The Next Generation of

Automatic Geophysical Observatory (AGO)

Telemetry Systems, Data Acquisition, and Power

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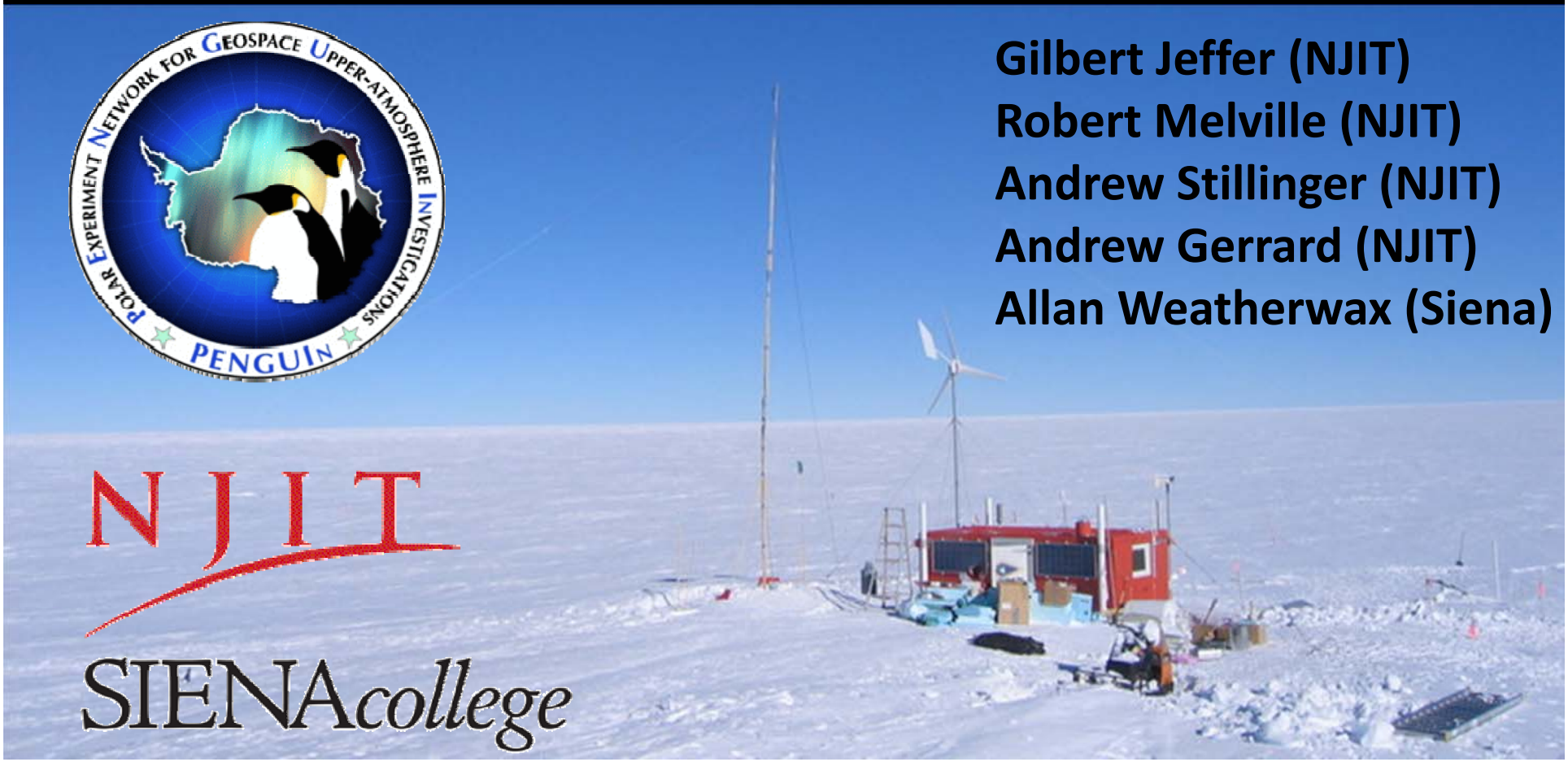

