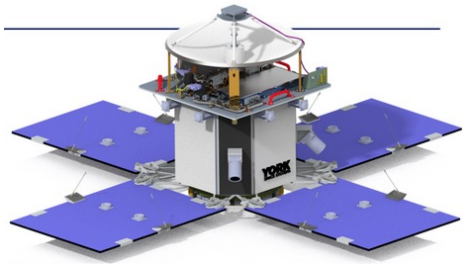
JHU/APL Polylingual Experimental Terminal (PExT) Conventional Experimental License Request



- Experiment Point of Contact:
  - Chris Haskins – 240-228-3405
  - Ron Schulze – 240-228-4924
- Objective:
  - Test a wideband Ka-band user terminal from LEO with existing and emerging commercial relay services and backwards compatibility to the legacy TDRS service
- Experiment Description: The Johns Hopkins Applied Physics Laboratory (JHUAPL) is a University Associated Research Center (UARC) that conducts basic research for the United States Government (USG)
  - 1 Ka-band transmitter and receiver using an APL 60 cm antenna tracking LEO, MEO, and GEO satellites
    - Operates as hosted payload in LEO
    - Spacecraft TT&C is not part of this application
    - Downlink to Spacecraft from commercial relay services are not part of this application; all are within allowed frequency ranges for each service
  - Terminal placed in LEO, on orbit 6/1/24 to 6/1/25
  - 24 hours/day potential operation
    - Can be reduced substantially if conflicts identified
- Location Details:
  - SpaceX Transporter 11 ride share
  - Launch: June/July 2024
  - Orbit:
    - 515 km SSO
    - MLTAN: 22:30 ± 30 min
- Emission Details (include for each signal if multiple)
  - Peak output power: See slide 6
  - Peak ERP: See slide 6
  - Frequency of operation: 25.25 to 31 GHz
  - Frequency Tolerance: ± 5 ppm
  - Signal Bandwidth: See slide 8
  - Signal Type/description: DVB-S2 or CCSDS
- Frequency Request Dates:
  - 6/1/2023 – 5/31/2024

Equipment Description:

- Antenna >6m above ground? Y
- Directional? Y
- Manufacturer: APL
- Model #: N/A
- Polarization: RHCP, LHCP
- 3-dB Beamwidth: 1.2°
- Orientation in horizontal plane: 0-360°
- Orientation in vertical plane: 0-180°

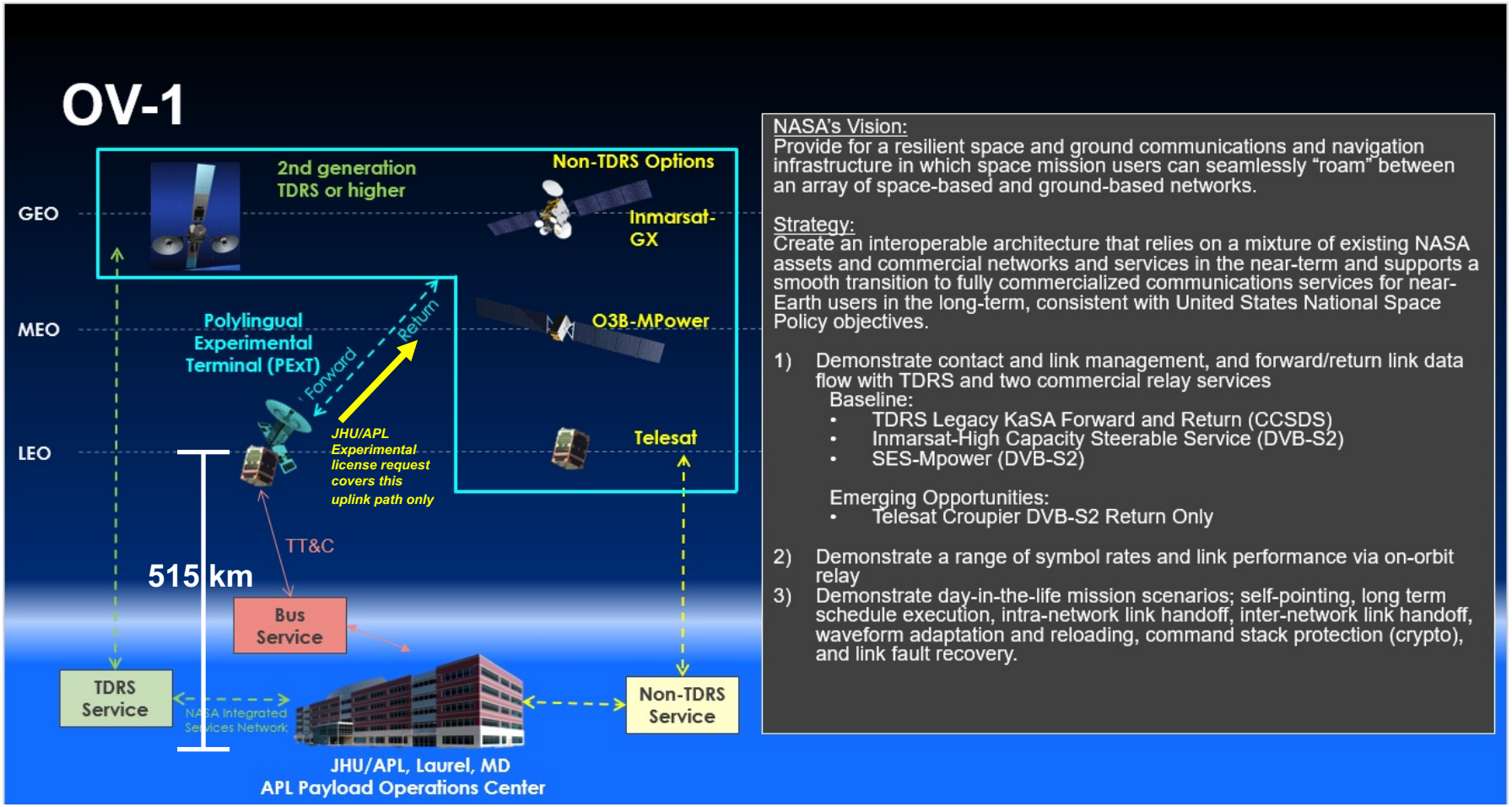
PExT Government Contract Narrative Statement Exhibit

