Familiar problems in polar instrumentation

What we have learned

What we are trying to do about them

Seth White

UNAVCO Polar Services

Polar Technology Conference 3/25/2011

Boiler Plate

UNAVCO:

A non-profit membership-governed consortium, facilitating geoscience research and education using geodesy. Government funded (NSF, NASA). Has 7-person professional staff dedicated to supporting polar research projects.

Status in 2011:

6 years engineering work on polar instrumentation technology

Designs used in ~120 continuously-operating remote polar stations

- ~110 GPS stations, ~90 with comms and ~30 with met
- ~10 stations with other instrumentation
- ~20 PI projects

PBO group also operates 135-station Alaska network (2003-present)

Station Designs

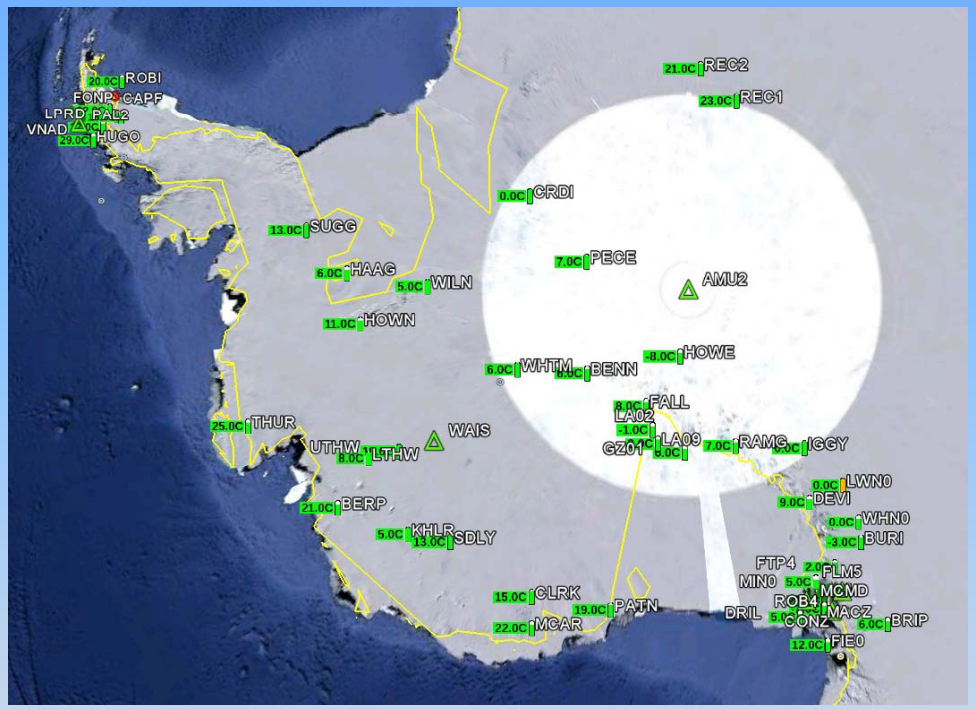
Two basic system designs: Continental Margin and Polar Plateau.
Also “hybrid” setup for West Antarctica (margin system with plateau frame)

