KySat-2: Status Report and Overview of C&DH and Communications Systems Design

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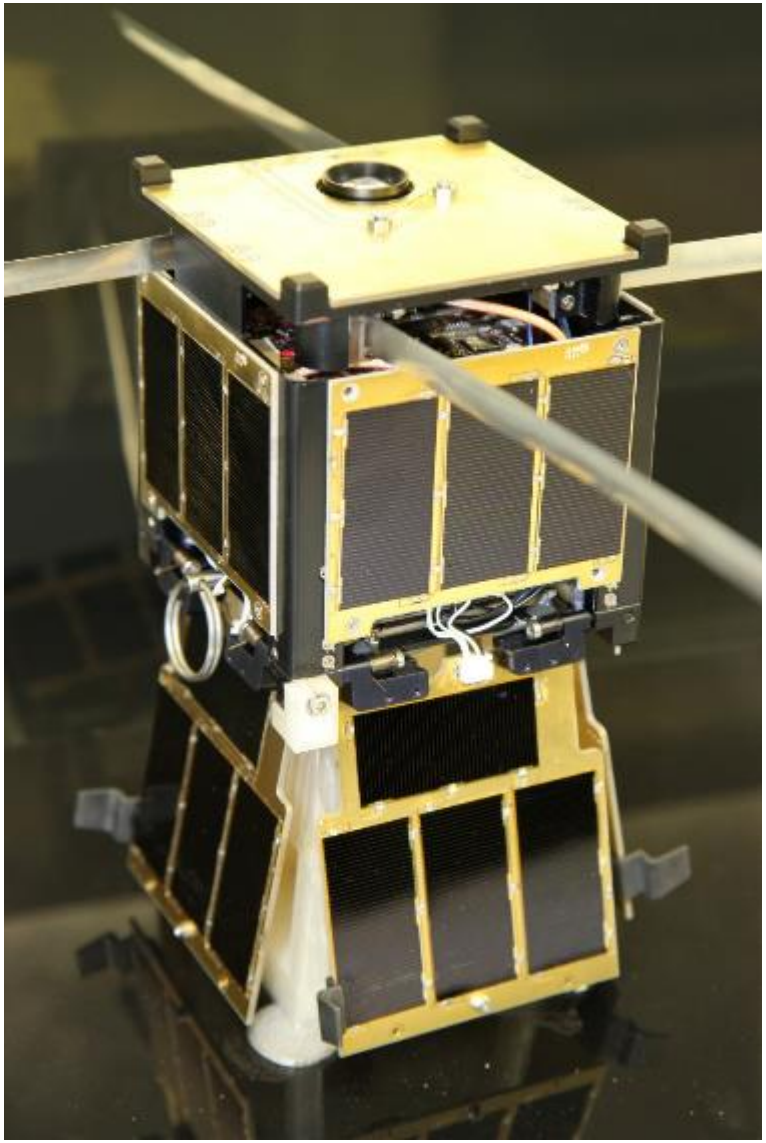
Overview

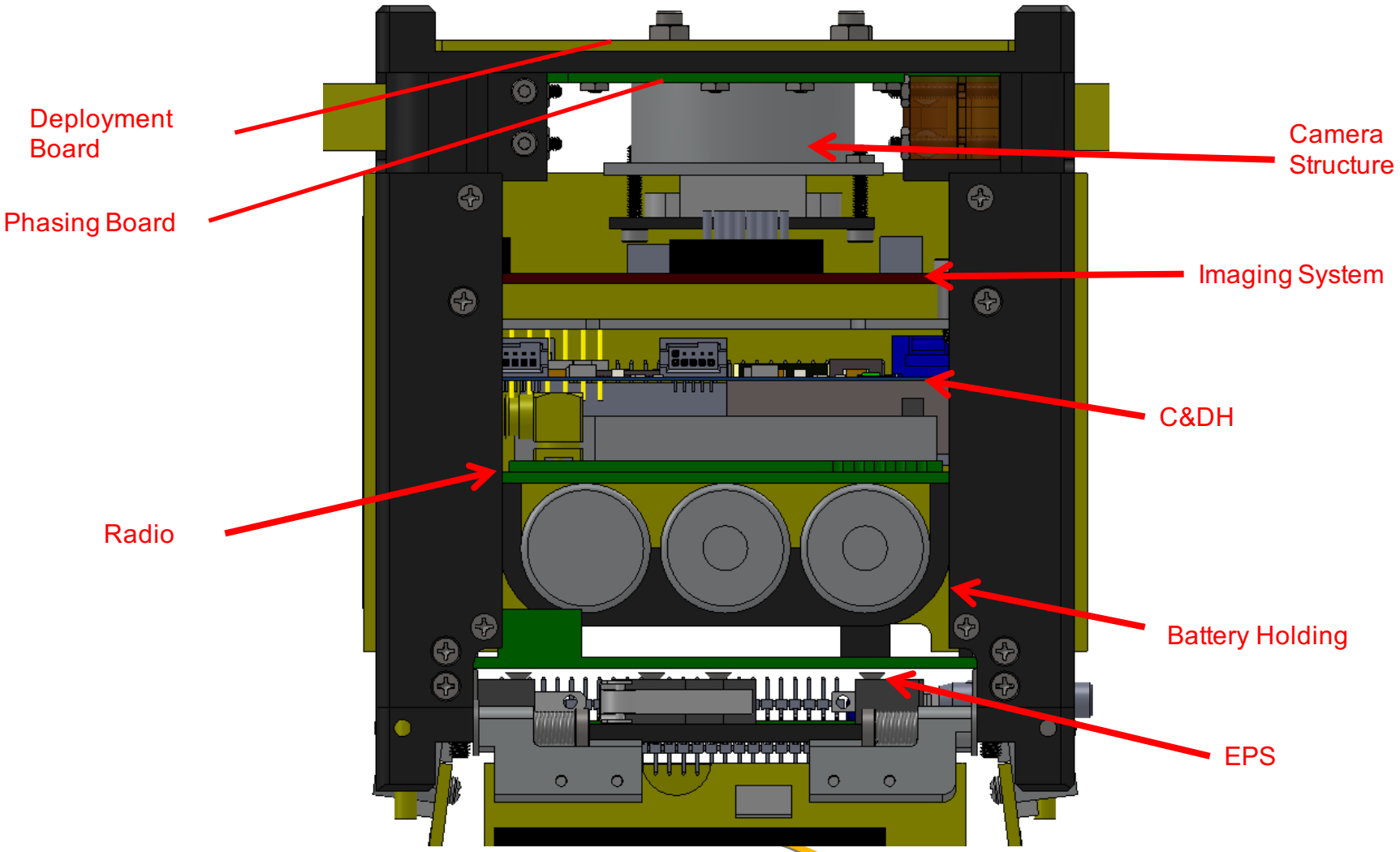
- Mission Goals
- Board Stackup
- Attitude Control System
- Communications System
- Command and Data Handling System
- Image Processing Unit
- Operations

KySat-2 Mission

- Goals:
  - Continue the goals of KySat-1
    - Educational/Public Outreach through photos and sensor data for K-12
  - Distributed processing architecture
  - Stellar Gyroscope Payload

