Polar Technology Conference
2016 Report
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Executive Summary

The annual Polar Technology Conference (PTC2016) was held in Littleton, Colorado, at Polar Field Services (PFS) headquarters 21-22 March, 2016.

Over 60 people attended, including federal employees, international attendees, contractors, technical staff, and industry representatives. Thirteen career scientists or graduate students attended as well.

Each day began with a keynote address: Kelly Brunt (University of Maryland) discussed NASA’s bipolar IceSat mission on the first morning, and Lars Berg Larsen (University of Copenhagen, Denmark) offered a history of the European ice coring effort in Greenland on the second. The two-day meeting was well-paced, with discussion periods between presentations and during breaks; indeed, conveners had to coax attendees back to the primary meeting after each break.

In addition to topics presented during many PTCs—e.g., related to power and communications challenges—two presentations introduced novel topics with growing polar implications. The first introduced the Lockheed Martin (LM) hybrid airships program. Lengthy discussion following the presentation indicated the interest generated by the potential of airships to support polar research. The second, the state of unattended aerial systems (UAS) in polar research, also garnered significant attention as participants explored the complex regulatory atmosphere bearing on use of UAS in the Polar Regions, notably in the Arctic.

Questionnaires submitted after the meeting offered positive feedback and suggestions for future venues and topics.

More than a decade after its inception, the PTC has grown to the point of needing significant administration and planning. After the meeting adjourned, the steering committee discussed future steps, including possible ways to attract early career scientists and mentor scientists.

This report describes PTC2016 presentations and includes a final agenda and a list of attendees, links to presentation abstracts and slide decks, and a summary of the post-meeting survey. It also describes the status of planning for PTC2017 at the time of publication (July 2016).

The meeting owes much to the team working behind the scenes, keeping costs for catering and event execution under control. Thanks to PFS, and to the NSF for its support of PTC2016 and interest in continuing and potentially expanding the workshop in the future.
Presentations

TODD VALENTIC

Opening Remarks

The convener began by describing PTC history, noting that the meeting had developed as an informal gathering organized by 5 Arctic program technicians and engineers who met at SRI, International in Menlo Park, CA, to reflect on technology efforts past and approaching. Conceived as an opportunity to “pop the hood,” as Valentic noted, the original attendees sought to answer two general questions, with the object of improving system reliability and enhancing safety:

1. How is it possible to collect the data?
2. What works and what does not?

A single lane of presentations allowed PTC attendees to avoid making tough decisions about the relative importance of topics. Emphasis on including discussions of successes and failures made the PTC different from science or technology conferences that focus on ‘success story’ presentations.

Attendance grew informally until, in 2007, the number of interested potential attendees exceeded the space available free of charge at SRI and other locations under consideration. As other institutions with facilities volunteered to host the meeting, the PTC assembled a steering committee to organize planning.

The committee quickly noticed that, as more staff and faculty from the hosting institution (and from other agencies nearby) attended, attracted by proximity, they brought fresh perspectives, questions, and answers. This invigorated the conversation.

Though increased attendance means that the PTC loses some of its grassroots flavor, it is still a unique opportunity for the community to explore solutions to the challenges of providing technology solutions in the remote Polar Regions, and each attendee brings new insight and problems to solve.
**KEYNOTE #1: KELLY BRUNT**

**NASA airborne and satellite laser altimetry**

This presentation traced the development of NASA’s various airborne and satellite altimeters.

NASA has constructed a long-term time-series of ice-sheet change based on airborne and satellite laser altimetry. Essentially, these studies measure elevation by bouncing light off Earth’s surface. Differences in repeated measurements yield changes in volume and mass.

The Ice, Cloud, and land Elevation Satellite (ICESat) mission operated from 2003 to 2009. It carried the Geoscience Laser Altimeter System (GLAS). Despite limitations (e.g., swamping at a slope of more than 1.5 meters and the requirement to stay below 86 degrees latitude), ICESat collected an unparalleled lidar dataset.

Currently, IceBridge, a P-3 airplane-based laser altimetry time series, bridges the gap between ICESat, which ended in 2009, and IceSat2, expected to launch in October 2017. IceBridge is NASA’s biggest airborne campaign. Instruments include 2 airborne laser altimeters: Airborne Topographic Mapper (ATM) and Laser Vegetation Imaging Sensor (LVIS), which operate from a NASA P-3 plane.

ICESat2 represents a major advancement in satellite altimetry technology (including photon-counting capability and multi-beam technology). To assist in satellite algorithm development, NASA has deployed two airborne laser altimeters to simulate ICESat-2 data: Multiple Altimeter Beam Experimental Lidar, or “MABEL”; and Slope Imaging Multi-polarization Photon-counting Lidar, or “SIMPL.”

Airborne simulators for ICESat2 laser altimeters flew on the NASA ER 2 high-altitude plane, whose pilot must wear life-support. Photo: Carla Thomas/NASA

These sensors have recorded intriguing features in the Antarctic ice sheets, including subglacial lakes and the fact that the grounding zone of the Filchner Ice Shelf, an ice body the size of Spain, is advancing and retreating 6-8 meters a day. NASA’s instruments have measured daily elevation changes 5 to 10 km upstream based on tides! The data suggest NASA is developing a sound sampling strategy for ICESat2.
JENNIFER MERCER

The Role of Technology in NSF’s Arctic Research Support and Logistics (RSL)

The presentation offered an overview of the RSL, outlined its primary functions and the science program since 1999, and described NSF’s goals for the Arctic program.