POLAR EXPERIMENT NETWORK FOR GEOSPACE UPPER-ATMOSPHERE INVESTIGATIONS
PENGUIN

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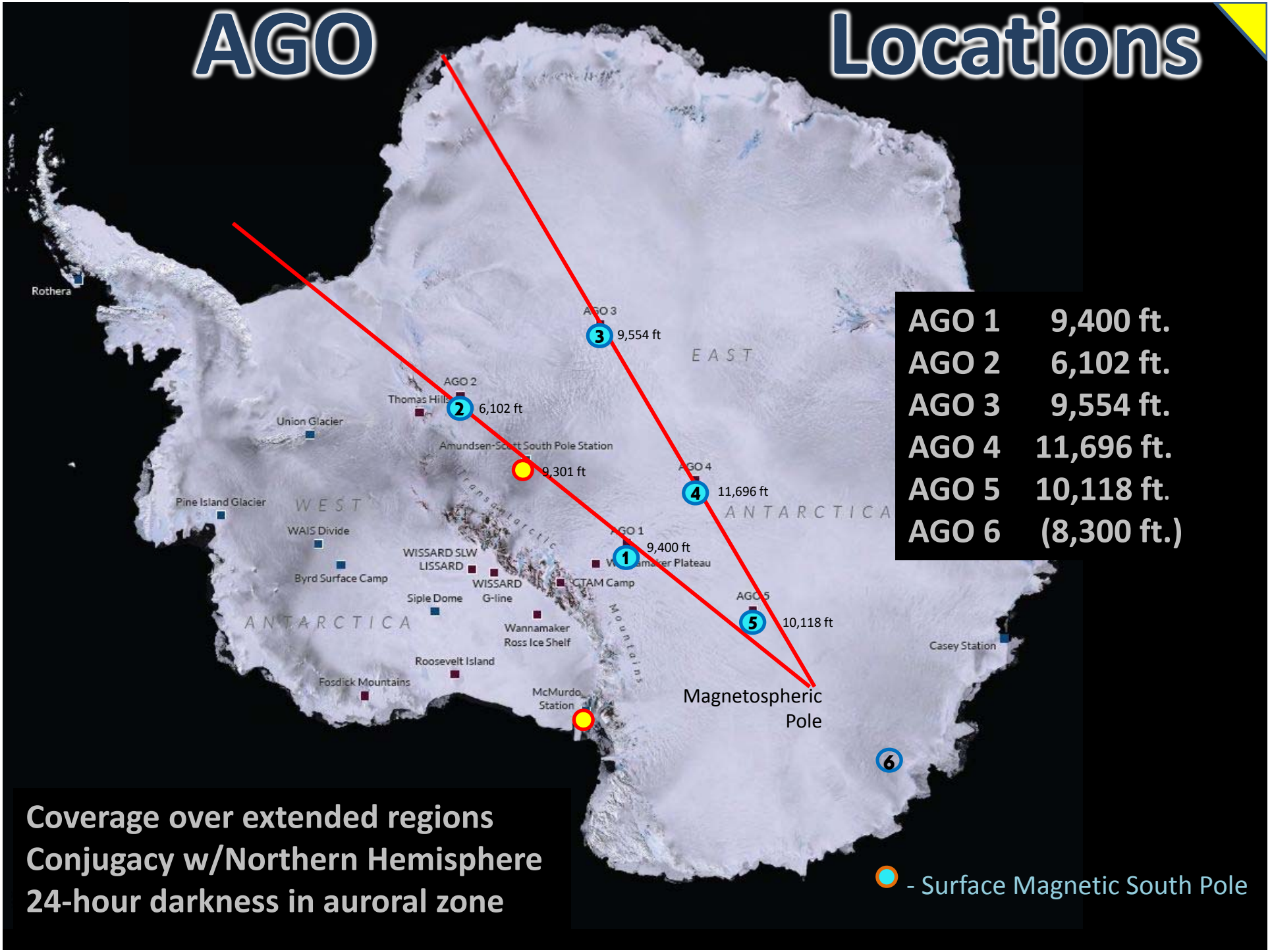
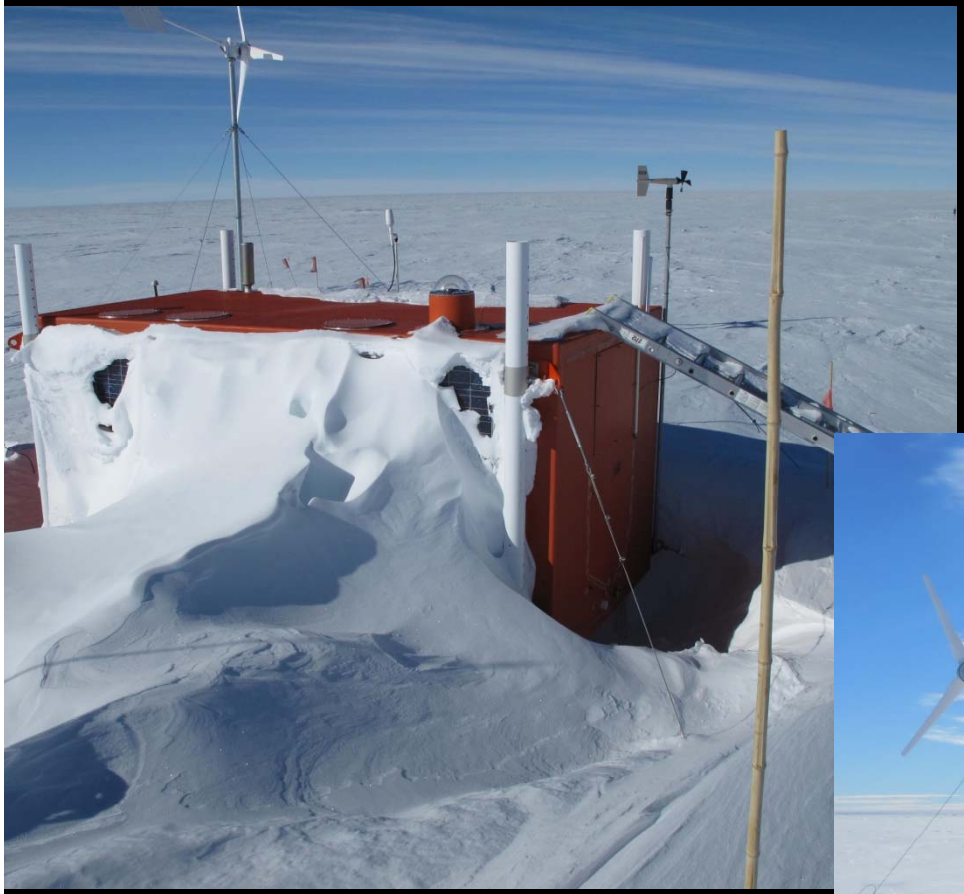
SIENAcollege

