Working on Polar Power and Comms…

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

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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
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
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
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