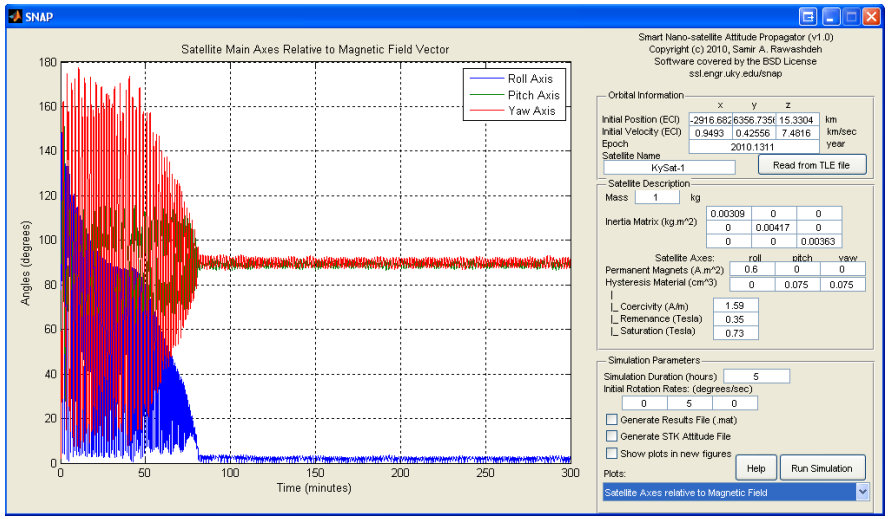


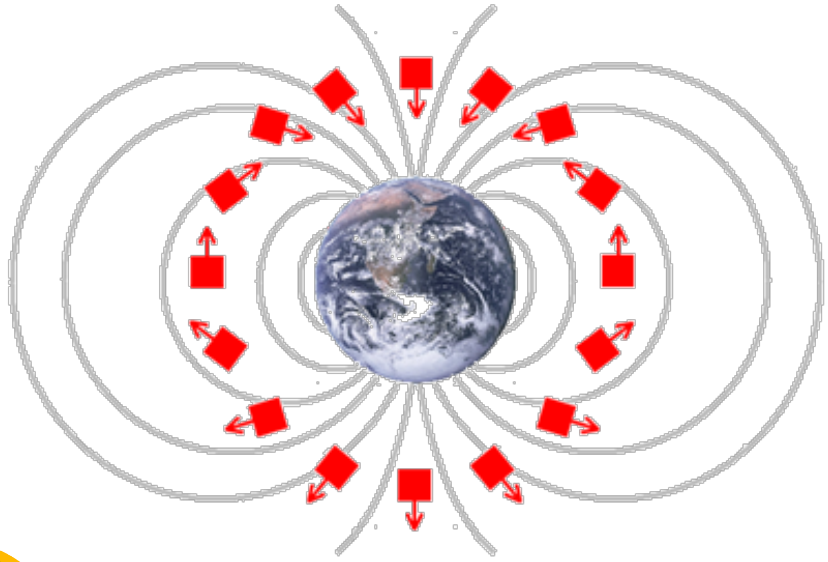
Board Stackup



Attitude Control

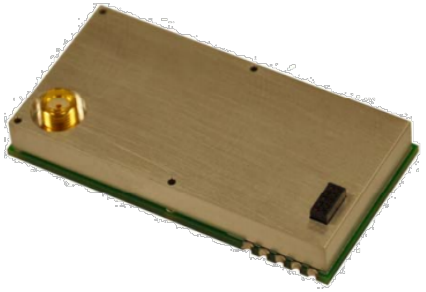
- Passive magnetic stabilization
  - Permanent neodymium magnets on z-axis, hysteresis material on x-y plane
  - Required magnetics found using Smart Nanosatellite Attitude Propagator (SNAP) developed by University of Kentucky

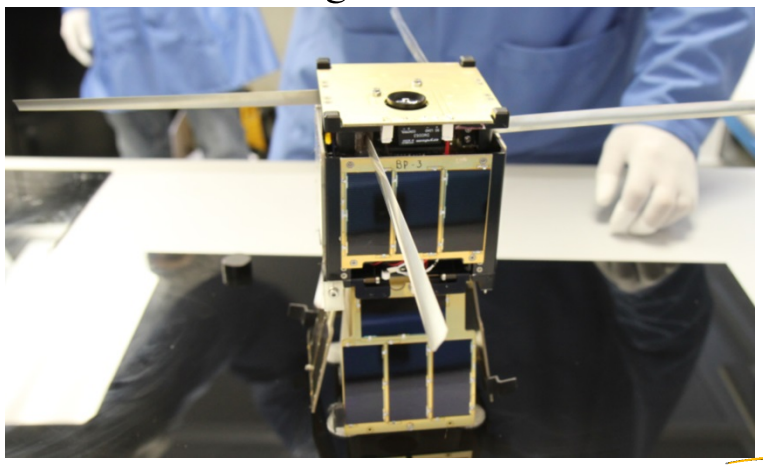


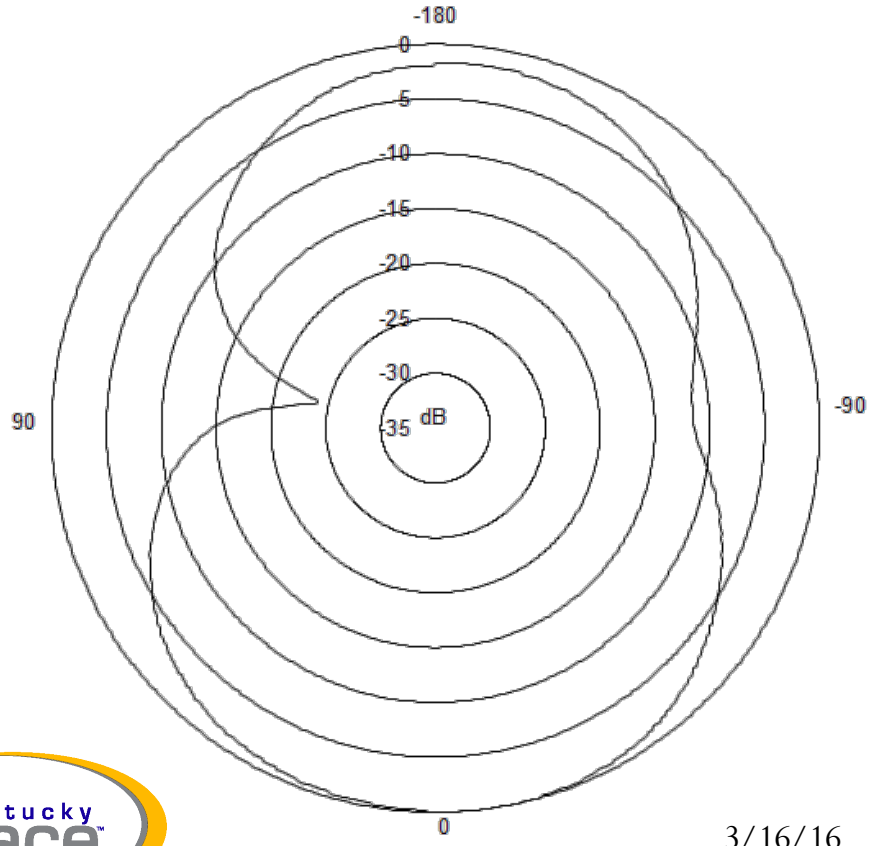


Communications System

- AstroDev Lithium-1 UHF Radio
  - 9600 baud
  - FSK modulation
  - UHF: 437.405 MHz
  - AX.25 packets
  - 1.5W transmit power
- Quad monopole antenna in omni-directional configuration

