# Introduction to DTN

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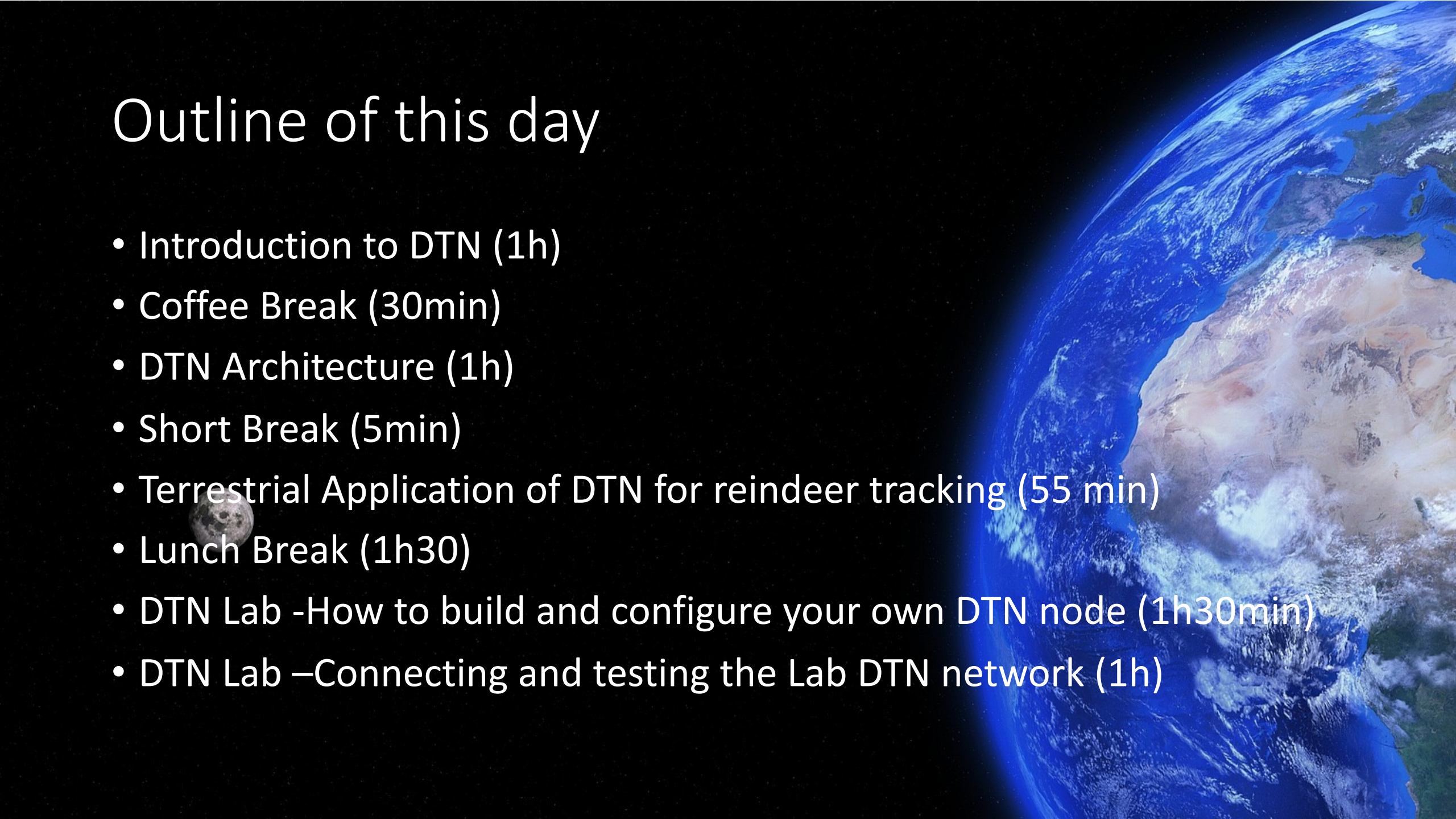
Interplanetary Networking Special Interest Group

Link to the NASA's Interplanetary Overlay Network course

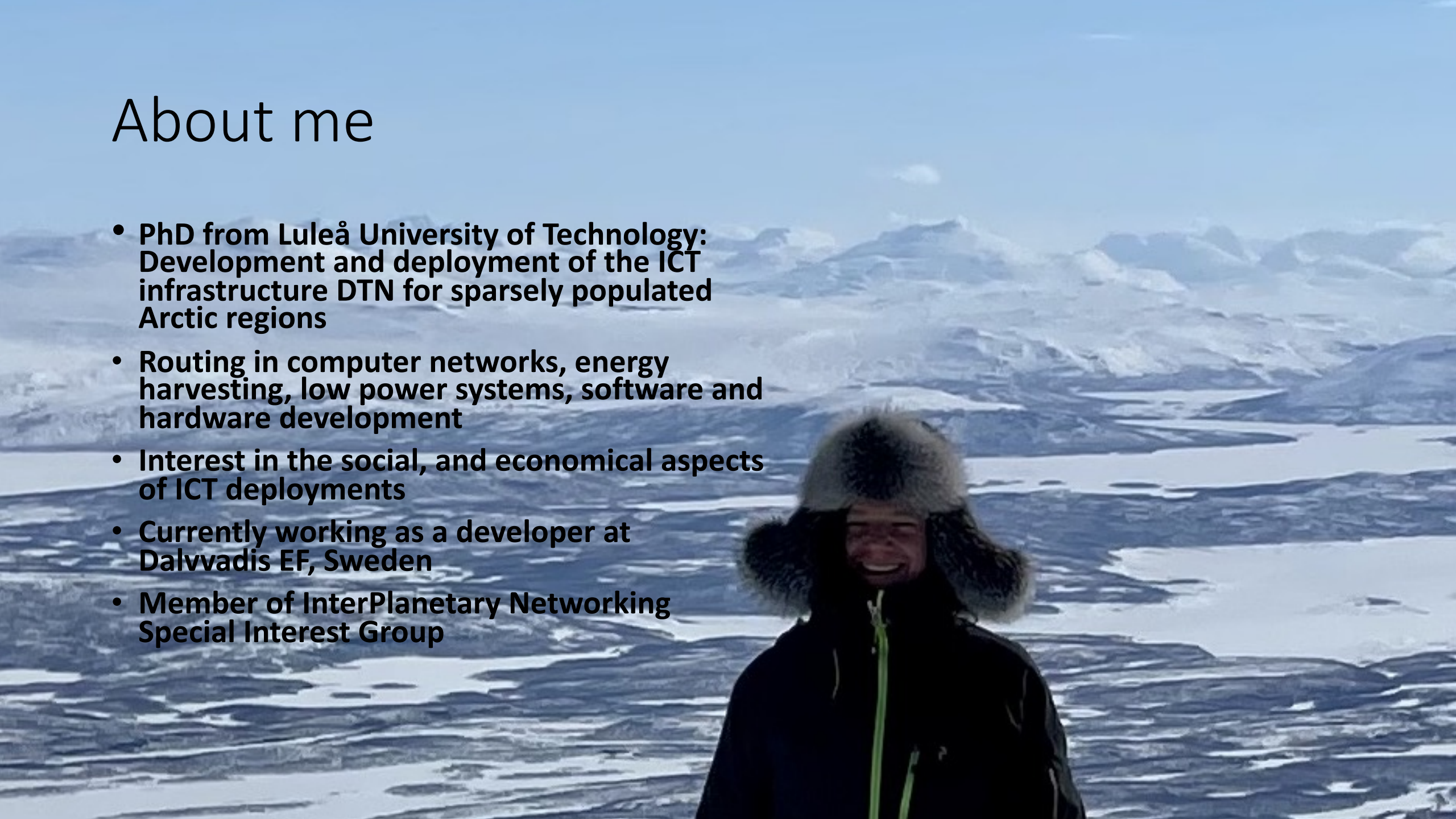
# Outline of this day

- Introduction to DTN (1h)
- Coffee Break (30min)
- DTN Architecture (1h)
- Short Break (5min)
- Terrestrial Application of DTN for reindeer tracking (55 min)
- Lunch Break (1h30)
- DTN Lab -How to build and configure your own DTN node (1h30min)
- DTN Lab –Connecting and testing the Lab DTN network (1h)

