Large aperture, high frequency, ground-stations for CubeSats: enabling high data rate X-band communications.

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The University of Arizona

Abstract

Data down-link rates on CubeSats are limited by both space and ground antenna gain. To improve the ground-station receiver gain available by retrofitting 6.1 m steerable radio telescopes to serve as an X-band ground stations. One or more of these ground stations will support several upcoming CubeSat missions. In particular, a recently selected NASA CubeSat Launch Initiative mission, CatSat will demonstrate video streaming from a 6U spacecraft, along with ionospheric radio sounding. CatSat is planned for launch in late-2020. We will present the current design of the ground station, the architecture of the streaming video cameras on CatSat, and lessons learned developing high
data rate CubeSat communications architectures in an open academic setting.

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PRESENTATION AGENDA

- History of the Antennas
- Antenna Locations
- Spacecraft Command Center
- Technical Capability
- Back End

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History of the Antennas

UArizona acquired six 6.1 meter radio telescopes that were previously part of the CARMA and BIMA arrays. The antennas are now owned and operated by the University of Arizona and are available to external users for ground station services.

Photo of CARMA array courtesy of The University of Chicago.

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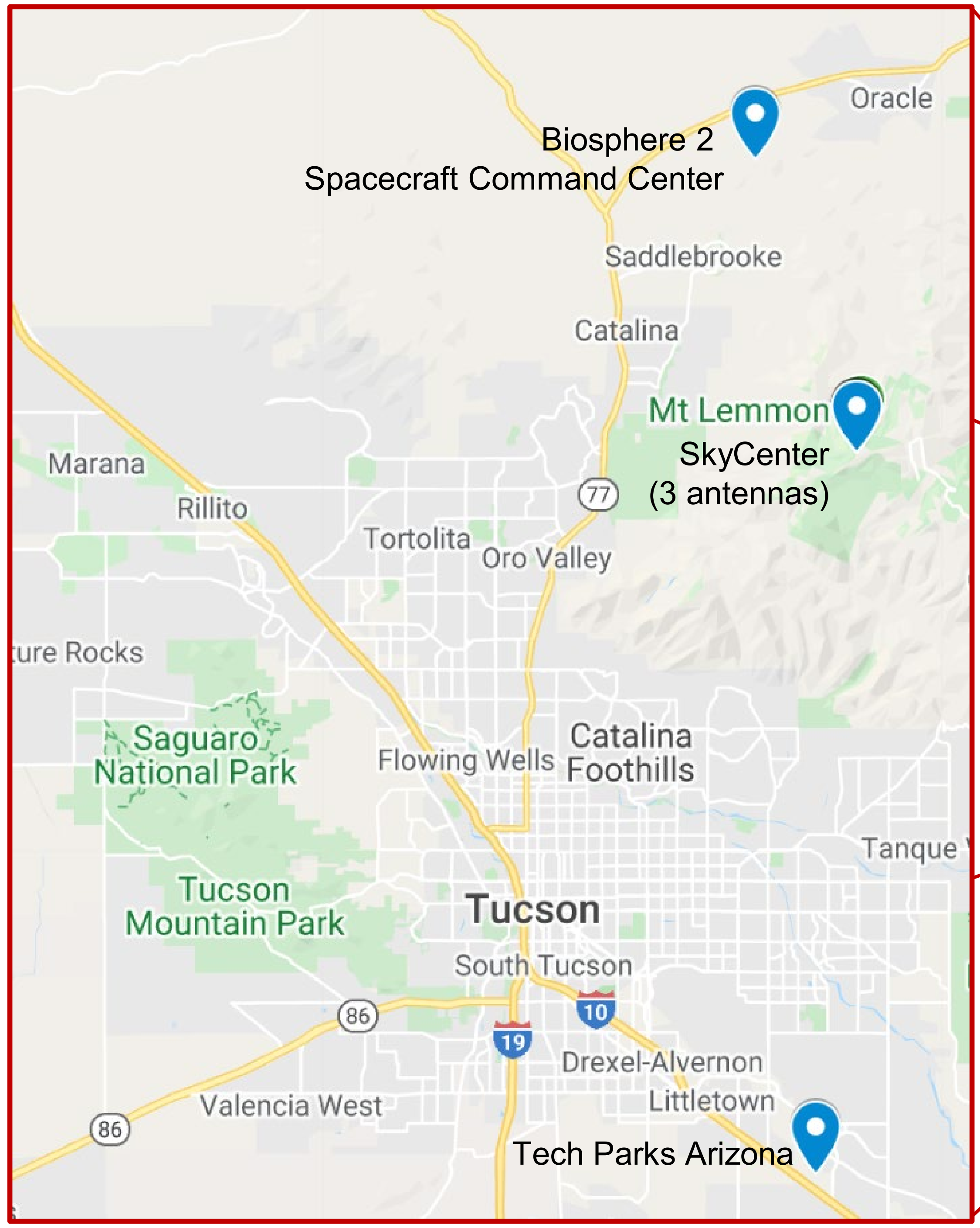
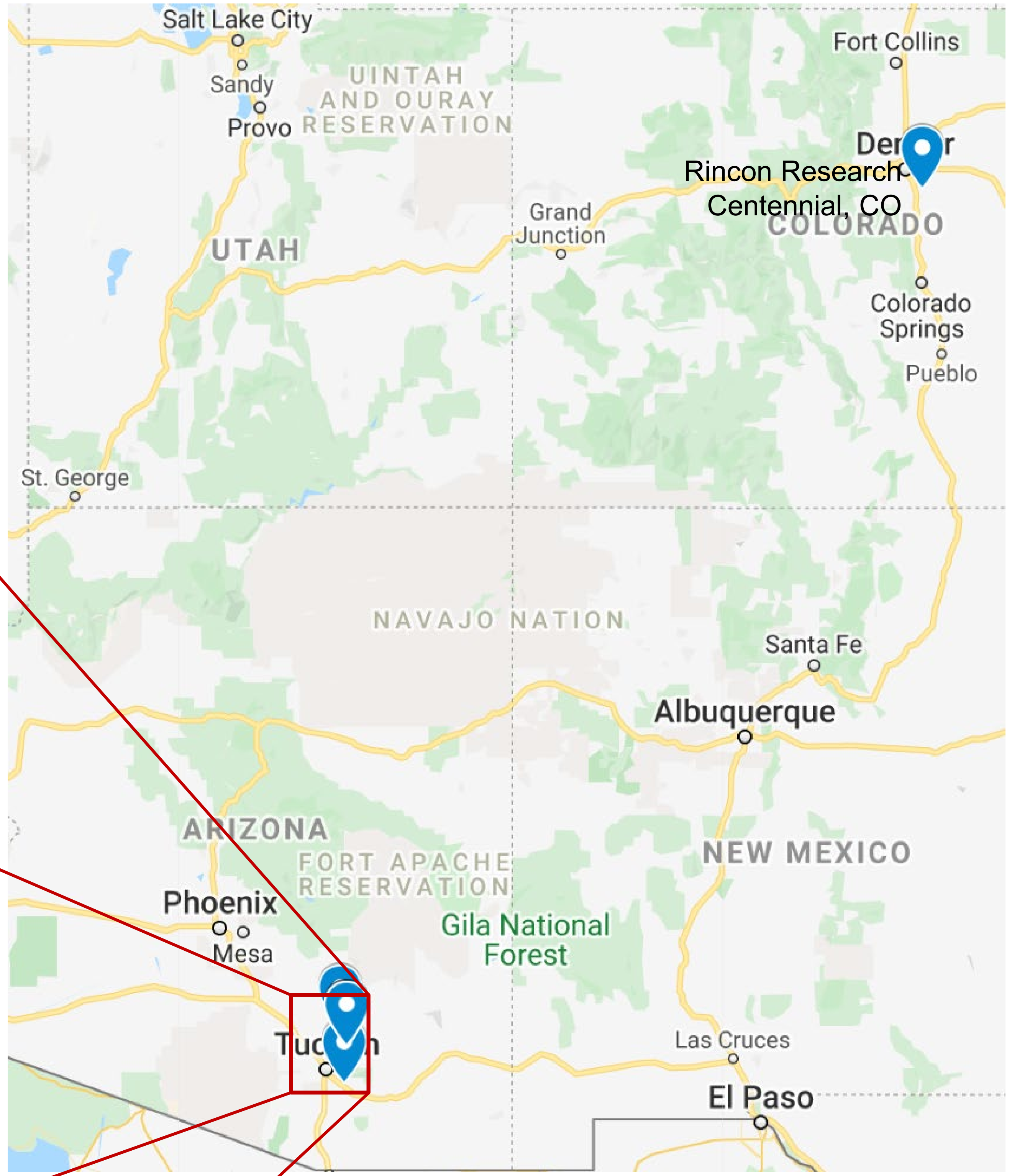
Antenna Locations

There are four antenna locations. One antenna will be at Tech Parks Arizona, south of Tucson, AZ; One will be at Rincon Research in Centennial, CO; three will be at the Mt. Lemmon SkyCenter East of Tucson, AZ; and one will be at Biosphere 2 in Globe, AZ.