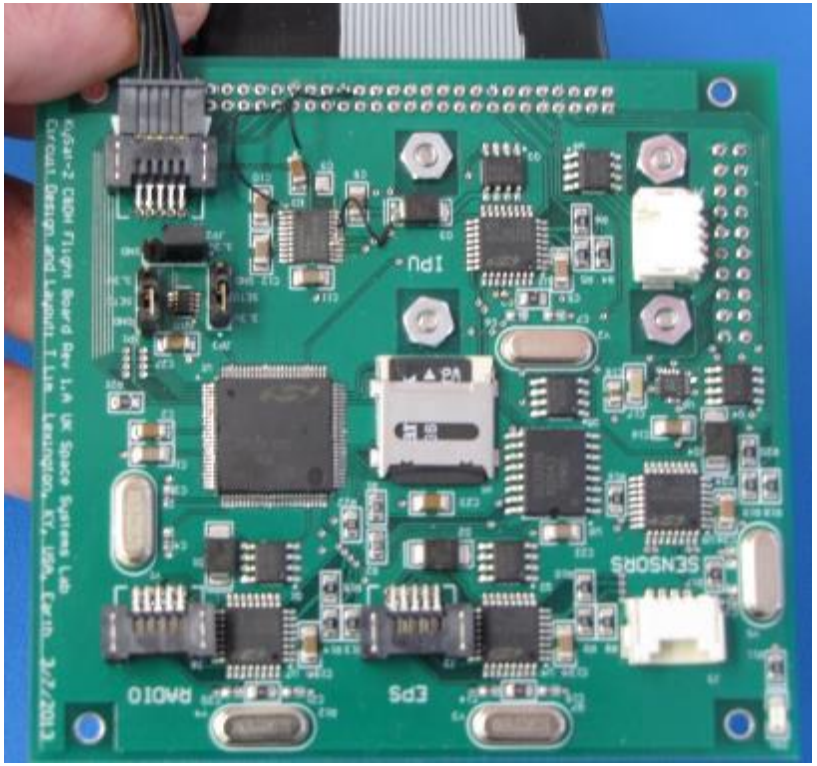




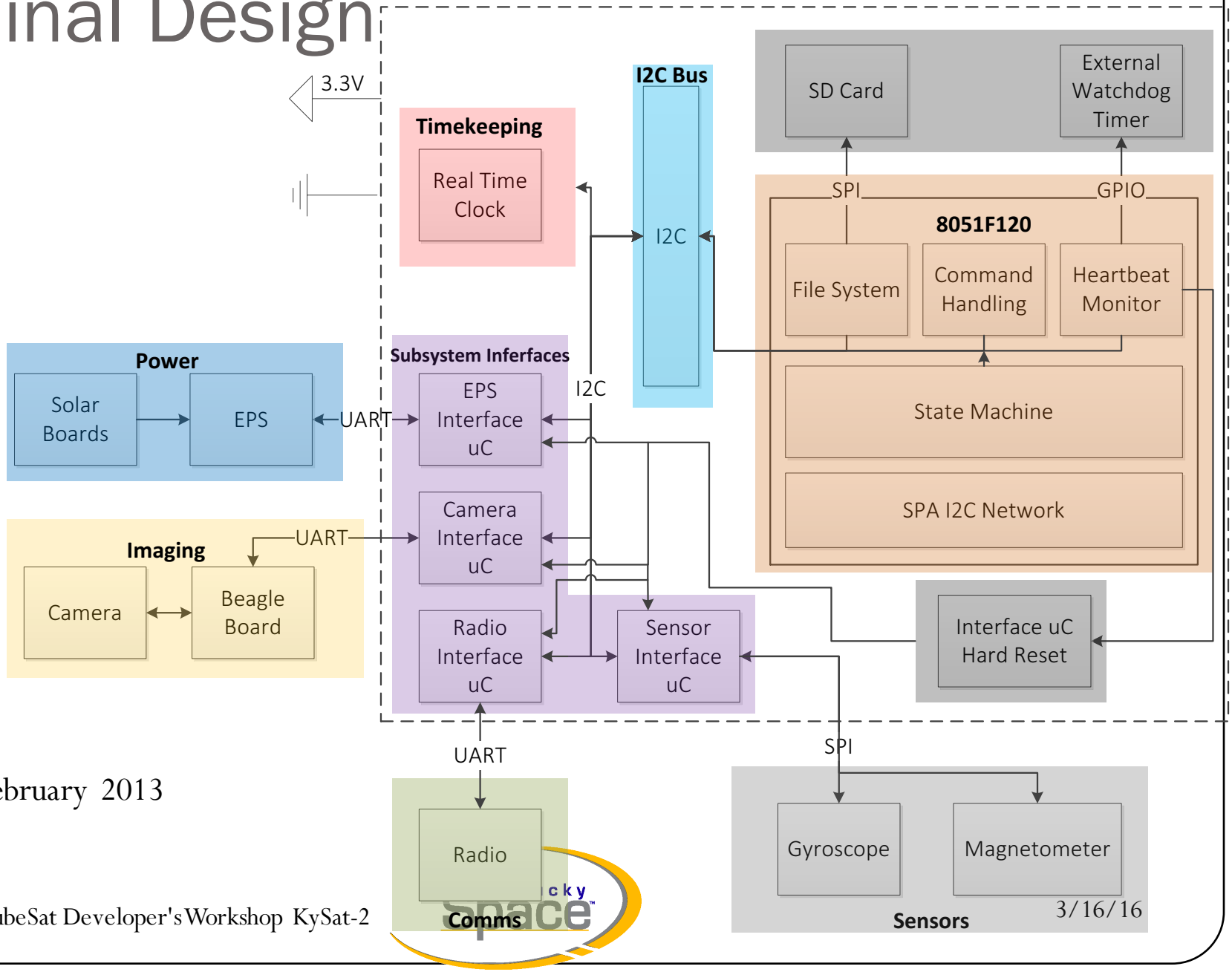


Command & Data Handling System

- Created by the Space Systems Lab
- Leverages aspects of Space Plug-and-play Avionics protocol (SPA)
  - SPA-1L for CubeLab Bus on International Space Station
  - COSMIAC's Trailblazer CubeSat
- Distributed processing architecture
  - SDM-L – mission processor
  - LASIMs – subsystem interface processors

