Advances in Remote Seismic Station Technology

Polar Technology Conference 2016

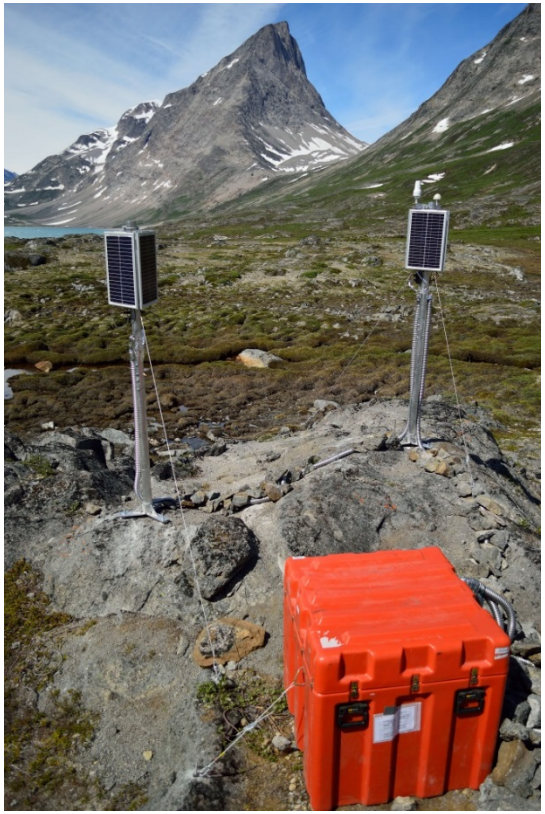
IRIS PASSCAL POLAR PROGRAM

NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY

NSF

Overview

- **PASSCAL Program**
  - Polar Program
- **Telemetry Updates**
  - Iridium Pilot Testing
  - RUTUS Tunnel Software
  - XI-202 Multi Firmware
- **Power Updates**
  - Aircells and DC-DC convertor
  - WT10 Wind Generator
- **Portability Updates**
  - RIS/DRIS Deployments
  - GEOICE MRI Project



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PASSCAL

Program for Array Seismic Studies of the Continental Lithosphere

- Facility provides instrumentation to NSF, DOE or otherwise funded seismological experiments around the world
- Services include, but are not limited to:
  - Seismic instrumentation
  - Equipment maintenance
  - Software
  - Data archiving
  - Training
  - Logistics and shipping
  - Engineering support
  - Field Support

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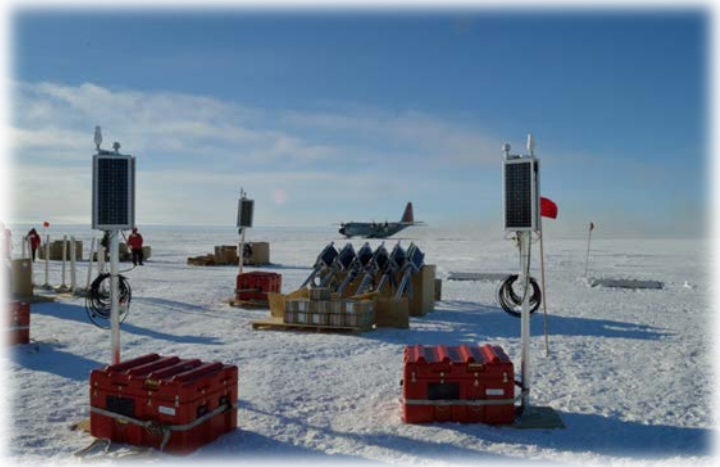
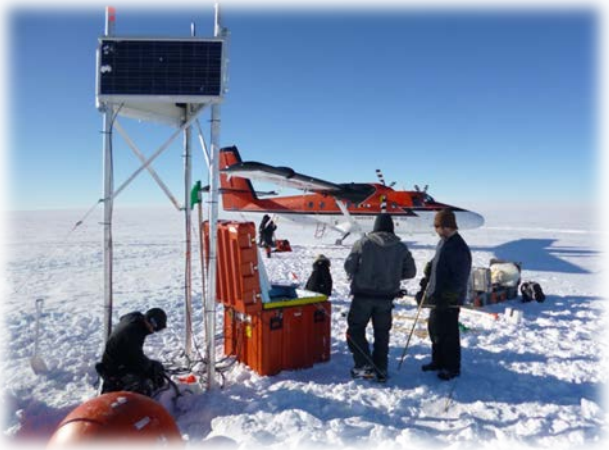
- Heavy focus on engineering and development due to harsh nature of polar environments
- Team spends ~14 months in the field each year, actual man hours spent is much higher





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Dedicated cold Testing Room:

- Warehouse climate control insufficient for summer freezer operation
- Enclosed room within warehouse with refrigerated air and heat exhaust vents

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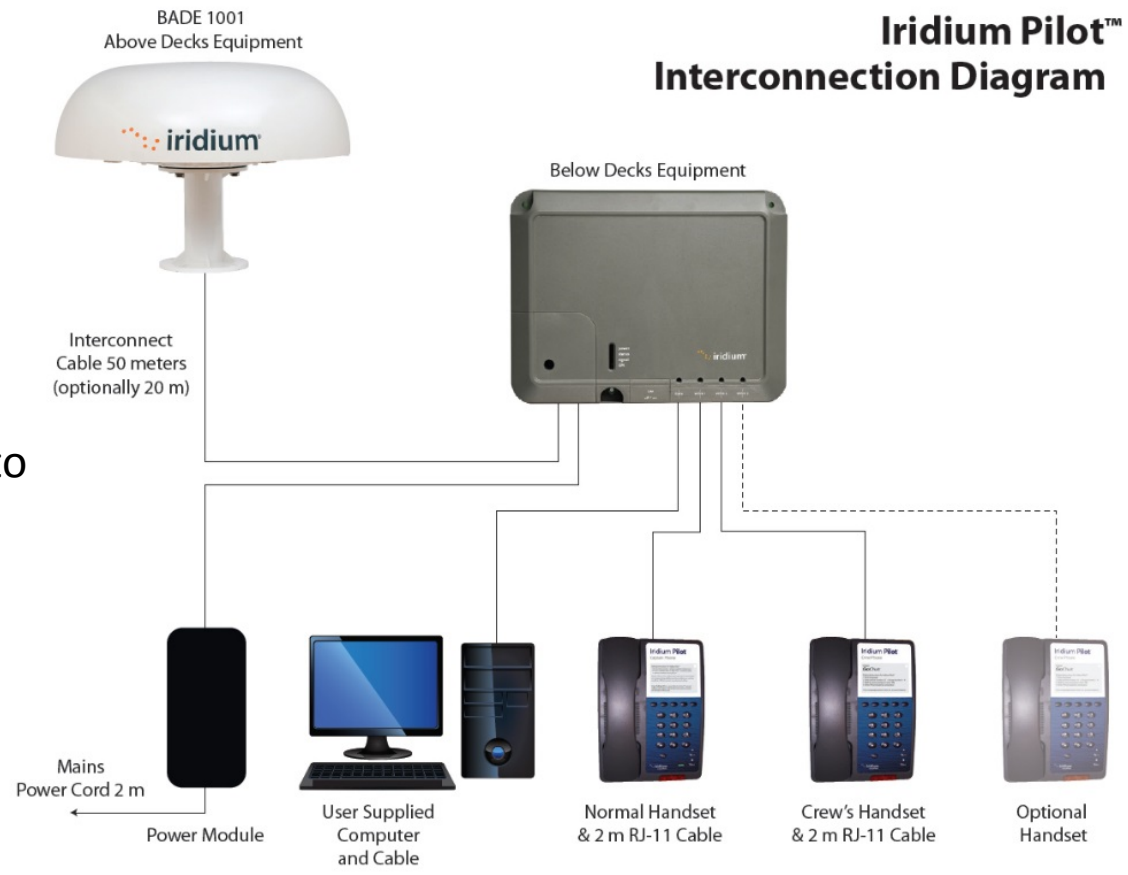
Iriduim Pilot

Funding was obtained from the **Greenland Ice Sheet Monitoring Network** (GLISN) for the testing of an **Iridium Pilot** system in interest of expanding “real-time” telemetry capability utilizing Iridium **OpenPort** service.