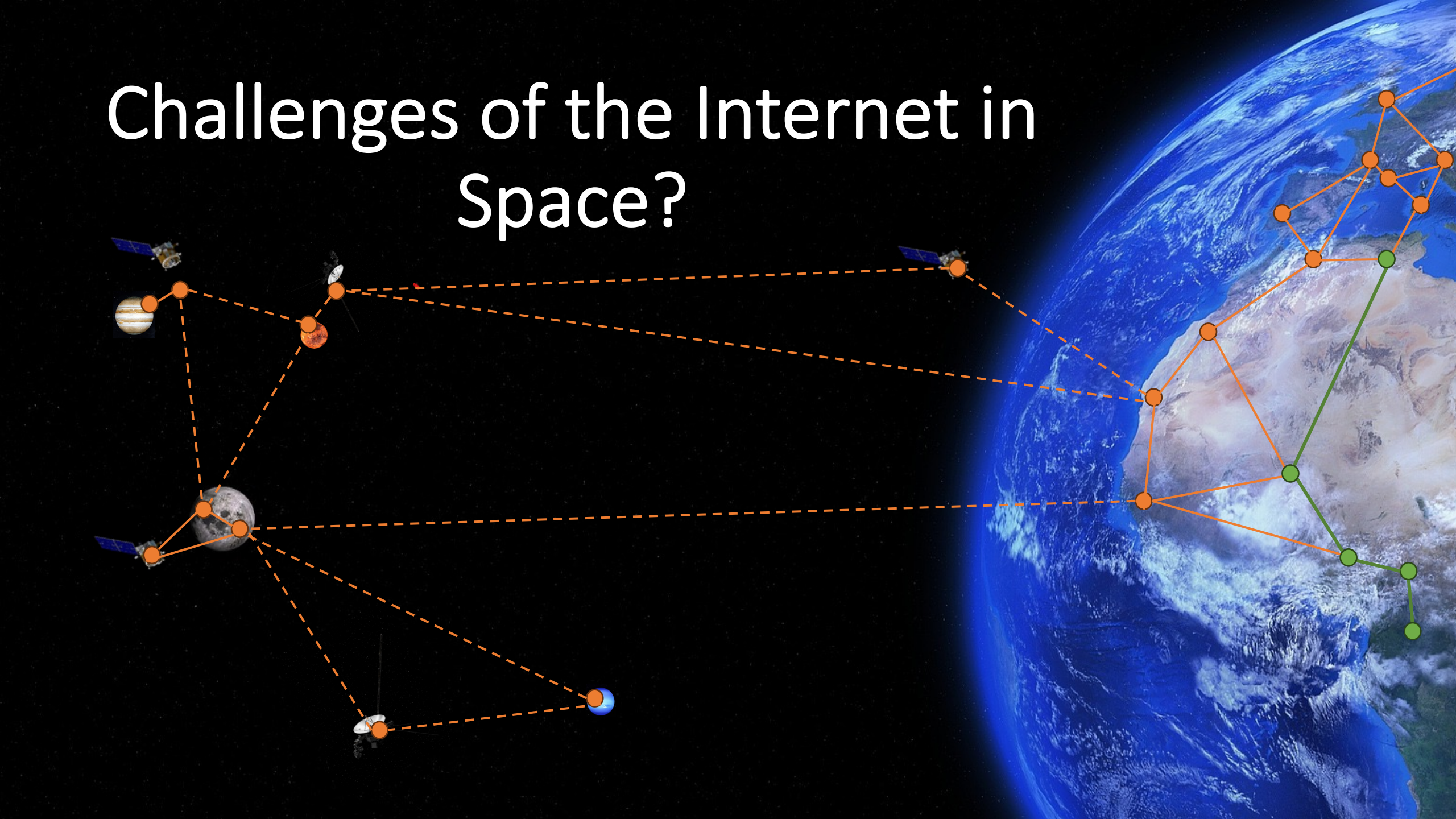


# About me

- **PhD from Luleå University of Technology: Development and deployment of the ICT infrastructure DTN for sparsely populated Arctic regions**
- **Routing in computer networks, energy harvesting, low power systems, software and hardware development**
- **Interest in the social, and economical aspects of ICT deployments**
- **Currently working as a developer at Dalvvadis EF, Sweden**
- **Member of InterPlanetary Networking Special Interest Group**

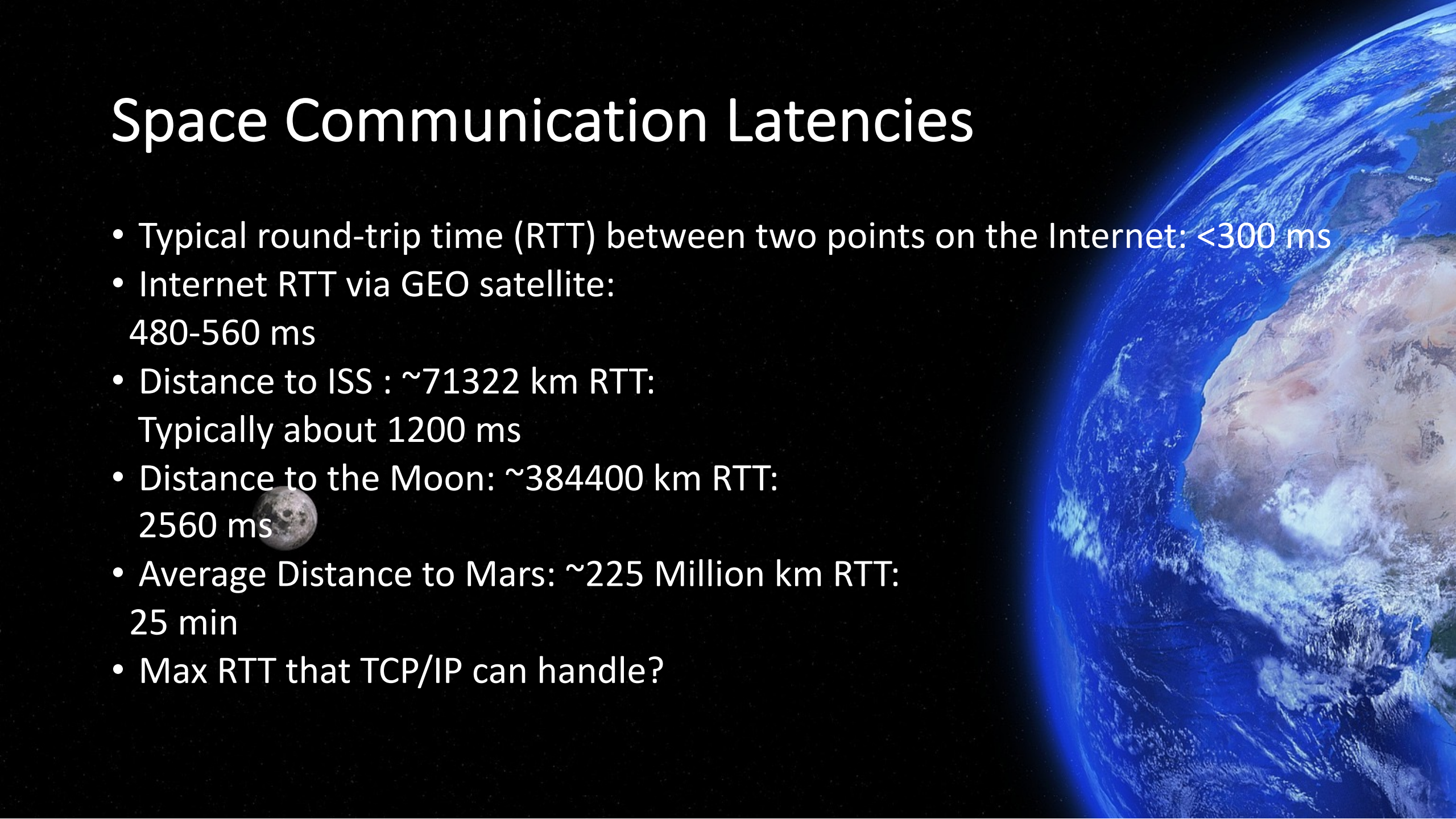


# Challenges of the Internet in Space?



# Space Communication Latencies

- Typical round-trip time (RTT) between two points on the Internet: <300 ms
- Internet RTT via GEO satellite:
  480-560 ms
- Distance to ISS : ~71322 km RTT:
  Typically about 1200 ms
- Distance to the Moon: ~384400 km RTT:
  2560 ms
- Average Distance to Mars: ~225 Million km RTT:
  25 min
- Max RTT that TCP/IP can handle?



