SPACE RENAISSANCE ACADEMY

Committee: Orbital Debris & Near-Earth Objects

Chair: Werner Grandl, architect & civil engineer

Biography: born 1957 in Vienna, Austria
1984 Technical University Vienna, degree in architecture
1985 military service, Austrian Air Force
1986- 1993 working in some engineering offices
since 1994 freelancing architect and consulting engineer
since 1987 various studies on space stations, space colonies, lunar base design and asteroid resource utilization

Space Debris: Space debris encompasses both natural meteoroid and artificial (human-made) orbital debris.

Natural Space Debris: Consists of small pieces of cometary and asteroid material called meteoroids.

Artificial Debris, also Known as "Orbital" Debris: Space "junk" orbiting Earth, such as used-up rocket stages and satellites, loose fragments from rocket explosions and collisions, dust and paint flakes, etc..

Near-Earth Objects (NEOs): NEOs are comets and asteroids that have been nudged by the gravitational attraction of planets into orbits that allow them to enter the Earth´s neighborhood. Potentially Hazardous Asteroids (PHAs) are coming close to the cislunar space. Some of them are crossing the Earth´s orbit around the sun. In recent years about 20,000 NEOs have been detected.

Why Orbital Debris are a Problem?

Space junk has become a growing area of concern as the region of space immediately surrounding Earth becomes more and more crowded with rocket parts, satellites and other man-made objects. These debris, which travels at approx. 15,700 miles per hour in Low-Earth Orbit (LEO), poses a threat to both manned spacecraft and orbital stations. Several countries including the USA, China and India have used missiles to blow up their own satellites creating lots of new debris. Russia´s latest missile test may have increased the total amount of space junk, including discarded pieces of rockets and satellites in LEO by as much as 10%. Over the International Space Station´s 23-year orbital lifetime, there have been about 30 close encounters with orbital debris requiring evasive action. Satellite operators will likely need to navigate around this new cloud of space junk for several years and possibly decades.

Why ODs can be profitably considered in-situ resources for the kick-off of Orbital Industrialization

Orbital debris cannot be considered only a threat to space navigation, and a general problem to be resolved by public money. As any other waste – e.g. urban wastes on Earth's surface – orbital waste can be a source of profit, if properly managed and processed, by means of proper technologies and industrial initiatives. Considering orbital debris only as an issue of necessary cleaning means to consider ODs just as a voice of expenditure, on the balance of the governments. In fact, there are also several laws proposals, oriented to impose each "polluter Country" to recover their own debris. Yet, such an approach will not solve the problem, due to several reasons. First, a technical reason: it will be possible, for an owner, to recover big wreckages, the owner of which can be identified, yet it will not be possible to identify the owners of the vast majority of debris, too small to detect their origin. Such a solution would then leave in space millions of small debris, the most dangerous for space navigation.

Secondly, the problem of space debris will be properly tackled only when it will be possible to draw a profit from them. By developing methods to "collect" man-made space debris in orbit, the harvested material could be processed on board of orbital workshops and contribute to the first steps of industrialization of the cislunar space.

In such a perspective, the promise of a return will justify investments. One of the goals of this committee will be to investigate existing business planes for the development of Orbital Debris Recovery and Reuse industries. We are aware that, such a market will one day have an end, due to the exhaustion of the main resource, provided that new debris will be no longer produced, and the major part of old debris will be one day recovered. However, considering the huge quantity of existing debris in orbit, we believe that investments will be covered, and a meaningful profit can be earned before exhaustion.

Cleaning orbit from debris, and turning them into a big business, requires both legal evolution and technological development. Abiotic space resources calls for abiotic space predators. We will need big "space whales"(Figure 1), to eat and metabolize small debris like sea whales eat plankton, and we will need restless agile "space sharks", seeking and catching big wreckages, avoiding them to collide, explode and produce new small debris.

