

Commercial Space Mining - a Current Overview
 (Current Overview: Status March 2013)

The founding of various private space-mining companies during the recent couple of months created the idea to attempt an overview of the various activities in the private sector but also within the Agencies ESA and NASA to summarize the prospects are of further governmental / industrial mining activities on the Moon and on Asteroids.

It shall be mentioned that this overview attempts by no means to be complete - yet it tried to collect the various pieces being published in the internet and in space oriented publications (like SpaceNews, Space, etc.).

As Rick Tumlinson (Chairman Deep Space Industries Inc.) said: "One company may be a fluke, two companies showing up? That's the beginning of an industry".

Readers are encouraged to provide corrections and/or update information to the Editor for SpaceOps News (joachimkehr@aol.com) in order to complete to overview as activities might progress. In particular, almost nothing is known about similar activities in China, Russia or India.

**"One company may be a fluke, two companies showing up?
 That's the beginning of an industry".**

Two items playing an important role in deep space mining are the UN's Outer Space Treaty of 1967 and the status of fusion reactor technology.

The **Outer Space Treaty** specifically prohibits that States claim rights over an Asteroid. The UN Treaty says that the moon and celestial bodies such as asteroids are not subject to national appropriation. The analogous interpretation would be the high seas agreement on Earth: One can take fish out of them and sell them. Another international treaty ("Moon Agreement") tries to regulate prospecting and mining on the Moon, however is not ratified by any of the spacefaring nations.

The **fusion reactor technology** is always mentioned in connection with helium-3 mining, i.e., either to be processed in situ or brought back to Earth. A MIT Technology Review from 2007 still put practical nuclear fusion into the future for another 50 years, however He3-He3 fusion, the only nonradioactive fusion with inertial electrostatic confinement (IEC) is promising as initial fusion reaction test showed (Kulcinski et al, [Fusion Technology Institute](#), Wisconsin).

Although the discussions with respect to the development of alternative transportation systems quieted down, further developments and break-throughs for a "space elevator" system might play an important role in the long run as well. A moon mining scenario as described in Frank Schätzing's fictional best-seller "[Limit]" therefore seems to become realistic after all..

- Glossary:
 DSI = Deep Space Industries
 ESTEC= European Space Technology Centre
 KSC= Kennedy Space Center
 NIAC = NASA Institute for Advanced Concepts

ESA / Laurent Pambaguian, [ESTEC: 3D Printing of a Moon Base](#)

Image	Goal	Technology	Remarks
	Exploration of 3D printing techniques for a habitable moon base	Construction of a four-person Moon base built out of lunar regolith	 <p>A 1.5 ton building block as demonstration</p>

Example of a 3D printed Moon base		of the capabilities of the 3D printing techniques was produced at ESTEC recently.
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NASA / Rachel Cox, KSC: [RASSOR = Regolith Advanced Surface Systems Operations Robot \("razor"\)](#)

Image	Goal	Technology	Remarks
	Development of an autonomous, sturdy "blue collar" robot for lunar excavations acting as "feeder" for a lunar processing plant.	Specification, design and test of a 100 pound robot for 2000 pounds of payload, consisting of a movable back and front drum with staggered shallow scoops allowing to "shave" the soil rather than scooping big chunks.	Tests with a prototype were made on various surfaces at KSC. More innovative design decisions have to be made for a space-ready vehicle. In September 2012 the NASA-IAC announced the " Robotic Asteroid Prospector " project to examine and evaluate the feasibility of asteroid mining.

[Deep Space Industries \(DSI\)](#) / **David Gump, Rick Tumlinson**

Image	Goal	Technology	Remarks
 <p>FireFly Inspector (Archimedes)</p>	DSI intends to build a fleet of asteroid "hunting" spacecraft (Inspector, Grappler, Harvester, etc.) to explore and exploit nearby asteroids for resources (metals, water, and other materials) Prospecting will start in 2015, sample return by 2016 and beginning of mining by 2023. Entrepreneurial funding, open for additional investors. Established : January 2012.	A fleet of small "FireFly" (25 kg each) spacecrafts will begin with the inspection of potential mining targets starting in 2015, later it is planned to "capture" near earth asteroids and return up to 150 pounds of material,	"We sit in a sea of resources. It's not something we can sit back and dream about". (R. Tumlinson)

[Golden Spike](#) / **Alan Stern, Gerry Griffin**

Image	Goal	Technology	Remarks
	Provide affordable, reliable, turn-key systems for frequent human expeditions to the Moon. Target price is \$1.5 billion per lunar landing and return mission. The space expeditions are planned to be marketed and sold to governmental agencies, companies and individuals around the world - for science, commerce, tourism and entertainment. Formed in 2010, market entry in December 2012.	Definition of flight systems using existing developments. For a typical mission two launches of two existing sets of launch vehicles are planned: one set to position the lunar lander into a low lunar orbit and one set to transport the crew in a capsule to meet the lander for an automated descent. The automated capsule would remain in orbit and would be used as return vehicle to Earth. Cooperation with 10 U.S. aerospace companies, including Armadillo Aerospace, Masten Space Systems, Northrop Grumman, Paragon Space Development, Space Florida, ULA and others.	For planning purposes Golden Spike assumes it could launch with Atlas 5 (ULA), Falcon 9 or Falcon Heavy (SpaceX).

[MoonEx \(Moon Express Inc.\)](#) / **Robert D. Richards, Naveen Jain, Barney Pell**

Image	Goal	Technology	Remarks
	Provide commercial lunar robotic transportation and data services with the long term goal of mining the Moon for resources including elements that are rare on earth like Niobium, Yttrium and Dysprosium. Ready for Moon landing in 2015.	Developments: Lunar Lander Test Vehicle (LTV) and a robotics lab for a lunar probe named "Moon Express Robotics Lab for INnovation" (MERLIN).	In December 2012 MoonEx aquired one of the Google Lunar X-Prize teams, "Rocket City Space Pioneers" from Dynetics. MoonEx is also partnered with NASA through a Space Act Agreement .
Lunar Lander and Infrastructure	Established: August 2010.		

Planetary Resources / Eric Anderson, Peter Diamandis (Advisors: James Cameron, Larry Page, Eric Schmidt)

Image	Goal	Technology	Remarks
	Asteroid mining and creation of a fuel depot in earth orbit by 2020.	Detection and interception of asteroids with a fleet of Arkyd spacecraft / telescopes. Extraction of water with laser techniques, metals can be extracted in situ. Creation of a fuel depot by using water from asteroids, broken down in space to liquid oxygen and liquid hydrogen for rocket fuel to be used for refueling commercial satellites or other spacecraft in earth orbits.	According to a study of the Keck-Institute for Space Studies it would be possible to move a 500 ton asteroid into a lunar orbit for further "processing".
Arkyd Interceptor	Established: April 2012.		