Earth. And that is just the beginning. The Human Being needs more time up there to perform a thorough search. And that requires energy. A Nuclear Fission Reactor is the solution for this need.

According to the thoughts of Robert Goddard (circa 1907) "The Navigation of the Solar System requires for its successful accomplishment on the disintegration of atomic matter". Goddard, at his time, realized that the nuclear energy would provide the necessary energy for a proper space navigation. And in fact, that is true. With a nuclear engine one may approach a comet or an asteroid to check for water presence [4]. In this sense Asteroid mining becomes a reality. With this mined material Humankind will finally start to fabricate items for space construction of complex structures that will become future living

modules for a space station or even a new ship to navigate through the Solar System, in great style. With the nuclear propulsion engine, it will also be possible to mine the Asteroid Belt which is a little further from the Mars orbit. The Asteroid Belt is between 2.2 to 3.2 AU from the Sun. 1 AU is 150 million Km, which is the radius of Earth´s orbit around the Sun. The Asteroid Belt has all kinds of ore [5] that one would require to make an alloy. So, it is like the Asteroid Belt represents the mines from which Humanity will extract materials to make metals, circuitry, glass, basically anything from the technological point of view. Again, to reach that distance in a reasonable time frame one needs the power of a nuclear rocket engine. Up to now, it is known that the asteroids of the belt also have water. That means that mapping these resources is like one finding a gas station in the middle of the desert. It is also important to realize the economic potential of mining operations on the Moon's surface, comets, Mars surface and Asteroid Belt [6, 7]. This economic potential will generate wealth, will create opportunities and it will open the inner Solar System to Human occupation. The potential for scientific development, technological development and Human endeavor is also great. But none of these views will became a reality without the systematic use of Nuclear Energy.

2. Conclusions

We need to take advantage of the water that was found on the Moon, Mars, comets, and asteroids. The He3 that exists in the surface of the Moon is an excellent fuel for Fusion Reactors. The potentials of the Moons' regolith as nuclear shielding seem to be something to further investigate. And all the materials that may be found in the Asteroid Belt will give Humankind to build in space. The new demands for electricity in space have grown from tenths of We to hundreds of kWe. And that is just the beginning as it is expected that units to tenths of MWe will soon be demanded. This is the prime moment for nuclear energy and its space application.

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References

[1] G. L. Bennett, "Mission interplanetary: Using radioisotope power to explore the solar system," Available on line since 21st, December 2017.

[2] World Nuclear Association, "Nuclear Reactors and Radioisotopes for Space," December 2014.

[3] L.N.F. Guimaraes, "TERRA Project Update (2019), A Brazilian Nuclear Space Microreactor Development," presented at XX ENFIR, October 2019.

[4] S. K. Borowsky, D. R. McCurdy and T. W. Packard, "Nuclear Thermal Propulsion (NTP): A Proven Growth Technology for Human NEO / Mars Exploration Missions" white paper, (01/10/2021). https://ntrs.nasa.gov/api/citations/20120003776/downloads/20120003776.pdf (2021)

[5] https://en.wikipedia.org/wiki/Asteroid_mining (2021)

[6] http://deepspaceindustries.com/first-commercial-interplanetary-mission/ (2016)

[7] https://deepspaceindustries.com/is-asteroid-mining-legal/ (2016)