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ACOUSTIC SHAPING: ENABLING TECHNOLOGY FOR A SPACE-BASED ECONOMY

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This abstract presents three points for discussion:

(1) Key to the development of civilization in space, is a space-based marketplace, where the need to compete in earth-based markets is removed, along with the constraint of launch costs from Earth.
(2) A body of technical results, obtained by the authors' team, indicates promise for non-contact manufacturing in space, of low-cost items required for human presence in space. This is presented along with various other techniques which hold promise.
(3) The economics of starting a space-based production company are heavily dependent on the presence of a rudimentary infrastructure. A national-level investment in space-based infrastructure, would be an essential catalyst for the development of a space-based economy. Some suggestions for the beginnings of this infrastructure are repeated from the literature.

Snapshot of space-based activities, 1999

The vast majority of human activity in space today is related to telecommunications and remote sensing. Offshoots of military initiatives, both have revolutionized earth-based markets, providing order-of-magnitude leaps in several technologies. Launch costs from Earth to low Earth orbit range from the claimed $4000 per kg to $29500 per kg depending on the size, sophistication and need for attention. The risk of satellite failure, and the extreme cost of repair, if at all possible, increase launch costs.

For obvious reasons, earth-based markets, and high launch cost per unit mass, dominate current thinking on space-based business. The criteria for space-manufacturing concepts are [1,2]:

1. the existence of an Earth-based market where high prices can be commanded for an extended period (examples: drug and crystal manufacture), or mass-market delivery can be achieved at a low per-customer cost (example: communication technology.
2. A 3-to-5 year Return on Investment is seen as being essential for space-based business concepts [3].

All of this constricts the rate of expansion economic activity in space. Grand dreams abound, of going to find water on the Moon to convert into propellant, or going to asteroids to mine platinum, or to Pluto to bring back Helium-3 [4]. Again, these are driven by the same criteria given above.

Point Number 1: Space-Based Markets

As long as attention is focused on high-value precious metals and fuels, only a low-level, subsistence economy appropriate for the frontier prospector can develop. It takes infrastructure to develop a true high-level economy. Economic activity migrates to places which offer basic infrastructure, first because people can find jobs creating products and services for other who live there, and eventually because it is convenient to live there. The process is self-sustaining and self-expanding, as the economy moves to higher and higher levels. This infrastructure is built from low-tech materials such as concrete, silicon dioxide and aluminum oxide, and base metals, not from platinum and Helium-3. The markets for these materials and products are thus in space, not on Earth. The creation of such a production economy implies demand for attendant services, and offshoot production plants, all dependent on space-based markets, not earth-based ones. Production of concrete from lunar materials has been considered, and the technology exists [5,6].

Point Number 2: The Technology of Acoustic Shaping

The concept of Acoustic Shaping has been studied at Georgia Tech through ground and flight experiments. In microgravity, resonant sound fields can form pulverized material into specified surface shapes. Flight experiments show good prospects for producing flat and curved panels, using materials such as pulverized solids and binder liquids, with non-contact, automated processing using sound generated in closed, pressurized containers. The shapes are appropriate for fuel tanks, heat shields, greenhouses, habitats, and plumbing. Success has the potential to accelerate human activities beyond Earth, by enabling mass-production of the paraphernalia essential to human activities. The ground-based research, numerical predictions and flight experiments needed to develop this technology are outlined in refs. [7-9].

Point Number 3: The Argument for Infrastructure

Recently, a team of Georgia Tech students under the guidance of the author, studied the avenues to develop their concept for space-based manufacturing of pressure vessels, heat-shields, and other low-tech, high-volume paraphernalia of extra-terrestrial human civilization. Their conclusion regarding the economics of the venture [9] was confirmed by the experience of the other student teams in the NMB program [10]:

Development of a basic infrastructure is a crucial step to every such endeavor. Such an infrastructure is beyond the capability of private enterprise to develop, since the payback period is far too long. It is well within the scope of what government can accomplish. However, with such an infrastructure developed, it is feasible and realistic to make a profit in space, focusing on space-based markets, and with significant independence from the vagaries of earth-based markets or individual space-mission programs.

Three basic items were identified for consideration by government agencies:

1. The establishment of a pressurized "industrial park" in low earth orbit using STS external tanks, a concept proposed in [4,11]. This would vastly reduce the cost of setting up production facilities of moderate size, needed to produce useful items in large enough quantities. Studies have shown than the "delta-v" needed to boost the external tank into orbit, rather than letting it fall into the Indian Ocean, is of the order of 100 mph, which appears to be achievable at an acceptable cost in STS payload.
2. The development of a robotically-operated, solar-powered electromagnetic mass driver facility on the moon. The "delta-v" needed to reach orbital speed from the moon, with moderate acceleration, can be achieved using a launcher of moderate length [4,9]. Such a facility would facilitate many enterprises which seek to establish mining operations or usage of lunar materials.
3. "Transit Systems" such as the "Cyclers" proposed by Aldrin [12] or tethers [13] will reduce transportation costs dramatically.

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