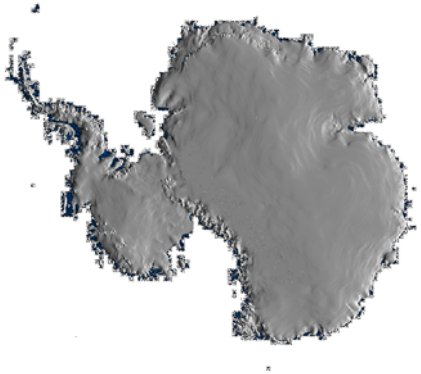


Raytheon

Polar Services

Presentation by:

Gary Ferentchak
PE, PMP

"Getting Data Off-Ice"

US Antarctic Program Satellite Communications

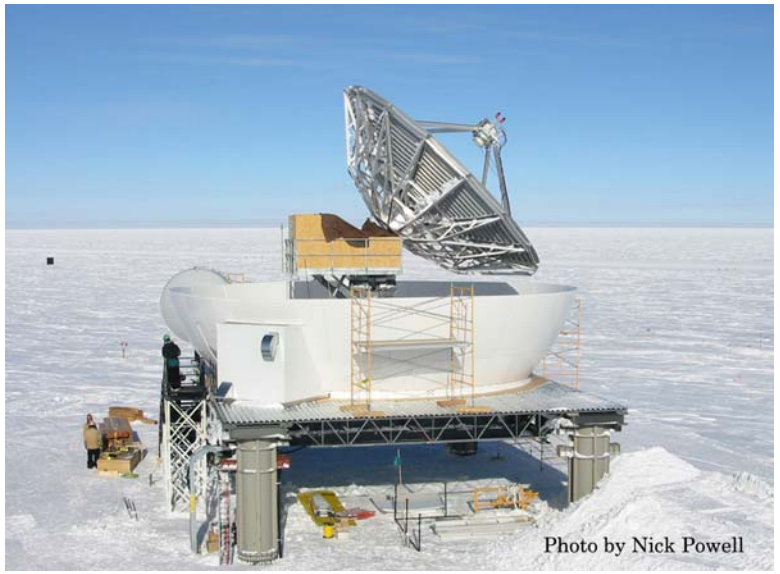
24-25 Apr 2008

Photo by Chris Demarest

Three ways to get science and operations data from Antarctica

Hand carry at the end of season

Iridium Phones & Modems



Broadband satellites

USAP Broadband Satellite Systems

- Palmer Station – 1 system
- McMurdo Station – 2 systems
- Amundsen-Scott South Pole Station – 3 Systems
- WAIS (summer) – 1 System
- Research Vessels – 1 per Ship

Narrow Band System

- Iridium Multi-Channel

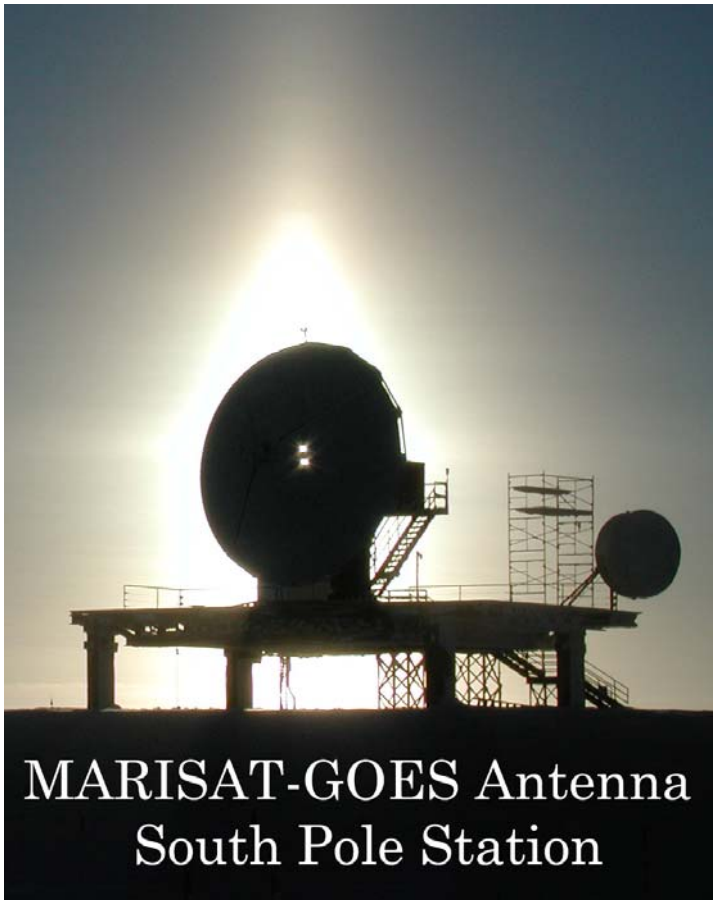
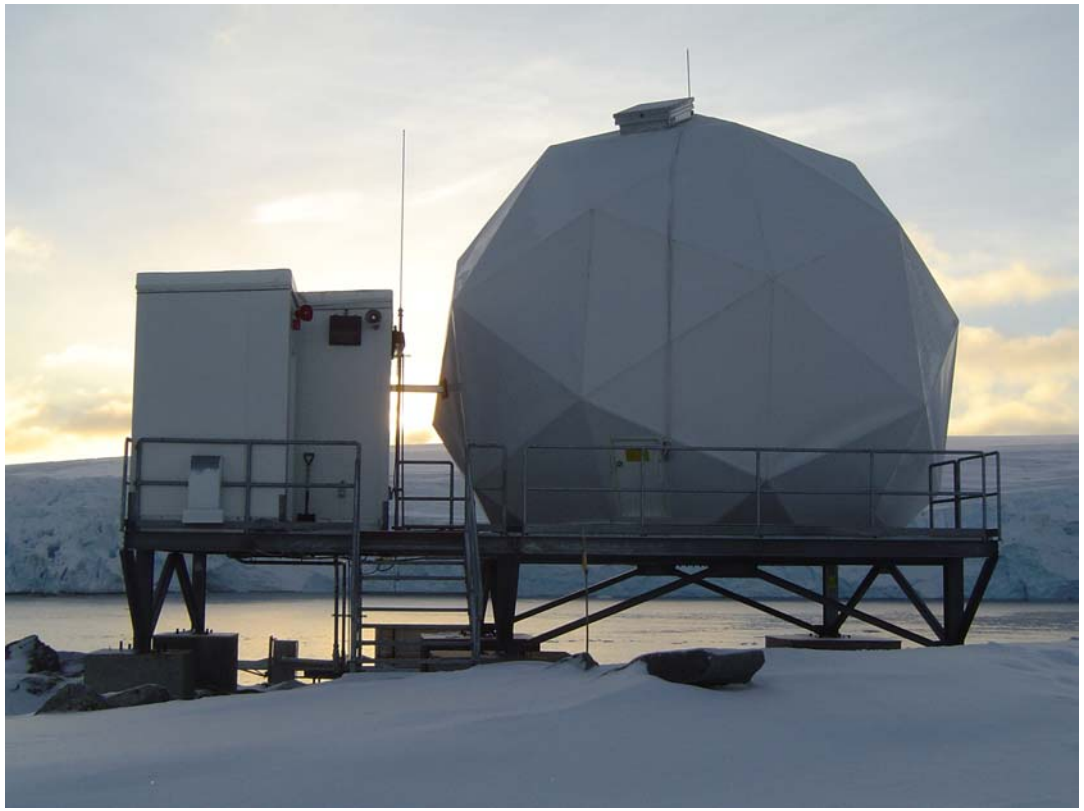


Photo by Dr. Will Silva

Palmer 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
Population served:
Summer: 30-44
Winter: 30



Primary Science Season: Austral Summer

McMurdo Station

Antenna 1: 11 meter (out of service)

Freq: Ku- Band (was C-Band)

Gnd Station: Australia (was WA State)

Provider: *was INTELSAT 701*

Data Rate: Pre 2006 – 1.5 Mbps

2006 – 3.0 Mbps

Provider: Optus D1 *(north/south)*

2009/10 Upgrade:

NSF Mission – 10/19 Mbps

NPOESS Mission – 50/01 Mbps

NPOESS , NASA, EUMETSAT, &

(DMSP – in discussion)