The antenna at Biosphere 2 will be the primary ground station for satellite communication and will include a Spacecraft Command Center where users and students can transmit and receive data.





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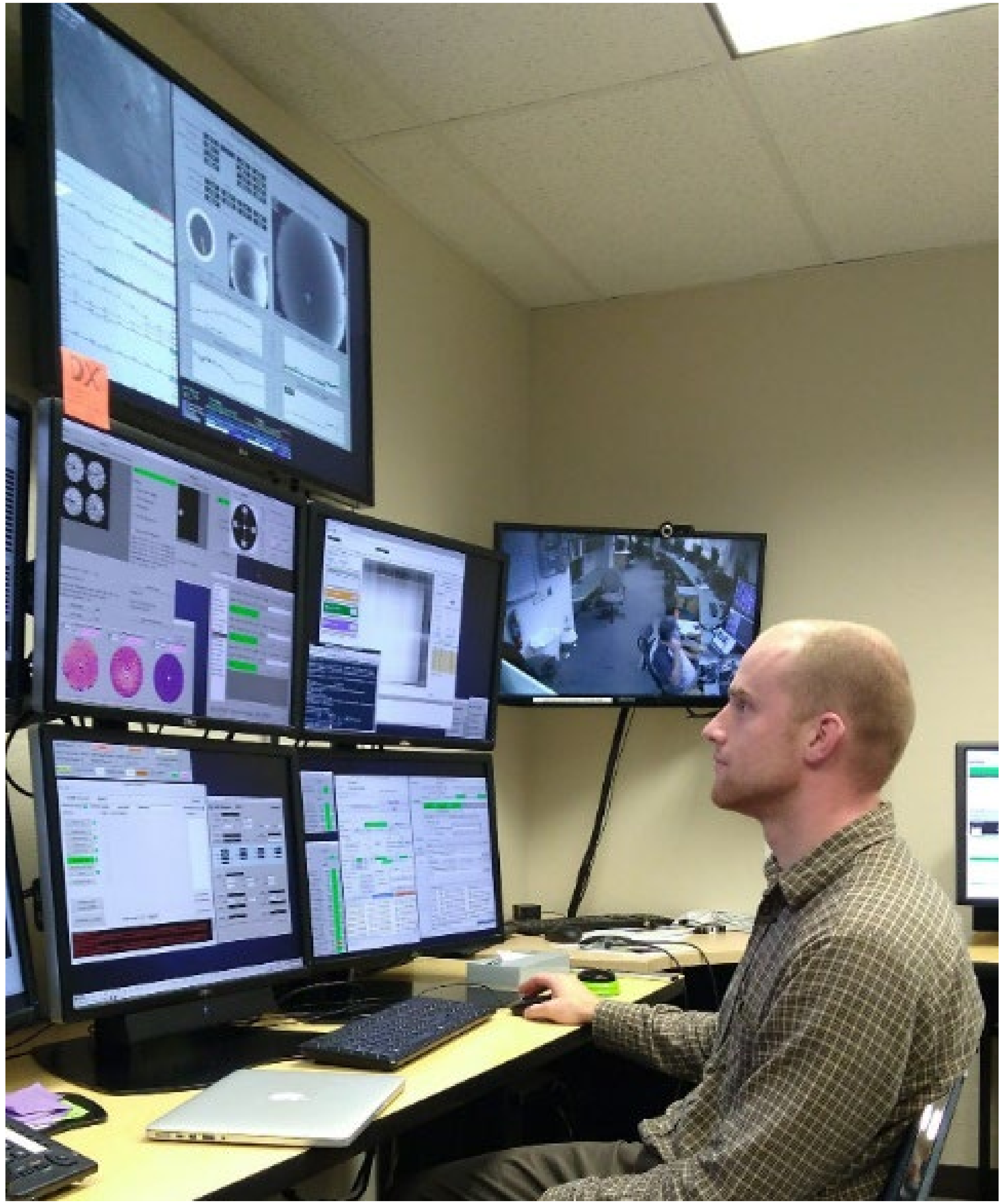
Spacecraft Command Center



The Spacecraft Command Center will be similar to the LBTI command center pictured here. .

