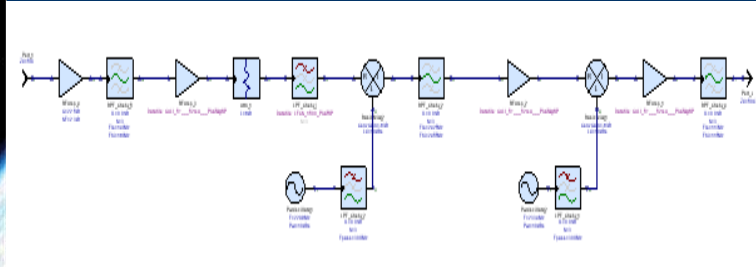
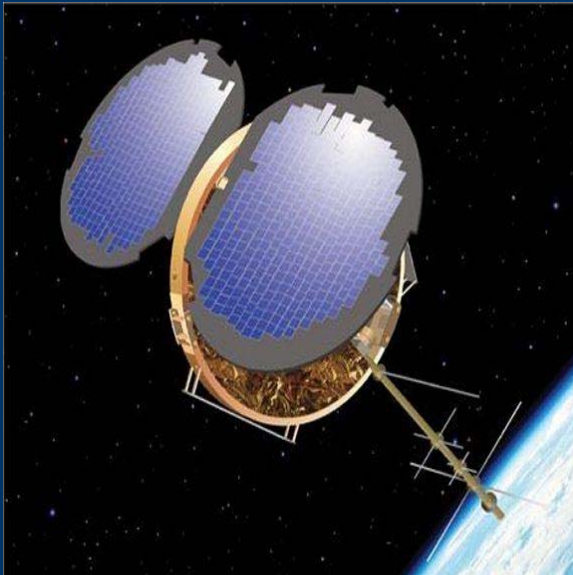


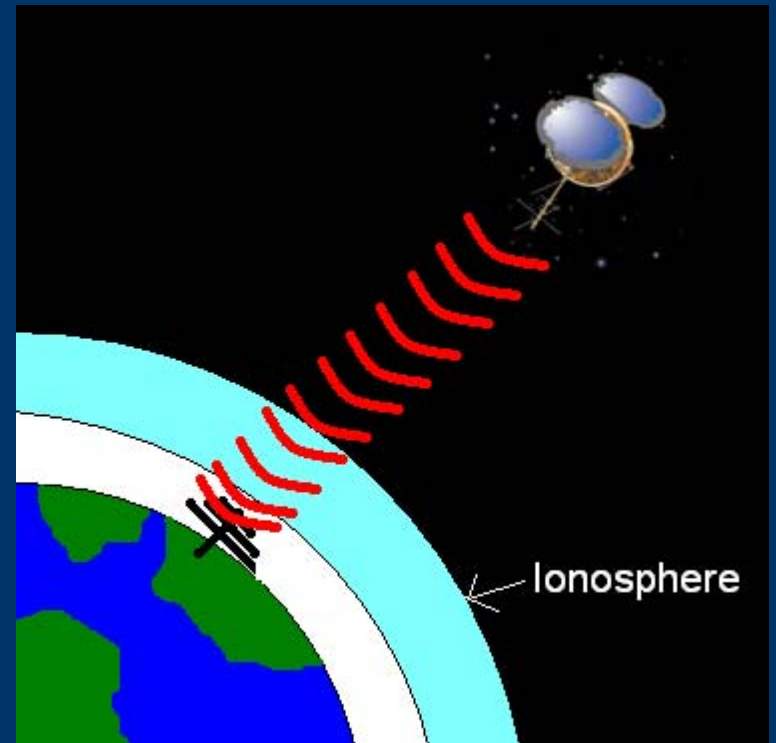
Integrated Beacon Receiver

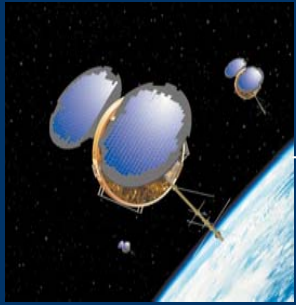


William Harmon
Rochester Institute of Technology
Advisors: Frank Lind, Jim Marchese

