

# **Polar Technology: Power & Communications Options**

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*Polar Technology Conference*

*Mountain View, California*

*24 April 2005*

## *Presentation Overview*

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- ❑ **PolarPower.Org Website**
- ❑ **User System Survey Results**
- ❑ **System Deployment Categories**
- ❑ **Communications Options**
- ❑ **Design Tradeoffs**
- ❑ **NSF's Arctic Logistics Support**

# Website on Power Systems for Polar Deployment

**PolarPower.org** Remote power systems for polar environments.

Home Technologies Examples Links Forums News Contact Search

Site Map  
About Us  
News

> [Home](#) >

### About the Site

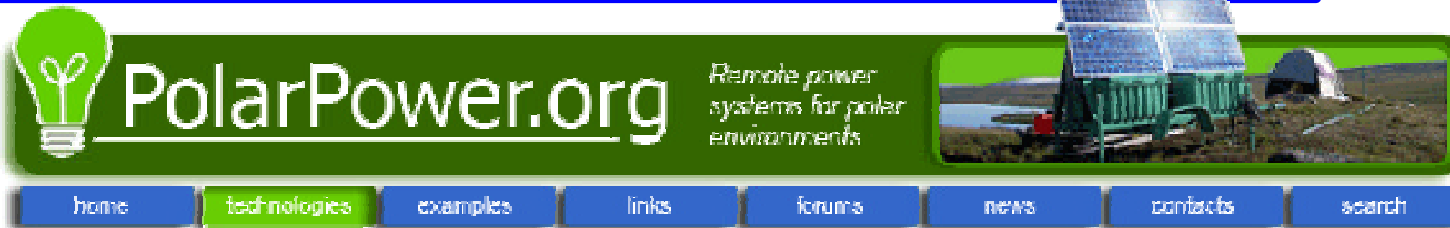
PolarPower.org is funded by [National Science Foundation](#) with the goal of providing a useful working resource for researchers in choosing, designing, implementing, and maintaining remote power systems in polar environments. The site will allow the polar research community to establish a foundation of knowledge, share experiences, and stay current on technological developments.

The development of this site was a direct result of recommendations from the [1999 Autonomous Systems in Extreme Environments Workshop](#) and the [2001 Renewable Energy Working Group Meeting/Workshop](#).

Looking for Polar Power, Inc.? They're at <http://polarpower.net>.



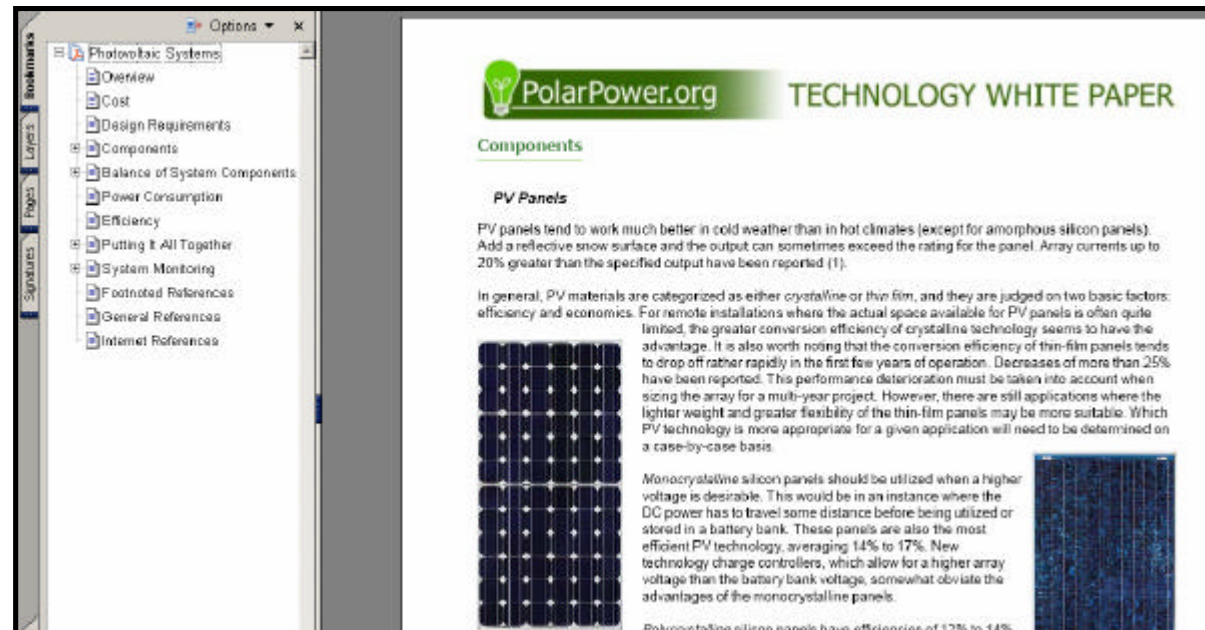
# Remote Power Technologies – Reference Papers



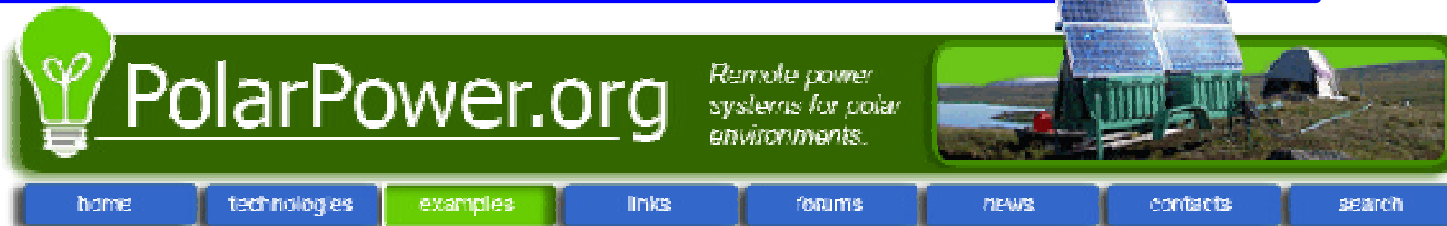
- ❑ Series of PDFs offering detailed discussions of available technologies, determining suitability, design and implementation considerations

- Topics such as...

- ✓ Solar
- ✓ Wind
- ✓ Engine Generator
- ✓ Electrical Fundamentals



## Case Studies as Examples



### Existing deployments as examples of the technology used

- Seeking additional write-ups
  - Systems
  - Components
    - Power Drain
    - Temperature Range
  - Lessons learned
  - Other?



Optima

Implementation Example

Ivotuk Autonomous Research Platform

VECO Polar Resources  
Power System: Tracy Dahl (tracypolar@tracovey.com)  
Communications System: Roy Stahlke (roy.stahlke@alaska.edu)  
<http://www.veco.com>  
<http://transport.alaska.gov/ivotuk/>

**Systems Overview**

Ivotuk is a small research site supporting autonomous instrumentation that is powered 24 hours a day, 365 days a year. The Ivotuk site also allows for near real-time transfer of the scientific data to the researchers' home institution along with the capability of remotely monitoring some of the scientific equipment and the power system.

**Location**

Ivotuk, Alaska, lies at the southwestern edge of the National Petroleum Reserve on the North Slope, well in the interior of Alaska (68.0° N, 155.0° W).

**Power Requirements/Instruments Powered by System**

Power is primarily required for the operation of meteorological experiments and data acquisition instrumentation as well as for the satellite communications system, which is necessary for the transfer of data to researchers' home institutions.

The system supports the power and data transfer needs of research instrumentation for Dr. Walter Oechel's Global Change Research Group (GCRG) at San Diego State University and the data transfer needs of Dr. Larry Hinman of the Water and Environmental Research Center (WERC) of the University of Alaska, Fairbanks.

GCRG's experiment consists of a suite of carbon flux and meteorological instruments. For more information on the specific instruments and data collected visit GCRG's web site at <http://www.usda.gov/ed/programs/ez/>. WERC maintains a meteorological tower at Ivotuk. For more information on those data and instruments please visit <http://www.uaf.edu/water/>.

A StarBand satellite system provides two-way, near real-time Internet connectivity. A pair of RF

# Discussion Forums




- **Researcher-driven discussions on remote power technologies**

Home Search Member List Faq Register Login

Welcome to PolarPower.org Forums.

You may enhance your user experience and customize your settings if you [register](#) for a free account. Registration is not required and is optional. Please note you must register to post to the forum.