NSF’s RSL program management structure has eight budgeting “portfolios” (e.g., science support, IT&C, sustaining facilities, etc.) to define and organize logistics support scope more accurately and specifically. Each of these have technology concerns and potential benefits.

Future areas of emphasis were noted, including the following:

- Supporting intrinsic ties between science and technology, with technology helping scientific research “push the boundaries”;
- Greater emphasis on leveraging interagency and international collaboration (e.g., Department of Defense [DOD], Forum of Arctic Research Operators, etc.), especially shared technology development;
- Expanded culture of discussing “near misses and incidents” (e.g. failures/mishaps) in technology;
- More emphasis on how to enable large-scale, year-round observing networks without large increases in funding.

To conclude, NSF has keen interest in technology advancements that support science goals while decreasing costs.

CATHERINE CAHILL

Flying UAS in Polar Regions: Operations and Regulations

This topic was presented by the director of the Alaska Center for Unmanned Aircraft Systems Integration (ACUASI) facility at University of Alaska, Fairbanks. ACUASI has legally flown a variety of small Unmanned Aircraft Systems (UAS) in the Arctic for the last 15 years.

ACUASI’s experience has provided numerous lessons in technologies and operational best practices.

UAS are ideal for high-risk—“dirty, dull, and dangerous”—activities, as Cahill noted. These include walrus surveys, which often involve counting animals on drifting sea ice floes. The “Ptarmigan” UAS overflew walrus herds without bothering the animals, an improvement over previous piloted airborne surveys. ACUASI’s UAS have participated in oil spill response drills and mass casualty exercises as well.
The Polar Regions lack a comprehensive UAS policy, and they also present specific challenges and increased costs for would-be UAS operators:

- UAS must be cold-hardened;
- People face increased risk in the cold, remote environment, including risk from wildlife;
- Lack of infrastructure makes logistics expensive and recovery difficult if a system is downed unintentionally;
- Fragile and/or areas of special importance could be damaged in a crash;
- Navigation can be difficult due to a lack of technology infrastructure;
- The region receives significant manned aircraft traffic, increasing risk;
- In Antarctica, operators face varying regulations depending on whose station is closest to the area of operation. In the Arctic, airspace is subject to inconsistent regulations and difficult permitting processes that vary between states and nations.

As the lead organization in the Federal Aviation Administration’s (FAA) Pan-Pacific UAS Test Range Complex and a member of the FAA’s Center of Excellence for UAS, ACUASI has helped improve regulations and guidance on flying UAS in Polar Regions. Before federal, state, local, and international partners go in the field, the center works with UAS users to help them avoid costly mistakes.

In 2015, the Arctic Council, a North Polar Region governing body composed of representatives from the eight Arctic nations (and other interested nations), engaged its Arctic Monitoring and Assessment Programme (AMAP) working group to address the issues surrounding growing use of UAS in the Arctic. With input from researchers representing each of the Arctic nations, the AMAP developed a guide, the Arctic Science Remotely Piloted Aircraft Systems (RPAS) Operator’s Handbook.

The AMAP guide marks the first step in developing consensus on an international policy. The NSF is developing a U.S. policy as well. Continued communication between entities and practitioners is essential for determining best practices—and for developing collaborations that make polar UAS deployments more affordable.

MICHAEL HUFF
Unmanned Aircraft Systems

SRI owns a few UAS for project-related experimentation. These systems are smaller than those described in the ACUASI presentation (just previous), but they can be put to similar uses and come with some of the same issues—the need to harden the system for the cold, harsh conditions of the Polar Regions, for example. SRI’s vehicles are also well-adapted to research needs, and are relatively low-cost and easy to transport.

UAS technology complements SRI’s expertise in sensors and remote sensing, and the company’s engineers have focused on developing for new commercial and government applications, using off-the-shelf systems, including the Infinity X9, with open source and open hardware that can
easily be adapted. This spares the time and cost of developing custom hardware.

Commercial applications for small UAS (sUAS) are growing because:

- Recent advances in small, low-power electronics make sUAS less technically complex to operate;
- Advances in battery technology make sUAS more practical;
- Developments in low-power, low-cost technology enables real-time communications between aircraft and pilot.

The regulatory environment is catching up, somewhat guided by the commercial needs for which UAS are primarily developed.

Navigation, weather, poor maps and charts, and signal reception quality are among the challenges and limitations. Magnetic and gyrocompasses can be problematic in a polar environment.

**Daniel Wagster**

**Iridium Distributed Tactical Communication System (DTCS)**

Antarctic Support Contractor (ASC) is evaluating the Iridium DTCS. This technology has potential to decrease communications costs and increase labor efficiencies.

**Robert Boyd**

**Hybrid Aircraft Overview**

Boyd manages Lockheed Martin’s (LM) Aeronautics Program group, Skunk Works, which has been developing hybrid aircraft for nearly 30 years. He presented LM’s hybrid airship, highlighting ways that it could benefit polar program logistics.

The hybrid aircraft is more affordable, flexible, and efficient than existing airplanes. Hybrids are specifically targeted for heavy lift transportation of equipment, supplies, and personnel to areas where there is little or no infrastructure. Though the airship is designed for cargo movement, it can be configured in ways to move passengers as well. This is the opposite of the standard aircraft designed for passenger transport, but which also can move cargo.

