POLYSAT
A University CubeSat Story

California Polytechnic State University, USA

PARIN PATEL

BRYAN KLOFAS
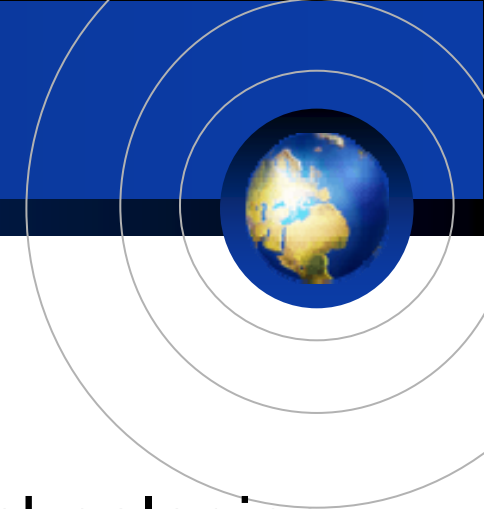
CubeSat Developer's Workshop

The Boeing Company, Huntington Beach California

April 20th 2007

PolySat

- Started in 1999 by a Multidisciplinary Team of Engineering Students

- Objective: Engineering Education

- Objective: Provide a reliable bus system to allow for flight qualification of a wide variety of small sensors and attitude control devices.

CP1

- **Magnetorquer developed by Cal Poly**
- **Sun Sensor developed by Optical Energy Technologies**

- **DNEPR 1 launch failure: July 26th 2006**
 - No in orbit operations

- **Valuable lessons learned**
  - CubeSat development: challenges & logistics
 - Non-Reoccurring Costs: Multiple Flight Units

Operations Experience

- **Training Objectives**
  - Successfully make contact with a CubeSat
  - Download and decode AX.25 digital data.
- **Trans-Pacific Collaboration with University of Tokyo**

- **Autonomous Beacon**
  - Locating the CubeSat after deployment
  - Acquisition of signal
  - Health status / contingency mode

- **Normal CubeSat**
  - 1/2 to 1 watt RF
- **U of Tokyo (XI-IV)**
  - Only 80 mW beacon: Morse Code
  - Comes in crystal clear!