- Designed as an expanded Iridium communication device for Marine applications
- Up to 15KB/sec transmission (3rd party tested), compared with ~250 Bytes/sec running to RUDICS on current hardware (XI-100)



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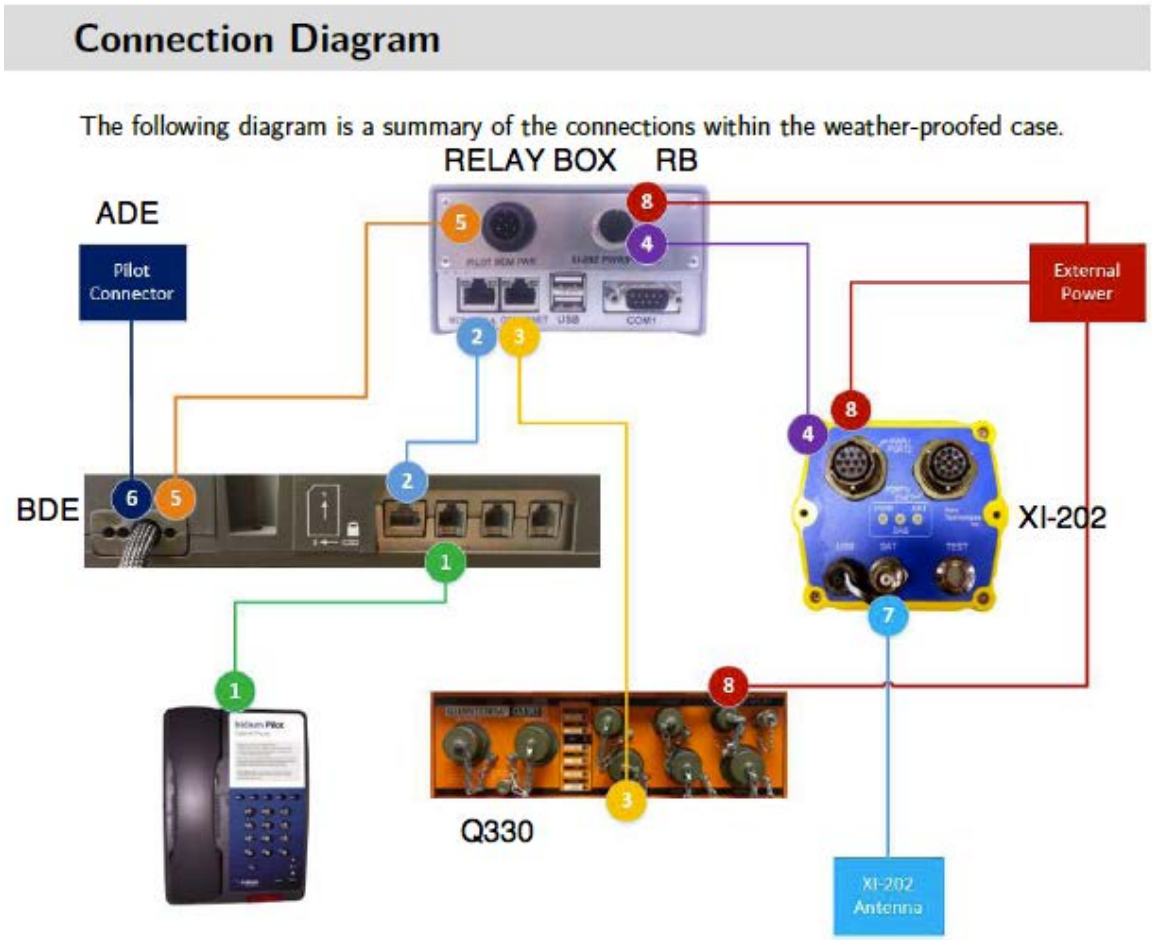
Iriduim Pilot



Xeos Integration

- XI-202 acts as controller for relay box, powering system at set time intervals
- Relay box controls power to Iridium “Below Deck Unit” (BDU)

Iriduim Pilot

Initial Testing

Initial testing of an Iridium Pilot unit has been conducted at the PIC over a period of 5 days. A Q330 system was run with a broadband seismometer attached, sampling at 40Hz and 1 Hz on 3 channels, in addition to 12 SOH channels sampling at .1 Hz. The Pilot timers were set for 4 25 minute sessions per day. Power and data throughput data was collected over the 5 day period.

Initial Results:

- Power:
  - 1.8W average over 24hr period
  - 25.4W Average recorded power when Pilot is on
- Data Rates:
  - 11.7 MB/day moved (Tx-Rx, from Pilot web interface)
  - 2.3 KB/sec average throughput*

*Published rates, confirmed by testing should be closer to 15KB/s. System needs optimization

Iriduim Pilot

Cost/Feasibilty: Estimated annual costs based on average Antarctic data production of 7.8Mbyte/mo. at 40 and 1Hz 3ch seismic data + SOH (~237Mbyte/mo).

- **Unit Cost:** $5000 (does this include Xeos hardware)
- **Cost/year 1 unit:** $8550 (based on published rates)
- Nominal additional cost of XI-202 commercial plan (~$200/yr)
- Pooling options available

PILOT Plan	Monthly Data Plans						
	0 MB	10 MB	25 MB	75 MB	200 MB	1000 MB	5000 MB
Double your Data Promo	N/A	N/A	N/A	Yes (150MB)	Yes (400 MB)	N/A	N/A
Monthly Rate Charge (USD)	$0.00	$120.00	$213.00	$421.50	$712.50	$1,387.50	$2,850.00
Overage Rate (per MB)	$15.00	$12.38	$8.93	$6.00	$3.90	$0.68	$0.53
2 year term commitment discount (USD)				$843.00	$1,425.00		
3 year term commitment discount (USD)				$2,107.50	$3,562.50		
Early Termination Fee (USD) 2 year				*$1,264.50*	*$2,137.50*		
Early Termination Fee (USD) 3 year				*$2,529.00*	*$4,275.00*		
One time User Credit (New Subscriber)				$2,000.00	$2,000.00		
Activation Fee (USD)		$50.00	$50.00	$50.00	$50.00	$50.00	$50.00
Minimum Term (years) to avoid fees				2 or 3	2 or 3		

Double your Data Promoation Details:
Details for new and eisting subscribers which activate on select Iridium OpenPort plans include:
- Receive double the monthly data allowance for 75MB and 200MB service packages;
- Standard overage eates apply for each service package;
- Requires 128Kbs data speed selection;
- No minimum term commitment required (month-to-month service);
- 18 month pricing confidence guarantee from date of plan activation;
- No activation fee; and
- No eligibility with any other promotion.

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Iriduim Pilot

Initial Results: Results of initial testing show that the Pilot could be an effective and affordable means of moving "real time" seismic data in some instances. Further testing and optimization is warranted.

