Requirements and Technical Specifications

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Outline

- Requirements and drivers
- Technical issues
- Synergy with robotic space program
- Recommendations

Design Issues

- Define Requirements
  - Link technical scope to scientific value
- Identify challenges and tall poles
  - Assess resource limitations
  - Focus effort on highest payoff
- Create modular, scalable designs
  - Standardize when possible

The Calculus

- Variables:
  - Equipment Cost and Reliability
    - Instrumentation
    - Power
    - Communications
  - Logistics

- Optimization:
  - Reliability must be optimized
  - Size and weight must be conserved
  - Costly equipment that minimizes logistics is cost-effective

Requirements

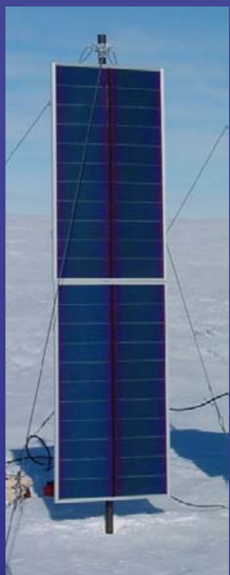
Type	Power Req.	Power Source(s)	Comms Req	Comms Sys	Instrumentation	Deployment Logistics	Issues
Simple Quasi-Cont. (itinerant) Lower prioity science	few W	Secondary batts with Solar - primary backup? possibly supercaps	Local, if any	Short haul modem/ Wifi if any	GPS, Non-volatile memory	Drop box at site, swap for data retreival	Requires visits but could be simple field logistics
Basic CGPS/Comms (maintain onsite) High priority science	5-7 W	Secondary batts with Solar - primary backup? possibly supercaps	Summer only	RF Modem or Iridium	GPS, Non-volatile memory, Comms, Environmental Sensors, others?	Basic infrstructure remains, swap subsystems	Comms system drives power system and/or site placement
Hub Station (maintain onsite) IGS station	10-?W	Secondary batts with Solar - primary backup, supercaps, possibly wind	Year-round	RF Modem or Iridium	GPS, Non-volatile memory, Comms, Environmental Sensors, others?	Basic infrstructure remains, swap subsystems	Comms system drives power system and/or site placement

Science and logistical requirements drive the station architectures

- Scientific data can be collected when convenient
- Operational data must be low-latency
- ***Network robustness is enhanced by data telemetry***

Power Systems

Solar



Wind

Other

(not feasible)

Secondary

Primary

Energy Storage
(Batteries)

Power Systems

- Sources:
  - Solar - COTS (a non-issue)
  - Primary Batteries (COTS Lithium cells)
  - Wind - feasible but avoid if necessary
    - Reduce moving parts
  - Other…(not feasible at present)
    - Fuel cells
    - Radioisotope (not allowed)
- Energy Storage
  - Batteries - the holy grail
  - Supercapacitors

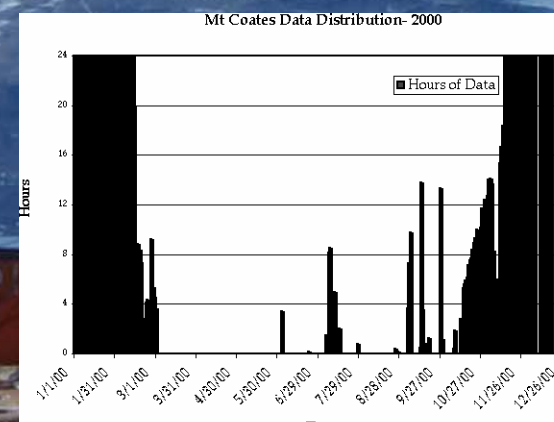
Wind Power

- Many turbines have been tested

One has survived!

