A Report on the Regulatory Study Question on CubeSats before the ITU and the Operational Use of the 460-470 MHz Band for CubeSats

CubeSat Workshop, August 11, 2012

Charles Swenson, Jacob Gunther, DICE team

Overview

- The ITU, NTIA, FCC
- A Study Question before the ITU
- DICE Operations experience and timeline
  - The 460 - 470 MHz band

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CubeSat Telemetry Systems are Limited by Regulation and Policy not Technology

What is the ITU, NTIA, FCC

- **ITU is the United Nations specialized agency for information and communication technologies**

Civilian Uses
Amateur
Radio, TV, Cellphone

Government Agencies
NASA
NSF
NOAA
DOD

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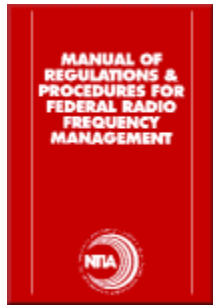
Regulations "The Law"

- The NTIA
  - US Frequency Allocations
  - http://www.ntia.doc.gov/osmhome/redbook/redbook.html
  - http://www.ntia.doc.gov/osmhome/redbook/4b.pdf
- The ITU
  - All satellites go through international licensing
- Category of usage
  - Earth to Space
  - Space to Earth

- Amateur
  - 430 - 440 MHz
  - 2.4 GHz
- ISM "industrial, scientific and medical"
  - 433.05 - 434.79 MHz
  - 2.402 - 2.417 GHz
- Government (Primary)
  - 137-138 MHz
  - 400 - 402 MHz
  - 450 MHz
  - 2.2 – 2.3 GHz
  - 5.25 – 5.46 GHz



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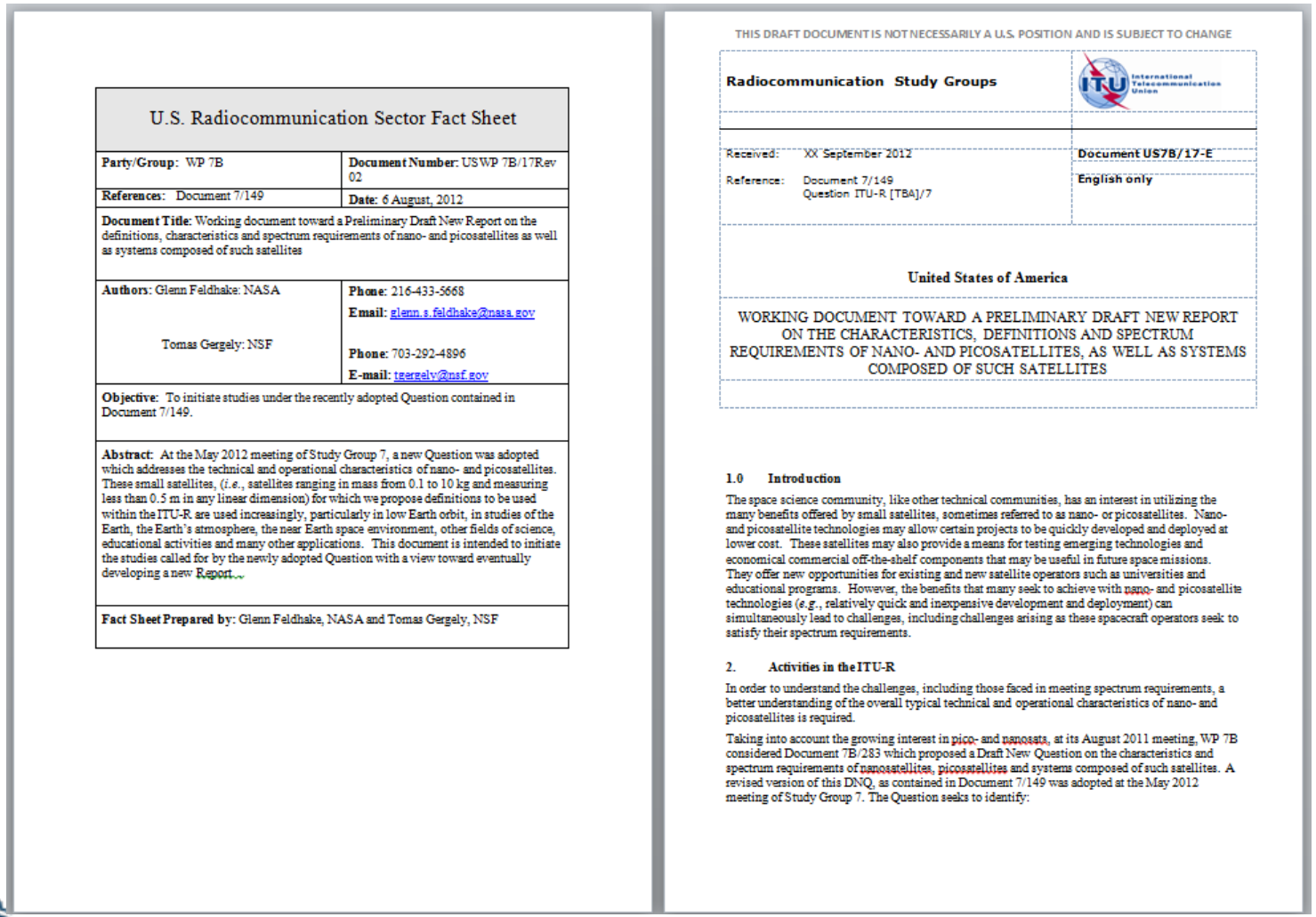
The ITU Study Question

- “the distinctive characteristics of nano and pico satellites and satellite systems in terms of their use of the radio spectrum as defined by data rates, transmissions time and bandwidths”
- “the specific spectrum requirements for nano and pico satellite systems”
- “under which radiocommunication services can nano and pico satellites and systems composed of those satellites, operate”
- The question further decides that, “that the results of the above studies should be included in one or more Recommendation(s) and/or Report(s);” and “that the above studies should be completed by 2015.”

US WP 7B Draft of Document



U.S. Radiocommunication Sector Fact Sheet

Party/Group: WP 7B	**Document Number:** USWP 7B/17Rev 02
References: Document 7/149	**Date:** 6 August, 2012
Document Title: Working document toward a Preliminary Draft New Report on the definitions, characteristics and spectrum requirements of nano- and picosatellites as well as systems composed of such satellites	
Authors: Glenn Feldhake: NASA Tomas Gergely: NSF	**Phone:** 216-433-5668 **Email:** glenn.s.feldhake@nasa.gov **Phone:** 703-292-4896 **E-mail:** tgergely@nsf.gov
Objective: To initiate studies under the recently adopted Question contained in Document 7/149.	
Abstract: At the May 2012 meeting of Study Group 7, a new Question was adopted which addresses the technical and operational characteristics of nano- and picosatellites. These small satellites, (*i.e.*, satellites ranging in mass from 0.1 to 10 kg and measuring less than 0.5 m in any linear dimension) for which we propose definitions to be used within the ITU-R are used increasingly, particularly in low Earth orbit, in studies of the Earth, the Earth's atmosphere, the near Earth space environment, other fields of science, educational activities and many other applications. This document is intended to initiate the studies called for by the newly adopted Question with a view toward eventually developing a new Report...	
Fact Sheet Prepared by: Glenn Feldhake, NASA and Tomas Gergely, NSF	

