Working on Polar Power and Comms…

…to help extend the reach of geophysical scientists' tentacles deeper into the polar regions

Kent Anderson and Tim Parker, PASSCAL
Bjorn Johns and Seth White, UNAVCO

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Project Goals
3 year effort: 10/06-12/09

- NSF Major Research Infrastructure (MRI) project

  "Collaborative Research: Development of a Power and Communication System for Remote Autonomous GPS and Seismic Stations in Antarctica

- Joint GPS/seismic effort
  - PASSCAL seismic consortium, New Mexico Tech, Socorro NM
  - UNAVCO GPS consortium, Boulder Colorado
  - Broader goal: provide a polar power/comms platform for other disciplines, instruments.

- Ultimate goal is a long-lifetime, lightweight, easily deployable system
  - Year-round power at high latitudes for 2.5 - 10 watt system (modular)
  - Year-round comms for data retrieval and limited system control
  - Deployable in two flights with 212 helo or Twin Otter (including recon)
  - Unique challenges for GPS versus seismic, but much overlap
  - Designs for plateau (extreme cold, low wind) and continental margin (warmer, high wind) conditions

- Similar goals to ARRO MRI project but different in scale
  - Many more stations, each station less logistically intensive
  - Each station much lower power and smaller data rates

What we have done so far:
Field Season 06-07

- Margin GPS Prototype: Minna Bluff
  - 5.25 watt system, Iridium comms
  - Solar, wind, SLA batteries, wind-hardened design
  - Projected winter power loss: 88 days. Design can accommodate doubling of wind and solar power; estimate this can yield 56 days downtime...

- Margin GPS Testbed: Ob Hill (McMurdo)
  - 4.8 watt system, met station, ethernet radio comms
  - Solar, high speed wind turbines, SLA batteries
    - Forgen 500 wind turbine
    - Modified Ampair Dolphin (Ronald Ross)
  - Engineering data recorded (11 channels): temperatures, voltages, power supplies/power draw

What we have done so far:
Field Season 06-07

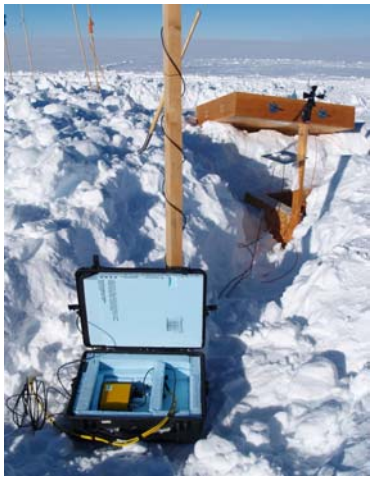
- Margin Seismic Testbed: Ob Hill (McMurdo)
  - 2-watt system. Solar, SLA batteries, lithium batteries
  - Data retrieval and control using McMurdo network and wireless ethernet modem

What we have done so far: Field Season 06-07

- Plateau Seismic Testbed: South Pole
  - Solar, rechargeable SLA batteries, non-rechargeable lithium batteries
    - Lithium packs ~50% efficient at -50 C
    - Shipping lithium batteries: tedious but doable
    - Custom power switching module
    - Heating pad for SLA batteries with separate small solar panel
  - Two independent systems installed to evaluate performance, ~ 2 watts each
    - One system running on lithium batteries only
    - One system on lithium and SLA batteries
  - Data retrieval and control using S. Pole network

What we have done so far:
Field Season 06-07

- Plateau GPS Testbed: SPRESSO
  - 3.5 watt GPS system, uses existing power and comms
  - Cold test for hardware, GPS data useful for SPRESSO site



