Data Retrieval from the Frozen Continent

IEEE ComSoc    July 21, 2011

Gary Ferentchak
Raytheon Polar Service Company

Black Island Teleport
McMurdo Station Antarctica
Austral Winter 2009
Photo by Anthony Powell
There are two ways to get science and operations data off-ice:

1 - Hand Carry

2 - Iridium Phones & Modems

2 - Broadband Satellites

McMurdo Station (Black Island)

Palmer Station

SMPGT – South Pole Station

Photo by Nick Fowell
Data Retrieval from the Frozen Continent

5th Largest Continent

1 ½ times the size of the United States

5.4 M sq. miles vs. 3.6 M sq. miles – doubles in winter
Data Retrieval from the Frozen Continent
As a continent - Antarctica Is the - - -

Highest: over a mile above sea level
Driest: less than 2” precipitation a yr
Coldest: -128.6° F at Vostok in 1983
Windiest: over 200 mph (katabatic winds)
Emptiest: no native people
Data Retrieval from the Frozen Continent

Antarctica Facts

For last 25 Million Years: *covered in ice* – 98% ice coverage
Once Home for: *dinosaurs, trees, and plants*
Portion of World’s Fresh Water / Ice: 70% / 90%
Largest Iceberg: *in 2000, 183 x 23 miles – big as CT*
Ocean Life: *Most prolific of all oceans – krill – one blue whale eats 4 tons/day for 6 months - daily intake would feed 1 person for 4 years*
Why so cold: *80% of incoming solar reflected back to space, remaining 20% absorbed by atmosphere or reflected by clouds*
If all glaciers melted:
*sea level rise = 200 feet*

Ice Core with ash from volcanic eruption
Data Retrieval from the Frozen Continent
Race to the South Pole - 1911

Amundsen
December 14, 1911

South Pole - 1st
Seen 100 Years
Ago This year

Scott
January 17, 1912

This year

100 Years
Ago

1911

1912

January 17,
Data Retrieval from the Frozen Continent
What Does Antarctica Look Like?

Typical Glacier –
Flow rate ~ 2-5 feet per day
Coverage – 98% of continent
Thickness – up to 3 miles
Trip to ocean from South Pole – 100,000 years

Largest Glacier: Lambert
Length: 250 miles
Width: 60 miles
Depth: 8000 feet
Flow rate: 5 – 11 feet/day
Beardmore Glacier
Length: 125 miles
Width: 25 miles
Depth: 7200 ft
Data Retrieval from the Frozen Continent
What Does Antarctica Look Like?

Literally: a river of ice
USAP Operational Satellite Systems

- Palmer Station – 1 system
- McMurdo Station – 2 systems
- South Pole Station – 3 systems
- Research Vessels – 1 per Ship
- Field Camps (austral summer):
  - WAIS – GOES Portable Terminal
  - CTAM – 8 channel IMCS (finished)
  - BYRD – 8 channel IMCS (ongoing)
  - PIG – 8 Channel IMCS (ongoing)
  - WISSARD – 12 channel IMCS (FY13)
  - Traverses - IMCS (3 ea – ongoing)
  - By others - Iridium OpenPort

IMCS = Iridium Multi-Channel System

GOES-3 11 meter Antenna
South Pole Station

NASA operates several satellite ground stations in support of the Space Shuttle and International Space Station missions.
Data Retrieval from the Frozen Continent
Palmer Station – Antarctic Peninsula

Only Station with persistent above freezing austral summer temperatures
Data Retrieval from the Frozen Continent
Palmer Station – Antarctic Peninsula

Palmer Ground Station

Antenna:        5 meter
Freq:               C- Band
Provider:        INTELSAT 707
Gnd Station:  California
Coverage:      24x7
Data Rates:    (duplex)
Pre 2006 – 384 Kbps
    2006 – 768 Kbps
    2008 – 1.544 Mbps
    2011 (soon) – 3.0 Mbps
Population served:
    Summer: 30 - 44
    Winter: 24 - 30

Primary Science Season: Austral Summer, some winter science
Design challenges (few):

• Long logistics chain

Benefits compared to other Antarctic research stations:

• Has solid rock foundation
• Moderate temperatures
• Many supply vessels
• Permanent operations

Palmer Station
(Go to Internet View)
Data Retrieval from the Frozen Continent
McMurdо Station – US Antarctic Gateway

Primary Science Season: Austral Summer
Data Retrieval from the Frozen Continent
McMurdo Station – US Antarctic Gateway

McMurdo Station

Black Island Teleport

Antenna 1: 11 meter  
Freq: Ku- Band  
Gnd Station: Australia  
Provider: Optus D1

Data Rate:  
Post 2006 – 1.5 Mbps  
Post 2008 – 10 Mbps  
Post 2011 – 50/10 Mbps

Operations: 24x7x365 (unmanned 7 months)

Mission: National Science Foundation (science), JPSS/NPOESS (weather), NASA (ISS, Shuttle Flights), EUMETSAT (weather), others
Black Island Teleport

(Backup system for the 11 meter system)

Antenna 2: 7.2 meter (refurb-Dec 2007)
Freq: Ku- Band
Gnd Station: Australia
Data Rate: 10 Mbps (duplex)
Operations: 24x7x365 (when active)
Provider: Optus D1
Design Challenges

- Must operate for 7 months unmanned – no teleport in the US can do this.
- Nearest facility: 22 air miles, 50 traverse miles, traverse difficult at end of austral summer
- Very low acquisition / visibility angle
Design Challenges cont.

• Parts delivery: 5 months in austral summer only – drives spare parts provisioning
• Must generate its own power: integrated solar, wind turbines, battery, generator
Design Challenges cont.

• Environmental survivability: 180-200 mph winds, heating building equipment rooms
• No hard wire/fiber access – toll grade microwave radios, backup radios
Design Challenges cont.

• Important issue – Must Have High Availability !!!
  • Redundancy, hot/warm automated failover
  • Remote monitoring and control
  • Remote diagnostics
  • Remote equipment switching
  • Remote access methods, etc.
  • Remote recovery from as many failures as possible

• Remote Monitor and Control for:
  • Satellite equipment
  • Power generation equipment
  • Building environmental
  • HF Radios
  • TV receiver system
McMurdo Station – Black Island Teleport

(Go to Live Internet)
Data Retrieval from the Frozen Continent

The Amundsen-Scott South Pole Station
The Polar Plateau – the largest desert on earth
The Amundsen-Scott South Pole Station

Population served: Summer – 260, Winter – 64
The structure has an aerodynamic design
summer population = 260, winter population = 50-60
Data Retrieval from the Frozen Continent

Before We Start - The Big Question ???

- Is Global Warming Affecting (pick one; Antarctica, Greenland, arctic)?
- 2009 - warmest year on record for South Pole Station - 54.3°F average

South Pole Temperature Distribution
Extreme Max/Min and Averages

30 year period: 1977-2006

Extreme Maximum: + 7°F     Extreme Minimum: -117°F

2009 temp – departure from normal - +2.6°F

Daily Average Temp w/Variation
Black = ave
Grn = low
Orn = High

Yearly Extremes
Red = High
Blue = Low

7/21/2011 | Page 28
Why are we here with our satellite ground stations?

South Pole Telescope

Worlds largest sub-millimeter microwave telescope
Data Retrieval from the Frozen Continent
Science at the South Pole Station

South Pole Telescope
IceCube is the world’s largest science experiment.
Data Retrieval from the Frozen Continent
Satellites at South Pole – Why so Difficult?
Data Retrieval from the Frozen Continent
GOES-3 & Skynet-4C Radome

GOES-3 Antenna: 9 meter
GOES Freq: L,S- Band
Provider: NSF
Gnd Station: Florida
Coverage: 6.75 hour / day
Data Rate: North–1.5 Mbps
          South–1.0 Mbps

Skynet Antenna: 2.4 meter
Freq:    X- Band
Provider: Intelsat
Gnd Station: United Kingdom
Coverage: 5.0 hour/ day
Data Rate: 1.5 Mbps

