Global Positioning System Receiver and Inter-Satellite Communications RF Design

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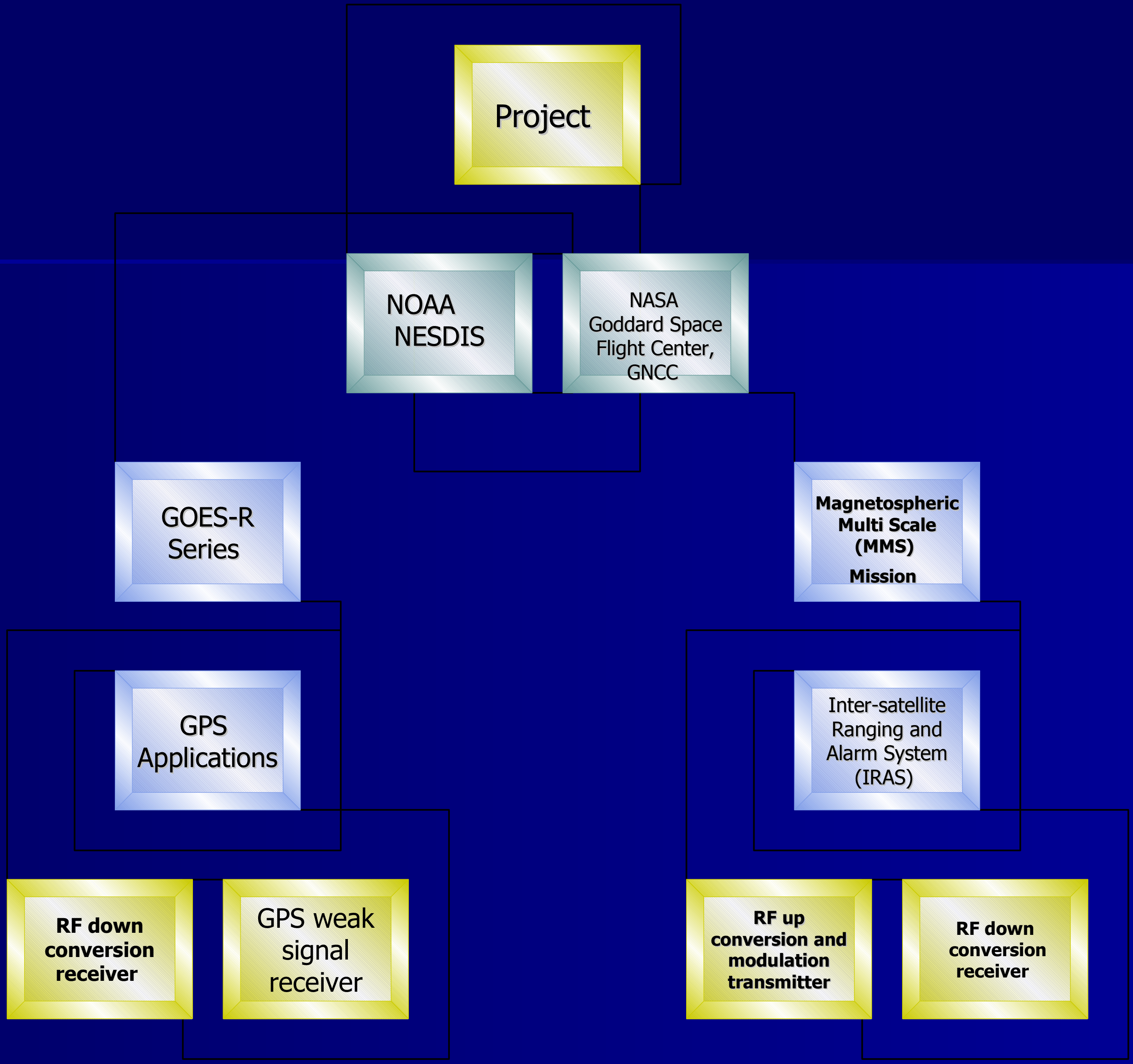
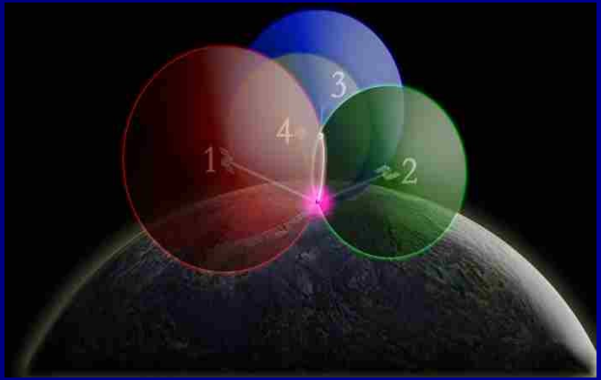

