



CINEMA

(Cubesat for Ions, Neutrals, Electrons, MAgnetic fields)

Robert Lin, PI
Peter R. Harvey
Manfred Bester
UC Berkeley

Co-I Institutions:

Kyung-Hee University, Korea

Imperial College London

Johns Hopkins University/Applied Physics Laboratory

Inter American University of Puerto Rico Bayamon



- Outline
 - CINEMA Mission Overview, Status, Issues
 - CINEMA Concept of Operations
 - Communications Options
 - Open Questions

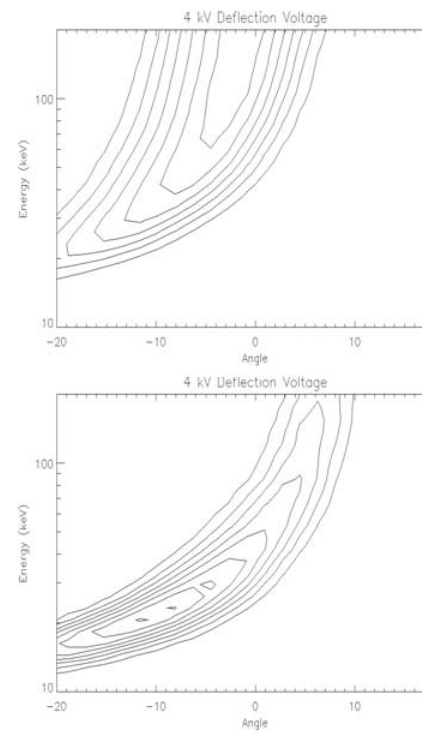
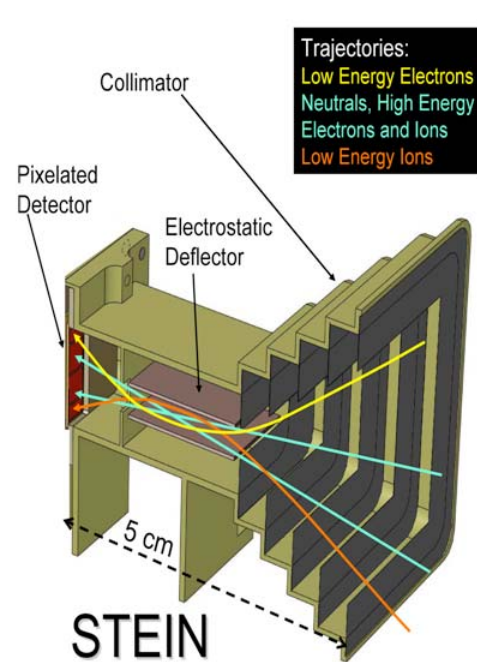
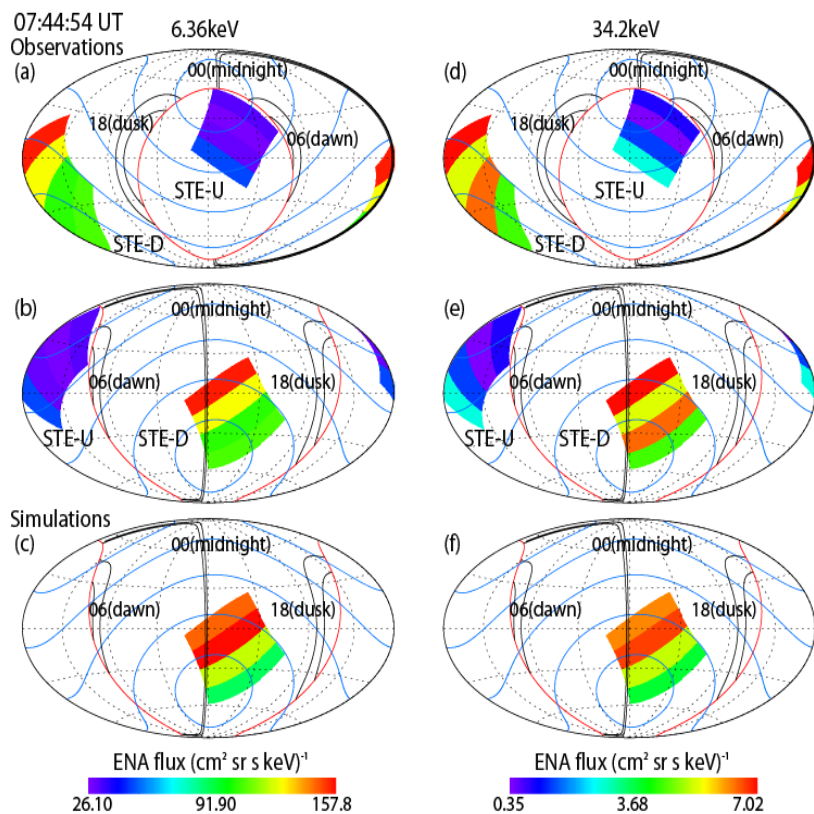