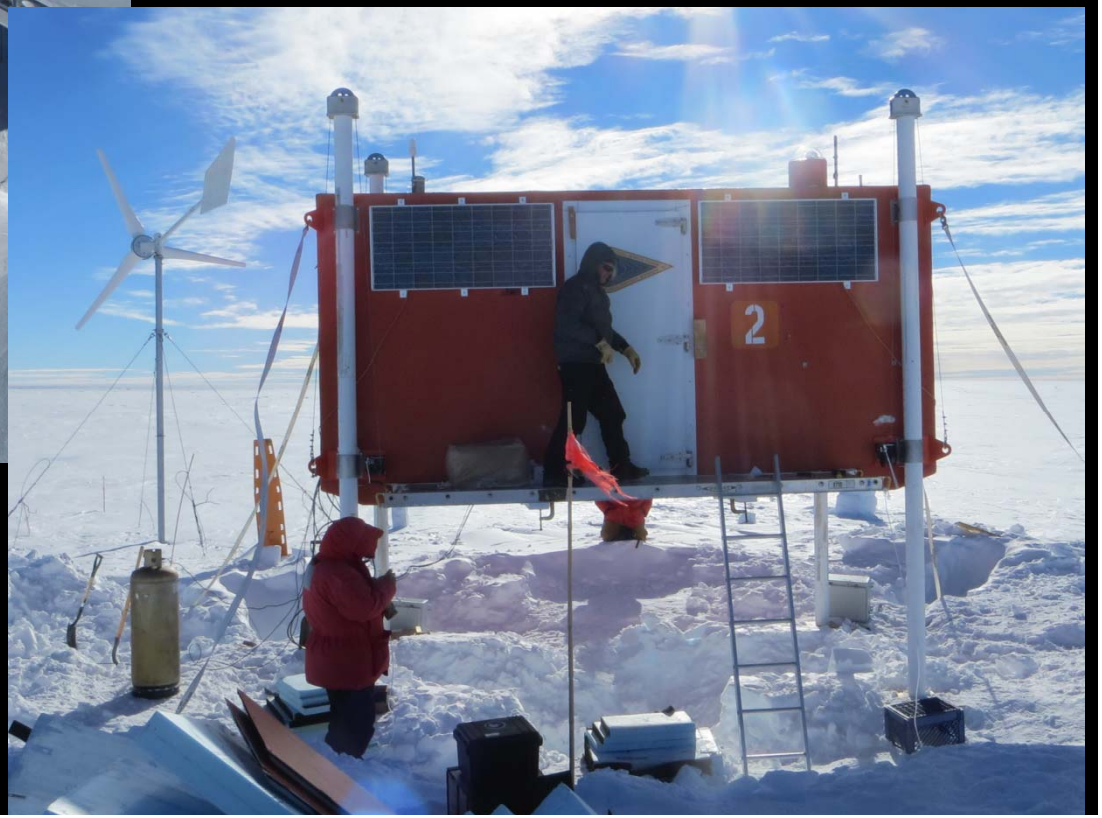

AGO Locations
AGO 1 9,400 ft.
AGO 2 6,102 ft.
AGO 3 9,554 ft.
AGO 4 11,696 ft.
AGO 5 10,118 ft.
AGO 6 (8,300 ft.)
Rothera
AGO 3
3
9,554 ft
EAST
AGO 2
Thomas Hills
2
6,102 ft
Union Glacier
Amundsen-Scott South Pole Station
9,301 ft
AGO 4
4
11,696 ft
ANTARCTICA
Pine Island Glacier
WEST
WAIS Divide
AGO 1
1
9,400 ft
WISSARD SLW
LISSARD
Byrd Surface Camp
WISSARD
G-line
CTAM Camp
Siple Dome
AGO 5
5
10,118 ft
ANTARCTICA
Wannamaker
Ross Ice Shelf
Casey Station
Roosevelt Island
Fosdick Mountains
McMurdo
Station
Magnetospheric
Pole
6
Coverage over extended regions
Conjugacy w/Northern Hemisphere
24-hour darkness in auroral zone
- Surface Magnetic South Pole

AGO Instrumentation

	Fluxgate	Induction coil	All-sky	Photometer	Riometer	VLF	HF	GPS/TEC	ELF
South Pole	Y	Y	Y	630/428 nm	Imaging	Y	Y	Y	Y
McMurdo	Y	Y		630/428 nm	Imaging	Y		Y	(???)
AGO	Y	Y	Y	Y	Imaging	Y	(Y)	Y	
Palmer Station	Y					Y			
Halley Station	Y	Y			Single beam	Y			
AAL-PIP [Adaptive Autonomous Low-Power Instrument Platform]	Y	Y						Y	
Australians	Y	Y							

AGO Servicing





SBD Telemetry Module

Designed by Bob Melville

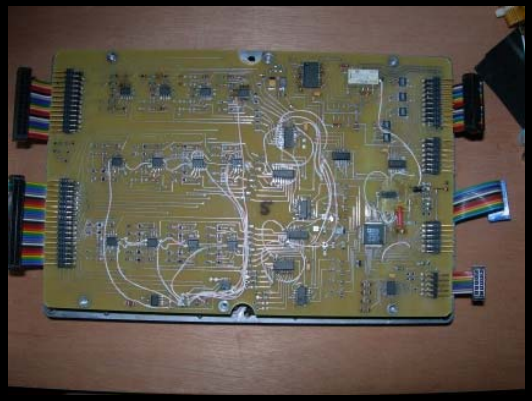
Telemetry components housed within heavily insulated case with small self-heater inside

Powered by separate batteries dedicated to communications

Insulated case resides within the larger insulated & heated instrument rack enclosure

Goal: Telemetry continues even when instruments powered down

Year-Round SBD Telemetry



AD943 µP based controller . . .

32 analog channels
(adj. voltage range and input impedance)

8 temperature measurement channels

4 digital channels
(one digital timer, inputs opto-isolated)

2 relays
(can be remotely controlled stateside)

9602a modem . . .

Home-made interface board

Experienced issues where comms go quiet for a period of time – *firmware TA11002 ?*

Methodology / Redundancy

Methods of transmitting the data . . .