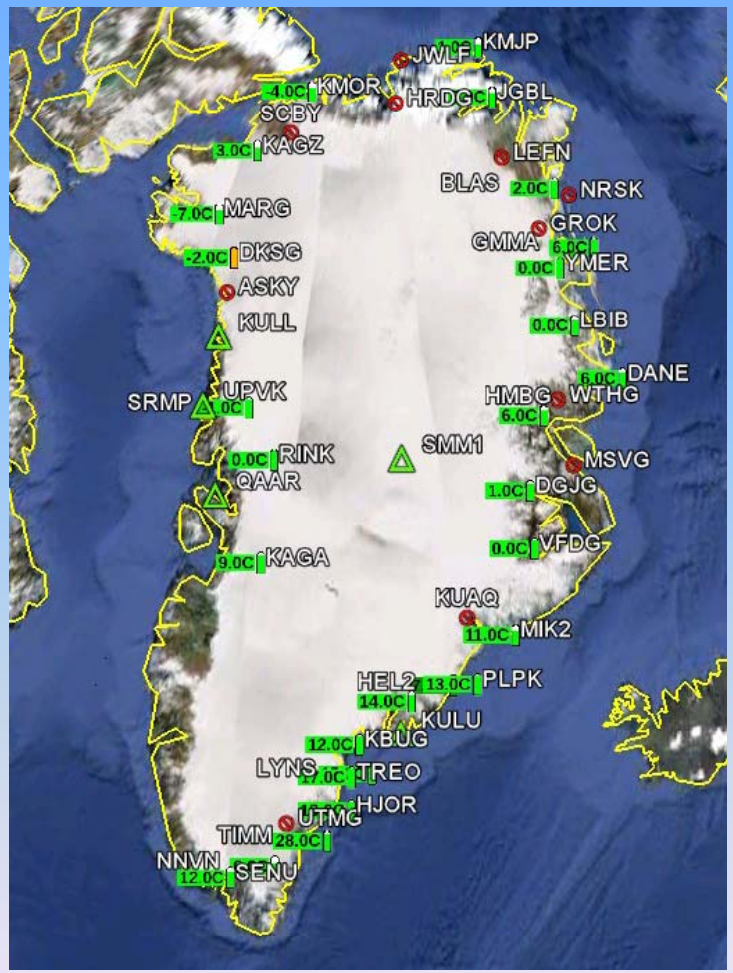
Margin system
BERP
Bear Peninsula

West Antarctic system
KHLR
Kohler Glacier

Plateau System
REC1
Recovery Lakes

Site Locations





Google earth status and SOH plots:
www.unavco.org/polartechnology

Common Problems

Logistics
- Major driver for technical advancement!
- Smaller, lighter, more robust = fewer field trips

Power
- Solar panels
- Charge regulation
- Lead-acid batteries (primary)
- Lithium batteries (backup)
- Cabling + power distribution
- **Wind power**

Static Electricity
- **System grounding / surge suppression**

Structural
- Straightforward, robusts installations
- Designs for specific environ. conditions

Reliability
- Rigorous component evaluation
- Pre-deployment cold testing

Communications
- Point-to-point networks (Freewave, Intuicom radio modems)
- **Iridium, Iridium, Iridium**

Wildlife
- **Polar bears**
- **Foxes**

Black: previous Polar Tech Conference presentations

Green: this presentation

Static Electricity

Polar regions

- Little lightning, but very high static environments. Static = hidden killer of electronics

- Difficult to achieve solid earth ground…we do not install earth grounds at polar stations

- UNAVCO: many observed instances of damage from static
    * Iridium modems: blown RF circuits and serial ports (15+ examples)
    * GPS receivers: blown power ports, serial ports, and ethernet ports (<10 examples)

- Examination of system vulnerabilities from static buildup + discharge…flaws found.
    * Integrity problems with system grounds (commons)
        - Older NAL DC-DC converters had no continuity from modem to system common => discharge path from charge on Iridium antenna was through GPS receiver!
        - Iridium timer switch broke negative lead, not positive
    * Lack of surge suppression
        - No means of dissipating charge buildup on Iridium RF circuit, GPS RF circuit, or serial lines between GPS and Iridium.
    * Plastic enclosures
        - Believe high voltages generated on plastic material, no means to dissipate to ground
        - Possible discharges from enclosure walls to electronics inside?

Static Electricity

Step 1: 2009-2010

- All component grounds tied together
- Surge protectors installed on on all serial lines (APC PS9-DTE)
- Install grounding plates on walls of plastic enclosures.
    * GPS + Iridium RF cables pass thru here
    * One ground lead to battery negative
- Use second available power port on GPS receiver for redundancy

Result

- Still experienced several communications outages during winter 2010
    But during following Antarctic field season…
- Main problem was GPS serial ports hung up. Believe static-induced. Solved by reboot.
- Also found two fried Iridium modems. Believe static-induced.
- GPS receivers still working…full data recovery.

