The ION Cubesat

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Overview

- ION History
- Mission
- What's onboard
- Software System
- ION Operations Model
- Lessons Learned

History

- Illinois Tiny Satellite Initiative (2001)
  - ION Cubesat
    - Illinois Observing Nanosat
- April 2005 Delivered ION
  - Awaiting DNEPR June 28, 2006
  - 3.5 years
  - Over 100 students
  - Costs:

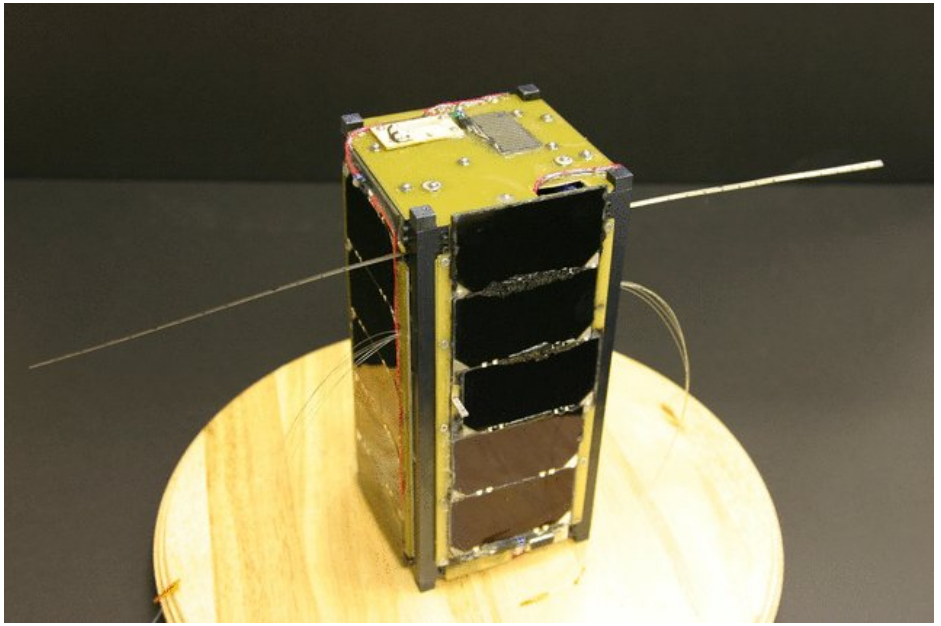
Parts	35000
Equipment	20000
Shop	30000 (700 hrs)
Launch	85000
TOTAL	170000

Organization

- Interdisciplinary Design Class
  - ~15 Students / semester
  - Juniors/Seniors
  - 2 Semesters
  - AE, CE, EE, ME, TAM, CS, GE
  - Senior Design credit
  - 2 graduate student PM/TA's
  - Minimal faculty involvement
- Teams (3-4)
  - Software, Electrical, Mechanical
  - ACS, Communications

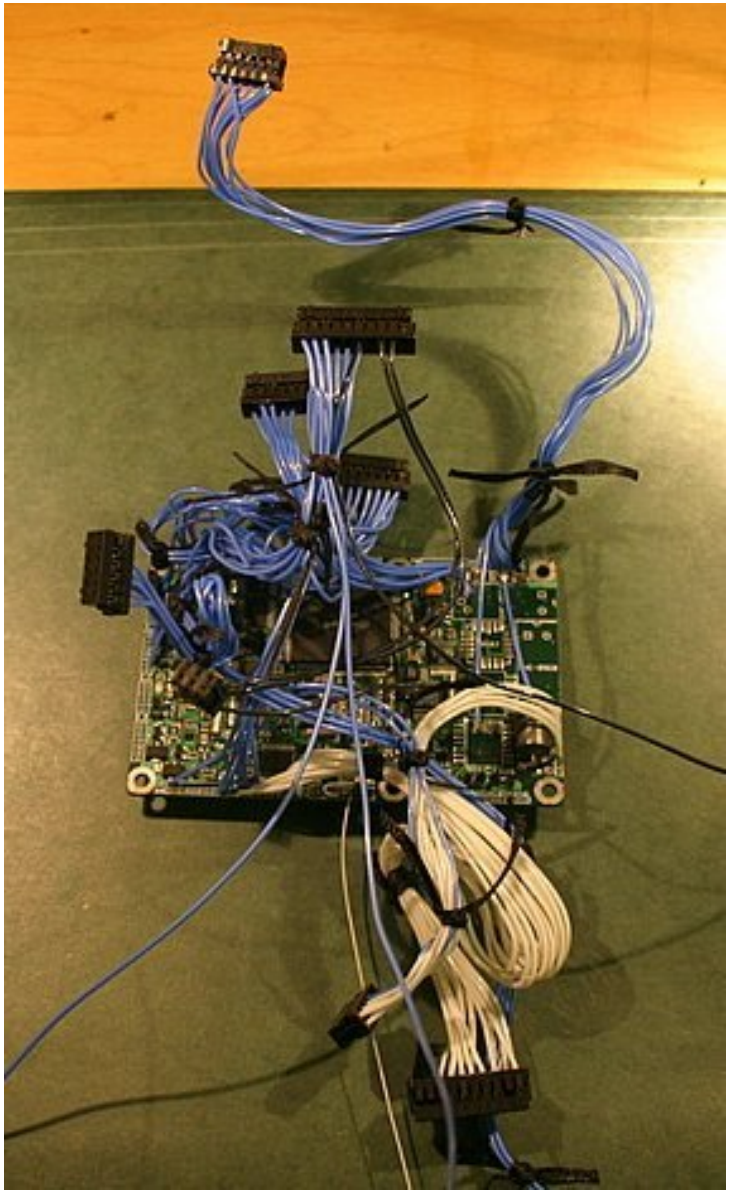
ION Mission Objectives

- Interdisciplinary senior design course for undergraduate students
- Measure oxygen airglow
- Test microvacuum arc thruster system
- Test SID flight computer
- Take photos!
- Demonstrate ground-based attitude control