Software Radio Beacon Receiver Project Overview

- Radio Signals that travel through the Ionosphere are affected by Ionospheric Structures
- Satellite Beacons have been used for many years to study these structures
- Software Radio provides a flexible way of measuring beacon signals
- New Three-Frequency CERTO beacons
 - 150.012 MHz, 400.032 MHz, 1066.752 MHz

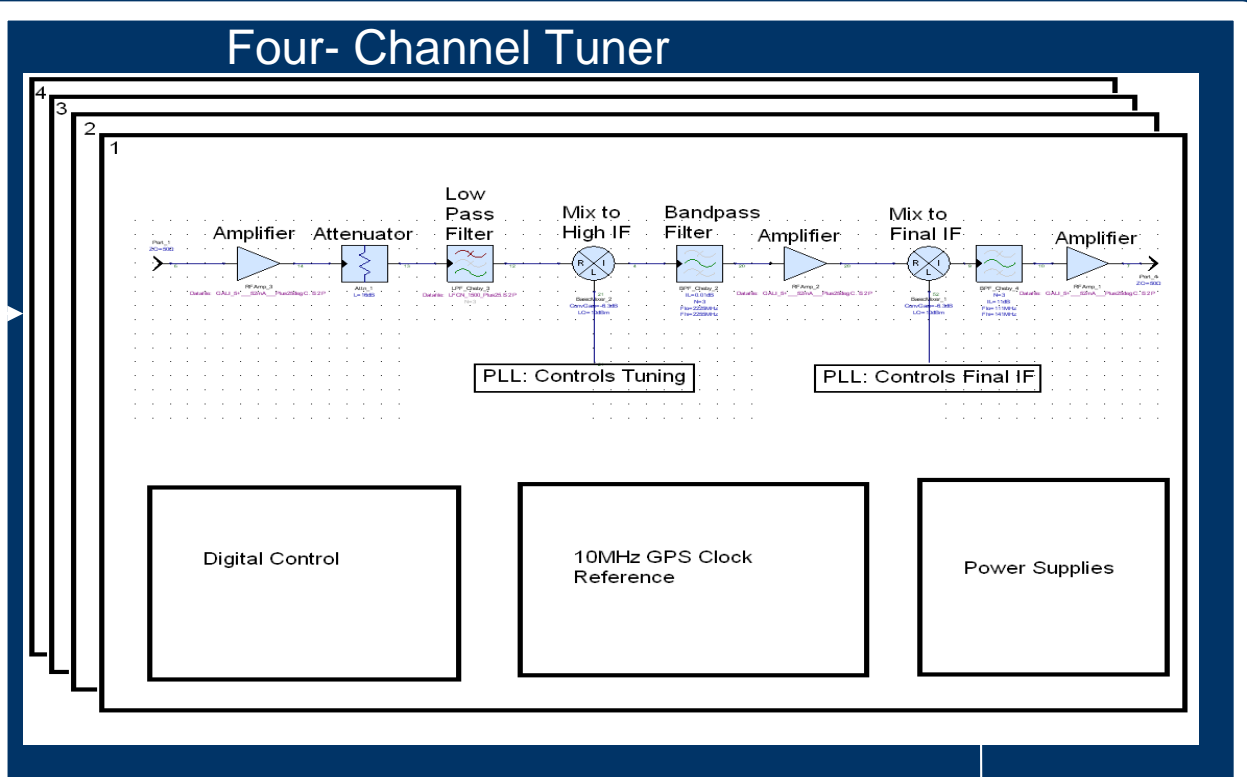




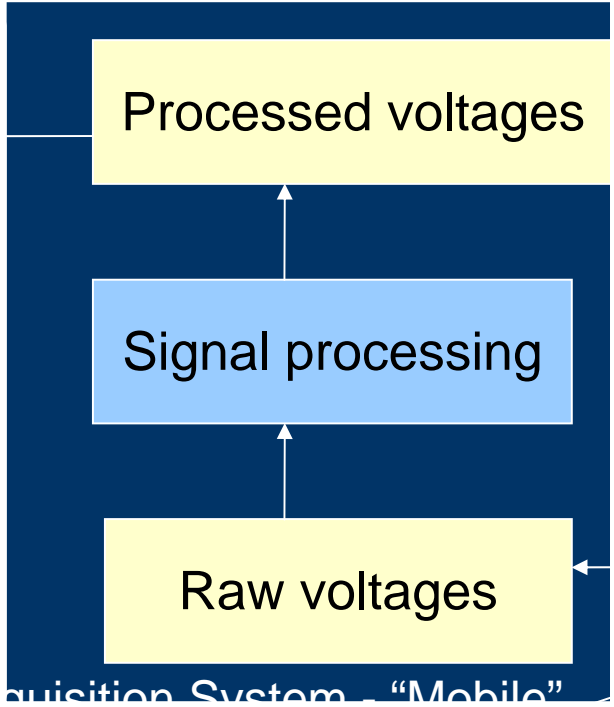
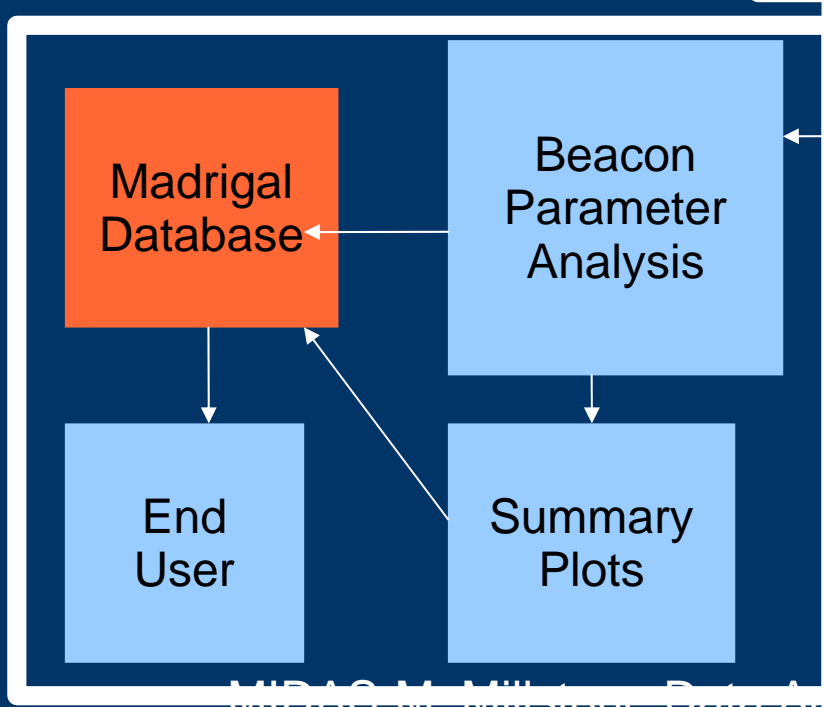
Beacon Carrying Satellites



Turnstile Antenna



Hardware/Software Boundary



MIDAS-M: Millstone Data Acquisition System - "Mobile"

Integrated Beacon Receiver Project Goals

- Create a Tuner to Convert Beacon Signals for Digitization by the MIDAS-M System
 - Challenges
 - RX Frequencies over a Wide Range (150-1067 MHz)
 - Narrow Band CW Tone
 - Doppler Shift of Signal due to Satellite Motion
 - Frequency Stability, Phase Stability
 - Relative Channel Phase Delay
 - Phase Coherence
 - Calibration
-
-

Link Budget

Transmitter Power
Antenna Gain



Example: 150.012 MHz
COSMIC CERTO Signal
(Altitude of 800km)

Free Space Loss

$$\begin{aligned} \text{FSL} &= \left(\frac{4\pi d}{\lambda} \right)^2 \\ &= \left(\frac{4\pi df}{c} \right)^2 \end{aligned}$$