Issues/Optimization:

- Antenna unit shuts off at -40C. This may be a firmware setting. More time is needed to source the cause.*
- The Q330 digitizer-server is the primary throughput restriction , being designed for minimum latency NOT maximum throughput.
    - This could be resolved by moving files off the data archiving unit , or pulling direct from Baler 44. Initial tests done by Xeos show peak throughputs of up to 15Kbyte/sec, which corresponds to the vendors claim for max throughput.
    - Make system "smarter", ie have Q330 control Pilot I/O, have relay power on Baler44 rather than powering continuously

Continued Testing

- Test unit will be installed at GLISN network site near DY2 site on the South Greenland Ice sheet this summer and run over winter
- Continued tuning of Q330 telemetry and Antelope server settings
- Environmental chamber cold testing

*Note: Antenna unit is temp rated for -30 to +70C
Receiver module temp rated for 0 to 50C

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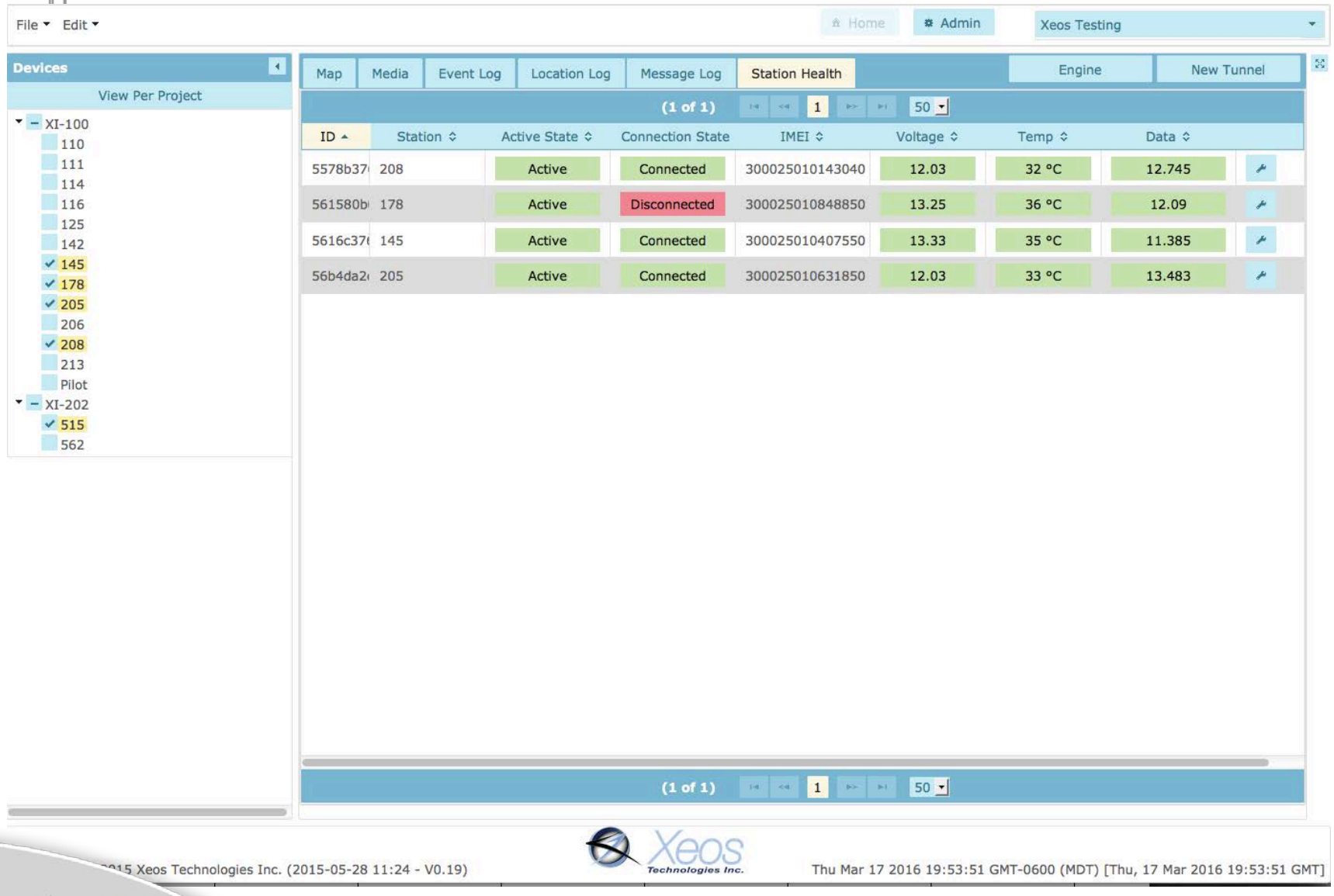
RUdics **TU**nnel **S**oftware (RUTUS)

Web interface developed by Xeos Technologies Inc. to improve and ease the configuration, control and data throughput of Xeos modems. The old tunnel was developed as a prototype. It is slow to use, buggy, and offers limited diagnostics.

Timeline:

May 2014	proposals
August 2014	we had some funding.
January 2015	RUTUS continuous testing begins at PIC with 2-7 modems.
June 2015	Tunnel core stabilizes
October 2015	Most GUI problems worked out
October to present	Continuous Testing continues with 3-4 modems

RUdics TUnnel Software (RUTUS)



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RUdics TUnnel Software (RUTUS)

Improvements over old tunnel:

- Eliminated socket hang issue
- Automatic modem configuration server for both xi100 and xi202 (continuously checks modem config states and adjusts if state does not agree with that setup in RUTUS). Note xi202 capability still under development.
- Tunnel configuration templates reduce configuration setup time and errors
- Allows IP based SBD reception of Mobile Originated (MO) messages (eliminates CPU hogging scanning of very large email accounts). Still allows email based SBD deliveries.
- Built in warnings to prevent duplicate port-usage configurations.

RUdics TUnnel Software (RUTUS)

Further Testing:

- Deploying new firmware on GLISN network this summer
- Continued in-house bench testing at PIC

Future developments:

- Integration of database into RUTUS
- Graphical interfaces to display RUDICS data flow, and SBD messaging frequency and types.
- Smart RUTUS-side management of rudics on off states of the modem to minimize power consumption.
- Capability to configure groups of modems via a single submit.
- Template based en-masse tunnel configurations

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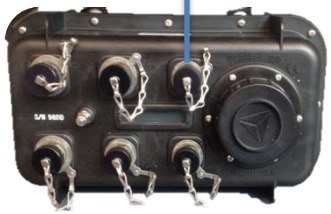
XI 202 Multi Firmware

XI-202 Multi Firmware

We are currently working with Xeos Technologies to develop firmware for the XI-202 (SBD only) capable of communicating with all data loggers currently used at the PIC for broadband seismology, expanding our capability to include Reftek and Nanometrics data loggers in addition to the Quanterra Q330, which was previously the only supported unit. The beta version is currently in testing and the software group is working on writing the parsers needed to translate the messages so they can be displayed on our webpage.

Quanterra Q330

Xeos Technologies XI-202



RefTek RT-130

Nanometrics Meridian/Centaur

Air Alkaline Batteries

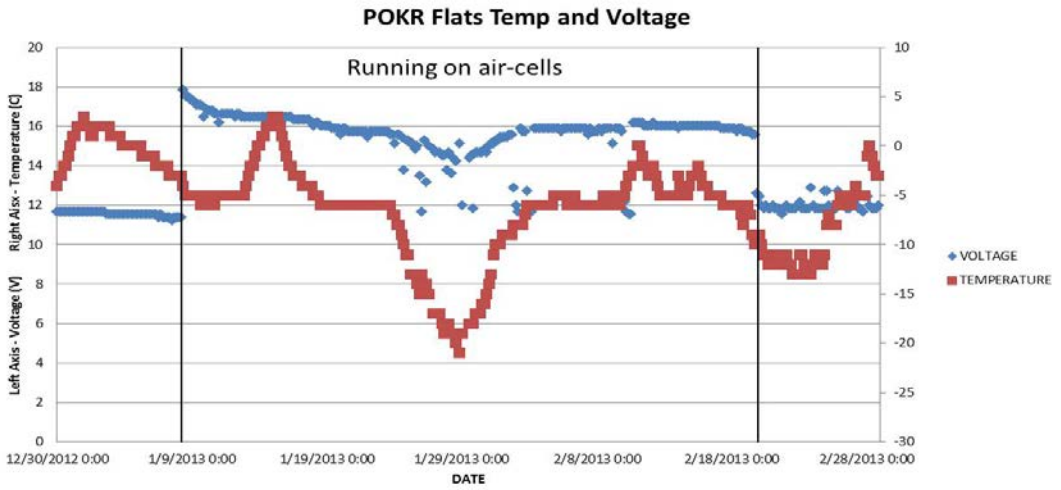
Due to increasing demand/interest in Air Alkaline Batteries, PASSCAL has been testing cells in a variety of conditions to verify characteristics.