Project
NOAA NESDIS
NASA Goddard Space Flight Center, GNCC
GOES-R Series
Magnetospheric Multi Scale (MMS) Mission
GPS Applications
Inter-satellite Ranging and Alarm System (IRAS)
RF down conversion receiver
GPS weak signal receiver
RF up conversion and modulation transmitter
RF down conversion receiver

GOES

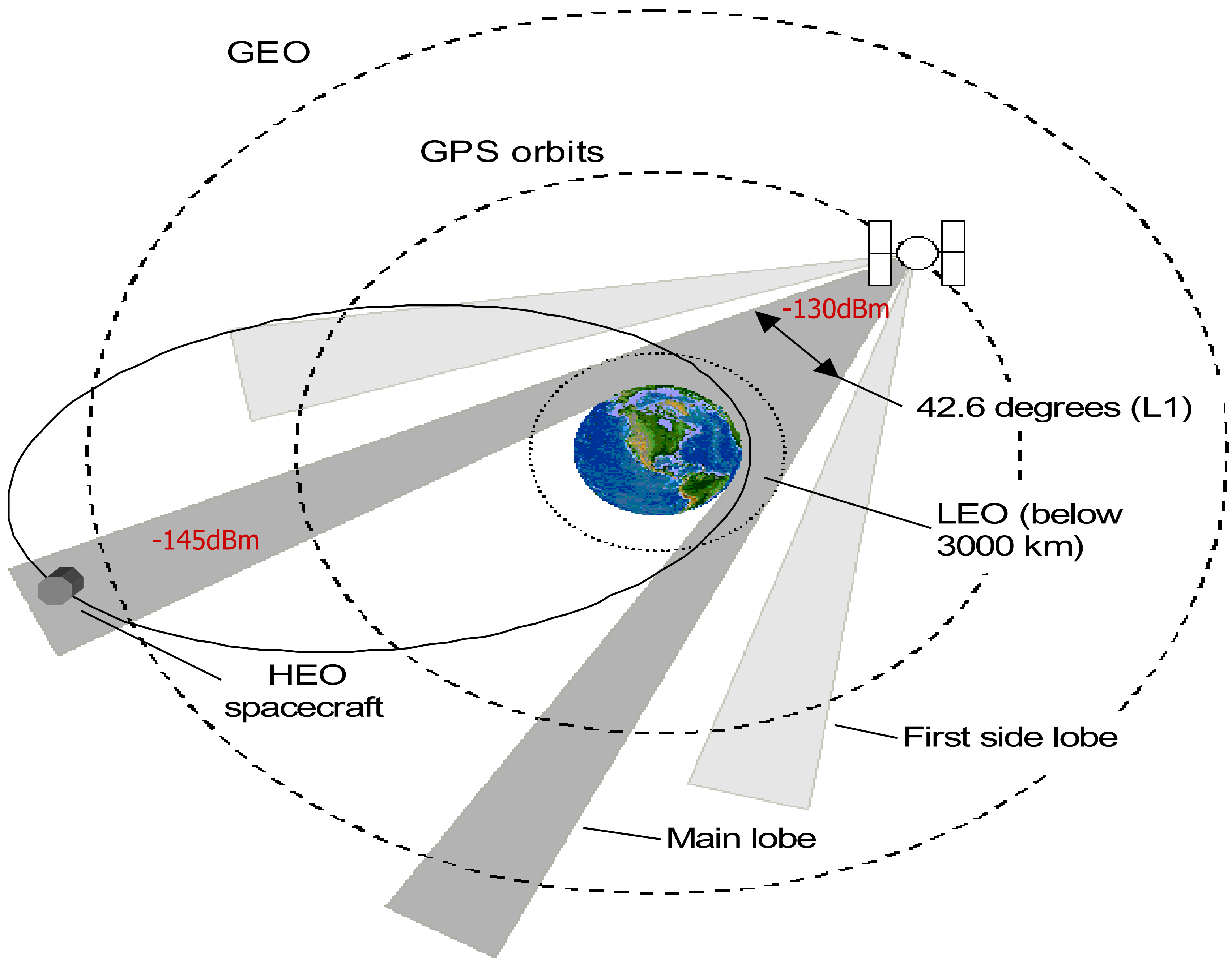
GOES Mission

- This constellation provide information about meteorological events in the Western atmosphere
- GOES-R measurements will result in more accurate weather forecasts, atmosphere, climate, and ocean monitoring.