THIS DRAFT DOCUMENT IS NOT NECESSARILY A U.S. POSITION AND IS SUBJECT TO CHANGE

Radiocommunication Study Groups	ITU International Telecommunication Union
Received: XX September 2012 Reference: Document 7/149 Question ITU-R [TBA]/7	**Document US7B/17-E** **English only**

United States of America

WORKING DOCUMENT TOWARD A PRELIMINARY DRAFT NEW REPORT ON THE CHARACTERISTICS, DEFINITIONS AND SPECTRUM REQUIREMENTS OF NANO- AND PICOSATELLITES, AS WELL AS SYSTEMS COMPOSED OF SUCH SATELLITES

1.0 Introduction

The space science community, like other technical communities, has an interest in utilizing the many benefits offered by small satellites, sometimes referred to as nano- or picosatellites. Nano- and picosatellite technologies may allow certain projects to be quickly developed and deployed at lower cost. These satellites may also provide a means for testing emerging technologies and economical commercial off-the-shelf components that may be useful in future space missions. They offer new opportunities for existing and new satellite operators such as universities and educational programs. However, the benefits that many seek to achieve with nano- and picosatellite technologies (*e.g.*, relatively quick and inexpensive development and deployment) can simultaneously lead to challenges, including challenges arising as these spacecraft operators seek to satisfy their spectrum requirements.

2. Activities in the ITU-R

In order to understand the challenges, including those faced in meeting spectrum requirements, a better understanding of the overall typical technical and operational characteristics of nano- and picosatellites is required.

Taking into account the growing interest in pico- and nanosats, at its August 2011 meeting, WP 7B considered Document 7B/283 which proposed a Draft New Question on the characteristics and spectrum requirements of nanosatellites, picosatellites and systems composed of such satellites. A revised version of this DNQ, as contained in Document 7/149 was adopted at the May 2012 meeting of Study Group 7. The Question seeks to identify:

Highlights of Draft

- **Development and operational lifecycle**
  - A characteristic to define?

TABLE 1

Typical mission lifetime of a nano- or picosatellite mission

Milestone	Day
Preliminary Design Review	0
Critical Design Review	53
Launch	206
In Orbit Tests	277
In Orbit Mission	287
De-orbit	392

- Typical Lifetime Characteristics?

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Highlights of Draft

- **3 Physical characteristics**
  - The CubeSat Standard
    - 1U, 2U, 3U
    - No discussion of larger
- **4 Launch and orbital characteristics**
  - Operator may have a number of potential launches available,
  - Will not have a knowledge of specific orbital characteristics.

Highlights of Draft

- **5 Spectrum requirements**
  - "Nano- and picosatellites have also occasionally used the 902-928 MHz and 2.4-2.5 GHz bands which are designated under note 5.150 of the Radio Regulations for use by industrial, scientific and medical (ISM) applications. ISM applications do not, however, include radiocommunication services. Developers should be aware that that nano- and picosatellites are not ISM applications, and that they consequently may not operate on the same unlicensed basis as ISM equipment"

Highlights of Draft

- The class of objects to which the studies apply:
  - A convenient way to classify satellites is by their mass.

TABLE 2

Classification of small satellites by mass

Denomination	Mass (kg)
Minisatellite	100-500
Microsatellite	10-100
Nanosatellite	1-10
Picosatellite	0.1-1
Femtosatellite	<0.1

Want a Copy?

- Charles.Swenson@USU.EDU

- **Send me comments on how you would create a legal definition of a nano- and picosatellite**

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Operational Use of the 460-470 MHz Band for CubeSats

DICE

NTIA "Red Book" Table on 460-470 MHz

Table of Frequency Allocations			410-698 MHz (UHF)		
International Table			United States Table		FCC Rule Part(s)
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table	
460-470 FIXED MOBILE Meteorological-satellite (space-to-Earth)			460-470 Meteorological-satellite (space-to-Earth)	460-462.5375 FIXED LAND MOBILE 5.289 US201 US209 NG124	Private Land Mobile (90)
				462.5375-462.7375 LAND MOBILE 5.289 US201	Personal Radio (95)
				462.7375-467.5375 FIXED LAND MOBILE 5.287 5.289 US201 US209 US216 NG124	Private Land Mobile (90)
				467.5375-467.7375 LAND MOBILE 5.287 5.289 US201	Personal Radio (95)
5.287 5.288 5.289 5.290			5.287 5.288 5.289 US201 US209 US216	467.7375-470 FIXED LAND MOBILE 5.288 5.289 US201 US216 NG124	Private Land Mobile (90)

Lower case means secondary user

Must read the notes

Regulations on 460 to 470 MHz

- 5.289 Earth exploration-satellite service applications, other than the meteorological-satellite service, may also be used in the bands 460-470 MHz and 1690-1710 MHz for space-to-Earth transmissions subject to not causing harmful interference to stations operating in accordance with the Table.
- US201 In the band 460-470 MHz, space stations in the Earth exploration-satellite service may be authorized for space-to-Earth transmissions on a secondary basis with respect to the fixed and mobile services. When operating in the meteorological-satellite service, such stations shall be protected from harmful interference from other applications of the Earth exploration-satellite service. The power flux-density produced at the Earth's surface by any space station in this band shall not exceed -152 dBW/m^2/4 kHz.

Frequency License 460-470 MHz Band

- **Frequency Allocation**
  - Started (7/20/2011)
  - Completed (8/25/2011)
- **The DICE team would like to express gratitude to Andy and the NTIA for processing the DICE application in record time.**

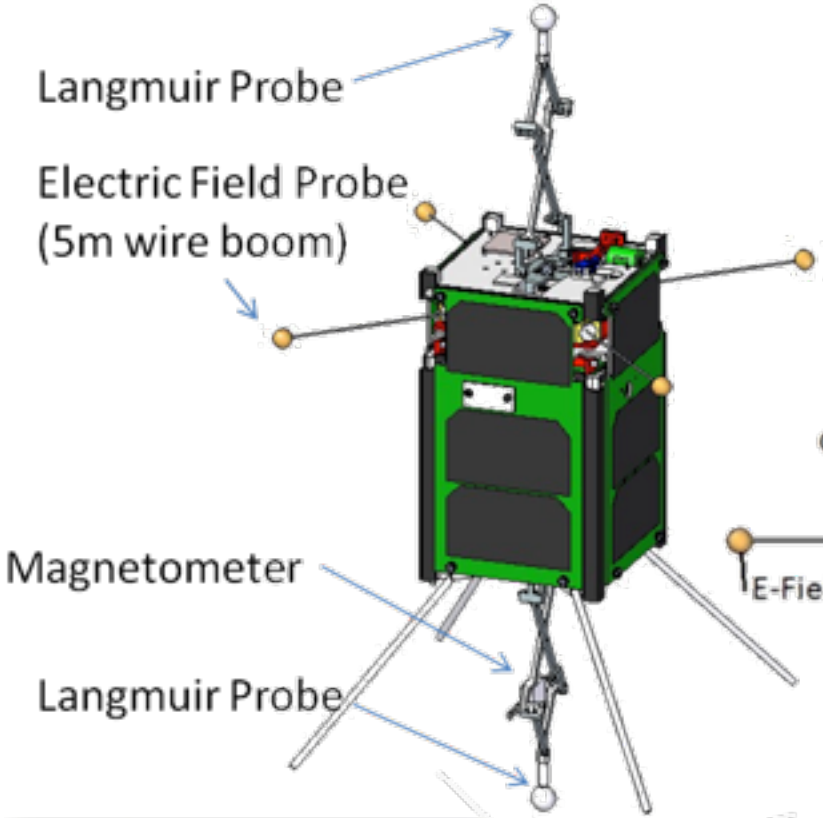
7/20/2011 -
"The DICE certification request has been submitted. There is no chance whatsoever that we will obtain certification and authorization by August 25, 2011, so that should be stricken from the list of scenarios right off the bat."