Ground station control can be remote.

An onsite command center will provide local control of the ground station.

Overnight housing and food service are available on the property and the Spacecraft Command Center is accessible 24/7.

The educational environment at Biosphere 2 makes this a perfect location for student involvement including mission operations, launch parties, and data collection.

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Antenna Performance

- Primary surface

  6.1 m diameter

  42 µm RMS surface shape error

  >97% Ruze efficiency in X and Ka bands

  System F# = F/D = 3.56

- Slewing Speeds

  2˚/s Azimuth and 3˚/s Elevation

  9 degree diameter keyhole (90 seconds of dead time) for direct overhead passes. No keyhole for passes below 85 degrees elevation.

  Tracking can be based on Two Line Elements (TLEs), azimuth and elevation coordinates, or other coordinate systems with real time, closed loop pointing correction.

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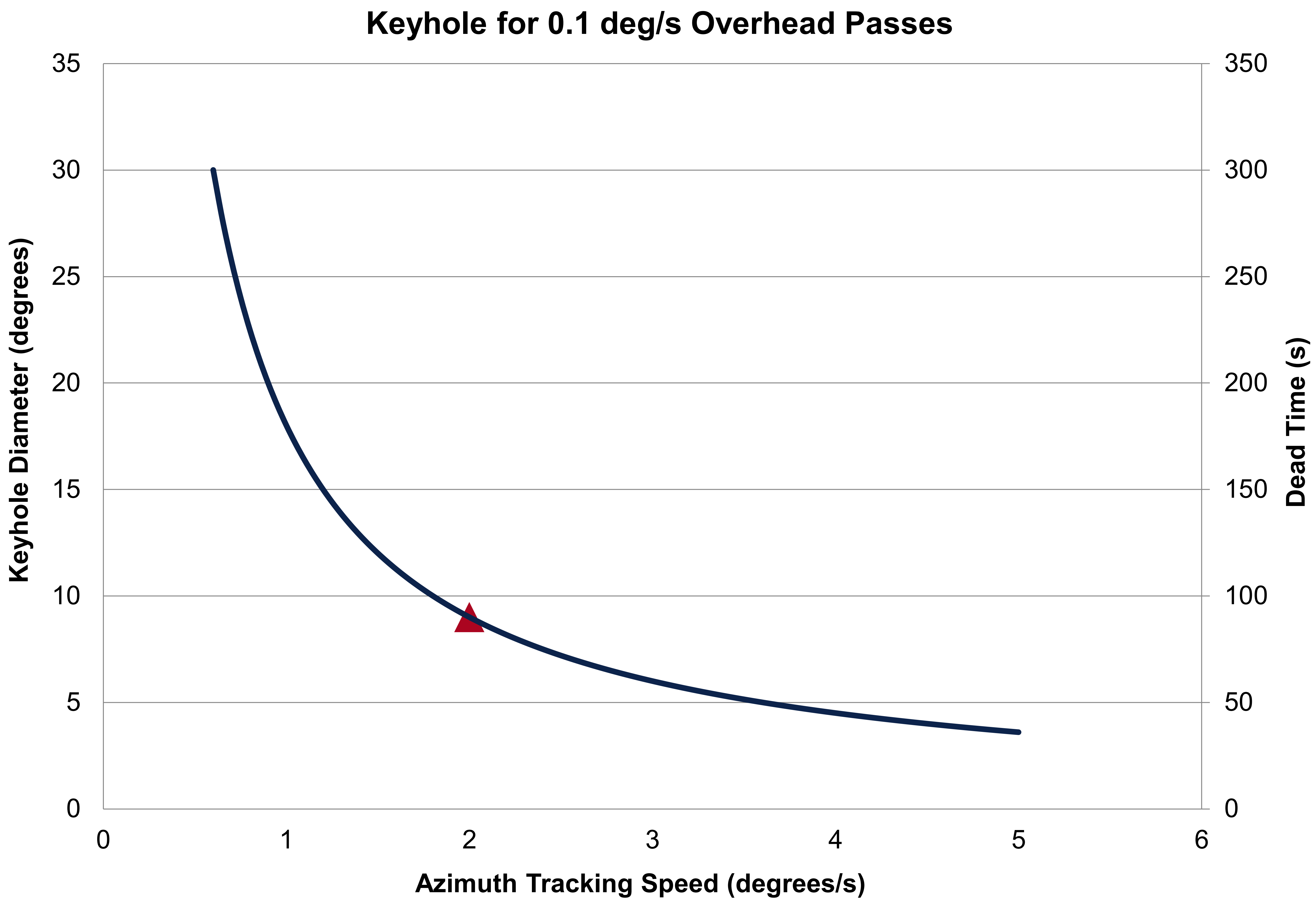
Keyhole