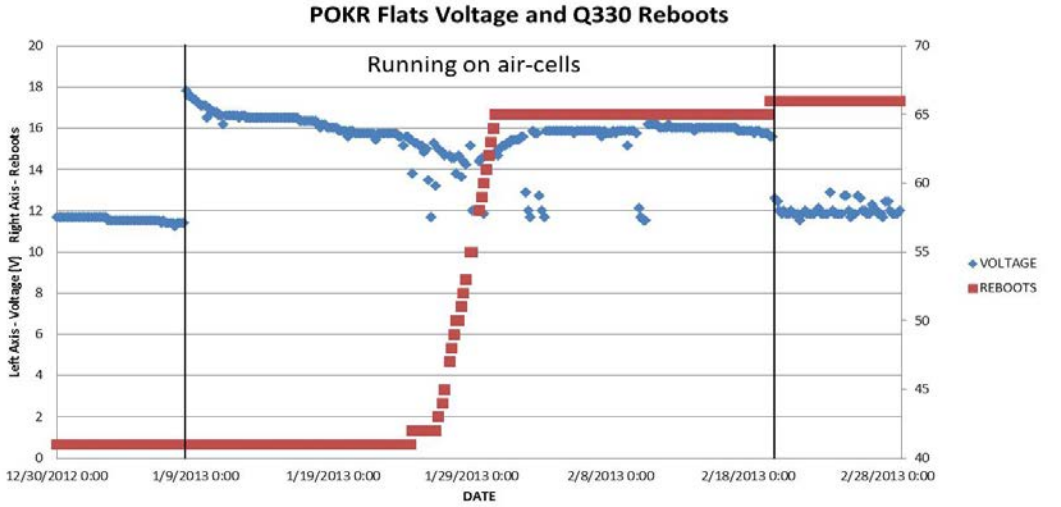
Pros

- High energy density
- Inexpensive
- Non-hazardous (easy to ship)

Cons

- High Impedance (can't source large amounts of current)
- Poor cold weather performance
- Require air supply





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Air Alkaline Batteries

Aircell in house testing

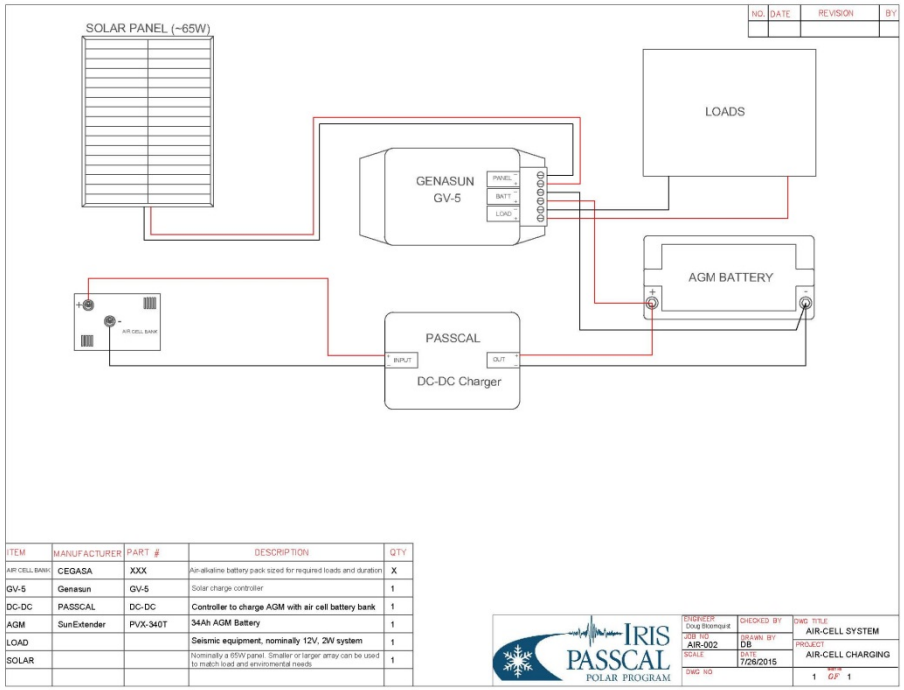
Air Alkaline Batteries

DC-DC convertor: In an attempt to bypass the cold weather limitations of Aircells, PASSCAL developed a DC-DC convertor to “trickle charge” a secondary battery capable of sourcing more current in the cold.

System running on 34Ah AGM battery -20C with DC-DC converter used to maintain the battery’s voltage with air cell bank

System running on air cells only. Note the reboots and data loss starting at -20C

- Wide input range (13-50V)
- Can be programmed for max output of 50 to 600mA
- ~94% efficient when pulling from a 17V source to charge a 12.6V battery (AGM)



ITEM	MANUFACTURER	PART #	DESCRIPTION	QTY
AIR CELL BANK	CEGASA	XXX	Air-alkaline battery pack sized for required loads and duration	X
GV-5	Genasun	GV-5	Solar charge controller	1
DC-DC	PASSCAL	DC-DC	Controller to charge AGM with air cell battery bank	1
AGM	SunExtender	PVX-340T	34Ah AGM Battery	1
LOAD			Seismic equipment, nominally 12V, 2W system	1
SOLAR			Nominally a 65W panel. Smaller or larger array can be used to match load and environmental needs	1