Conclusion: problem mitigated but not eliminated…however…

…the Engineer's Victory Dance was still in order

Static Electricity

Step 2: 2010-2011

- Install formal surge protection on GPS and Iridium RF lines
    * Huber-Suhner 3402.17.K gas-discharge device, 90V threshold. No effect on GPS signals.
    * Nextek QSSTFTFAU00 quarter-wave device. No interference with Iridium transmissions.
- Install two heavier grounding leads from ground plate on enclosure wall to battery negative
- Install entire GPS electronics board inside anti-static bag (seriously); two leads to batt. negative
- New GPS receiver firmware delivered which allows periodic auto-reboot

Result

- Too soon to tell, but early returns are positive: no Antarctic sites have lost Iridium comms yet

Conclusion: will know more after winter 2011

Static Electricity

Ground plate and leads inside enclosure

Surge suppressors outside enclosure

Board inside anti-static bag

Iridium Communications

Existing UNAVCO download system

- Dial-up connectivity for ~90 sites
- Automated retrieval of GPS and state-of-health data
- On-demand connection for system control and configuration

Performance is OK but…

- Modem-to-modem operation is less optimal than RUDICS
    * Slower throughput, more call drops (two satellite hops vs. one for RUDICS)
    * Our dial-in structure results in more power consumption
    * Iridium base station needed = a hassle. Modems, SIMs, other hardware, interference, etc.
- Off-the shelf hardware reliability
    * New 9522B devices (e.g. NAL A3LA-X) more reliable than 9522A but still problematic
    * Brand-new devices occasionally non-functional or do not meet -30C temp spec (!)
    * For the POLENET project, have resorted to using two independent modems at each site (!!)
    * Recent purchase: all 12 new A3LA-X modems will not register DOD SIM cards (!!!)

Iridium Communications

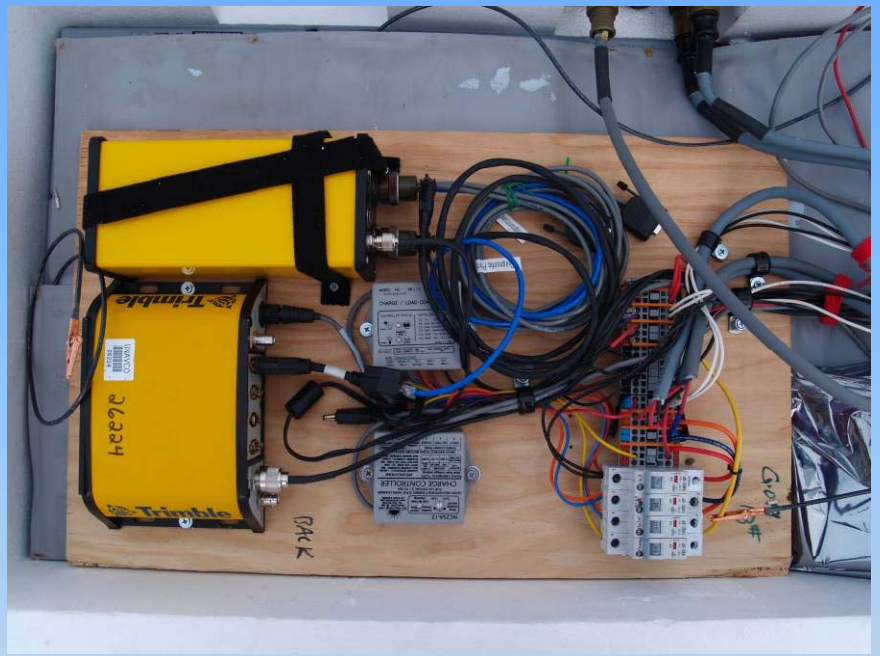
Moving Forward: Advanced modem from Xeos Technologies