Global Positioning System (GPS)



- Satellite radio navigation system
- Passive system that uses trilateration positioning method
- Array of satellites to measure position, velocity and time
- Positioned on the middle earth orbit (MEO)
- Designed to measure on the lower earth orbit (LEO) down to earth's surface
- GOES-R GPS application could be used to validate measurements


GEO
GPS orbits
-130dBm
42.6 degrees (L1)
LEO (below 3000 km)
-145dBm
HEO spacecraft
First side lobe
Main lobe

Objectives

- To design, build and test Radio Frequency (RF) chains
  - Magnetospheric Multi Scale (MMS) mission, IRAS:
    - Down-conversion frequency receiver and power amplification
    - Up-conversion and phase modulator transmitter
- Global Positioning System:
    - Weak signal down-conversion frequency receiver and power amplification
- For future GOES-R applications and others

Design Requirements

- GPS receiver:

  Input of -111dBm at 1.57542 GHz for an output of +4dBm at 35.42MHz

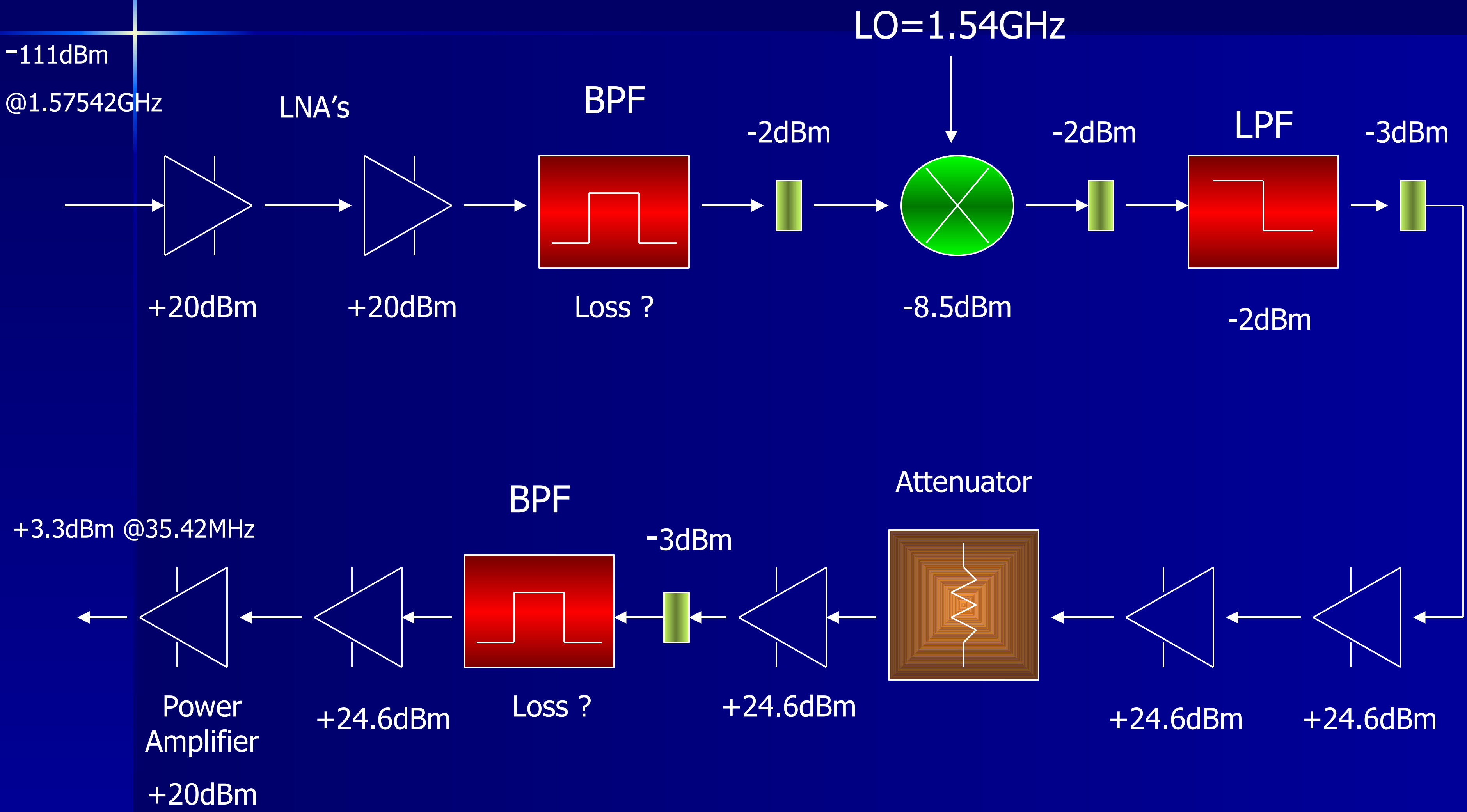
- IRAS communications system:
  - Transmitter: pulse train from a Digital to Analog Converter (DAC) of 2V peak-to-peak of +10dBm input
  - Receiver: input of -111dBm at 2.05 GHz for an output of +4dBm at 35.42MHz
- Power representation

