IP in Deep Space:
Key Characteristics, Use Cases, and Requirements
draft-ietf-tiptop-usecase-00

IETF 123 TIPTOP WG Meeting

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https://datatracker.ietf.org/doc/draft-ietf-tiptop-usecase/

We now have a WG draft (this was formerly draft-many-tiptop-usecase version 3). Version 1 of this draft was published on March 2nd and version 2 March 18th; here I will discuss changes from version 1.

This draft targets the WG charter item for "Key characteristics, uses cases, and requirements" (Informational).

Note: Some topics may migrate between the other architecture draft and this one.

- Architecture: https://datatracker.ietf.org/doc/draft-many-tiptop-ip-architecture/
- The WG charter calls for its adoption by November, 2025.
- There will likely also be some migration between discussions here and the new IRTF Space Research Group.

Topics Covered

Provides background/context on deep space link layers, operational aspects, and application layer topics.

Considers common facets, as well as points specific to different mission operating locations (Moon, Mars, Lagrange points, etc.). Note that for the planets, the cruise phase is an important, if mobile, location.

Develops requirements for consideration in the other WG documents.

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Challenges

We are trying to have a general document, but there are many specific details that vary between missions, and we try to be clear about those.

- Wide range of device capabilities.
- General differences between Moon and Mars.
- Differences between crewed and uncrewed missions (e.g. available coverage, redundancy, etc.).
- Special considerations for Lagrange point, surface-based missions, etc.

For requirements, we want to focus on the similarities (needs in common) and accommodate the distinctions that are needed.

Example: Lunar Assets

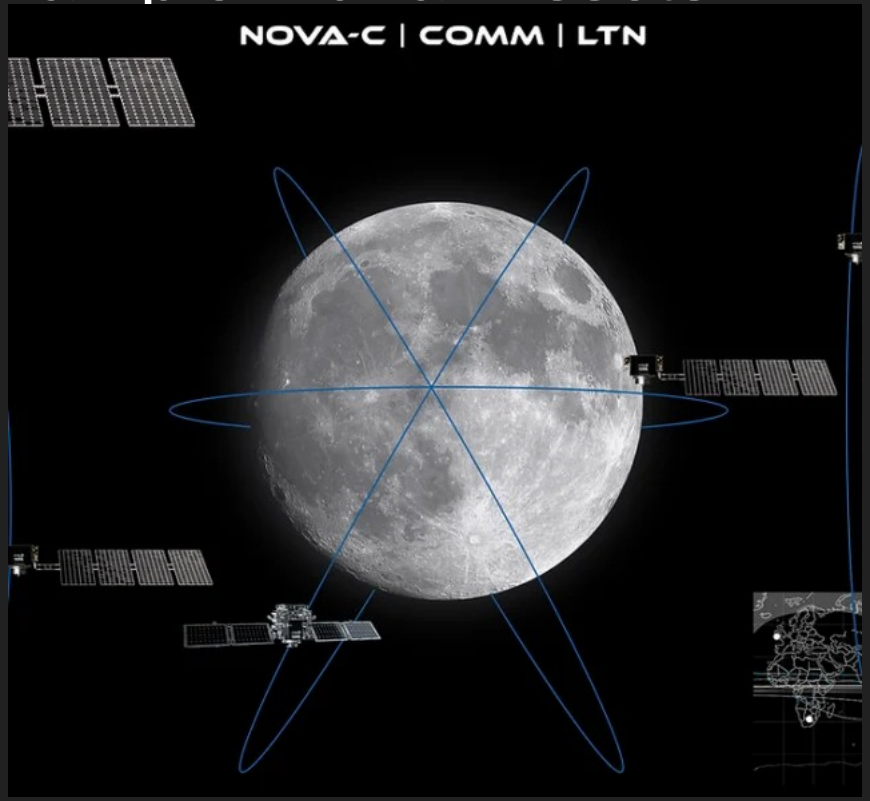


Image from Intuitive Machines

May have significant connectivity options, including:

- Multiple orbiting relay systems
- Multiple direct-with-Earth (DWE) providers
- Surface-to-surface networks

Much lower RTTs than Mars (seconds vs minutes), driving different ways of operating.

Differences between surface and orbiting missions.

The lunar far-side can have rather different communications requirements than other regions (near-side, LLO).

NASA has awarded Intuitive Machines a long-term contract potentially to develop, launch and operate a five-satellite communications and navigation network around the Moon. The first element may be launchednext year.