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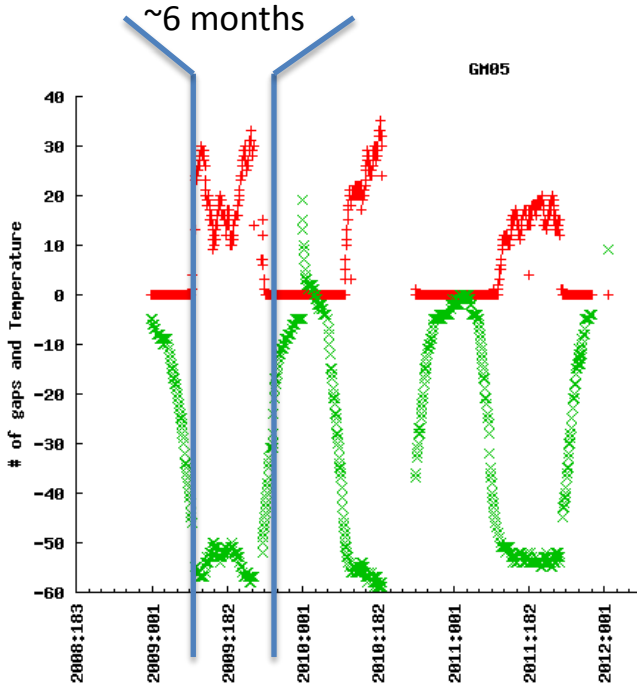
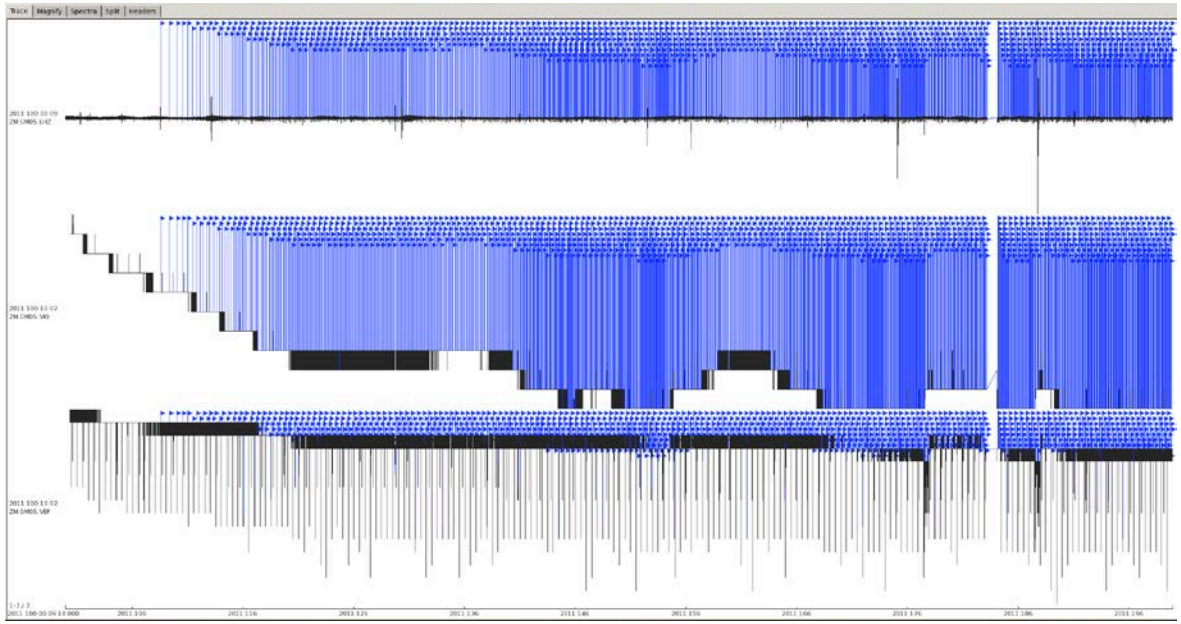
DESIGNER: Doug Bloomquist
CHECKED BY:
JOB NO.: AIR-002
DRAWN BY: DB
SCALE:
DATE: 7/26/2015
DWG NO.
DWG TITLE: AIR-CELL SYSTEM
PROJECT: AIR-CELL CHARGING
SHEET 1 OF 1

Wind Powered Heater

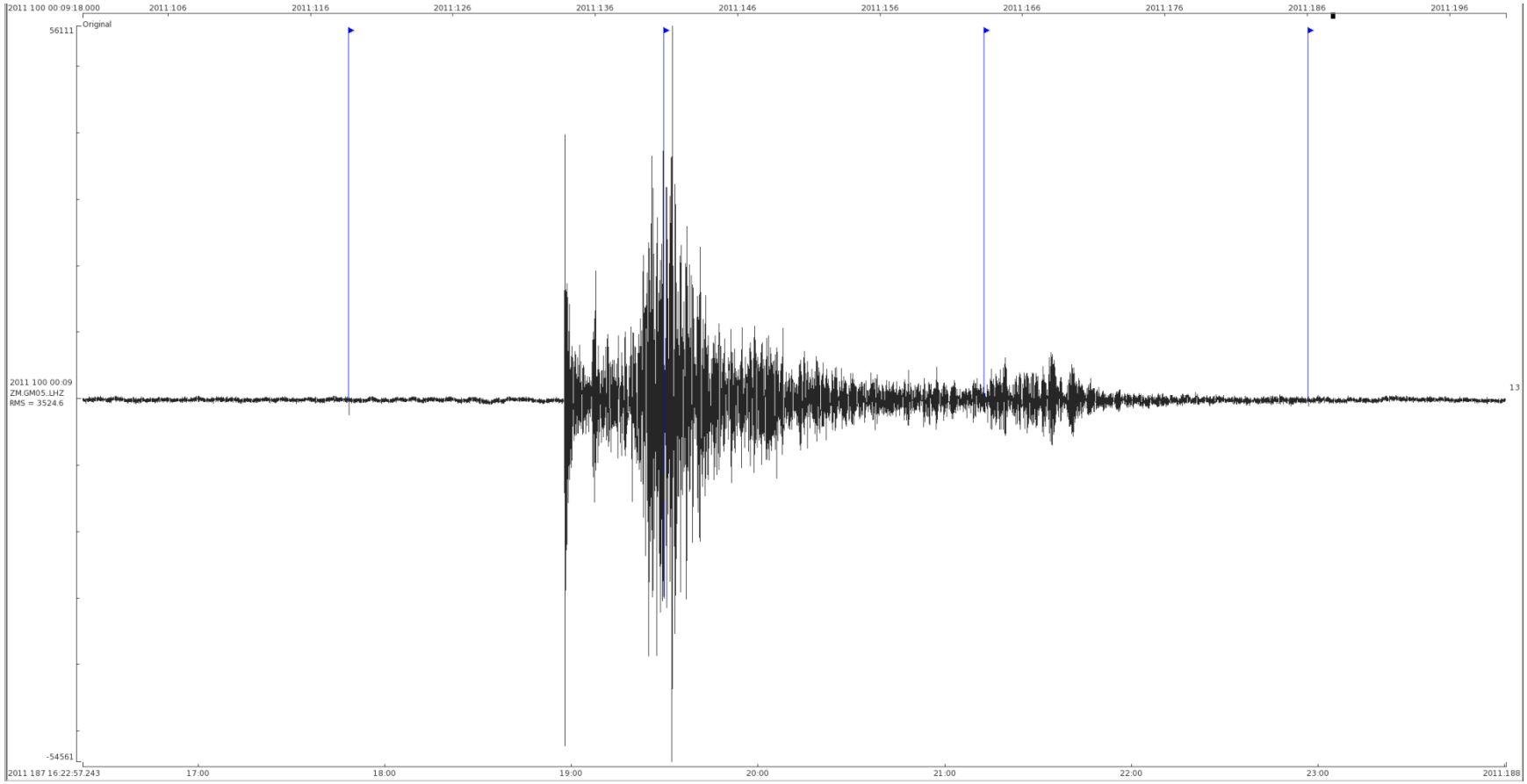
Year round stations operating on the East Antarctic Plateu experience data gaps and poor clock quality during the winter months due to a the VCO operating out of spec, resulting in weeks or even months of data that is discontinuous to the point of being unusable (AGAPs).