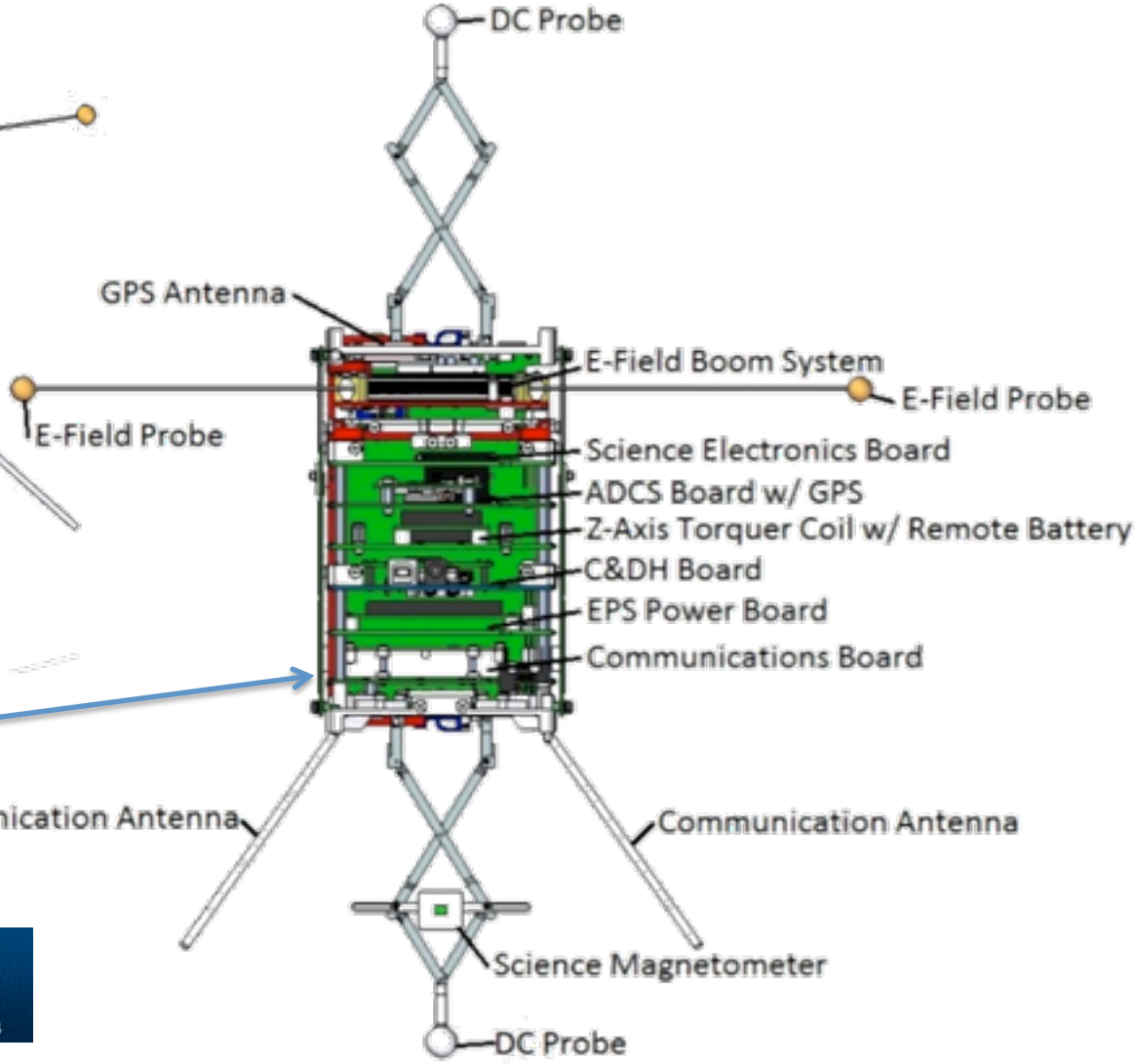
-Andy Clegg
(NSF Spectrum Manager)

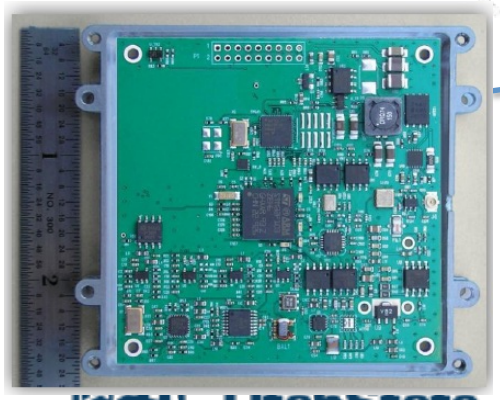
8/25/2011 –
"Attached are the approved frequency assignments for the DICE ground stations, suitable for framing. The spacecraft assignment was sent previously (NSF 110002). This completes all of the needed paperwork."

-Andy Clegg
(NSF Spectrum Manager)

DICE CubeSats (X2)