During a direct overhead pass in LEO orbits (0.1 degree per second), with 2 degrees per second azimuth slewing, the antennas have a 9 degree diameter keyhole, which is equivalent to 90 seconds of silent time. Antenna control will automatically reacquire targets as quickly as possible. Passes below 85 degrees elevation will not have any keyhole.

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Back End

Antennas

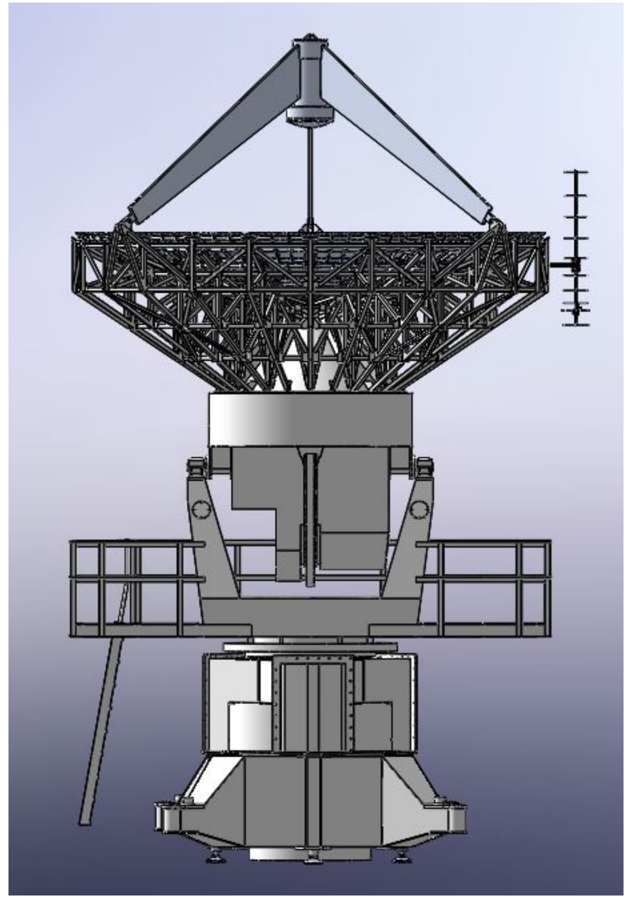
Initial receivers will include

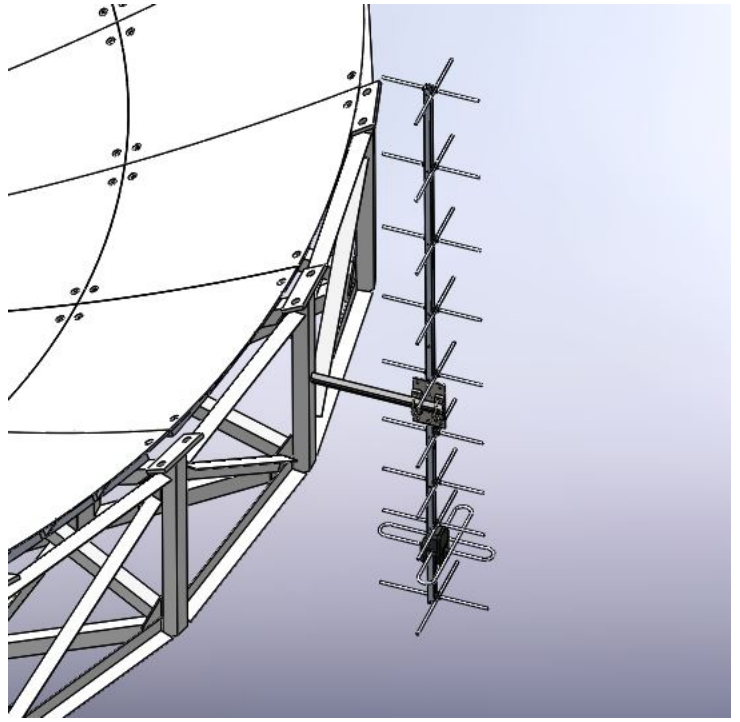
- 10.47 GHz horn
- HF (7 MHz through 29 MHz) antenna
- 435 MHz outboard Yagi