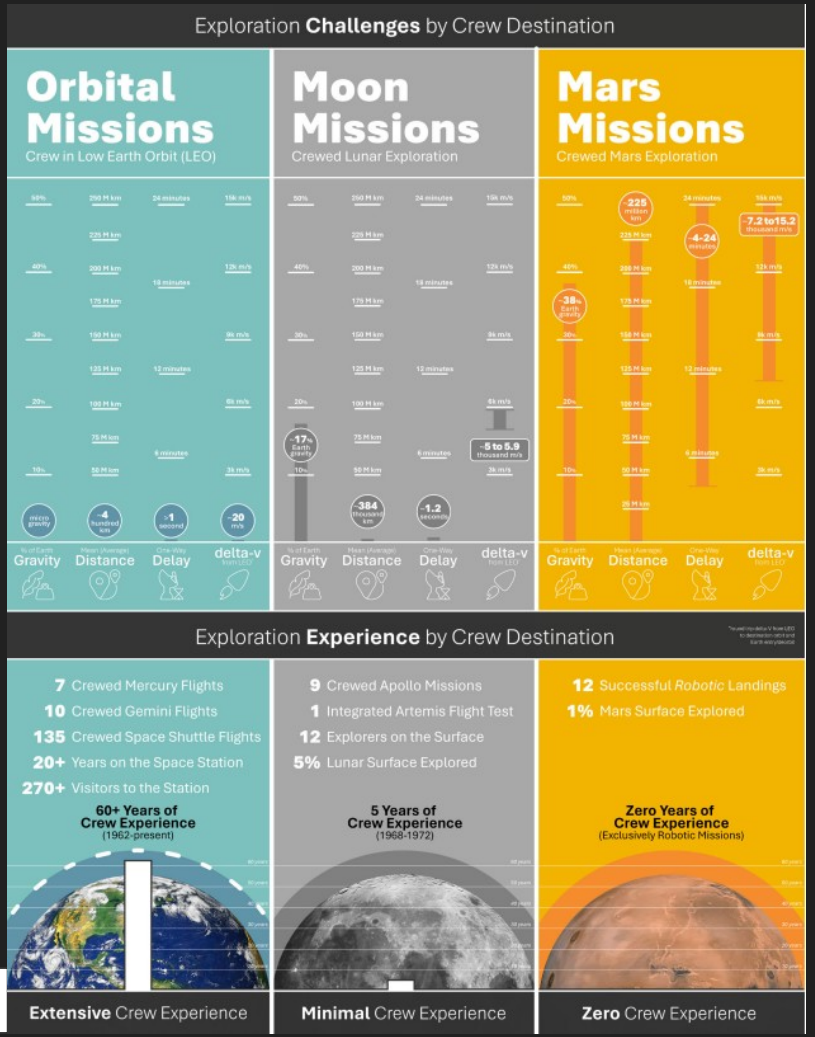
Example: Mars

Even less is certain about how networks will evolve for Mars missions.

Likely much less DWE opportunity as well as less routing opportunities and longer disconnection periods compared to other settings.

Similarities:

- Application aspects:
  - Commanding (low rate)
  - Telemetry
  - Science data (bulk transfer)
  - Messaging
  - Etc.
- Security aspects.
- A stated goal is to re-use many systems developed for lunar missions.



From Moon To Mars Archtecture Executive Summary:
https://www.nasa.gov/wp-content/uploads/2024/12/2024-architecture-executive-overview.pdf?emrc=4a55b3

Requirements Areas (Current Draft)

We focused on differences / gaps between the common terrestrial usage of IP stack protocols and the deep space use cases

1. Store-and-forward
2. Time
3. Signaling and Exchanges
4. Bandwidth
5. Transport
6. Transport
7. Addressing and Routing
8. Recovery on Reboot
9. Security Considerations

Not much time to discuss these in depth today; continue to discuss details on mailing list and in future WG meetings, after adoption.

Changes Draft 1 -> 3

The Introduction and Limitations of this document sections were substantially wordsmithed and (I think) improved.

Details and references to the CCSDS were added, as was a mention of LunaNet.

The text on (relatively slow moving) mobile networks on the lunar or martian surface was improved.

“2.6. Spacecraft Onboard” was substantially rewritten.

Sections 4.5 (Transport) and 4.7 (Recovery on reboot) were filled in, as was a draft Security Section.

Next Steps

We need to continue the discussion on the mailing list.

Based on recent discussion on the mailing list, I think that the Security Section needs more attention to reach group consensus.