- This conventional experimental License Application is to test a wideband Ka-band user terminal from LEO with multiple commercial relay services and backwards compatibility to TDRSS service.
- Antenna tracking LEO, MEO, and GEO satellites.
- Operate as hosted payload in LEO.
  - Spacecraft TT&C is not part of this application.
  - Downlink to Spacecraft from commercial relay services are not part of this application. All downlinks are within the allowable frequency ranges for each service.
- The project is research initiated under the NASA contract 80MSFC20D0004 / 80MSFC22F0103.
- Current launch window: SpaceX Transporter 11 ride share, June/July 2024
- Expected on orbit period of June 2024 to Jun3 2025 (12 months)

PExT Mobile Area of Operation and Antenna Exhibit (1 of 2)

- Mobile Area of Operation
  - Radio will be a hosted payload on a York Space Systems' bus in LEO
  - Satellite will be operating globally in Sun Synchronous Orbit (SSO)
  - 97.50° circular orbit, MLTAN 22:30 ± 30 min
- Single 60 cm Ka-band antenna for transmit and receive
- Directional Antenna Half Power Beam Width
  - Forward (Rx) link: 1.8°
  - Return (Tx) link: 1.2°
- 60 CM Directional Antenna Orientation:
  - Horizontal: 0 - 360°
  - Vertical: 0 – 180°
  - Hemispherical pointing direction, always oriented sideways or up in reference to Earth
- Antenna Height
  - Radio will be installed on a satellite in LEO, altitude of 515 ± 15 km
  - Altitude of the antenna will be such that it will be out of aircraft operating range
  - Exact ground elevation cannot be determined due to global operation
  - Exact distance to nearest aircraft landing area cannot be determined due to global operation

PExT Mobile Area of Operation and Antenna Exhibit (2 of 2)



NASA's Vision:
Provide for a resilient space and ground communications and navigation infrastructure in which space mission users can seamlessly "roam" between an array of space-based and ground-based networks.

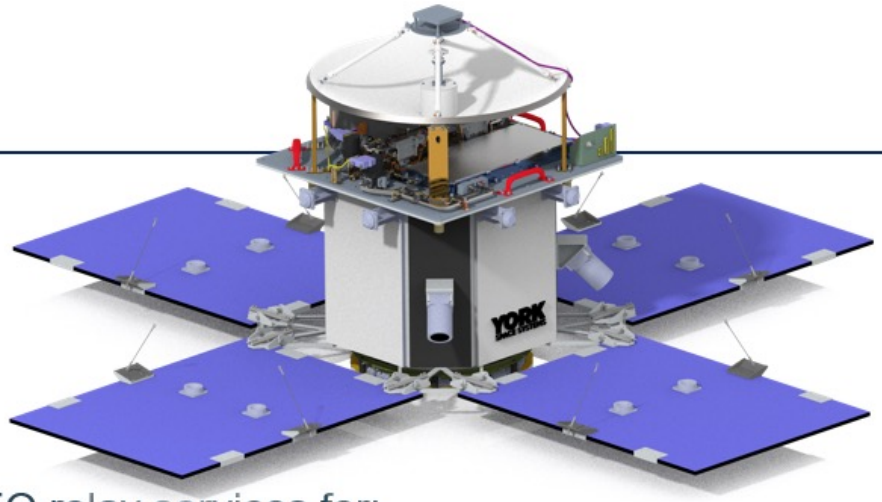
Strategy:
Create an interoperable architecture that relies on a mixture of existing NASA assets and commercial networks and services in the near-term and supports a smooth transition to fully commercialized communications services for near-Earth users in the long-term, consistent with United States National Space Policy objectives.