In 2006, LM launched a prototype about one-third the size of the smallest current airship—with a footprint similar to that of a football field. The P791 Demonstrator was a 120-foot piloted airship, built to prove the viability of the technology. Specifications include:

- Full Vectored Thrust Technology: vertical takeoff removes need for a runway;
- Closed Loop Digital Flight Control;
- Air cushion grip landing system: the craft floats on hover pads that grip the ground for stability during ground time and windy conditions, but which reduce friction during flight;
- An envelope made of material cold-hardened to -40F, enabling operational capacity in conditions that ground most planes and helicopters;
- A maximum payload of about 47,000 lbs. in a 10 x 10 x 60ft space;
• Fuel capacity of about 5,000 gallons, for a range of 1,400 nm: the airship can fly long-range roundtrip missions without refueling.

LM anticipates commercial operators will be flying the airship in 2019. They argue that, because it can fly in a variety of weather conditions, operating from soil, ice, snow, water, etc., the airframe will improve access to austere regions year-round, stimulating economic development and food security. The ship also is environmentally sensitive, with low noise and emissions and a small footprint. Because cost factors (e.g., fuel) are 10 times lower than competing helicopters, LM’s airship promises to make road less development affordable.

LM asserts that, pound for pound, its airship is about 10 times more fuel-efficient than traditional helicopters. The Demonstrator requires little infrastructure—an open, flat, circular surface about 1.5 times the length of the aircraft.

The Demonstrator recently passed 10 years of experimental operation without incident. In spite of this success and the obvious potential savings offered by LM airships, commercial deals were still in development at the time of the PTC2016 workshop.1

1 An announcement regarding LM’s first commercial contract came 10 days after PTC2016.
Hebert described IRIS/PASSCAL (IRIS) advances since PTC2015 in telemetry, station power, and station portability. IRIS continues to expand its Iridium capabilities with firmware developments for compatibility with additional data loggers, updates in RUdics TUnnel Software (RUTUS), and the introduction of Iridium Pilot systems for seismic data transfer. IRIS has also been testing other power solutions, including air cells with associated DC-DC converters and WT10 wind generator/heaters. Finally, IRIS has made advances in field logistics with deployment of a next generation seismic station on the RIS/DRIS Antarctic experiments and the development of a multimode pool of instrumentation for polar use.

IRIS purchased an Iridium Pilot for testing, potentially to expand “real-time” telemetry capabilities. The Pilot uses Iridium OpenPort service, which allows for significantly increased data transmission rates. Xeos Technologies helped integrate the Pilot with IRIS’s existing systems to allow remote control operation.

With further testing and optimization, the Pilot could be an effective and affordable means of moving real time data. Power requirements and data throughput need additional development.

IRIS is building a down-sized (but rugged) micro-wind turbine that can generate power at the low wind speeds experienced on the polar plateau. It is small and light so it can be deployed by twin otter as well as snowmobile traverse.

IRIS is developing a new, rapid deployment, seismic observatory for ice-covered regions called the Geophysical Earth Observatory for Ice-Covered Environments (GEOICE). This seismic array will provide increased observational capabilities and logistical efficiencies needed to seismically image the structures and dynamic behavior of both the solid Earth and overlying ice in remote ice-covered regions. GEOICE instruments will be designed to withstand icy and/or wet conditions and need little oversight.

GEOICE units include a mixed phase array consisting of broad- and intermediate-band seismometers complete with power systems and environmentally sealed enclosures. They were tested in 2015 on Taku Glacier, Alaska.

SOURCE: Jason Hebert
ANDREW STILLINGER

Status of the Automatic Geophysical Observatory (AGO) Network on the High Antarctic Plateau

Stillinger provided an update on the AGO program, which originally was designed by Lockheed Martin for the NSF to provide the geophysical community a self-powered and self-heated remote station for data collection that could operate through the long polar winter.

The AGO network was installed in 1983 at six sites in Antarctica. The sites were designed to detect the rate and amount of change in Earth’s magnetic field, a mission that made high-latitude sites on Antarctica ideal. Each unit has large, 1000 w wind turbines and solar panels, with lead acid battery backups and telemetry. Project gear and instruments are stored inside a small box, on two 19-inch racks.

Though the wind turbines were expected to augment power during the dark months, winds are calmer then; thus, the only dropouts occurred during the winter. Engineers concluded that, to be useful, wind turbines would need much lighter, more responsive blades. Data was transferred via Iridium short burst data (SBD) satellite link, including huge files of magnetometer data.

The initial power system was both complex and inefficient, requiring six 400-pound propane tanks at each site to burn thermocouples with a Freon system, radiators and a massive control system. In addition to the requirement to ship 2,500 pounds of propane annually by LC-130, the system required high-pressure nitrogen to force propane out of the tanks. Moreover, a byproduct of propane fuel, water, created a 2,500 pound block of ice, which encased the unit and had to be chipped away by hand before technicians could access the unit.

The Polar Engineering Development Center (PEDC), which maintains the AGOs, has not visited the sites for several years. The systems are all working, so the team has had time to think about improving the data acquisition, power, and other new aspects of the program instead of trouble-shooting issues with the current infrastructure. Engineers have leveraged recent technology advances to design a simplified system using robust components, offering potential savings in cost and carbon footprint, while improving efficiency and reliability as well.
A new data acquisition system is reliable and easy to maintain. Engineers have used off-the-shelf parts, enabled daily files (local storage) or direct to SQL database (telemetry), and built the system to withstand field deployments, including the need for very low-power computers to run the operating system.

