Interplanetary Internet Architecture, Addressing, and Routing

NANOG 98

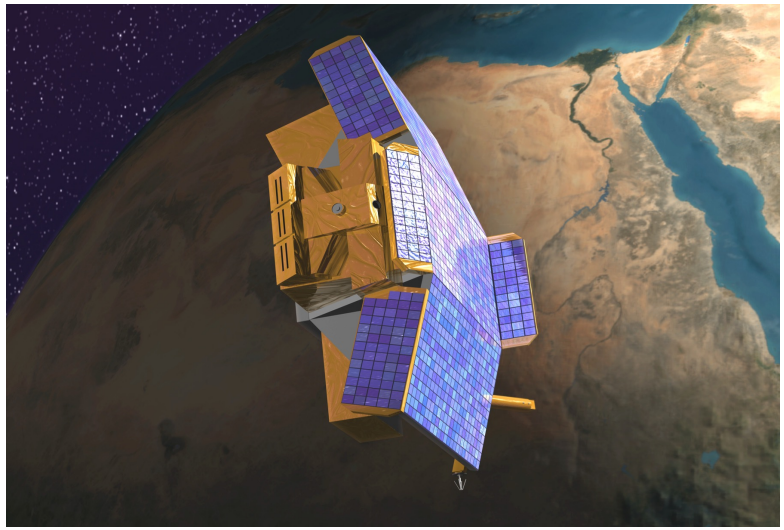
Wesley Eddy (wes@aalyria.com)

Outline

- Background
  - Deep Space IP
  - IETF TIPTOP
- Interplanetary Internet
  - Architecture
  - Addressing
  - Routing