Figure 1. Orbital Debris estimation 2021[1]

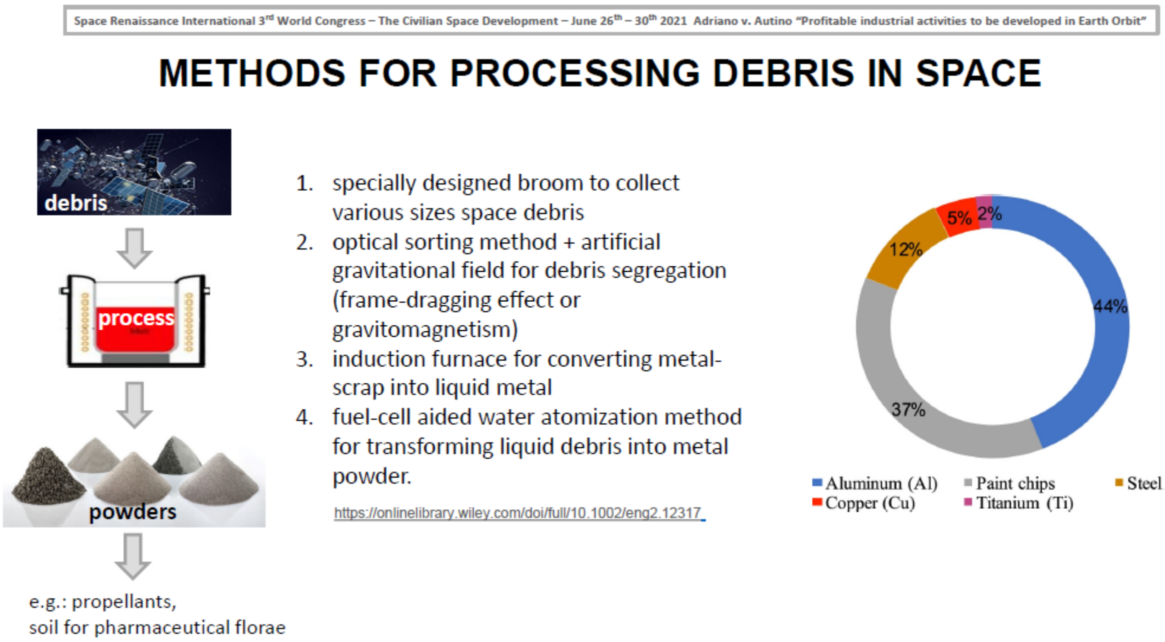

Figure 2. Methods for processing debris in space[1]

[1] https://2021.spacerenaissance.space/wp-content/uploads/2021/08/PAPER-SRIC3-SDE-2.3-02.031.pdf

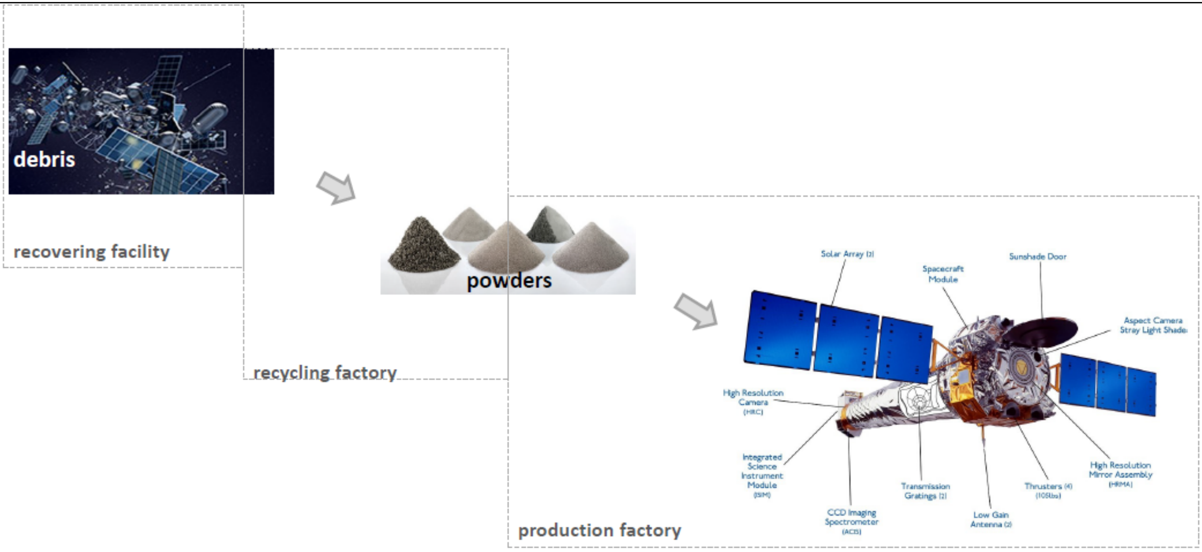

Figure 3. Circular Economy in space[1]

Why NEOs are a Problem?