Cadet-U

L3 communications

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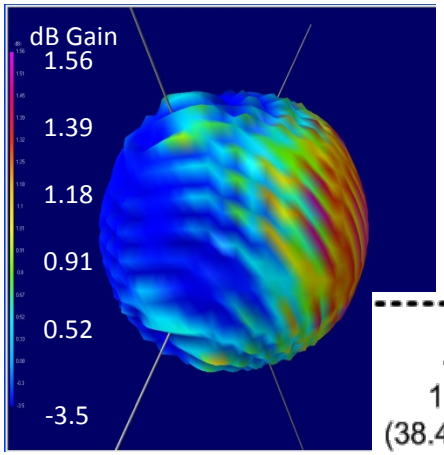
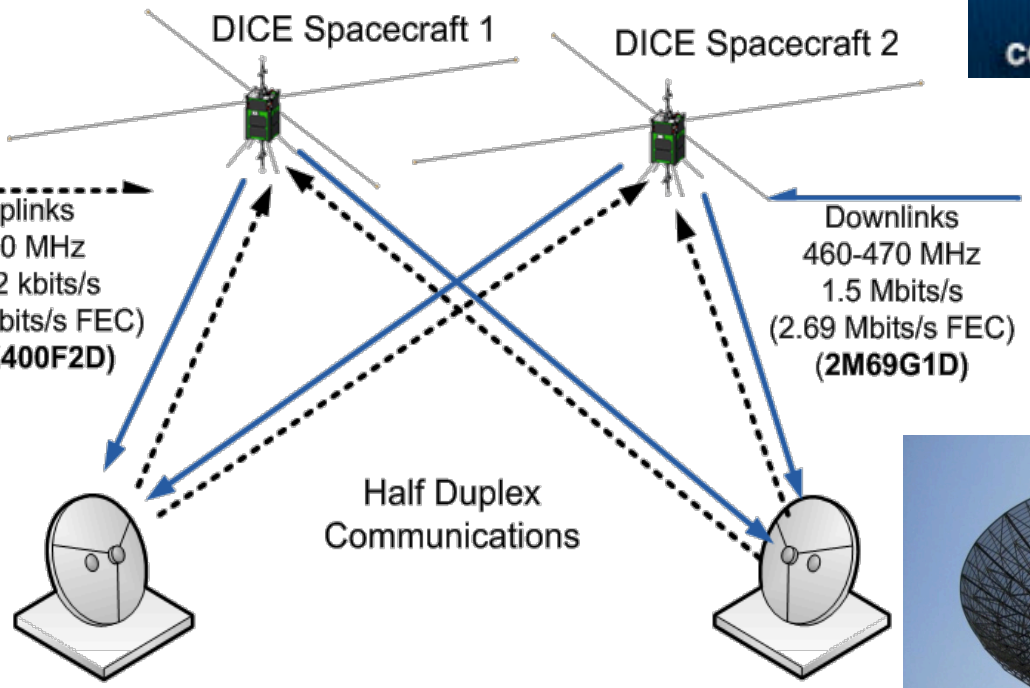
DICE Telemetry Systems (3 Mbit/s)





With FEC the throughput is 2.69 Mbps on downlink

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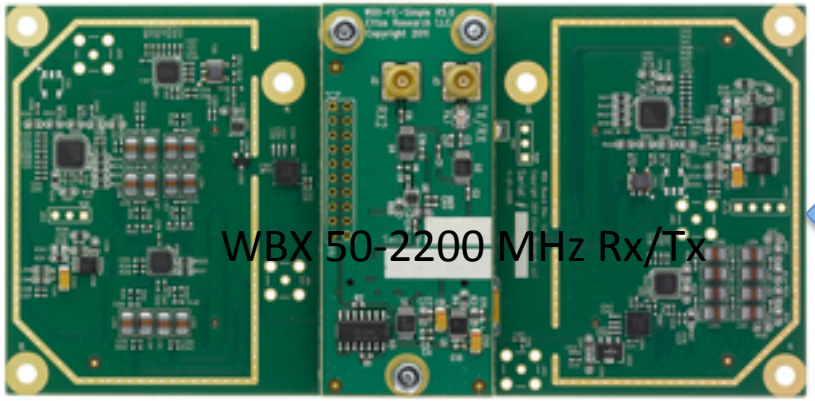
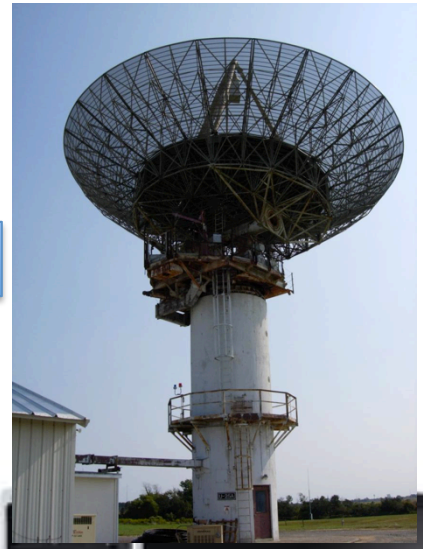
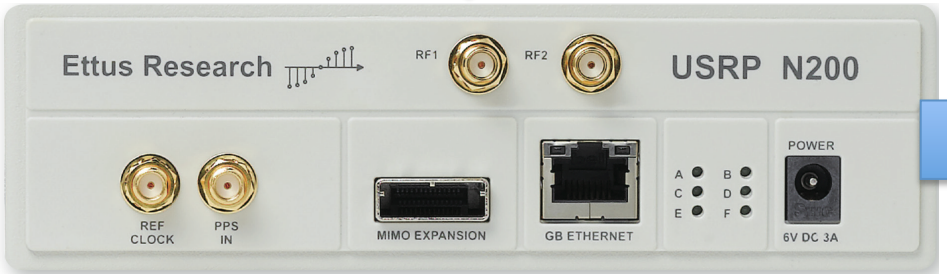
Telemetry System



LNA/BPF/Switch





Ethernet

10 Msamp/s I/Q data

Software Radio

MSQL Database

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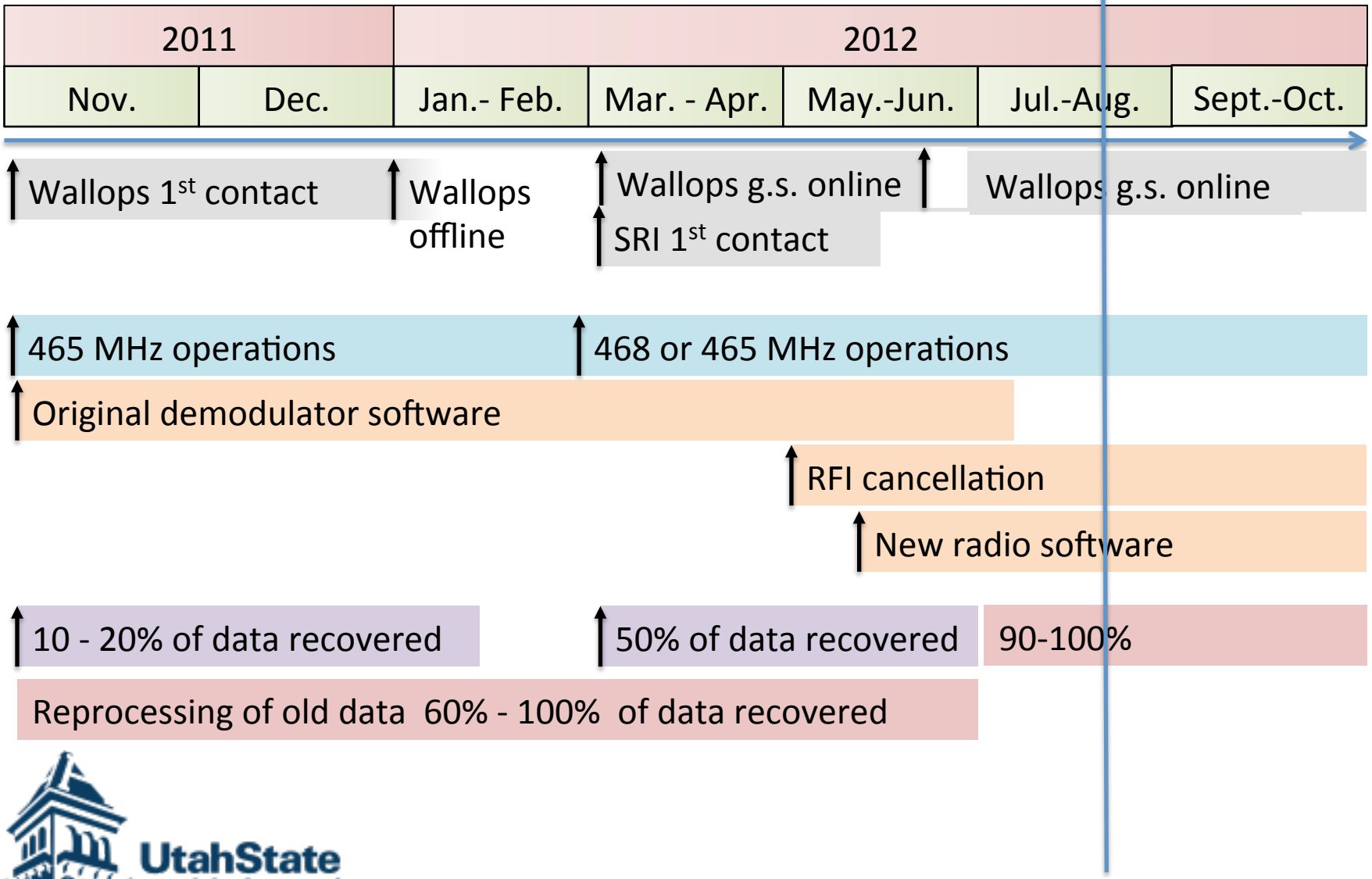
Timeline