The control circuitry is derived from open design concepts for ease of maintenance. The system monitors key voltages and currents, with information feeding into a telemetry system for remote monitoring. The new power system has internal voltage regulators, and is situated within a blue board enclosure; heavy finned aluminum heat-sinks dissipate 200 w each.

When PEDC staff service the AGOs in 2016, they will install the new systems. The refreshed AGOs will consist of five installations on the East Antarctic Plateau. Each insulated and heated unit will have two 19-inch racks with open space to accommodate new instruments. The electronics will be robust to about -40°C, with reliable power (about 200 w at 28 v). Telemetry will be facilitated via Iridium connectivity using both modem and SBD. PEDC will make routine service missions.

MICHAEL LUCIBELLA
Dateline: Antarctica

As the new editor of The Antarctic Sun newsletter and e-zine, Lucibella completed his first season in Antarctica in 2015-16. Though his beat is unique, and many traditional tools of the reporter’s trade (e.g., notebooks) have been replaced by industry innovations, many characteristics of a good story remain.

These characters include the value of new, unusual, and/or unexpected subjects and interesting individuals; the merit of research; the value of compelling images/multimedia; the appeal personal interest stories have). Lucibella offered best practices for interacting with members of the media, and provided advice on how to deliver a strong message if one has just five minutes with a reporter. The latter emphasized the importance of providing the “so-what” factor, which brings the science into the realm of issues that average readers care about.

KEYNOTE #2: LARS BERG LARSEN
Thirty years’ experience in Deep Ice Core Drilling Camps

Larsen, an ice coring technology expert from the University of Copenhagen, surveyed Greenland ice coring history, describing “European” efforts from the early 1900s through the contemporary International Deep Ice Core Drilling project, East Greenland Ice-core Project, or EGRIP, which completed its first field season on the North East Greenland Ice Stream (NEGIS) in 2015.

His talk focused on technology developments made by University of Copenhagen, which has conducted ice coring operations since the early 1970s and has managed deep field drilling camps since the beginning of the 1980s. The first fixed
camp structures built in the late 1980s—heavy, square structures—gave way to the carefully engineered NEEM drill camp dome. The NEEM camp leveraged innovations and new designs in all aspects—large, deep-field camp build-outs to increase safety, lower costs and limit environmental impacts. At the same time, technology advances in computers and communication have made possible the demands for a “modern” 2016 field camp.

Larsen described the design of the EGRIP camp, developed using ‘recycled’ structures from the NEEM camp, which was put in during 2015. The camp designers gave a lot of consideration to prevailing winds and slope to limit snow accumulation.

Those participating in the Greenland Ice Sheet Project, at left in 1980, learned early that buildings placed on the ice sheet surface would soon be buried by snow accumulation: The NEEM dome, engineered to slough snow and be portable, en route to EGRIP in 2015. SOURCE: LB Larsen

JASON WEALE

The Evolving Arctic Domain: Meeting the Challenge

The opening of the Arctic has led to a variety of U.S. national policies regarding the region, many of which describe the need for increased domain awareness. Federal agencies wish to maximize resources effectively to solve problems and avoid redundancy of effort. In response, the defense department has identified three “capability thrusts”—areas of focus—to address the need for increased security: 1. engage public and private sector agencies as partners; 2. develop capabilities to protect the environment and its natural resources; 3. improve infrastructure to address changing conditions.

Through Cold Regions Research Engineering Laboratory (CRREL), the U.S. Army’s Engineer Research and Development Center has developed six main areas of focus to address the three capability thrusts DOD has defined.
These include modeling waterways, developing autonomous sensors to help understand weather and climate dynamics; developing a holistic understanding of the environment; improving oil spill mitigation and response, especially in areas covered by sea ice; and durable adaptation—that is, developing engineering technology so structures last, even as the environment changes. An example of durable adaptation is the effort to design and engineer buildings to withstand permafrost degradation. Improvements in these areas will help stakeholders make knowledge-based decisions that mitigate risks in the Arctic to national security, operations, and the environment.

To achieve this goal, CRREL is currently building capacity to enhance Arctic domain awareness and to conduct scientific and engineering activities that will evolve infrastructure and operations as conditions and requirements change.

**SCOTT DALTON**

**Power and Telemetry Systems for Real-Time Earthquake Monitoring in Alaska**

Dalton began working at the Alaska Earthquake Center (AEC), which operates a network of over 130 seismic stations across Alaska, in 2013. The center provides earthquake hazard information in real time, and had a data return rate of just 79% when Dalton began. Records indicated that power outages and telemetry latencies were causative issues, so Dalton systematically addressed both areas to improve performance.

Because AEC inherited many of the systems from other projects, telemetry varied, to include modem-to-modem Freewave, cell modem, very small aperture terminal (VSAT), and the State of Alaska Telecommunications System (SATS).

Telemetry was affected by topography, limitations of the system itself, or damage due to weather or animals. For example, in the Chugach / Wrangell mountain region, line-of-site issues were originally addressed by piggybacking telemetry requirements for multiple sites onto one. But all the receive antennae linking to a single node tended to create interference, so technicians rearranged the network, creating chains of telemetry weaving through mountains.