Additional receivers can be added as necessary

Radios

- Software Defined Radio
- Custom radios can be installed





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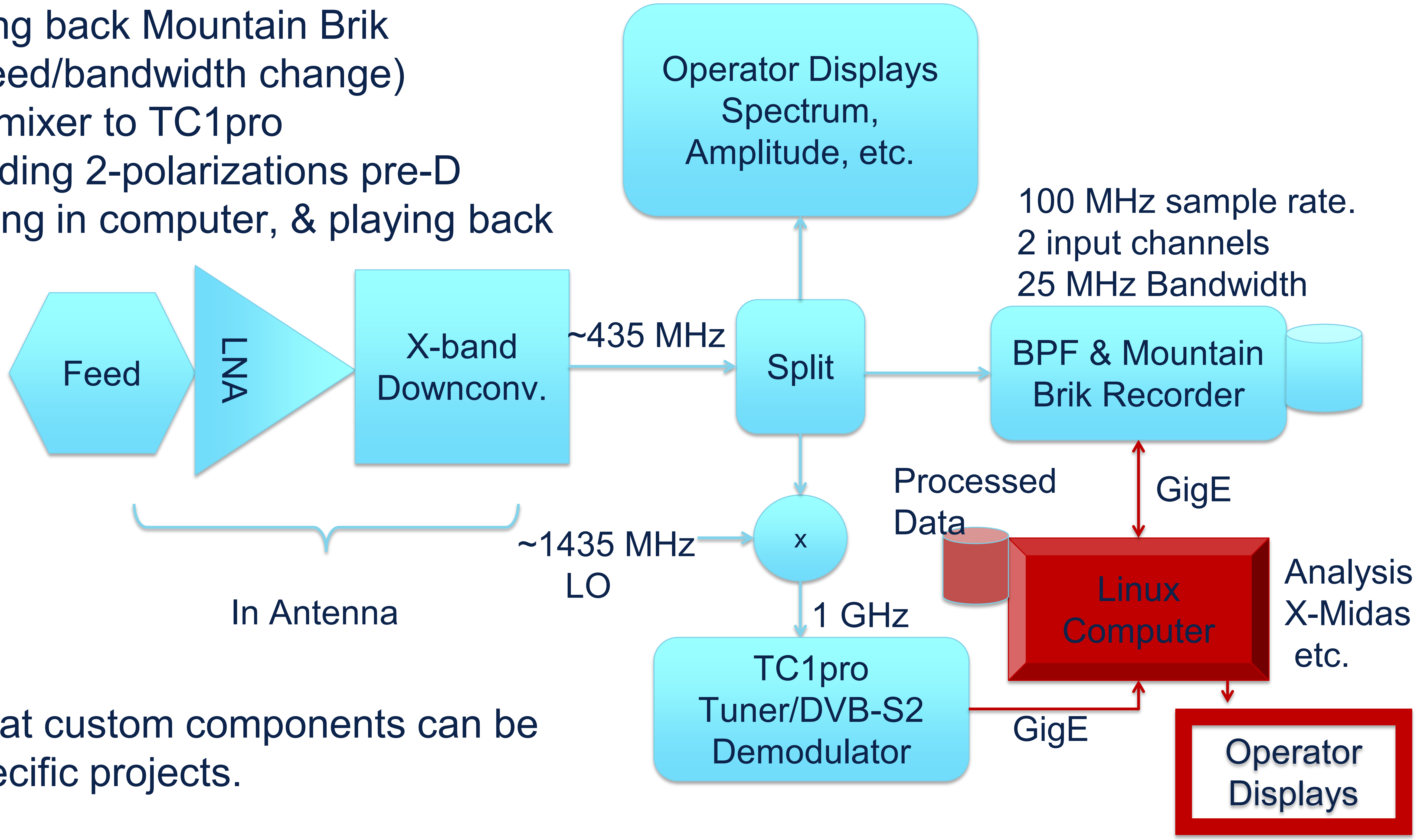
Back End Block Diagram

Note possibilities:
1. Playing back Mountain Brik (with speed/bandwidth change) through mixer to TC1pro
2. Recording 2-polarizations pre-D Processing in computer, & playing back



Signal Path (blue) and Digital Processing (red)

Also note that custom components can be used for specific projects.

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