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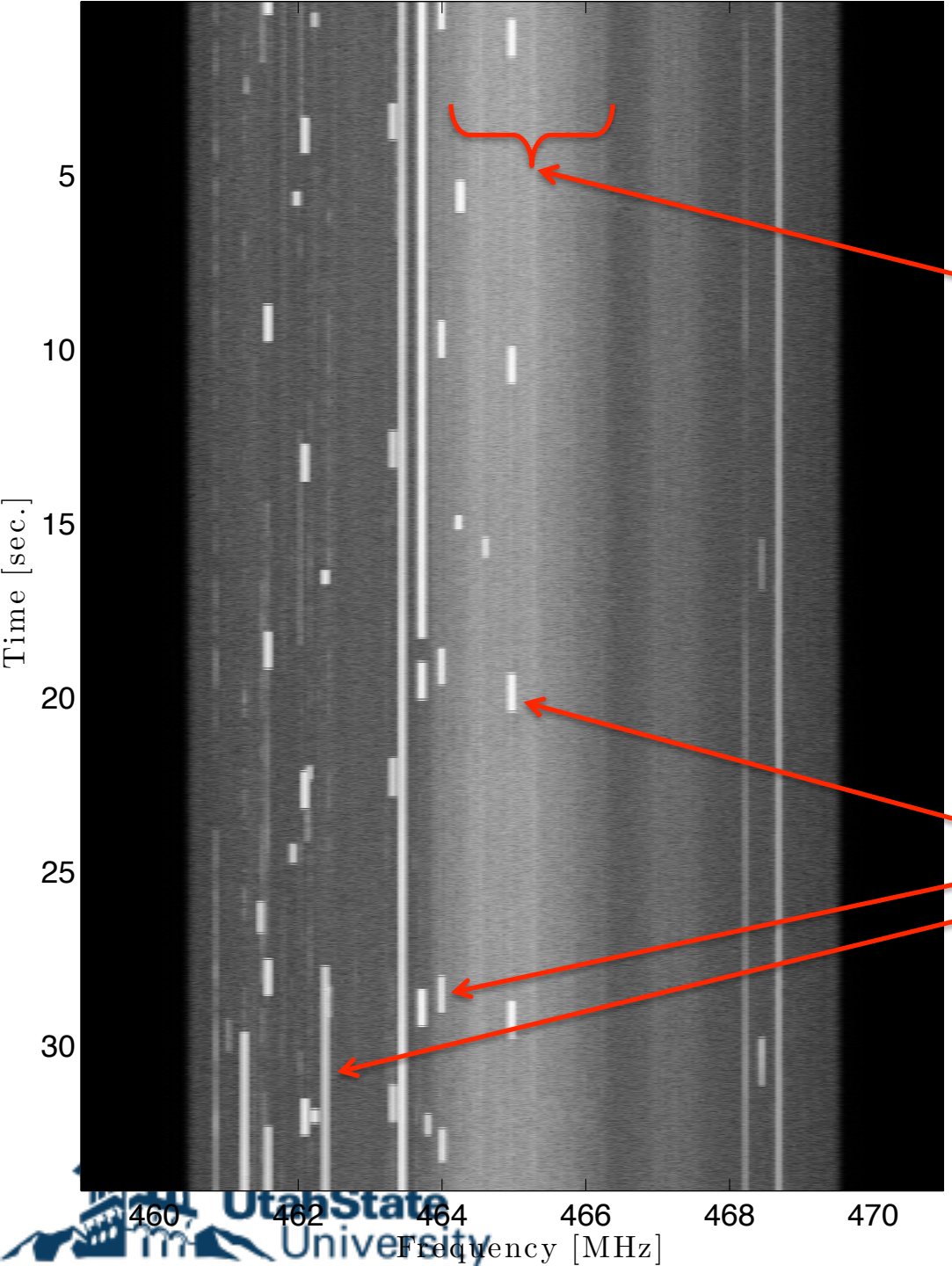
Spectrogram