Primary Science Season: Austral Summer

McMurdo Station

Antenna 2: **7.2 meter (Dec 2007)**

Freq: **Ku- Band**

Gnd Station: **Australia**

Data Rate: **10 Mbps (duplex)**

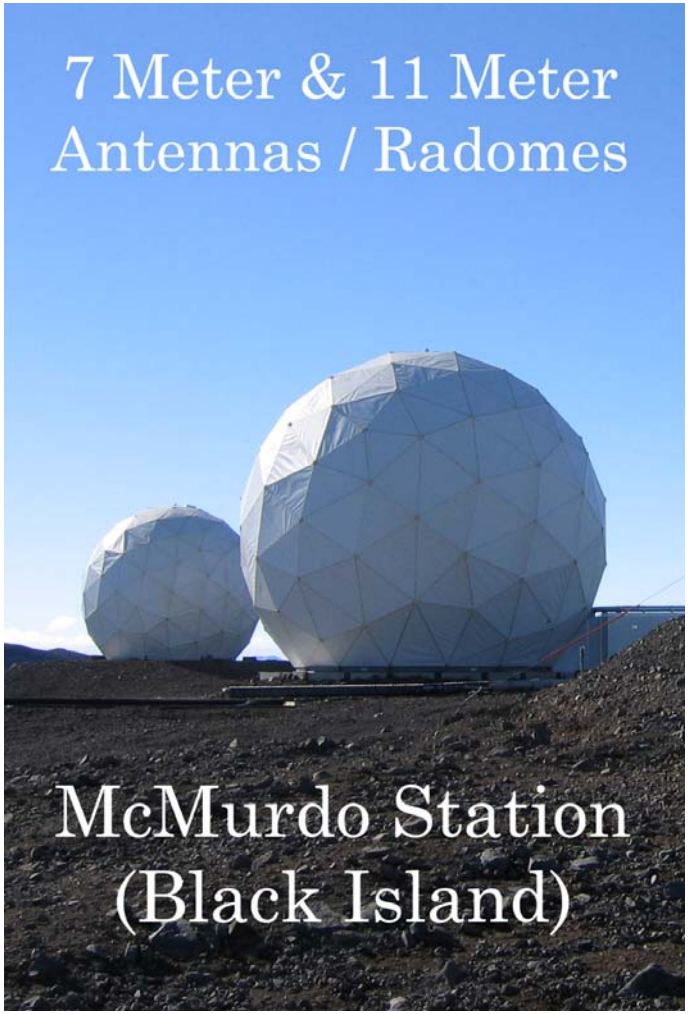
Coverage: **24x7**

Provider: **Optus D1**

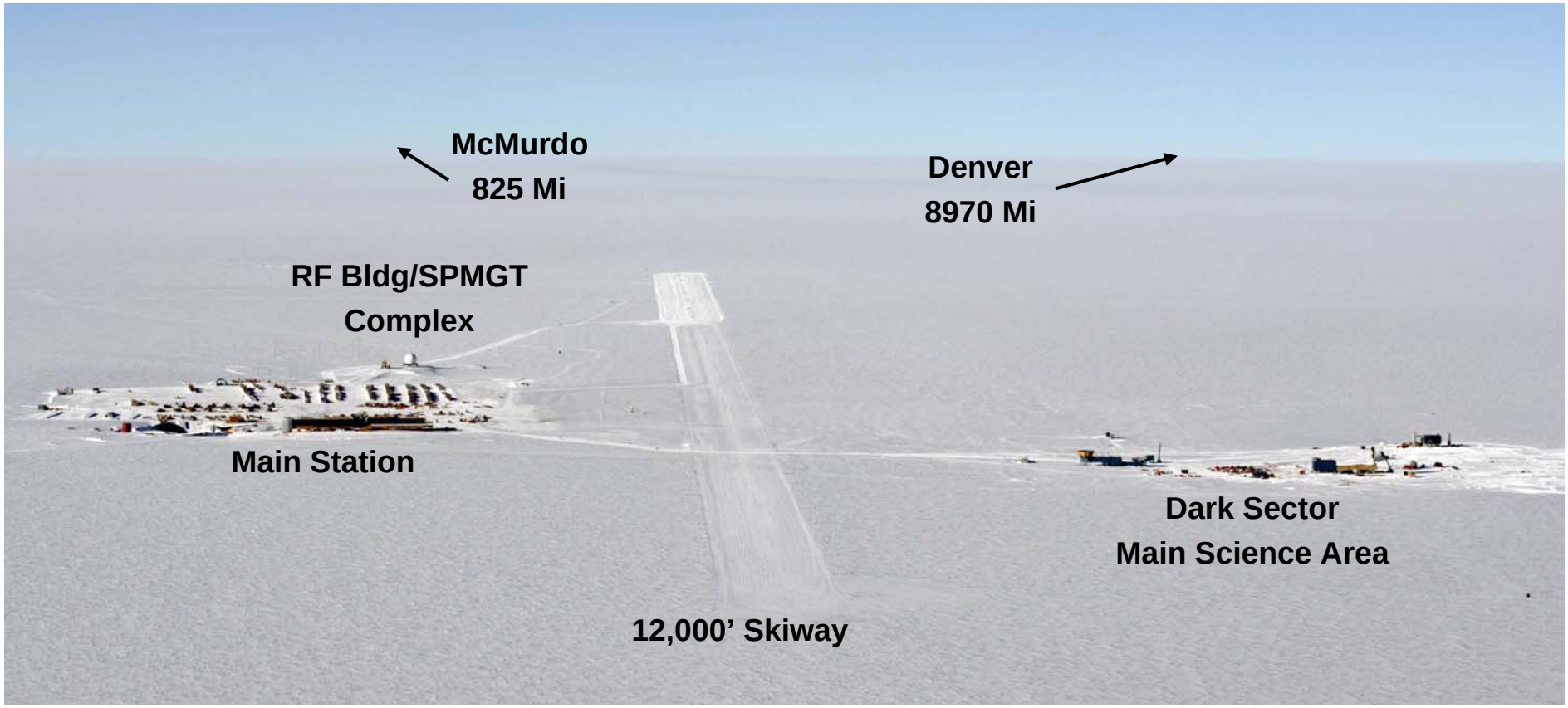
This 7.2 Meter System Becomes The Backup System For The NSF Mission when the 11 Meter System Is Commissioned in 2010