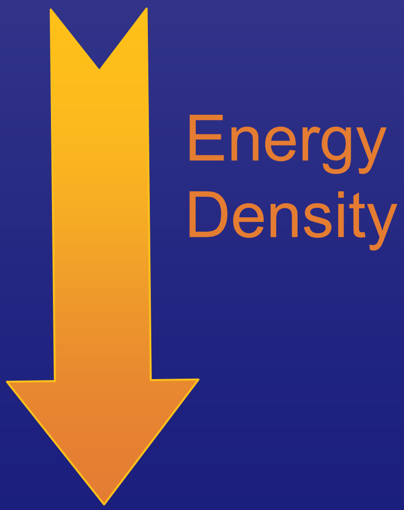
- Lessons learned:
  - Rime ice is a major hazard to moving parts on horizontal axis turbines
  - Excess power is a liability

Øy Windside
WS-015B



Energy Storage

- Energy density (kg/Amp-hr) must be maximized
  - Minimizes logistics
- Must maintain capacity over temperature
- Must have high cycle life and appropriate discharge rate
- Secondary batteries store energy
  - Gel Cells (traditional, cheap, not low-T)
  - Ni-Cd (cold-temp, $$)
  - COTS Li-ion (cold-temp, $$)
  - Colder temp electrolytes for Li-ion
  - Super capacitors (new)



QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Courtesy M. Smart, JPL

Instrumentation

- Key Attributes:
  - Low power (board-level)
  - Low-temperature operation (-20C)
  - Reliability