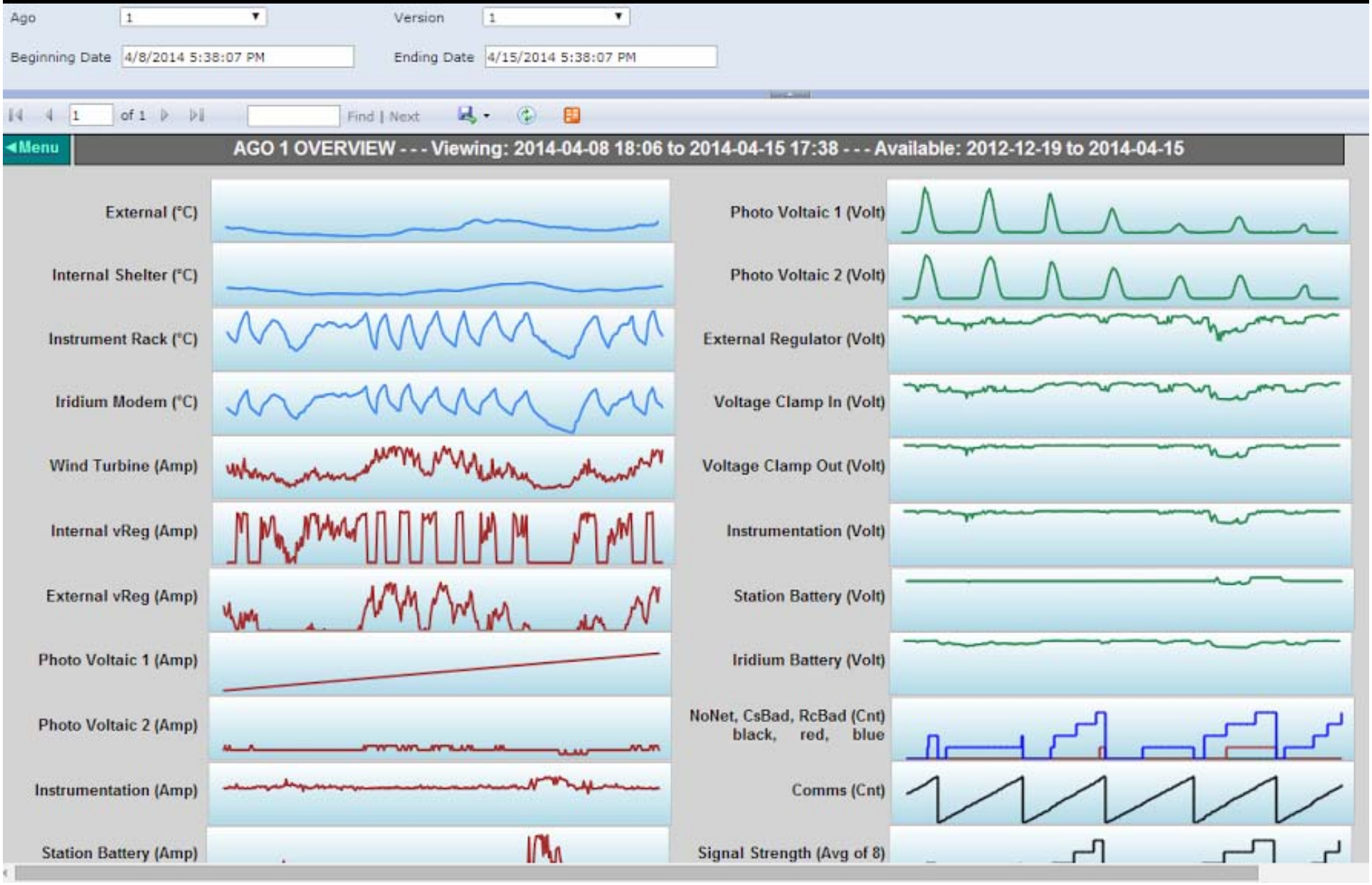
1. **Sample inputs and send one block per sample**
   (telemetry-only stations – AGOs 2, 3, and 4)
2. **Accumulate samples over time and send periodically**
   (station with both telemetry and science data – AGO 1)

Methods of receiving the data . . .

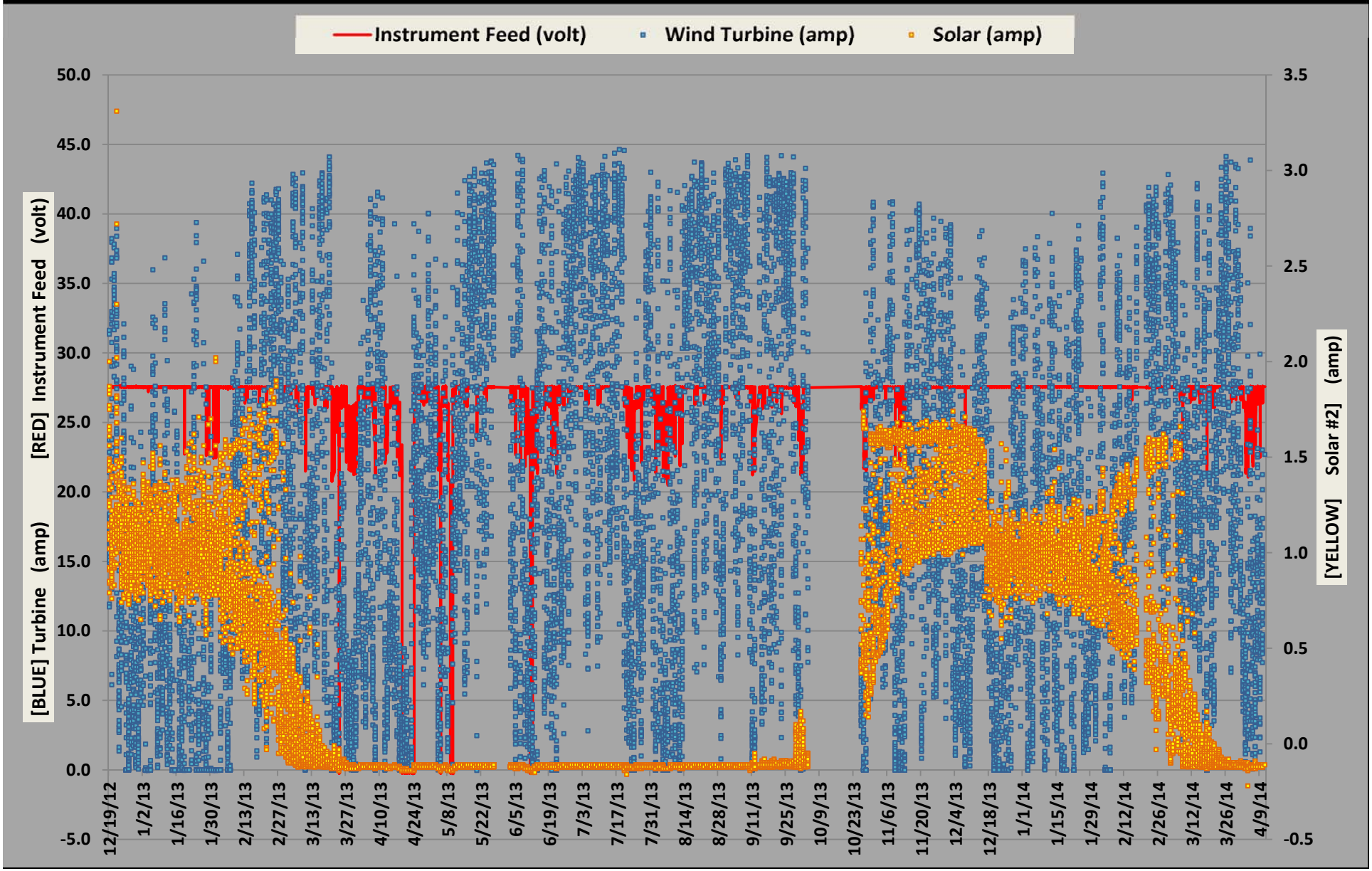
Multiple destinations can be set up . . .