- Initial development project completed
- Can connect to generic Ethernet devices at remote site using Iridium SBD + RUDICS
- Active internal heating, switched relay output, ethernet + serial communications
- Allows remote upload of modem firmware
- Xeos software: IP tunnel manager application

Testing Status

- Field testing at McMurdo Station
    * Begun January 2011, continuing through winter 2011
    * So far so good – reliable connections, improved throughput
- Greenland Ice Sheet Monitoring Network (GLISN)
    * Xeos modems to be fielded with GPS at PASSCAL seismic stations, spring 2011
    * One modem for seismic, one for GPS
        - **Sensor independence:** identical firmware on both modems
        - Device-specific SBD commands are used for individual instruments

Iridium Communications



Xeos XI-100 modem with GPS system electronics, McMurdo Station

Iridium Communications

Xeos Technologies Inc.

Mon 21 Mar 11 :: 9:20:55 pm

Status | View Logs | Shutdown

Name	Status	Last Connected	Rx/Tx	V/T/RSSI	
DEVO	Active / Disconnected	21-03-2011 09:00:55 PM	3 KB / 96 KB	14.02 V / 12 C / 5	Details Restart
4923K35618	Active / Connected	21-03-2011 09:16:41 PM	55 KB / 89 KB	14.16 V / 30 C / 5	Details Restart

Add New Site | Restart All

Status | View Logs | Shutdown

Name	Iridium Address	Status	Last Connected	
4923K35618	*:5758	Active Connected	21-03-2011 09:16:41 PM	Edit Delete Reset Stats

Log Path: /iridium/sites/4923K35618/logs/test
Connection Script:

Status of Health

Firmware Version: 3.2.324 **Battery Voltage:** 14.16 V **Last Temperature:** 30 C **RSSI:** 5

Configuration

Mode: Single RUDICS Session **Set:** SBD Mode | Single RUDICS Session | Full Time RUDICS

SBD Check Interval: 5 minutes [5] Set SBD Check Interval

Auto RUDICS Inverval: Disabled [0] Set Auto RUDICS Interval

Configuration Last Updated: 21-03-2011 09:19:11 PM

Tunnels

Name	Local <-> Remote	Protocol	Status	Rx/Tx
4923K35618	69.44.86.75:2005 <--> 192.168.0.4:80	TCP	Connected (1)	Rx: 54365 Tx: 70159

Add New Site

UNAVCO

Iridium Communications

What's Next?

- Additional functionality is feasible; needs focused development on specific enhancements.

- Robust ethernet switching on remote end?
    * Would enable communication to multiple Ethernet devices through one modem
    * Roughly a 1x advance in existing functionality

- Multiplexed modems at remote end?
    * Higher throughput, redundancy in communications hardware
    * More like a 2x advance

- Ability to use modem as field internet connectivity solution?
    * UNAVCO and others use Iridium handsets and modems for dial-up field email + internet
    * Using RUDICS represents major step forward in field comms performance
    * ~3x advance

Wildlife

Polar Bears

- One North Greenland site confirmed destroyed by polar bear
    * Two separate attacks resulted in 31 of 44 lost months of data
    * Some structural damage, but GPS+Iridium+power cable damage was what killed the system
    * ¾ of battery bank drained to 7 volts due to broken cables
- 2010 site visit: rebuilt with hardened components
    * GPS, Iridium, and power cables armored with metal flex conduit
    * Power/comms cables tied to frame w/metal hose clamps, GPS cable anchored to rock w/bolts
    * Solar panels and battery connections with “hidden” cable exit points
- Results
    * Station survived winter and is powering back up (not known if bear revisited)
    * Plan to install three more “bear” kits at other vulnerable sites, summer 2011

Foxes

- Bite marks on cables at several sites. Believe death of one site due to bites in GPS cable.
- Use bite-proof conduit for all exposed cables