Doppler Shift

$$f' = f + \frac{fv}{c}$$

TX Power: +30 dBm

TX Antenna Gain: +4 dBi

Free Space Loss: -134 dB

RX Antenna Gain: +5 dBi

+ Cable Loss: -0.7 dB

At Analog Input: -95.7 dBm

Preamp Gain: +22.5 dB

Wideband Filter: -3 dB

+ Beacon Tuner: +45 dB

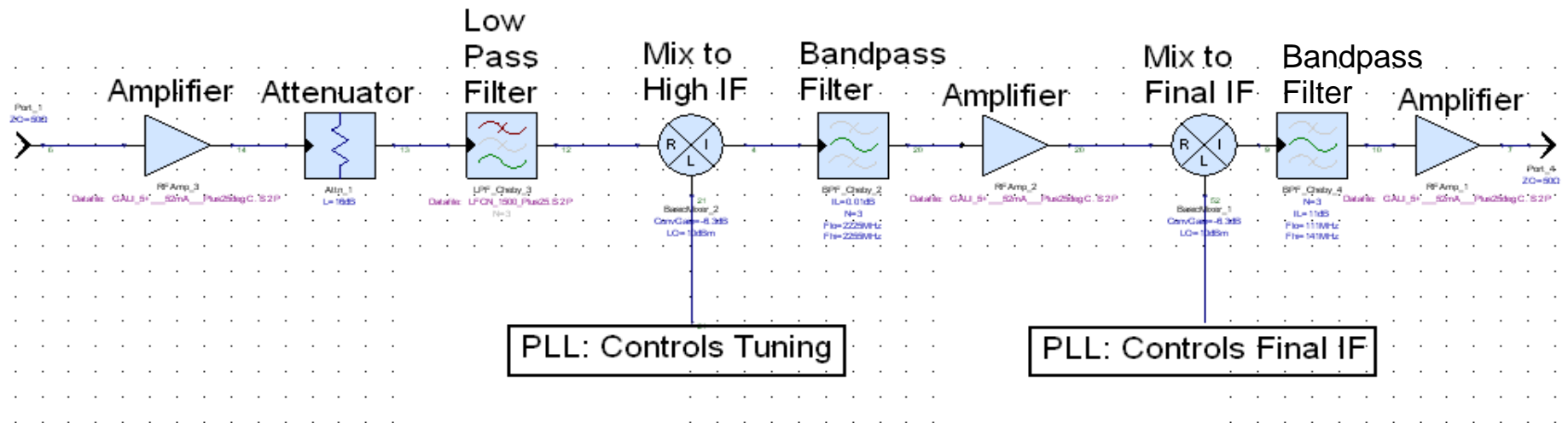
At Digital RX Input: -31.2 dBm

Doppler Shift (~7.5 km/s):
Frequency shifts ± 3.5 kHz

Example Satellite Pass



Receiver Architecture



Digital Control

10MHz GPS Clock Reference

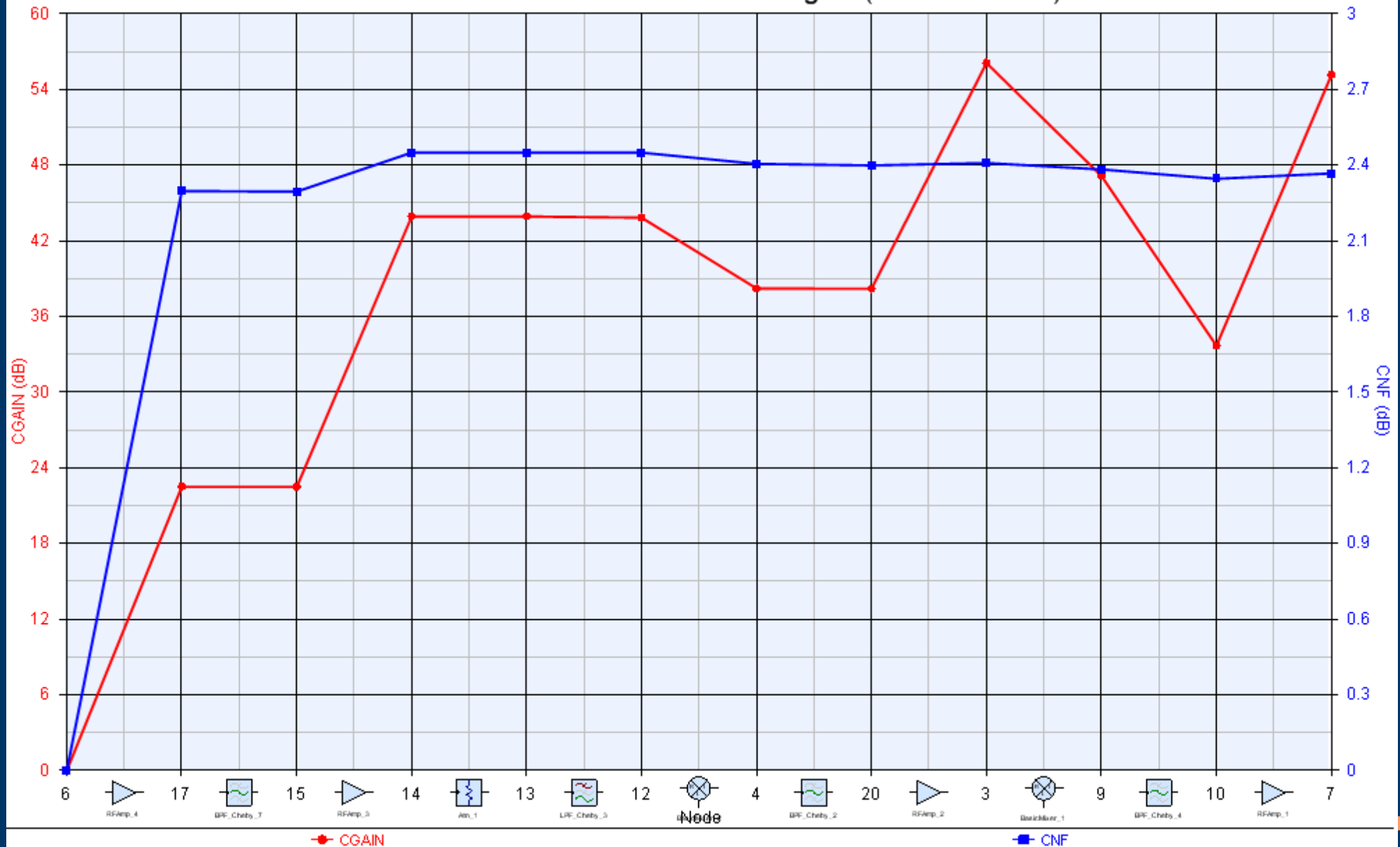
Power Supplies

Tuner Simulations

- What was Simulated?
 - Dynamic range
 - Gain
 - Noise Figure
 - Selectivity
- Evaluate Tuner Architectures and Performance
- Results of simulations
 - Tuner can receive all beacon signals
 - Typical RFI can be tolerated
 - Low Noise figure
 - Led to a Refined Final Design of all Stages

Example Tuner Simulation

Cascaded Gain and Cascaded Noise Figure (0dB attenuation)



Up-Converting
Oscillator

Tuner Channel

Digital Control and
Ethernet Interface

2nd Tuner Channel,
Identical to 1st

10MHz GPS
Clock Interface

Dc to V_i-Converting
Oscillator

Future Work

- Five boards have been fabricated
 - Assembly Underway
 - Electrical Testing & Firmware Programming
 - Tuner Performance Testing
 - Testing with Real Satellite Beacon Signals
 - Higher level integration on future design
 - Use of Tuner with other MIDAS-M Applications
 - Deployment of Beacon Tuners at Field Sites
-
-

Special Thanks To...

- Project Supervisors
 - Frank Lind
 - Jim Marchese
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 - Damian Ancukiewicz
 - Software Providers
 - Alanix/Eagleware
 - Altium Designer Pro
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