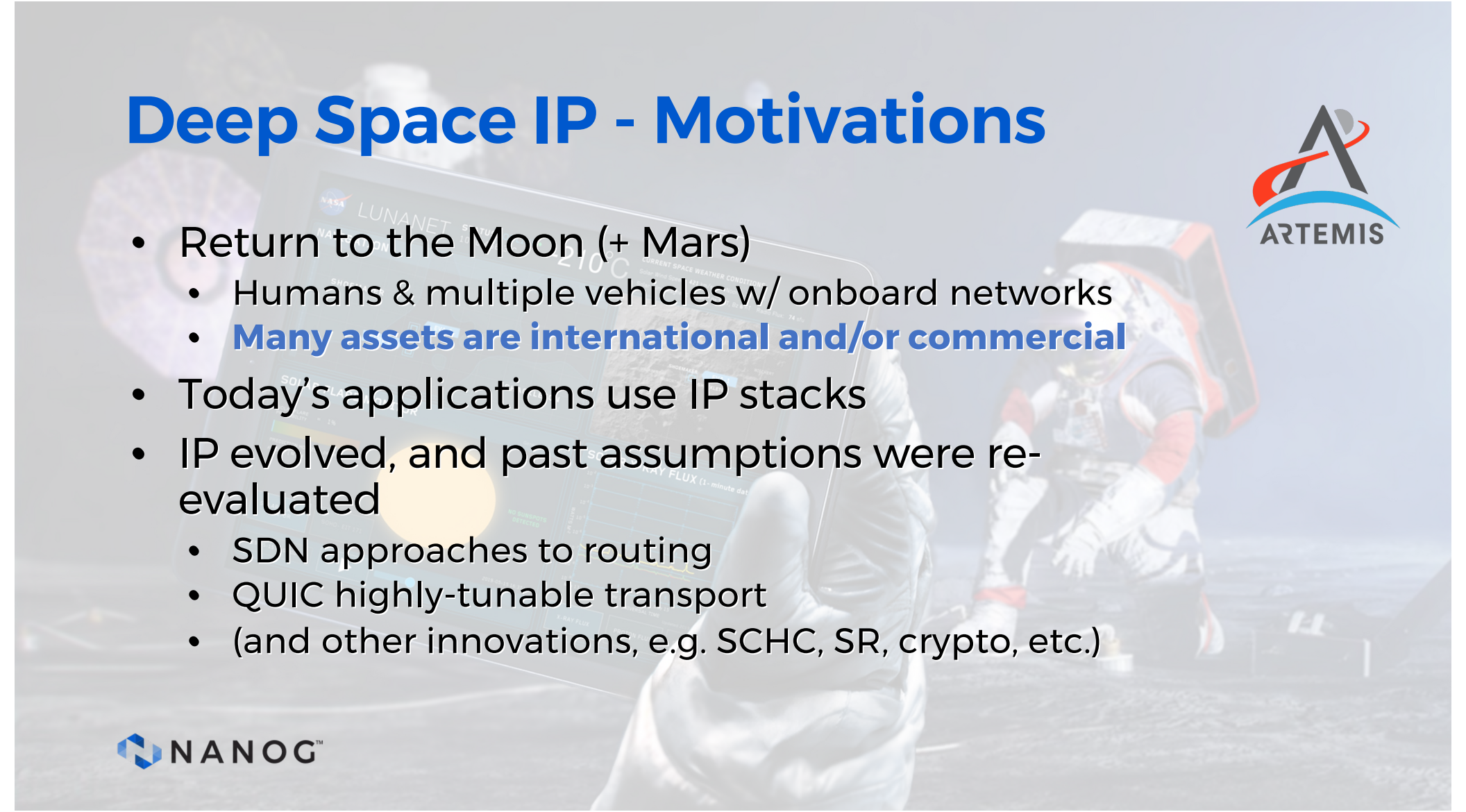
IP in Space – Early History

- 20+ years ago IP was starting to be used in space (in LEO)
  - ~2000 UoSat-12, ~2003 CANDOS, and CHIPS using TCP/IP, NTP, etc. over HDLC
  - Increasing avionics complexity and onboard networks
- Questions arose how far this could go, due to protocol timers, handshakes, etc.
  - 2005 IEEE Spectrum Article