Flight Computer

- Small Integrated Datalogger (SID)
  - Tether Applications
  - Hitachi SH7045 SH2
  - 7 Mhz, 1 MB RAM, 8 MB Flash
  - RTC's, Temperature
  - 32 A->D, 24 GPIO



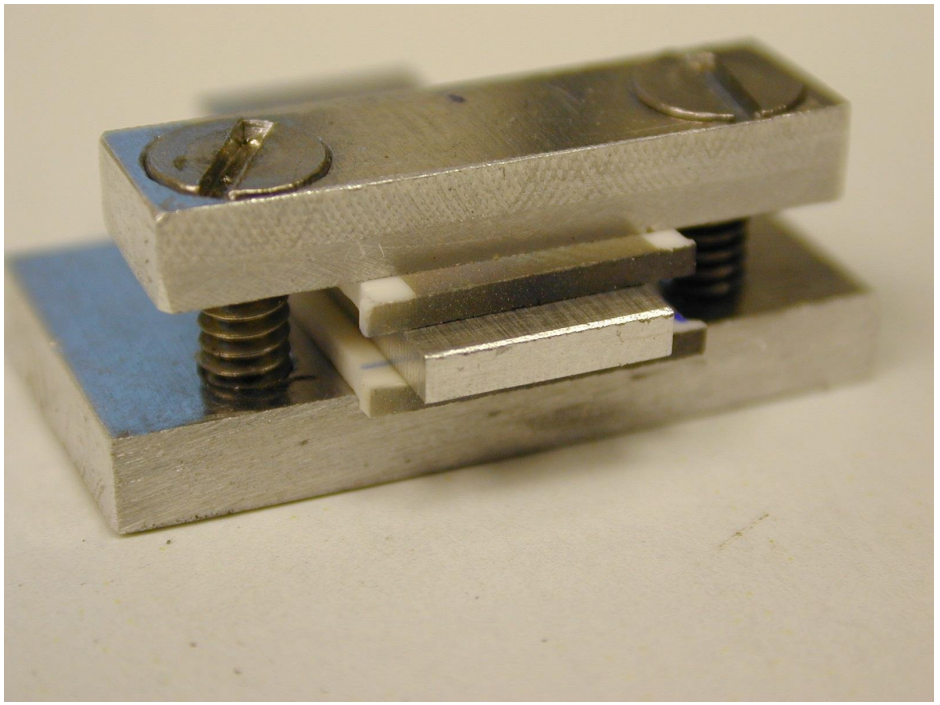
Payload

- Photo Multiplier Tube (PMT)
  - Hamamatsu H7155
  - 763 nm filter
  - One photon one pulse
  - Protection diodes/logic

- PB-300 CMOS Camera
  - 640x480 black and white

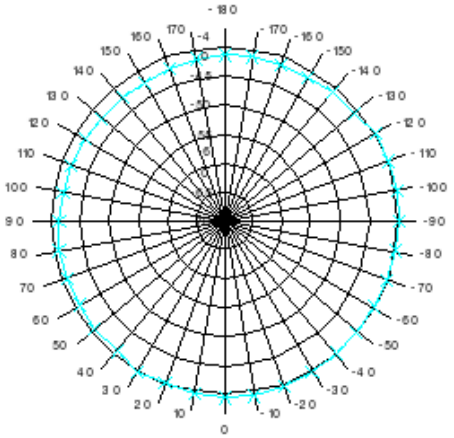
Payload (cont...)

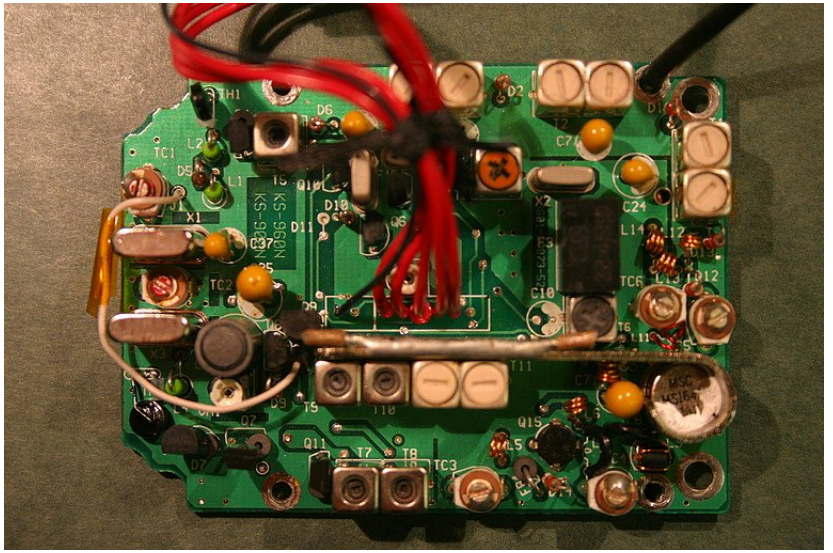
- 4 Electronic Thrusters
  - Arc across cathode + anode
  - Cathode material ejected
  - 10 uN/W
  - 4 secs firing = 90 deg in 10 min
  - Thrusters+Electronics 150g
- Conductive Deposition Monitor
  - Detect exhaust material

