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Introductory Chapter: A Tipping Point for a Return to the Moon

Yann H. Chemin

1. A new economic influx towards a cheaper access to the Moon

We are living at the onset of another return to the Moon, this time during another phase of our planetary development, a more peaceful one. With the rise of private access to space (**Table 1**), the cost of sending cargo/crew to Low Earth Orbit (LEO) is plummeting, and to add to it, with a rocket relaunch timetable of 15 days. It is a simple corollary to think that the short-term assembly of a large spacecraft in LEO can be done. As a consequence, humanity could reach to the Moon cheaper with logistical support for much longer missions than what was done 50 years ago, during the golden age of Luna and Apollo scientific missions.

Waiting for the wake of the giants and the first manned missions to the Moon (again, at least in this twenty-first century) and through to Mars (**Figure 1**), the Moon resources have had a new rekindled interest by researchers within the last 20 years with the Clementine and Chandrayaan missions, among others. The Moon, over these two last decades, has become the exploratory ground to missions from different countries, some of them new to space probe building: Israel (Beresheet), India (Chandrayaan-1/Chandrayaan-2), China (Chang'e-1–Chang'e-4), Japan (Kaguya) and European Union (SMART-1). Some of the missions have a lander component (Beresheet, Chandrayaan-2, Chang'e-3/Chang'e-4), and even some have a mobile robotic explorer (Chang'e-3). Surface/elevation mapping, exosphere, radiation and volatile composition are the main subjects of interest for mission controls around the world, besides the engineering proof of work for orbital control, landing automation and sample return. Already China is launching a sample on the far side of the Moon this year (Chang'e-5), India being both an orbiter and a lander (Chandrayaan-2). In 2020, Russia is planning a lander (Luna-25). Finally, in 2021, Japan will also land with its SLIM mission. The number of missions including landing components is steady in these coming years; however, the only known manned mission towards the Moon is EM-2 orbital mission of the USA, planned

Company	Cargo to LEO	Crew to LEO
Blue Origin		Development
Boeing		Development
Northrop Grumman Innovation Systems	Operational	
Orbital	Retired	
Sierra Nevada Corporation	Development	Development
SpaceX	Operational	Operational

Table 1.
Private transport to LEO (operational/development).

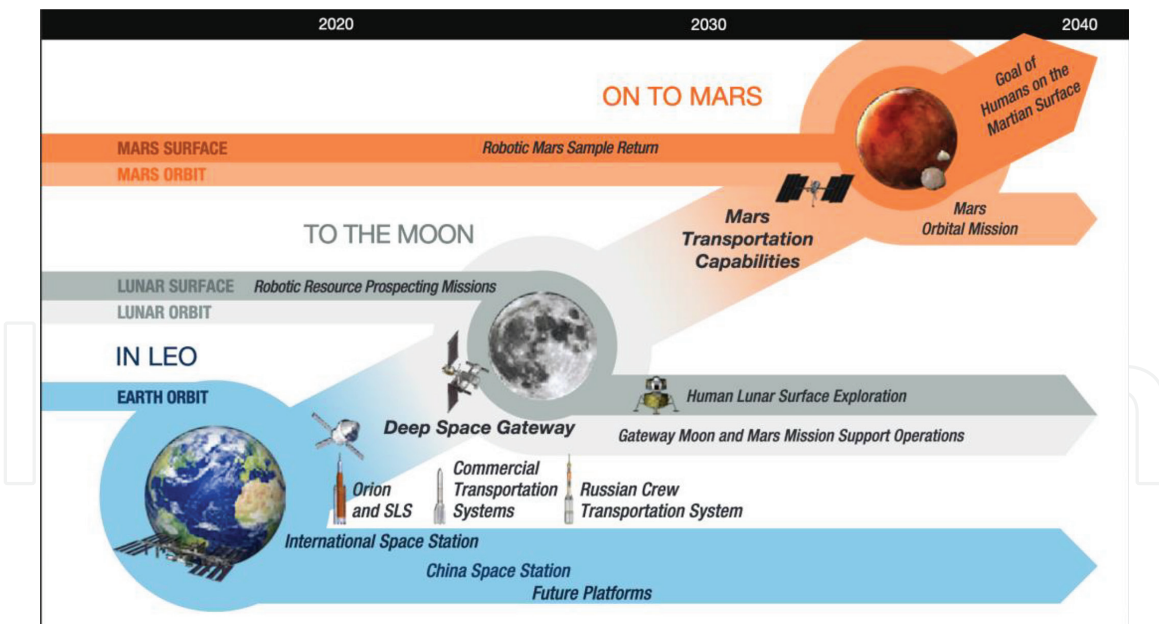


Figure 1.
The Global Exploration Roadmap [1].

Company	Company
Asteroid Mining Corporation Ltd., UK	NEO Resource Atlas
Aten Engineering	OffWorld
Deep Space Industries	Planetary Resources
Kleos Space	Planetoid Mines Company
Moon Express	TransAstra

Table 2.
Asteroid mining companies.

in 2023. This leaves humans on the Moon to another decade probably, unless some country/company wants to make a statement by bringing the element of surprise and precipitating this prospect.

The Moon has several interesting conditions that humanity can use. It has an enhanced slingshot effect to the Earth, coupled with a much lower gravity. Launching into the solar system from the Moon has significant advantages. One of them could develop with the asteroid mining/capture private endeavours (Table 2). Its lack of atmosphere also brings advantages to astronomical observation, more so with a large distributed array [2].

2. Humanity near-future: studying the Moon on-site

The prospect of such various interests (and others) having the Moon in the midst of their plans brings also the possibility of surface dwellers. This translates into a new interest in cheaper field survey from surface dwellers [3] giving a vastly deeper geological understanding of the lunar surface elements/processes. This also opens the way for installing seismologic and heat transfer monitoring stations for a more automated monitoring of the Moon interior. Similarly, human health studies will certainly make major strides from the first longer periods on the Moon surface [4, 5].

From water to ³Helium [6], various types of useful resources can be extracted and activated if appropriate machinery can be transported on-site or various

processes developed to extract actively/passively useful elements from the regolith. Within that perspective, this already drove the choice of landing the China rover on thorium-rich regolith. It turns out that In Situ Resource Utilisation (ISRU) becomes paramount to improve the residence conditions of humans living (medium or long term) on the Moon.

It may take another 20 years to see some practical set-up of humans actually being on the Moon, taking two generations to reach back to the lunar surface and picking up field research where we prematurely stopped it in the 1970s, with a 70-year recess. In the meantime, it becomes rather obvious that the Moon is renewed in its aura of the Earth's first harbour to the solar system and the first non-Earth scientific playground.

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