### PolarPower.org Forums

A forum to discuss remote power applications for the polar regions.  
Managed by [VECO Polar Resources](#) using open source software developed by [Telligent Systems, Inc.](#)

**Login Now**


Username  Password  Remember Me

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Welcome, today is Thursday, April 21, 2005 5:12 PM (GMT -8)

[Active](#) | [Unanswered](#)

Forums	Last Post	Threads	Posts
<p><input checked="" type="checkbox"/> <a href="#">Remote Power Technologies</a></p>			
<p> <b>Polarpower.org Feedback</b> Have comments or questions about PolarPower.org site design, content, etc.? Please post them here!</p>	<p><b>Forum Discussion</b> by Tracy 25 Feb 2005 6:49 PM</p>	1	1

[PolarPower.org Forums](#) (please select) ▼

**Forum Statistics**

 **12** users have contributed to **35** threads and **39** posts.

In the past 24 hours, we have **0** new thread(s), **0** new post(s), and **0** new user(s).

In the past 3 days, the most popular thread for everyone has been "". Our members have mostly viewed the thread titled "". The most posts were made to "".

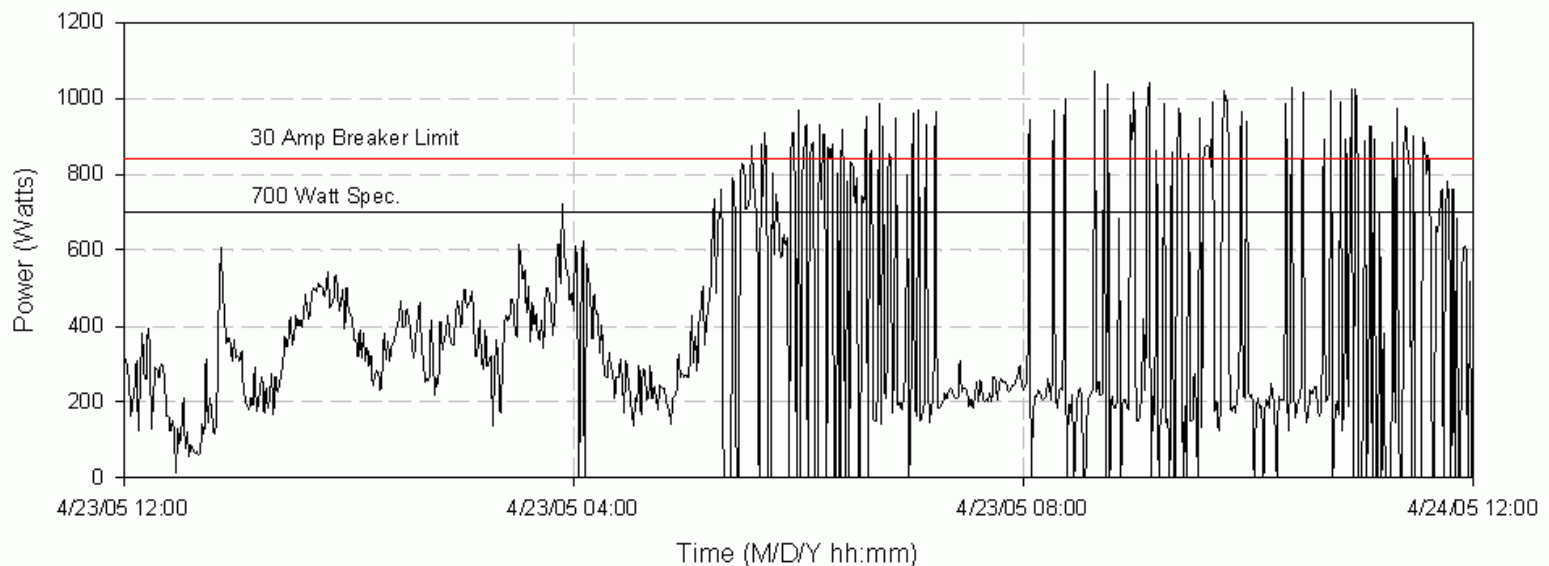
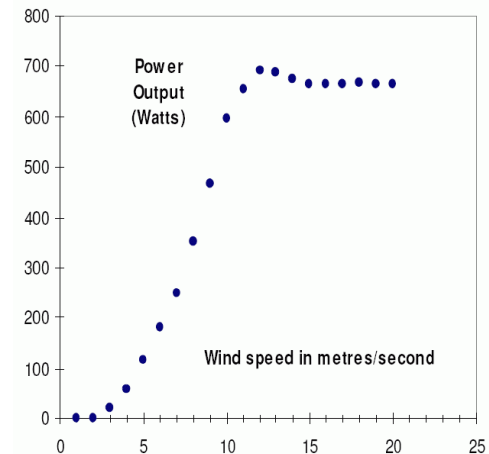
Please welcome our newest member .

**Top 10 users in past 24 hrs**



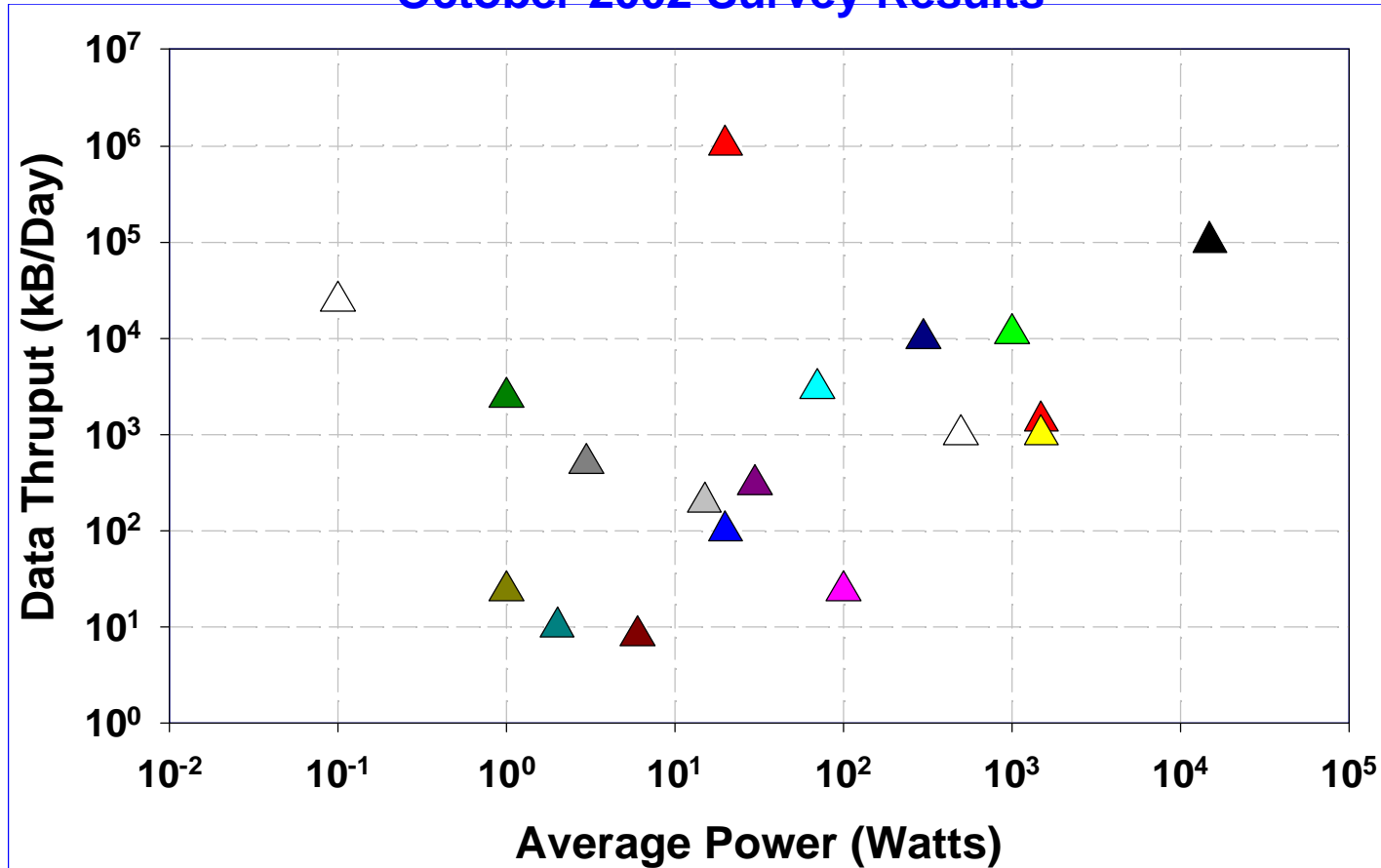
## Verify Component Specifications

- **Proven WT600 Wind Turbine**
  - **600 Watts nominal**
  - **700 Watts max**
- **30-Amp breaker tripped during wind event in December 2004 at 38 Amps measured**
  - **Replaced with 50-Amp breaker in March 2005**