Please read and discuss, so that we push this to publication.

Predictable Interruptions: Superior Conjunction

In the solar system, the planet (and many asteroids) orbit close to the ecliptic plane and so once a synodic period (the mutual Earth-object orbital repeat period) they pass behind the Sun.

This is called in astronomy a ***superior conjunction***. We plan to describe better and give references in a new draft.

In the absence of relays, superior conjunctions cause blackouts (cessations of communications) as the plasma near the Sun disrupts radio waves (note that optical communication receivers don't like being pointed at the Sun so they will likely have a comparable blackout but there is less data on that).

For Mars, these interruptions are order 2 weeks every 779.94 days. At present, probes or rovers are mostly put on standby during this period. A human presence will drive a demand for relays welll separated from the Earth ***and*** Mars, but that will take a while.

This is also likely to happen when crews are in transit to and from Mars (which tends to worry mission planners) but it will depend on the chosen trajectory.

Predictable Interruptions: Superior Conjunction

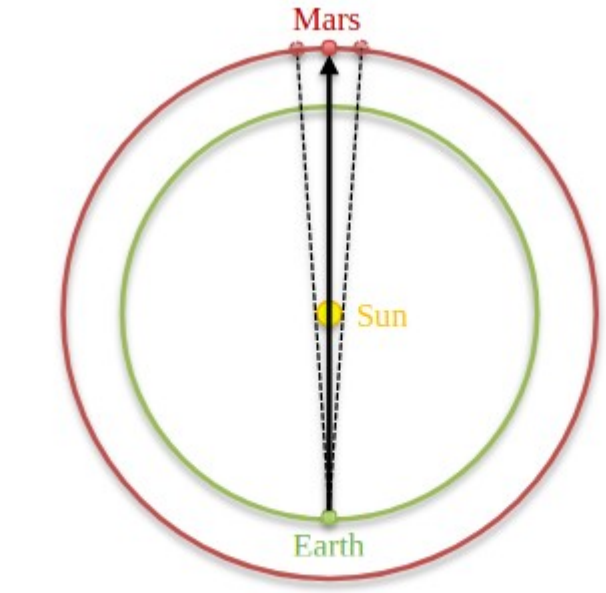


Fig. 1 Example of Earth-Sun-Mars conjunction.

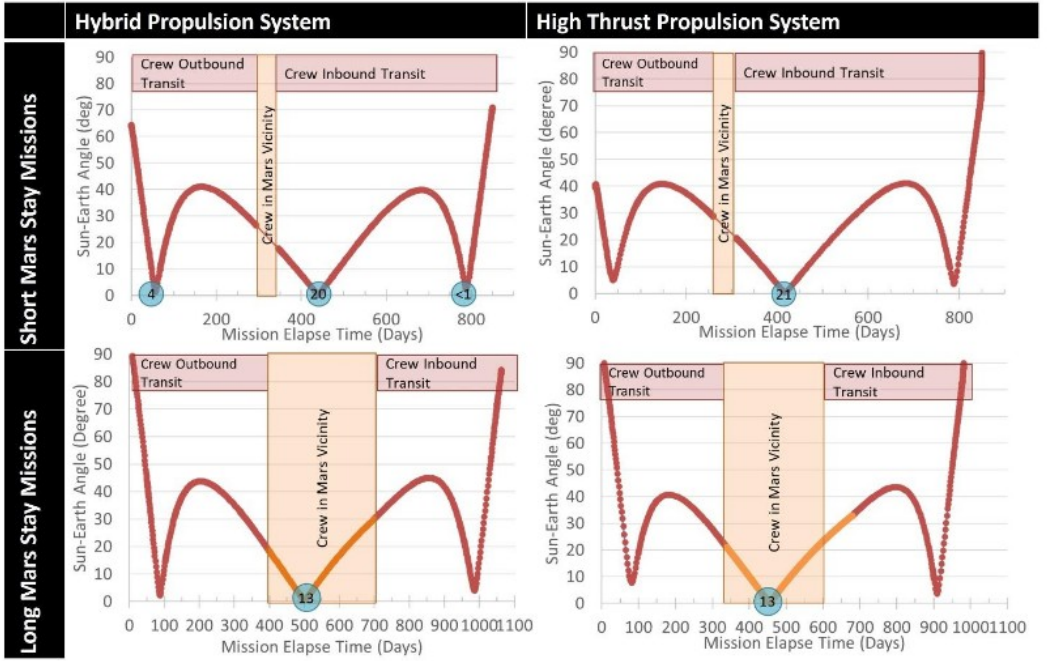


Fig. 6 Time history of the sun-spacecraft-Mars angle for the four reference trajectories including potential durations.