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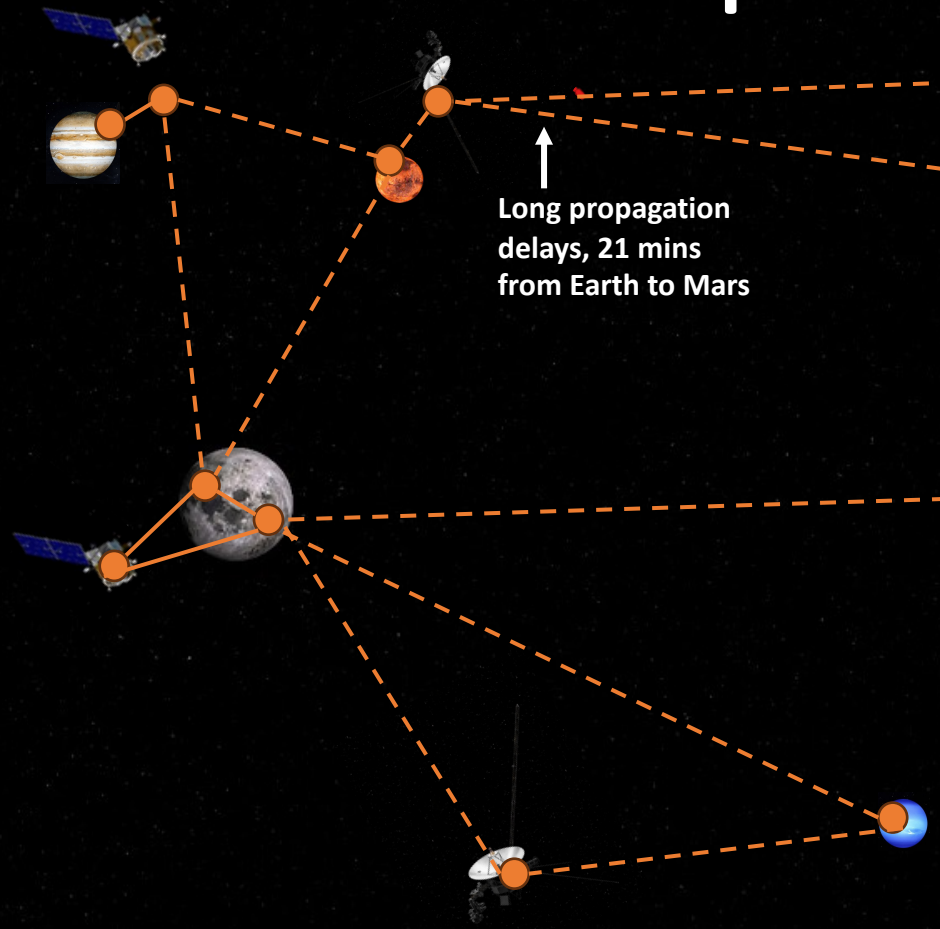
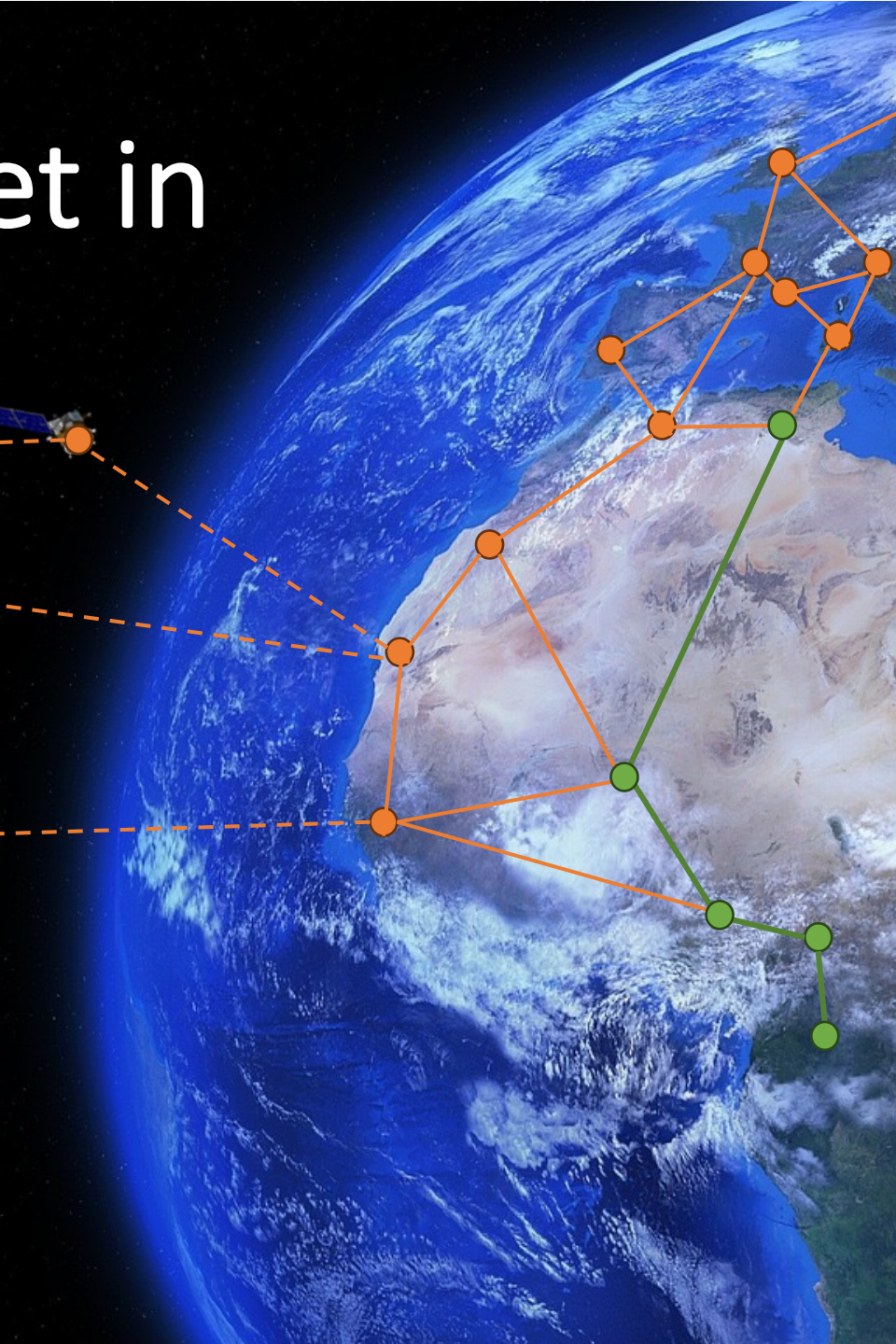
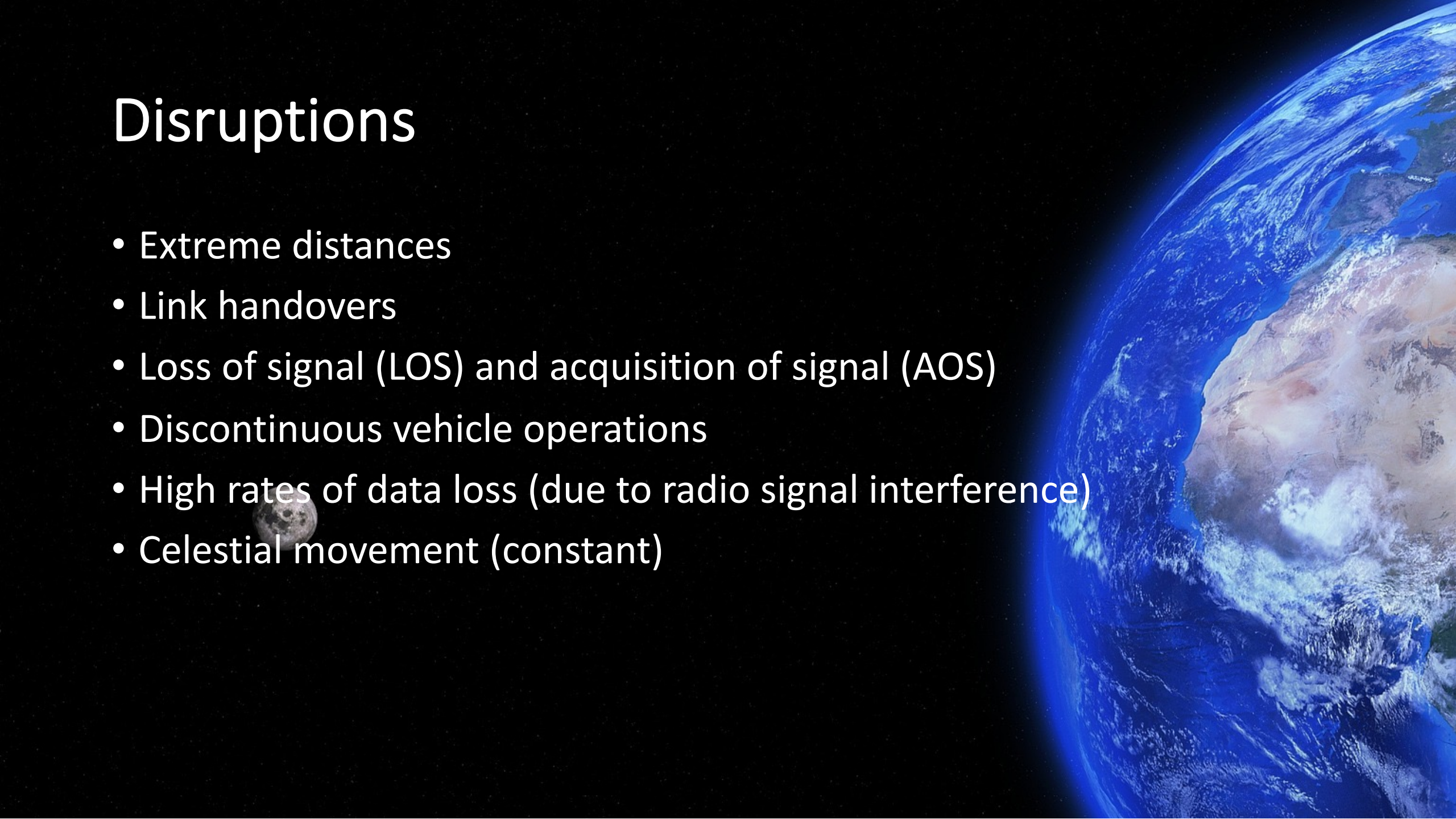