Population served: Summer: 1100

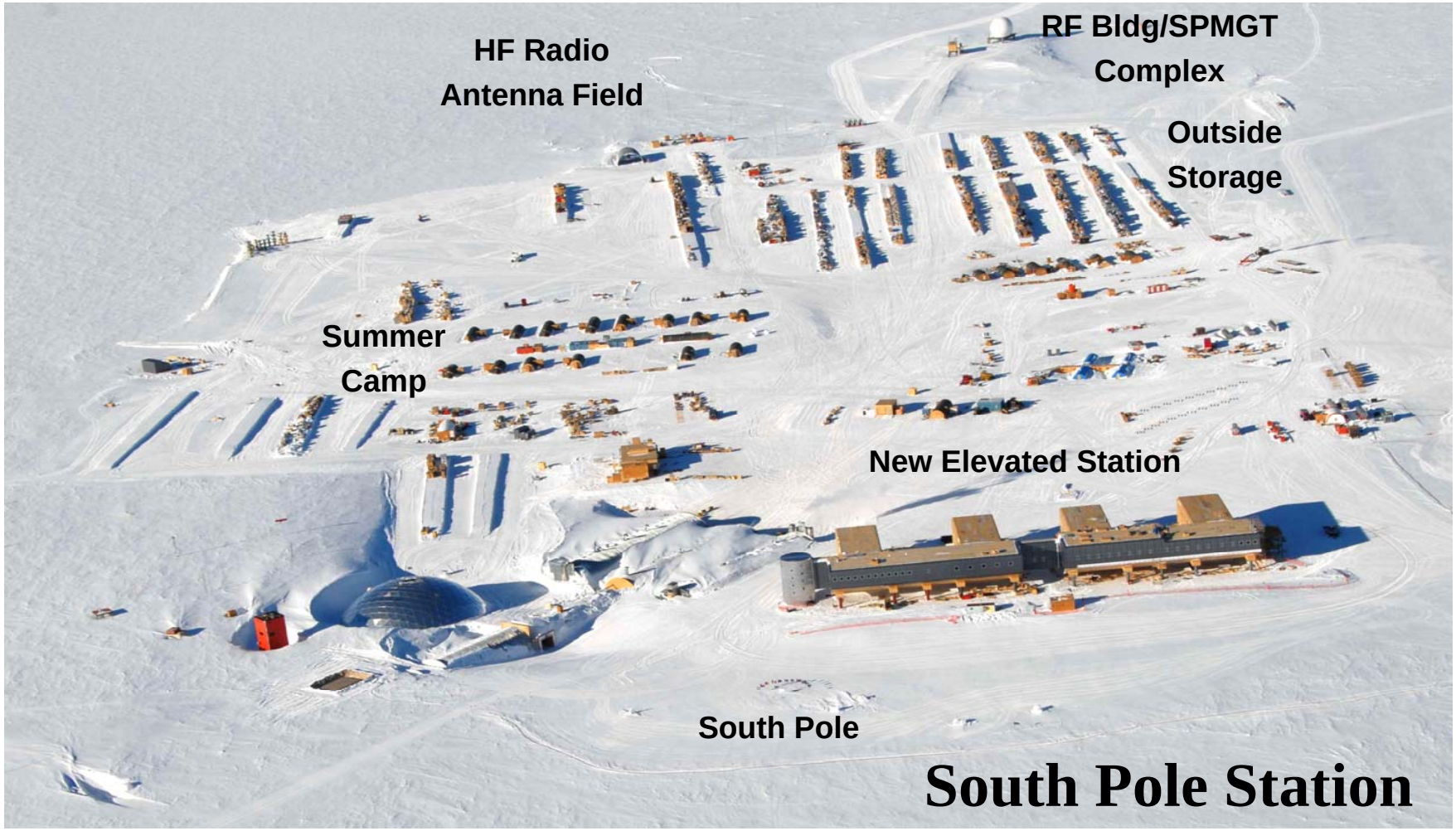
Winter: 103-160



South Pole Station



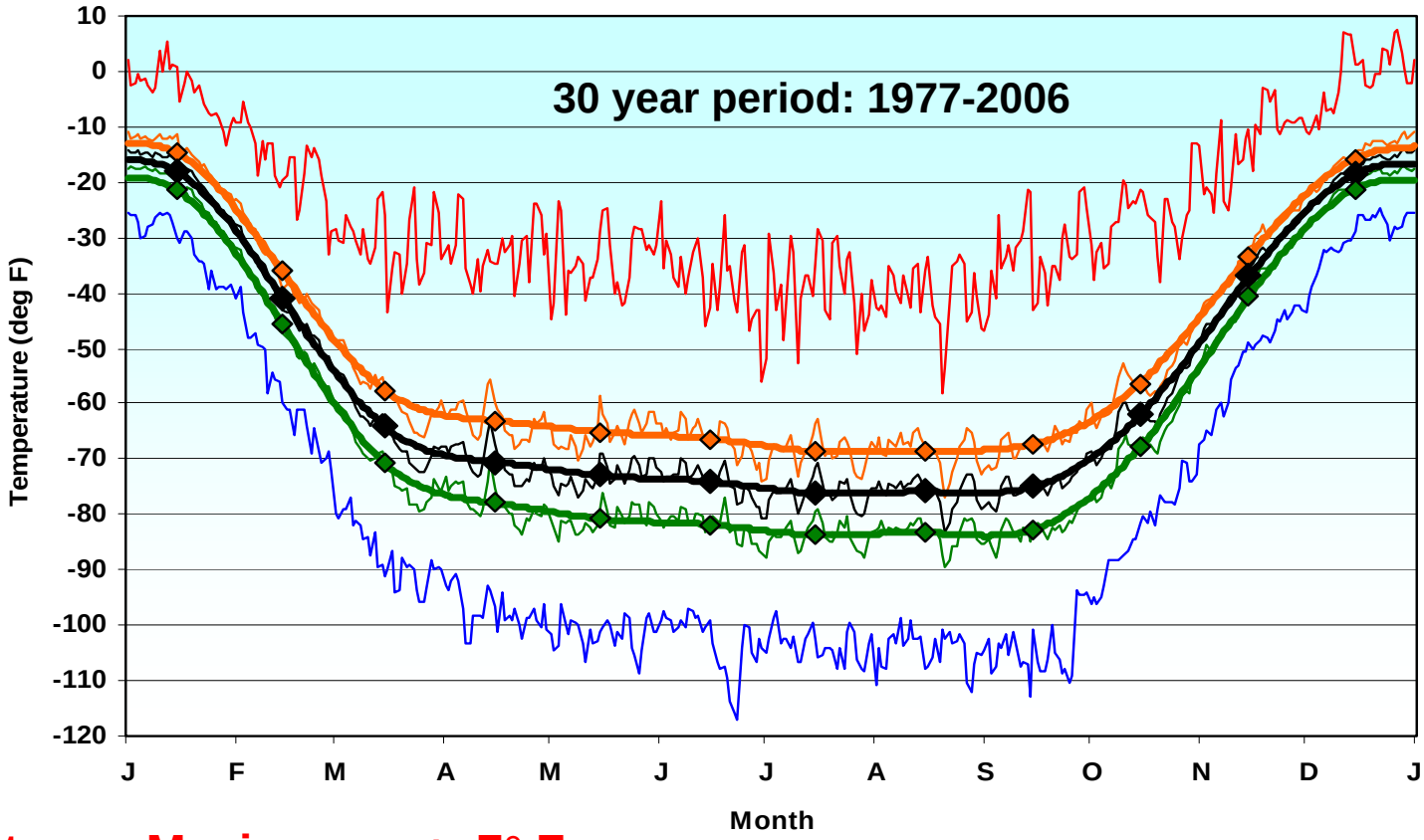
Primary Science Season: Austral Winter



Population served: Summer – 260, Winter – 64

South Pole Temperature Distribution

Extreme Max/Min and Averages



Daily Average Temp w/Variation

Black = ave

Grn = low

Orn = High

Yearly Extremes

Red = High

Blue = Low

Extreme Maximum: + 7° F

Extreme Minimum: -117° F

South Pole Station

Science Data Transport Demand

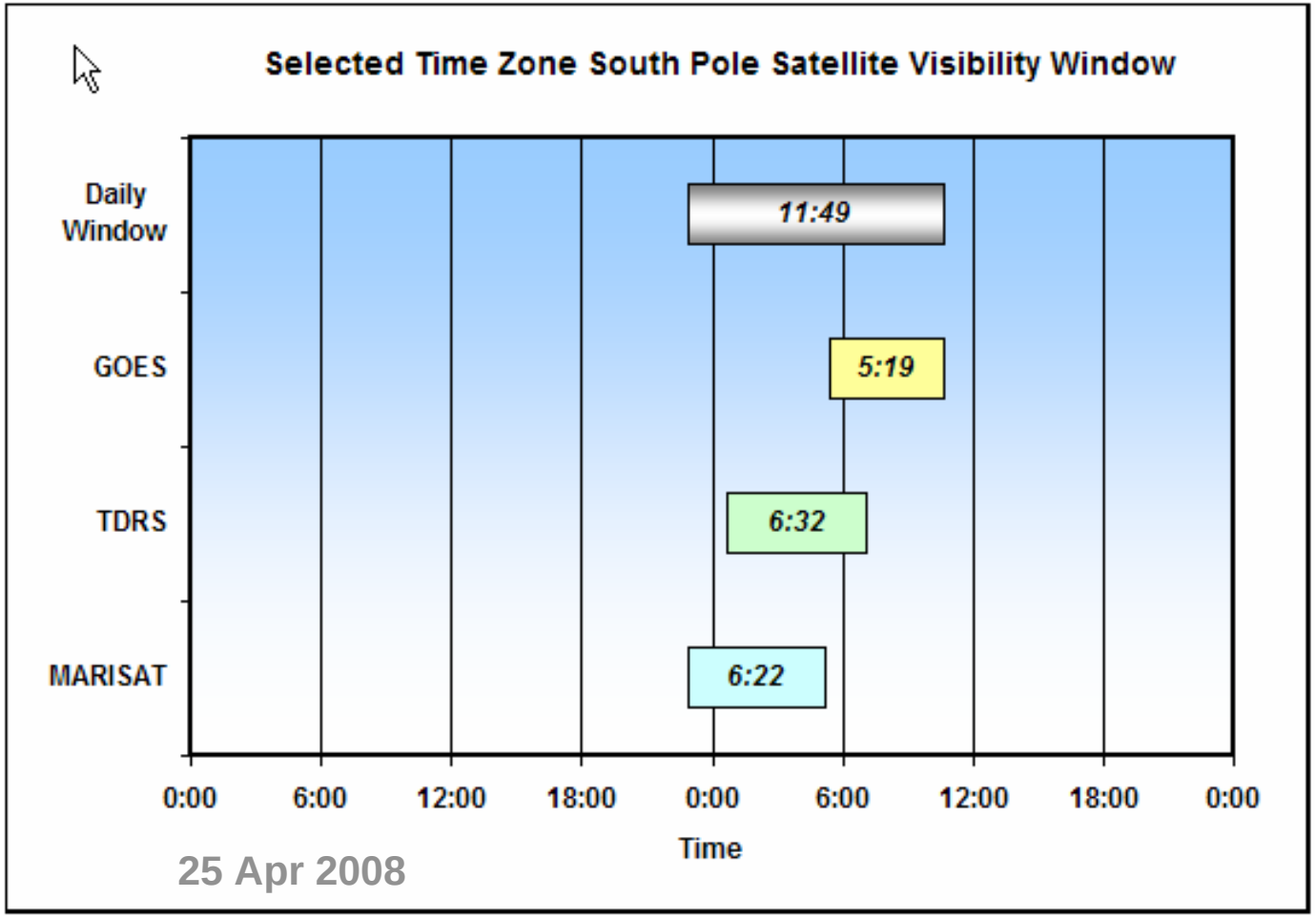
	Demand	Capacity
2006 –	10 GBytes / Day	10 GB/Day
2007 –	65 GBytes / Day	85 GB/Day
2008 –	90*GBytes / Day	100 GB/Day
	(Mid-Season Upgrade	120 GB/Day)
2009 –	110**GBytes / Day	160+ GB/Day***
2010+	TBD GBytes / Day	160+ GB/Day***

* = operational usage

** = estimated usage to be validated by operational use

*** = on TDRS F1 only, F3/4/5/6/7 will be less than F1 due to satellite scheduling availability and cost

South Pole Station – Broadband Coverage Window

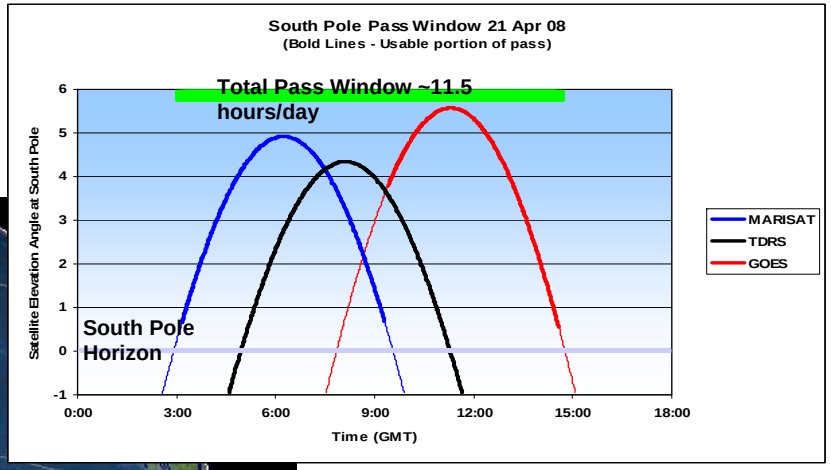


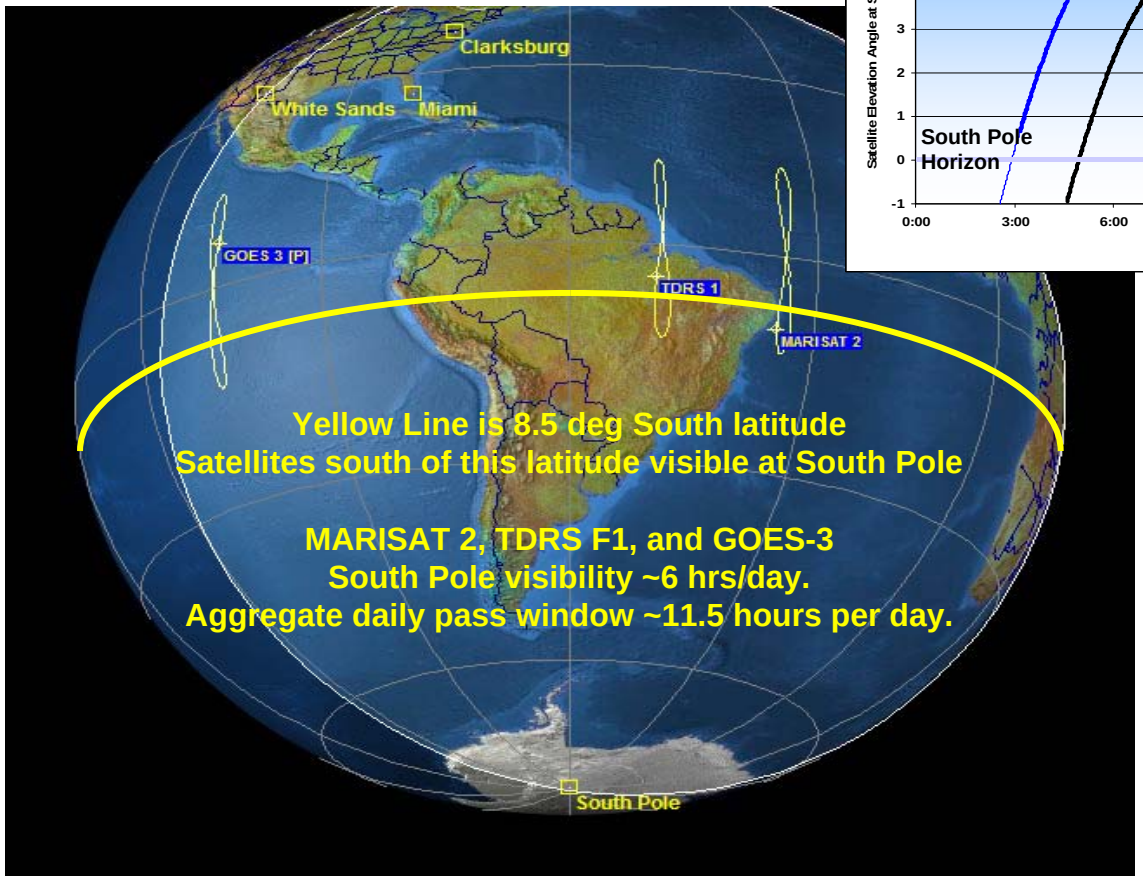
The 28.8 Kbps Iridium Multi-Channel System Comes Up Whenever One of These Satellites is Not Visible