From https://ntrs.nasa.gov/api/citations/20220013418/downloads/ASCEND-Communication%20Delays%2C%20Disruptions%2C%20and%20Blackouts%20for%20Crewed%20Mars%20Missions.pdf

A Word on Timing

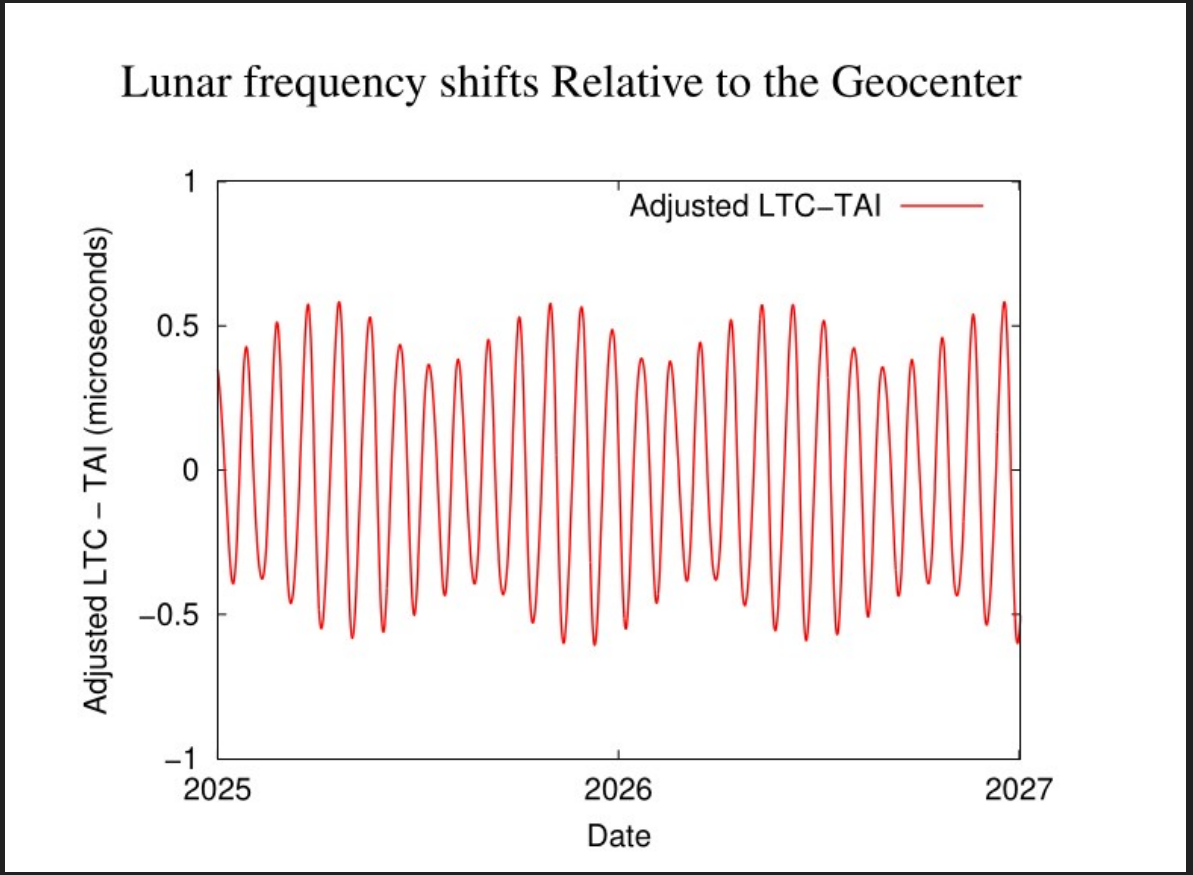
Relativistic Timing becomes important as you move away from the Earth.

This will inevitably have network implications.

A “proper” clock on the surface of the Moon will be blue-shifted by ~56 microsec/day with respect to one on the surface of the Earth.

I predict a “Lunar Adjusted time” will be adopted to remove that (GPS does that now).

Martian time-slips are be more like a msec/day, and will vary much more over a synodic period, so Mars time will have to run free of Earth time.

These shifts have security and other network implications, and should be referred to the IRTF SPACE RG..

Lunar Adjusted Time relative to Earth