$$dB = 10\log(\mathrm{P}) \qquad dBm = 10\log\left(\frac{P}{1mW}\right)$$

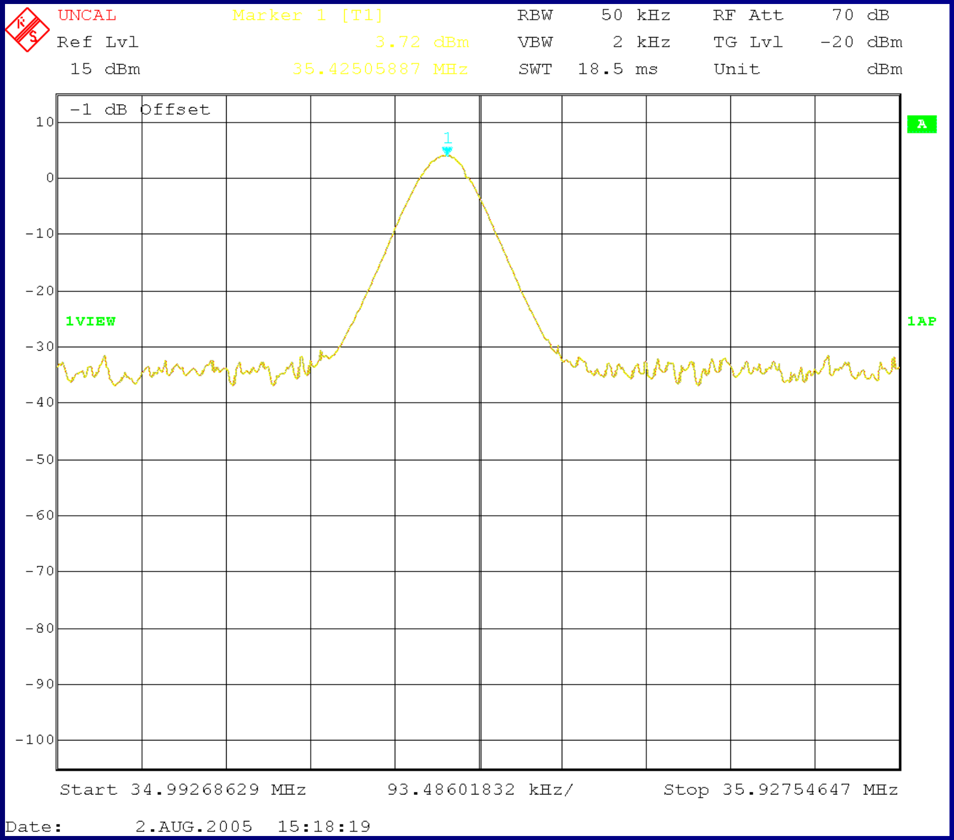
Methodology

- Understanding of Electrical Engineering design skills
- Study information about RF design
- Know the requirements and specifications for the design
- Build and test the systems
- Data analyses about overall effectiveness of the chain