On a daily basis, about one hundred tons of interplanetary material drifts down to the Earth´s surface. Most of the smallest particles that reach the Earth´s surface are tiny dust particles that are released by comets as their ices vaporize when the comet comes close to the sun. Larger interplanetary material originates as the collision fragments of colliding asteroids some eons ago. With an average interval of about 10,000 years, rocky or iron asteroids larger than about 100 meters would be expected to reach the Earth´s surface and cause local disasters or produce tidal waves that can inundate coastal areas. On an average of every hundred thousand years asteroids larger than one kilometer could cause global disasters. In this case the impact debris would spread throughout the atmosphere, so that plant and animal life would suffer from acid rain, partial blocking of sunlight and from firestorms resulting from heated impact debris raining back to the Earth´s surface. It is evident that an impact beyond a certain magnitude could erase human civilization. If there would be any survivors, those humans would be pushed back into the stone age. Collisions with NEOs have occurred in the past (Figure 4) and we should remain alert to the possibility of future Earth approaches, such as 99942 Apophis in 2030 (Wagner & Wie 2010).

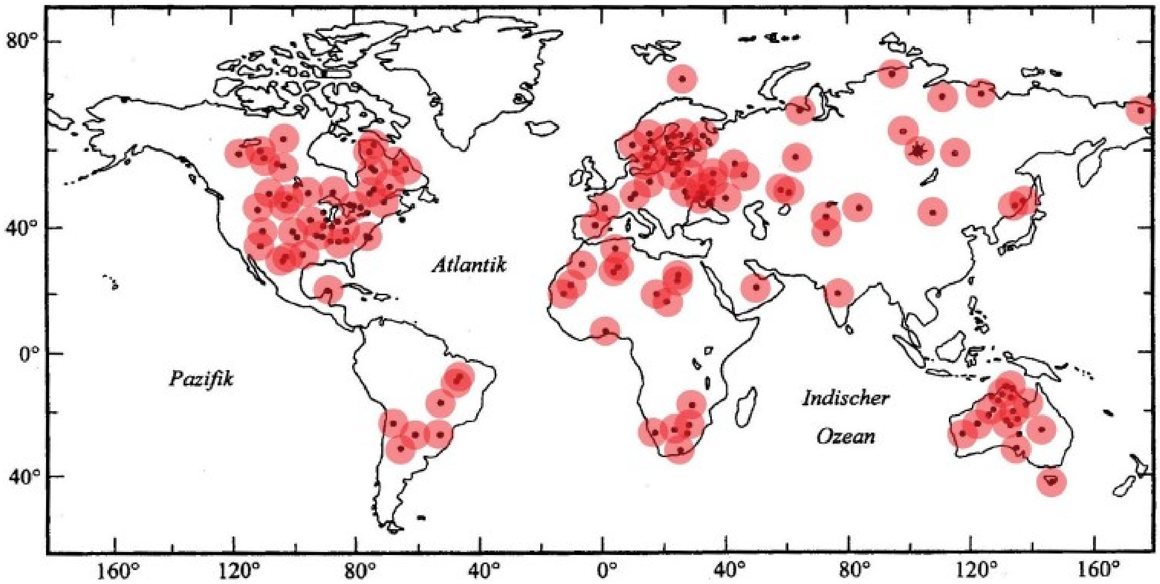

Figure 4. Asteroid impact craters on Earth (Köberl 1998)

How to mitigate the NEO threat

On 26 September 2022 the NASA operated semi-robotic probe DART (Double Asteroid Redirection Test) hit Dimorphos, the minor-planet moon of the asteroid Didymos 1996GT and changed the small moon´s orbit around the asteroid successfully. This event is considered to be the first test to change an asteroid´s trajectory by a so-called kinetic impact. The original trajectory of the twin asteroids had been watched and calculated for many years and scientists had plenty of time to prepare the 10 month mission for the 610 kg probe. But what to do if an asteroid is detected too late or is too big for any counter-measures with current technology? According to Brian Marsden of the British Minor Planet Center it is hardly possible to calculate an asteroid´s trajectory seriously by using terrestrial telescopes:"The small spread of those initial observations really means that we have only two independent fixes of the object in the sky...the two positions are each described by two coordinates on the sky background, so we have just four independent pieces of information altogether. But the orbit of an object we can reasonably presume to be traveling in a conic with the sun at a focus requires six pieces of information in order uniquely to define it"(Marsden 2004). So how to get the two missing coordinates to calculate the path of a NEO ? In 2006 Rudolf Dvorak, Vienna Institute of Astronomy, in cooperation with Werner Grandl (Grandl 2009), proposed to post robotic telescopes in the Lagrange Points L4 and L5 of the Sun-Earth system. The two robotic space telescopes together with terrestrial telescopes would enable astronomers to define an asteroid´s orbit by the required six quantities. By this space-based array of observatories we could detect NEOs very early (Figure 5).