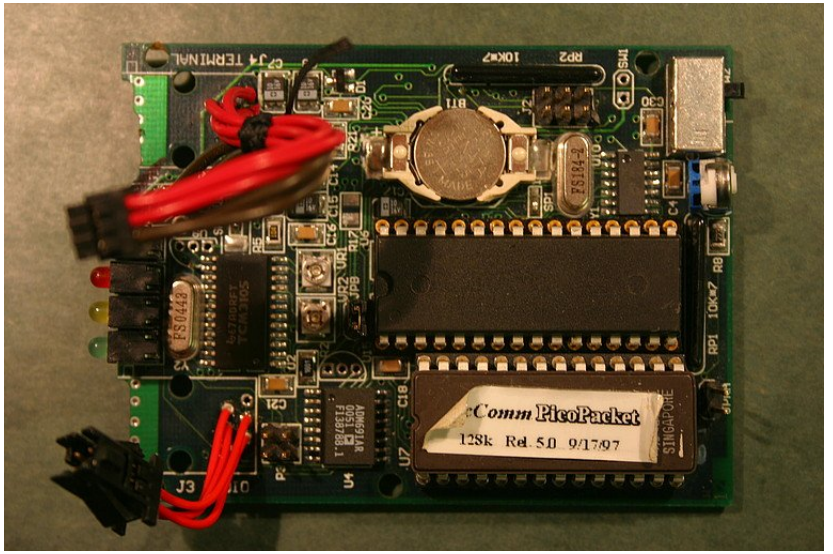


Communications

- Transceiver
  - TEKK KS960
  - 437.505 Mhz
  - Replace electrolytic capacitors!
  - Don't overheat!
- TNC
  - PicoPacket
  - 1200 baud
- Dipole Antenna
  - 1.04 SWR