One of 14 AEC sites with SATS microwave telemetry, an option limited to sites along the road system. **SOURCE:** Scott Dalton

Sites using firmware had stability issues. Technicians designed stations with stand-alone power systems sized and built to last multiple years between service visits. If a station dropped off, the one-way communications capability of the Firmware prevented a remote system reboot; the site would remain down until technicians could visit. To address this issue, a circuit was
built with a microcontroller programed to ping the system at regular intervals. If the ping didn’t come through, the microcontroller would trigger a reboot.

A number of sites were damaged by extreme weather (e.g., high winds) and animals (e.g., bears). Engineers ruggedized these stations when they visit the site.

For batteries, because of the varied methods of accomplishing telemetry, power loads varied more than typically seen in similar networks. This made a standard approach difficult, so components that could not be standardized (e.g., generator size), were scaled. For power systems, interior Alaska sites were easy due to predictable snow and sun inputs. Coastal installations were less predictable, so proper siting was addressed to limit performance drops due to snow accumulation or wind events.

Cumulatively, these changes have resulted in an annual data return rate improved by more than 12% since 2012. In 2015, that rate was 91%.

ADAM LEWINTER

The ATLAS System: An Autonomous Terrestrial Laser Scanner Engineered to Monitor Large Tidewater Glaciers

LeWinter described the autonomous, full-waveform, long range (6-10 km) terrestrial laser scanner (ATLAS) system deployed to capture LiDAR time-lapse data across the entire terminus of Helheim Glacier, a tidewater glacier in southeast Greenland. Optimized for snow and ice, the laser produces multi-dimensional point-cloud measurements, resulting in three-dimensional depictions of the lower reaches of the glacier, its terminus, and the mélange to distances in excess of 6 km.

ATLAS improves on previous systems by being autonomous, having programmable scan intervals, capability to communicate data daily via satellite, and higher resolution products.

The protective housing had to be modified to withstand 150 mph winds. It also had to rotate independently of the scanner with active heating and cooling.

LiDAR uses laser pulses to create 3-D measurements of any physical surface. Upwards of 300,000 laser pulses are generated per second, all while panning and tilting the sensor, for a 3-D point cloud. SOURCE: Adam LeWinter

ATLAS was programmed to scan four times daily, and each scan delivered about 200MB of data after compression. A Sutron 9210 data logger and communications system stored and delivered the data daily.

Power design was complex because the requirements were significant, and as technology advances, so do the power requirements.
The system used 327 w solar photovoltaic panels with aluminum backing and 400 w wind turbines. Backup power was provided by methanol fuel cells and lithium battery packs, the latter designed in-house. Lead acid batteries needed to cover the power requirement would have weighed about 1,600 pounds total, while the lithium batteries weighed just 400 pounds total.

The solar panels proved to be a solid design, but all of the wind turbines have self-destructed. When the team returned to Helheim Glacier for maintenance, they programmed the methanol battery to turn on for a certain amount of time to recharge the lithium batteries, and then turn off again. This has worked very well.

**ROB BAUER**

*The Automated Met-Ice-Geophysics-Ocean Observing System -- AMIGOS-II*

Bauer reviewed the design and initial test results of a new type of weather and water measurement station, named AMIGOS-II, intended for use on Antarctic ice shelves or fast ice / sea ice areas where ocean, climate, and ice motion data are desired.

Designed to measure weather, snow conditions, water currents, and temperatures where ice shelves meet oceans, the system consists of an aluminum tower about 6 m high, and a wireline ocean string extending 50 to 1000 m below the ice surface. An onboard GPS measures any movement of the station. A camera captures sky conditions, snowfall, and storms. Data are sent to NSIDC using a satellite phone system.

Researchers are proposing a prototype for installation in several Antarctic regions where changing ocean circulation has brought above-freezing water in contact with the coastline of the continent and its ice sheet, which leads to rapid melting and faster glacier ice flow.

A network of these stations would allow scientists to better understand how ocean currents and wind shifts in the far southern continent are affecting the ice sheet, and would support better predictions of ice melt.
NICOLAS BAYOU

Powering Science at High Latitudes

Along with land surveying and 3-D mapping services using lidar technology, UNAVCO Polar Services (UPS) provides solutions for powering science instruments. Bayou presented a mature power system, developed based on the extensive and successful “POLENET” Network.

POLENET features about 100 working GPS Stations with communications in Greenland and Antarctica with a data collection success rate of about 90%.

POLENET locations require three system setups: margin rock, glacier (which is screwed into ice), and plateau (wherein the base may be buried). Some extremely remote stations must be able to store data, while others have communications for data transport.

Currently, UPS is developing a system for PI David Holland to use at Helheim Glacier. The requirements call for seven autonomous GPS sites to be installed near the front of the glacier. Because of the challenging terrain and risk of loss, UPS developed a small network where each site could radio back to a data communications hub. For the initial use, with little time to develop a system, UPS provided a GPS receiver applied to the front of a Raspberry pie Linus box with a flash card. This could download data from up to 16 sites. The unit was placed in a little pelican case, with a display. With two weeks to develop the system, and for about $200, the system worked well. In total the entire system cost about $1,500 for summer only use. For year round POLENET-style systems, the cost ranges from $15,000 to $25,000.

UPS is also developing a ground radar for scanning the glacier in summer only.