Our signal

NBFM interference

Y287500c_500_1000
Wallops Island, Virginia

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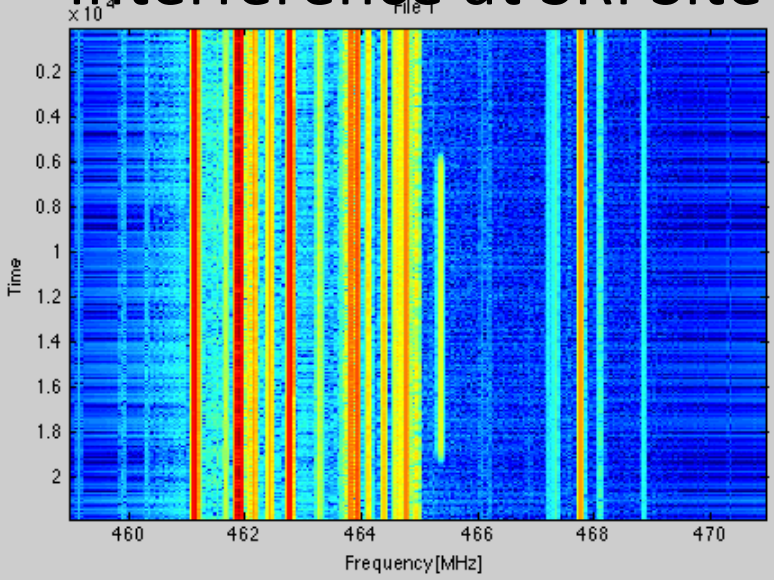
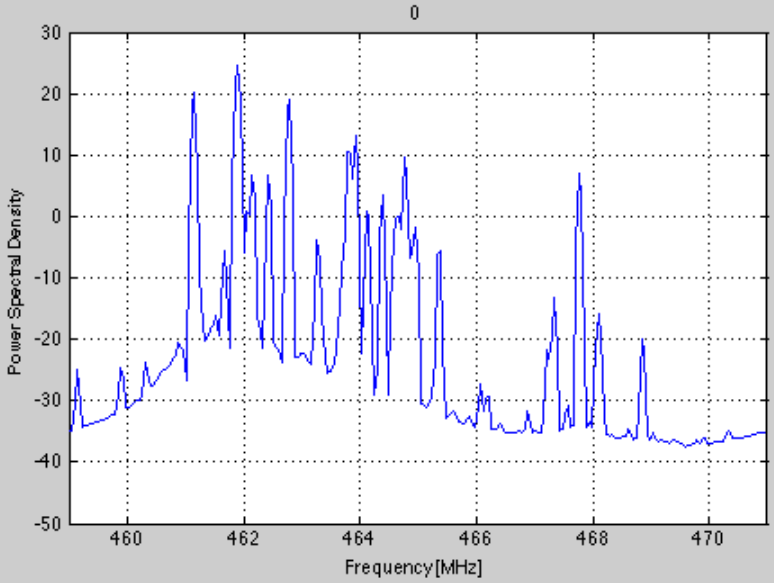
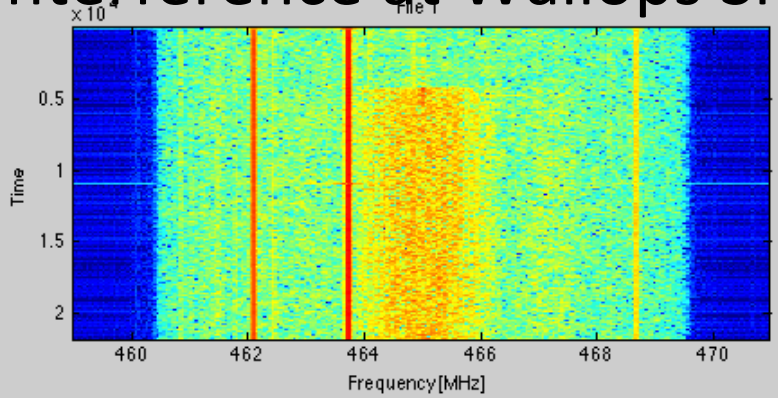
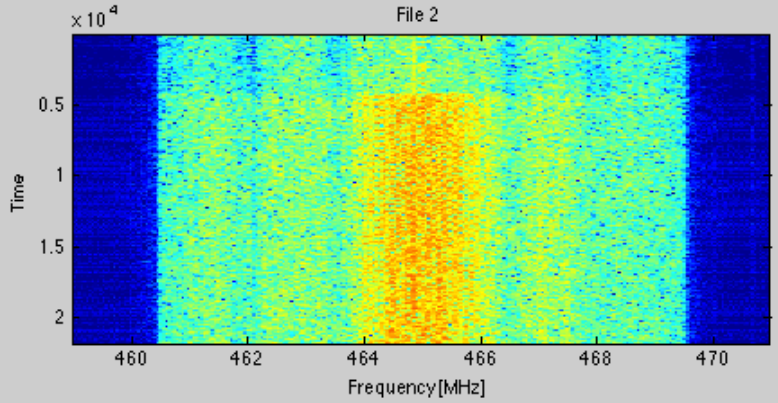
Interference at SRI Site