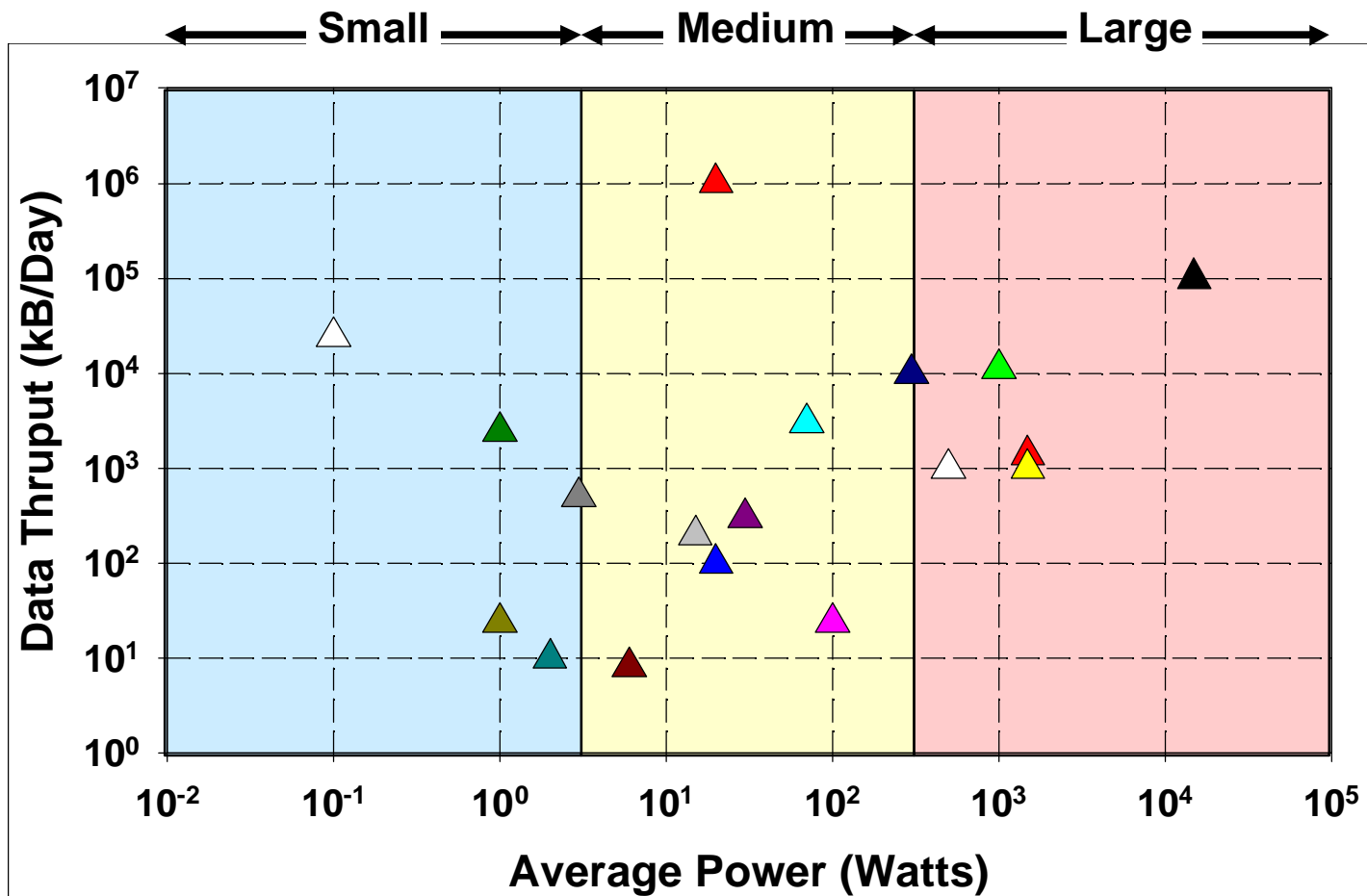
# Data Throughput vs. Average Power

## October 2002 Survey Results

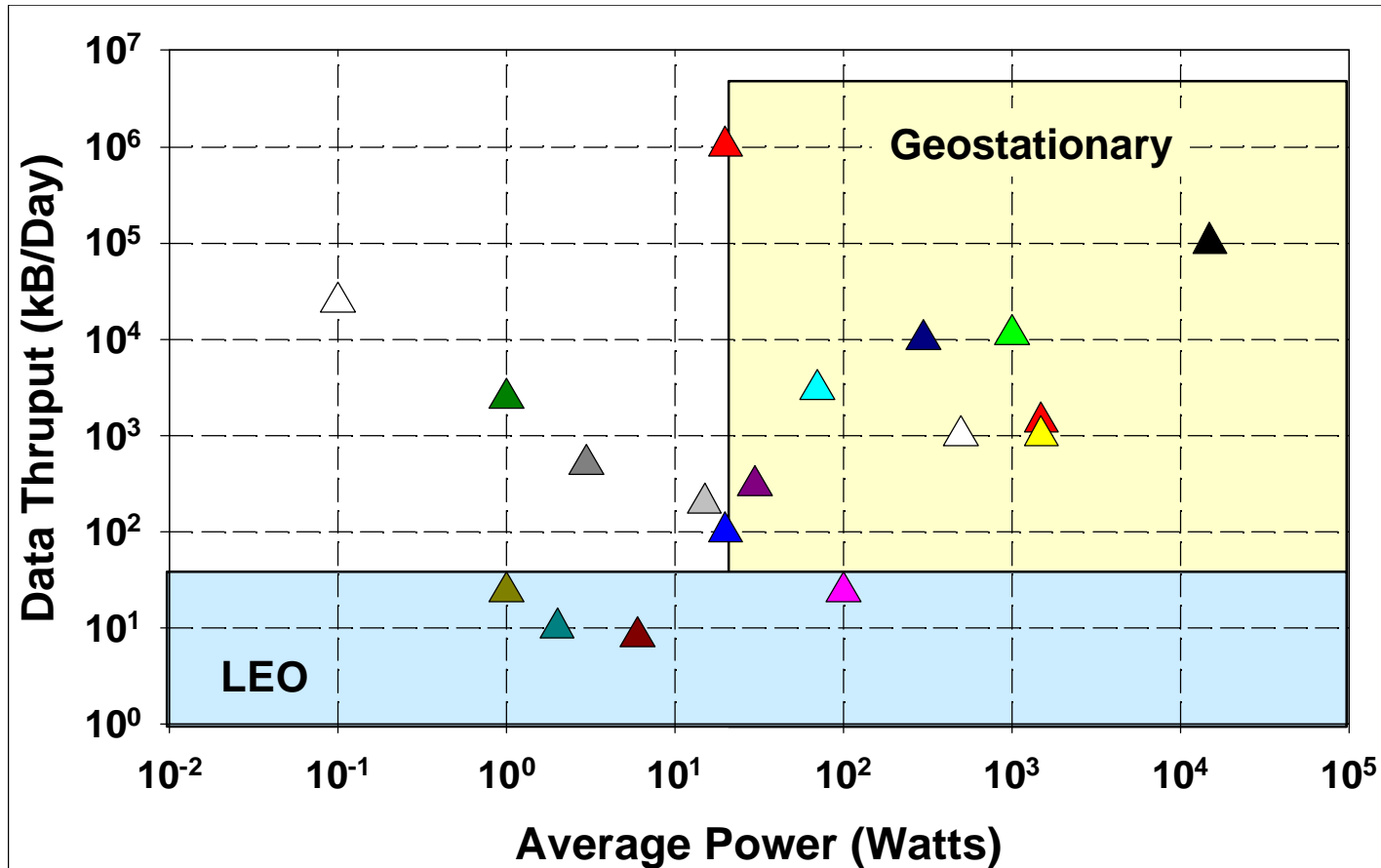




## Data Throughput vs. Average Power (Power Class)



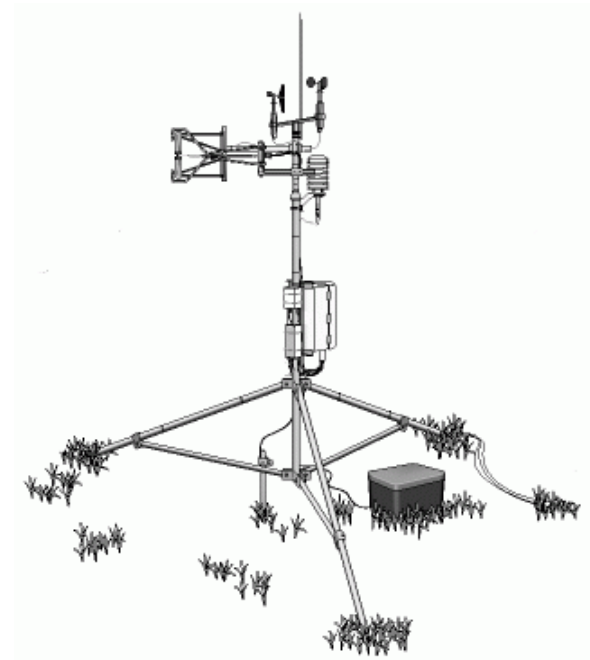
## Data Throughput vs. Average Power (Satellite Comms)