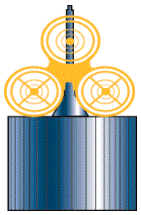
Roughly 12.5 hours/day Using 3.5 Million Airtime Minutes/Year

Satellites in use at South Pole:

MARISAT F2, TDRS F1, GOES-3 Geosynchronous satellites (70s/early 80s era), Inclinations 12.5 to 13.5 deg



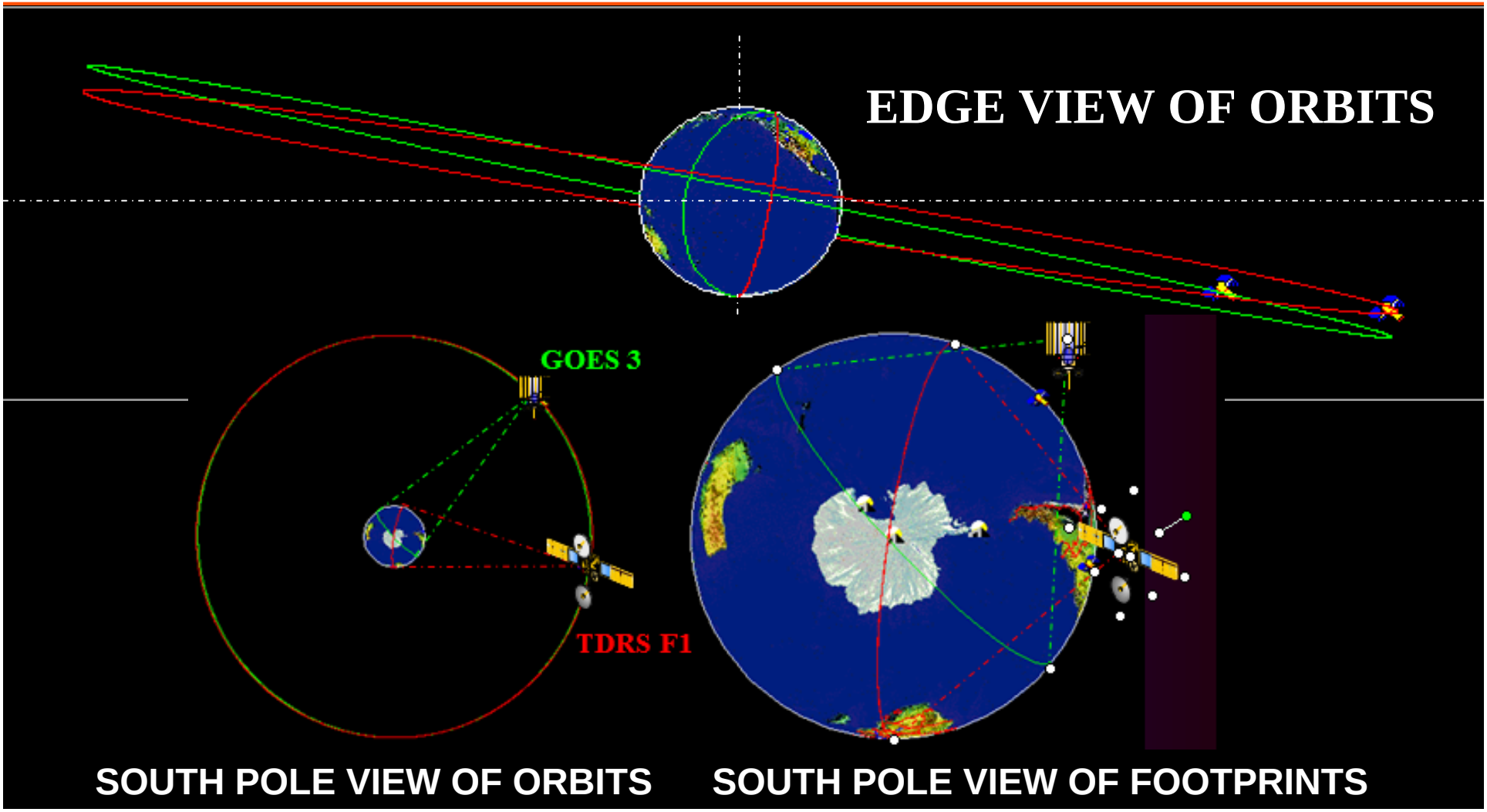


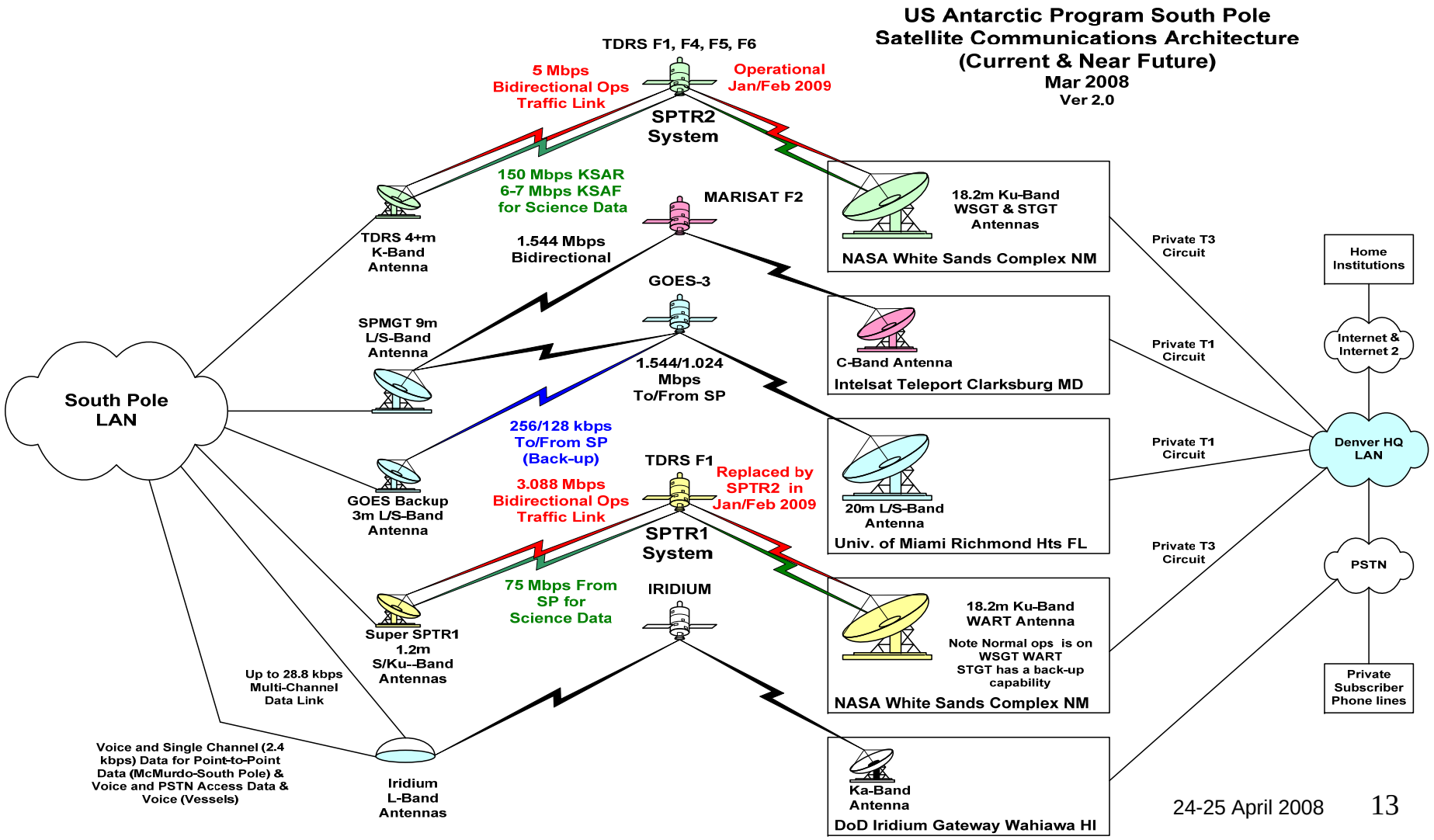


MARISAT F2
(NORAD Cat # 9478)

TDRS F1
(NORAD Cat # 13969)

GOES-3
(NORAD Cat # 10953)

