

Enagaging The Mining Industry In ISRU. Dale Boucher¹ and Douglas Morrison², ¹Interstellar Mining, One Yonge Street, Suite 1506, Toronto, Ontario, Canada, M5E 1E5, dboucher.deltion@gmail.com, ²Centre for Excellence in Mining Innovation (105 Elm Street, Sudbury, Ontario, Canada, P3C 1T3, dmorrison@cemi.ca).

Introduction:

To many organizations in the mining sector, there appears to be little connection between the terrestrial mining business and ISRU. The massive scale of materials handling required in the mining industry compared to the extremely small volume of material movement currently anticipated on the Moon is a strong indicator of this disconnect. There are two disruptive forces at work in these sectors:

1. the underestimation by the mining industry of the technical-economic challenges that must be resolved if the industry is to deliver the metals and minerals that are required to meet the energy transition to a low-carbon economy, and
2. the under-estimation by the Space Sector of the fundamental engineering challenges that must be addressed to achieve a continuous human presence on the moon.

Mining Industry:

The Mining Industry is comprised of five distinct elements;

1. Major Mining Corporations ('Majors'),
2. Mid-Tier Mining Companies ('Mid-tiers'),
3. Mineral Exploration Companies ('Juniors'),
4. Original Equipment Manufacturer (OEM) Companies, and
5. Mining Service and Supply (MSS) Companies.

With an additional 4 elements consisting of:

6. Industry Associations
7. Research Groups
8. Business Incubators and Technology Testbeds,
9. Innovation and Commercialization organizations.

Mining companies are generally considered to be elements 1, 2 and 3 with the remaining elements considered to be Mining Services and Supply (MSS). This split is fuzzy, since many of the mining companies will often take on some or all of the tasks that are usually considered to be within the MSS group.

Mining companies strictly adhere to the Return On Investment (ROI) curves depicted in Figure 1. These curves are determined long before any mining operation even begins its construction phase, so the mining companies are reluctant to pursue any actions which may negatively affect this ROI.

The MSS group is, by nature, agile and driven by market opportunities with shorter lead times. Many in the MSS group actively pursue new opportunities with the end game being enough of an edge over the competition to gain a significant market share. Most MSS companies will adhere to simple linear programming techniques to determine investment potential in new technologies or services.

CEMI's Approach to Innovation

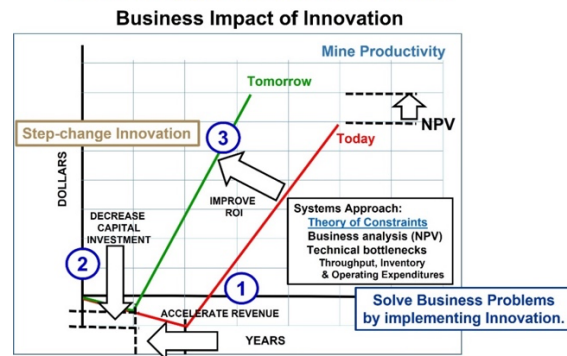


Figure 1: Mining Industry typical ROI curve

Approaches:

To encourage mining industry participation in ISRU, the approach must be keyed to the drivers for each of the two groups involved. The end goal must be to change the investment ROI early. For mining companies, the approach is to show that there can be a net positive improvement to the ROI curve over the life of the mine, typically 5 or more years. This should be demonstrated early in the mine cycle and with sufficient confidence that investors can be certain mine management groups will achieve the intended results. For existing mining operations, if a net improvement can be shown within one or two fiscal quarters, then the risk is considered reduced and new ideas can be adopted. Once one mining company adopts a new technology and demonstrates net benefit, other miners will follow. This is best described as the "first to be second" attitude in mining.

For the MSS group, the approach must be to demonstrate that the investment in a new technology will have a net positive improvement in their operations within one or two fiscal years and that there is a real opportunity for expansion of their product line or market slice. Thus, the development of a one-off or custom item with long time lines and unstable budget is not attractive to the MSS providers. Incremental improve-

ments in an existing product line, however are very attractive, since the market is established and product improvement will generally allow the provider to expand market share.

In the space sector, product developments chase missions on a per mission basis. Funding for technology development focuses on the development of unique technologies or capabilities to try to answer science questions. Space agencies refer to this concept as technology enabled science. This usually results in one-off developments yielding orphaned and dead-end technologies. The development cycle itself is long and produces a series of prototypes of the technology as the tech migrates through the TRL scale. Funding of the tech development is inherently not stable or predictable enough to encourage mining vendors to participate.

Barriers:

The main barriers to participation in ISRU that the mining industry faces are :

- 1) Potential negative effects on existing mine and MSS operations (loss of focus)
- 2) Problematic security protocols (ITAR, vetting employees and managing security issues at a level not required for their existing client base).
- 3) Testing opportunities to confirm operational capabilities and demonstrate to reluctant and tech-averse end users (mining companies) that the product is commercially viable.
- 4) Clean room assembly process utilizing experienced staff for flight hardware, for which the mining industry has no existing requirement.
- 5) Lack of understanding by the mining sector on the realities of space 'mining.' While many in the mining sector claim to understand what space mining is, very few really grasp the complexities or differences imposed by the extremely difficult conditions that exists on the lunar surface. The MSS group is generally intrigued by the concept of space mining and the interest in participation in developing techs for this sector is very high, so long as the MSS providers perceive an operating model that connects these new systems to the needs of their traditional customer base.
- 6) There is little understanding of the possible collaborations between mining and space sector technology developers.
- 7) Fear of loss of ROI due to low volumes of product. The terrestrial MSS relies on large volumes of product to reduce costs and provide sustainable employment for their personnel.
- 8) Building prototypes requires significant resources. Space technologies are virtually all prototypes, from a mining perspective. This reduces ROI due to

the loss of product completions (widgets out the door).

- 9) Many of the mining sector companies consider space to be a future workplace. Thus, the mining sector does not want to engage in space development because of a perceived need to solve issues on earth first, which translates into ROI for all involved.
- 10) Fear of loss of IP. It is a known hazard in mining and a less well known hazard for the transition to space based activities.
- 11) Regulatory regimes can discourage participation. There are a number of regulatory issues that could be amended with very little cost to the government, that would encourage participation in space technology development.
- 12) Lack of stable funding or large quantities of product (build to print?).

Recommendations:

1. **Develop an Operational Roadmap** for Lunar ISRU that will address the priorities, timelines and gaps that exist between real and assumed capability to execute physical developments on the surface of the moon. The existing ISECG Functional Roadmap encourages higher-level resource utilization topics to be investigated while the basic engineering capabilities that would make them possible have largely been ignored.
2. **Respond to the Ecosystem Interest** by scheduling a program of engagement events specific to the Mining Industry. Mining innovators are not researchers, they are commercial enterprises with techniques and technologies that they intend to use to grow their businesses.
3. **Establish a Commercial Model for Mining & Space Innovation.** There must be a clear pathway that illustrates how investments in technologies designed for applications in ISRU can be translated to versions of these technological solutions that have application to terrestrial mining operations.
4. **Stimulate cross-sector investment for Mining and Space Innovators.** Both sectors need to attract greater involvement from private sector investors. Eg, the mining sector already has the flow-through share program which, if used as an **Investment Model** for the Lunar ISRU, would accelerate private investment in ISRU.