## *Small System*

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- ❑ **Single tower deployment**
- ❑ **Battery bank as primary power source**
  - **< 3 Watts average power**
  - **Photovoltaic array or wind turbine as secondary source**
- ❑ **Low data throughput requirement**
  - **Daily data & status report**
- ❑ **LEO satellite communications service**
  - **Iridium**
  - **Argos**
  - **Orbcomm**
- ❑ **Geostationary satellites**
  - **GOES**

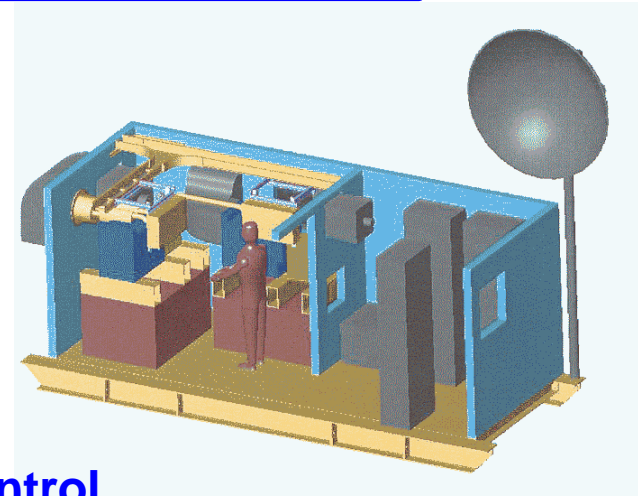


**SRI International**

## *Medium System*

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- ❑ **Generator in shelter**
  - 3 to 300 Watts average power
  - Some thermal management
  - Fuel storage
  
- ❑ **Moderate data throughput**
  - Updates hourly or more often
  - Remote monitoring and system control
  
- ❑ **Geostationary satellite communications system**
  
- ❑ **Need smaller system for easier deployment**
  - Modular elements to increase capacity



## *Large System*

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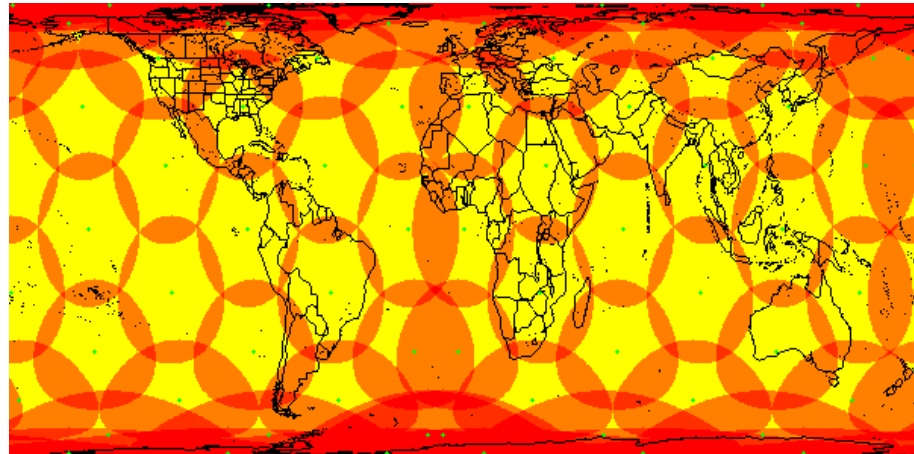
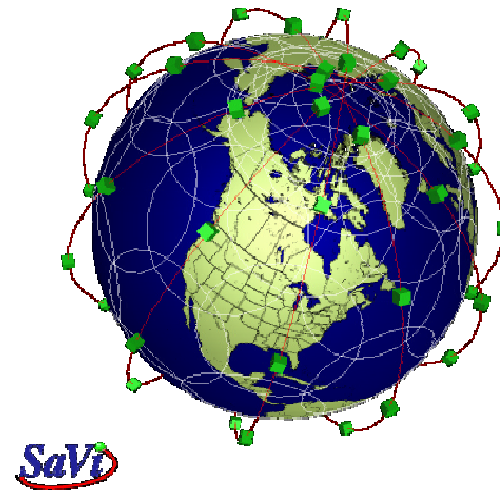
- ❑ **Permanent Camps**
  - **Summit Camp**
  - **Toolik Lake**
- ❑ **> 300 Watts Average Power**
  - **Multiple generator systems**
  - **Major refueling logistics**
- ❑ **Large data communications needs**
  - **Data transfers**
  - **E-mail**
  - **Weather**
  - **Logistics planning**
- ❑ **Geostationary satellite Internet access or scheduled polar-orbit satellite service**
- ❑ **WLAN within camp**



## *Iridium Satellite Service*

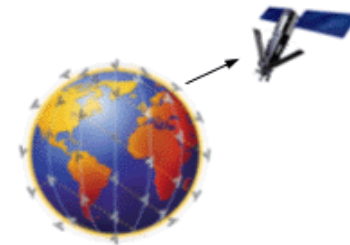
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- ❑ **Low Earth Orbiting (LEO)**
  - **66 active satellites**
  
- ❑ **Global coverage**
  - **Always in view**
  - **Concentration at the poles**
  
- ❑ **Voice and data**
  - **2400 bps**
  - **Full duplex**
  
- ❑ **Service cost (commercial)**
  - **\$30.60 / month plus**
  - **\$1.02 / minute**



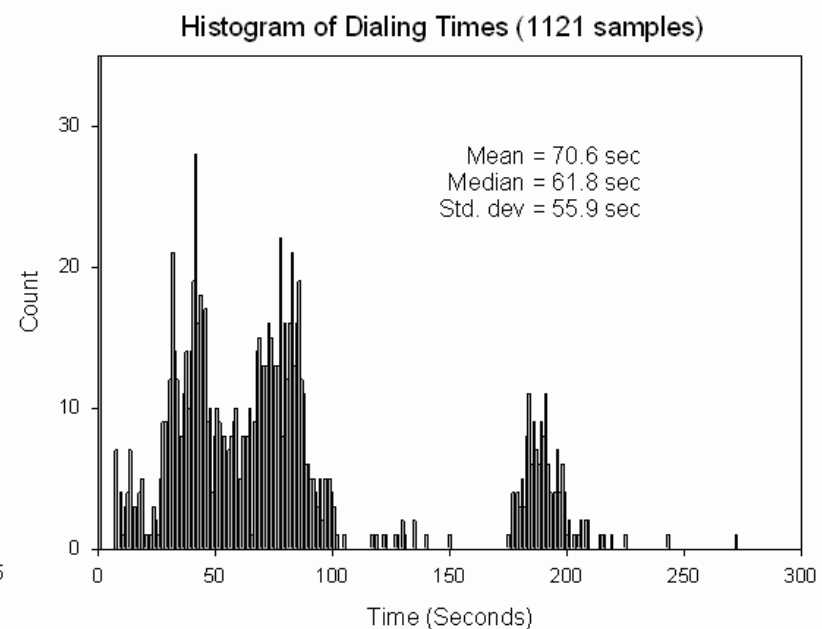
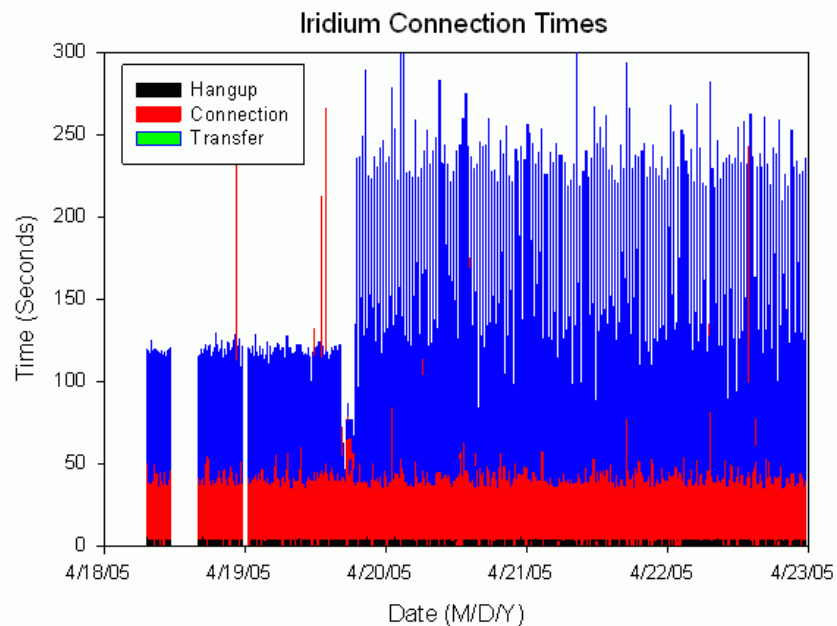
## Iridium Satellite Service (cont'd)