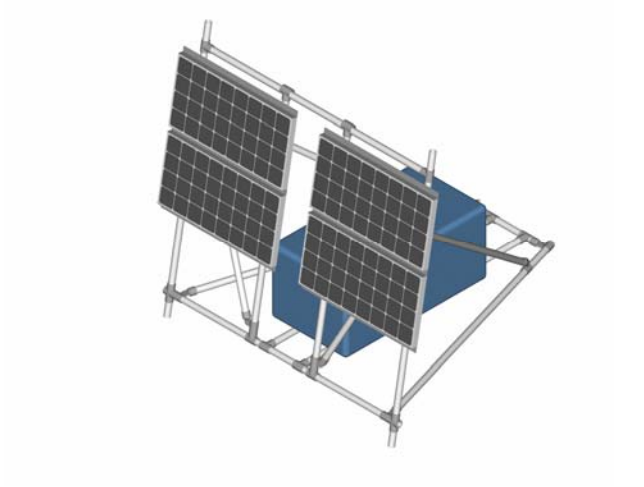
- Colorado GPS Testbed: Niwot Ridge
  - High-altitude, windy test site; used for installation trial and wind turbine testing

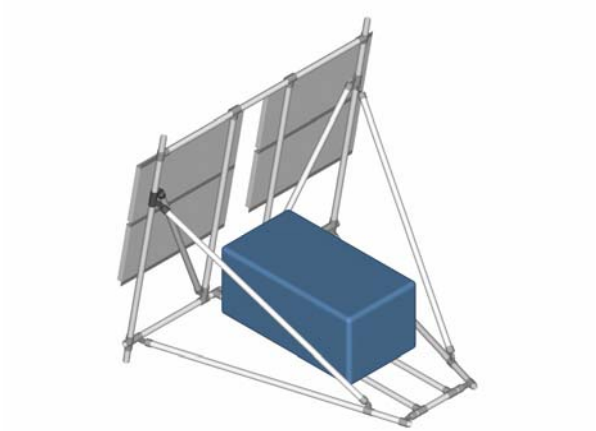
UNAVCO

What we have done so far: UNAVCO Development Activities

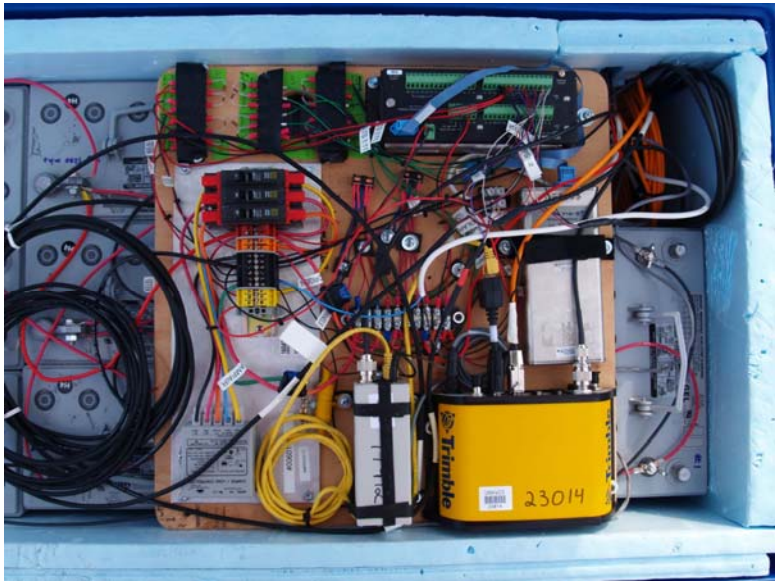
- Sealed lead-acid battery cold tests: GEL vs. AGM
  - Cold-chamber soak and then charge/discharge cycle. Room temp to -50 C.
  - GEL & AGM useless below -30 C, but recover when warm after freeze at -70 C.
- Iridium SBD development: data retrieval and state of health (Alberto Behar)
- Standardize connectors/cable for power
  - MIL-DTL-5015 circular bayonet connectors: rugged, unique pin combos
  - Polar Wire “Arctic Ultraflex” cable; cheap and flexible at -50 C
- Solar panel frame: wind-hardened design
  - Frame supports solar panels, enclosures, antennas, wind turbines
  - UNAVCO version A: aluminum pipe frame, 150+ mph wind gust
  - Will be deployed in Greenland this summer (Greenland POLENET project)
- Power budget analyses for high latitude winter performance
  - Predicts system lifetime: power input versus power draw
  - Accuracy validated by predicting performance of existing systems