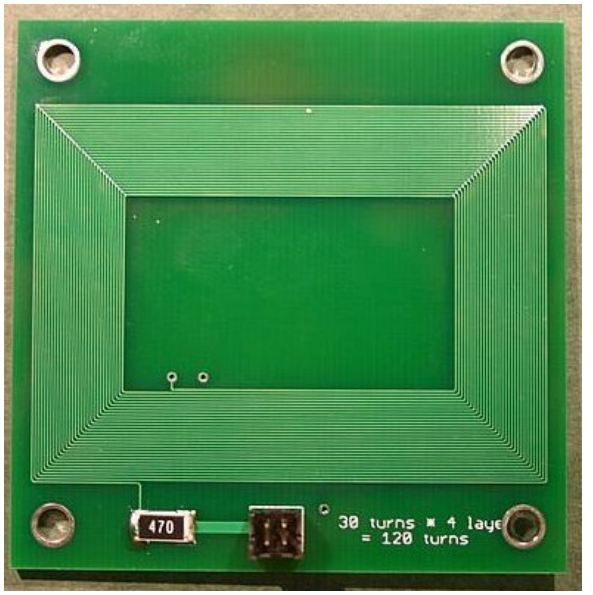


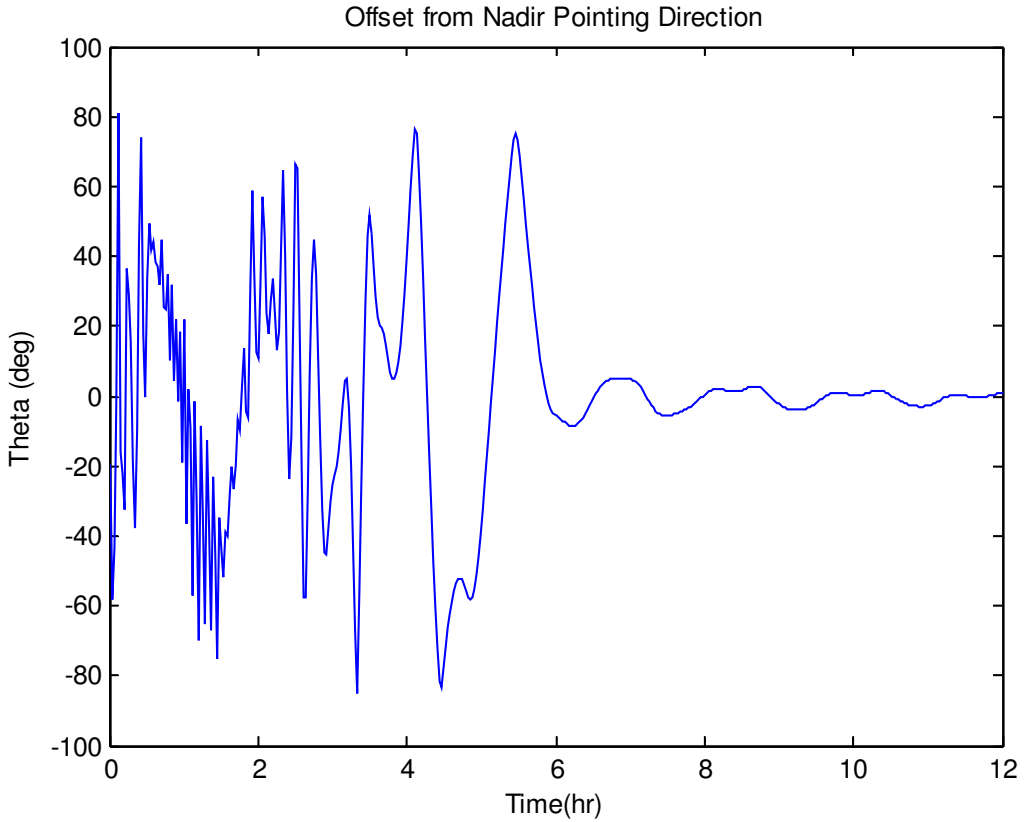


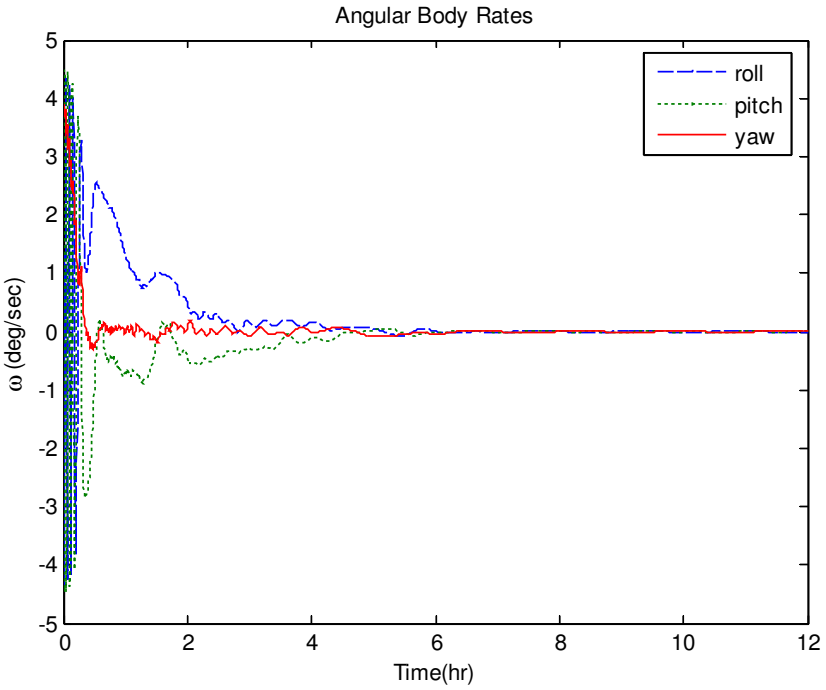


Attitude Determination & Control

- Honeywell HMC2003 Magnetometer