- ❑ **Rugged (voice and) data transceiver**
  - \$1,200 transceiver
  - \$260 omnidirectional antenna & cable
  - \$150 AC power supply
- ❑ **3 Watts transmit power consumption**
  - Datalogger can switch power to unit for power conservation
- ❑ **Serial data interface to instrumentation**
  - Simple subset of a Data Transport Network
  - Short Burst Data
- ❑ **Techniques for enhanced data handling**
  - Bonding for higher data rate
  - DoD unlimited access SIMs (20 MB/day)



## Iridium Communications Parameters

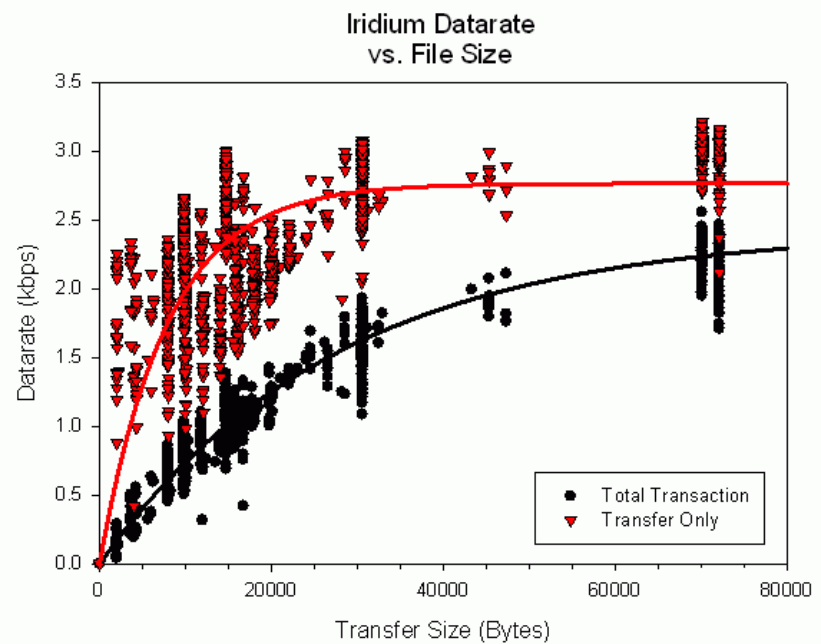
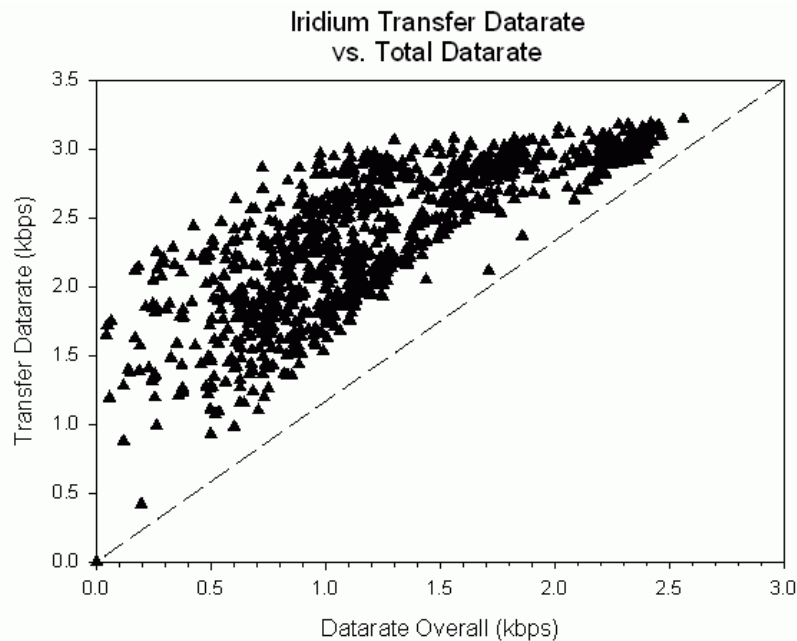
- ❑ ISU to ISU connection; Master and Slave co-located
- ❑ Variable ZIP file size to 70 KB; protocol overhead added
- ❑ Transfers every 5 minutes
- ❑ Dialing time is significant to connection time, affecting thruput





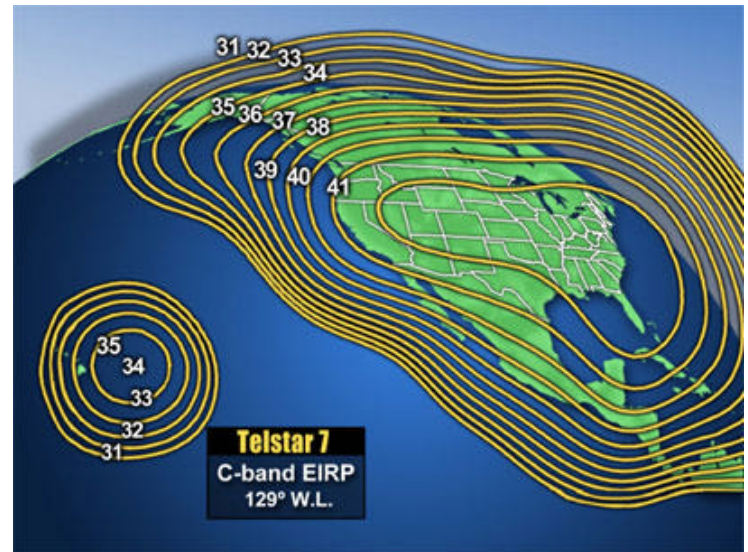
## Iridium Communications Parameters (Cont'd)

- ❑ Dial-up connection time significantly impacts datarate
- ❑ “Flattening” at about 35 KB



## StarBand Satellite Service

- **Geostationary**
  - Telstar 7 (129° W)
  - AMC 4 (101° W)
  
- **No service above 72° Latitude**
  - Large dish required in Alaska
  - Low look angles
  - Susceptible to icing
  
- **High on-demand data rates**
  - 500 kbps downlink
  - 80 kbps uplink



## StarBand Satellite Service (cont'd)

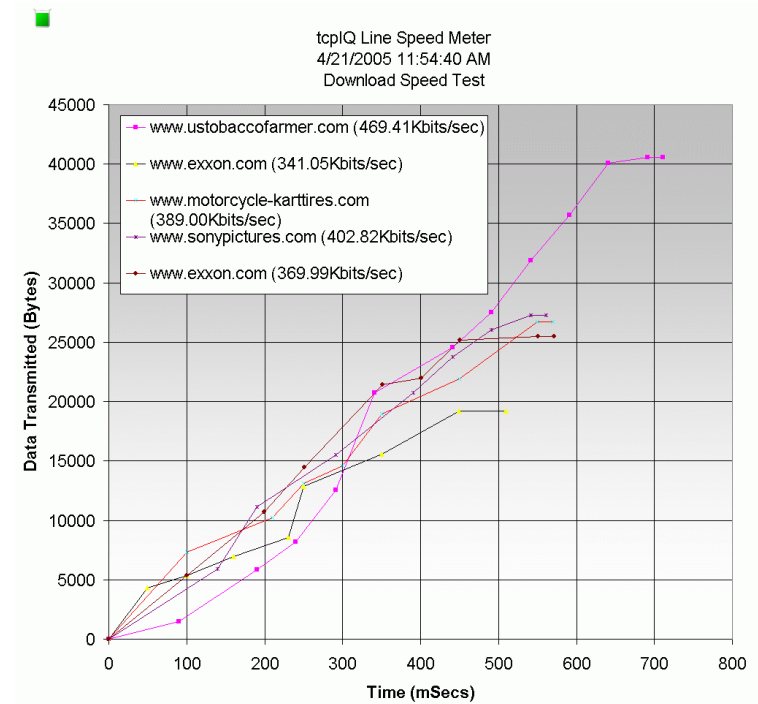
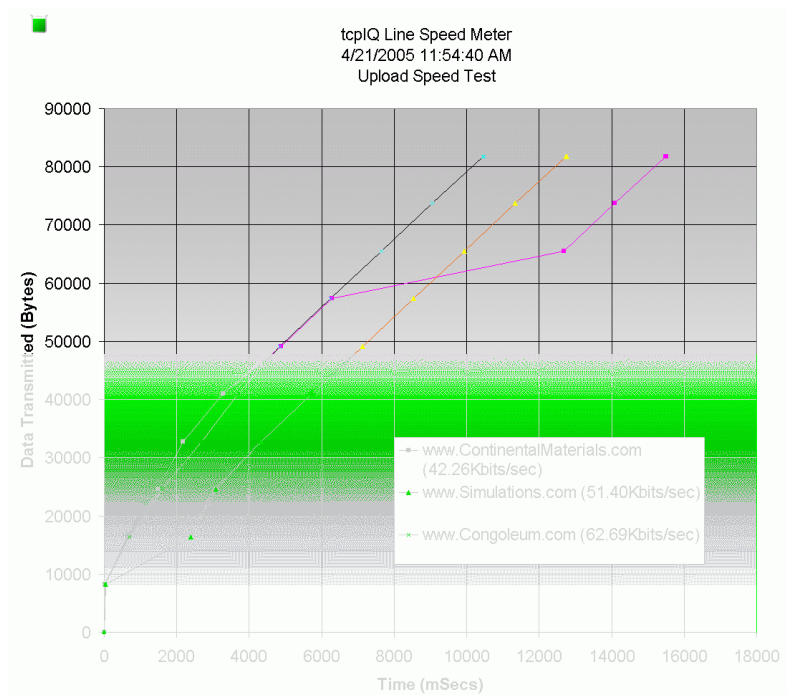
- ❑ **Commercial service**
  - \$150 / month (2 year contract)
  - Always on service
  - 500 MB / week upload limit
    - » 6.6 kbps average limit for “good neighbor”
  