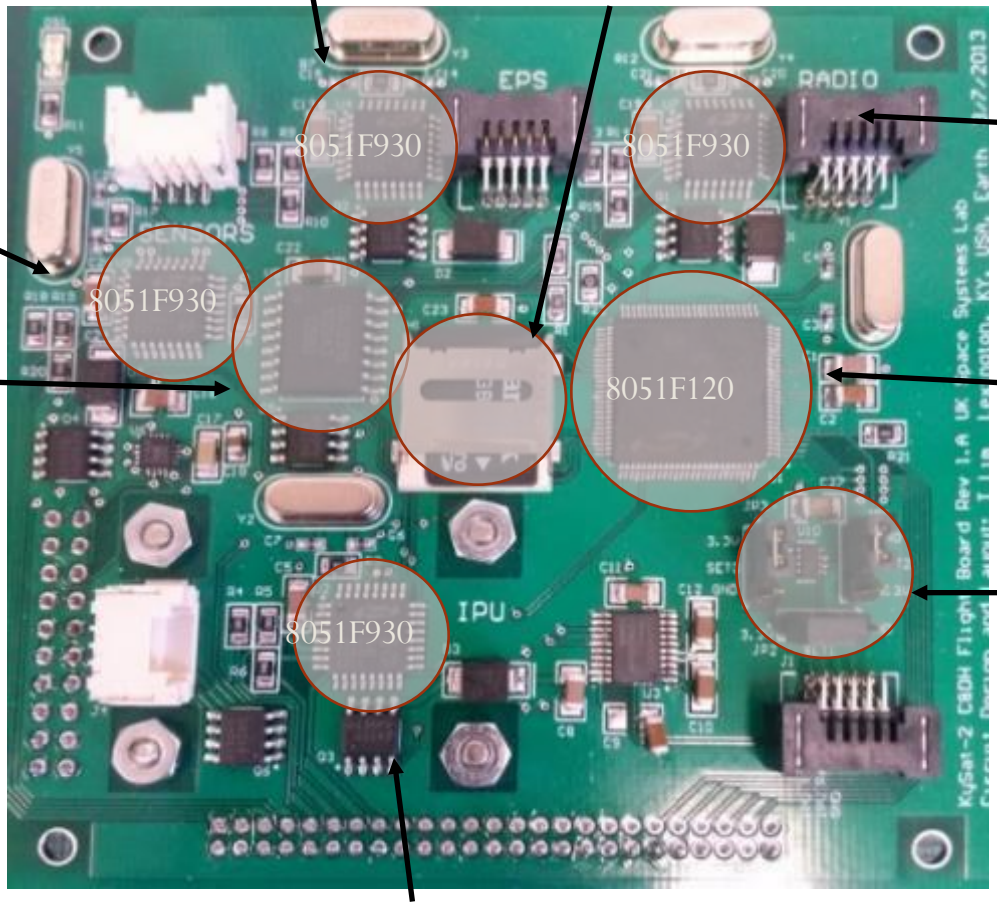


Final Design

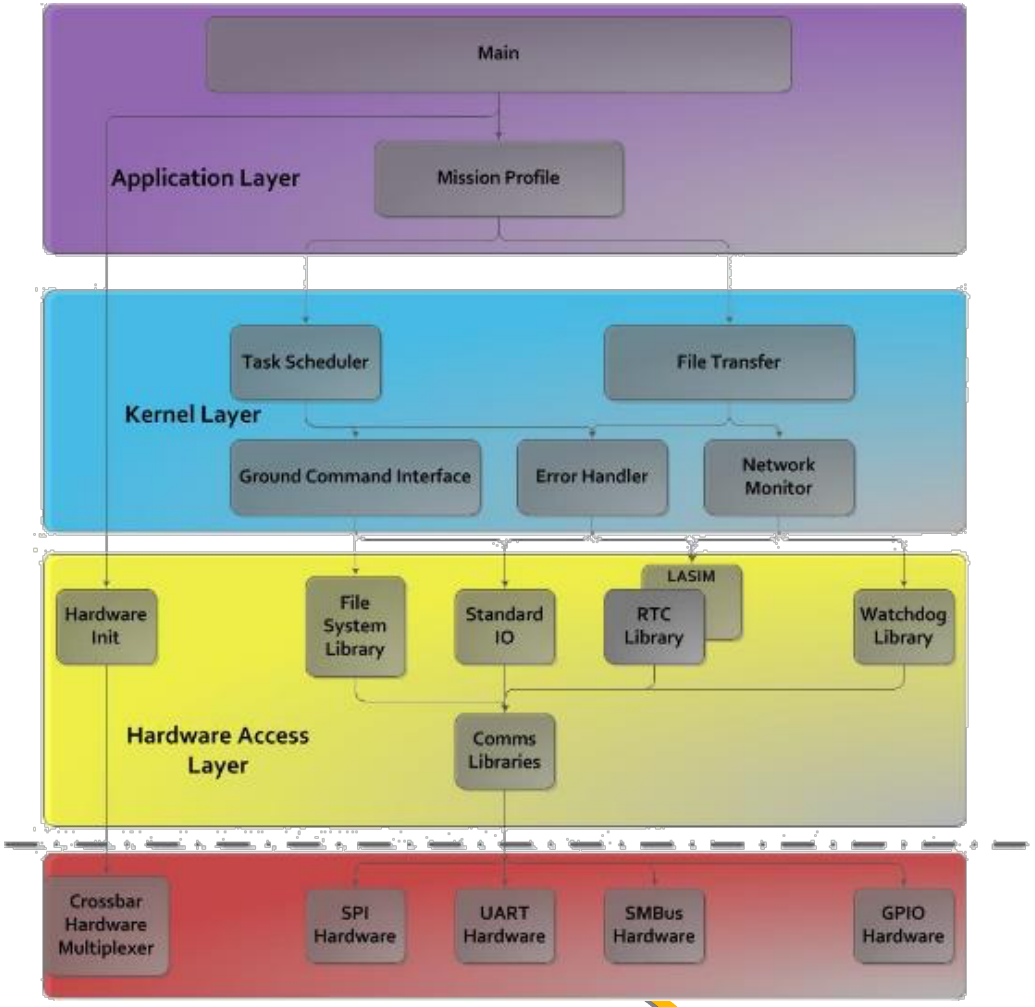


5 February 2013

C&DH Hardware



Software Architecture



Mission-Specific

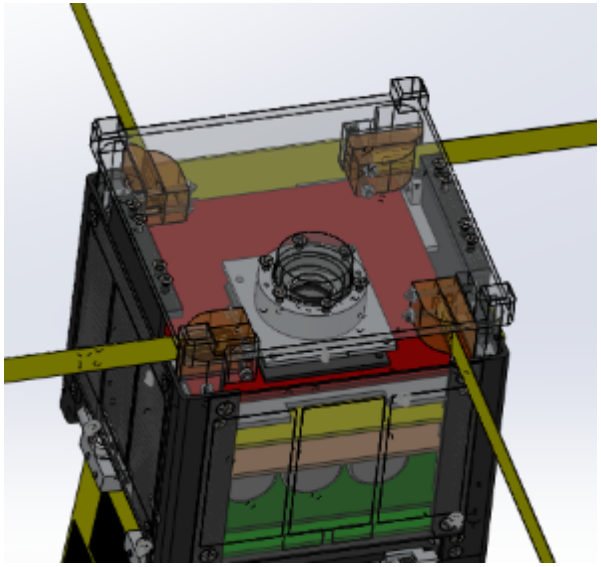
Hardware-Specific

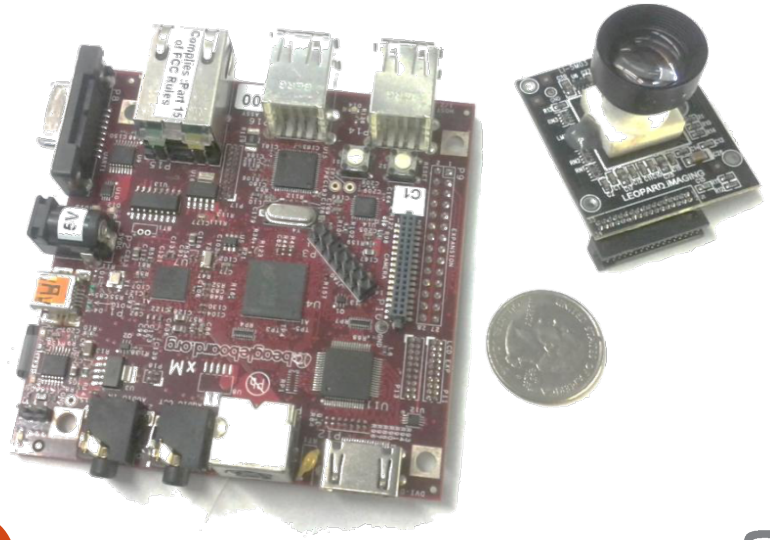
KySat-2 C&DH Architecture

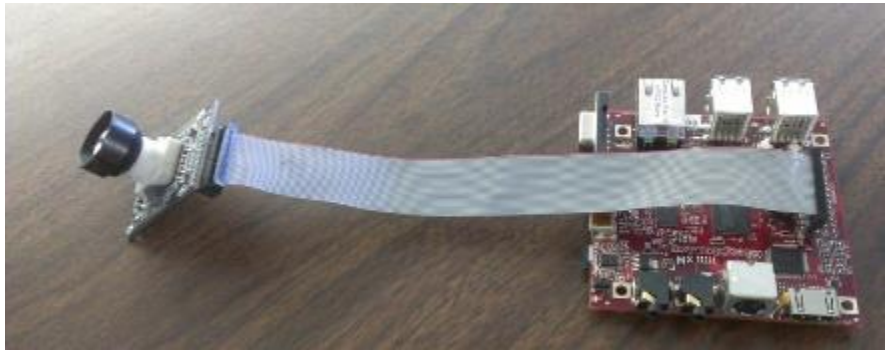
- Strengths
  - Custom PCB allowed for full functionality control
  - Programming API allowed for multiple students to seamlessly develop LASIM code
  - Hardware requirements abstracted from task execution
- Challenges
  - Initial need for time-consuming PCB revisions
  - Added software complexity to implement networked bus
  - Hardware bottleneck introduced latency in software transactions

Image Processing Unit

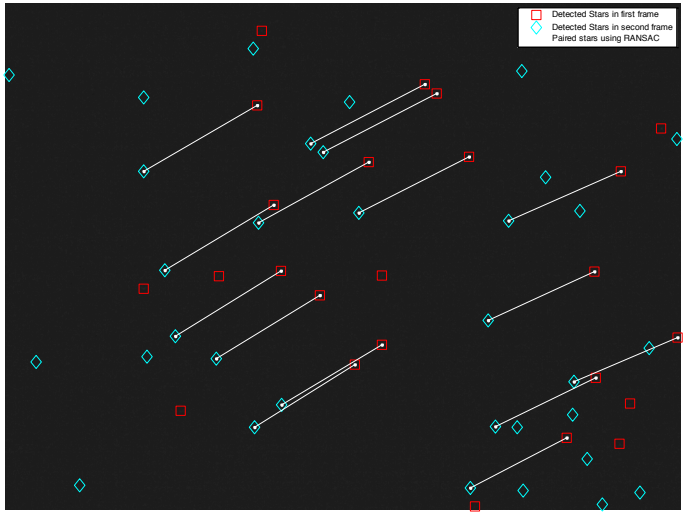
- BeagleBoard-xM
- 5MP CMOS Sensor
- Gain and exposure control
- OpenCV image processing