XI-IV (U of Tokyo)
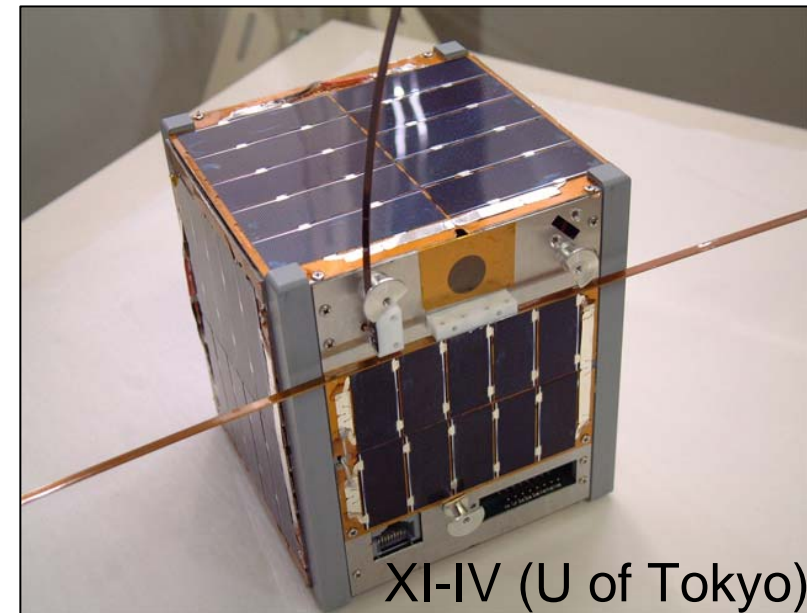
XI-IV Images
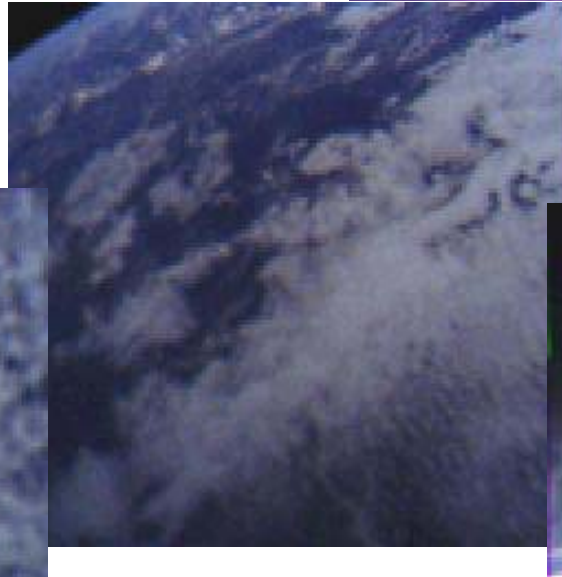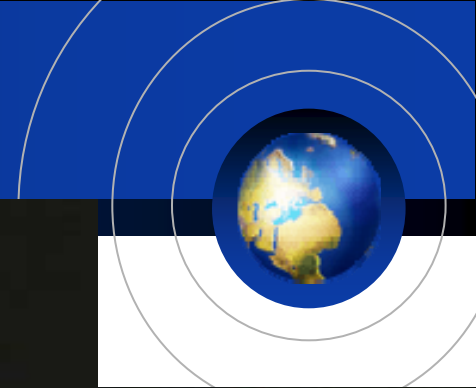
- **CP2.1 manifested as CP4**
  - Energy Storage and Dissipation Experiments
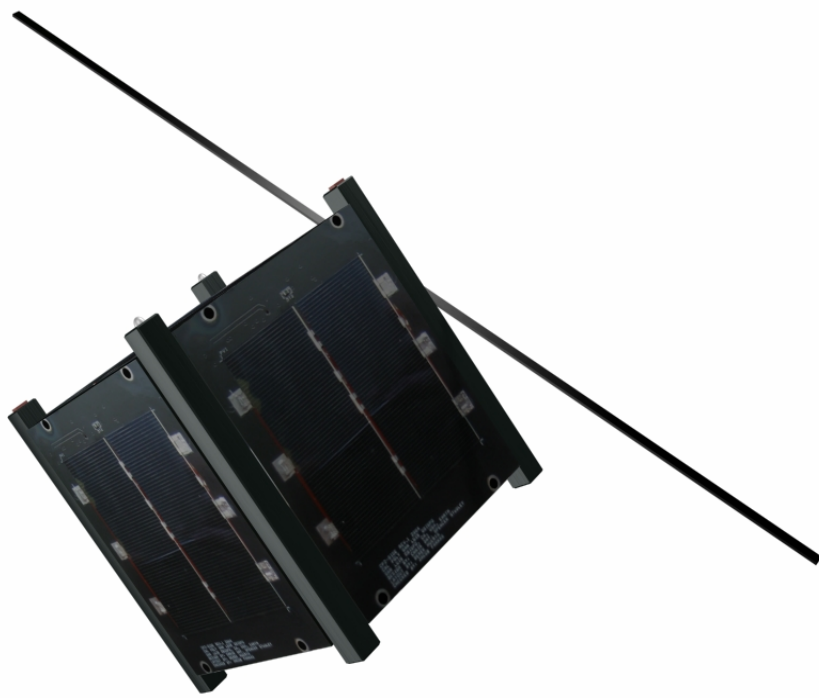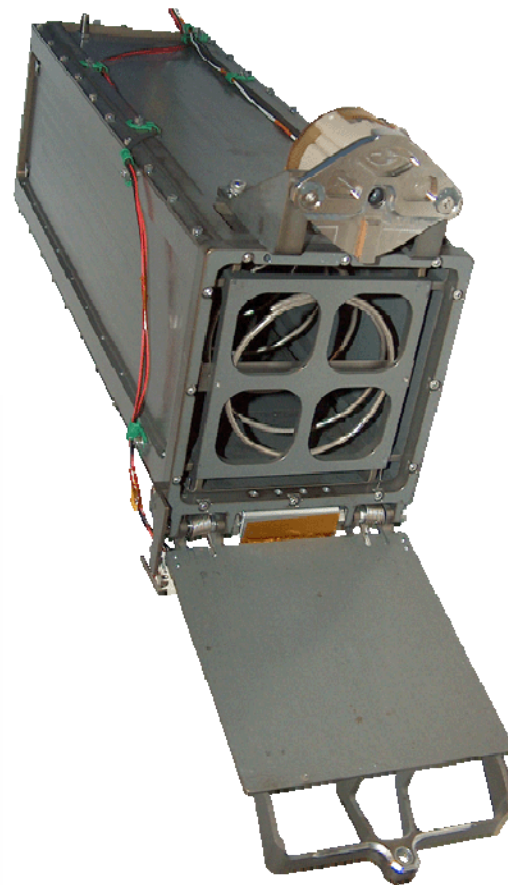 - Test and Characterize CPbus