Long propagation delays, 21 mins from Earth to Mars



# Disruptions

- Extreme distances
- Link handovers
- Loss of signal (LOS) and acquisition of signal (AOS)
- Discontinuous vehicle operations
- High rates of data loss (due to radio signal interference)
- Celestial movement (constant)



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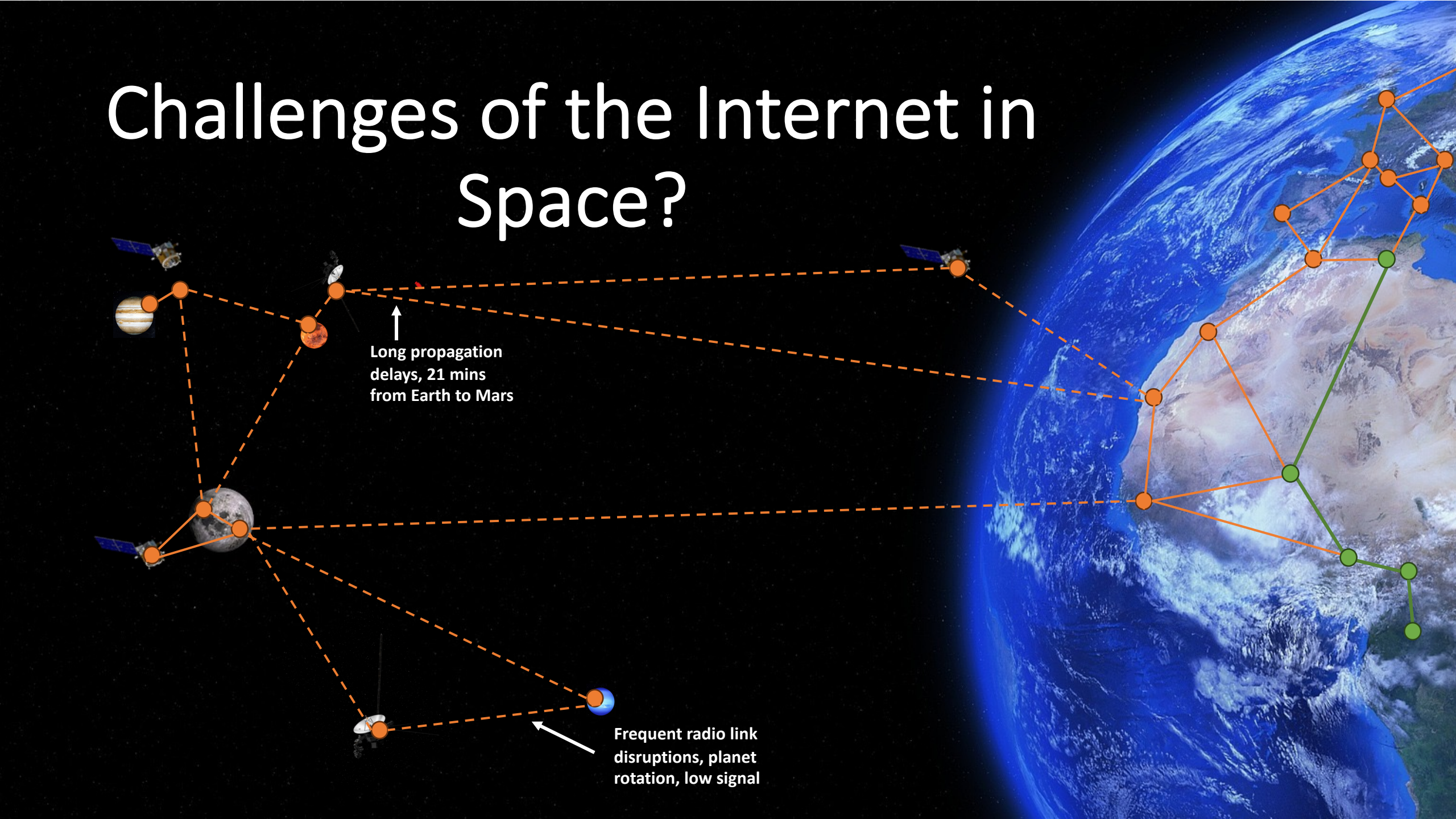
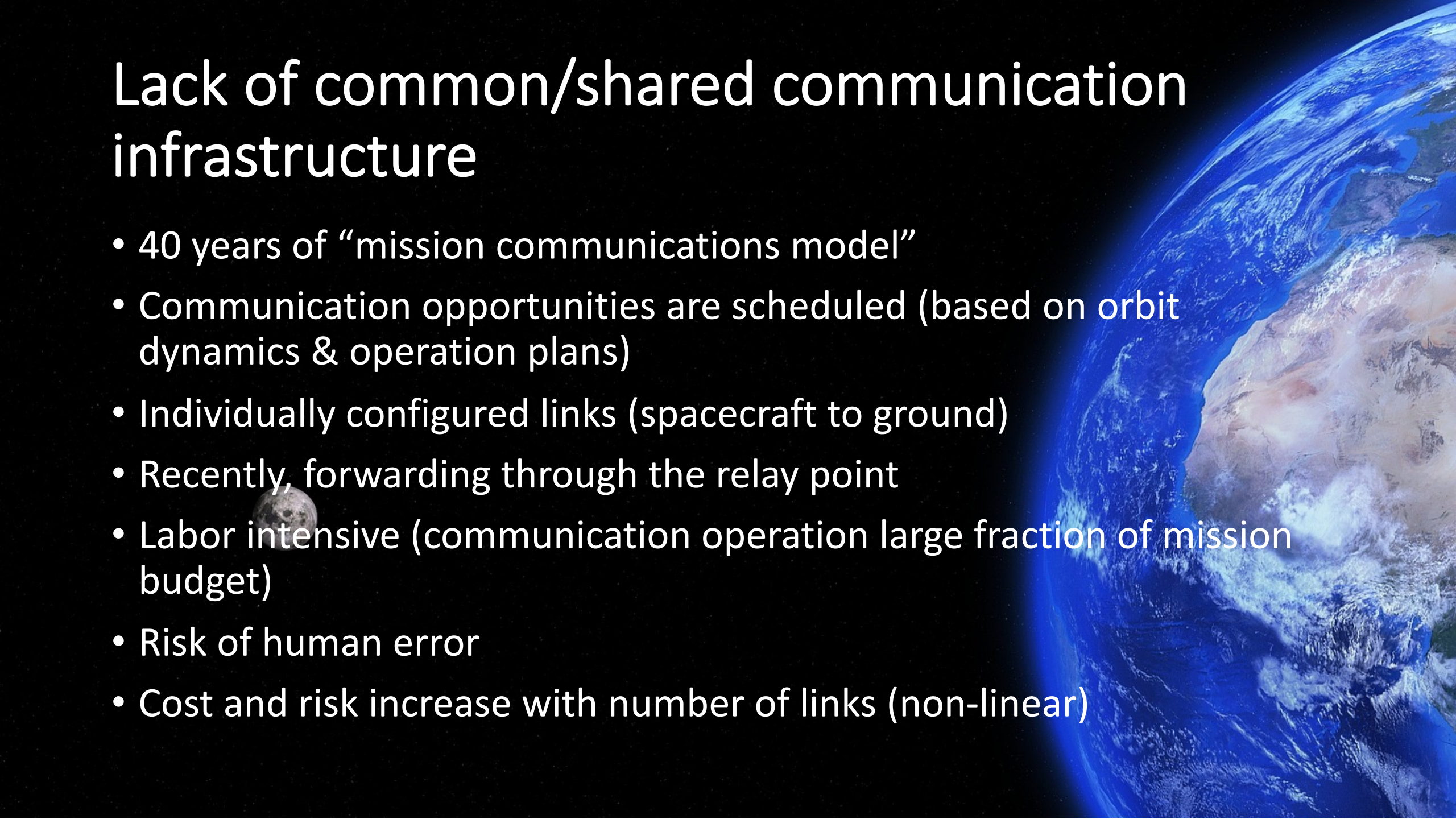