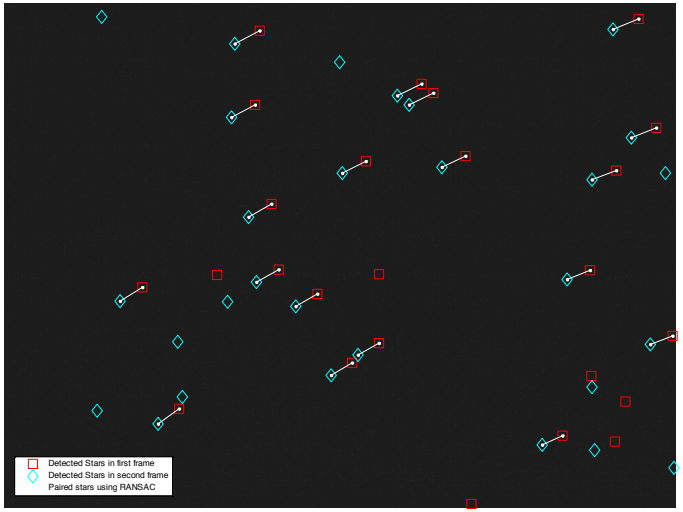


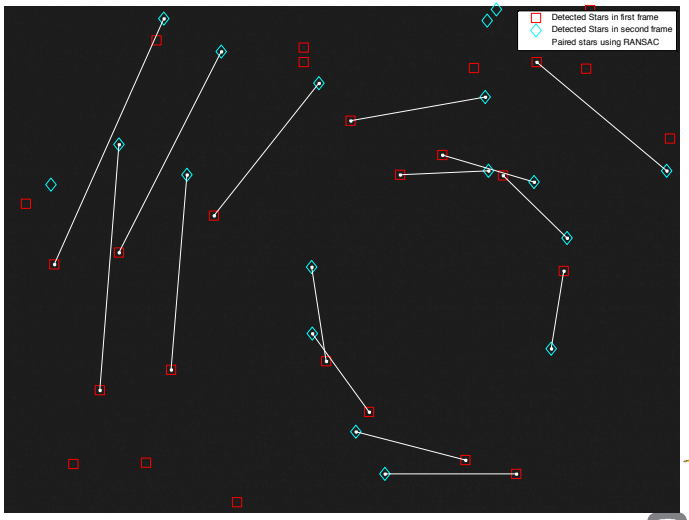


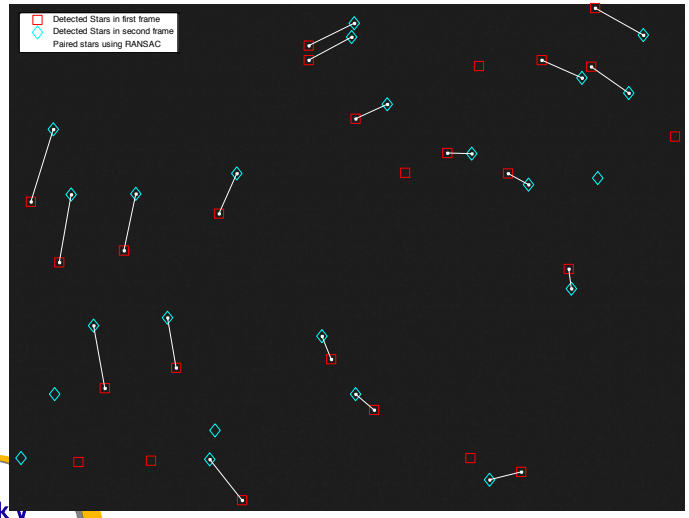


Stellar Gyroscope Examples



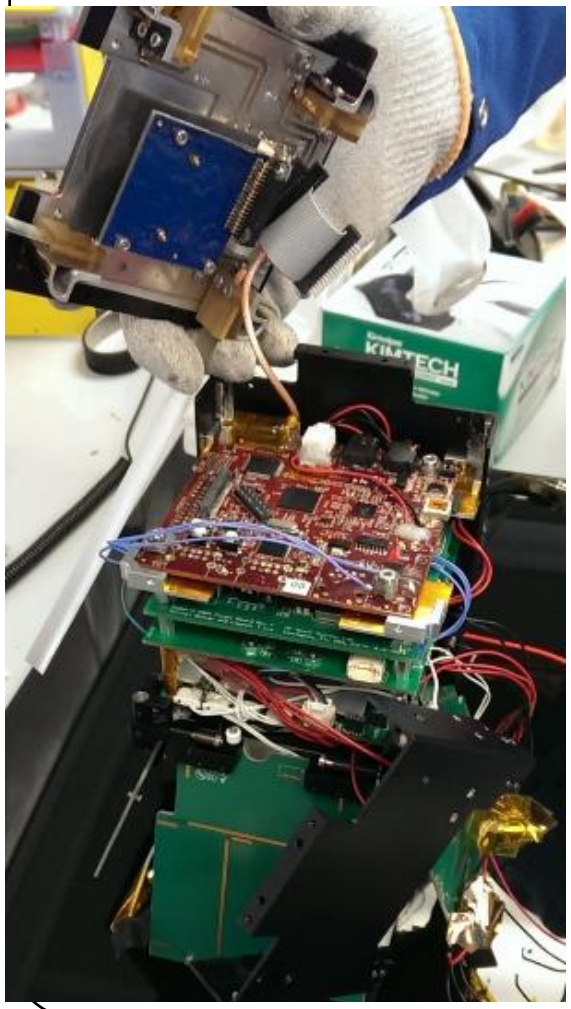


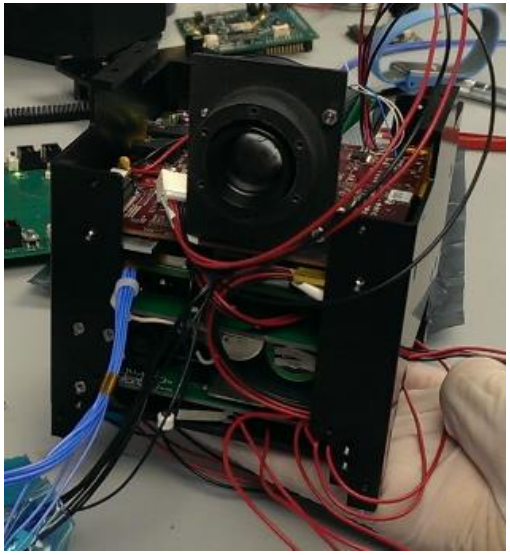


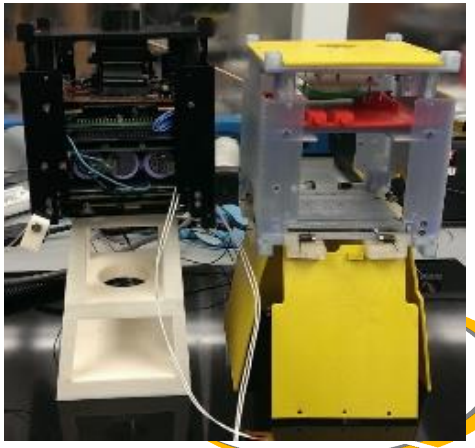


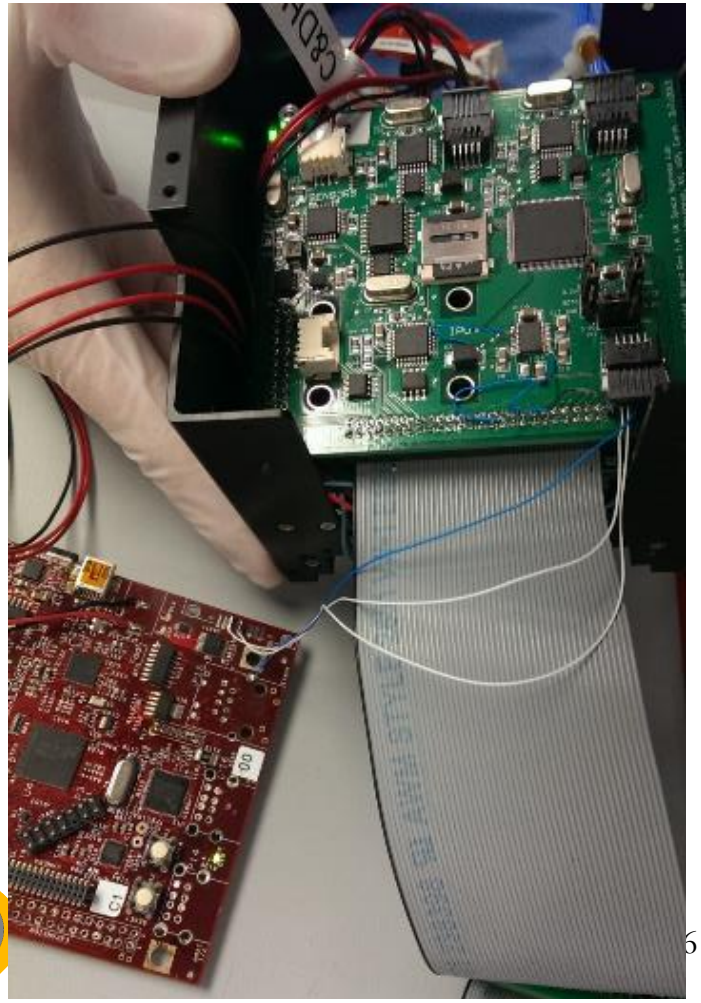
KySat-2 Integration

- Two KySat-2 models built: "Luke" and "Leia" in July and August 2013









Launch

- KySat-2 “Leia” launched on November 19, 2013
- Wallops Flight Facility, VA
- Orbital Sciences Minotaur-I
  - 500km circular orbit, 40.5 degree inclination
- First contact made by RA4CTR in Russia 1.5 hours later:

```
f2013-11-20 13:43:01.180 UTC: [78 Bytes KISS Frame (without CRC)]
ctrl: 3   PID: F0 {UI}   59 Payload Bytes
from KK4AJJ to CQ:
  1 > D5 CE 36 63 0F 05 0C 00 00 00 00 0B 03 0B 03 0B 03 0B 03 27
 21 > 70 04 A3 0A 42 00 02 03 A5 FF FE 00 02 00 42 FF FE 00 00 27
 41 > 6F 07 03 0C 03 0B 03 FD 9C 17 00 01 00 1D 0B 77 38 4B 5D
XO6c.....'p.?.B...?яю...Вяю..'o.....э?.....w8K]