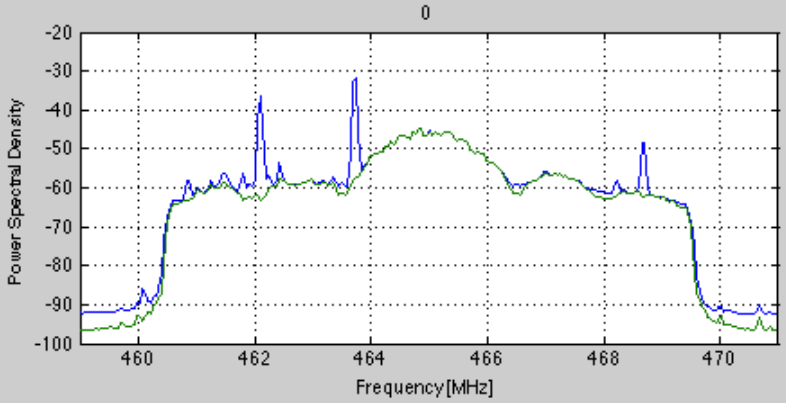




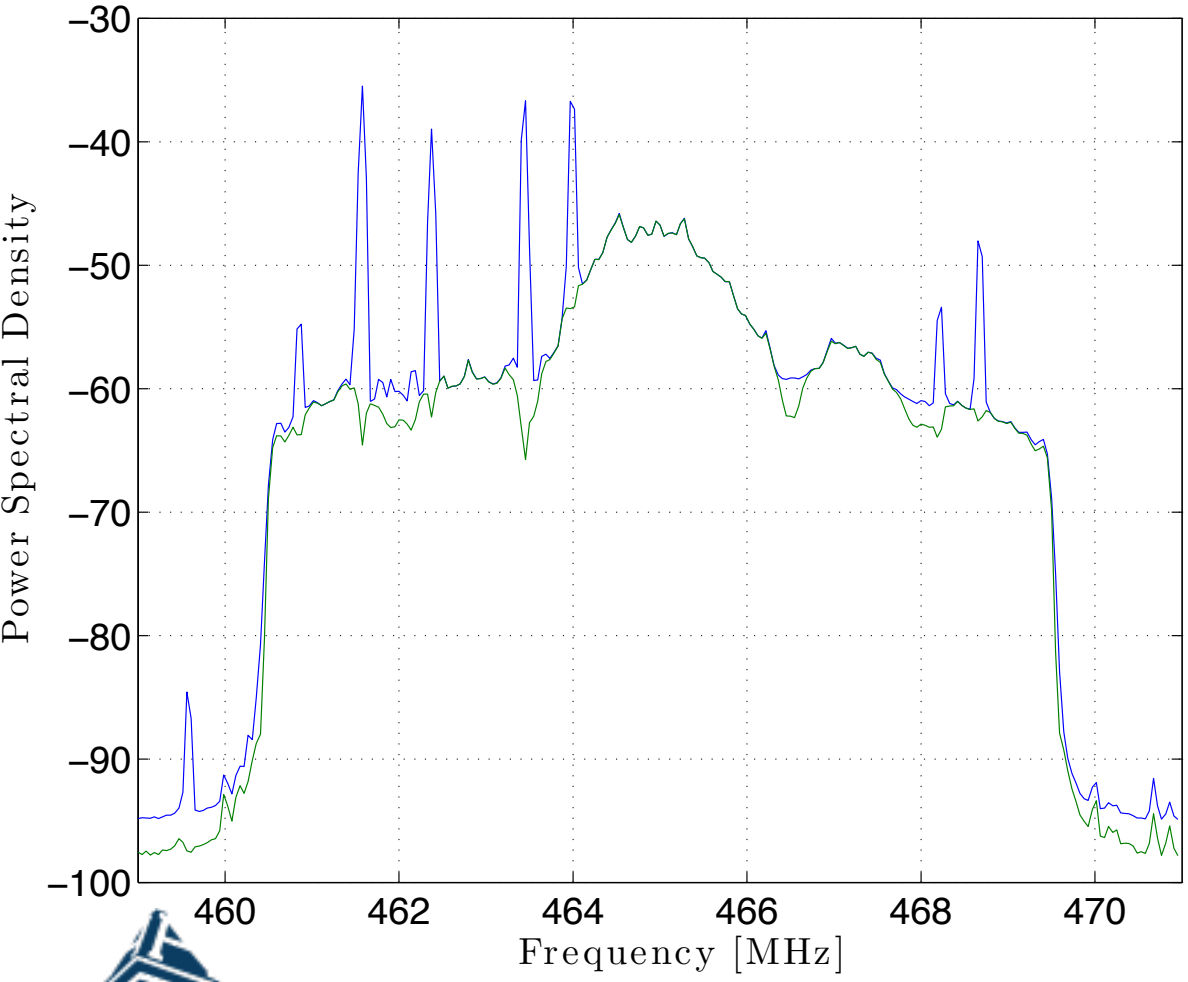
Interference at Wallops Site

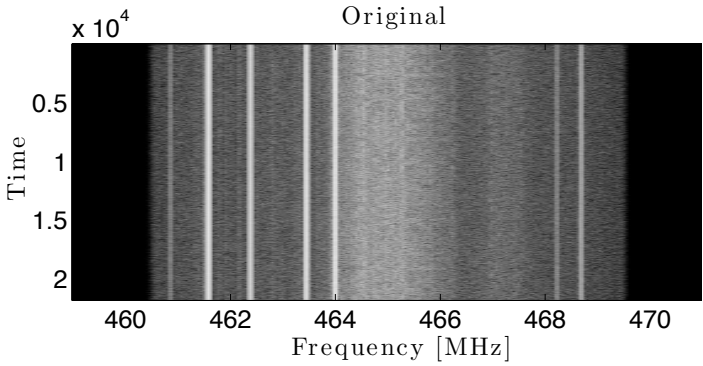


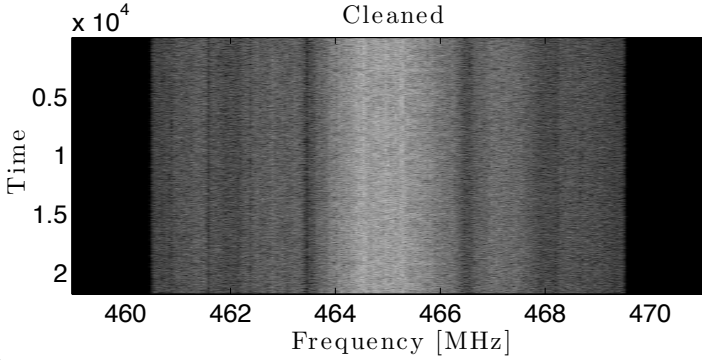


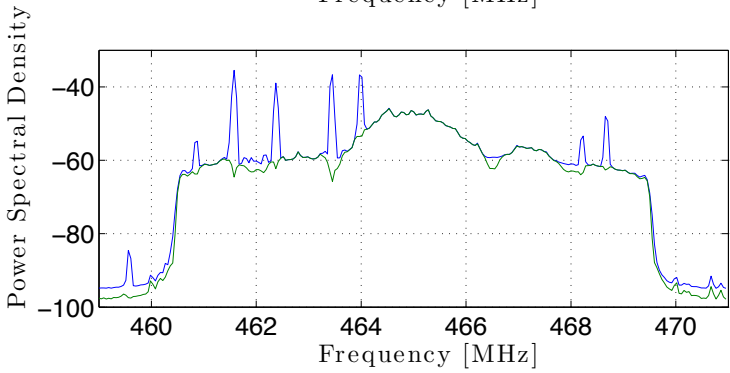


Before and After









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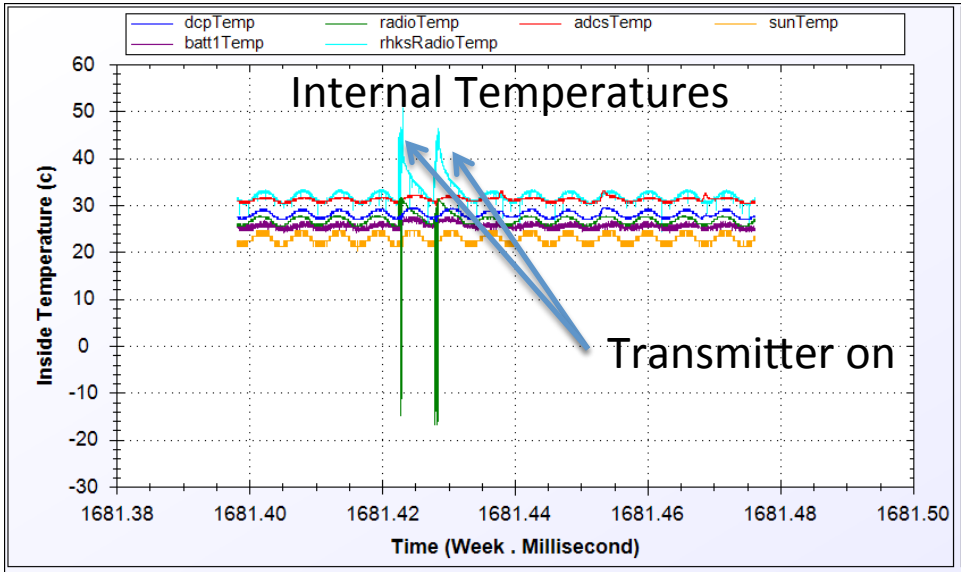
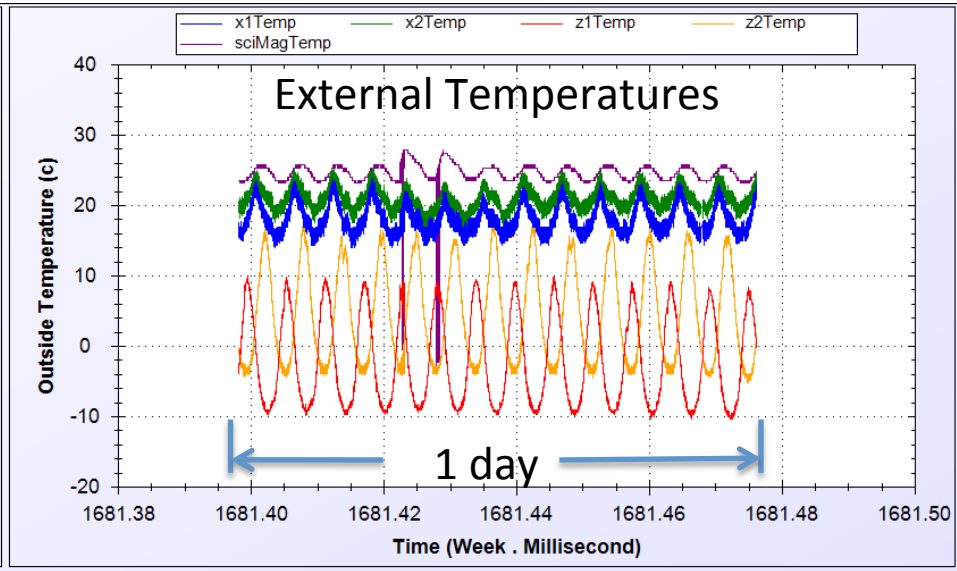
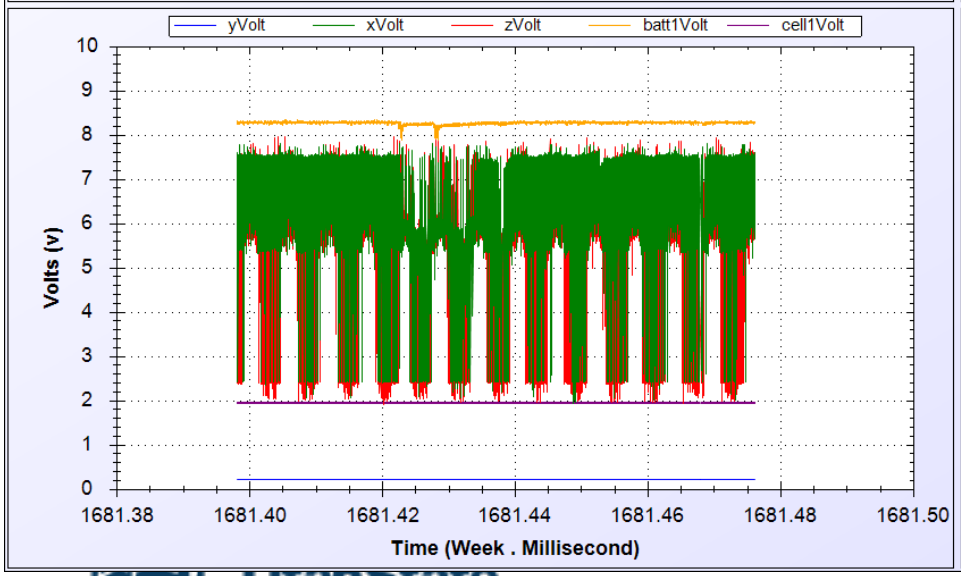
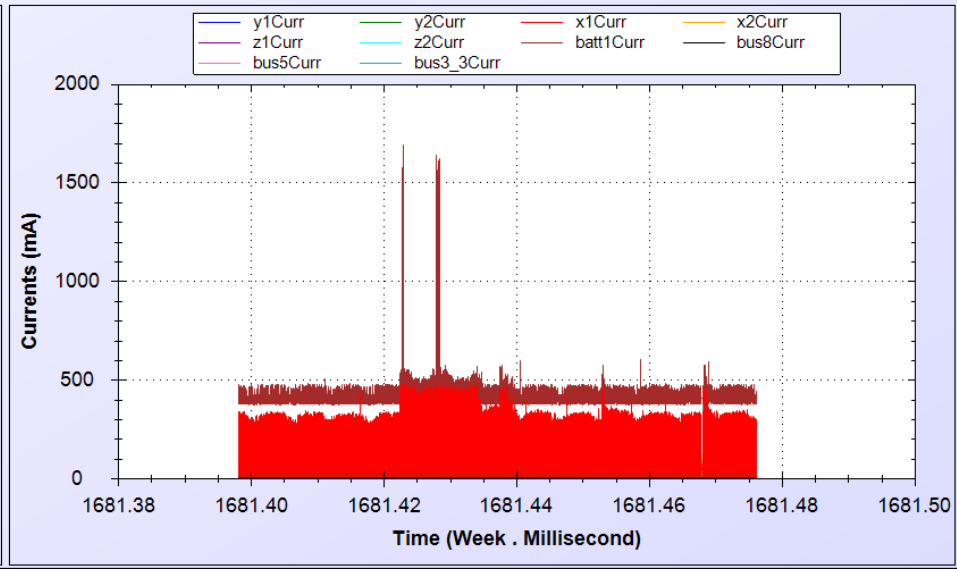
Housekeeping Data









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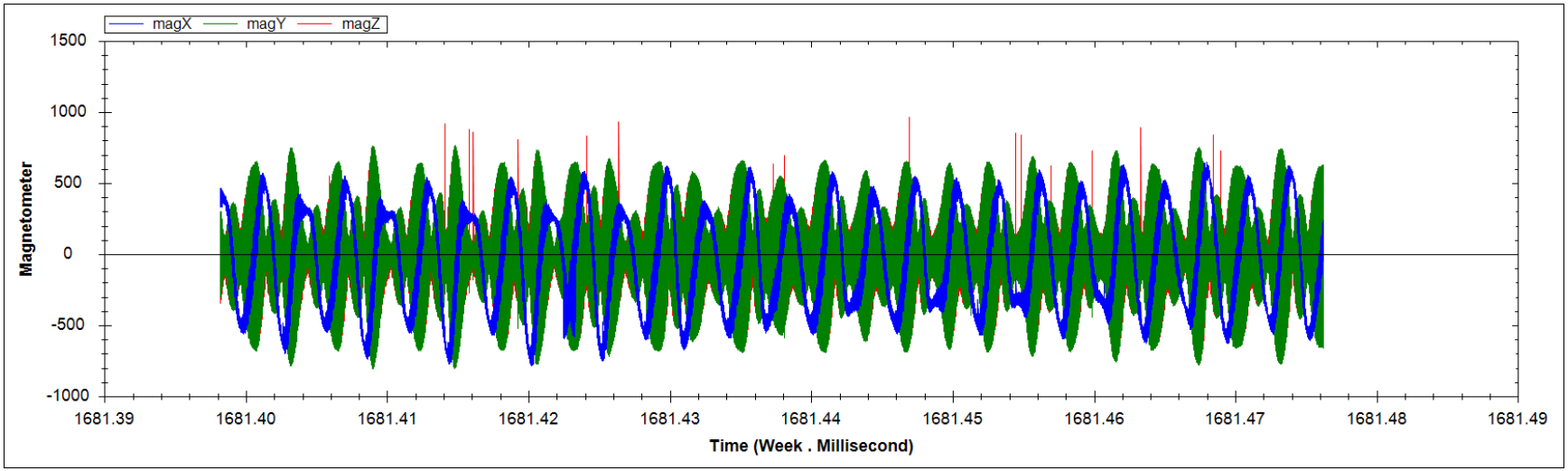
Magnetometer Data



Summary

- Interference at 465 MHz
  1. Software modifications
     - More robust demodulator
     - Added interference cancellation
  2. Moved carrier frequency from 465 to 468 MHz
- Pointing problems: Wallops, Jan. 1 – Feb. 15
- Periodic lock-ups of the satellites
- Second ground station at SRI, Mar. 10, 2012
- Steadily improving and getting more science data down and into database
- Interference by the Accomack TV Booster Station June 10 – June 19
- 460-470 MHz band can be used for high-speed downlink
- Willing to share what we have learned about frequency licensing with the NTIA