- ❑ **Commercial hardware**
  - \$600 modem
  - \$200 – 1000 dish (1.2 – 1.8 m)
  - Certified dish installer required
  - 0° to +50° C operating range
  
- ❑ **Model 360**
  - Required a PC w/ Windows OS
    - » Virus and Worm attacks
  - 27 Watts + PC power
  
- ❑ **Model 480Pro**
  - Built-in 4-port router
    - » Controlled communications interface
  - 20 Watts



# StarBand Data Transfer Rates

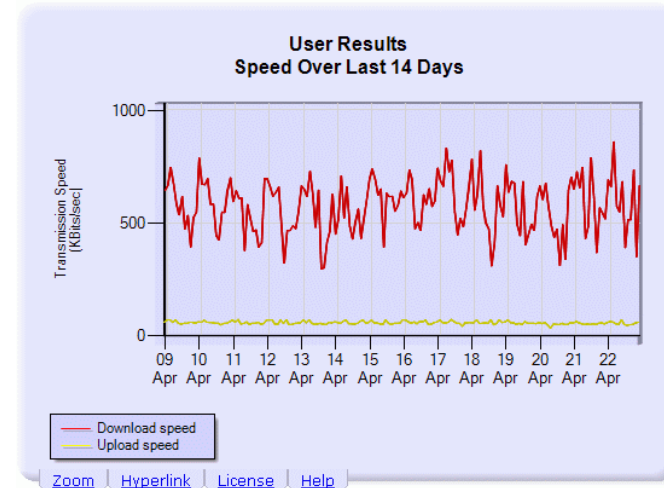
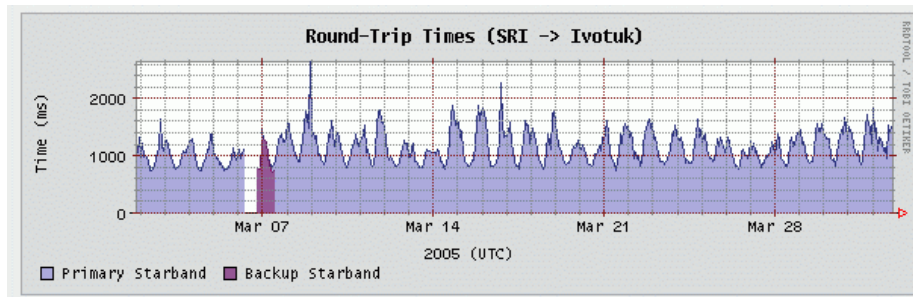
❑ **Downlink: 390 kbps**

❑ **Uplink: 74.5 kbps**

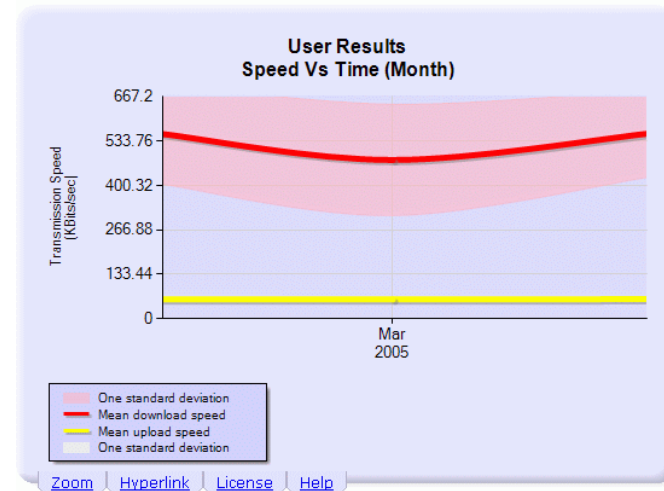


# StarBand Network Parameters

- Channel Capacity
  - Diurnal and Weekly load variations

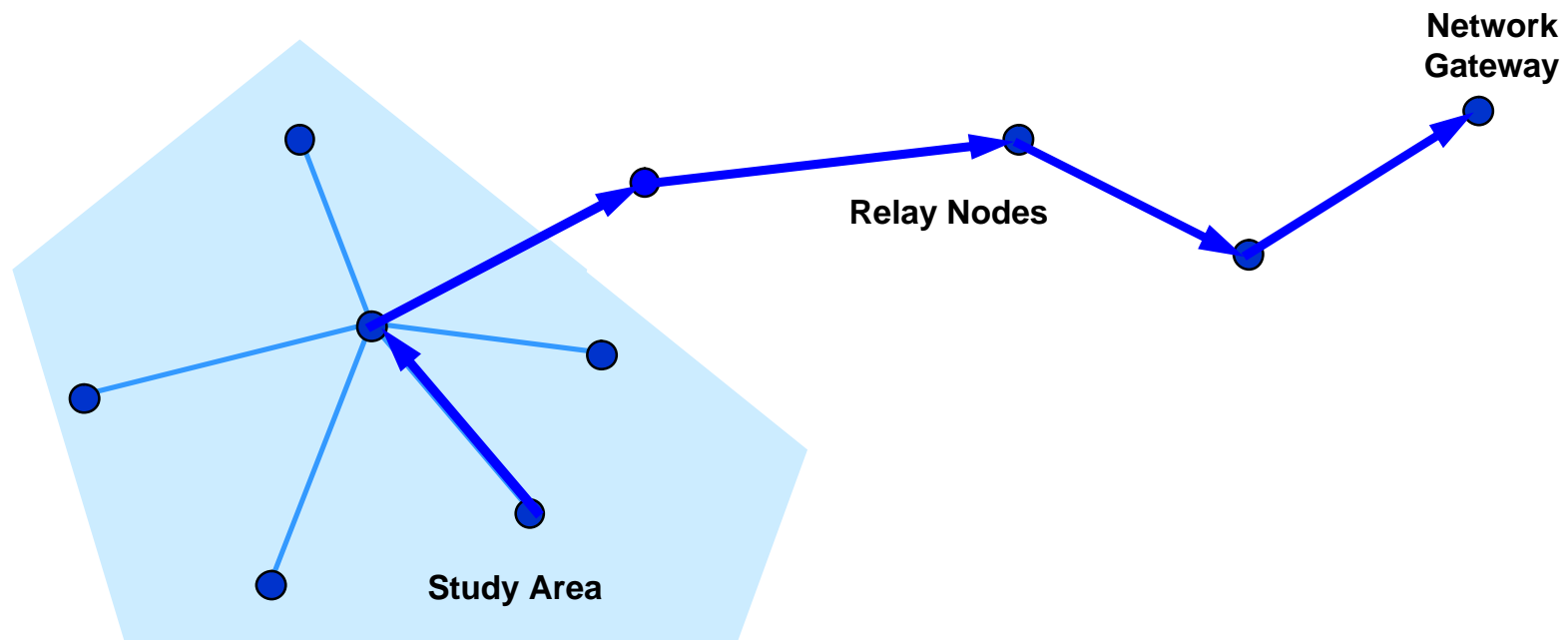


User Results		
	Last 24 hours	Last 7 days
Number of tests	12	84
Download speed	599.18 KBits/sec 74.90 KBytes/sec	584.78 KBits/sec 73.10 KBytes/sec
Upload speed	56.30 KBits/sec 7.04 KBytes/sec	57.42 KBits/sec 7.18 KBytes/sec
DNS Speed	1580.00 mSec	1508.00 mSec
Latency	240.00 mSec	250.00 mSec



## Terrestrial Packet Radio Network

- ❑ Traditional relay network (i.e., packet forwarding)
- ❑ Initial deployment costs
- ❑ Routine maintenance as a recurring cost
- ❑ Star network topology is common