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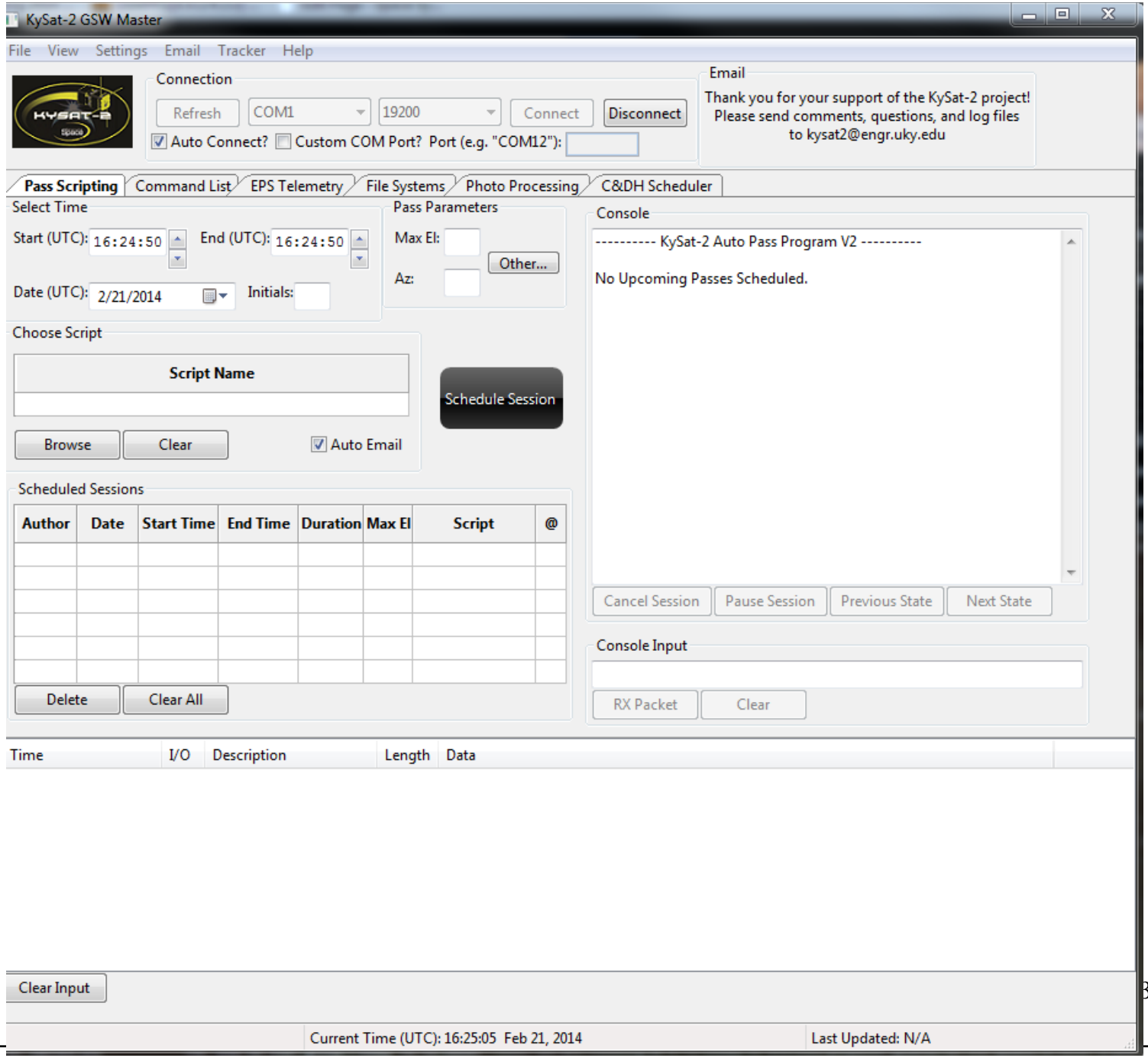
Ground Stations

- Two ground stations at UK
  - VHF/UHF roof-mounted Yagi antennas with azimuth/elevation rotor control, SatPC32 and Ham Radio Deluxe automatic tracking software
- Three ground stations at MSU
  - VHF/UHF Yagi antennas
  - 21m parabolic dish

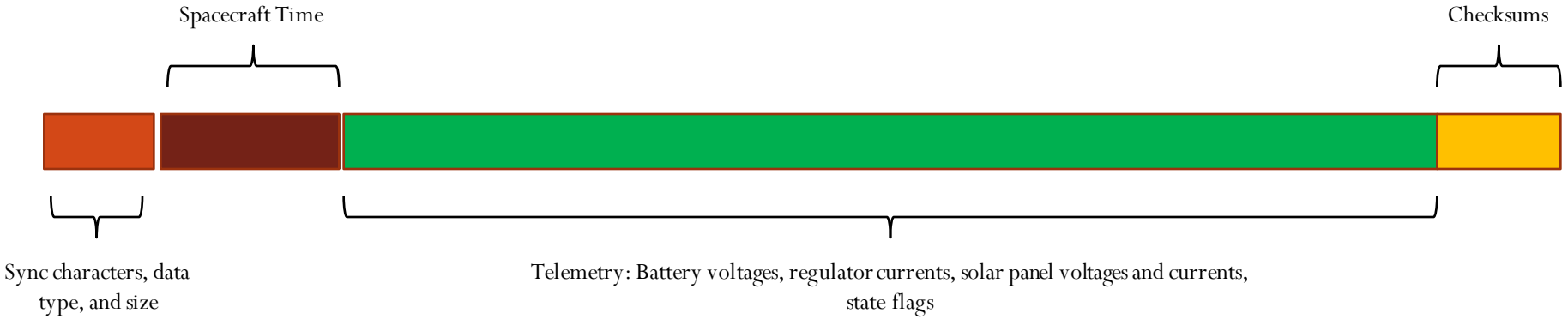
Operations

- wxPython-based GUI
  - Large user base with plenty of libraries and examples
  - Cross-platform compatibility
- Master Ground Station Software
  - For UK and MSU ground teams
  - Full command set, image processing, C&DH scheduler debugging
  - Scripting: can read Python scripts to automate passes, make decisions based on satellite response
  - In conjunction with ground station automation, can completely schedule and automate data collection
- HAM Ground Station Software
  - Decodes beacons, limited transmit functionality, automatically sends beacons to server at Kentucky Space
  - Available at: ssl.engineering.uky.edu/amateur-radio-operators


KySat-2 GSW Master
