ASCEND

DEEP-SPACE (Geosynchronous Orbits and Above): GOVERNMENT'S ROLE IN ACCELERATING SUSTAINABLE DEEP SPACE EXPLORATION & SPACE COMMERCIALIZATION

MICRO-17 Session Summary

Executive Summary

A panel session and a roundtable discussion on Deep Space (Geosynchronous Orbit and Above): Government's Role in Accelerating Sustainable Deep Space Exploration were held at 2022 ASCEND to review similar historic challenges and solutions from other domains and attempts to highlight possible opportunities for the United States and partners to accelerate deep space exploration in a safe, sustainable ecosystem. This report discusses the status and strategic implications, while making actionable recommendations to the government and commercial partners.

Introduction

Global civil and commercial teams see significant opportunity in deep space (beyond geostationary orbit (GEO)). Opportunities include exploration to the moon, Mars and beyond, tourism, mining, and science and technology to enable deep space observations and more. Unfortunately, deep space missions are costly and have significant technical barriers to entry with limited supporting infrastructure available. Challenges include launch, communications, space weather sensing, anomaly resolution, and position, navigation and timing. Additional missions such as servicing and crisis response are still extremely complex, and the needed technology is still maturing. As the NASA and commercial communities venture deeper into space, there is a growing need to enhance and accelerate deep space access and sustainability through Department of Defense (DoD) and civil partnerships within the United States (DoD/NASA/Department of Commerce) and with the international community (e.g., ESA, etc.).

The panel session reviewed similar historic challenges/solutions from other domains and highlighted possible opportunities for the United States and its partners to accelerate deep space exploration in a safe, sustainable ecosystem. The panel briefly discussed current deep space initiatives and significant progress (e.g., Artemis and the Artemis Accords). The panel also outlined challenges, historical context, and possible "tipping point" events that will fully enable commercial concepts. Participants from commercial companies and industry groups provided their inputs to this problem. In contrast, the roundtable session gathered inputs from small group participants on the same topic — identify remaining barriers and next steps required to further commercialization in the deep space ecosystem. Specifically, the small groups were asked what actions the U.S. government can take to enhance and accelerate deep space exploration, scientific discovery, and commercial development through innovation, partnerships, and core investments in the deep space ecosystem to reduce the financial and technical barriers to entry. The output of both sessions was to formulate discrete technical, contractual, or partnership solutions, opportunities, and recommendations for U.S. government/allied action.

Panel Session Conclusions

Historically, deep space is also entering its third phase of exploration with an uncertain outcome. The Soviet-U.S. race to the moon (phase 1) was followed by an exponential increase in technology maturation (phase 2). Multiple countries are now exploring deep space. Lunar landings have been performed by three countries, five countries have satellites in orbit around the moon, and multiple international commercial ventures are investigating the moon as a source of income – many of which are not part of the cooperative Artemis Accords. The United Arab Emirates Hope probe also recently reached Mars' orbit, making it the first Arab country to reach Mars and the fifth country globally to reach the red planet.

Phase 3 of deep space exploration also represents a conjunction of space sectors – intertwined, connected, and closer. The November 2022 U.S. National Cislunar Science & Technology Strategy outlines how fostering scientific discovery, economic development, and international cooperation are essential to sustaining leadership in this area. Tangible evidence includes the partnership with the European Space Agency on the European Service Module to get to astronauts to the moon and the pressurized rover from Japan. There are also clear lines of responsibility within the U.S. government. NASA relies on the U.S. Space Force (USSF) for recovery and launch vehicle range operations while the USSF supports human space flight and space debris conjunction assessment for geosynchronous orbit and below commercial and civil space. The Planetary Defense Coordination Office is a great example of deep space situational awareness (SSA) cooperation.

The most significant government-led deep space initiative is the NASA Artemis program. NASA's Artemis website (as of 1 December 2022) states:

> "With Artemis missions, NASA will land the first woman and first person of color on the Moon, using innovative technologies to explore more of the lunar surface than ever before. We will collaborate with commercial and international partners and establish the first long-term presence on the Moon. Then, we will use what we learn on and around the Moon to take the next giant leap: sending the first astronauts to Mars."

Artemis I launched on 16 November 2022, with Artemis II-IV currently being built. Artemis I marks the agency's return to lunar exploration as established by the Apollo program decades earlier. Artemis will build off of the Apollo program, but with an emphasis on a sustainable deep space presence. The program will have very visible science objectives and also leverage lessons-learned from the International Space Station's (ISS) commercial and international partnerships. Not being afraid to fail while executing with speed and discipline will be key tenants.

The program also includes the Artemis Accords policy framework. The Artemis Accords are a series of non-binding multilateral agreements between the U.S. government and other partner nations participating in the Artemis Program. As of July 2022, 21 countries and one territory have signed the accords, including eight in Europe, seven in Asia, three in North America, two in Oceania and two in South America. Drafted by NASA and the U.S. Department of State, the Accords establish a framework for cooperation in the civil exploration and peaceful use of the moon, Mars, and other astronomical objects. They are explicitly grounded in the United Nations Outer Space Treaty of 1967, which signatories are obliged to uphold, and cite most major UN-brokered conventions constituting space law.