CINEMA Overview

- CINEMA Overview
 - Mission goal is to study space plasma physics and space weather using magnetometers and particle detectors
 - UCB has collaboration with Kyung-Hee University in Seoul, South Korea (two additional spacecraft)
 - All three spacecraft together called TRIO

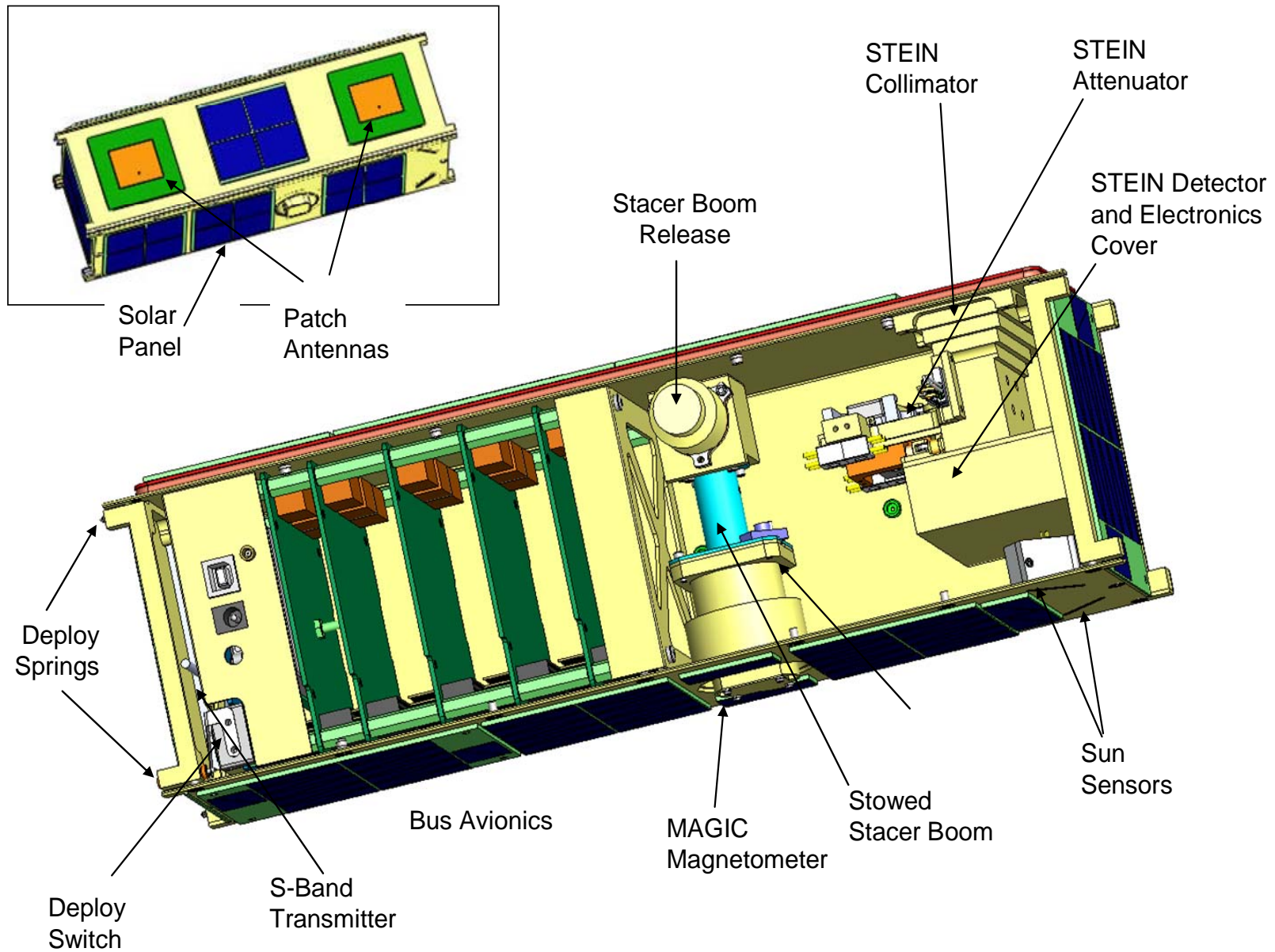


CINEMA STEIN Detector





CINEMA Spacecraft Layout





- CINEMA Status
 - NSF-UCB Funding Started 10/1/09
 - Student Selections Completed (12 at UCB, 5 at KHU)
 - Weekly Conference Calls in progress
 - Mission Requirements, Software Reqs Complete
 - Electronics Specifications in progress
 - Trade Studies Completed for CPU, EPS, GSE S/W
 - Laboratory set up Complete
 - Development systems (2) delivered
 - LHCP Antenna breadboard testing in progress
 - Initial contacts for RF licensing
 - Solar Array make/buy decision expected January
 - CDR planned for late January



- CINEMA Issues

- Limited communications with Imperial and KyungHee due to time zone differences
- KHU spacecraft (TRIO-2 and TRIO-3) mission overlap with CINEMA (TRIO-1) requires coordinated launches.
- Potential ITAR issues (bilateral control of US/Korean spacecraft)
- Proposed RF plan (MicroHard 2.4 GHz) not acceptable to NASA or KHU
- Revised plan (UHF up, Sband down) will require a new ground antenna