1. **Direct IP – Sent to NJ-based server, direct to database**
   (12-hour store and retry if not successfully delivered)
2. **eMail – Sent to a dedicated Gmail account**
   (Binary attachments are kept as off-site backup)

Station Telemetry Reporting

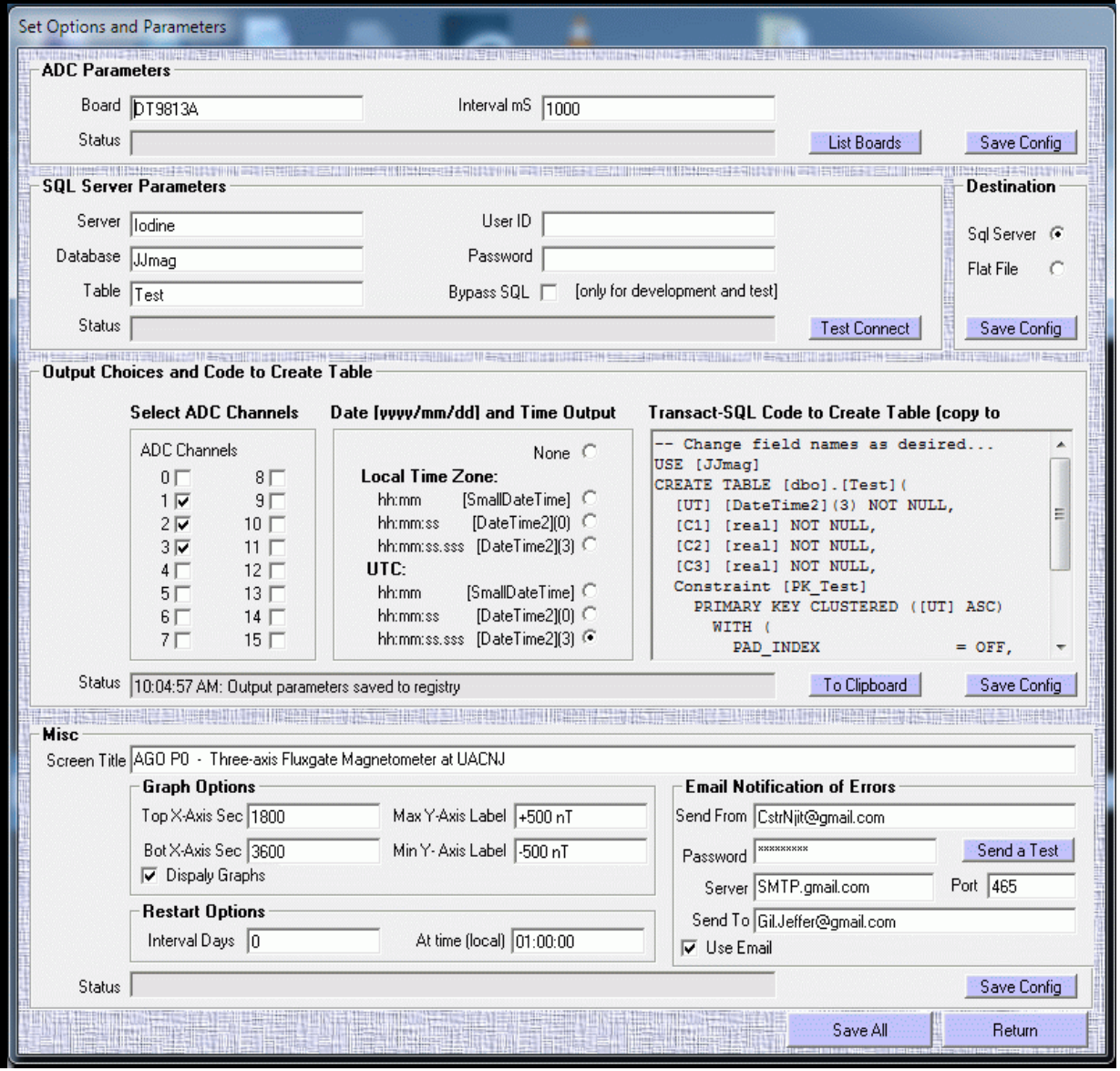


AGO 1: Investigating Telemetry



New Data Acquisition System

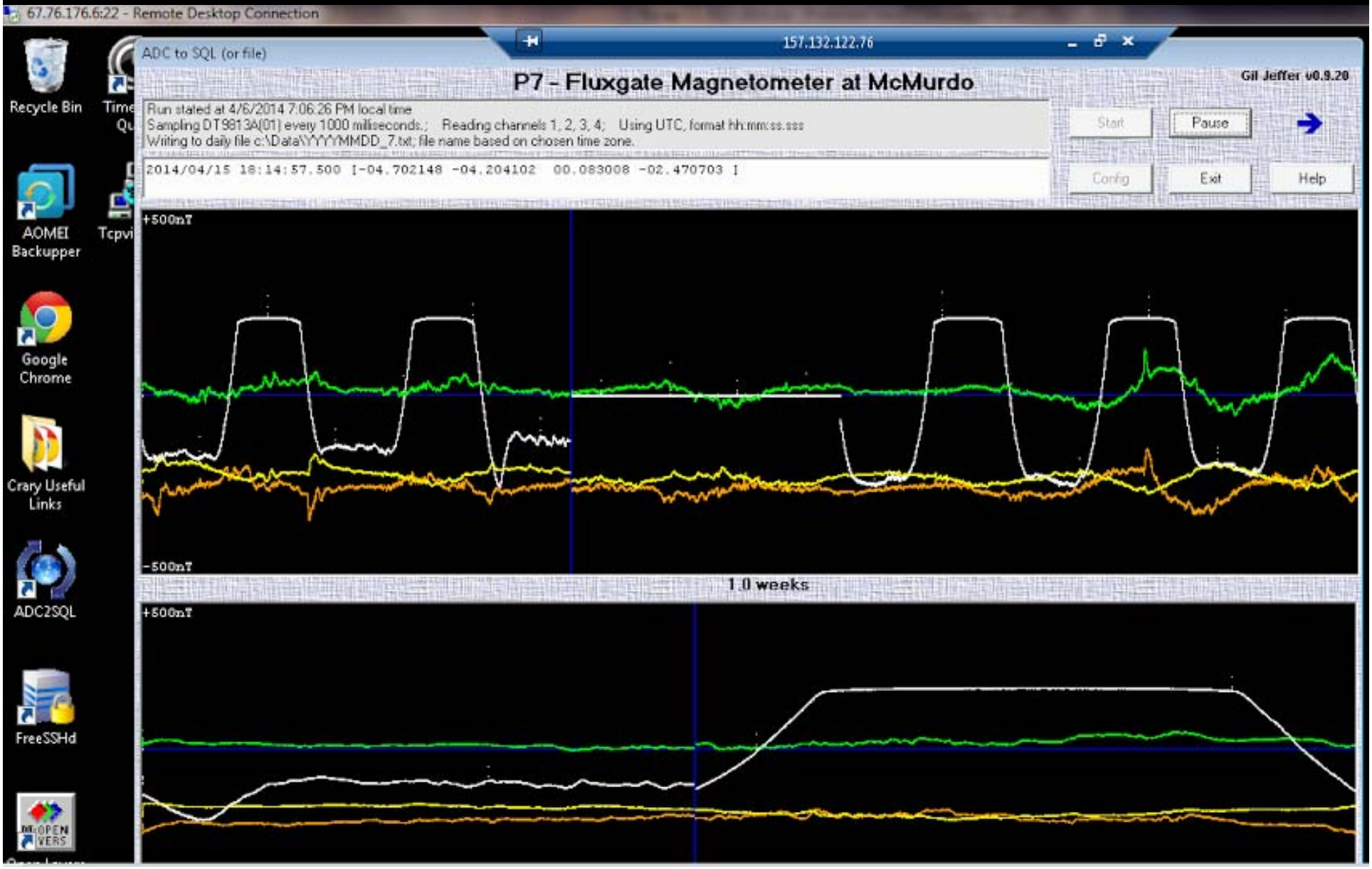
- Replace aging system with off-the-shelf parts
- Interface to various Data-Translation ADC devices
- Writes to daily files or direct to SQL database
- Can run multiple ADC units on one computer