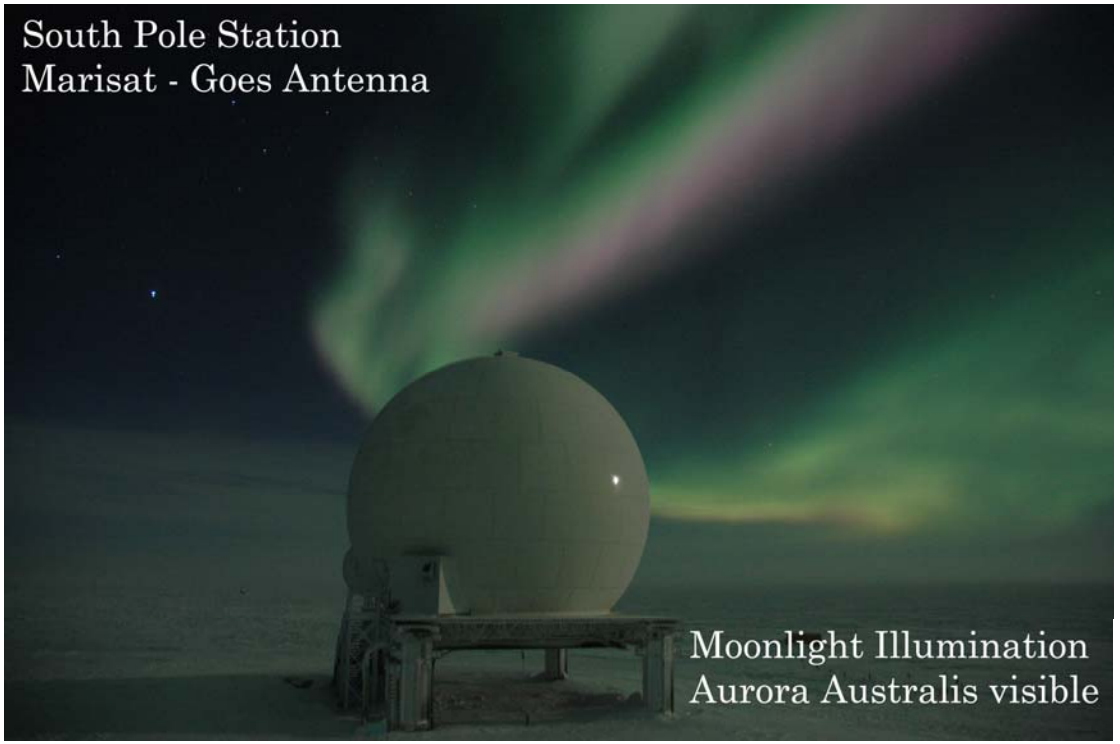

EDGE VIEW OF ORBITS
GOES 3
TDRS F1
SOUTH POLE VIEW OF ORBITS
SOUTH POLE VIEW OF FOOTPRINTS


US Antarctic Program South Pole
Satellite Communications Architecture
(Current & Near Future)
Mar 2008
Ver 2.0
TDRS F1, F4, F5, F6
5 Mbps
Bidirectional Ops
Traffic Link
Operational
Jan/Feb 2009
SPTR2
System
150 Mbps KSAR
6-7 Mbps KSAF
for Science Data
MARISAT F2
TDRS 4+m
K-Band
Antenna
1.544 Mbps
Bidirectional
GOES-3
SPMGT 9m
L/S-Band
Antenna
1.544/1.024
Mbps
To/From SP
256/128 kbps
To/From SP
(Back-up)
TDRS F1
Replaced by
SPTR2 in
Jan/Feb 2009
3.088 Mbps
Bidirectional Ops
Traffic Link
SPTR1
System
IRIDIUM
75 Mbps From
SP for
Science Data
South Pole
LAN
GOES Backup
3m L/S-Band
Antenna
Super SPTR1
1.2m
S/Ku--Band
Antennas
Up to 28.8 kbps
Multi-Channel
Data Link
Voice and Single Channel (2.4
kbps) Data for Point-to-Point
Data (McMurdo-South Pole) &
Voice and PSTN Access Data &
Voice (Vessels)
Iridium
L-Band
Antennas
18.2m Ku-Band
WSGT & STGT
Antennas
NASA White Sands Complex NM
C-Band Antenna
Intelsat Teleport Clarksburg MD
20m L/S-Band
Antenna
Univ. of Miami Richmond Hts FL
18.2m Ku-Band
WART Antenna
Note Normal ops is on
WSGT WART
STGT has a back-up
capability
NASA White Sands Complex NM
Ka-Band
Antenna
DoD Iridium Gateway Wahiawa HI
Private T3
Circuit
Private T1
Circuit
Private T1
Circuit
Private T3
Circuit
Home
Institutions
Internet &
Internet 2
Denver HQ
LAN
PSTN
Private
Subscriber
Phone lines

South Pole Station

Antenna: 9 meter
GOES Freq: L,S- Band
Provider: NSF
Gnd Station: Florida
Coverage: 5.3 hour / day
Data Rate: North–1.5 Mbps
South–1.0 Mbps

MARISAT Freq: L- Band
Provider: US Gov
Gnd Station: Maryland
Coverage: 6.3 hour/ day
Data Rate: 1.544 Mbps



MARISAT – GOES Shared Antenna

Primary Science Season: Austral Winter

South Pole Station – SPTR1

Antenna: 1.2 meter

Ops Freq: S- Band

Coverage: (S) 6.0 hour/day (TDRS F1 Only)

Pre 2007 – 1.5 Mbps

Data Rate: 2007 – 3.0 Mbps

Science Freq: Ku-Band (north only)

Coverage: (Ku) 4.9 hour/day (TDRS F1 Only)

Pre 2007 – 5 Mbps

2007 – 60 Mbps

Data Rate: 2008 – 75-90 Mbps (June)

Provider: NASA

Gnd Station: White Sands

South Pole Station – SPTR2 – Live Jan/Feb 2009

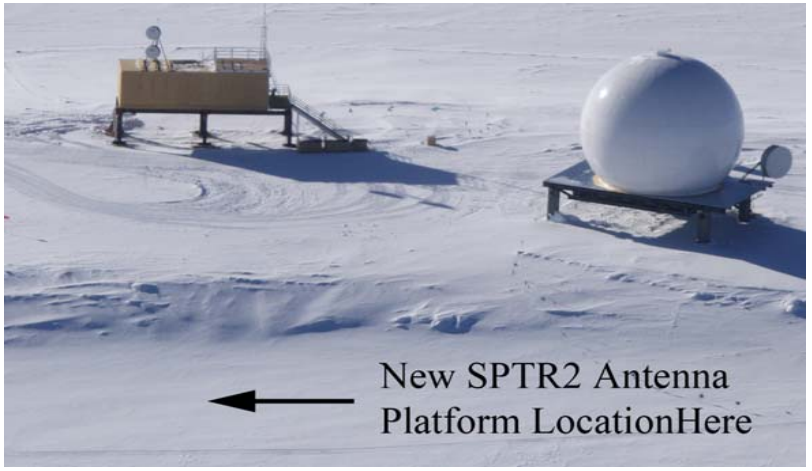
Antenna: 4 meter

(Fast Tracking Ka-Band Capability)

Ops Freq: S- Band

Coverage: (S) 6.0 hour/day

Data Rate 2009: ***5.0 Mbps***



Science Freq: Ku-Band (some bi)

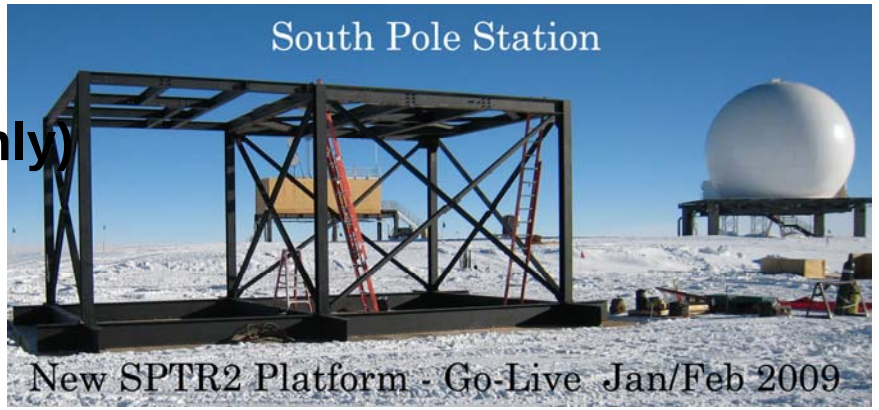
Coverage: (Ku) 6.0 hour/day (F1 only)

Coverage: (Ku) 2.0 hour/day (Fx)

Data Rate 2009: ***up to 150 Mbps***

Provider: NASA

Gnd Station: White Sands



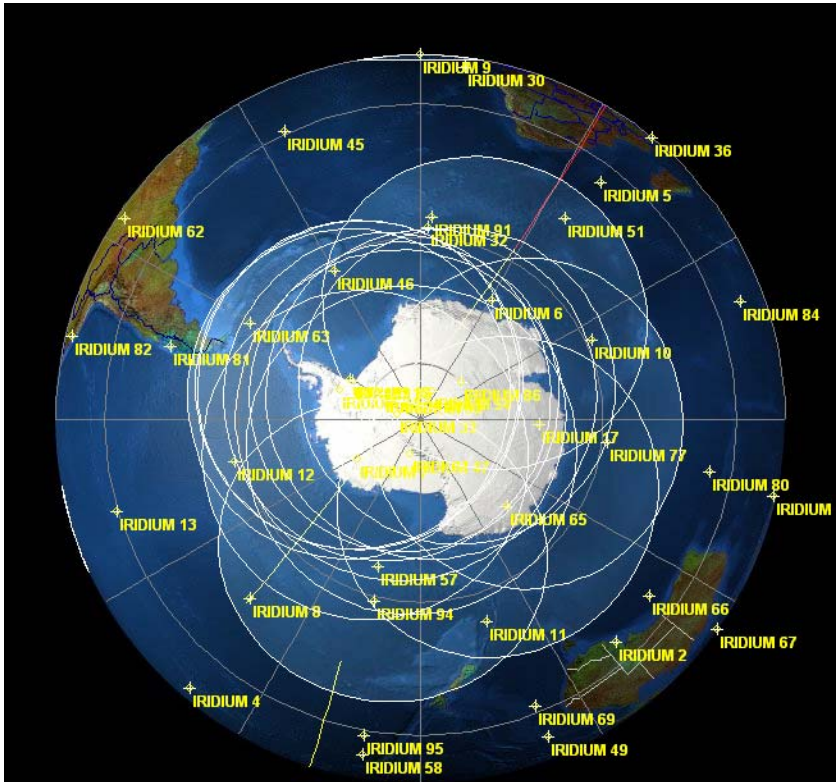
South Pole Station – Iridium Multi-Channel System

Hardware:

- 12 Iridium Data Channels
- Inverse Multiplexed (ML-PPP)
- Data rate: 2005=0, 2006: 9.6 Kbps
  2007: 28.8 Kbps

Operations:

- Operates whenever the main satellites are not visible
- CTBTO -Treaty Compliance Data
- Carries > 50% of Station E-mail
- Weather Data / Flight Operations
- Critical Op Data / SSH to Equip



Actual Iridium Footprint Over Antarctica

West Antarctic Divide (WAIS) – Portable GOES-3

Antenna: 2 meter

Freq: L,S-Band

Gnd Station: Florida

Data Rate: 38.4 Kbps

(Data Rate can be upgraded to 60-76 Kbps)

(Shares South Pole GOES-3 Capacity)