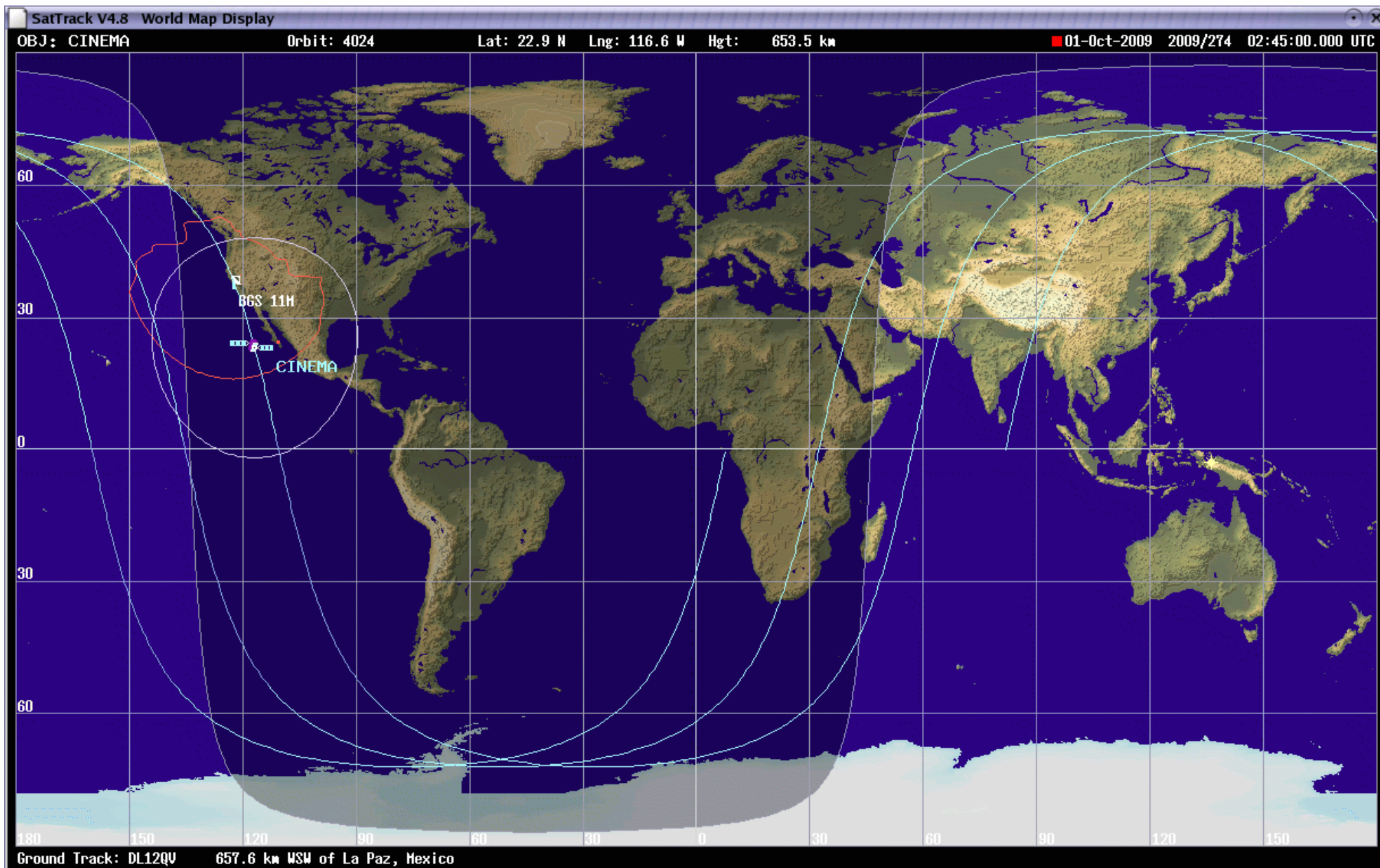


CINEMA Concept of Operations

- **CINEMA Concept of Operations**
 - Mission Orbit
 - Spin-stabilized spacecraft
 - Baseline orbit 650 km circular at 72° inclination
 - Pass Coverage
 - Typically 4 passes/day with 30 min access time
 - Tracking via TLEs downloaded from USSTRATCOM
 - Data Recovery
 - Store-and-forward scheme, downlink at 1 Mbps
 - Recoverable science data volume 760 Mbits/day
 - Ground Segment
 - MOC and ground station co-located at UCB/SSL
 - Look into using heritage control system (ITOS)



Typical CINEMA Ground Track





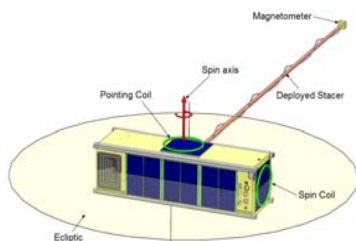
Communications Options

- **Communications Options**
 - Telecom Trades
 - Frequency band selection
 - Flight transmitters & receivers