Wildlife

GPS antenna with armored cable and exit point

Solar panel with armored cable and “hidden” exit point

Panels and enclosures with “hidden” cable exit points

Wind Turbines

High-Speed Turbines (Low Power)

- Small, vertical axis turbine: ideal for low-power remote stations at extreme wind sites
    * Survivability trumps efficiency! Vertical axis = compact, one moving part
    * Very few commercial products available at present…
- Forgen 500
    * Lightweight, easy to install, low power, moderately expensive. From UK.
    * Can get good LT bearings + cable + black finish
    * Used at dozens of polar sites. Many success stories, many failures (mainly structural)
    * Now available with side-mount “U” bracket and top bearing – will increase survivability
- Leading Edge LE-v50 turbine
    * New offering from UK, similar cost to Forgen 500, has side-mount bracket
    * Slightly larger, claimed power output is much higher, needs external rectifier
    * Plan to acquire test units spring 2011
- WindKinetic
    * New offering from Italy, prototype phase (demo unit available at PTC), cost unknown
    * Plan to acquire test unit spring 2011

Wind Turbines

Forgen 500, shown without optional side-mount bracket

Leading Edge LE-v50, shown with side-mount bracket

Wind Turbines

High-Speed Turbines (Medium Power)

- Demand exists for “medium power” remote instrument stations, 10-20W (GPS = ~5W)

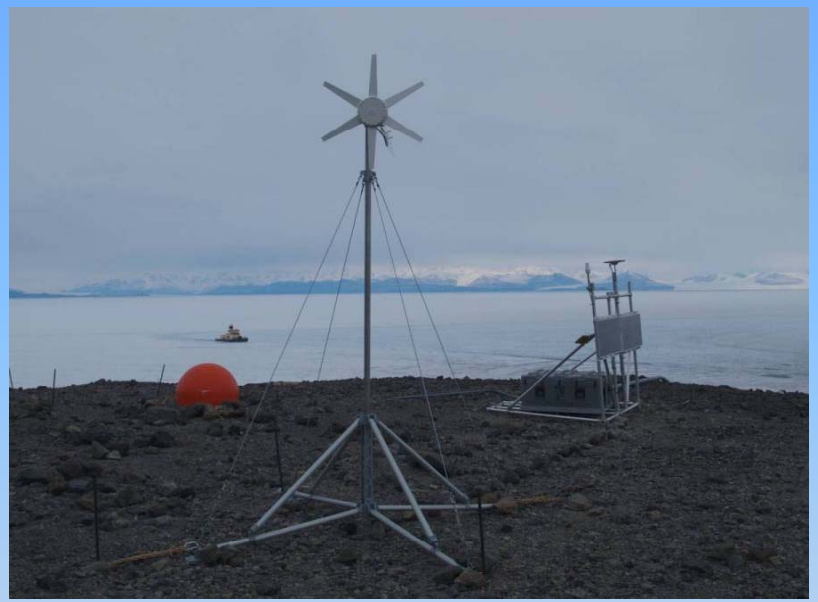
- Wind power would greatly reduce need for transport of large battery banks

- UNAVCO is testing Rutland 910-3 at McMurdo station, winter 2011
    * Furling design turns turbine out of wind at ~35 knots
    * Survivability demonstrated in US ARRO project (testing on Ross Ice Shelf) and New Zealand Darwin Glacier project (blue ice, strong katabatic winds)

- Regulation is key
    * Using Flexcharge NC25A regulator w/STEP Warmfloor heating pad network as divert load
    * Goal is to maintain relatively constant load on turbine during charging and diverting

- Also testing Aerogen 4 turbine at UNAVCO alpine test site
    * UNAVCO has proven this turbine for polar plateau environment (deep cold, light wind)
    * Currently testing to evaluate high-speed limits of turbine (non-furling design)