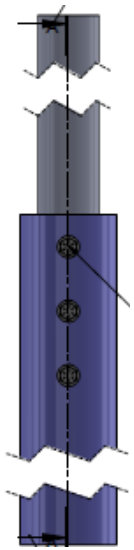
Wind Powered Heater

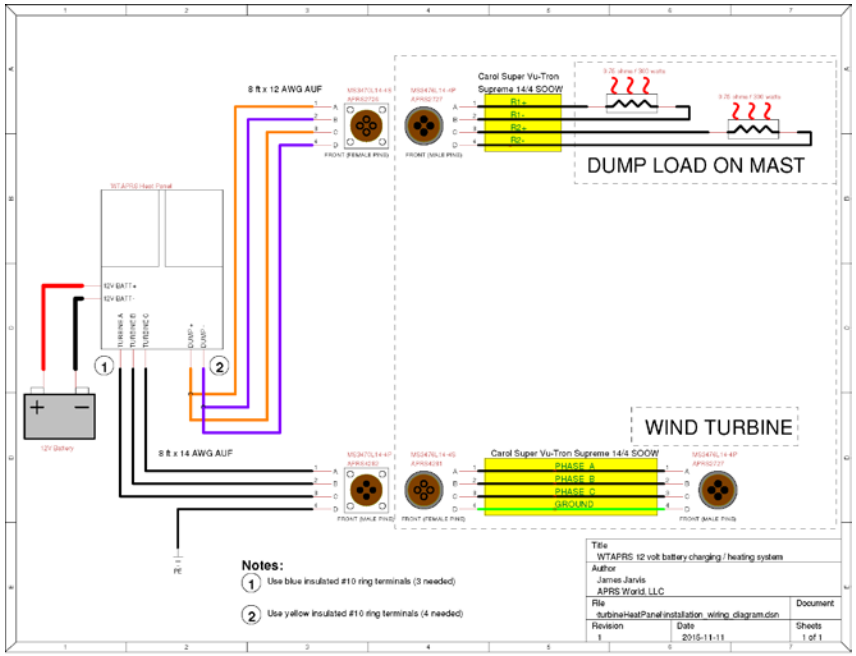
7.6 Earthquake Near NZ in 2011



Wind Powered Heater

In an attempt to mitigate this problem, we have worked with **APRS World** to develop a heater/controller to attempt to keep the stations above the operating spec of the VCO. Test units were installed at P061, a previously existing seismic station in the East Antarctic, and at our test site near Castle Rock, just North of McMurdo Station.

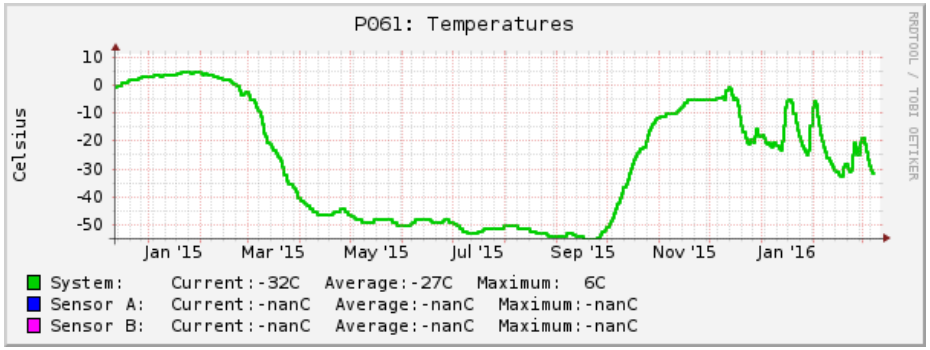


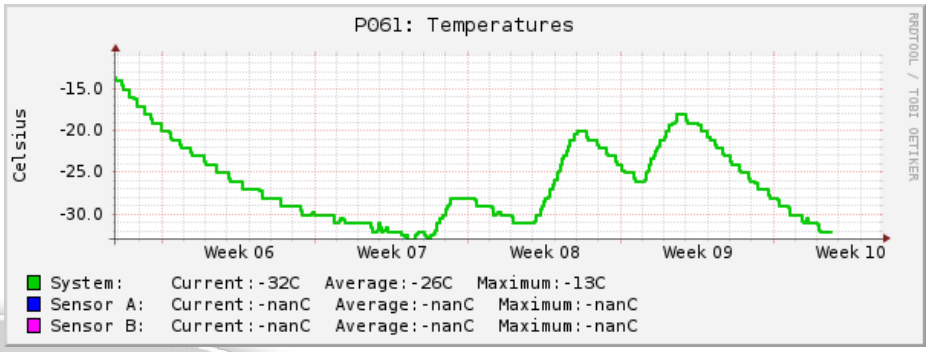


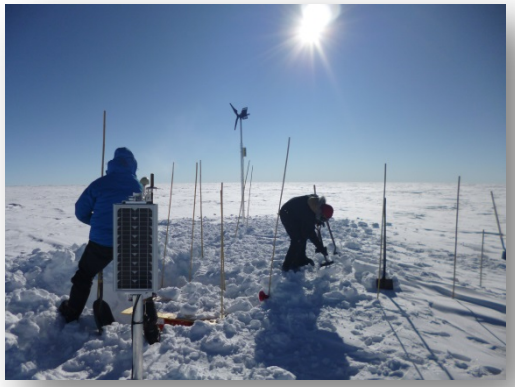
Wind Powered Heater

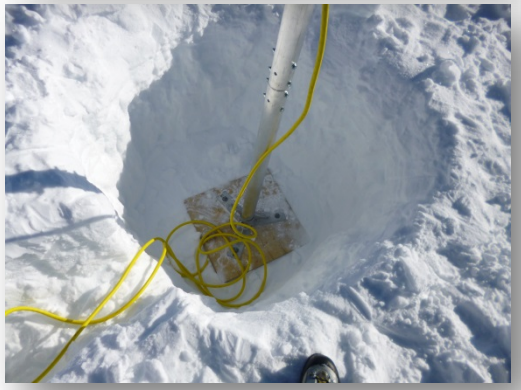
P061

- Wind turbine system isolated from seismic system (charging separate battery which is not powering equipment) and solar charge system
- Low wind speed, very cold (higher startup speeds as grease gets colder)
- Intermittent heating, efficacy remains to be seen as temps approach VCO limit