File View Settings Email Tracker Help
Connection
Refresh COM1 19200 Connect Disconnect
Auto Connect? Custom COM Port? Port (e.g. "COM12"):
Email
Thank you for your support of the KySat-2 project!
Please send comments, questions, and log files
to kysat2@engr.uky.edu
Pass Scripting Command List EPS Telemetry File Systems Photo Processing C&DH Scheduler
Select Time
Start (UTC): 16:24:50 End (UTC): 16:24:50
Date (UTC): 2/21/2014 Initials:
Pass Parameters
Max El: Az: Other...
Console
---------- KySat-2 Auto Pass Program V2 ----------
No Upcoming Passes Scheduled.
Choose Script
Script Name
Browse Clear Auto Email
Schedule Session
Cancel Session Pause Session Previous State Next State
Scheduled Sessions
Author Date Start Time End Time Duration Max El Script @
Delete Clear All
Console Input
RX Packet Clear
Time I/O Description Length Data
Clear Input
Current Time (UTC): 16:25:05 Feb 21, 2014
Last Updated: N/A

Operations

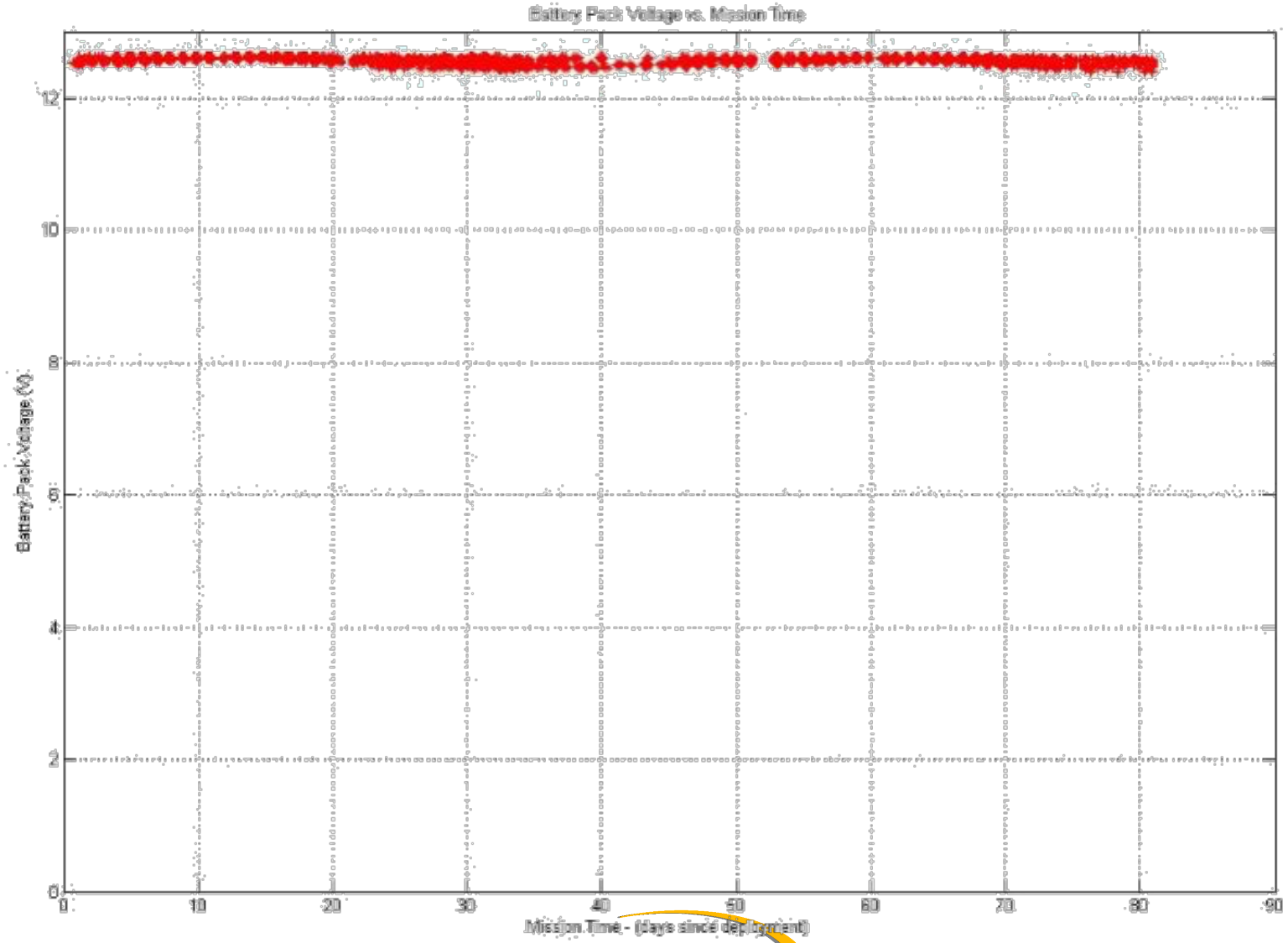
- Collected over 12,000 unique beacons since launch



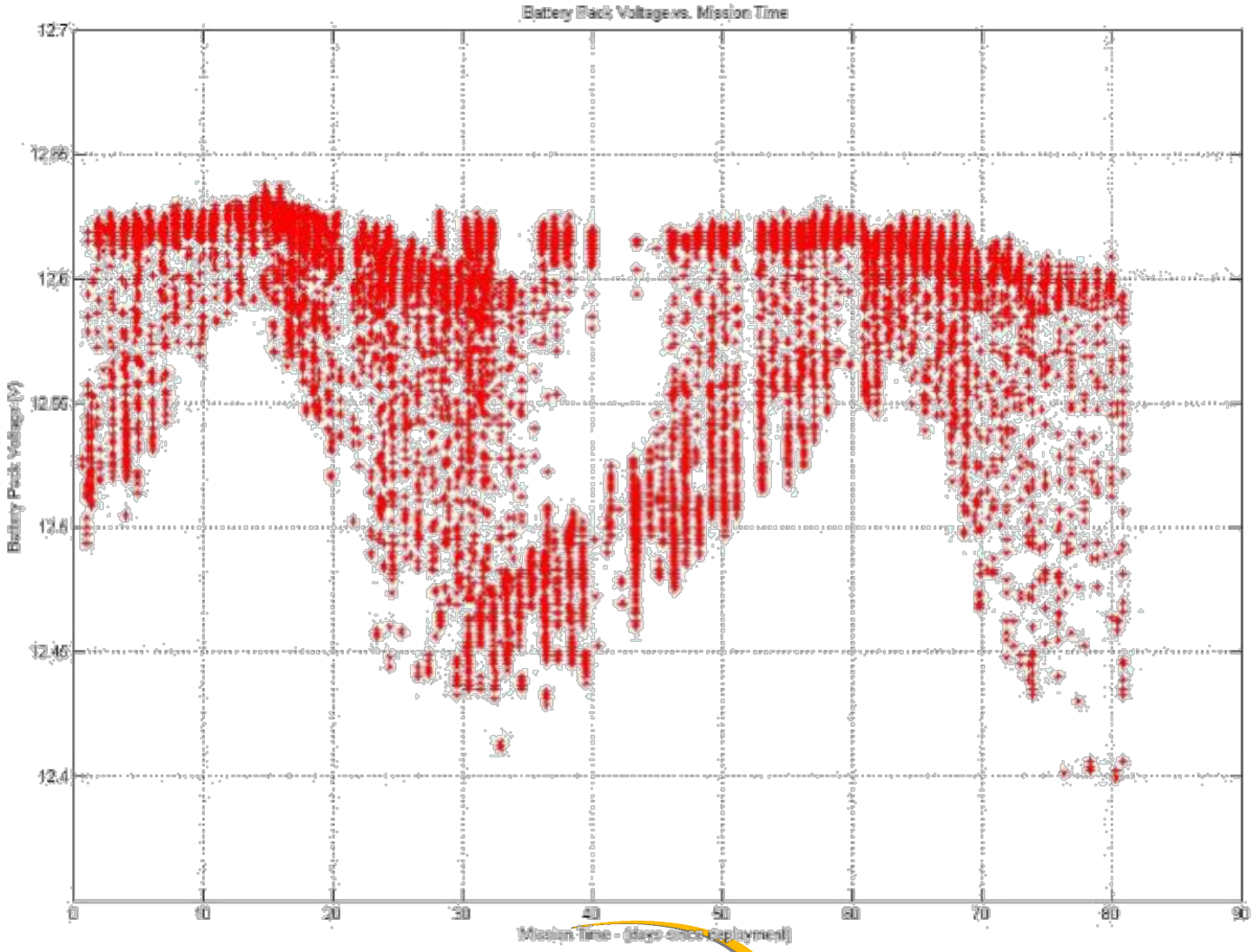