UPS’s experience with Trimble’s Global Navigation Satellite System receivers was the final topic of the talk. These compact yet durable units offer flexible configuration and a choice of software, and result in real-time decimeter accuracy. UPS has found they can make these receivers do about anything they want!

UNAVCO staff maintain power and communications systems for a POLENET station on Mt. Erebus. This site is bolted into rock. Photo: Joe Pettit
JAMES JARVIS

APRS World Wind Turbine Update

Jarvis provided an update on APRS World’s WT10 and WT14 micro wind turbines and their polar deployments.

WT10 was deployed near the South Pole for IRIS to heat instrument enclosures and charge a 12-volt battery. IRIS tried an experimental, snow-anchored mast. A heating panel charged a battery and then warmed the interior of the enclosure until a set temperature was reached, at which point the excess power would be dumped.

To ruggedize for the South Pole, ultrasonic cleaning techniques were used to remove grease from the bearings. Molykote 33 low temperature grease was then used to help the turbine stay flexible at cold temperatures. The turbine was then placed at a low wind area about 250 miles from SP. Last year, this turbine was off line for about 2 weeks. This year, the turbine has been off only for about an hour due to a storm.

The WT10 has been deployed in Alaska. It supplies power for an ocean current sensor, ultrasonic weather station, and dock navigational light station right off a dock in Juneau. The installation has 10 to 20 w continuous load, which has been supplied by the turbine only, at 100% uptime, since 2015. It supplements solar power in the winter months for a seismic monitoring site on the Bering Glacier. Since being augmented by the turbine, the site has been online 100% of the time.

NOAA’s climate research network in Alaska has been trying to use EFOY-brand clean fuel cells to charge their batteries, but these can’t get below freezing. So where there is a wind source, NOAA is putting in wind turbines. WT14s generate 50 w of power at 12 MPH, but the acoustic signature is not suitable for inhabited spaces. APRS is working at detuning them to reduce the noise.

With the WT14s, the bearings on yaw and bearings on the main rotor shaft and brushes need to be maintained about every 2 years. Riming is a significant challenge on wind turbine blades.

A WT10 wind turbine in Juneau, Alaska.
SOURCE: James Jarvis
RYAN BIERMA

Updates and Plans for the Earthscope Alaska Transportable Array

EarthScope’s Transportable Array in Alaska and Canada (ATA) is an array of 105 high quality broadband seismographs. Operated by the IRIS Consortium on behalf of the NSF, ATA provides an MRI of Earth’s upper mantle.

IRIS installed 32 new and 7 refurbished borehole seismic stations during 2015. Each installation involved drilling a hole about 3 m deep. Challenges included damage to an overheating drill rig, malfunctioning charge controllers, and enclosure humidity causing battery corrosion. Fixes, including plans to alter the enclosure to reduce humidity and purchase of moisture reducing battery bags, are underway.

TRACY DAHL

COTS to Custom: Developing project specific solutions from off the shelf components

Using commercial off the shelf (COTS) renewable energy solutions whenever possible can save money and offer better success rates than custom approaches, but few complete COTS solutions target the polar power niche. Still, high quality individual components are engineered, tested, and warranted against failure; these can be used to produce custom solutions that are efficient, reliable, and appropriate for the extreme polar environment. Dahl presented examples of hybrid systems he has developed over the years.

Dahl recommended that engineers develop a list of “The Stuff That Works,” to be posted on the Polar Power website. Quick examples could be Vicor AC/DC power supplies and Morningstar charge controllers, for example.
# Appendix A: Agenda

## Monday, March 21

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<tr>
<td><strong>Kelly Brunt</strong>: NASA airborne and satellite laser altimetry</td>
<td></td>
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<tr>
<td>Vendor introductions</td>
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<tr>
<td><em>Morning break</em></td>
<td></td>
</tr>
<tr>
<td><strong>Jen Mercer</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Catherine Cahill</strong>: Flying UAS in Polar Regions: Operations and Regulations</td>
<td></td>
</tr>
<tr>
<td><strong>Michael Huff</strong>: SRI Unmanned Aircraft Systems</td>
<td></td>
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<tr>
<td><em>Lunch (provided)</em></td>
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<tr>
<td><strong>Robert Boyd</strong>: Hybrid Aircraft Overview</td>
<td></td>
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<tr>
<td><em>Afternoon Break</em></td>
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<tr>
<td><strong>Daniel Wagster</strong>: Iridium DTCS</td>
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<tr>
<td><strong>Andrew Stillinger</strong>: Status of the Automatic Geophysical Observatory Network on the High Antarctic Plateau</td>
<td></td>
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<tr>
<td><strong>Michael Lucibella</strong>: Dateline: Antarctica</td>
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<tr>
<td>Wrap up</td>
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<tr>
<td>Social Event at the Rox Bar and Grill</td>
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## Tuesday, March 22

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker(s)</th>
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<tbody>
<tr>
<td>Welcome and introductions</td>
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<tr>
<td>Keynote #2</td>
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<tr>
<td><strong>Lars Berg Larsen</strong>: 30 years’ experience in Deep Ice Core Drilling Camps</td>
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<tr>
<td><strong>Jason Weale</strong>: The Evolving Arctic Domain: Meeting the Challenge</td>
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<tr>
<td><em>Morning break</em></td>
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<tr>
<td><strong>Scott Dalton</strong>: Power and Telemetry Systems for Real-Time Earthquake Monitoring in Alaska</td>
<td></td>
</tr>
<tr>
<td><strong>Adam LeWinter</strong>: The ATLAS System: An Autonomous Terrestrial Laser Scanner Engineered to Monitor Large Tidewater Glaciers</td>
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### Schedule of Events