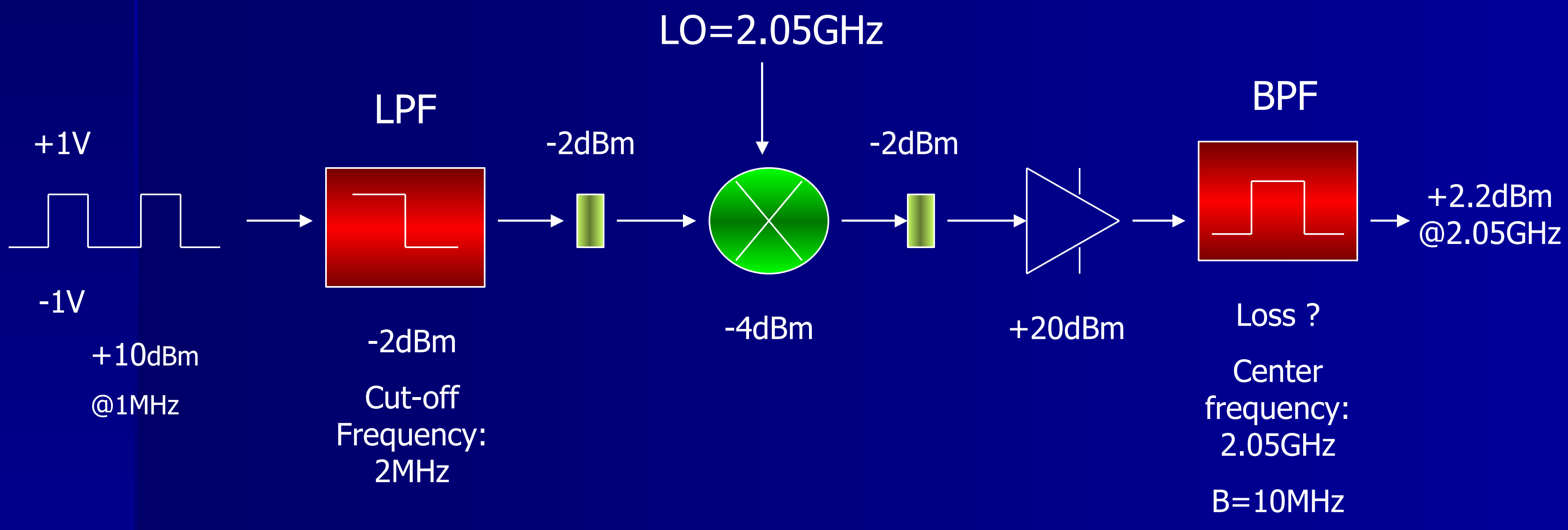
GPS Receiver



Receiver output

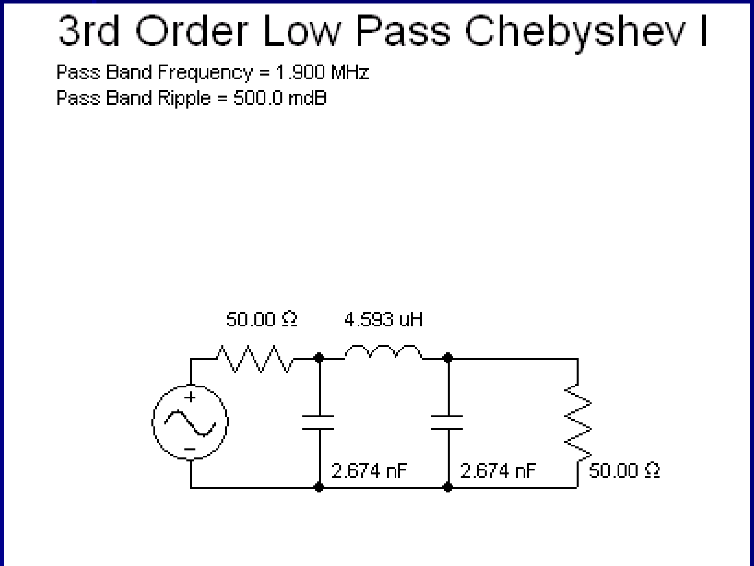


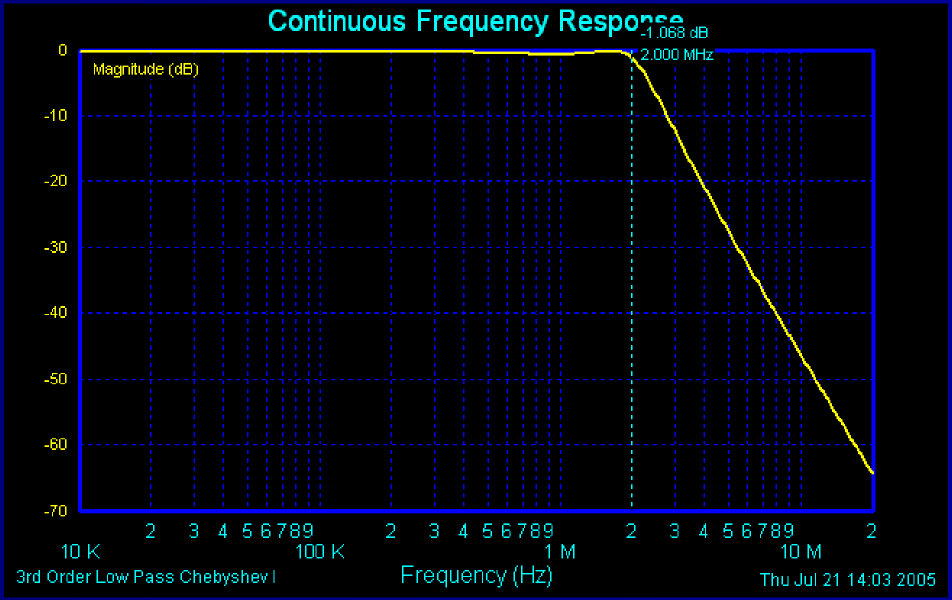
IRAS transmitter



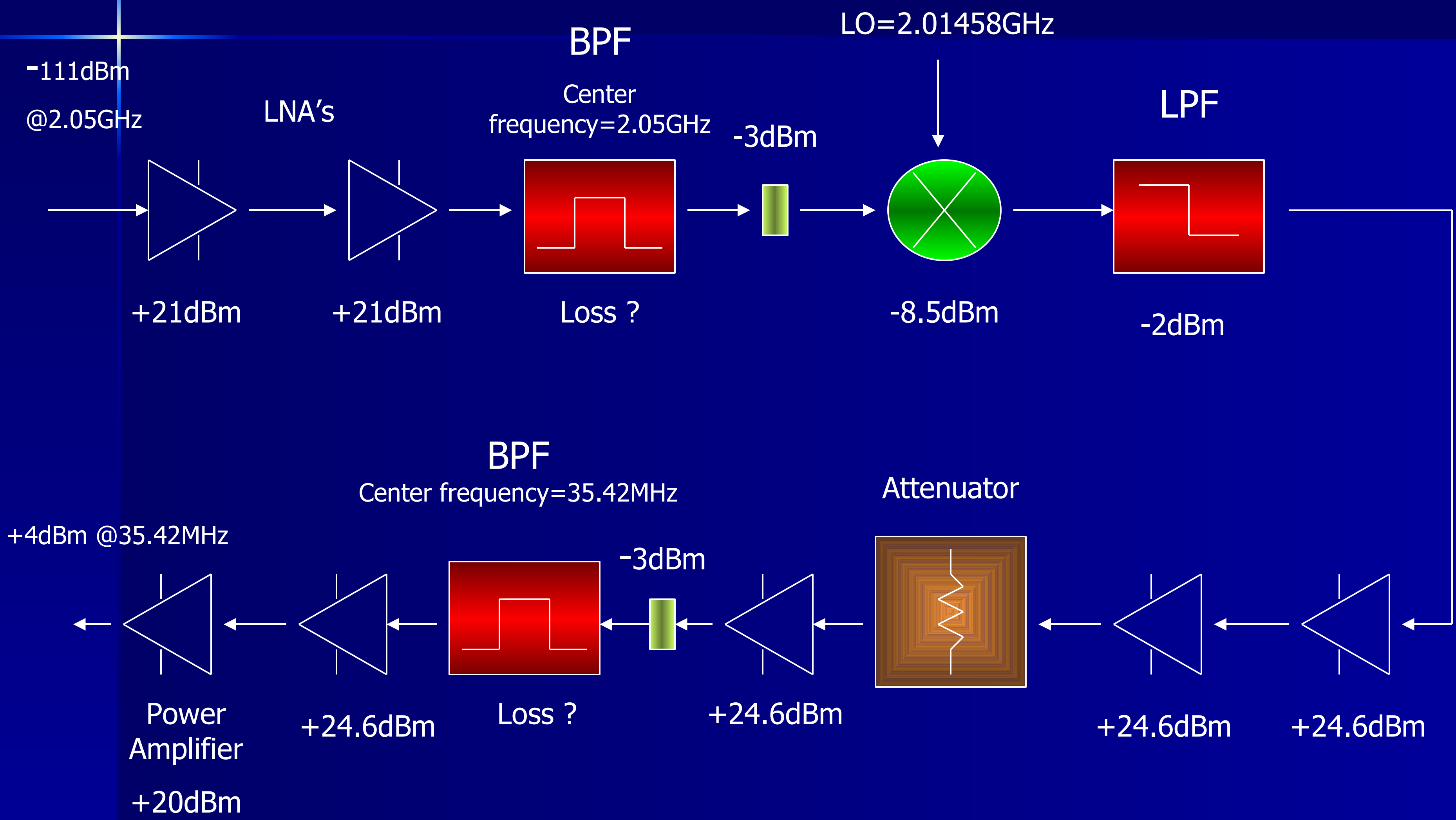
Low Pass Filter Design

- Cut-off frequency= 2MHz @ -1dB, Pass Band Frequency=1.9MHz, Pass Band Ripple= 0.5dB





IRAS Receiver



Acquired Knowledge

- Hands-on Engineering design
- System requirements and specifications
- RF principles and applications
- Filter design and implementation
- Overall system effectiveness analyses

References

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- Jeyasunder, David. *Magnetospheric Multi-Scale Mission Observatory/Spacecraft Requirements Document. Code 461* Goddard Space Flight Center, 2005
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- Filter Free design software
- NESDIS Office of Systems Development, *GOES-R.* http://www.osd.noaa.gov/goes_R/