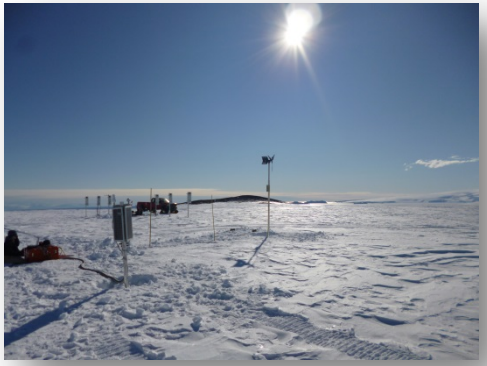


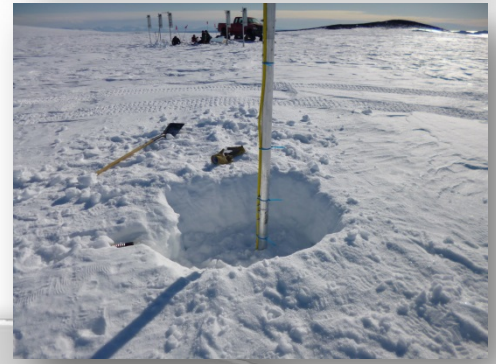


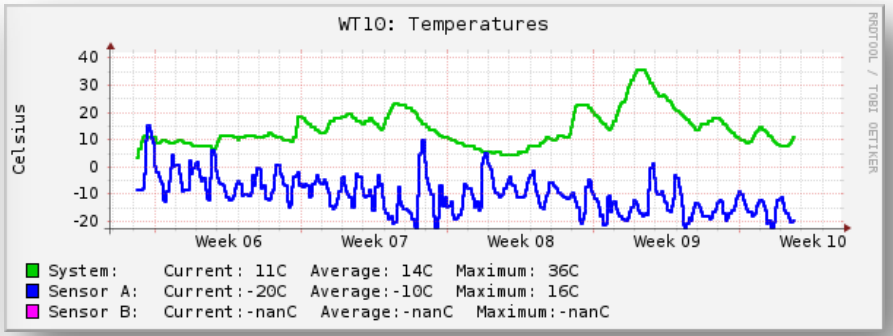
Wind Powered Heater

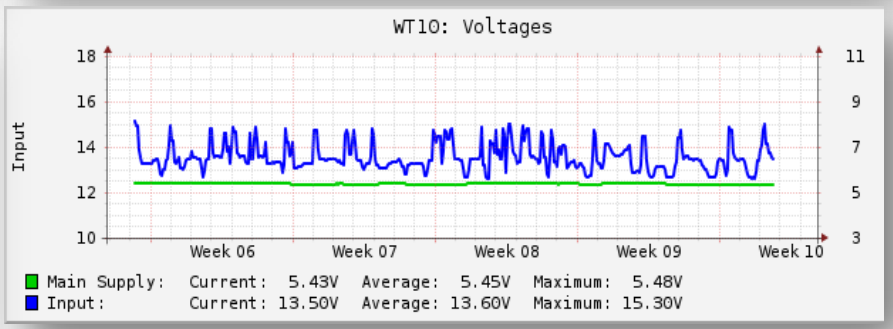
Castle Rock

- Wind turbine system charging 2 34Ah AGMs, paralleled with solar and also powering equipment
- Strong and consistent wind keeping batteries charged and box warm. Longevity/durability of turbine/install method will be the takeaway here





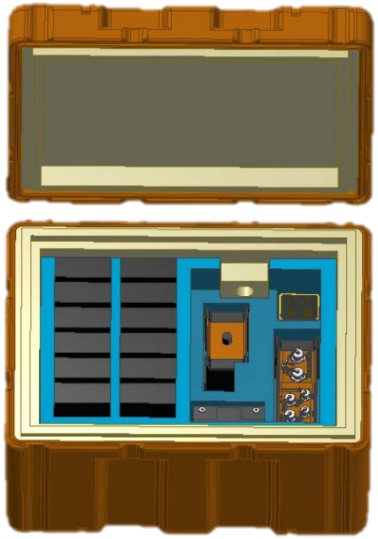




Next Generation Seismic Station

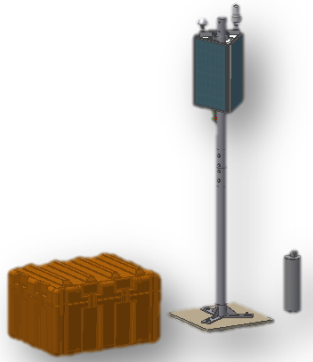
Development prompted by funding for 3 separate funded projects for deployment during the 2014/15 Antarctic season.

- Focus on rugged design and reliability at minimal logistical and financial cost
- Unprecedented 44 stations successfully deployed during 2014-15 season



Semi-permanent, Extreme Cold Station

- 8x 108Ah AGM Batteries
- Heavily insulated enclosure
- Broadband Surface Seismometer in insulated vault
- Appx total weight 1000 lbs
- 5-10 year battery life



2 year, Moderate Cold Station

- 10-12x Lithium Primary batteries +1 34Ah AGM
- Moderately insulated enclosure
- Direct bury broadband posthole seismometer
- Appx total weight 250 lbs
- 2 year battery life

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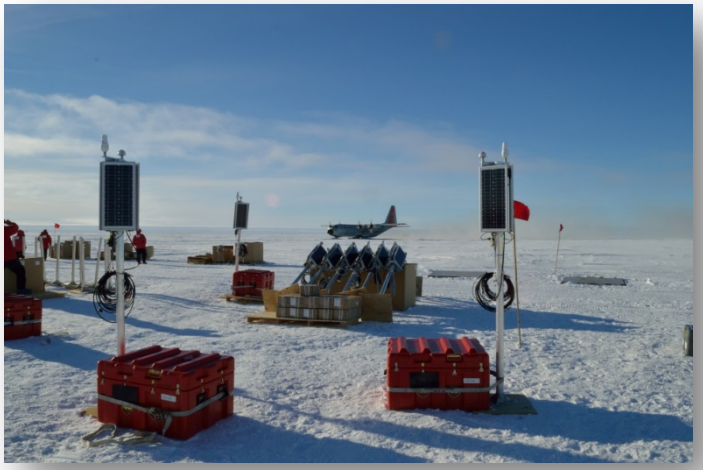
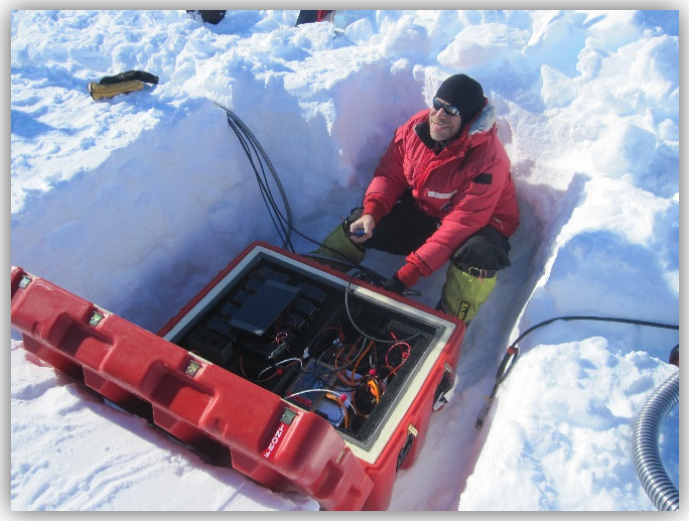
Next Generation Seismic Station

44 RIS Enclosure Systems installed in the 2014-2015 Antarctic Season

2015/16 Service results/data return:

- Great success overall!!
- ~2hr service time at each station
- >95% data return
  - ~4 sites had issues during AGM-Li switching transition
  - 1 baler failure resulting in ~1 mo. Data loss





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GeoIce MRI

MRI – Partnership between Central Washington University and IRIS to develop new instrumentation specifically for polar regions. Will include a mixed phase array consisting of broadband and intermediate band seismometers complete with power systems and enclosures.

- Low power, both types integrate a digitizer and post hole seismometer for installation in snow/ice
- Environmentally sealed, built for limited and difficult logistics
- Improved tilt tolerance
- Target is 125 element array
- Two Nanometrics “All-in-one” units, a Meridian Compact, intermediate band instrument and a Meridian 120 broadband unit currently operating at South Pole SPRESSO site

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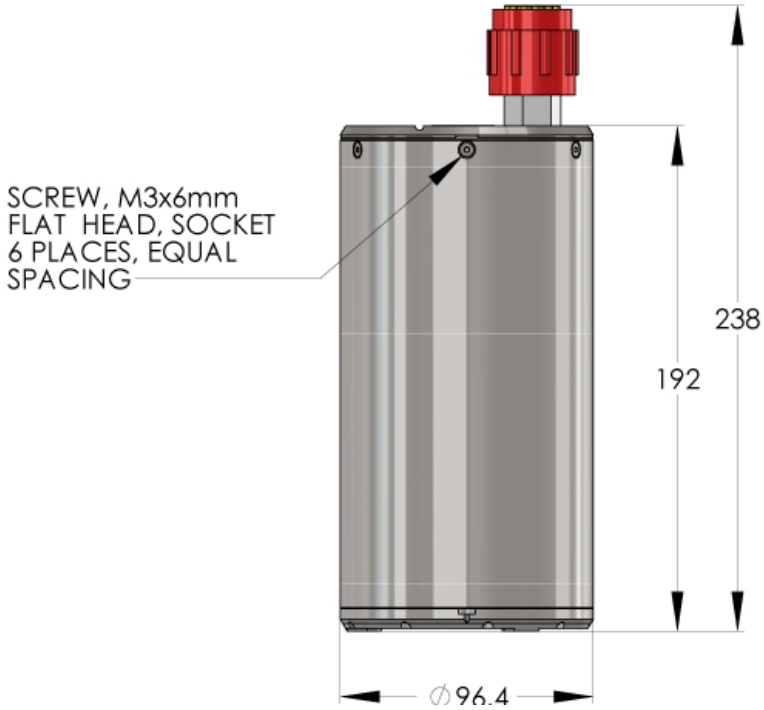
GeoIce MRI

New revision fixes many early mechanical issues:

- Updated connector for field usability
- Ruggedized Surface Interface Unit (SIU)
- Better isolation between data logger and sensor



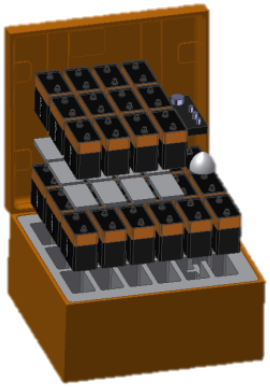
GeoIce MRI

Taku Glacier Test Deployment: Several systems were deployed on and around the Taku glacier near Juneau AK during the Summer and Fall of 2015 in both "Summer Only" and year-round configurations .