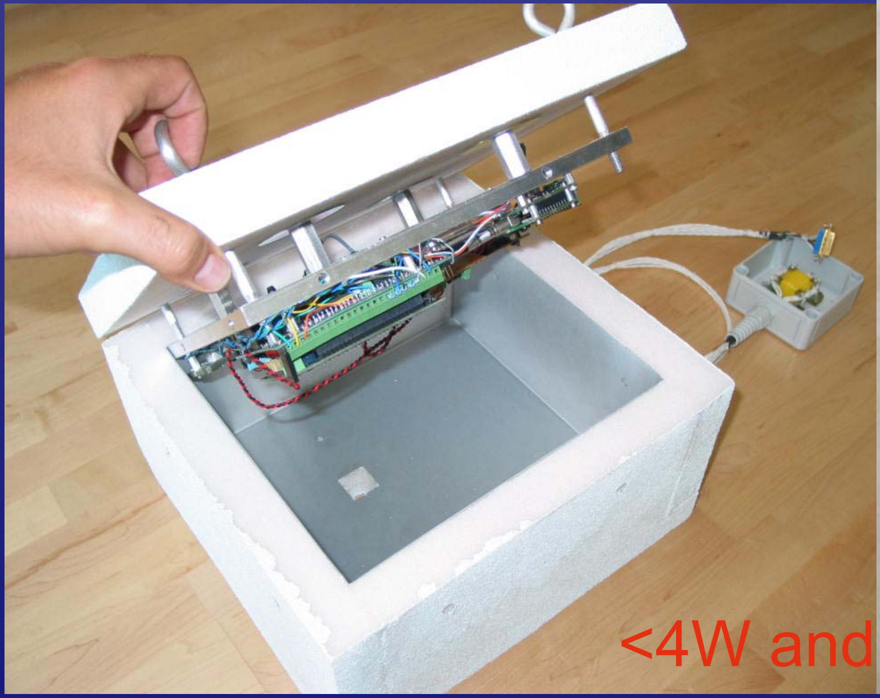
Communications

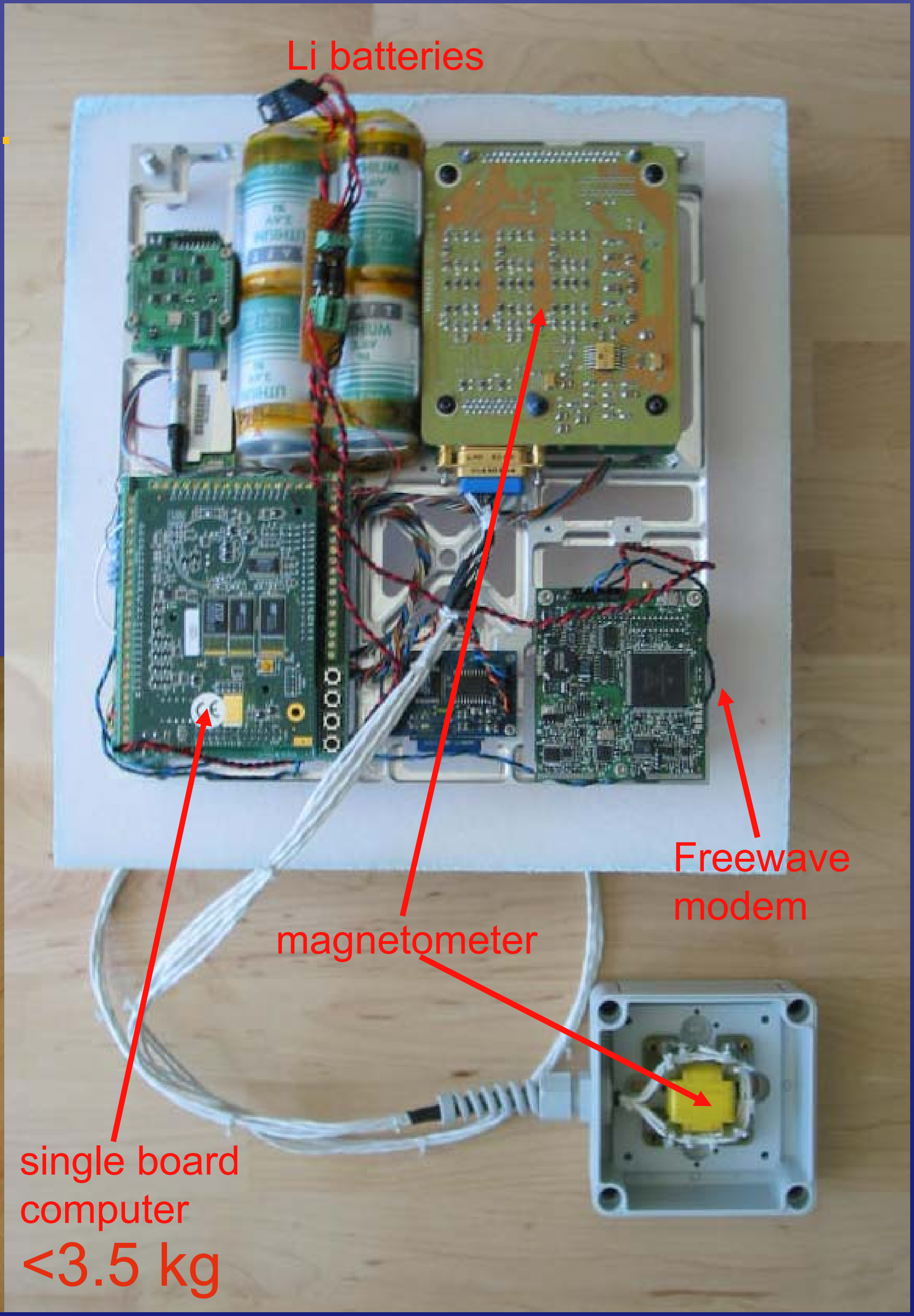
- Iridium
  - Low bandwidth (High power)
  - Excellent availability
- RF Modems
  - High bandwidth (Low power)
  - Line-of-sight limitations
- WiFi
  - Short haul to Iridium or RF
- Argos
  - Similar to Iridium

Picosat and UAV System Engineering (PAUSE)

C. Raymond, PI/A. Behar, Tech Lead.

- Stratospheric balloon tests in October 2004/April 2005
  - Components, software and architecture can be reused for GPS stations
  - Package underwent lab thermal testing (30 C to -60C)