<table>
<thead>
<tr>
<th>Speaker</th>
<th>Topic</th>
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<tbody>
<tr>
<td>Jason Hebert</td>
<td>Advances in Remote Seismic Station Technology</td>
</tr>
<tr>
<td>Lunch (provided) and posters</td>
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<tr>
<td>Rob Bauer</td>
<td>The Automated Met-Ice-Geophysics-Ocean Observing System -- AMIGOS-II</td>
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<tr>
<td>Nicolas Bayou</td>
<td>Powering Science at high latitudes</td>
</tr>
<tr>
<td>James Jarvis</td>
<td>APRS World Wind Turbine Update</td>
</tr>
<tr>
<td>Ryan Bierma</td>
<td>Updates and Plans for the Earthscope Alaska Transportable Array</td>
</tr>
<tr>
<td>Tracy Dahl</td>
<td>Controlling static electricity</td>
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<td></td>
<td>Panel discussion on static and grounding issues</td>
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<tr>
<td>Afternoon Break</td>
<td></td>
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<tr>
<td>Tracy Dahl</td>
<td>COTS To Custom: Developing project specific solutions from off the shelf components</td>
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<tr>
<td></td>
<td>Panel with Steering Committee members to discuss future directions for the PTC. How to improve, what is desired, etc.</td>
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<tr>
<td></td>
<td>Meeting wrap-up</td>
</tr>
<tr>
<td></td>
<td>Meeting adjourned</td>
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The "solar chalet" near Toolik Field Station, Alaska, is a mixture of COTS components and out-of-the-box thinking. Photo: Tracy Dahl
## Appendix B: Attendees

<table>
<thead>
<tr>
<th>NAME</th>
<th>AFFILIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kent Anderson</td>
<td>IRIS/PASSCAL</td>
</tr>
<tr>
<td>Dick Armstrong</td>
<td>Richard S. Armstrong, PE, LLC</td>
</tr>
<tr>
<td>Joseph Baca</td>
<td>Lockheed Martin/Antarctic Support Contractor (ASC)</td>
</tr>
<tr>
<td>Rob Bauer</td>
<td>University of Colorado at Boulder, National Snow and Ice Data Center (NSIDC)</td>
</tr>
<tr>
<td>Nicolas Bayou</td>
<td>UNAVCO</td>
</tr>
<tr>
<td>Lars Berg Larsen</td>
<td>University of Copenhagen, Denmark</td>
</tr>
<tr>
<td>Ryan Bierma</td>
<td>IRIS/PASSCAL</td>
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<tr>
<td>Robert Boyd</td>
<td>Lockheed Martin</td>
</tr>
<tr>
<td>Steve Brownell</td>
<td>Lockheed Martin/ASC</td>
</tr>
<tr>
<td>Kelly Brunt</td>
<td>University of Maryland, Earth System Science Interdisciplinary Center</td>
</tr>
<tr>
<td>Catherine Cahill</td>
<td>University of Alaska-Fairbanks, Alaska Center for Unmanned Aircraft Systems Integration</td>
</tr>
<tr>
<td>Paul Carpenter</td>
<td>IRIS/PASSCAL</td>
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<tr>
<td>Jeffrey Casper</td>
<td>SRI International/CH2MHILL Polar Services (CPS)</td>
</tr>
<tr>
<td>Satish Chetty</td>
<td>Beyond 66 Solutions</td>
</tr>
<tr>
<td>Dean Childs</td>
<td>IRIS/PASSCAL</td>
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<tr>
<td>Tracy Dahl</td>
<td>Polar Field Services/CPS</td>
</tr>
<tr>
<td>Scott Dalton</td>
<td>UAF, Alaska Earthquake Center</td>
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<tr>
<td>Leo Delarm</td>
<td>Super Structures Worldwide and Camp Facilities LLC</td>
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<tr>
<td>Michael Duvernois</td>
<td>University of Wisconsin-Madison, WIPAC</td>
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<tr>
<td>Patrick Haggerty</td>
<td>Division of Polar Programs, National Science Foundation</td>
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<tr>
<td>Barry Hamilton</td>
<td>Red Canyon Software</td>
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<tr>
<td>Jason Hebert</td>
<td>IRIS/PASSCAL</td>
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<td>Brendan Hodge</td>
<td>UNAVCO</td>
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<td>Kyle Hoppe</td>
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<tr>
<td>Michael Huff</td>
<td>SRI International/CPS</td>
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<tr>
<td>Derek Inglis</td>
<td>Xeos Technologies Inc.</td>
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<tr>
<td>James Jarvis</td>
<td>APRS World, LLC</td>
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<tr>
<td>NAME</td>
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<tr>
<td>Sarah Kaye</td>
<td>ManTech, U.S. Coast Guard</td>
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<tr>
<td>Charles Lee</td>
<td>University of Waikato, New Zealand</td>
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<td>Adam LeWinter</td>
<td>Cold Regions Research and Engineering Laboratory (CRREL)</td>
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<td>Michael Lucibella</td>
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<tr>
<td>Michael MacFerrin</td>
<td>University of Colorado, Cooperative Institute for Research in Environmental Sciences (CIRES)</td>
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<td>Ian McEwen</td>
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<tr>
<td>Jennifer Mercer</td>
<td>Alternative Experts, LLC (ALEX)</td>
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<td>Spencer Niebuhr</td>
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<tr>
<td>Kevin Nikolaus</td>
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<tr>
<td>Gregg Noble</td>
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<tr>
<td>Thomas Nylen</td>
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<tr>
<td>Matt Okraszewski</td>
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<tr>
<td>Randy Olsen</td>
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<tr>
<td>Paul Passmore</td>
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<td>Joseph Pettit</td>
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<tr>
<td>Thomas Quinn</td>
<td>Polar Field Services/CPS</td>
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<tr>
<td>Kip Rithner</td>
<td>Polar Field Services/CPS</td>
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<tr>
<td>Ronald Ross</td>
<td>Polar66 Engineering</td>
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<tr>
<td>Robbie Score</td>
<td>Polar Field Services/CPS</td>
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<tr>
<td>Mark Seefeldt</td>
<td>University of Colorado-Boulder, CIRES</td>
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<tr>
<td>Madieu Sesay</td>
<td>Gambia Methodist Academy</td>
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<tr>
<td>David Smith</td>
<td>CH2MILL/CPS</td>
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<tr>
<td>William Spindler</td>
<td>USAP Veteran, Self-employed engineer</td>
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<tr>
<td>Andrew Stillinger</td>
<td>New Jersey Institute of Technology, Center for Solar-Terrestrial Research</td>
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<tr>
<td>Todd Valentic</td>
<td>SRI International/CPS</td>
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<tr>
<td>Jeff Van Velder</td>
<td>Xeos Technologies Inc.</td>
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<td>Daniel Wagster</td>
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<tr>
<td>Jason Weale</td>
<td>CRREL</td>
</tr>
<tr>
<td>NAME</td>
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<tr>
<td>Jessica White</td>
<td>CaseTech, Inc.</td>
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<tr>
<td>Steven White</td>
<td>CaseTech, Inc.</td>
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<tr>
<td>Timothy White</td>
<td>University of Colorado, NSIDC</td>
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<tr>
<td>Susan Zager</td>
<td>Rocky Mountain College of Art and Design</td>
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<tr>
<td>Annie Zaino</td>
<td>UNAVCO</td>
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Researchers with Center for Remote Sensing of Ice Sheets fly a UAS near Kangerlussuaq, Greenland. Photo: Kevin Pettway
Appendix C: Post Meeting Survey