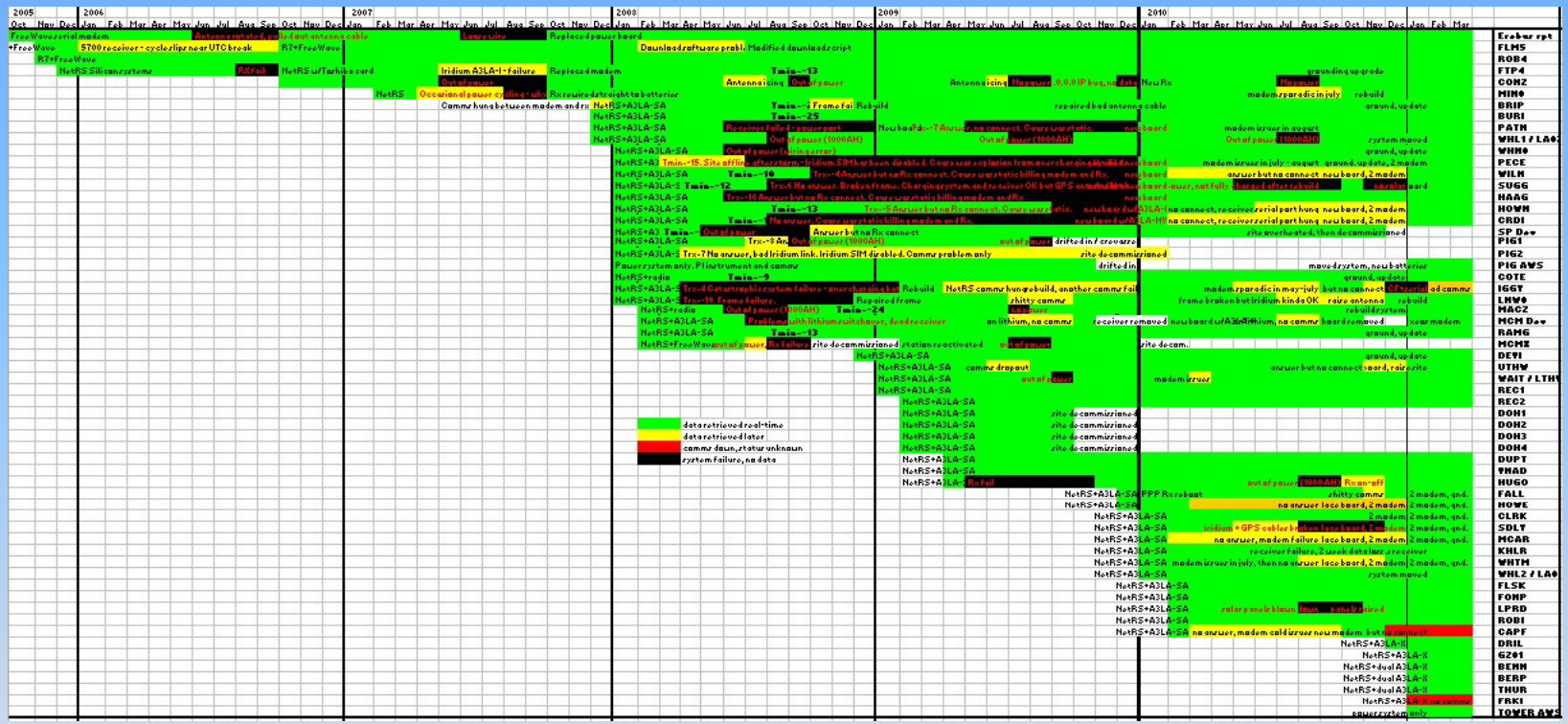
Wind Turbines



Rutland 910-3 at McMurdo Station
(mast borrowed from U. Canterbury)