- Solar cells as sun sensors
- Torque Coils

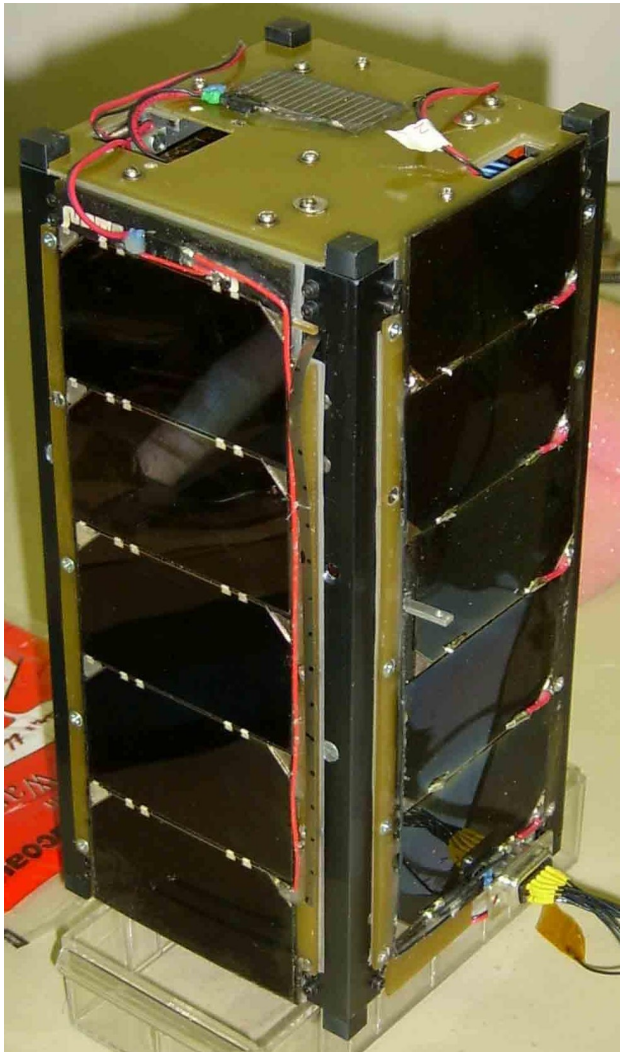






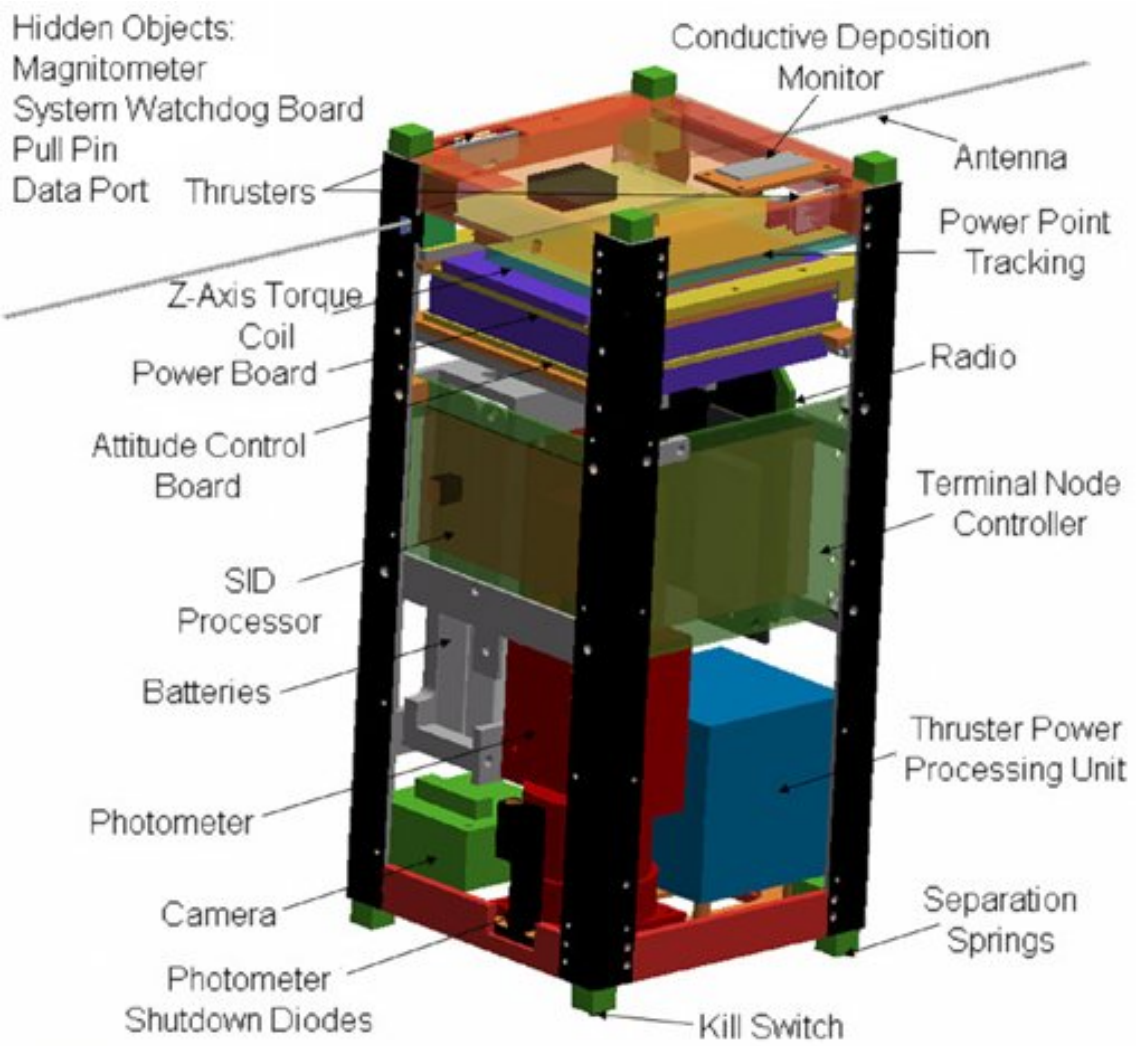
Power

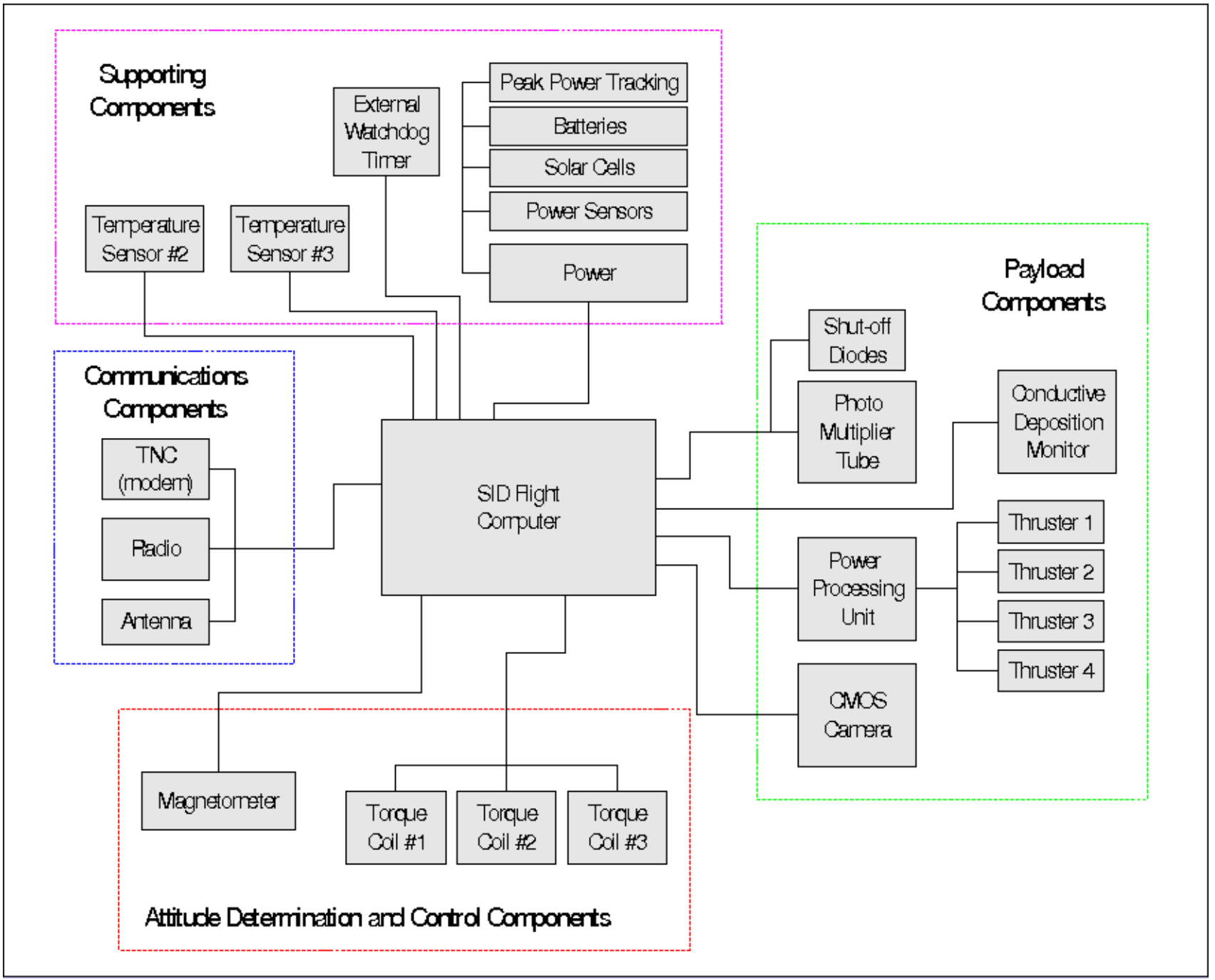
- Emcore Solar Cells
  - ~27.5% Eff.
  - 5 on each side
  - Buy the ones w/ diodes!
- Panasonic CGP345010
  - 2 x 1400 mAh
- Peak Power Tracking
- Budget
  - 5 Watts peak generation
  - Avg 3 W – 1 W ineff = 2 W
  - Avg. Consumption 1.25 W