Primary Science Season: Austral Winter

South Pole Station
Marisat - Goes Antenna

Moonlight Illumination
Aurora Australis visible

GOES-3 & Skynet-4C Radome
SPTR-2 Antenna: 4 meter/fast tracking – dual band

**Ops Freq:** S- Band

**Data Rate:** 5.0 Mbps

**Science Freq:** Ku-Band

**Data Rate:** up to 150 Mbps

**Visibility:** 6.0+ hours/day

**Contact time:** 4.0 hours/day

**Provider:** NASA

**Gnd Station:** White Sands

**Future capability:** Ka-Band

**Significant Store & Forward System as the front end**
Data Retrieval from the Frozen Continent

Satellites Coverage Window

Must compete with ISS, Space Shuttle missions, other NASA missions for connect time – varies every day
Iridium Multi-Channel System (IMCS)

Hardware:
- 12 Iridium Data Channels
- Inverse Multiplexed (ML-PPP)
- Data rate: 28.8 Kbps

Operations:
- Operates whenever the main satellites are not visible
- CTBTO -Treaty Compliance Data
- Carries > 48% of Station E-mail
- Weather Data / Flight Operations
- Critical Op Data / SSH to Equip
Design & Construction Challenges

• South Pole Station: open to flights 110 days/year
• Construction window: 100 days/year (some equipment has smaller use window)
• Parts/equipment delivery: 100 days/year – drives spare parts provisioning
• Crew changes: up to 2 times/year
• Environmental: every year sees -100 deg F
• Extremely low acquisition/look angle
• Systems: must be designed to re-start even after cold soak
• Systems: must be designed for maintenance with gloves
• Winter access to equipment maybe limited by temp
Data Retrieval from the Frozen Continent
Satellites at South Pole – Why so Difficult?

Design Challenges cont.

• Important issue – Must Have High Availability:
  • Redundancy, hot/warm automated failover
  • Remote monitoring and control
  • Remote diagnostics
  • Remote equipment switching
  • Remote access methods, etc.
  • Need remote recovery from as many conditions as possible
  • Power management: UPS, conditioning, control
  • Link acceleration / compression / latency tolerance
• Remote Monitor and Control for:
  • Satellite equipment – 3 ground stations
  • Building environmental – 3 structures
  • HF Radios
Data Retrieval from the Frozen Continent
South Pole TDRS Relay (SPTR2)

Foundation – how to build on 2 miles of ice that moves 33’ each year
Data Retrieval from the Frozen Continent
South Pole TDRS Relay (SPTR2)
Data Retrieval from the Frozen Continent
South Pole TDRS Relay (SPTR2)
Data Retrieval from the Frozen Continent
South Pole TDRS Relay  (SPTR2)

SPTR2 Ground Station

- Radome
- Aircraft Warning Beacon (red)
- Building Locator Beacon (red)
- Antenna Armed for Motion Warning (red)
- RF Emission Active (amber)
Data Retrieval from the Frozen Continent
Iridium Multi-Channel Systems

Large field camps have populations of 50-95 personnel Byrd Field
- 850 miles from McMurdo Station
- 700 miles from the South Pole Station
- 10,000 miles from home and no local IT shop

What do you need for communications in today’s remote research environment that brings hi-tech instrumentation, aviation missions, etc.?

Answer: Phones, e-mail, wireless networking, Instant Messaging, Store & Forward data transmission, etc.

Byrd Field Camp: 2010 thru 2014
Data Retrieval from the Frozen Continent
Satellite Systems for Field Camps and Traverses

Iridium Multi-Channel System

Installing the Iridium Antenna Array

Kevin’s castle
Kevin Bliss – Server/Apps

Bob Croke – IMCS Engineer

Iridium Antenna Array
IT in a Box

- Camp wide wireless
- E-mail (size limited)
- Instant Messaging (text only)
- Secure off-continent file transport (size limited)
- Local file sharing
- Local print services
- Local computer kiosks
- Remotely managed after put-in

Portable Iridium Multi-Channel System for Remote Field Camps
Data Retrieval from the Frozen Continent
Satellite Systems for Field Camps and Traverses
Questions?

Think we should start charging a tourist fee?