 - Flight antennas
 - Ground Station
 - BGS 11m Parabolic Reflector
 - BGS UHF Helix
 - Link Budgets
 - S-band downlink
 - UHF uplink
 - Spectrum Licensing Options
 - Preferred approach is government license



Communications Concept

Low-rate Command Link
UHF, 400-470 MHz
FM, 9.6 kbps, No coding



High-rate Telemetry Link
S-band, 2200-2290 MHz
FM, 1 Mbps, Reed-Solomon coding

CINEMA



BGS Helix Antenna



BGS 11m Antenna



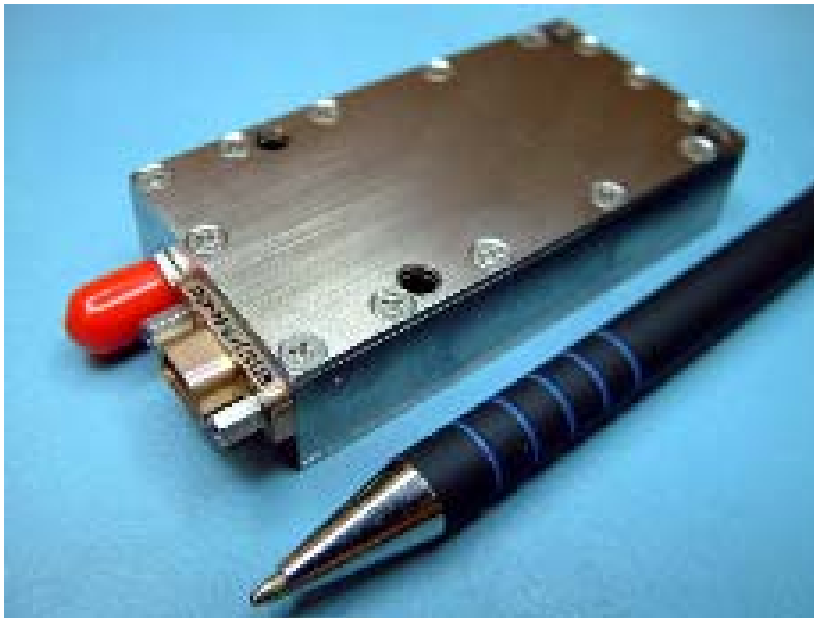
MOC at UCB/SSL



High-rate S-Band Telemetry Link

- High-rate S-Band Telemetry Link

- Transceiver options: SpaceQuest, Emhiser (FM)
- Heritage: CHIPSAT, various others
- Spectrum licensing: Need government license
- Trades: Can use BGS “as is”
High link margin
Low cost
Low risk