Coverage: 5.3 Hours/day

Provider: NSF

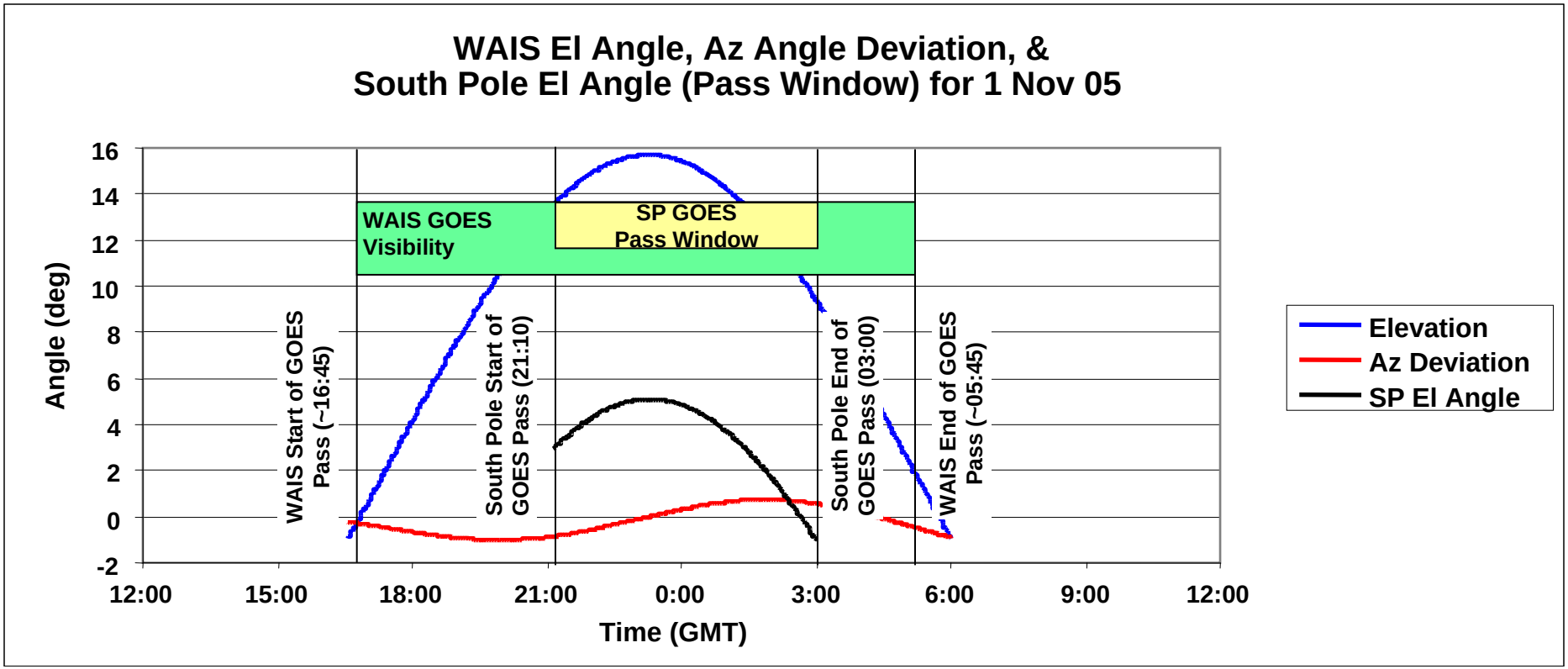
2 units available + spare

Science Season: Austral Summer

Population served:

Summer – 60 to 90

Winter – 0



Notes:

1. Calculations based on location of 79° 32’ S, 120° 00’ W
2. WAIS daily GOES satellite pass length: ~ 13:00 hours per day
3. Overlap/Non Overlap durations with South Pole ~5.8/7.2 hrs per day respectively
4. Total WAIS Az Deviation is ~1.8 degrees (-1.0 To +0.8 deg from midpass Az, 11.6 deg)
5. Max WAIS elevation angle is ~15.7 degrees

Iridium Technologies

- Open Port (new)
- Multi-Channel Systems
- Short Burst Data
- RUDICS
- Dial-Up
- Integration to PBX
- Integration to VoIP
- Iridium NEXT - 2nd Generation

Iridium Open Port

- Marine Grade
- No Moving Parts
- Priced per megabyte
- IP based / Cat 5 Connector
- Three VoIP Lines
- IP Data (9.6 Kbps to 128 Kbps)
- VoIP & Data Can Run Concurrently
- Has Completed Sea Trials
- Cost Effective v.s. INMARSAT

Below Deck Unit

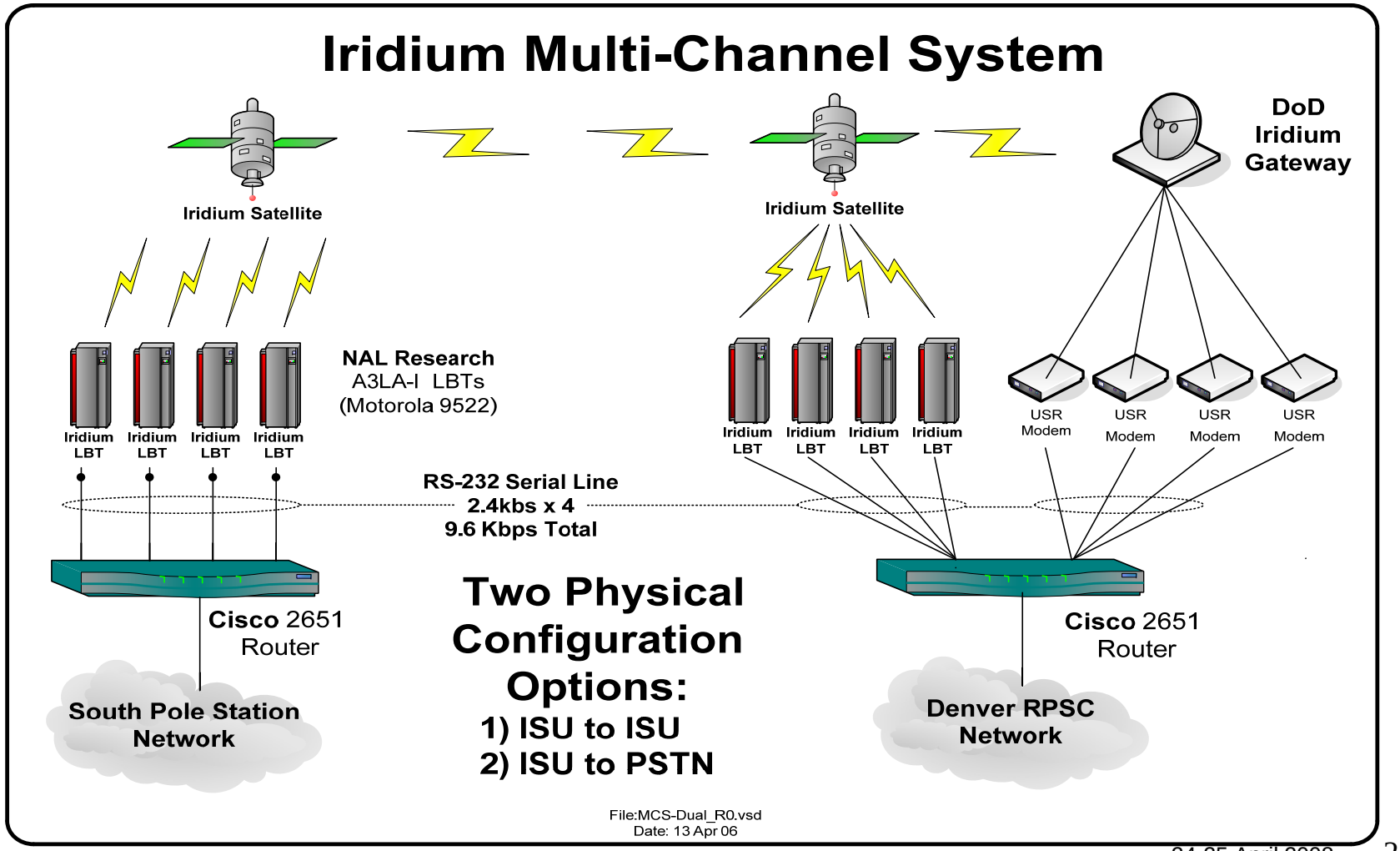
8”x10”x2” – 3 lbs

http://www.designwithmgi.com/iridiumeverywhere/IE_Volume3_Issue1.pdf

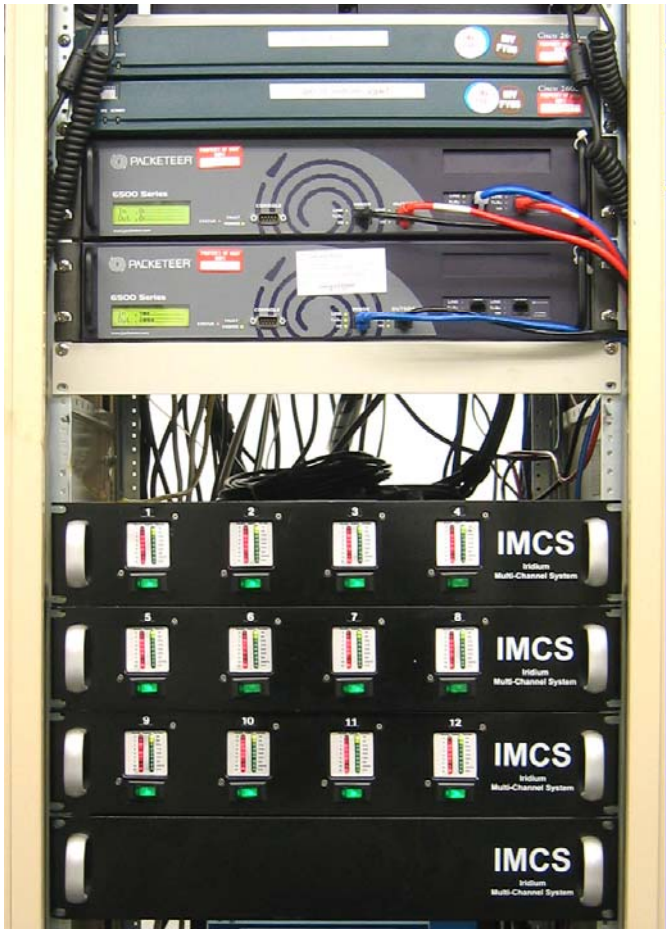
Iridium Open Port

Information Courtesy of Dr. Ngoc Hoang – NAL Research

- Beta Testing Will Run From 15 May - For About 6 Months
- 50 Beta Units (Not Available for Resale)
- Who Will Get Beta Units - Go to Top 10 Service Providers & Iridium Corporate
- Commercial Gateway Service Available First - After Beta Testing Is Completed
- DoD Gateway Service Being Discussed
- Approximate Cost of Hardware - $5000-$6000
- Per Byte Transport Cost - Not Known Yet
- Service Available to Foreign Counties - Yes
- Temperature Rating (Antarctic Service) - Not Known Yet