1) Demonstrate contact and link management, and forward/return link data flow with TDRS and two commercial relay services
   Baseline:
   - TDRS Legacy KaSA Forward and Return (CCSDS)
   - Inmarsat-High Capacity Steerable Service (DVB-S2)
   - SES-Mpower (DVB-S2)

   Emerging Opportunities:
   - Telesat Croupier DVB-S2 Return Only

2) Demonstrate a range of symbol rates and link performance via on-orbit relay
3) Demonstrate day-in-the-life mission scenarios; self-pointing, long term schedule execution, intra-network link handoff, inter-network link handoff, waveform adaptation and reloading, command stack protection (crypto), and link fault recovery.

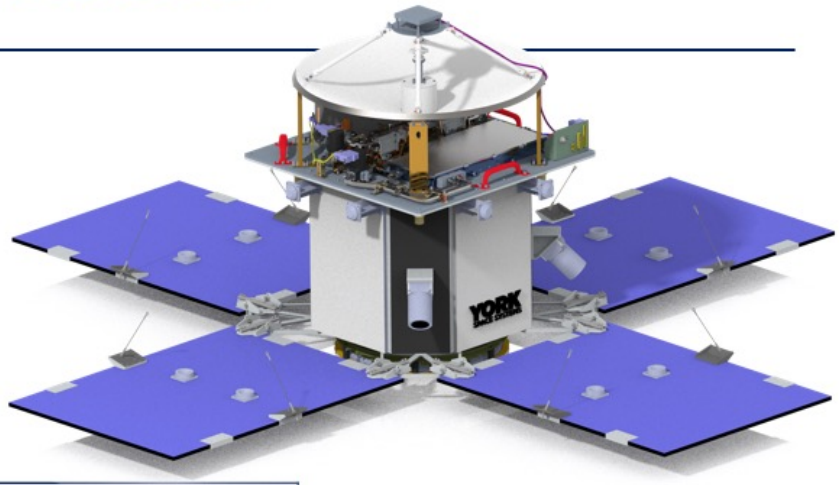
Test Objectives



- Maximize return data volume:
  - Inmarsat and MPower: QPSK(1/2)
  - Telesat QPSK(5/6)
- Demonstrate spectral efficient waveforms
  - Inmarsat and Mpower: 8PSK(3/5)
  - Telesat: 8PSK(3/5)
- Demonstrate data rate capabilities of MEO and GEO relay services for:
  - Range of data rates: FWD: 10-40 Mbps, RTN: 10-50 Mbps
  - MODCODs: QPSK, 8PSK, Telesat (all, range dependent)
- Store and forward a large data file
  - Uplink on one service (Inmarsat, TDRS, Mpower) and return on a different service (Telesat)
- Demonstrate utility of POC initiated transfer of data (via virtual network adapter)
- Demonstrate encrypted forward link (TDRS, Mpower)
- Demonstrate inflight update of PExT FPGA and/or SW
- Goal: Simulate a low-rate emergency link via GEO relay service (Inmarsat, TDRS)

PExT High Level Specifications

- 06/01/2024 Launch:
- Orbit: 515 ± 15km, 97.5°circular orbit, MLTAN: 22:30 ±30 minutes
- 6-month mission
- PExT integrated with a commercial S-class bus, no propulsion
- Body mounted 0.6 meter antenna (can be scaled for the other missions)
- DVB-S2, CCSDS standards (Long Range Capability: DVB-S2X)
- Data Rates
  - Forward Links: up to 53 Mbps (Long Range Objective/Capability: 490 Mbps)
  - Return Links up to 375-Mbps (Long Range Objective/Capability: 1Gbps)



Parameter					
Mass	<25 kg				
Power	<220 W peak				
Polarization Configurations	Tx	RHCP	RHCP	LHCP	LHCP
	Rx	RHCP	LHCP	RHCP	LHCP
Forward D/L Frequencies	17.70-23.50 GHz			G/T	~6 dB/K
Return U/L Frequencies	27-27.50 GHz 27.50-31.00 GHz			EIRP (1-dB OBO)	44.2 dBW 46.7 dBW