- **CP3**
  - Attitude Determination using a suite of sensors
  - Attitude Control using Magnetorquers in each side panel
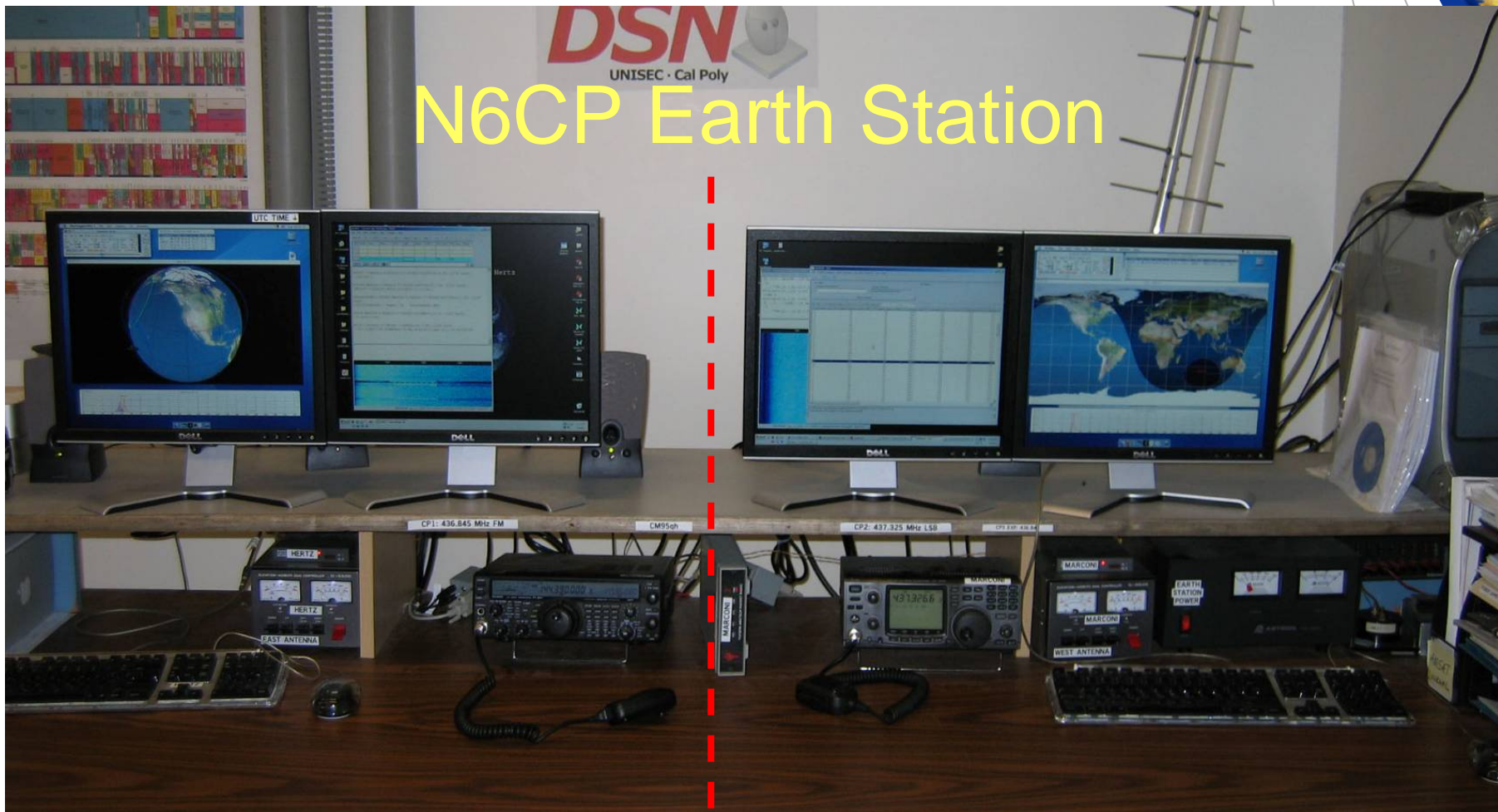 - Observation Imagers: lots of data to download!