What does it all look like?

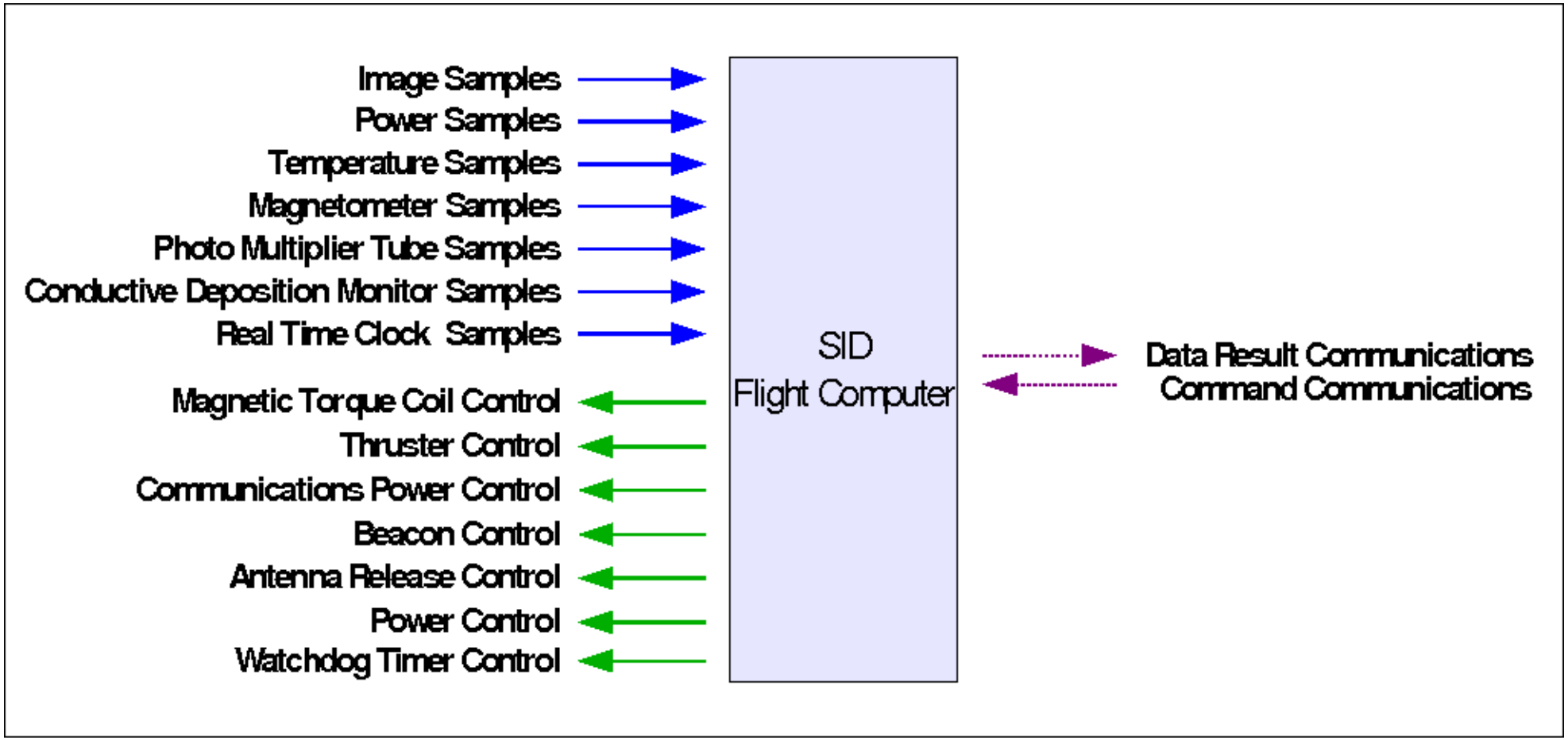
Theory vs Practice





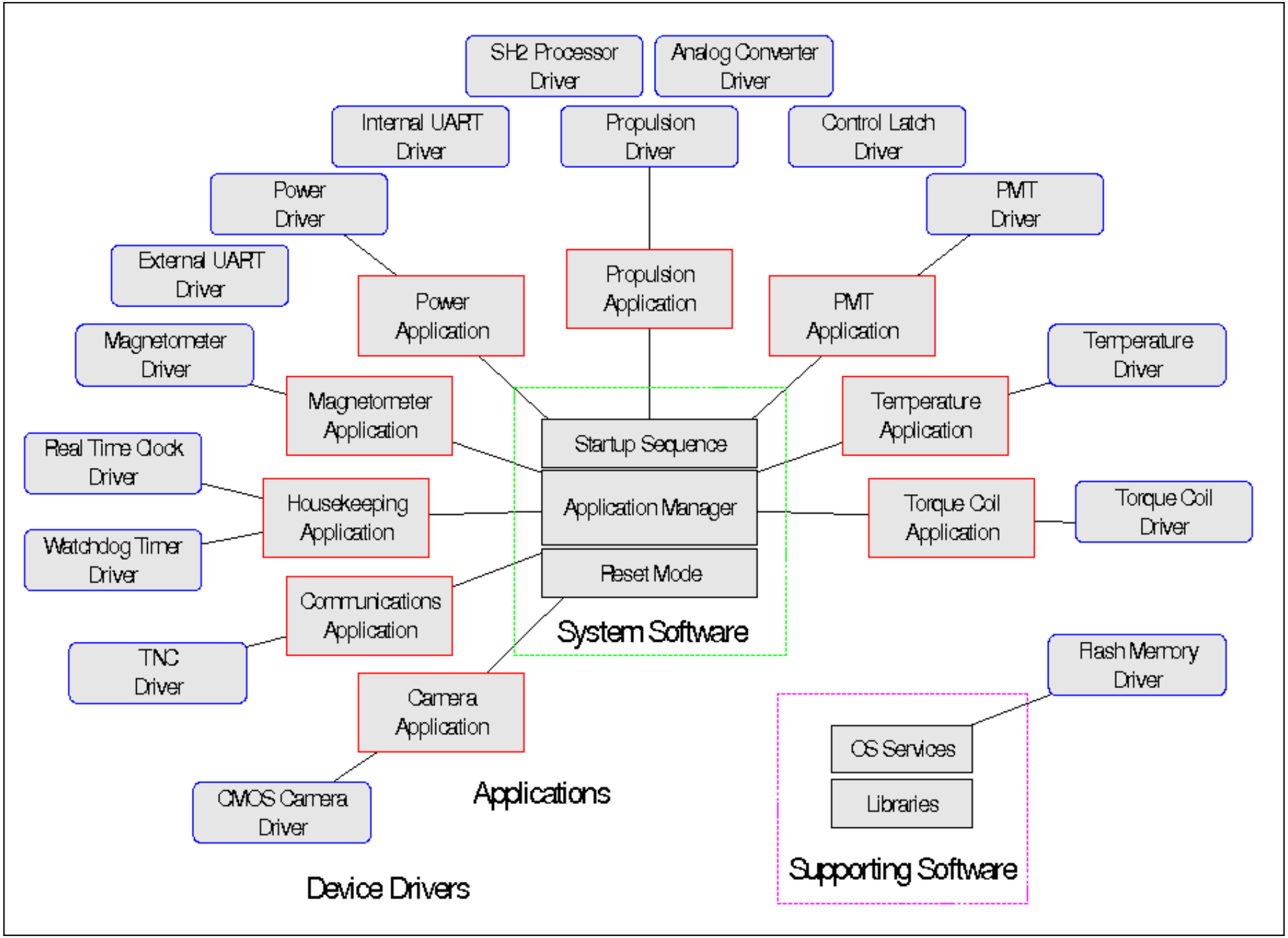
- Some observations....

ION Functional Requirements



Software Design Decisions

- 1) Abstract away details of hardware
  - *Drivers* components
  - Responsible for manipulating hardware
- 2) Simulate subsystems in software
  - *Applications* components
  - Responsible for using hardware when scheduled
- 3) Write a generic scheduling system
  - ION is just a fancy radio control toy
  - Allows use of any device as scheduled from ground
    - Allows for mission to be changed
    - Makes no assumptions on device use


SH2 Processor Driver
Analog Converter Driver
Internal UART Driver
Propulsion Driver
Control Latch Driver
Power Driver
PMT Driver
External UART Driver
Propulsion Application
Power Application
PMT Application
Magnetometer Driver
Temperature Driver
Magnetometer Application
Temperature Application
Real Time Clock Driver
Startup Sequence
Housekeeping Application
Application Manager
Torque Coil Application
Torque Coil Driver
Watchdog Timer Driver
Reset Mode
Communications Application
System Software
TNC Driver
Flash Memory Driver
Camera Application
OS Services
Libraries
CMOS Camera Driver
Applications
Supporting Software
Device Drivers

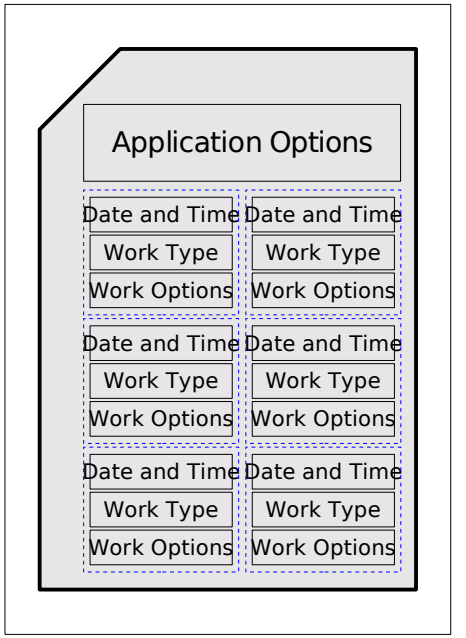
Some Technical Details...