Iridium Multi-Channel System
Iridium Satellite
Iridium Satellite
DoD Iridium Gateway
NAL Research
A3LA-I LBTs
(Motorola 9522)
Iridium LBT
Iridium LBT
Iridium LBT
Iridium LBT
Iridium LBT
Iridium LBT
Iridium LBT
Iridium LBT
USR Modem
USR Modem
USR Modem
USR Modem
RS-232 Serial Line
2.4kbs x 4
9.6 Kbps Total
Cisco 2651 Router
Cisco 2651 Router
South Pole Station Network
Denver RPSC Network
Two Physical Configuration Options:
1) ISU to ISU
2) ISU to PSTN
File:MCS-Dual_R0.vsd
Date: 13 Apr 06

South Pole Station – Iridium Multi-Channel System



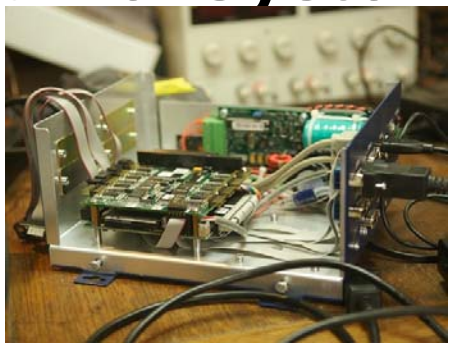
- IMCS Edge Router
- Iridium Voice Gateway Router
- Packeteer 6500
- Packeteer 6500

Iridium Multi-Channel System (IMCS)

- IMCS Chassis #1; Iridium Channels 1 thru 4
- IMCS Chassis #2; Iridium Channels 5 thru 8
- IMCS Chassis #3; Iridium Channels 9 thru 12
- IMCS - Spare Parts Drawer

Flavors of Iridium Multi-Channel Systems

National Science Foundation / Raytheon Polar Service -12 Channels

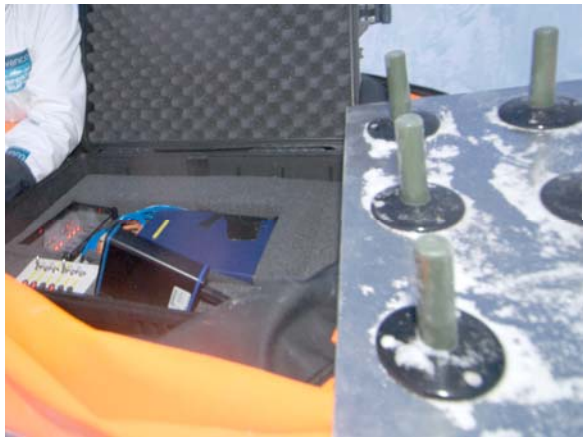


Arctic Survey - UK
6 - Channels

General Dynamics *Reachback*
Linux – 4 Channel

Kansas Univ
Linux, 4-8 Channels

Other Iridium Multi-Channel System Users



Artic Survey 2009/10

Pen Hadow

Russia to Canada via the North Pole

Dr Andrew Jackson

USGCC *Healy*

Arctic Research

Communications

KU PRISM

Greenland & Antarctica Research

Radar Ice Mapping

Dr Victor Frost

Iridium – Short Burst Data

Rapid Growth – Cost Effective – Easy to Use – Service incl w/SIM

- **NSF Science Usage 3 Years Ago = ~0**
- **NSF Science Usage on 13 Apr 2008 – Shown Below**

Mobile Originated (# of messages):

30 Minutes	1 Hour	2 Hours	4 Hours	8 Hours	12 Hours	1 Day	7 Days	45 Days
102	247	545	1152	2347	3623	7380	51950	227802

Mobile Terminated (# of messages):

30 Minutes	1 Hour	2 Hours	4 Hours	8 Hours	12 Hours	1 Day	7 Days	45 Days
	0	1	8	8	8	9	170	1540

Iridium – Short Burst Data

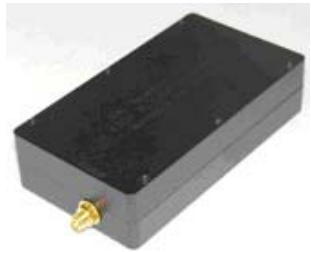
Most Common Delivery Options:

- **Email – Body**
- **Email – Plain Text**
- **Direct IP**
- **Send - 1960 Bytes (A3LA)**
- **Receive - 1890 Bytes (A3LA)**

Note: must request provisioning for any unit

Note: Some Government Restriction(s) On Foreign Use of 9601 unit

When Procuring 9601's: Must specify "EMSS Capable" - not all 9601's are usable on the DoD Iridium Gateway – three providers in US.



9601 SBD Only Modem

Send – 205 bytes

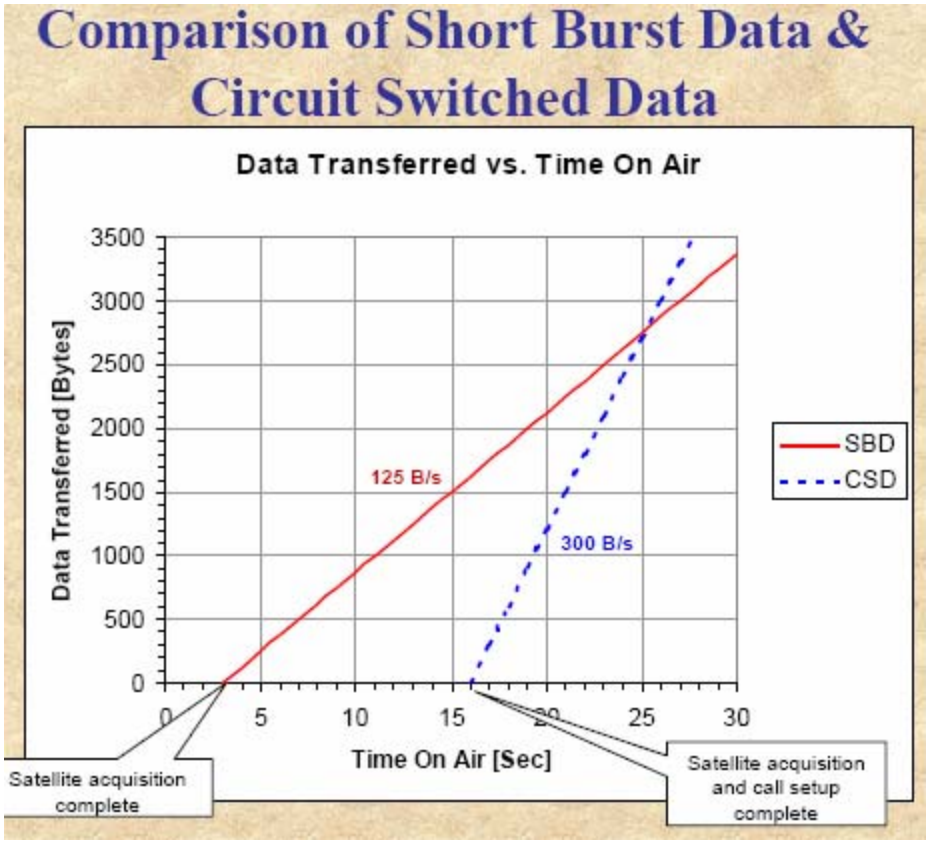
Receive – 135 bytes

Latency < 60 seconds

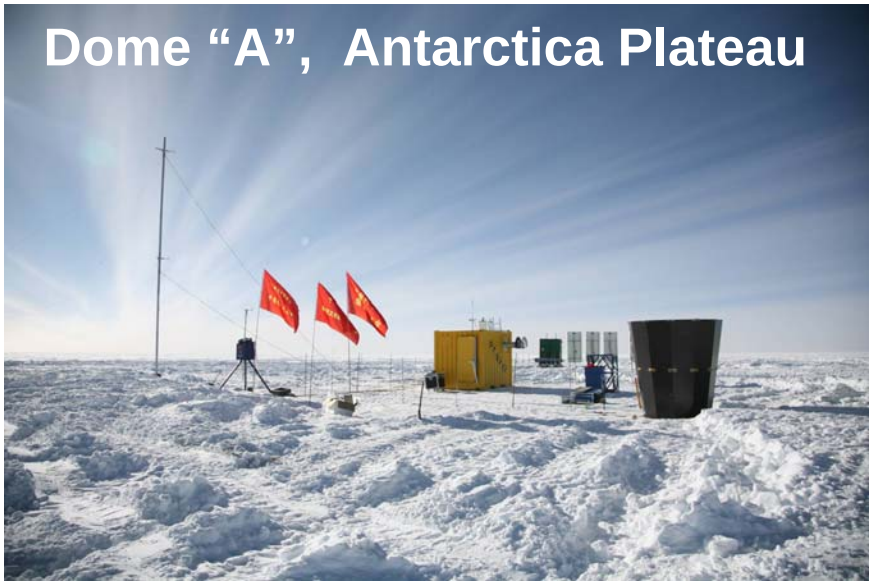
Cost < $500

Iridium – Short Burst Data

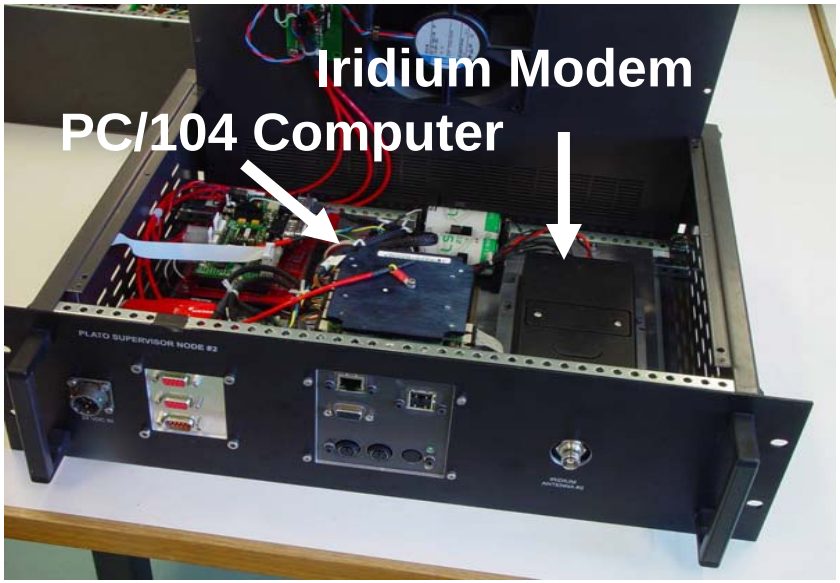
- SBD Messages are Delivered Much Quicker Than Dial-Up
- Direct IP= Fastest Delivery Mode
- Less Power Consumption
- 99.x% Delivery On First Attempt – Varies With Message Size
- SBD Session Controlled By Extended "AT" Command Set
- Does Not Require Registration to Iridium Space Network