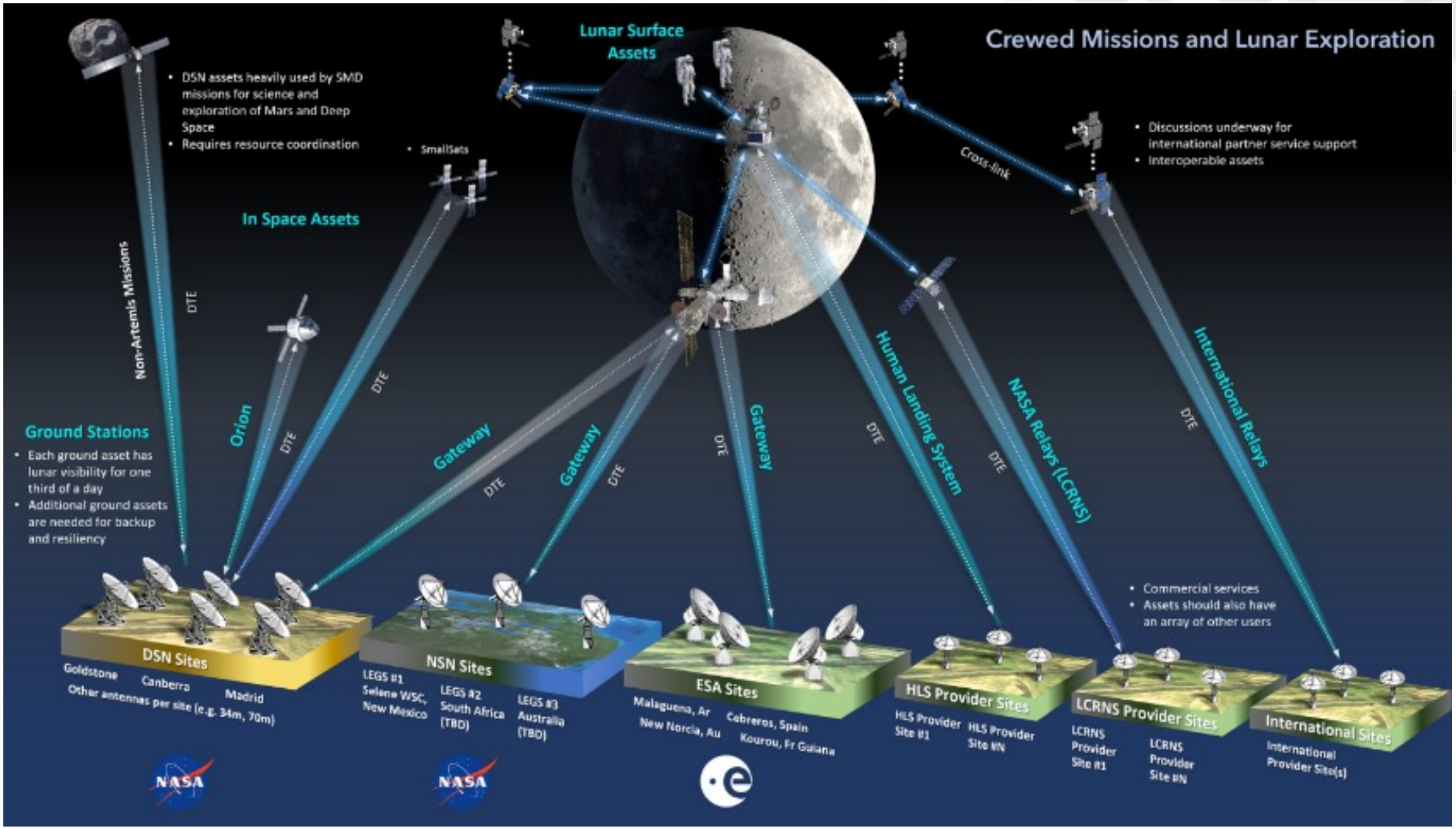


CHIPS
NASA, Public domain, via Wikimedia Commons

Deep Space IP - Motivations



- Return to the Moon (+ Mars)
  - Humans & multiple vehicles w/ onboard networks
  - **Many assets are international and/or commercial**
- Today's applications use IP stacks
- IP evolved, and past assumptions were re-evaluated
  - SDN approaches to routing
  - QUIC highly-tunable transport
  - (and other innovations, e.g. SCHC, SR, crypto, etc.)

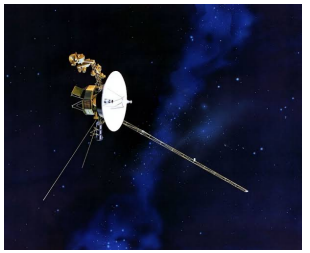


https://www.nasa.gov/wp-content/uploads/2024/01/lunar-communications-and-navigation-architecture.pdf

Deep Space IP – Early Results

- Marc Blanchet organized a lot of effort to see what modern IP stacks can do
- IETF 124 Hackathon
  - Discord, Slack, Apple Messages, Youtube, some web browsing all work at Lunar delays!!!
- “Ping” simulated to Voyager distances
- Simulation software & results:
  - https://github.com/deepspaceip/deepspace-ip-simulations



