

## Ten Asteroid Mining Milestones in 2018-2019

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### Abstract

In 2018, the space-resource-utilisation (SRU) of asteroids community passed through significant changes with important milestones, which are evolving rapidly. I summarise the state of the international community of asteroid mining at this point in time in 2019.

### 1. Introduction

The utilisation of space resources will provide an extension of our SpaceShip Earth to include space infrastructures for, and of, our robots that are orbiting the Earth and traveling beyond. With space resources we can service, recycle, or build anew, in space, without the limitations of carrying the resources from the Earth. Telecommunications, Earth observations, planetary research, extraterrestrial life explorations, are just a few examples, which can be implemented cheaper and more efficiently using resources in space.

It's no longer a question of 'if' but of 'when'. The endeavour of the in-space utilisation of asteroid resources have attractive features over their lunar and Martian counterparts, in that their low gravity, large quantities, and tiny sizes lead to different legal regimes for their utilisation and hence are more attractive for private funders to build in space with these resources. Yet that is not what the world witnessed in 2018 with the two largest asteroid companies acquired by non-asteroid mining entities. The largest asteroid mining risk takers were considered too risky by the private or government funders.

However, taking place in the background of the high-profile events were, and are, significant developments which demonstrates that the international academic, research, legal and business communities accept in-space resource utilisation, including that of asteroids, as a serious field of endeavour. Here I list the milestones in 2018 and 2019.

### 1.1 Transition to 2nd Generation Asteroid Mining Companies with Lessons Learned

Non-asteroid mining companies acquired planetary Resources and Deep Space Industries in 2018. Lessons learned through this transition to a new generation of asteroid mining companies include:

- Companies need a better balance of venture capital funding and offered products.
- A passionate asteroid mining CEO is critical.
- We have new industry space resource utilisation niches filled by smaller companies.
- Exolith Lab at Univ of Central Florida acquired DSI's simulant activities
- PRI becomes a resources trust entity with blockchain, and that makes perfect sense. (1)

### 1.2 PWC Value-Chain Document (i.e. "Roadmap") completed

The Price Waterhouse Coopers detailed value-chain document that provides the Luxembourg government with a Roadmap for SRU is completed and in the Luxembourg Government's hands. (2). Other government entities are working on similar roadmaps.

### 1.3 Water Thrusters (DSI/BSI) are flying in space

Water extracted from asteroids can provide radiation-shielding, water for living in space, and especially water thrusters to propel a spacecraft to the next target. Four spacecraft with water propulsion systems, i.e. 'steam engines' were launched in the late Fall 2018 by Space-X with dozens more planned and being built by Bradford Space Industries, the company which acquired Deep Space Industries in 2018. Three HawkEye 360s [3] and one Capella-1 spacecraft were launched in December 2018. [4]

## **1.4 SRU Legal framework active by world's actors**

Regulatory guidelines for space resource utilisation called the “Building Blocks” are in vigorous discussion in the Hague International Space Resources Governance Working Group since 2016 [5]. The United Nations Member States are actively discussing the future of international cooperation in the peaceful uses of outer space with revisions of the Outer Space Treaty [6].

## **1.5 Research Community focussed on asteroid composition**

The Asteroid Intersections with In-Space Mine Engineering 2018 conference took place in Luxembourg in April 2018 focussing on the science knowledge gaps related to asteroid composition [7]. Meanwhile it has been a tremendous year of active asteroid scientific results by the NASA OSIRIS-REx and JAXA Hayabusa-2 space missions.

## **1.6 Near-Earth SRU heating up**

Some examples of companies with an SRU business model that can be applied to asteroid mining in the future include: Made in Space (USA / Luxembourg), Orbit Fab (USA), Terrestrial Celestial Materials (Ireland) and Cislunar Industries (Luxembourg).

## **1.7 New bridges built to hot lunar space mining**

The SRU community recognizes that bridges need to be built between the asteroid and lunar mining communities. Examples where such conversations took place are: ASIME 2018, CSM Space Resources Roundtable 2018, 2018 ESA Lunar Resources Workshop, Luxembourg Space Mining Summit

## **1.8 Many funded space resource-related feasibility studies (NASA, UAE, ...)**

## **1.9 First SRU Education Programs**

The Colorado School of Mines was the first in this new academic degree. Others are following, for example: the University of Luxembourg

## **1.10 New knowledge gained Government actors in SRU support**

However, “User Manuals” are needed for navigating through the private-public-funded SRU paths, otherwise hundreds of thousands funds are wasted.

## **Summary and Conclusions**

While there remains a psychological element of science fiction to the international asteroid mining activities, I hope that I’ve demonstrated that the in-space utilisation of asteroids is proceeding actively and seriously.

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## **References**

- [1] Prisco, G. “ConsenSys and Planetary Resources: First reactions” at Medium. 2 November 2018. <https://isn.page.link/X9ut>
- [2] Luxembourg Space Agency. “Opportunities for Space Resource Utilization. Study Summary.” December 2018. <https://isn.page.link/1FKV> and the PWC presentation at the Mining Space Summit 2018 available here: <https://isn.page.link/4DbX> [3] <https://isn.page.link/Yna7> HawkEye Satellite Missions. eo-portal.
- [4] “Space-X launches swarm of satellites.” SpaceFlight Now. 3 December 2018. <https://isn.page.link/UjIM>
- [5] The Hague International Space Resources Governance Working Group <https://isn.page.link/3UqH> [6] UNOOSA: <https://isn.page.link/UsNn>
- [7] Graps, A. + 43 co-authors: ASIME 2018 White Paper. Asteroid Composition -- Answers to Questions from the Asteroid Miners @ ArXiv <https://isn.page.link/bNWN>