- Parallel deployment at both MCM & SPA
- Enhancements for serial and cadence by channel



MCM / SPA Data Acquisition

Stress-testing curiously of the TSA – and it survived!

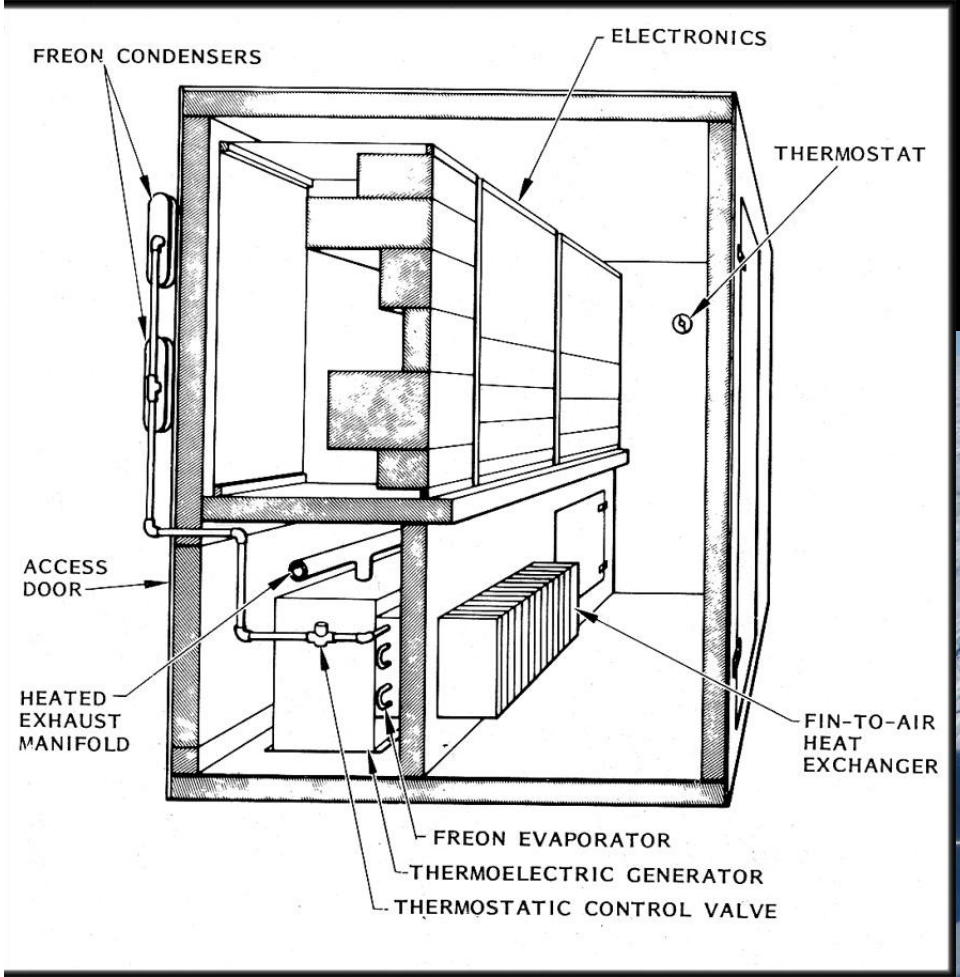
Remote Desktop or SSH



Mods for Field Deployment

- Very low-power computer
- Fanless design
- Solid-State drive

Early AGO Power System



Complex, inefficient system

Over 2,500 lbs propane per year

Expensive C-130 supply flights

2,500 lbs propane
= 2,500 lbs water
= 2,500 lb lump of ice

Last-Generation Power

Solar Panels

Four total (2 x 2)