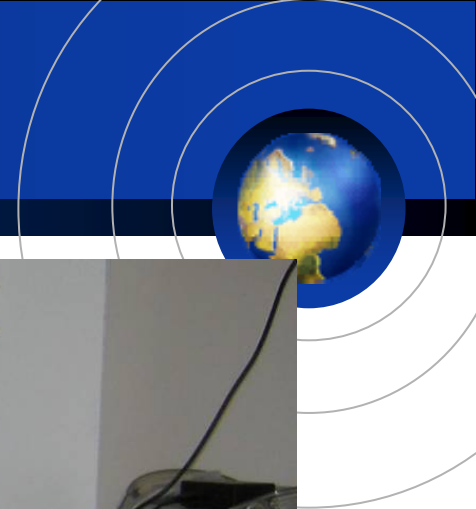# Deployment to First Contact

- Launch
- P-POD deployment
- Antenna deployment
- First beacon
- First possible pass
- First contact

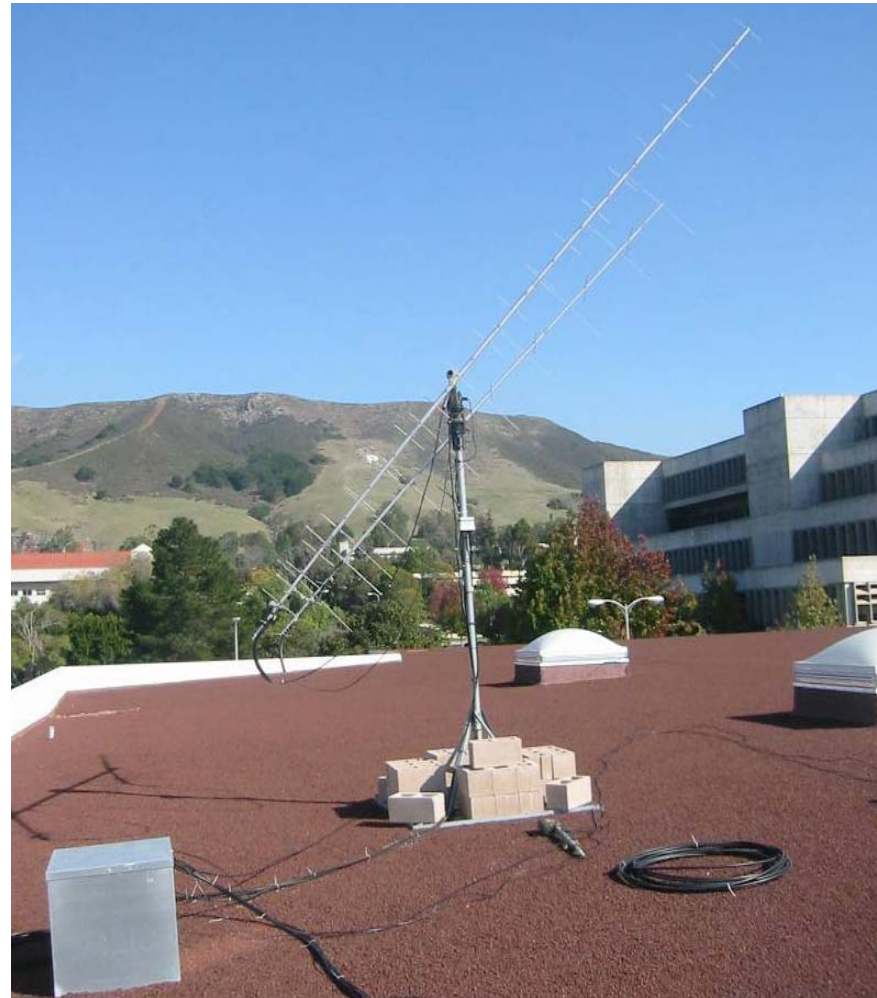N6CP Earth Station

- Yeasu FT-847 and Icom IC-910
- Yaesu G-5500
- MixW Software TNC
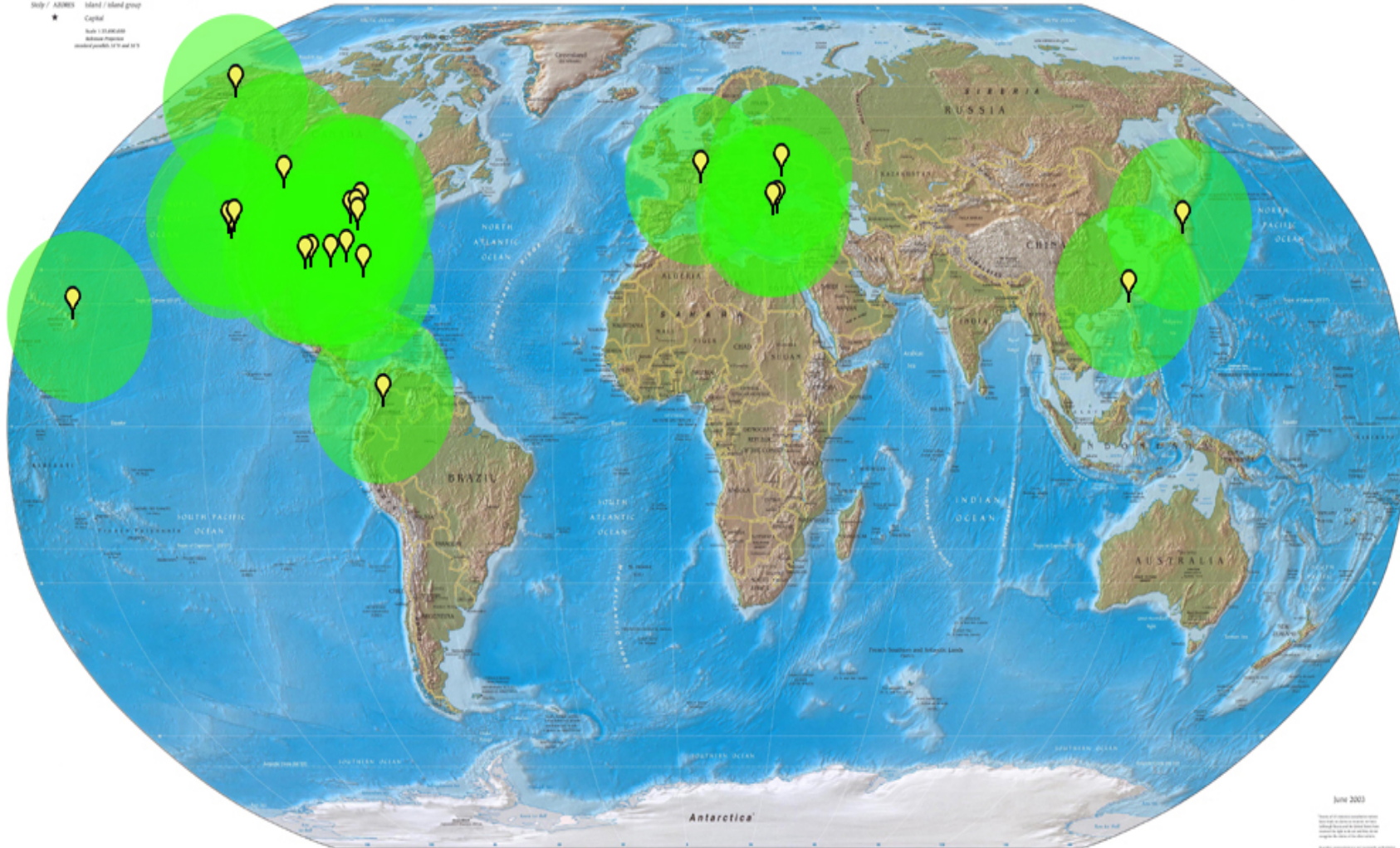- Mac Doppler Pro for tracking