Wind-hardened solar panel frame





Acquisition of engineering data for winter performance from McMurdo GPS testbed



UNAVCO

What we have done so far: PASSCAL Development Activities

- Lithium thionyl chloride battery packs (Tadiran Batteries Ltd):
  - Good: Lightweight, high power density, relatively good capacity in the cold
  - Bad: non-rechargeable, extremely expensive, shipping is tedious
  - Cold testing completed, field deployments underway
- Power switching module for multiple battery banks
- Custom Iridium controller development
  - Serial data, ethernet data, logic functions, ON/OFF functions, command/control functionality; field prototype in 2007-08 season
  - Focused on seismic needs; platform is adaptable and useful for GPS
- Cold-hardening
  - New Guralp cold-rated seismic sensor, will be fielded during 2007-08 season
  - Insulating enclosure is critical due to electronics temp specs (-40 C)
    - Very low power output from electronics means minimal heating
    - Vacuum panel insulation required

Power switching module

Lithium battery packs inside vacuum panel insulated enclosure

UNAVCO

Upcoming Development

- Project website…“under construction”
  - Summaries of advances made by MRI; current best practices
  - Component specifications and part drawings
  - Links from polarpower.org
- Wind turbine testing and development
  - High-speed wind turbine: Margin applications
    - Forgen 500 has been tested with success by BAS and UNAVCO; will be deployed in Greenland
    - Extremely low power output; mechanical design could be improved
  - Low-speed wind turbine: Plateau applications
- Heat transfer analyses and enclosure optimization
- Analyze engineering data from testbeds
  - Ob Hill: wind turbines, met data, voltages, temperatures, power budget
  - Niwot Ridge: wind turbines
  - South Pole: battery performance, enclosure insulation, cold performance

Upcoming Development

- Integration of GPS and seismic systems
- Customized solar charge controller design (?)
- Research new battery technologies
  - Battery technology is evolving in real time
  - Might be possible to use expensive lightweight batteries if the tradeoff is logistics savings in integer numbers of flights
- Stand-alone data storage units: may allow use of low-power GPS receivers?
- Continue cold and wind-hardening of components and systems
- Five “Science Kits” for 2007-08 field season, five for 2008-09.
  - These systems will represent current MRI best practices
  - Systems built by UNAVCO/PASSCAL, deployed by NSF-funded PI’s
  - Get better “statistics” on system performance and solicit community feedback

Year 2 Field Season Goals

- 3 person field team, 5 week deployment: January-February 2008
- Goal is year-round operation at all sites
  - "high-risk" technologies at testbed sites,
  - "low-risk" technologies at prototype sites.
- Margin Seismic and GPS Prototype: Minna Bluff
  - Add additional wind turbine, solar panels, additional components to GPS
  - Install co-located but independent seismic margin prototype
- McMurdo GPS Testbed: Ob Hill
  - Upgrade site with advanced components; telemeter engineering data
  - Integrate and relocate seismic and GPS stations.

Year 2 Field Season Goals

- Plateau GPS Prototype: Location TBD
  - Install GPS station with solar, wind, SLA batteries, comms
  - Cold-hardened station design; active battery heating

- South Pole Seismic and GPS Testbed
  - Install GPS station with advanced components, telemeter engineering data
  - Additional GPS/seismic equipment testing at SPRESSO site

Suggestions welcome from the group on…

- Wind turbines: high-speed and low-speed
- Solar charge controllers…does the ideal controller exist?
- Enclosure insulation / thermal management
- Advanced battery technologies
- Polar comms
  - Currently, Iridium is only real option for very high latitude
  - Inmarsat at mid-high North latitude, SRI currently uses
  - Point-to-point in vicinity of research stations
  - We looked into meteor burst comms; interesting but not feasible for us
    - Low data rates means that modem would be 24/7 to transfer 1 MB/day
    - Very high power during transmit means that only small datafiles can be sent
    - Because comms are free this system becomes very cost-effective compared to Iridium after only a few years