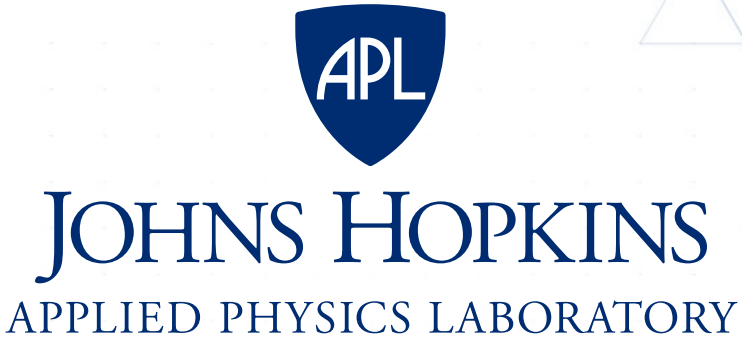
PExT Terminal Pre-set Return Link Configurations

Preset	Description	Frequency (GHz)	Type	RTN					Polarization	Coherency Enabled	Ground Modem
				Data Rate (Mbps)	Symbol Rate (Msps)	Spreading Factor	Modulation	Encoding			
2	Inmarsat I5-F1 Emergency-Rate	29-29.5, 30-31	DVB-S2	0.15	0.3	1.2	QPSK	LDPC 1/4	LHCP/RHCP	OFF	CDM-760
3	Inmarsat I5-F1 Nominal			37.5	37.5	1.2	QPSK	LDPC 1/2	LHCP/RHCP	OFF	CDM-760
4	Inmarsat I5-F1 BW Efficient			20	10	1.2	8PSK	LDPC 2/3	LHCP/RHCP	OFF	CDM-760
5	O3B mPower Low-Rate	27.5-29.1 29.5-30	DVB-S2	12.45	12.45	1.2	QPSK	LDPC 1/2	LHCP/RHCP	OFF	CDM-760
6	O3B mPower Nominal			37.35	24.9	1.2	QPSK	LDPC 3/4	LHCP/RHCP	OFF	CDM-760
7	O3B mPower High Rate			49.8	49.8	1.2	QPSK	LDPC 1/2	LHCP/RHCP	OFF	CDM-760
8	O3B mPower BW Efficient			24.9	12.45	1.2	8PSK	LDPC 2/3	LHCP/RHCP	OFF	CDM-760
9	O3B mPower Symmetric			24.9	24.9	1.2	QPSK	LDPC 1/2	LHCP/RHCP	OFF	CDM-760
10	Telesat Nominal A	27.6-29.1 29.5-30.0	DVB-S2	100	100	1.35	QPSK	LDPC 1/2	LHCP/RHCP	OFF	MDM6000
11	Telesat Nominal B			166.6	100	1.35	QPSK	LDPC 5/6	LHCP/RHCP	OFF	MDM6000
12	Telesat BW Efficient			180	100	1.35	8PSK	LDPC 3/5	LHCP/RHCP	OFF	MDM6000
13	TDRSS Antenna Calibration	25.25-27.5	CCSDS	1	1		QPSK	Conv 1/2	LHCP/RHCP	ON	STG
14	TDRSS Commissioning			5	5		QPSK	Conv 1/2	LHCP/RHCP	ON	STG
15	TDRSS Nominal			5	5		QPSK	Conv 1/2	LHCP/RHCP	ON	STG

- Inmarsat's emission bandwidths listed in Form 442 are bounding cases of minimum and maximum
  - Specific bandwidths used in operation will be based on test scenarios coordinated with relay service prior to transmitting

JHU/APL PExT Pre-Coordination Summary

- The planned PExT payload MODCOD and symbol rate tables limit EIRP spectral density to allowable levels per the below charts
  - A link analysis supporting this is maintained with each service provider and is being pre-coordinated with the following:
    - Inmarsat GX: Jeff Galloway
    - O3b MPower: Eric Gunzelman
    - Telesat: Rich Pang
    - TDRS: Bill Horne, Lynna McGrath
- The PExT payload operates within the allowable frequency ranges and polarizations for each service during their contacts (i.e., the payload operates at the specific frequency and polarization required by each service for that particular contact).
- York Space Systems will maintain control authority of the space vehicle, will be the primary stop button contact for the communications payload, and has the ability to disable the payload during operations should a conflict arise. APL will be the backup stop button contact.
  - York contact: TBD
  - APL contact: Chris Haskins, chris.haskins@jhuapl.edu, 240-228-3405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