# Lack of common/shared communication infrastructure

- 40 years of “mission communications model”
- Communication opportunities are scheduled (based on orbit dynamics & operation plans)
- Individually configured links (spacecraft to ground)
- Recently, forwarding through the relay point
- Labor intensive (communication operation large fraction of mission budget)
- Risk of human error
- Cost and risk increase with number of links (non-linear)



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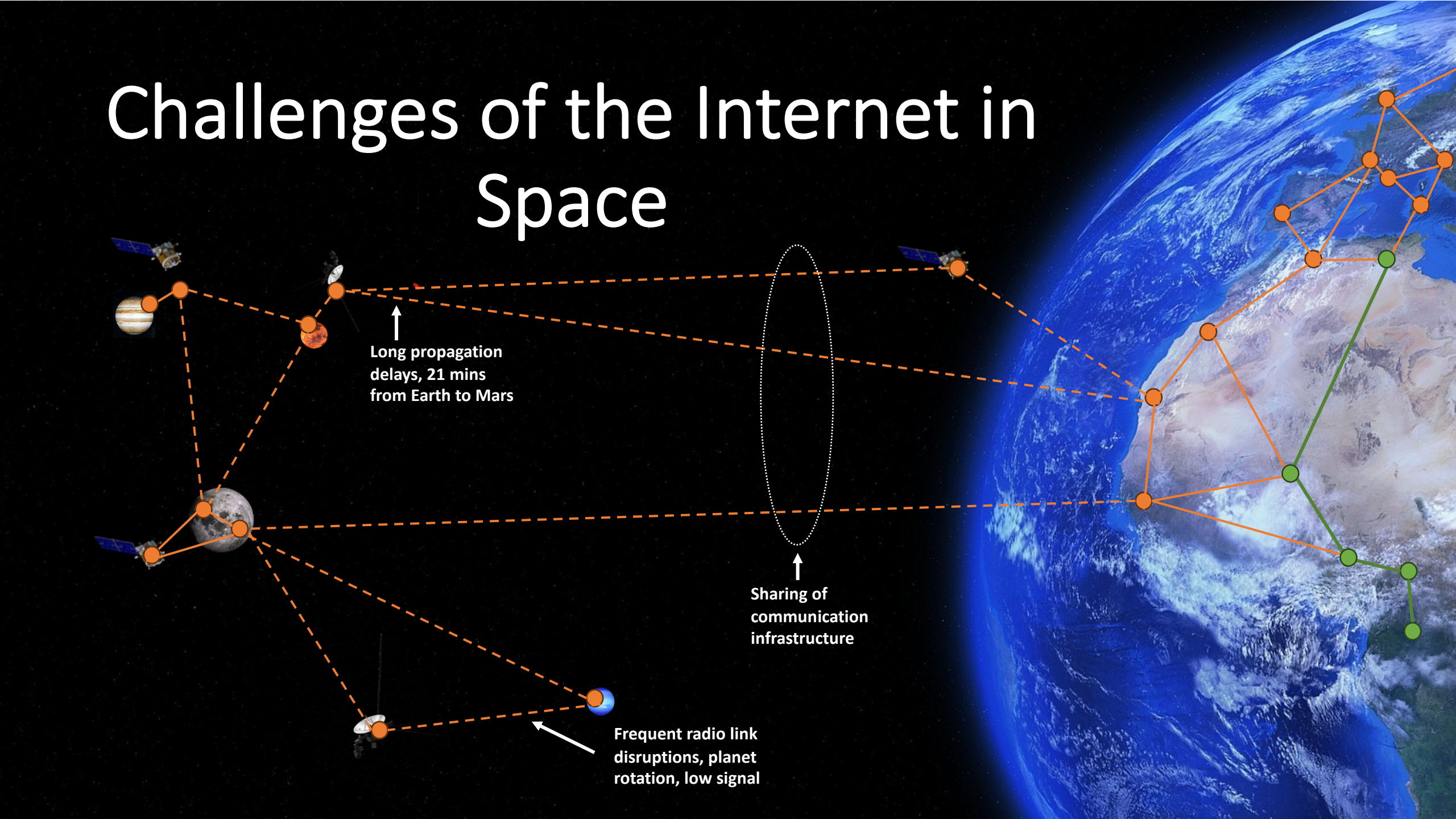
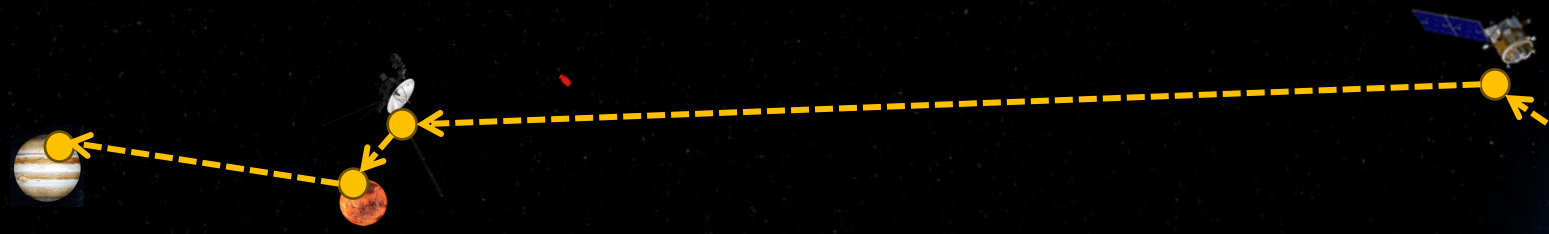
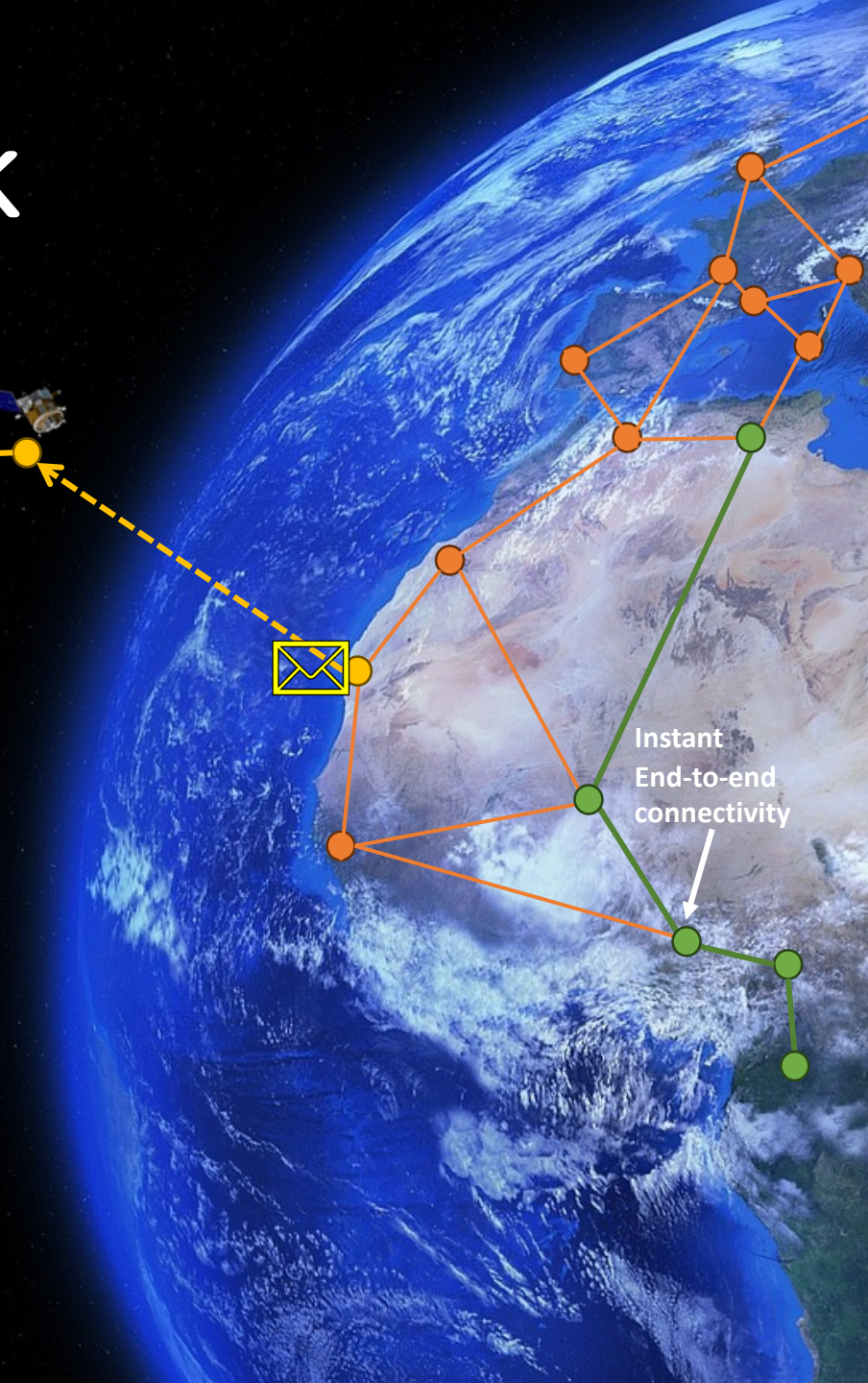


# Delay Tolerant Network

Building block of future Interplanetary Internet

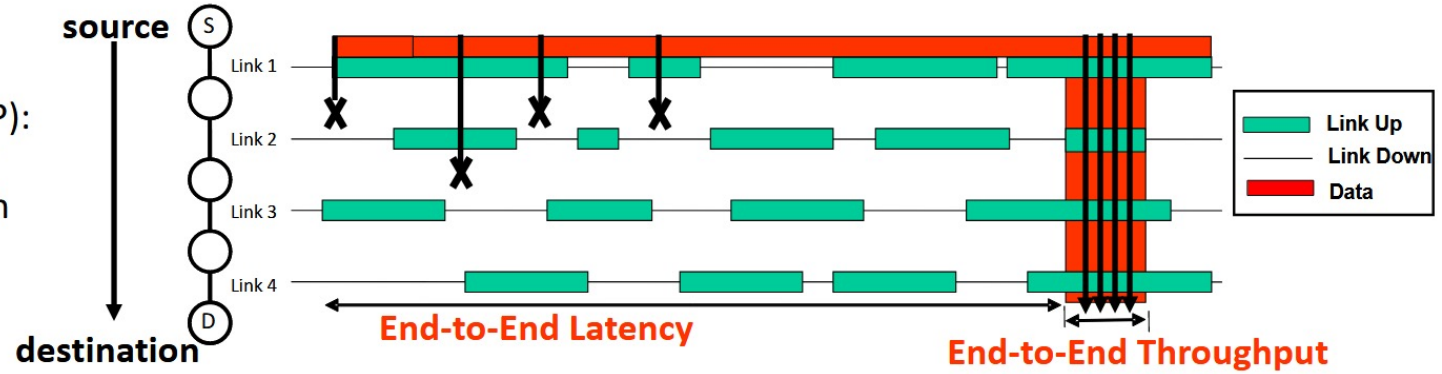


- Store-And-Froward principle
- Open standard
- Share and utilize space infrastructure
- Wide range of communication technologies
- Simplify and unify the development of space services
- Adopted by NASA, JAXA, ESA and defence industry