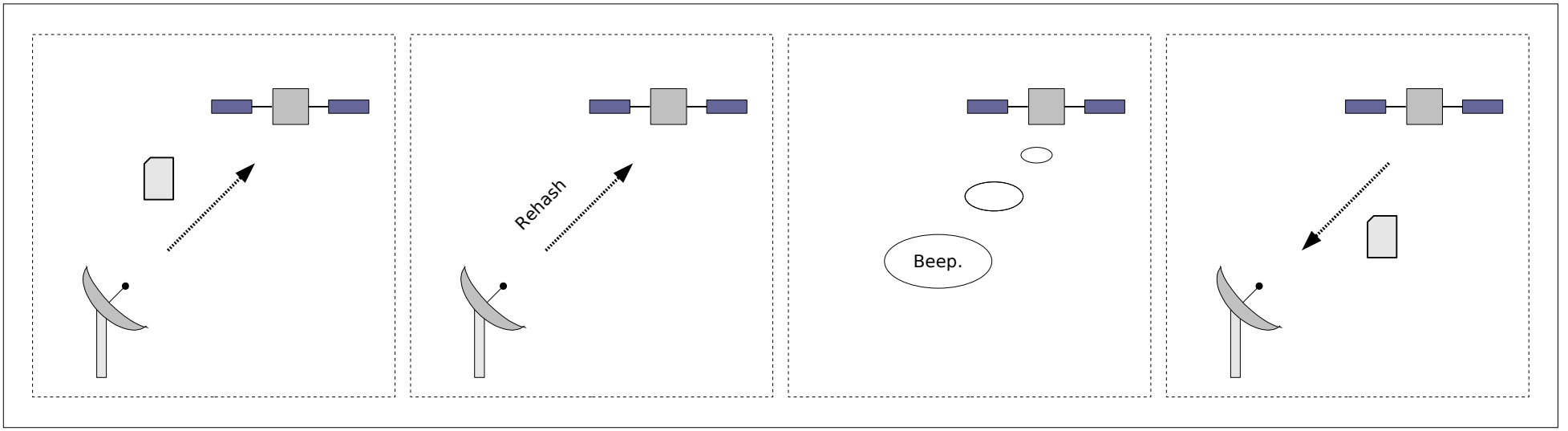
- Everything from scratch...
  - Operating System, Scheduler Cooperative Multitasking, Alarms/Callbacks, Messaging, Time Keeping, File System, Device Drivers, Boot Loader, ELF Format Binaries, Memory Management, Custom Communications Protocol, JPEG compression, error logging system
  - 18 months
  - 35,000 lines ASM/C/C++
- Don't recommend this. Follow COTS philosophy
- Do's:
  - CVS, Bug Tracking, Code reviews

ION Operations

- ION is a passive instrument

  1) Make schedules of work on the ground
  2) Upload (ftp-like) schedules
  3) “Rehash” appropriate applications
  4) Wait
  5) Download and interpret results
  6) Repeat



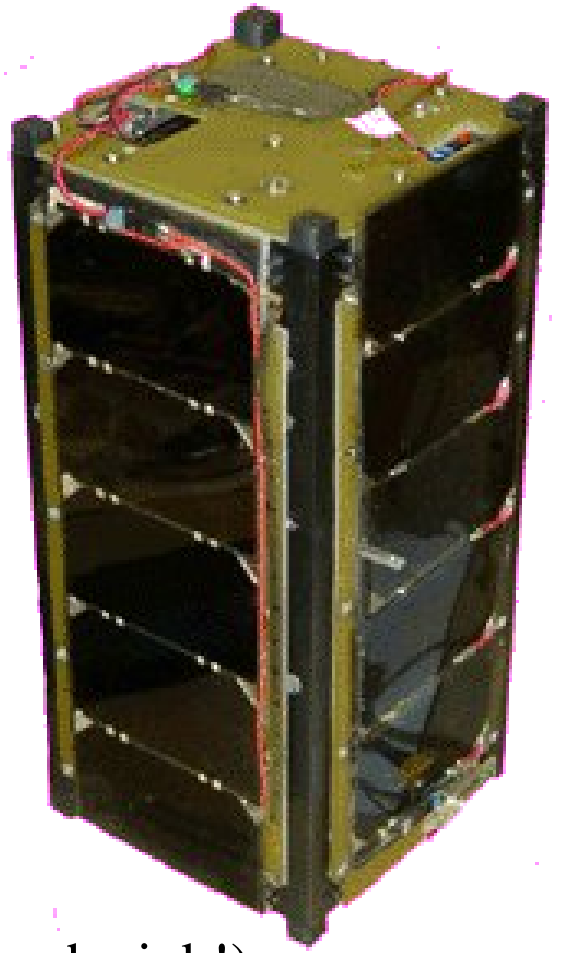


A Few Lessons Learned

- Create clear mission requirements
- Give students a full overview (Regular turnaround)
  - Document! Distinguish between historical + current
- Use intelligent/independent hardware subsystems
  - Digital communications buses. Use I2C or USB or similar.
  - Define interfaces early!
- Use COTS hardware and *software*
- Make sure CS guys know EE stuff
  - Logic analyzers, interpret datasheets, implement specs, embedded dev.
- Worry about launch later
- Design for test

Further Information

- University of Illinois at Urbana-Champaign
  - ION Cubesat: http://cubesat.ece.uiuc.edu
  - Dr. Gary Swenson (swenson1@uiuc.edu)
  - Dr. Victoria Coverstone (vcc@uiuc.edu)
  - Dr. Matt Frank (mif@uiuc.edu)
  - Purvesh Thacker (pthakker@uiuc.edu)



- University of California – San Diego
  - Mike Dabrowski (mjdabrow@interave.net) (I need a job!)
  - *The Design of a Software System for a Small Space Satellite*