



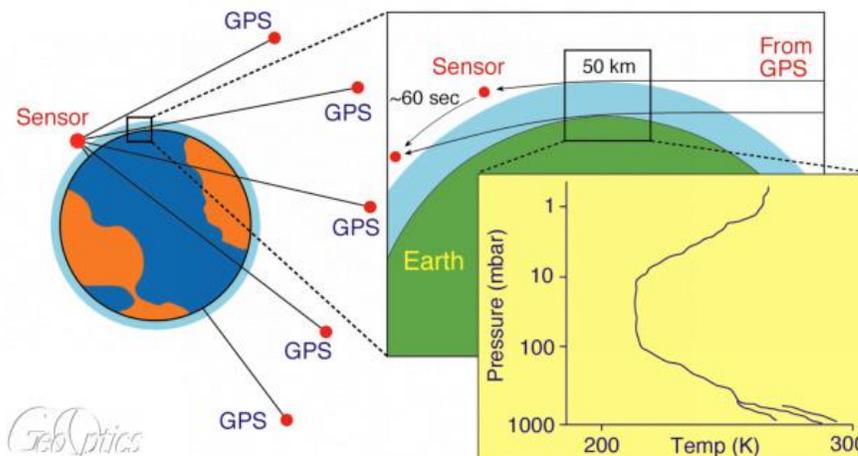
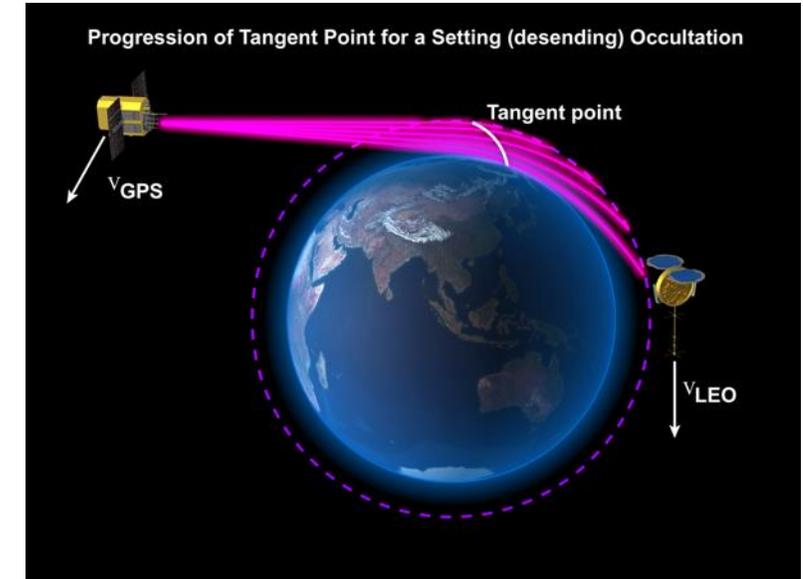
Small Satellites: The Execution and Launch of a GPS Radio Occultation Instrument in a 6U Nanosatellite

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Background



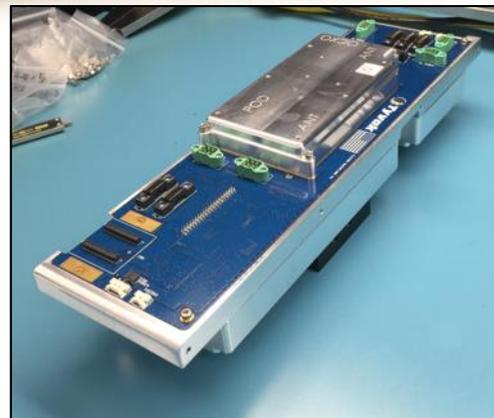
- Tyvak is developing the GeoOptics, Inc. CICERO constellation of satellites.
 - Completed first three satellites in the constellation
 - Intended to gather vital data on the Earth's weather, climate and environment.
- Program utilizes Tyvak's Endeavour small satellite platform
 - 6U CubeSat, high-speed communications, 3-axis high performance attitude control
 - The CICERO Constellation will test and demonstrate the newly developed instrument and the integrated satellites
- Data gathered will provide:
 - Weather monitoring and forecasting information to the National Oceanic and Atmospheric Administration (NOAA)
 - Science and Weather Data to Other government and commercial customers.



In the past, larger satellites have executed these missions. Small satellite missions can collect more distributed data with faster revisit times around Earth.

The GPS Radio Occultation instrument development emphasized building an instrument of equal quality to previous instruments.