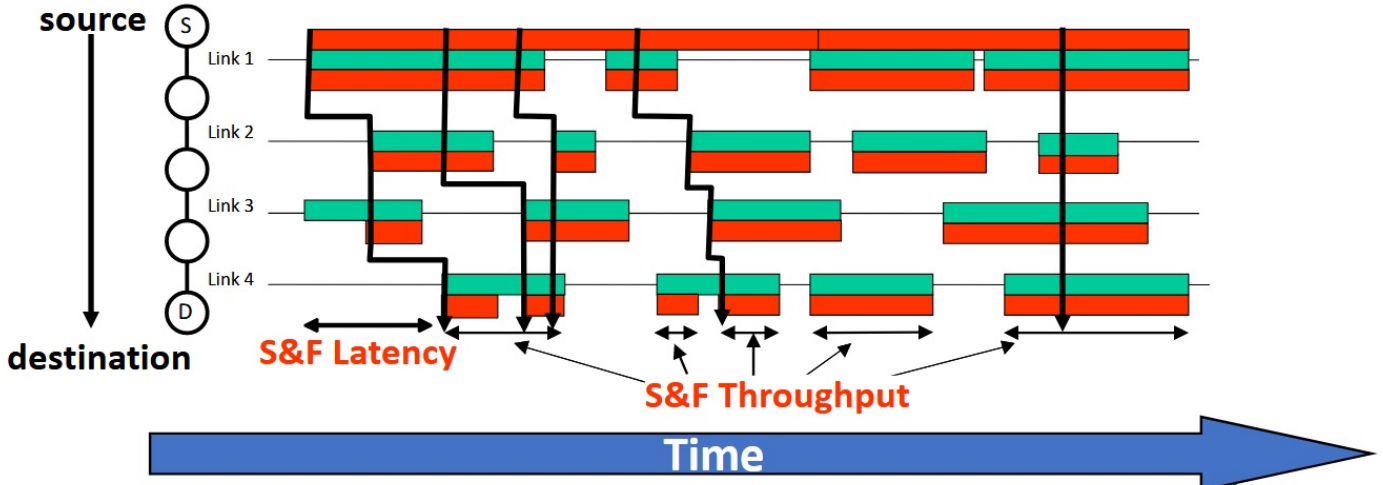


# Reliable data delivery: TCP vs DTN

End-to-end (IP): Must wait for complete path



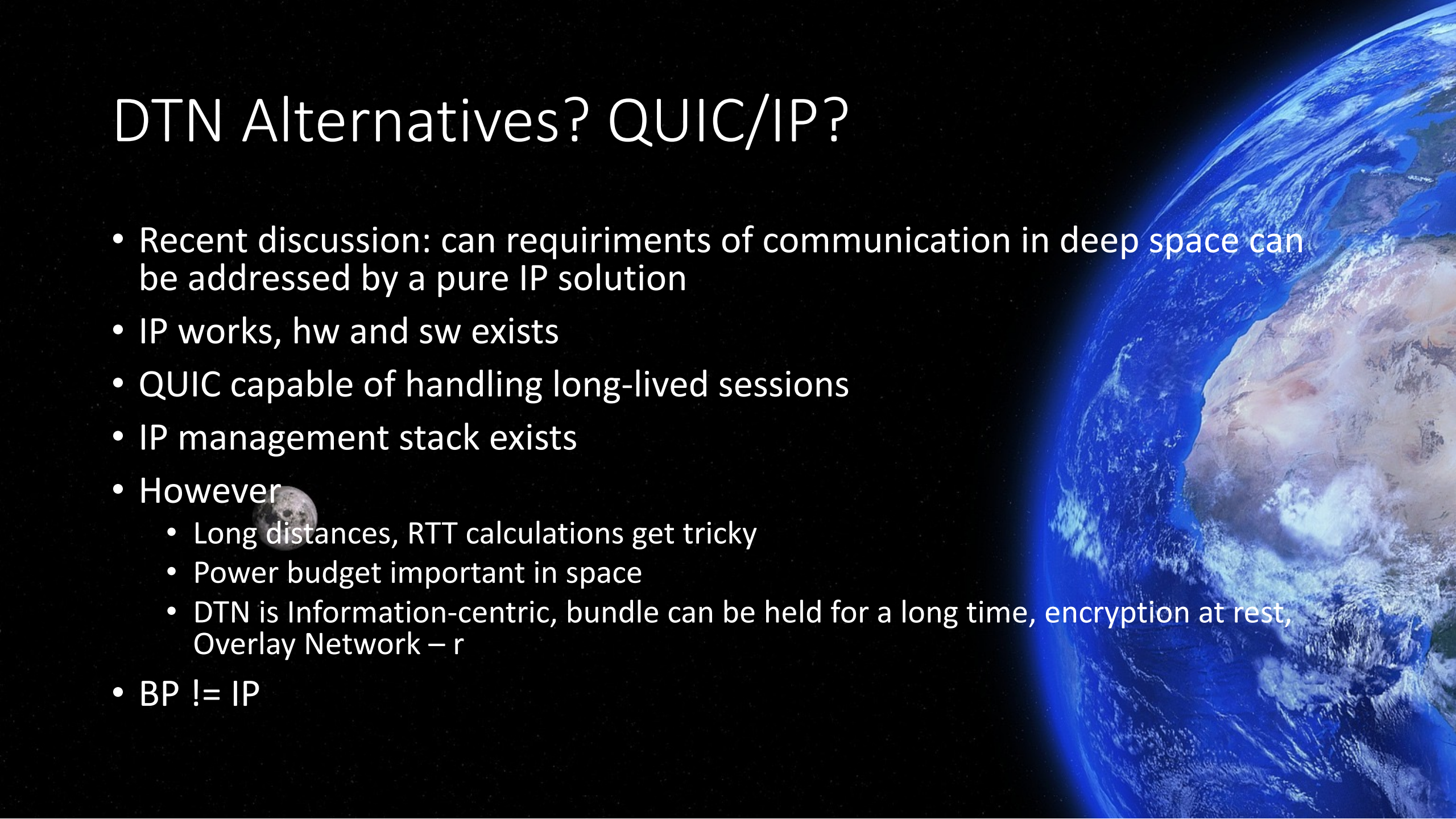

Store-and-Forward (DTN): Incremental progress w/o end-to-end path




***DTN Can Reduce Delay and Increase Throughput***

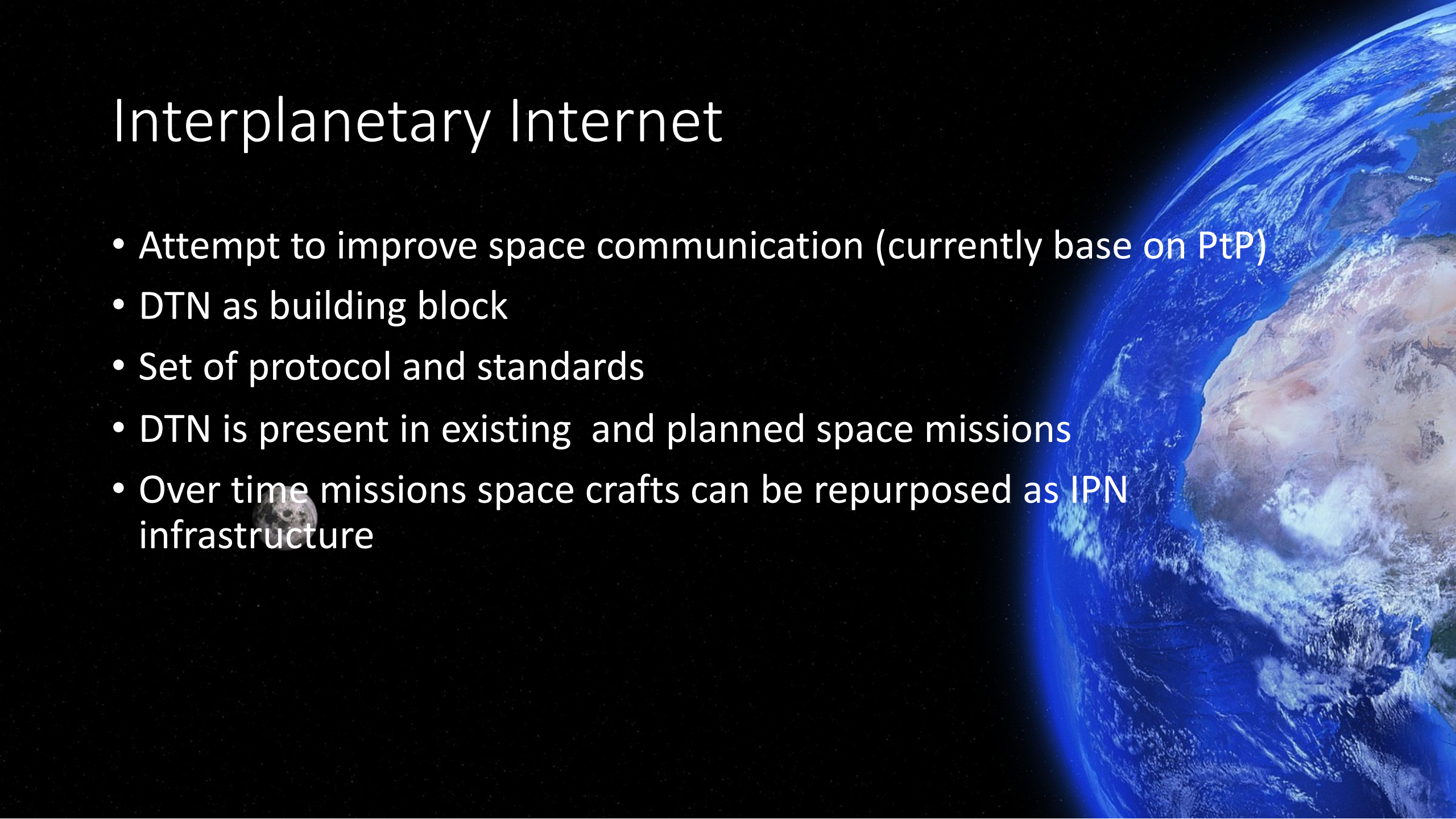
# DTN Alternatives? QUIC/IP?