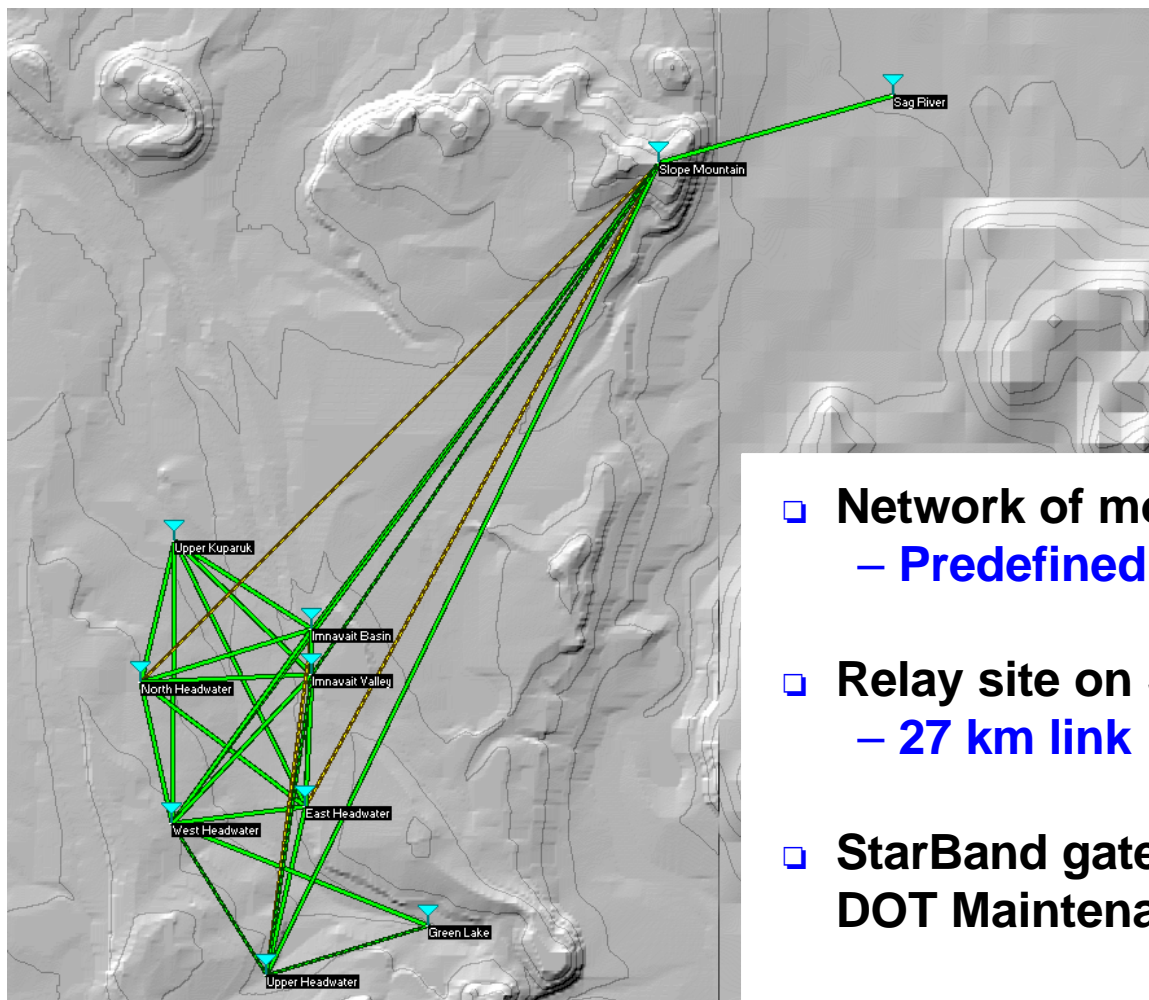
## *FreeWave ISM Band Transceivers*

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- ❑ **ISM Band Spread Spectrum**
  - 902 – 928 MHz
  - 7 hopping bands
- ❑ **Data Rate**
  - 38.4 or 115.2 kbps
  - RS-232/422/485 or Ethernet interface
- ❑ **Programmable Power Consumption**
  - 0.1 to 1 W transmitter power
  - 6 W maximum while transmitting
  - 72 mW in sleep mode
  - 6 to 30 VDC input range
- ❑ **Environmental**
  - Temperature: - 40 to + 75°C
  - Ruggedized
  - Waterproof version available
- ❑ **Cost**
  - ~ \$800



## WERC's Upper Kupaaruk Network

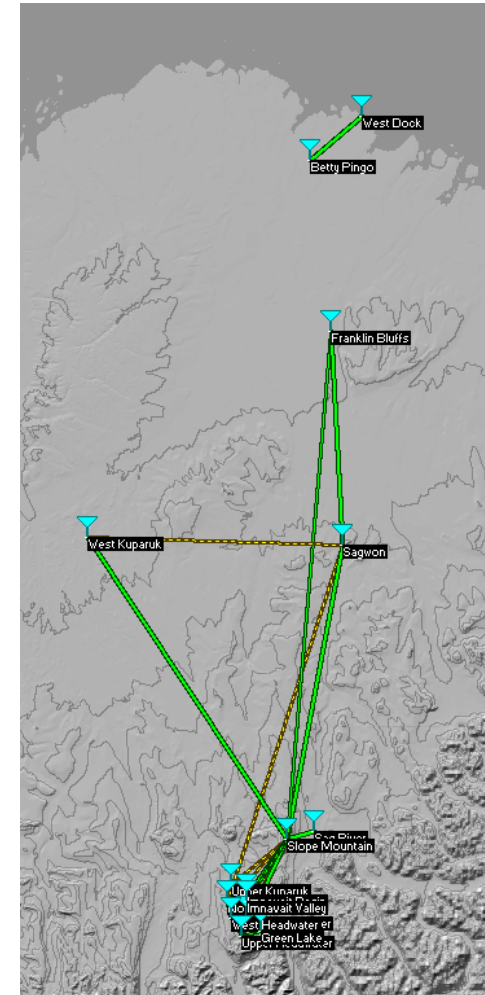
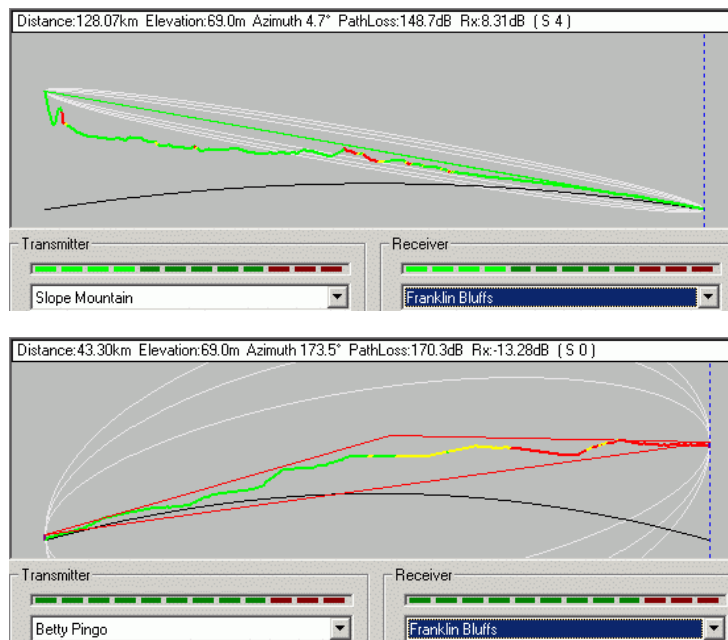


- ❑ Network of monitoring stations  
– Predefined relay topology
- ❑ Relay site on Slope Mountain  
– 27 km link
- ❑ StarBand gateway at Sag River  
DOT Maintenance Station