Cion - CICERO Instrument for GPS-RO



• Key Challenges & Experiences

- Miniaturize the instrument from a power and mass perspective but ensure end data product quality and support essential JPL heritage software compatibility.
- The quality and effectiveness of collaboration is far superior when the collaborators are within driving distance. JPL has been on-sight for system test verifications, and design reviews.

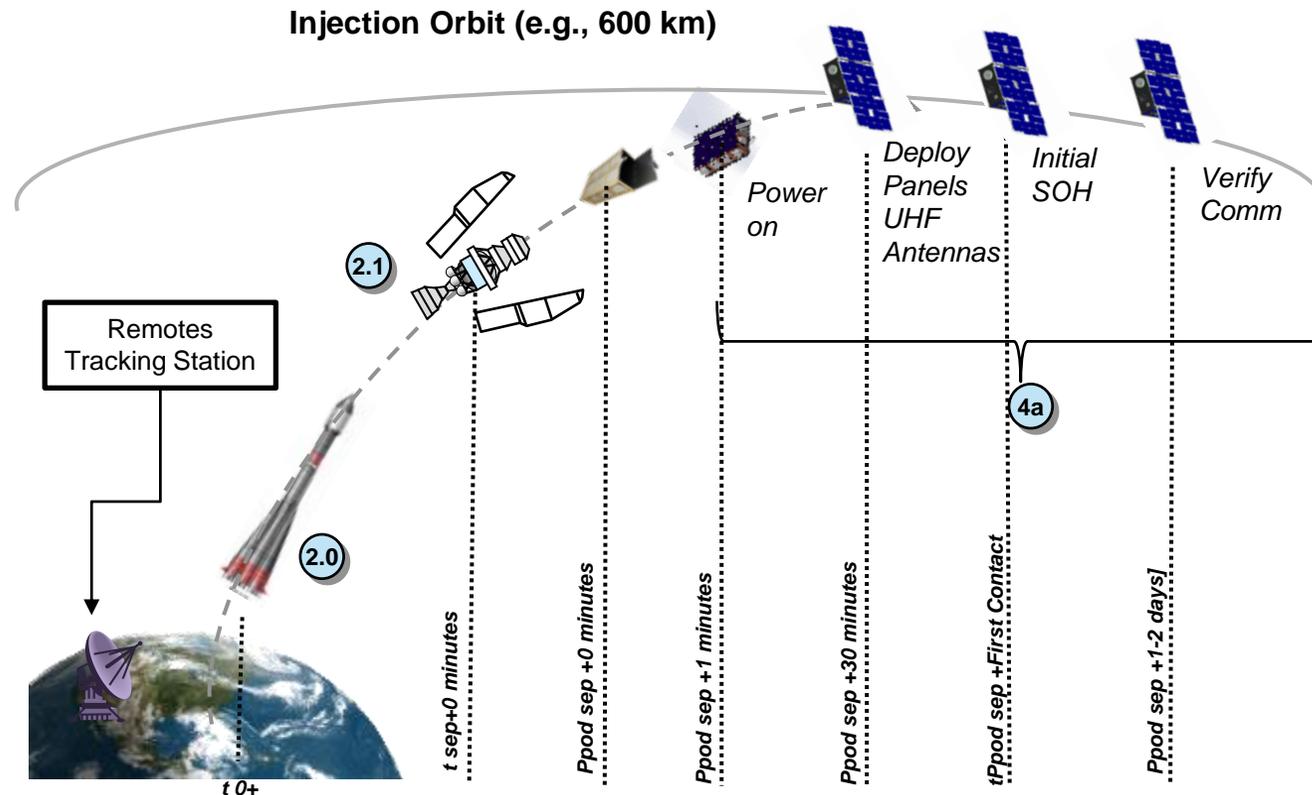
• Cion Instrument Features:

- RF Inputs: 3 antenna inputs with 4 down converters each
- Processor: 1.2 GHz Dual Core Arm processor
- RAM: 1GB Flash: up to 256GB
- DSP: Programmable FPGA for Digital Signal Processing
- Sub-channels: 16 GPS (8 dual freq satellites)
- External Clock: High performance Osc (10MHz, $\sim 5 \times 10^{-12}$)
- Ext PPS output and Ext event input

• Accommodations:

- Volume: 3U available
- 30cm X 10cm X 6cm utilized by final payload configuration
- Mass: 1.2kg
- Power: ~ 8 watts at 12 VDC
- Comm Interfaces Available : Two RS 422, USB and Ethernet

