CAN WE ACHIEVE ECONOMIC SUSTAINABILITY IN THE SPACE ECONOMY? Jeffrey Cleveland, Colorado School of Mines, 1500 Illinois St, Golden, CO 80401; jeffreycleveland@mines.edu

Introduction. The topic of sustainability has grown over the years to touch upon numerous facets of human activity: our interaction with, and use of, the environment; agriculture; corporate business; education; ecology; energy; even social and political structures. In some instances, the concept of economic sustainability has started to become an area of critical thought and discussion. However, there is little evidence of any serious examination of economic sustainability regarding the space economy.

As space activity continues to expand beyond the historical model of government-led missions, this concept of sustainability has begun to emerge regarding to the long-term viability of the space economy. While recent years have seen rapid growth in launch cadence (with its corresponding decrease in launched cost per kilogram), private investment, and commercial participation, high rates of growth do not inherently imply sustainability.

In this presentation, we tackle one of the central questions facing academics, policymakers, and industry participants alike: Can the space economy achieve economic sustainability? And what does that really mean?

Defining the Space Economy. This analysis begins by defining the space economy using official national accounts data from the U.S. Bureau of Economic Analysis, along with widely cited global assessments from international institutions. This data tells a mixed story at best: nominal statistics imply a steadily growing economy, while adjusted-for-inflation growth of the US space economy has been relatively flat for the past decade. Global space activity, meanwhile, has grown at a faster rate. Underlying these statistics are questions of what is driving growth (demand v. supply); where economic activity is centered; and how public vs. private investment fuels the space economy.

Space Economy Scope
- Mfr and ops of spacecraft, satellites, components
- Launch services
- Satellite communications
- Navigation
- Earth sensing, observation
- All other related gov't and commercial activity [2]

Size
- Global: ~$650 billion [3, 4]
- U.S.: ~250 billion [5]

Trajectory (CAGR)

Global (2015–2024) [6]
- Nominal: ≈ 8.7%
- Real: ≈ 5.6%

U.S. (2012–2023) [7]
- Nominal: ≈ 2.1%
- Real: ≈ **-0.8%**

What is Sustainability? Firms across the space industry mirror many aspects of a galaxy's star life cycle: birth, growth, maturation, and perhaps even death. Once past the start-up stage, most companies have a laser focus on growth: produce more, sell more, earn more…and repeat *ad infinitum*. Companies that survive and thrive achieve what Webster defines as growth: progressive development and evolution; increase and expansion. [1] But can this cycle be repeated forever?

Research indicates a broad set of definitions addressing the concept of sustainability. Key elements include [8–15]:
- "…future generations…"
- "…planetary boundaries…"
- "…[prevent] unacceptable environmental change…"
- "…understanding capacity of ecosystems…"
- "…non-declining intergenerational opportunities…"
- "…internalize environmental stewardship…"
- "…environmental, economic, and social pillars…"

Creating a Multi-dimensional Framework. To address these issues, we introduce a multi-dimensional framework for defining economic sustainability in space, moving beyond conventional basic environmental definitions. The framework identifies six interrelated dimensions:

Figure 1. Economic Sustainability Model for the Space Economy.

- **Financial sustainability**, the ability to attract, retain, and grow capital across long time horizons
- **Technological sustainability**, reliability, scalability, and risk reduction
- **Temporal sustainability**, alignment across long investment horizons and multiple generations
- **Environmental and Resource sustainability**, including orbital congestion and long-term system carrying capacities
- **Legal sustainability**, operating in an environment of legal and regulatory uncertainty
- **Constituent sustainability**, the durability of stakeholder support, including governments, investors, and end users

These pillars will allow us to begin to determine whether activity in space can continue to achieve periodic success, or if it has what it takes to be sustainable long-term.

Real-World Proof Points and Discussion. We then anchor these ideas with a litany of real-world examples from the last 25 years of commercial space activity. Global launch statistics from 2000 to the present demonstrate that orbital launch has achieved high technical reliability (although not airline flight levels of reliability), with success rates exceeding 95 percent, even as annual launch volumes have increased dramatically. But lunar landing mission statistics over the past decade tell a markedly different story.

Figure 2. Lunar Landing Mission Success Rate, 2015-2025

However, we see a trend in company-specific data — particularly among the fleet of space-focused companies that went public through Special Purpose Acquisition Companies (SPACs) in 2020 and beyond — of remarkable technical achievements failing to translate to economic sustainability. Several firms achieved operational milestones yet struggled to maintain shareholder value, while others are currently riding the wave of unmitigated shareholder valuations that defy gravity due to overall market and sector buoyancy, regardless of actual worthiness.

The presentation also examines emerging pathways that may support sustainable economic outcomes across the framework's six dimensions. These include the development of dual-use technologies that serve both space and terrestrial markets (the latter providing firms with much needed ongoing revenue); infrastructure-oriented business models in cislunar space that enable downstream activity rather than relying on single-mission economics; and evolving procurement approaches that gradually shift demand risk from governments to commercial markets. The analysis emphasizes that sustainability in space is unlikely to arise from technological progress alone, but from institutional arrangements, market mechanisms, and governance structures that align incentives extending over very long time horizons.

Summary Rather than attempting to provide solutions, this presentation offers a framework through which we can identify, evaluate, and solve for sustainability. By taking a hard look at the space economy through the lenses of economics, history, and current events, we can begin to identify which parts of the space economy are built to last — and which are not. This presentation aligns with several objectives of the 2026 Space Resources Roundtable by directly addressing specific economic, environmental, and ethical aspects of space resource utilization, and by framing sustainability as an economic challenge demanding deliberate strategy, and not merely technological optimism based solely on opportunistic success.

References.

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