Each rated 240 watts

50 watts shaded side

African Windpower 3.6 Turbine

Permanent magnet alternator

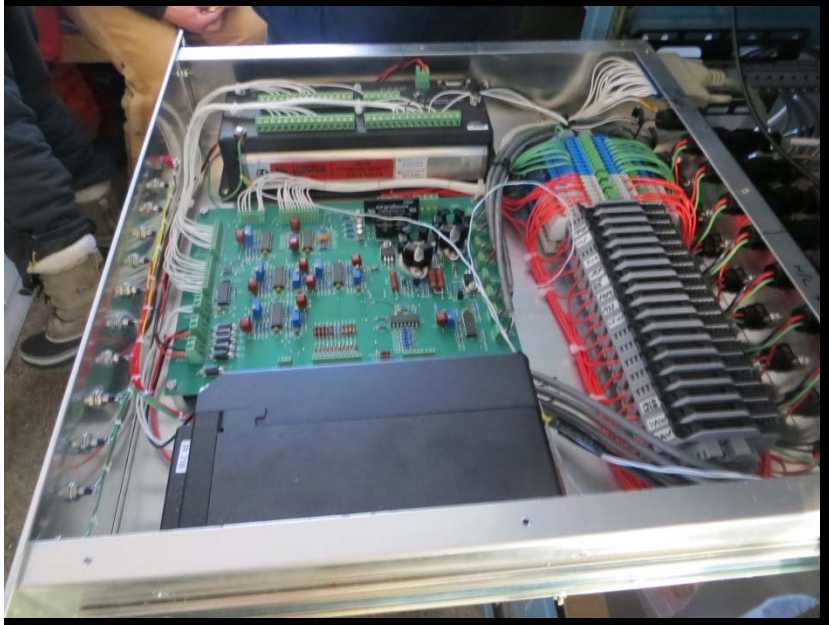
Can supply over 1,000 watts

Ice-fog infiltration of grease

Sealed bearings weren't

New shield fixed this problem

Still Problems on the Inside



Complex system design

Charge controller failures

Low-voltage dropout failures

Many unique, one-of-a-kind parts

Could not handle delivered power

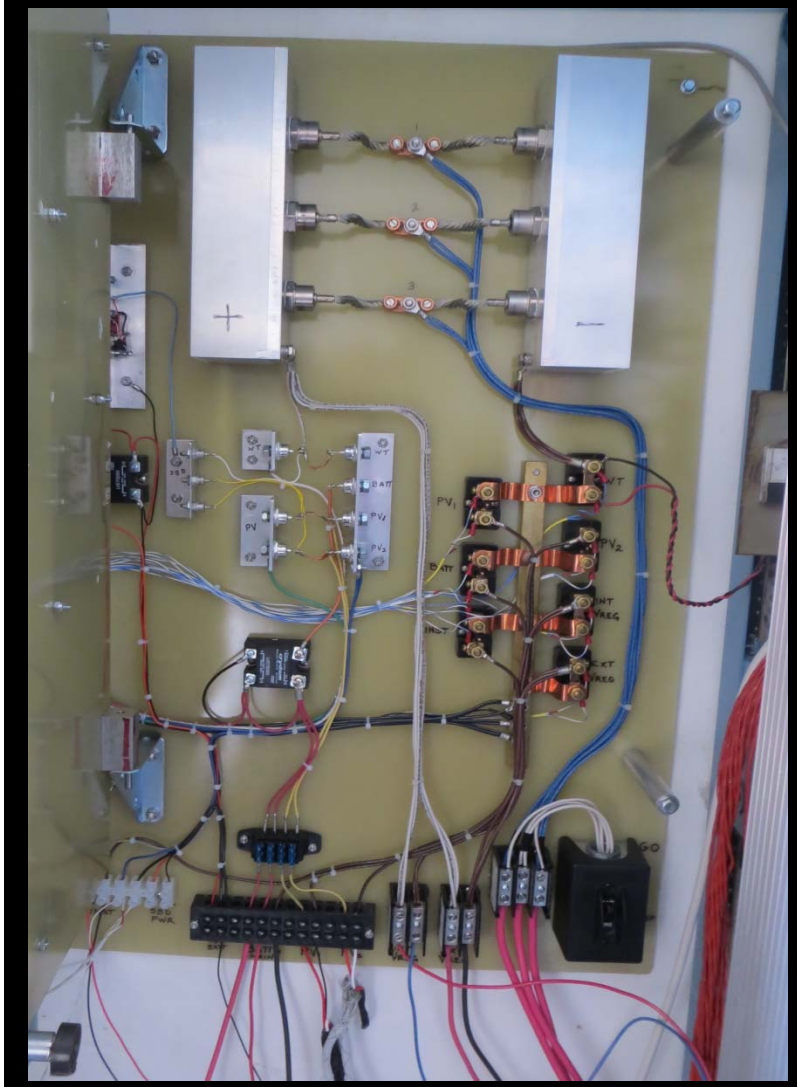
Thin wires high resistance connection

Crispy, flaking insulation from heat

Dump loads melting fiberglass walls

Next Generation Power

Simplified design utilizing robust components



Control circuitry . . .

Designed by Andy Stillinger

Open design for ease of maintenance

Outfitted to monitor key voltages and currents – feeds into telemetry system

Next Generation Power

Internal voltage regulators . . .