Antennas

- 145 and 437MHz yagis
- No 2.4 GHz equipment yet…

The Ground Station Network

Physical Map of the World, June 2003

GENSO Background

- Global Educational Network for Satellite Operators
- Started under the International Space Education Board, a collaboration between CSA, ESA, JAXA, and NASA
- Approved on 5 October 2006
- Project to link low-cost earth stations

Canada

esa

JAXA Japan Aerospace Exploration Agency
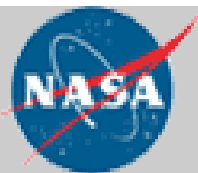
National Aeronautics and Space Administration

genso

What is GENSO

- A system to link ground stations using the internet
- Three parts:
  - Central server
    - Authentication and registration
  - Mission Control Client
    - Scheduling of Ground Station Servers
    - 1 MCC per satellite developer
  - Ground Station Servers
    - Actual interface between rotors/radio and internet

Central Server

- 3 central servers located around the world
  - Europe
  - California (Cal Poly or SRI)
  - Japan
- Tasked with Authentication and Registration only
- All other functions (scheduling, data transfer) will go peer-to-peer between Mission Control Clients and Ground Station Servers

Mission Control Client

- A program that runs on a personal computer that can control Ground Station Servers
- Uses the Central Servers to get IP addresses for individual GSS, then contacts the GSS's directly to:
  - Schedule an active session
  - Download decoded data
  - Control the radios and rotors to track a satellite during an active session
  - IRC Client ?
  - Skype Client?

Ground Station Server

- Compatible with a majority of ground stations currently operating
- "Passive" tracking:
  - Will track all satellites it can decode all the time
  - Will forward data on to MCC
- "Active" tracking:
  - Someone at a MCC is actively controlling the rotors and radio, looking at the decoded data, and listening to the audio
  - Must be scheduled prior to satellite pass and cleared with GSS
  - Requires offline interaction and parties that know each other
- Store audio/data locally and stream to MCC as bandwidth allows
- IRC and/or Skype client?
- Scheduling process:
  - Prioritized

"Standard" Earth Station

- Icom IC-910 radio with computer interface

- M2 OR2800P-DC for Azimuth and MT-1000 for elevation

- Symek TNC 31S

- Antennas:
  - 2MCP22 for 145 MHz
  - 436CP42UG for 437 MHz
  - 1 metre dish for S-band (downlink only)

The Ground Station Network

- Latest update on CP3/CP4
- Able to hear, not decode

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