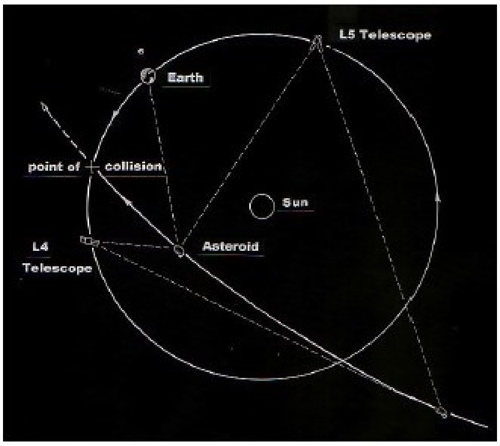

Figure 5. Space-base array of telescopes to gain six coordinates of an asteroid trajectory

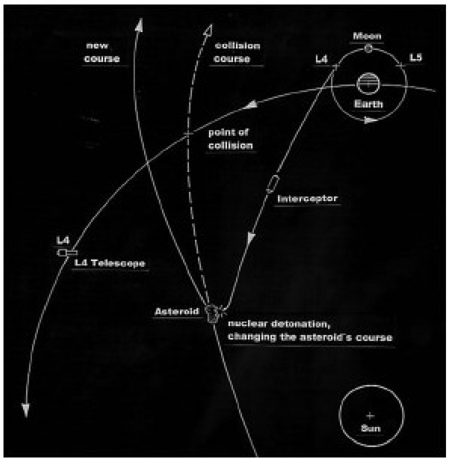

Figure 6. Intercepting an hazardous asteroid by a lateral nuclear detonation

Why NEOs can be profitably considered in-situ resources for the kick-off of space industrialization and settlement.

Considerations similar to the ones made about ODs can be made about Near Earth Objects. The risk posed by NEOs is different from the one posed by ODs. A killer asteroid impact on Earth is estimated in the order of one in millions years, yet with a potential life ending effect. The probability of an orbital debris impact on a spacecraft is very much higher, with a high risk for the life of the spacecraft's passengers, yet zero danger for life on Earth.

Thinking about existential risk posed by NEOs, we could say that developing technologies and methodologies to protect our planet from possible impacts is a moral duty, even bigger than the obligation to reclaim orbit from space debris. Yet, the potential market is very much bigger as well. And, maybe more important, such a market will not be subject to an end, yet we can just imagine a continuous growth.

NEOs have a great potential for the following reasons, at least:

- Asteroids mining can yield raw materials for producing fuel in space and for the building of space infrastructures.
- NEOs – properly dug inside – can be used to build space habitats, endowed with simulated gravity by rotation, and a valid protection from cosmic radiation, by the interposition of many meters of rock between the habitat and the external space.

Committee Objectives:

This committee's objectives is to actively participate in the discussion of these two topics from a multidisciplinary point of view.

Research objects

a) estimate possible ROI of a OD R&R industry
b) estimate the potential duration of OD R&R industry, based on the quantity of existing materials and capability to exploit them
c) analyzing existing business plans about OD R&R industry
d) analyzing existing technologies studies and projects for (big and small) orbital debris recovery
e) analyzing existing business plans about NEOs mining industry
f) analyzing existing technologies studies and projects for NEOs mining

Current Efforts & State of the Art (here shall be attached references to existing literature, polices, agreements and formal recommendation made by the specialists)

Coming soon

- ESA'S ANNUAL SPACE ENVIRONMENT (Unclassified) Prepared by ESA Space Debris Office - REPORT 2021
- The United States Space Surveillance Network (SSN)
- UNCOPUOS Guidelines for the Long-Term Sustainability of Outer Space Activities published in 2019

Development Plan(s), Agenda, Current Works, Projects, Meetings

Coming soon

Partnerships

- Can we partner with ESA, NASA and other agencies to act as extension of their educational network?
- Can we start a study or survey with the space agencies?
- Can we connect with the IAA and AIAA?

Coming soon

Resources (A list of organizations and offices working on this topic). **Coming soon**

Note: this sample methodology for the Space Debris & Near-Earth Objects Committee is based on an initial proposal by Nancy Wolfson.

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