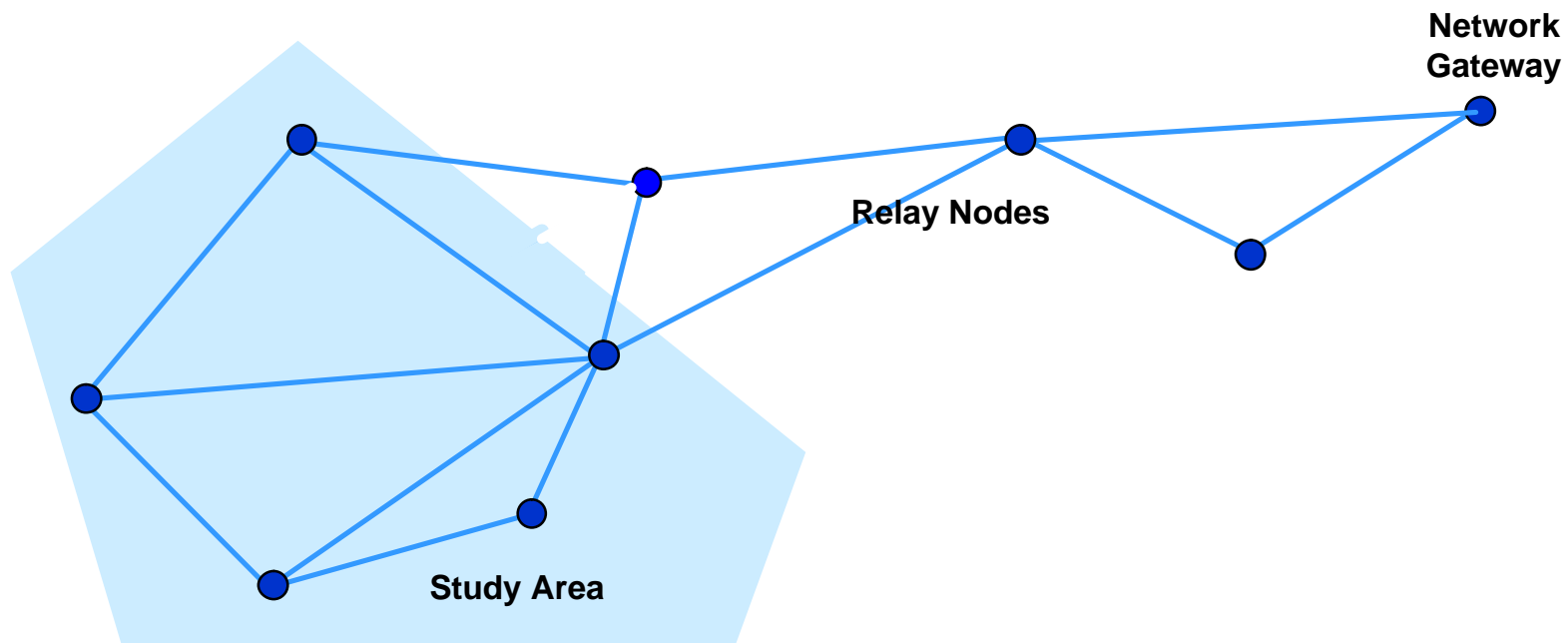
## Network Topology Extension

- ❑ Topography dictates whether links might succeed
- ❑ Earth curvature is significant on long links
- ❑ Lower frequencies will propagate better
- ❑ Range is inversely proportional to data rate



## Peer-to-Peer Packet Radio Network

- **Mobile Ad-Hoc Network (MANET) protocols**
  - **Alternate routing for reliability and load sharing**
  - **Self-reconstituting for dynamic conditions**
- **Mostly practical in dense, mobile network**



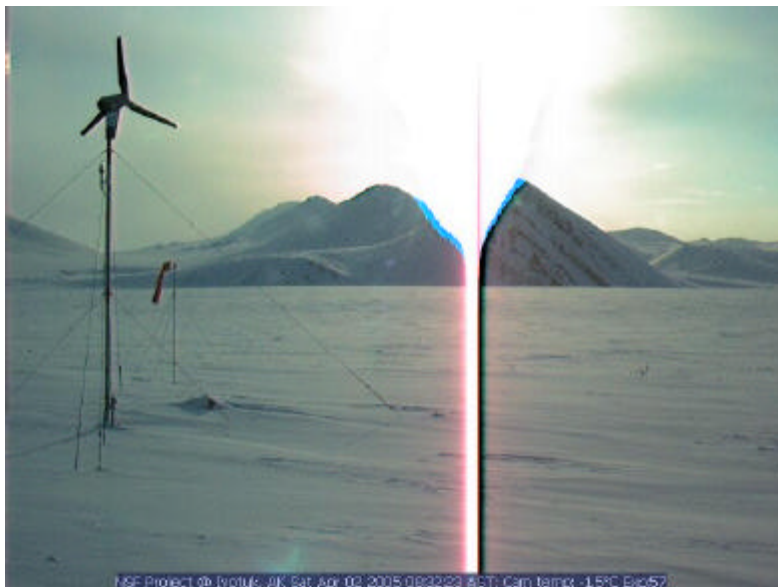
## StarDot Technologies Netcam

- ❑ Rugged design
- ❑ Internal Web & FTP servers
- ❑ Standard: 640 x 480 max  
Megapixel: 1280 x 960 max



## StarDot Technologies Netcam (Cont'd)

- ❑ Robust sensor resists burning with direct view of the sun
  - Any polar deployment will view the sun during some part of the year
  - Gradual burning of red solar arcs
- ❑ Internal Boa Web server hangs on StarBand (long delay) links
- ❑ Slow exposure adaptation



## *Netcam MP Problems*

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- ❑ **Internal DC/DC converters will lock to others causing power supply ripple that is visible in the image**
  - **MP CCD is very susceptible to noise on negative supply**
  - **Requires addition of additional capacitors (1000  $\mu$ F)**
  - **“Only happens at remote locations”**
- ❑ **Red blooming in bright sun**



## Slow Scan Webcam Test on StarBand Model 484

- ❑ **Sony SNC-RZ25N Network Camera**
  - **MPEG-4 compression for streaming video**
  - **12 W static; 6 W more during PTZ operations**
- ❑ **Approximate frame rate:**
  - **3 fps for 640 x 480 image size**
  - **6 fps for 320 x 240 image size**
- ❑ **Needs NAT buffer on long delay StarBand link**



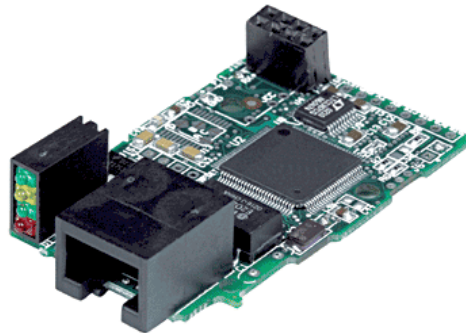
## Rugged, Flexible Processor Systems

- **Control & Data Acquisition**
  - Sensor system
  - Power system
  - Communications system
  - Thermal control
  
- **Single Board Computers**
  - Rugged
  - Low power
  - Powerful as laptop



## Ethernet Interfaces Becoming Common

- ❑ Common bus with wide IP address range
- ❑ Interfaces to other buses
  - Serial
  - Web
- ❑ Caution with power requirements
  - Intended for high speed data transfers



**Newport iServer**



**Lantronix XPort**



## USB Bus Data Acquisition

### □ Simple Data Acquisition Systems



## NSF's Arctic Logistics Support through VPR

### Who Qualifies?

- Primarily Arctic Program, but support given to other OPP, non-Polar directorates within NSF, and even non-NSF agencies
- 2004 support (over 100 projects)
  - NSF/OPP - 63%
  - Other NSF – 18%
  - Other US gov't (mostly NASA) – 8%
  - Foreign Funding Agencies – 9%



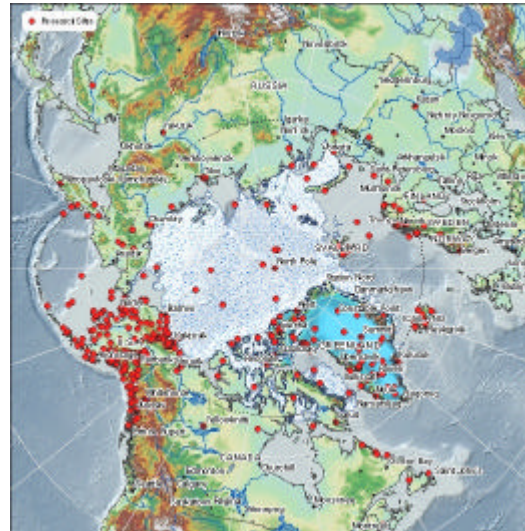
### NSF's Arctic Logistics Contractor: VECO Polar Resources



- Collaborative effort
  - **VECO, USA** – Contract lead & management, construction, engineering
  - **Polar Field Services** – Project planning, field management and logistics
  - **SRI International** – Communications
- Funded through NSF's Arctic Research Support and Logistics Program

### Areas of Support

- **Field Camps & Gear**
- **Air & Ground Transport**
- **Cargo Movement**
- **Safety & Remote Medical**
- **Polar Technologies**
  - ⇒ **Construction & Engineering**
  - ⇒ **Communications**
  - ⇒ **Power Systems**



### Locations

- **Alaska**
- **Greenland**
- **Canada**
- **Russia**
- **Arctic Ocean**
- **Northern Europe**

### How to get support?

- **Contact VPR ([www.vecopolar.com](http://www.vecopolar.com))**
- **Obtain support letter/logistics estimate to include in your NSF proposal**
- **Non-NSF support determined with Simon Stephenson, NSF Arctic Research Support and Logistics Program Manager, on a case-by-case basis and may include interagency funds transfer or cost-reimbursable support**