<4W and <3.5 kg

PAUSE Demonstrates aerial Comms Architecture

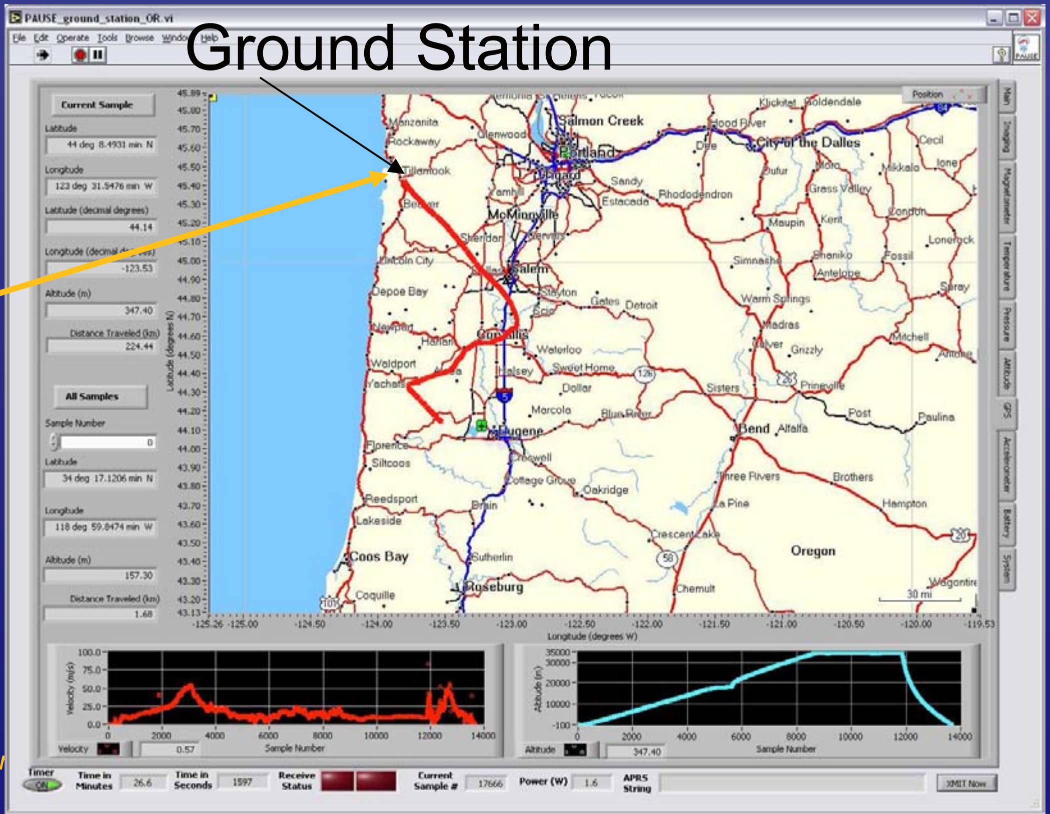
http://robotics.jpl.nasa.gov/~behar/PAUSE/PAUSE.html

Telemetry Rate: 48 kbps
Range (this flight): 180 km
Ambient Temp: -50C

Radio Modems (FreeWaves)