Launch and Early Operations (LEOPS)



• Launch

- Rideshare using 6U dispenser
- Power on

• Initialize

- Only core avionics will turn on
- Deployables released
- ADCS turn on and auto transition to sun pointing

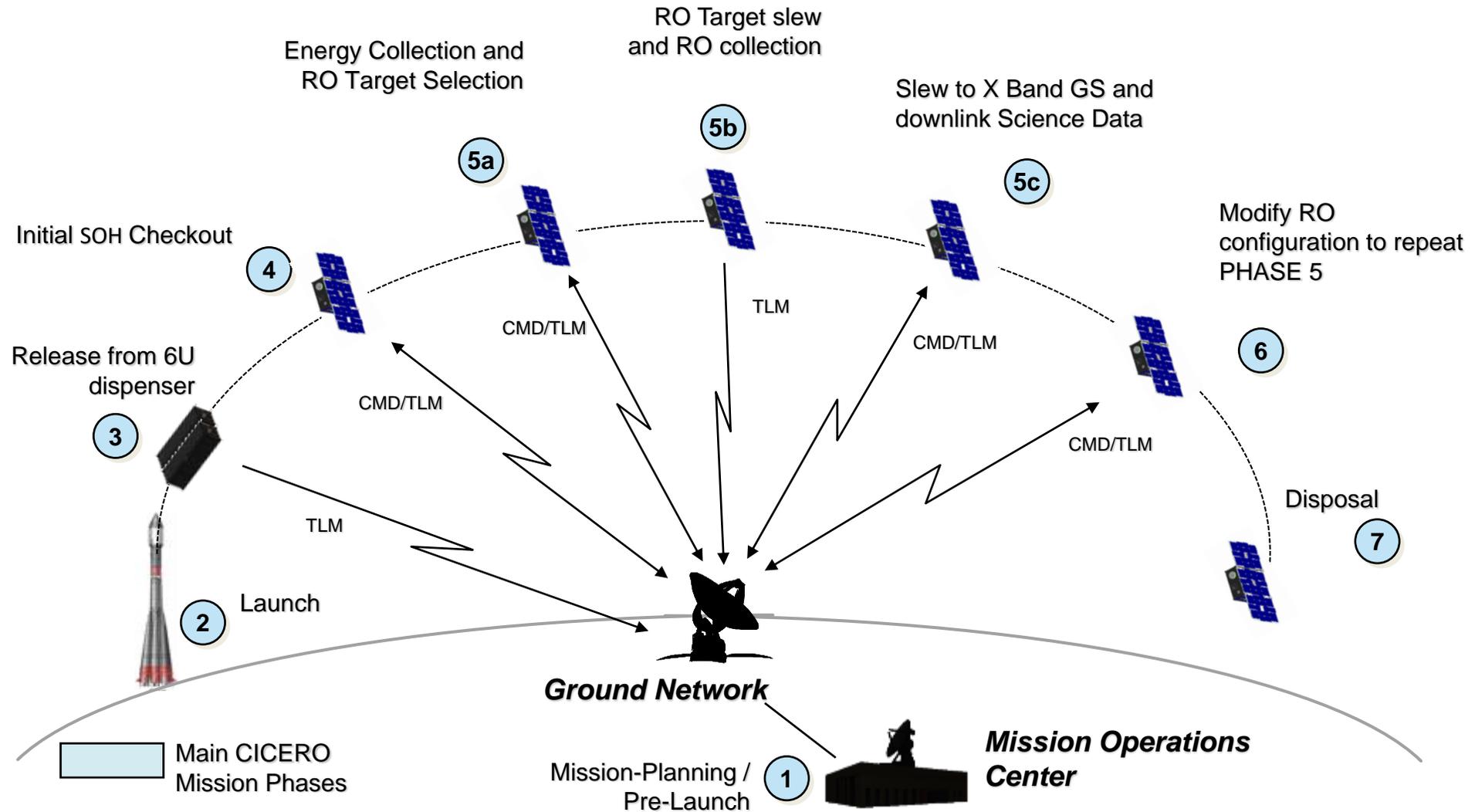
• Initial SOH

- GPS seeded Propagator used to initiate SOH over UHF stations
- SOH on demand if GPS not available

