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THE CIS-LUNAR ECOSYSTEM SIMULATOR - AN INTERACTIVE SYSTEMS MODEL AND SCENARIOS OF THE RESOURCES INDUSTRY

Abstract

Several private companies are planning to establish new business ecosystems in space, the most famous being SpaceX's Mars colonization plan. This study's task is to model future ecosystems in cis-Lunar space, for a leading small space company, using a recently-developed multi-methodology based on System Dynamics and scenario planning. The client's goal is to help create the ecosystem, by promoting stakeholder engagement with a logical vision, and by understanding societal dynamics and key levers. The ecosystem is a space resources industry focused on Lunar water, presented as a dynamic online simulator. The scope includes both economics and engineering, with the objective: "*To articulate a credible, feasible $40B cis-Lunar economy: 'vision 2040'*".

System Dynamics (SD) modeling is common in business & policy planning, popularized by *The Limits to Growth*. It visually shows a problem's "dynamic structure", and models both social & technical variables. Formal scenario planning grew out of WW2 planning, and became famous via Shell after the 1970s oil shocks. Scenarios are imaginative "histories of the future", that articulate plausible futures and isolate key decisions. SD and scenario planning have complementarities, which we employ.

We first narrow down candidate markets to GEO telecom and exploration markets, focusing on the supply side. Scenario planning ranks *Quantity & accessibility of resource finds* as the most critical uncertainty, followed by *Priorities of government expenditure on resource exploration*. The SD model is based on oil industry models, and is primarily four interacting systems: a resources *it exploration system*, a *production system* focused on resources sales, an *R&D system* increasing the level of exploration technology, and a *demand system* (with underlying *satellite industry*). There are also a *natural (resources) system*, and *government system* - a source of exogenous interventions.

The SD model helps articulate 2 distinct scenarios in detail (from 4 key identified). *Moonopolis* is characterized by plentiful resource finds, strong government support for production, and a significant private on-orbit refuelling market. *Apollo 2.0* is a low-resources scenario, but with robust government support.

Sensitivity analysis of 20-year ecosystem size reveals the top third of 25 variables *each* impact by a factor of 2. Production uncertainties dominate; the structure of the problem seems to be a series of further bottlenecks. Ecosystem sizes of $20B/year by 2040 may be achievable. Users can vary uncertainties and assumptions, observing real-time impacts on ecosystem dynamics. The simulator captures rich data on user beliefs, and can be a tool for planning workshops.