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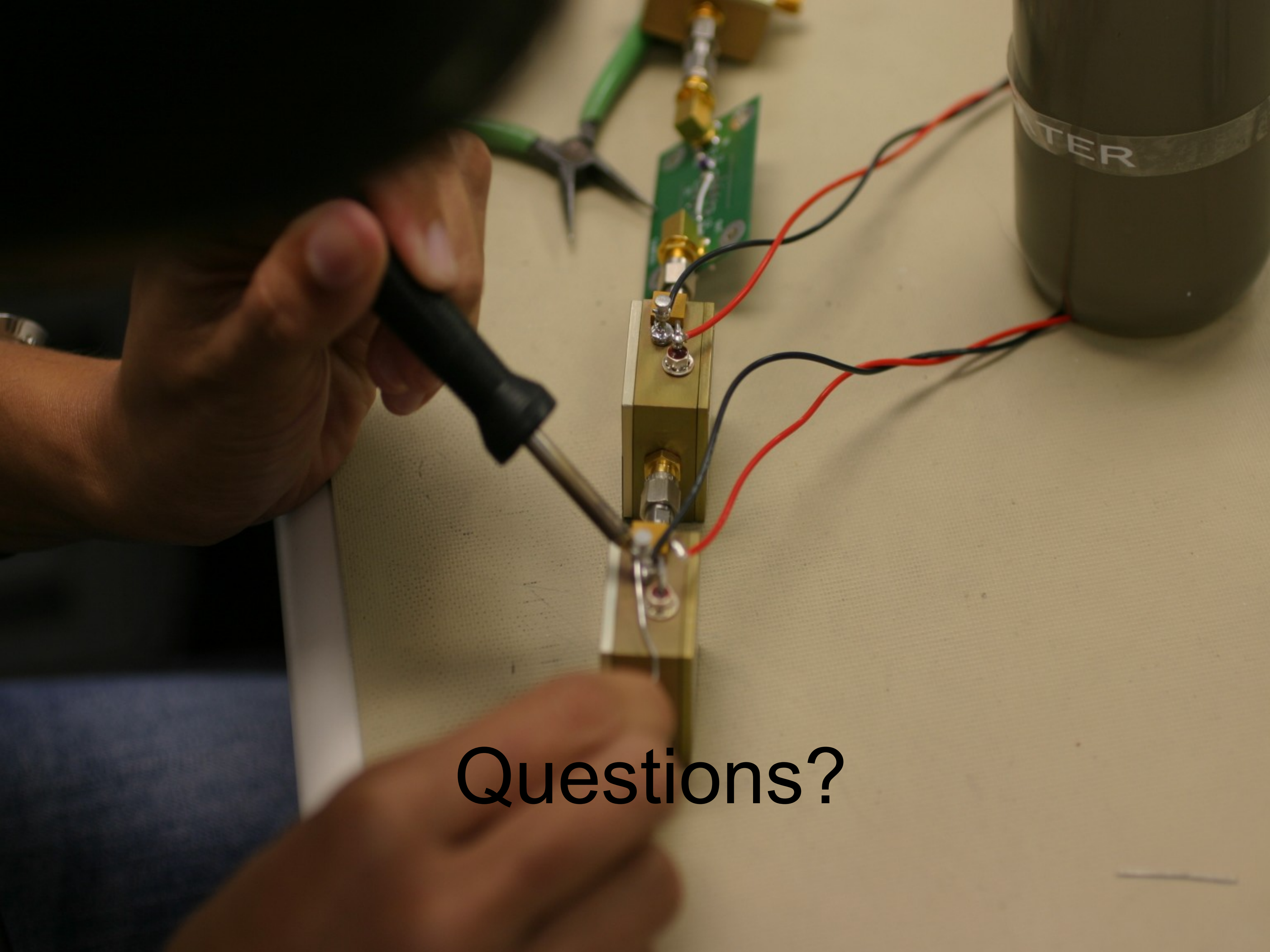
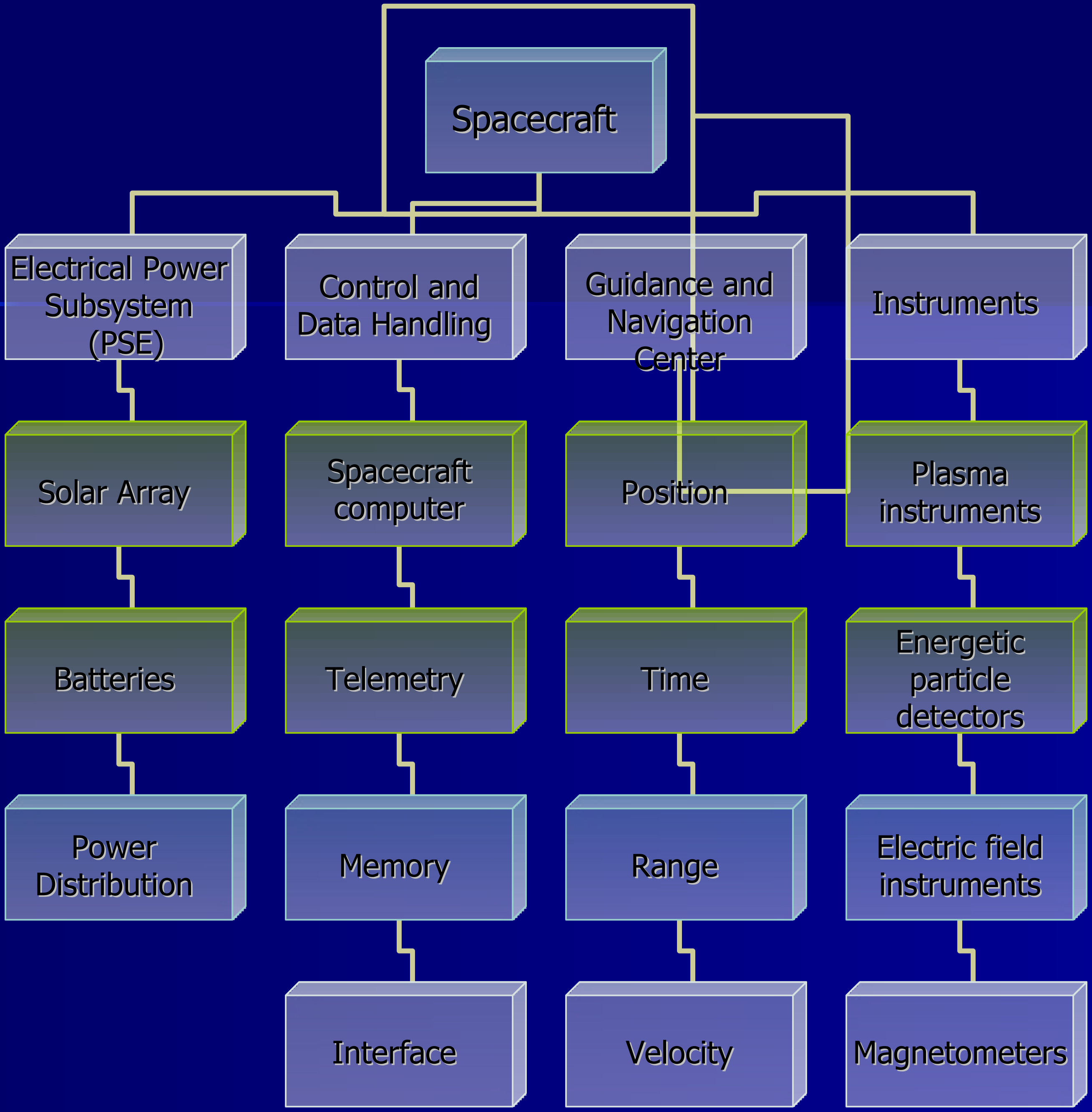
- NWS Aviation Services Branch