Vehicle

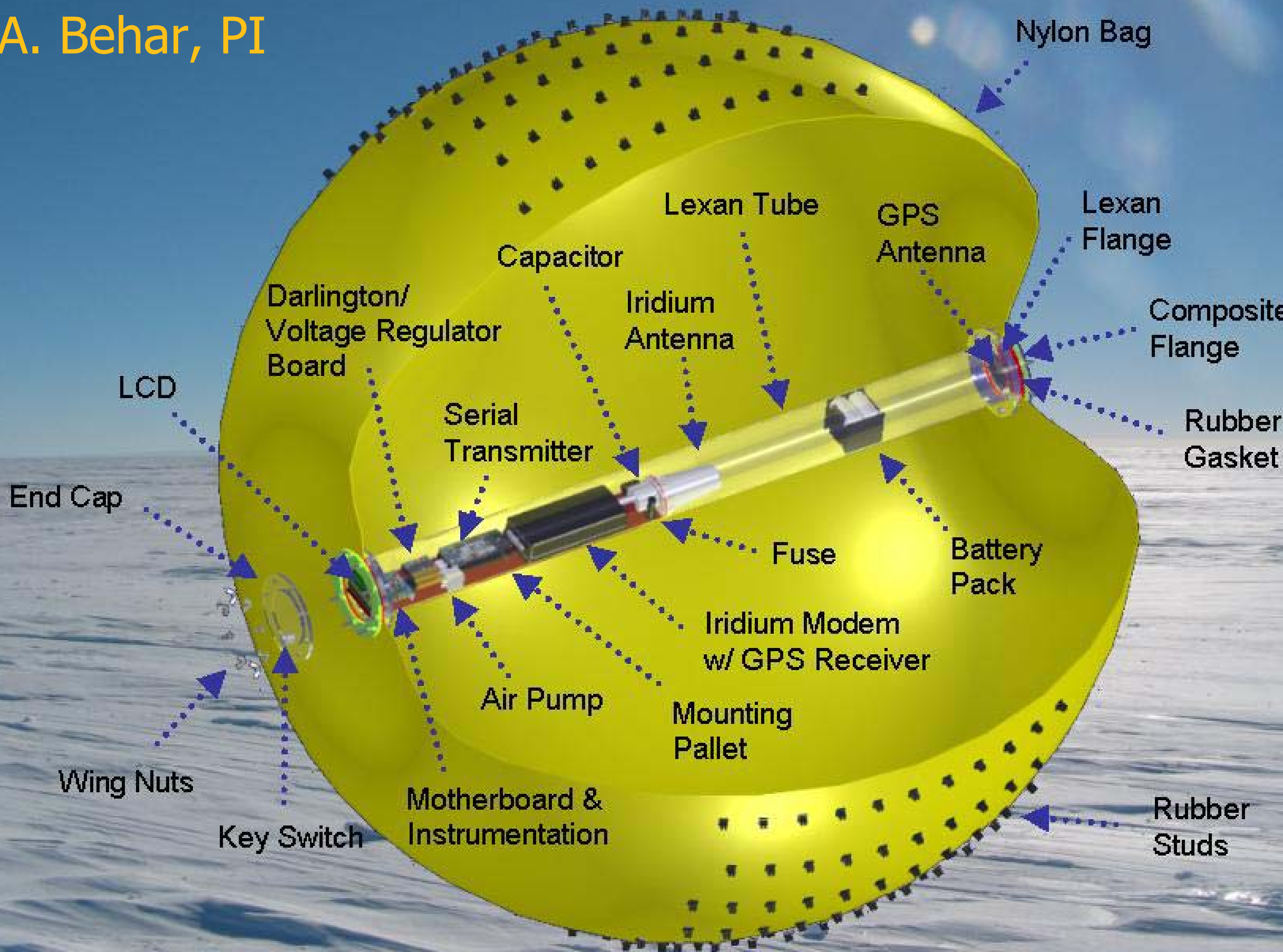
Plane



The Widest Crevasse: System Engineering

- Antarctic remote systems are more like systems for Mars than Earth
  - Lightweight and low-power
  - Limited data bandwidth
- Must be simple and low-maintenance
- Robust and Reliable!!
  - Fault protection software
  - Low-temp components
  - Rigorous screening and Quality Assurance inspections of parts and workmanship
  - Grounding schemes
  - Testing

Tumbleweed Polar Rover
A. Behar, PI



System Operation

- Thermal environment
  - Run system cold (-20C?)
  - Need a (crude) thermal model
- Software/Firmware
  - Battery health management
  - Data compression
  - Fault recovery
  - Data handling and storage

Summary/Recommendations

- Define a set of detailed requirements linking technical drivers to science results
- Devise comms strategy
  - Hybrid strategy is probably optimal
- Develop/implement high density energy storage
  - Synergy with NASA robotic exploration
  - Develop a standard Antarctic secondary battery
- Adopt a robust system engineering approach
  - Run as cold as instrumentation allows
  - Pay attention to software development