On the commercial side, deep space activities are still in the development phase and are not as mature as near-Earth (GEO and below) commercial operations. Deep space commercial ventures are dominated by in-situ resource utilization (ISRU) opportunities with available dollars diluted across several activities. Substantial progress may involve focusing funding on a few ideas, which could lead to zero money in some area. However, the future looks very bright for ISRU given the massive inefficiencies of logistically supporting deep space missions from the Earth. What a logistics In-space Servicing Assembly and Manufacturing (ISAM) infrastructure architecture entails to support deep space is still developing.

The conjunction or intersection of deep space commercial and government is becoming clearer with the publication of the U.S. National Cislunar Science & Technology Strategy. For example, space situational awareness is the necessary foundation to enable transparency and safe operations for all entities operating in cislunar space. As activities in cislunar space increase, the U.S. government will define requirements for new space situational awareness capabilities, including associated reference systems and data-sharing approaches. In addition, communications and positioning, navigation, and timing (PNT) are the common information infrastructure needed for all activities in cislunar space, including lunar orbit and lunar surface missions. This objective will ensure that infrastructure deployed for NASA's Artemis program can also help enable a cooperative and sustainable ecosystem in cislunar space. Implementing needed cislunar communications and PNT capabilities with scalable and interoperable approaches can foster new commercial development and lower barriers to entry while advancing responsible and safe spaceflight practices.

For deep space commercialization to rapidly accelerate, several "tipping point" policy and technology maturations must occur. For example, nuclear thermal propulsion for beyond-lunar missions will be important, while the long distances from the Earth to deep space will require artificial intelligence, machine learning and autonomy to overcome a lack of hands-on capability. Agriculture in the right environment will also be needed for sustained operations. Finally, a solid business case for deep space along with retired risks in technology and norms of behavior policies will be key drivers. The commercial opportunities with the highest returns on investment are somewhat unclear.

Roundtable Conclusions and Recommendations

OVERALL CONCLUSIONS:

1. Private sector needs a clear and consistent demand signal. The White House-level National Science and Technology Council outlined this problem in the In-Space Servicing, Assemble and Manufacturing (ISAM) National Strategy, but there is no White House-level strategy in ISRU or other deep space commercial opportunities to drive government and commercial investment.
2. Commercial systems need to continue to be tested. The USSF and NASA have excellent test facilities for helping mature deep space technology. Commercial ventures need continued support in key areas with Cooperative Research and Development Agreements (CRADA).
3. Look for service-like agreements with commercial entities that can enable the U.S. government to be an anchor tenant for commercial provides. Several companies are already discussing "landers as a service" type of offerings. These types of capabilities should be identified and grown.
4. Government will have to provide some initial services: space situational awareness, communications, PNT services, lunar landing zones. The U.S. government already provides SSA services (conjunction assessment) for commercial GEO communications satellite owners and the global positioning systems (GPS) and other global navigation satellite services (GNSS) offer terrestrial PNT services. A plan for government-provided services needs to be developed.
5. Non-standard government programs such as X-Prizes may be the right vehicle to spur innovation and commercial ventures. There is a recognition the available dollars in this area may be diluted to the point that progress is too slow. An X-Prize may be the right way forward to rapidly spur innovation.

RECOMMENDATIONS:

1. Sustainability needs to be defined and the needed technologies to support such a concept
   - Meaning of sustainability
   - Needed logistics
   - Needed technology
2. Develop a national strategy and definitions in ISRU
   - Something like the ISAM strategy for cislunar S&T strategy is needed
   - Roadmaps are needed; while it is uncomfortable to pick winners and losers, it may be necessary to select a few to make real progress
   - Clearly define capabilities the government will provide (PNT, SATCOM, SSA, landing zones, etc.)
   - Engagement with venture capital groups to determine what is needed, what may have high return on investment, and how/if the U.S. government can be an anchor tenant
3. Improvements to the small business engagement processes, including
   - Cross-agency single portal for small businesses to engage with government space
   - X-Prizes in deep space may be the right engine to start innovation

Acknowledgments

AIAA would like to thank the following people who participated in the panel and roundtable:

PANEL:

Moderator: Russ Teehan, Kuiper Government Solutions Principal Solutions Architect, Amazon

James Free, Associate Administrator, Exploration Systems Development, NASA

Lt. Gen. John Shaw, Deputy Commander, U.S. Space Command

ROUNDTABLE MODERATORS:

Lead Moderator: Lawrence (Robbie) Robertson, Lead Space Experimentalist, Air Force Research Laboratory

Joseph Anderson, Vice President, SpaceLogistics LLC

Dean Bellamy, Executive Vice President, National Security Space, Redwire Space

Joseph Pelfrey, Deputy Director, NASA Marshall Space Flight Center

Col. Joseph Roth, USSF, Director, Innovation and Prototyping Delta and Senior Materiel Leader/Commander SSC Detachment 1, Space Systems Command

Note that this summary of the panel and roundtable output does not capture the specific words or opinions or any of the participants.