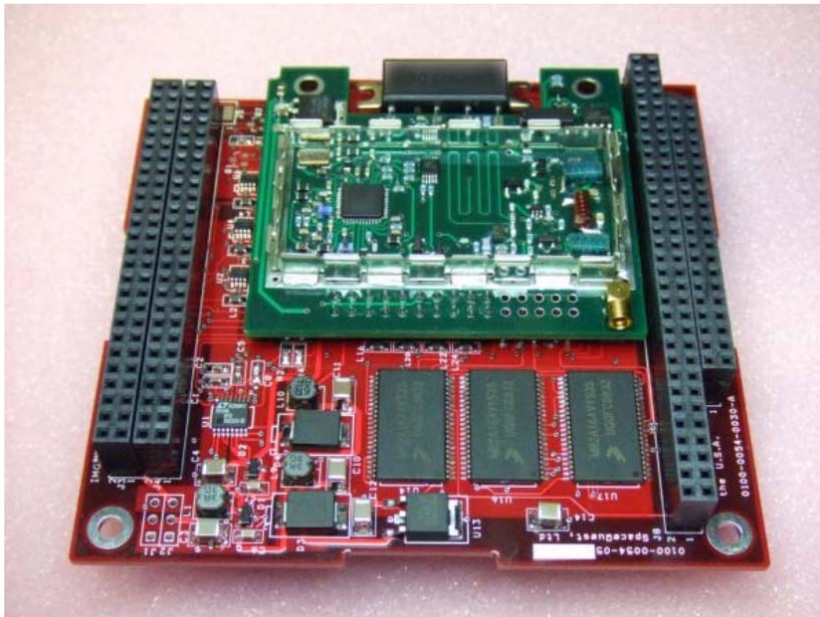


SpaceQuest
TX-2400 Transmitter



Low-rate UHF Command Link

- Low-rate UHF Command Link
 - Receiver options: SpaceQuest (FM)
 - Heritage: Unknown
 - Spectrum licensing: Need government license
 - Trades: Can use low-cost ground station equipment



- High link margin
- Low cost
- Low risk

SpaceQuest
CTR-450 CubeSat Transceiver
(Use only receiver section for CINEMA)



Link Budgets

- Link Budgets for S-band and UHF Links

S-Band Telemetry Link	
Frequency	2250 MHz
Modulation	FM
Spacecraft Antenna Gain	-5.0 dBic
Spacecraft EIRP	-6.0 dBW
Range	2500 km
Path Loss	167.5 dB
Polarization and Pointing Losses	1.0 dB
Ground Station G/T (11-m Dish)	26.6 dB/K
Data Rate	1000 kbps
Bandwidth	3000 kHz
Coding Gain (Reed-Solomon)	4.3 dB
BER	10^{-6}
Required Eb/No	10.2 dB
Predicted Eb/No	16.0 dB
Implementation Loss	2.3 dB
Link Margin	3.5 dB

UHF Command Link	
Frequency	401 MHz
Modulation	FM
Ground Station Antenna Gain	14.8 dBic
Ground Station EIRP	27.8 dBW
Range	2500 km
Path Loss	152.5 dB
Polarization and Pointing Losses	3.0 dB
Spacecraft G/T (Monopole Whip)	-29.5 dB/K
Data Rate	9.6 kbps
Bandwidth	25.9 kHz
Coding Gain (No Coding)	0 dB
BER	10^{-6}
Required Eb/No	14.5 dB
Predicted Eb/No	27.2 dB
Implementation Loss	2.3 dB
Link Margin	10.4 dB



- Open Questions
 - Since CINEMA is funded by the NSF, can we obtain a NTIA license for downlink in the 2200-2290 MHz?
 - Is FM downlink at 1 Msps (all coding included) with a FM deviation of ± 350 kHz (total bandwidth 2.7 MHz) allowable in the 2200-2290 MHz band?
 - Can we obtain a NTIA license for a UHF uplink in the 400-405 MHz or 460-470 MHz bands with FM and a data rate of 9.6 kbps?
 - Which other options might be available?