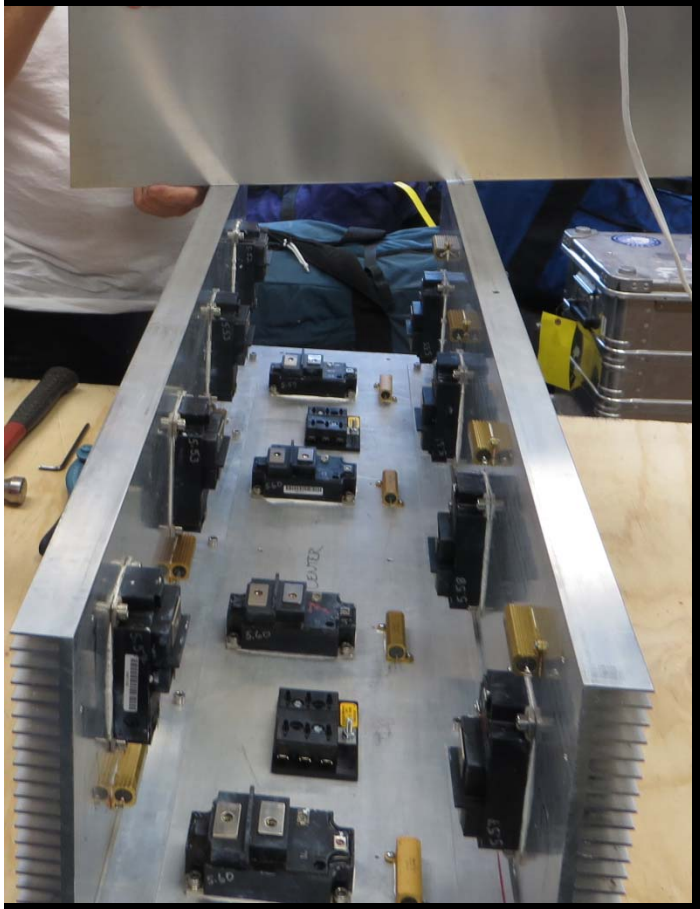
Situated within blue board enclosure

Heavy finned aluminum heatsinks

Dissipate 200 watts each

Heat instruments within the enclosure

Next Generation Power

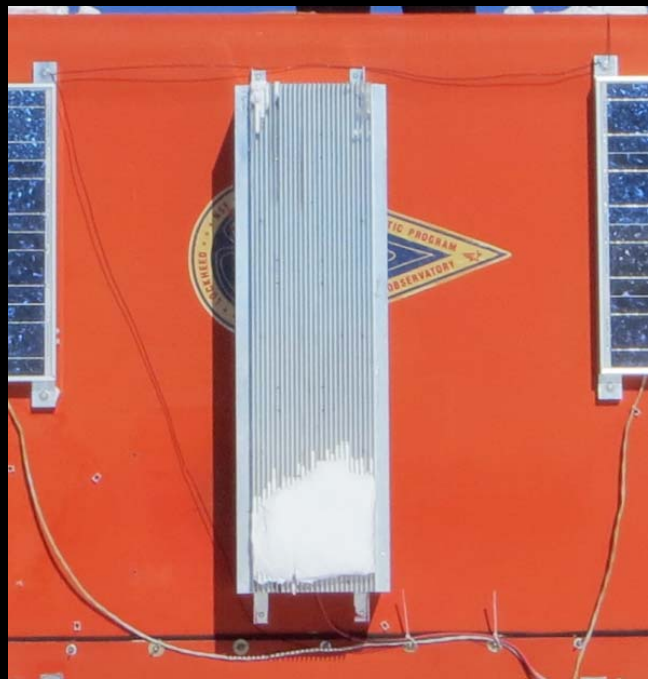


External voltage regulator . . .

Mounted externally on wall of AGO

Contains 12 x 800 watt IGBT transistors
(Used in MRIs, electric cars, welders, etc)

Capable of dissipating ~10 Kw



After installation at an AGO,

Wet finger stuck to heat sink while it was dissapating 1 Kw

Power System Operation Notes

Simple limit switches replaced earlier computer
- cut power to science equipment when enclosure < -40C
- turns on internal vReg if < 0C, heating enclosure
- turns off internal vReg if > 30C (gives longer drift down if power goes off)

Loads
- Charge batteries (4-5 amp)
- Science equipment (2 amp)

Logic
Wind up, temp low, internal vReg draws current above what is used, limits to 28 volts
More wind, int vReg draws more current (can do up to 15 amp total 450-500 watts)
Even more, voltage goes to 30V and also starts dumping to external (never goes > 32 volts)
If internal temp gets high enough, internal vReg shuts off and all goes to external vReg

Winter, if no wind
- Instruments can continue to run from 1 to 1 ½ days, until temperature drops < -40C
- Instruments restart when wind picks up and the internal vReg can warm the enclosure
- Never limited by battery capacity, only temperature (and batteries never used for heating)

Never any outages in summer
- Drifting snow can cover the down-wind (door) side solar panels
- Solar panels on up-wind side alone are enough to keep station going

Departure - All Bundled Up

Three layers of blue board insulate the instruments within each AGO

Rather than heat the entire AGO, this smaller volume allows the resistive heating to maintain > - 40° C

A tight seal between blue board panels is absolutely <u>essential</u>!

Next Generation AGOs

Wind turbines at AGOs 1, 3, 4, and 5 have been operating continuously for 3 ½ years without maintenance or problems

Turbine at AGO 2 has been operating for 2 ½ years due to the inability of getting there due to bad weather the year the others were serviced

Telemetry systems have been operating since they were installed at AGO 1, 2, 3, and 4 during the 2012-2013 season

As previously mentioned, we have experienced periods without communication but each time they have come back online showing that the station is operating.

Instrument Siting at AGOs

- Five installations
  East Ant. Plateau
- Two 19-inch racks
  With open space
- Insulated & heated
  Electronics > -40°C (typical)
- Reliable power
  ~100 watts @ 28v
- Iridium connectivity
  Modem and SBD
- Service missions

The infrastructure is already there . . .

. . . AGO Program ??? Funding ???

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AntarcticGeospace.org

Future Science Opportunities in Antarctica and the Southern Ocean

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Solar-Terrestrial Research in Polar Regions: Past, Present, and Future

NSF Workshop Report [2014]

Sustainable energy at the 100-W level for scientific sites on the Antarctic Plateau: Lessons learned from the PENGUIn-AGO project, Review of Scientific Instruments

Melville, R., A. Stillinger, A. Gerrard, A. Weatherwax (2014. currently in press]