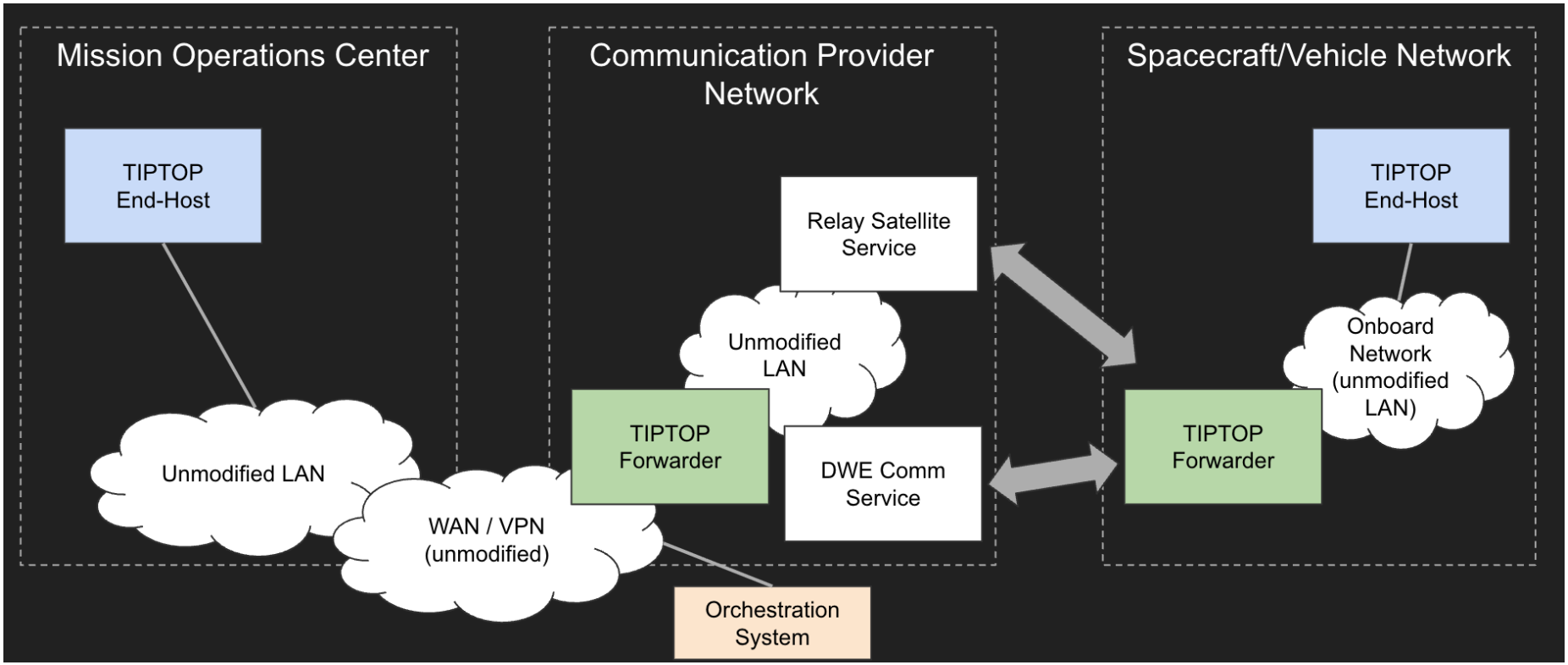


IETF TIPTOP



- Taking IP To Other Planets (TIPTOP)
- 2025 - Working group formed in Internet Area
- Charter items:
  - Key characteristics, use cases, and requirements
  - Architecture
  - QUIC configuration
  - DNS considerations

Architecture



https://datatracker.ietf.org/doc/draft-ietf-tiptop-ip-architecture/

Addressing

- Significant discussions ongoing about IP addressing
  - IETF, ARIN, RIPE, …
- IPv6 (but maybe also IPv4)
- One RIR or many?
- Agreement: Policies should encourage aggregation
- Address blocks per planet
  - And moon?
  - And Lagrange point?
  - Asteroids?
  - Who defines list of planets?

Routing

- Scheduling, scheduling, scheduling
- Within a domain, time-varying routes can be coordinated according to the scheduled connectivity.
  - PCE-like centralized route computation, with information distributed to nodes well in advance
  - Information-sharing between domains may need to be worked out someday (i.e. time-varying BGP)
  - Sending/receiving behaviors can be coordinated all the way up to the application layer

Routing

- Temporospatial SDN (TS-SDN)
  - 2022 SIGCOMM - SDN in the stratosphere: Loon's aerospace mesh network
- Aalyria Spacetime grew from the Loon code, and is an example TS-SDN orchestration system for space networks, with open-source APIs
- Outernet Council "Federation" interfaces for multi-operator systems
  - https://www.outernetcouncil.org/



AALYRIA

Conclusions

- Interplanetary IP is real!
- TIPTOP is working on the details.
  - There are many interesting things to work out.
  - Some of them only really matter if we're very successful.

Hope to see you all someday at the SSNOG!
(Solar System Network Operators Group)

Thank you!

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