Aerogen 4 at South Pole

Overall Performance: Antarctica 2005-2011

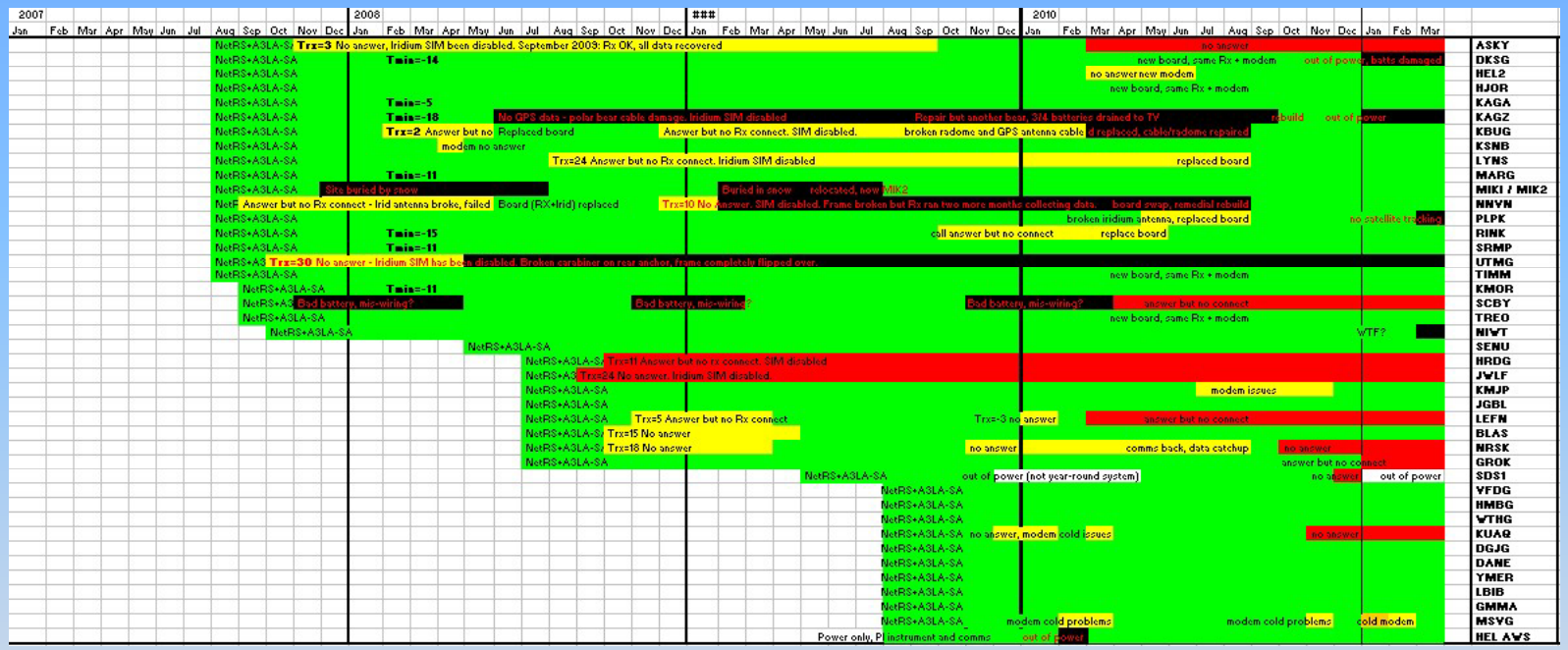


Green = data retrieved remotely **Yellow** = data retrieved on-site

Red = status unknown (no comms) **Black** = data lost

Overall: 87% data retrieved (78% remotely). 1% more may still be retrieved (88% o'all).

Overall Performance: Greenland 2007-2011



Green = data retrieved remotely **Yellow** = data retrieved on-site

Red = status unknown (no comms) **Black** = data lost

Overall: 83% data retrieved (73% remotely). 9% more may still be retrieved (92% o'all).

Contact

UNAVCO support (primary):	support at unavco dot org
Seth White (secondary):	white at unavco dot org
Hardware, drawings, tests, SOH:	www.unavco.org/polartechnology