• Verify Comm

- Checkout uplink/downlink using UHF, downlink using X-Band

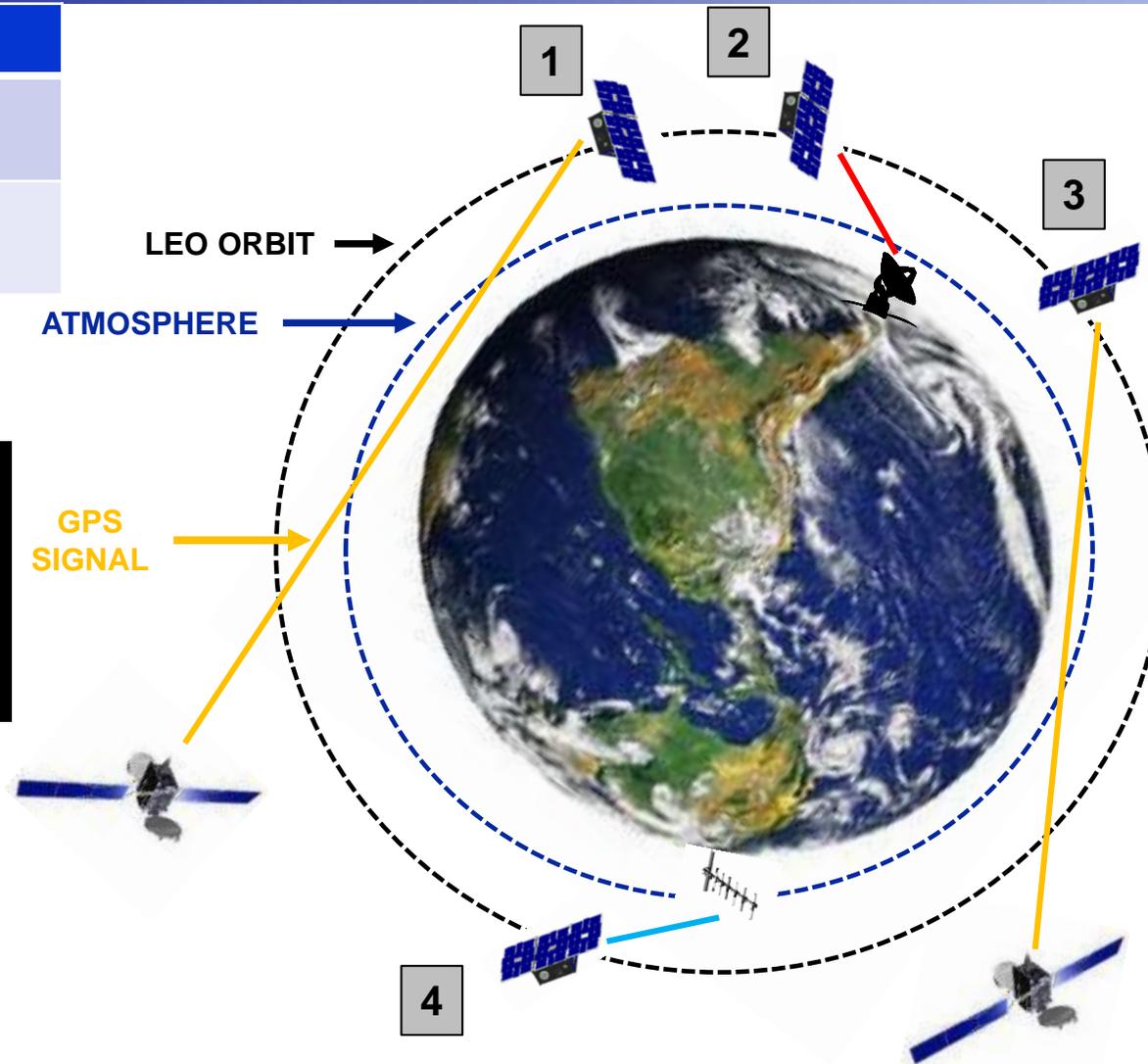
Summary of CICERO Mission Phases



Mission Operations Overview



LEGEND	
	GPS/GNSS
	CICERO



- 1. Nominal RO Collection –** CICERO-OP1 collects RO while slewing for Sun-Pointing
- 2. X-Band Data Downlink –** Every orbit CICERO has at least 1 pass with X-Band station for downlink
- 3. Target RO Collection –** CICERO-OP1 slews to target RO collection
- 4. UHF Uplink –** Uplink any specific RO targets or modify collection angle