Iridium – Short Burst Data User – "PLATO"



PLATO is a China-Australia-UK-US Collaboration



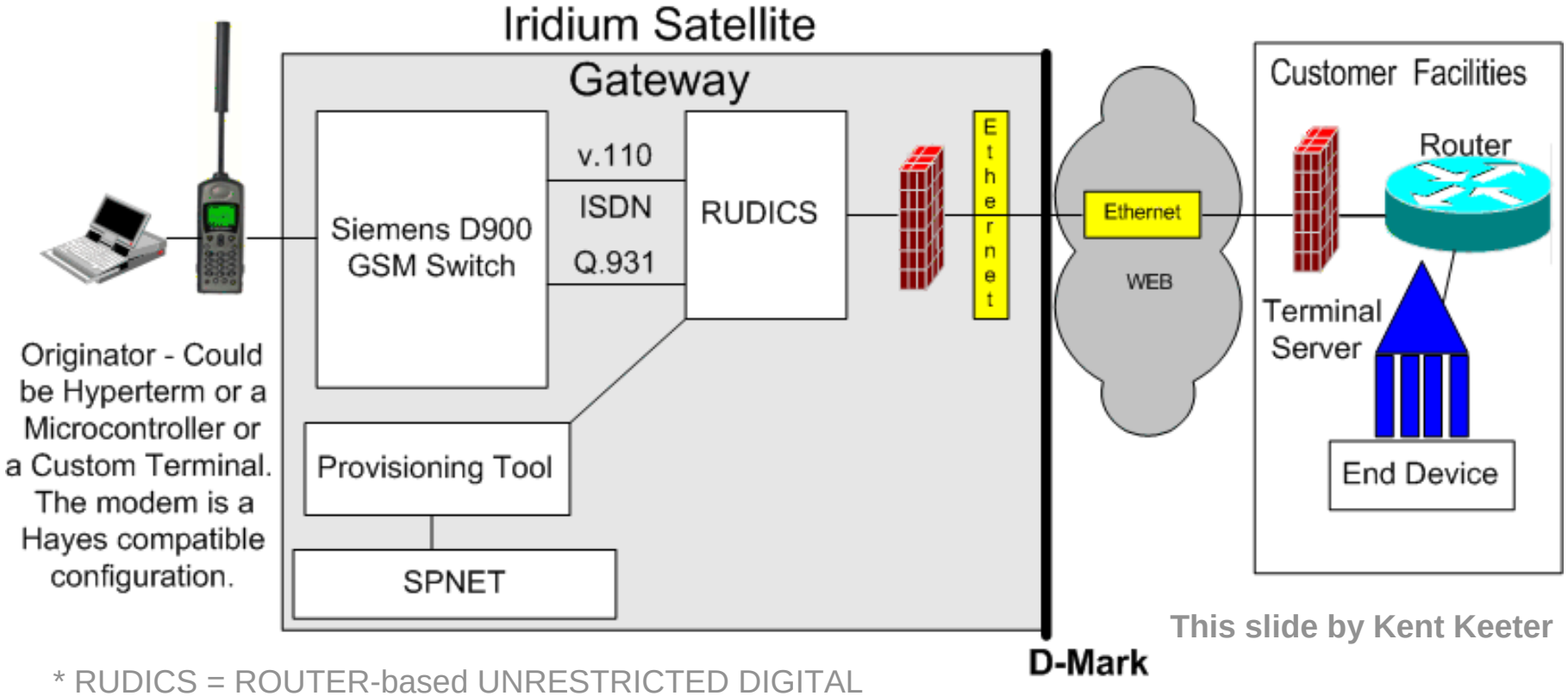
One of Two Supervisory Linux Computers

Highest Antarctic Research Station – 13,428 Feet, One Of The Coldest Naturally Occurring Places On Earth (<-120 Deg F), Dome A Is Believed To Be The Best Site For Ground-based Astronomy, Robotic Observatory - Operates Up To 11 Months Unattended

Photos and information provided by Dr. Michael Ashley – U. of New South Wales

Iridium – RUDICS*

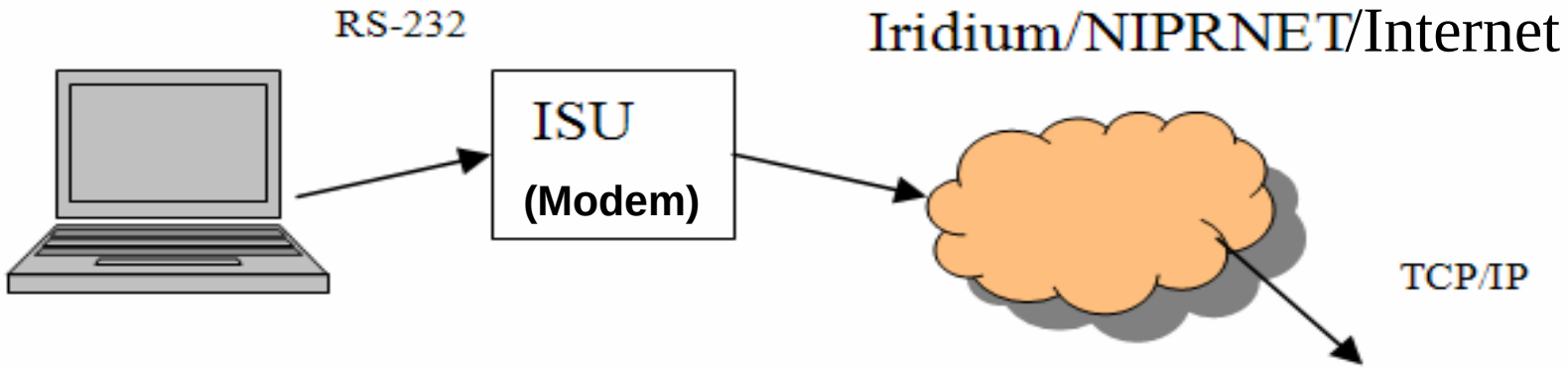
Custom Device-ISU-GW-RUDICS-WWW-Terminal Server- Custom Device/Server



This slide by Kent Keeter

* RUDICS = ROUTER-based UNRESTRICTED DIGITAL INFORMATION CONNECTIVITY SOLUTION

Iridium – RUDICS



PC client (remote) Running Hyperterm

Need More Capacity than SBD?

RUDICS Is Highly Valuable for Science Groups Operating Numerous Sets of Remote Field Instrumentation

PC running server application (Java or C/C++)

This slide by Kent Keeter

Iridium – RUDICS – NOAA User

Global ARGO project:

- RUDICS Chosen As A Scalable Communications Solution
- 140 Iridium Equipped Apexs Worldwide, 100 Are Using RUDICS
- APEX Profiling Drifters Typically Deliver Data At The End Of 7 Day Dive
- 58 APEX Drifters Under Antarctic Ice
- Instrument Can Detect Ice Before It Reaches The Surface And Re-dive
- Can Store Months Worth Of Profiles
- When Drifter Surfaces - GPS Fix Received

Iridium – PSTN & VoIP Integration

- Sailor has FXO port = very easy integration to PSTN or VoIP equipment
- Beam RST-100 has FXS port - intelligent RJ11/POTS/PBX
- Both have Voice & Data
- Sailor needs Ring Signal converter - European square wave/voltage to US sine wave/voltage Viking RG-10A inexpensive and works well.

Eurocom Sailor Unit

Beam RST-100

Iridium NEXT – Second Generation

Switch to Iridium Confidential & Proprietary PPT Slides

Normal Iridium Behaviors

Issues that must be addressed during the design of remote systems

Iridium Call Drop Data

Call Drop Frequency (Presented as Average Up Time per Channel)

- **Denver to Denver: Nights & Weekends 122 Min**
- **Denver to Denver: Prime Business Hours 30-50 Min**
- **South Pole to Denver 50-75 Min**

Typical S. Pole to Den Call Drops per 24 Hours

Date	Async33	Async34	Async35	Async36
4/3	28	24	18	28
4/4	13	17	9	17
4/5	9	17	11	20
4/6	28	24	13	39
4/7	18	20	11	20

Iridium – Dial-Up

Everyone Does Dial-Up – Remote Usage Reminder

- **Disable "PIN" and "Call Forwarding" For Modem Use**
- **Power Cycle Modems Once / Week Or Sooner** (Cures Many Evils)
- **ALWAYS Dial-out Occasionally** (Loss of Registration Issue Example)
- **Use More Than One Communications Mode – Devices Can Be Concurrently Provisioned For: Dial-up, SBD, RUDICS, SMS, Etc.**
- **DoD SIMs and Commercial SIMs Do Not Talk To Each Other !!!**
- **Remember the Iridium Dial Plan – There Are Different Access Codes For NADP, 800#'S, Intl, Etc.** (Iridium Is Country Code "8") 008-816-763-12345
- **Be able To Reconfigure Remote Systems On-The-Fly** (Epoch Change Example)
- **Have Intelligent "Phone-Home" Algorithm – No Blind Dialing**

Network Performance Across Iridium – Dial-Up

- Windows Applications and Windows TCP/IP stack are not tolerant of the large time delays across the constellation
- Round Trip Ping Denver > South Pole > Denver (seconds):

  Low - 0.9 , Ave - 1.3, High - 4.8 (DAV or PSTN) (OK for Windows)

  Low - 1.9 , Ave - 2.8, High - 10+ (Non-DAV) (Not OK for Windows)

Authorized Government User Iridium Costs

Government User Iridium Costs

All but 9601 SBD Service

Monthly SIM Cost = $305

- Airtime Minutes = Unlimited
- Short Burst Data = Unlimited *
- SMS = Unlimited
- RUDICS = Unlimited
- Internet = Unlimited

* = all but 9601 SBD only modem

Open Port - DoD pricing being discussed

Availability: US Government Agencies, NSF Grantees and Some US Allies

9601 SBD Modem

Monthly Service Cost

- One Time Setup: $81
- Monthly Recurring : $10.63
- Plus - per byte costs of:

Plan	Monthly USAGE	Rate per Month
Tier I	Unlimited	$136.50
Tier II	100 kb	$68.25
Tier III	30 kb	$26.26
Tier IV	Inactive	$10.50


Questions???
Feb 2008

Artic Sunset w/ Photoshop Enhancement

Questions ???