- Distributed network maintenance and data transfer verified and nominal
- Power system persistence, power budget verified
- Communications downlink verified
- Mission clock ran continuously to Launch + 110 days

International Beacons

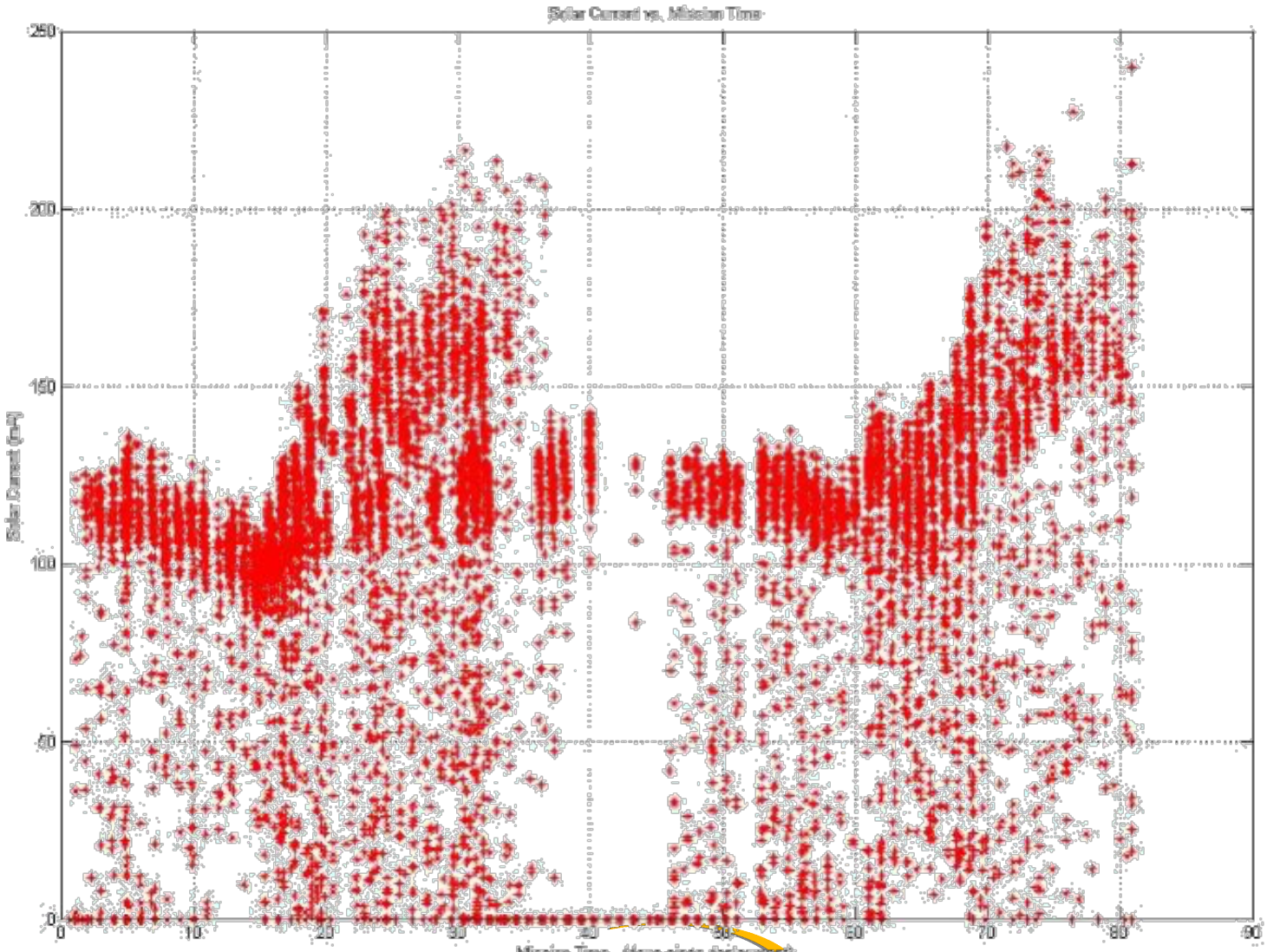
Large scale Battery String Voltage – 80 days



Small scale Battery String Voltage – 80 days



Solar Cell Current – 80 days



Uplink

- Excellent downlink, but some problems with uplink limiting commanding and science operations

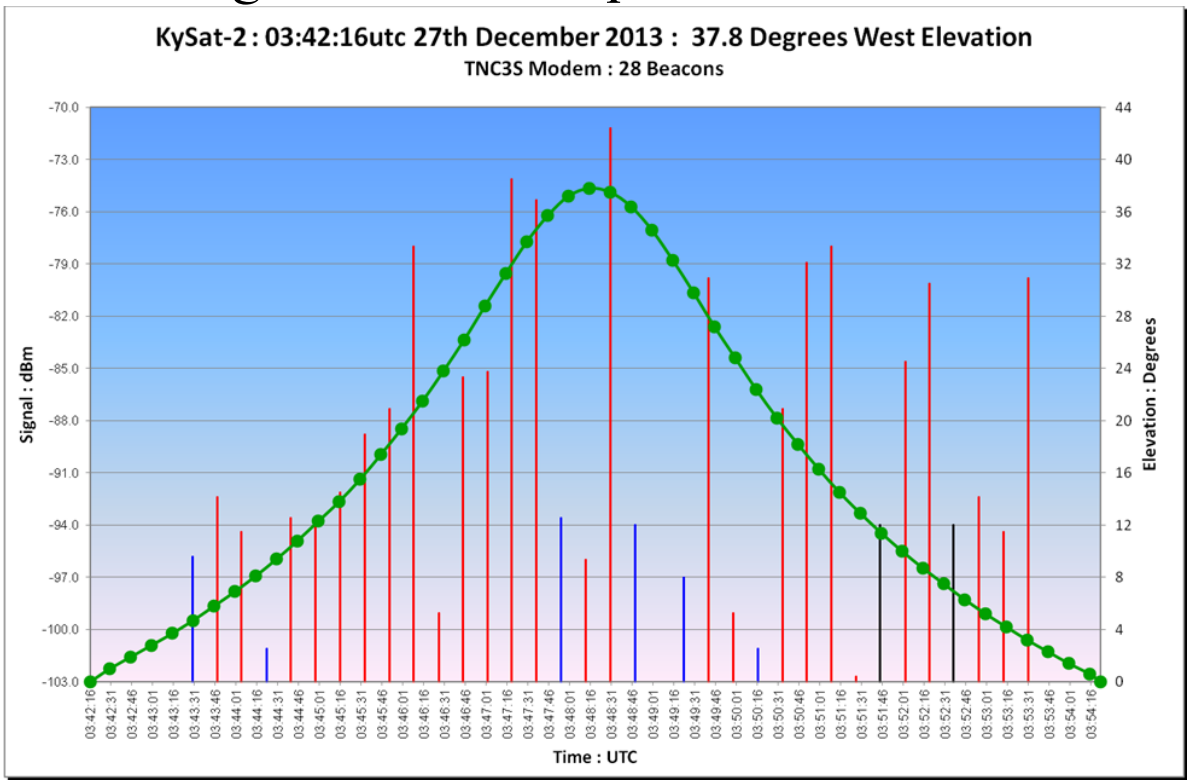
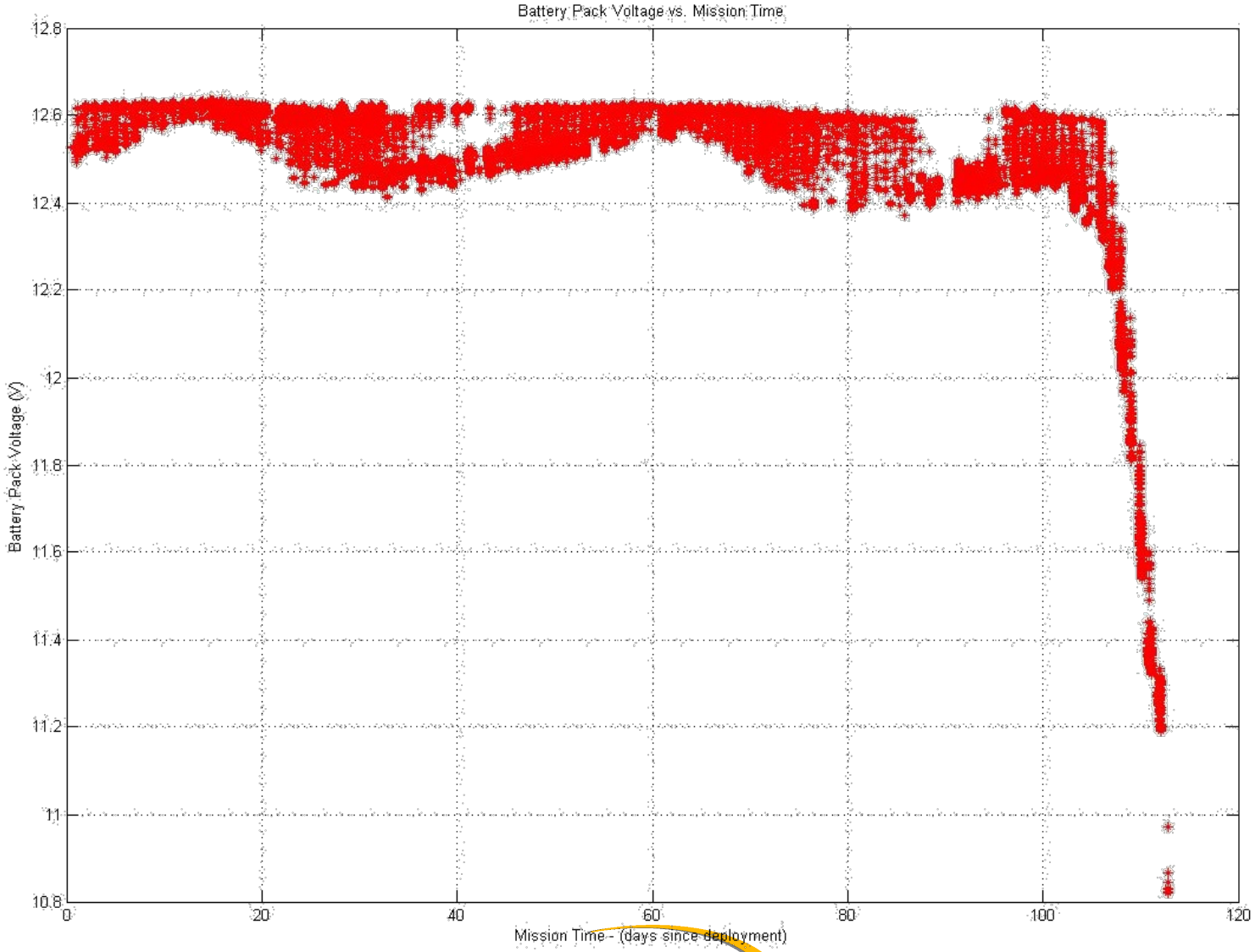


Image credit: Colin Hurst VK5HI

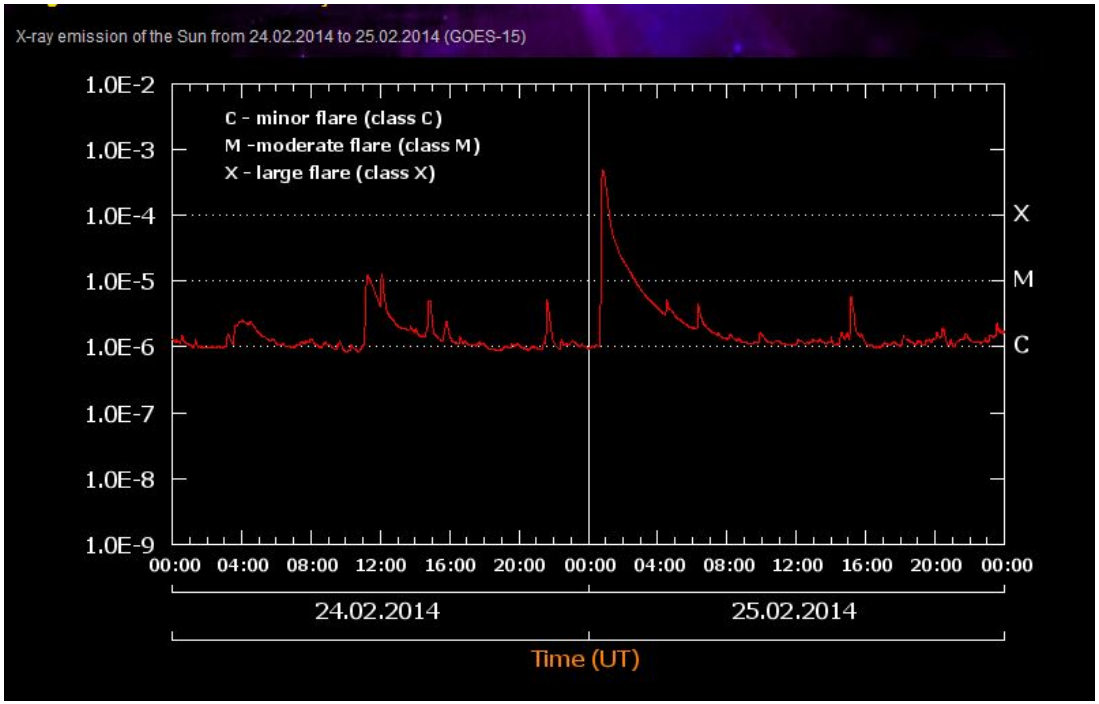
Battery Voltage Anomaly – 110 days

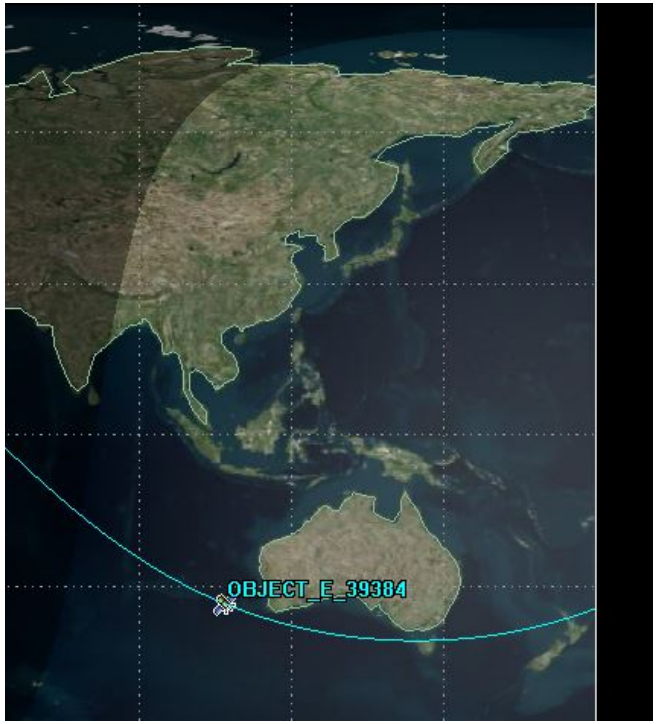


Battery Voltage Anomaly Cause

- Suspected cause: X4.9 solar flare on 25 February, largest of 2014
- Simulations show that KySat-2 was in the sun for the event

Image from: http://www.tesis.lebedev.ru/en/sun_flares.html?m=2&d=25&y=2014





Thank You

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