- Focus on modularity; ability to expand station by adding battery power without removing existing equipment
- Several different battery chemistries and configurations tested used

Lithium Primary System

Aircell System



Alkaline System

Station	Chemistry	# Batteries	SIU	Sensor	Panel	Box Model
Winter 1	Alkaline	30x MN918	External	Compact	20W	AL2221-1802
Winter 2	Aircell	3x 6V 4AS10	External	Compact	20W	AL1616-0505
Winter 3	LTC	2x Custom Pack	External	Compact	20W	AL1616-0404
Winter 4	AGM	4x 108Ah	Internal	Compact	45W	AL3018-0905
Winter 5	LiFePO4	3x 100Ah	Internal	Compact	45W	AL2216-1203
Winter 6	AGM	8x 108Ah	Internal	120	45W	AL3018-0905
Winter 7	LiFePO4	6x 100Ah	Internal	120	2x 45W	AL2216-1203

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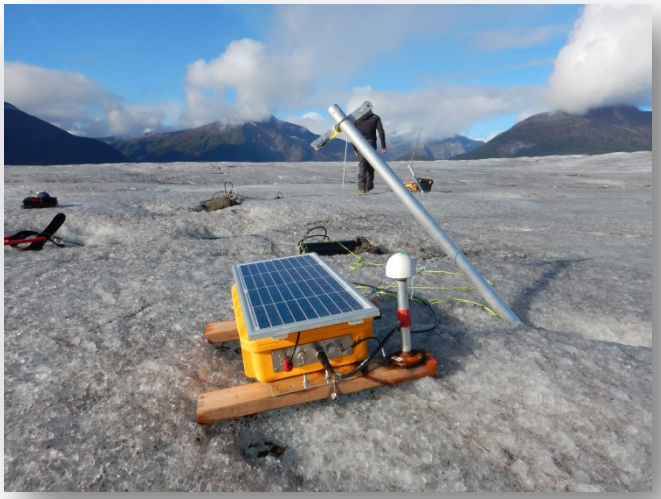
GeoIce MRI



GeoIce MRI

Solar Panel Mast Pull Down Test

Configuration 1 **Configuration 2**

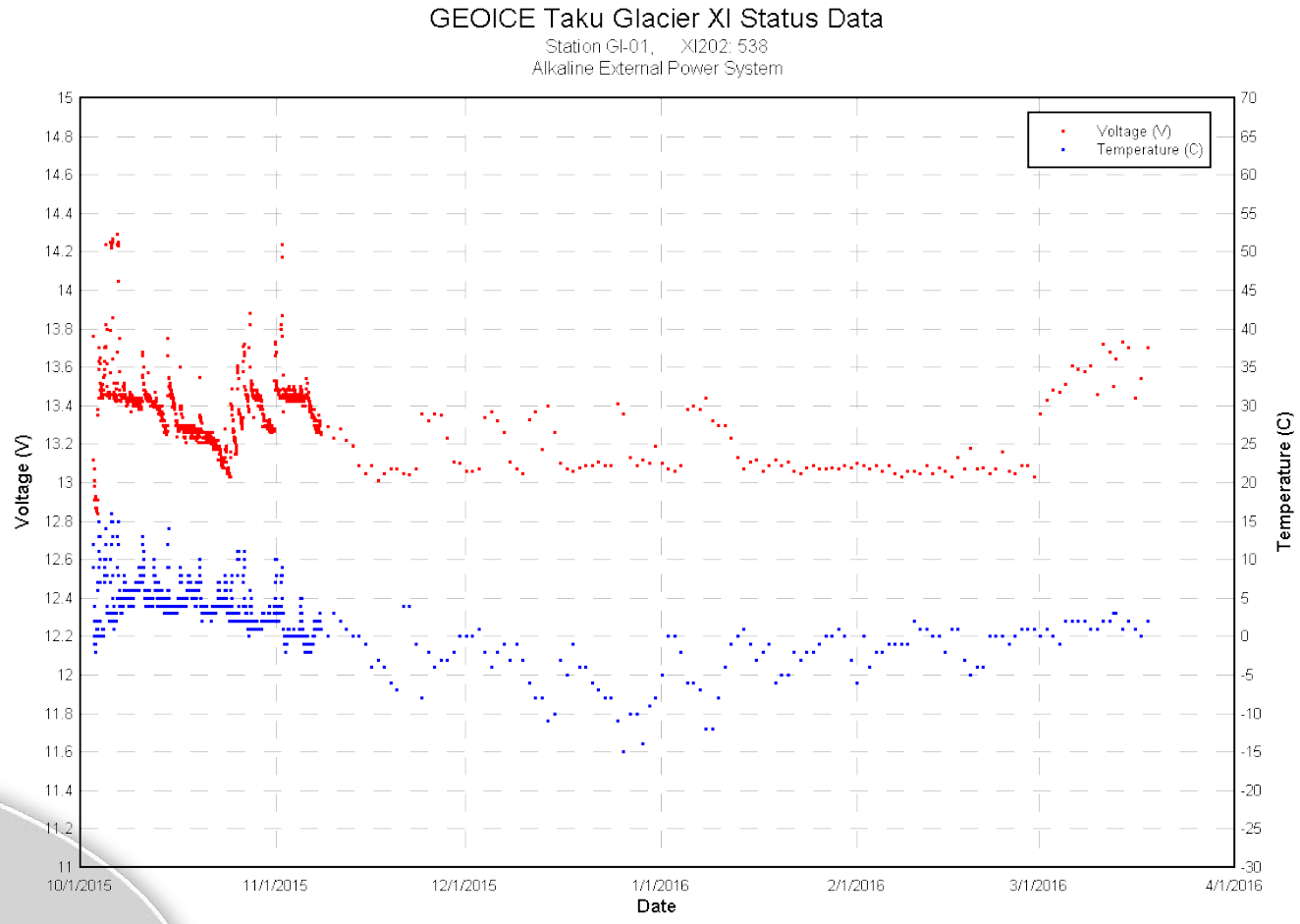
Results

Configuration 1 began to plastically deform at 550 lbs, without pulling out. While testing Configuration 2 the rope attached to the truck broke at 688 lbs, with no signs of plastic deformation or pullout (other than a very slight lean) in the mast. Further testing would be required to determine final failure load for Configuration 2.

GeoIce MRI

Further Testing:

- **SPRESSO** and **Castle Rock:** 1 of each type of Meridian was installed at SPRESSO (South Pole test site) and Castle Rock (McMurdo test site). Both stations are being “real-time” telemetered.
- In house lab testing/characterization ongoing



ANY QUESTIONS??

IRIS PASSCAL POLAR PROGRAM