Plans for next summer

Find a project that includes both Engineering and Atmospheric Science in order to integrate an interdisciplinary background for Graduate studies consideration.


Questions?

Backup Slides


Spacecraft
Electrical Power Subsystem (PSE)
Control and Data Handling
Guidance and Navigation Center
Instruments
Solar Array
Spacecraft computer
Position
Plasma instruments
Batteries
Telemetry
Time
Energetic particle detectors
Power Distribution
Memory
Range
Electric field instruments
Interface
Velocity
Magnetometers

Inter Satellite Ranging and Alarm System (IRAS)

- IRAS is part of MMS
- Ranging:
  - It is used to measure the relative distances among four satellites forming a tetrahedron
- Alarm:
  - Passing packets of orbit data
  - Pass alarm messages between the observatories

Electrical Engineering Facts

- Transmitter:
  - Source of data information and process the signal for transmission to another medium
- Receiver:
  - Receives a signal from an external source to process the information
- Amplifier:
  - Integrated circuit that increases the power, voltage or current of a signal
- Mixer:
  - Mixes the RF signal with the local oscillator signal to obtain the IF output.

Electrical Engineering Facts

- Filter: sort out unwanted frequency ranges
  - Low Pass (LPF), High Pass (HPF), Band Pass (BPF), Band Reject (BRF)
- Modulation: alter a signal inserting a carrier
  - Phase Modulation (PM)
    - Encoding of information into a carrier wave by variation of its phase in accordance with an input signal
- Power representation in decibels, dB or dBm

$$dB = 10\log(\mathrm{P}) \qquad dBm = 10\log\left(\frac{P}{1mW}\right)$$

Materials

- Amplifiers
- Band Pass filters, Low Pass filters
- Mixer
- Power amplifiers
- Attenuators
- Coaxial cables
- Spectrum analyzer
- Power supply and signal generator