- Recent discussion: can requiriments of communication in deep space can be addressed by a pure IP solution
- IP works, hw and sw exists
- QUIC capable of handling long-lived sessions
- IP management stack exists
- However
  - Long distances, RTT calculations get tricky
  - Power budget important in space
  - DTN is Information-centric, bundle can be held for a long time, encryption at rest, Overlay Network – r
- BP != IP



# Interplanetary Internet

- Attempt to improve space communication (currently base on PtP)
- DTN as building block
- Set of protocol and standards
- DTN is present in existing  and planned space missions
- Over time missions space crafts can be repurposed as IPN infrastructure



# Deep Space Network

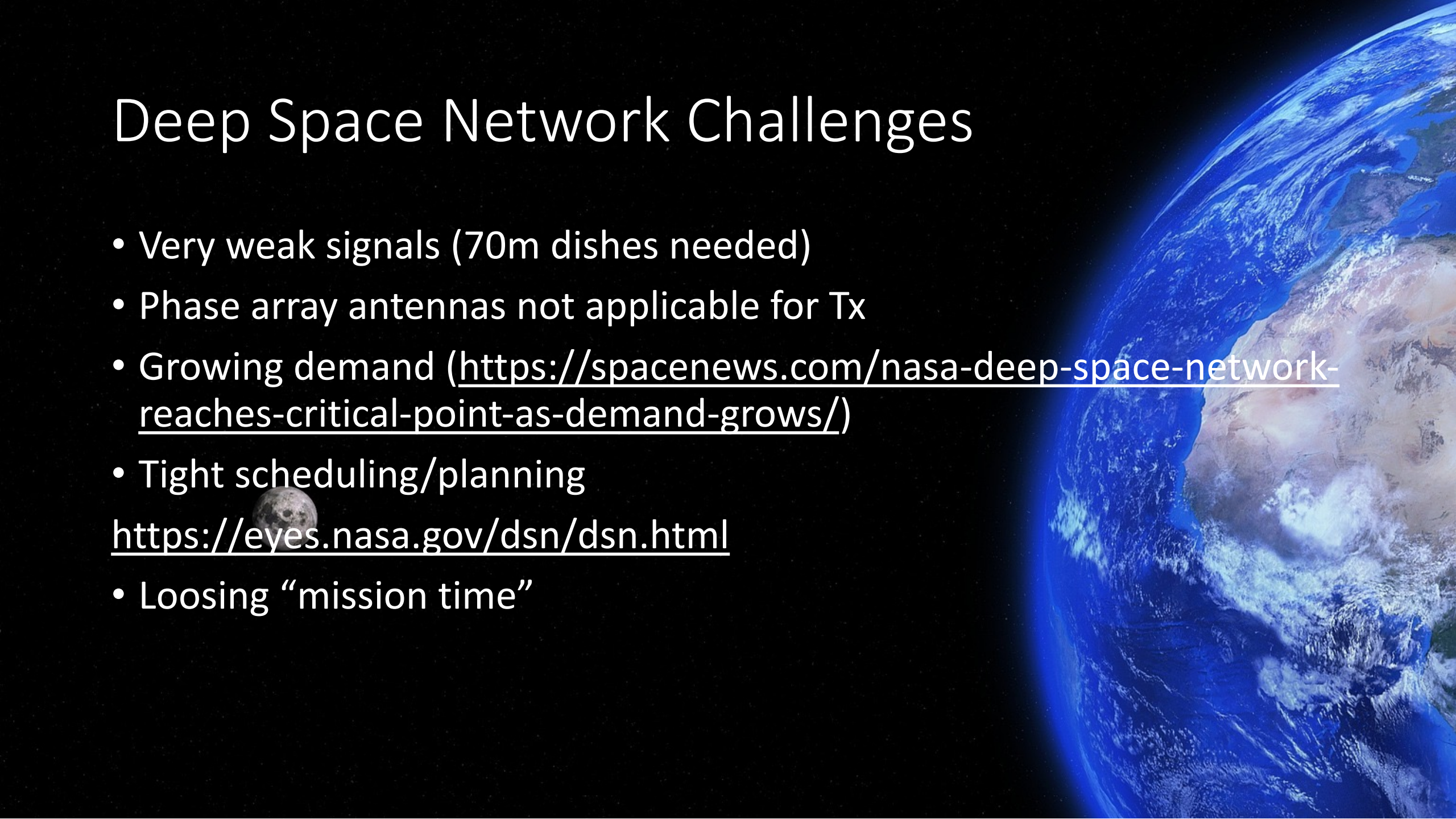
- Managed by NASA
- System of antennas (Australia, California and Spain)

# Deep Space Network Challenges

- Very weak signals (70m dishes needed)
- Phase array antennas not applicable for Tx
- Growing demand (https://spacenews.com/nasa-deep-space-network-reaches-critical-point-as-demand-grows/)
- Tight scheduling/planning

https://eyes.nasa.gov/dsn/dsn.html

- Loosing “mission time”



# How deep into space can we reach?

- Vint Cerf’s vision of reaching Alphacentauri A
- With current propulsion systems 65000 years
- How to signal back to earth (4.4 light years)
- Using high pulse lasers
- How to detect beam (that spreads over 4.4 light year distance)
- Synthetic aperture, scattered around our solar system

# The time is right

- The core of DTN – Bundle Protocol 7 is matured
- DTN is in transition from research to industry/markets
- Space deployments are booming
- Radio spectrum in space is getting scarce
- DTN Competence is needed
- Lots of development needed (both in implementations, services, API)
- DTN has a big potential in terrestrial application

# Standardization bodies

- Internet Engineering Task Force (IETF)
  - **Delay Tolerant Networking Working Group (dtnwg)**
- The Consultative Committee for Space Data Systems (CCSDS)
- Internet Assigned Numbering Authority (IANA)
- Key DTN related RFCs:
  - RFC4838 Delay-Tolerant Networking Architecture
  - RFC5050 Bundle Protocol Specification
  - RFC 9171 Bundle Protocol Version 7

# Open Interplanetary Internet Platform

## Open-source

- Building a collaborative terrestial IPN backbone(ongoing)
- Currently possible to get a valid IPN node nr.
- Building an DTN-of-Things Stack
  - Arduino Library for the sensors
  - ION Implementation for DTN concentrator
- Provide a free access to a terrestrial DTN backbone
- Access: http://openipn.org

LateLab AB

# DTN services

- Messaging system (NSIM)
- Mail
- Web
- Social media
- File transfer
- Metrological data
- Sensor network
- Medical records
- Video streaming (HDTN projects)
- Video/Audio podcasts
- Etc.
- Current Internet trend of centralizing services not favorable for DTN

# How to join IPNSIG?

- Open and free membership
- Projects Working Group
  - Building and testing an operational terrestrial DTN backbone
  - Various projects (mobile phone messaging, environmental monitoring in cave, reindeer tracking in Arctic, management of DTN, etc.)
  - Plans to expand network to Space
  - Open to any project/experiment
- Contact me (samo@grasic.net)
- Or join the ipnsigpwg@googlegroups.com
- Online meeting every second Friday
- https://youtu.be/5rnbRdkrn70?si=Bfff4qdgfpueMqbi