Collection Flexibility

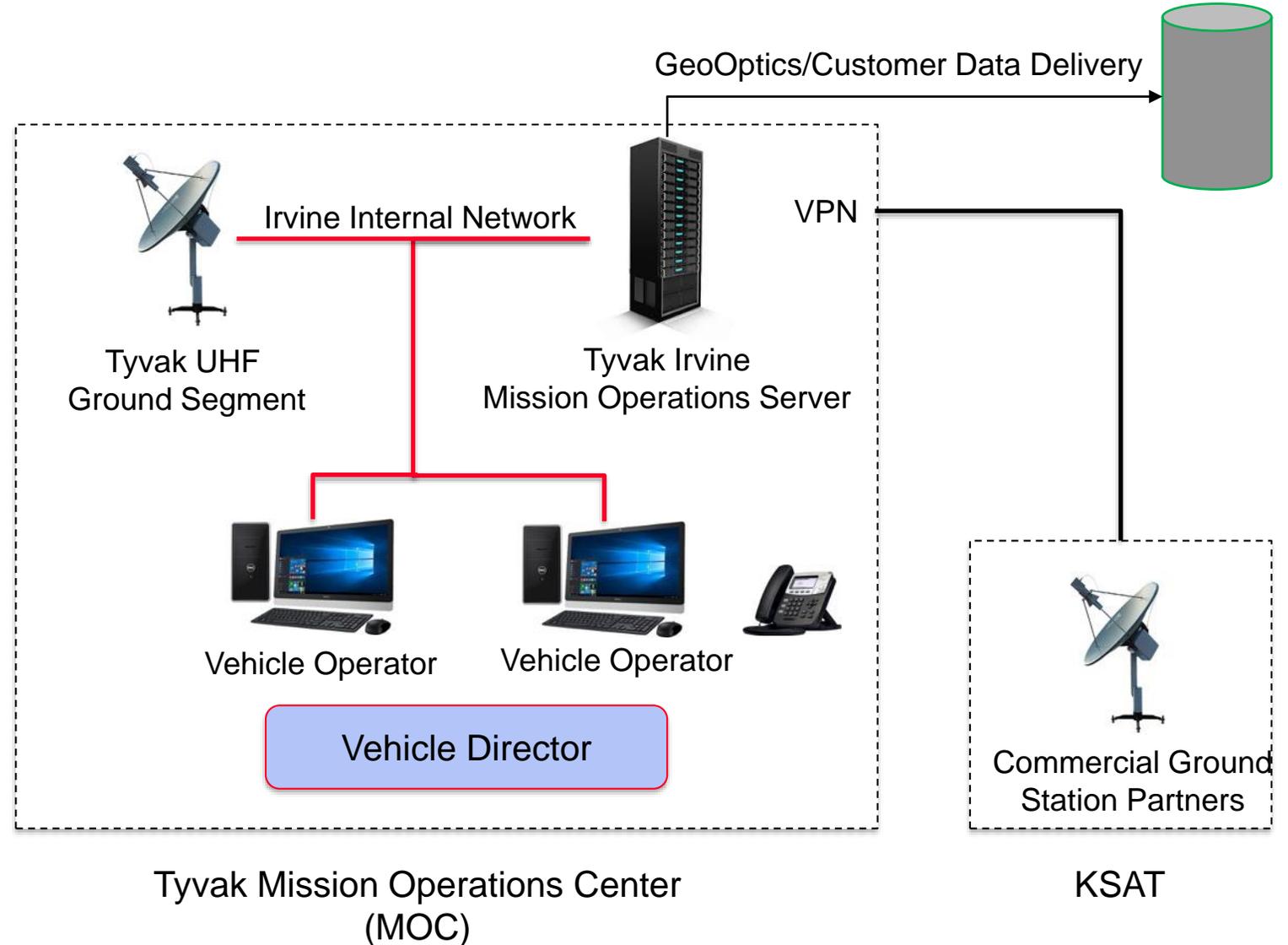
Spacecraft will slew for optimal RO coverage and also to track certain events prioritized by operators

High Degree of Automation

Each spacecraft has the ability to operate more than a weeks worth of automated collection and data downlink events

Mission Operations

- Mission Operation Center (Tyvak, Irvine)
 - Main UHF system on-site
 - Additional UHF station is available K-SAT site in Tromso
 - UHF only
 - All data from all sites comes directly to Tyvak once downlinked
- Kongsberg Satellite Services (K-Sat)
 - Additional Downlink Stations available for X-Band



Nominal Operations are mostly autonomous for the routine RO collection and Data Downlink. Fault Flag notify operators of any off nominal cases and put the spacecraft into Safe Mode.

Timeline

