Terms of Reference for TDAMM Communications SAG

Space-based astrophysics requires that missions be able to downlink data to the ground. In the burgeoning field of time domain and multi-messenger astrophysics (TDAMM), the science drives the frequency of this communication both for downlinking data, and uplinking commands. In the last few decades, NASA has provided a wide array of options for communications, including Near Space Network (NSN), which is composed of Direct-to-Earth (DTE) ground stations for communicating with mission in Near Earth orbits; the Space Relay (SR), which operates a fleet of geostationary satellites known as the Tracking and Data Relay Satellite System (TDRSS); and finally the Deep Space Network (DSN) for communicating with missions at larger distances (e.g. Planetary Distances, Lagrange points).
The current fleet of rapidly-communicating TDAMM missions (e.g. Fermi, Swift, NICER) have utilized TDRSS assets to perform low-latency alerts and commanding that have enabled transformational TDAMM science. However, in the future it has been communicated[1] that TDRSS will be decommissioned, and replaced by a commercial service by 2030 with some period of overlap. The goal of this SAG is to, based on the science drivers, define requirements for comms systems to enable rapid commanding and downlinking of data for future NASA TDAMM missions. The SAG will define the requirements for communications that would enable future NASA TDAMM missions. The capabilities that would be enabled by the stringent comms requirements for TDAMM missions likely meet the needs of other future NASA missions.

Questions to be considered will be:

Science Drivers
1. How do the most rapidly evolving transient and variable TDAMM sources drive the requirements for commanding latency, data downlink latency, and data rates? What other TDAMM science drives these requirements?

Impacts of Not Meeting Requirements
2. What are the impacts on science for not meeting the required latency and availability? What science will be lost if latencies are significantly higher than requested. How does the discovery space scale with latency, and speed of data recovery?

Non-LEO orbits
3. How can rapid access to missions in missions in orbits outside of near Earth, such as L1/L2 orbits or cislunar orbits, be improved? Missions outside of LEO are limited and expensive, and require high bandwidth data downlinks from distant missions. However, given that these orbits provide many advantages, e.g. ability to observe for long periods without Earth obscuration and a more stable thermal environment, it is clear that demand for next-generation TDAMM missions in non-LEO will increase in the future. What are the science requirements for a next-generation comms system to support TDAMM missions, that drive latency and coverage percentage for communications?

Bandwidth

[1] https://www.nasa.gov/press-release/nasa-industry-to-collaborate-on-space-communications-by-2025

4. What are the requirements for bandwidth for future missions, especially TDAMM missions? Improvements in sensitivity generally lead to increased data volume. TDRSS provides Single Access (SA) Ku/Ka band for Low Earth Orbit (LEO) missions with large data volumes. How will this capability be maintained or increased in the future?

Latency and Coverage

5. What are the science drivers for low-latency commanding and downlinking of data for future TDAMM missions? Future TDAMM missions will likely trigger observations in response to a variety of ground and space based sources, so high-availability low-latency commanding will be crucial to maximize science return of these facilities. Rapid downlinking of data for fast turn around analysis and reporting of results is vital in the transient community to ensure rapid follow-up by all facilities. Maximizing high-quality coverage at all times ensures latencies are low for a variety of orbits.

Cost

6. How can NASA provide low latency and high bandwidth communications for missions scaling from CubeSats to Flagships, not disadvantaging TDAMM missions proposal costs? Proposal costs associated with comms are often prohibitively higher for TDAMM missions due to the need for low latency and high availability. Communications terminals need to meet the cost, mass, volume, and power requirements of missions of all scales.

Availability and Scheduling

7. Scheduling NASA comms assets requires significant lead times and personpower. How can NASA provide more flexible scheduling of NASA comms assets? TDAMM missions may be enabled by the rapid scheduling of passes in order to both downlink data and upload commands. Having this work in an automated fashion would lower cost of operations, removing requirements for example of having Mission Operations staffed 24/7. In addition, human-in-the-loop scheduling increases latency significantly.

Future Capability

8. Proposed missions and Announcement of Opportunities (AOs) have limitations on future comms solutions, however the AO documentation is not clear on what the capabilities are over time as the comm networks evolve. How can the evolving plan be better communicated to proposers? How can NASA improve opportunities for TDAMM missions limited by the current long-term outlook for SN, NSN, and DSN, relative to missions with more comms flexibility?

To address these questions in a timely manner to provide input to NASA to meet the needs of future TDAMM missions, we proposed to create a TDAMM Communications SAG. This SAG will be chaired by Jamie Kennea and Judith Racusin and will include representation from community stakeholders. PhysCOS and COR will advertise that community members may apply for SAG participation via a webform expressing interest and expertise, as well as reaching out to specific experts. After an application period of 1 month, the SAG chairs will select members for the group, maximizing diversity of experience and viewpoints. The TDAMM Comm SAG will have a 1-2 day hybrid kickoff meeting, and will continue to meet virtually at a regular cadence of at least once per month. The goal of analyzing the above questions to compose and publish a report, will be delivered to NASA HQ, by December 2023.