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ISRU AND THE OFF-EARTH MINING VALUE-CHAIN: AN INTEGRATED CIRCULAR ECONOMY FOR SPACE RESOURCES

Abstract

The well-established terrestrial mining industry easily lends its expertise and technology to space-mining needs. The mining value chain, commonly cited as an analogue for space resources, is typically portrayed as a linear process. However, changes have occurred to the terrestrial chain over recent years as technology, economies and societal expectations have evolved. The industry is adapting to the circular economy. Although the transition is slow, closed-loop thinking is encouraging new technologies and practices. Energy options are being diversified and water use is being reduced, elements and minerals discarded in waste are being recovered and mines are finding new ways to reduce environmental footprints. In some cases a mined void is getting a new-lease of life. The chain is aiming towards a zero-waste, high-value industry whose activities will act as a loop and not simply linear.

The concept of in-situ resource utilization (ISRU) itself, is established on the principles of waste reduction: why use Earth's resources to transport other Earth resources to the moon or Mars, when resources are available out there? Quite often though, ISRU value chains are not presented with waste avoidance in mind, and rehabilitation or remediation are often not even considered in the value chain, leaving the onlooker with the impression that ISRU ignores the environmental footprint. While that is not true as it is an area of research and commitment in its own right, there is an opportunity to present the industry as an ISRU value-loop, that clearly defines the philosophy and practice around a new kind of mining industry, influenced by the most modern of terrestrial mining practices. The circular economy is a natural industrial progression on Earth and beyond. As well as ISRU to save Earth resources the idea of space-waste use, collecting and utilizing technology discarded in to orbit over the years, is developing.

We present a circular ISRU 'value loop' reinforced by cross-cutting, support systems that use a common process in terrestrial mining, the Environmental Impact Statement, to measure, monitor and mitigate the processes including:

• Resources prospecting • Use of discards • Site planning beyond its life as a mine • Selective mining • Resource transport • Storing, Refining, Manufacturing and Supplying products • Redefining and rehabilitating the site • Value from every grain moved • Avoiding resource and capitals waste

Considering every activity as a whole-of-life-cycle process will avoid loss of energy, and value and improve off-Earth activities.