PTC2016 participants responded to surveys distributed on Day 2. Surveys contained 10 questions for which a rating was requested, and three open-ended requests for response. The 22 responses are summarized here. Some respondents skipped some questions.

The following table summarizes responses to 10 statements to which attendees selected the response closest to their own; the numbers represent the number of responses with the particular rating. Though respondents could select “Strongly Disagree” or “Disagree,” none did, so those ratings have been omitted.

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>NEITHER AGREE NOR DISAGREE</th>
<th>AGREE</th>
<th>STRONGLY AGREE</th>
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<tbody>
<tr>
<td>1. I found PTC 2016 to be valuable.</td>
<td>0</td>
<td>5</td>
<td>17</td>
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<tr>
<td>2. The agenda was appropriate and topical.</td>
<td>0</td>
<td>9</td>
<td>13</td>
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<tr>
<td>3. I’m going home with new information that will improve my ability to perform my job.</td>
<td>0</td>
<td>9</td>
<td>13</td>
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<tr>
<td>4. The speakers and their presentations were relevant to my work.</td>
<td>0</td>
<td>10</td>
<td>12</td>
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<tr>
<td>5. The posters and vendor displays were relevant.</td>
<td>4</td>
<td>13</td>
<td>5</td>
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<tr>
<td>6. The panel discussions addressed topics relevant to my work.</td>
<td>4</td>
<td>7</td>
<td>7</td>
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<tr>
<td>7. There was sufficient time for talks, questions, and discussions.</td>
<td>0</td>
<td>8</td>
<td>11</td>
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<tr>
<td>8. There was sufficient breakout time for discussion with other participants.</td>
<td>1</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>9. I’m glad I attended PTC2016.</td>
<td>0</td>
<td>4</td>
<td>18</td>
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<tr>
<td>10. I hope to attend PTC2017.</td>
<td>1</td>
<td>4</td>
<td>17</td>
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</table>

The survey included three open-ended requests for information. Below, each request is followed by the responses received, reproduced as faithfully as possible.

11. What did you like about this year’s PTC?

- The Lockheed presentation - if true it’s a game changer.
- Good info. Everything presented was quality and relevant or interesting.
- The connections I made. The reception was very nice as well.
- New topics.
- My first time to attend – great focused meeting.
- Nice variety of topics, site locations. Vendors provided excellent in-depth info. Sci participants provide useful development and prototyping stories.
- UAS discussions/presentations/regulations, battery war stories, discussions.
- Useful information and experience shared by presenters.
- Keynote talks, UAS regulations, opportunity to discuss technologies, issues, solutions
- Good variety.
- An “open” schedule, enough breaks to allow discussions, 1:1.
- I like the small size and short duration, makes it personal and accessible.
- The variety of topics.
- Lots of new faces and new topics mixed in well with updates on old topics.
- All of the talks were excellent.
- Really good choice of speakers, good topics, and good attendance. Hope to see this event grow even bigger.
- Like the flexibility of the agenda as the day went on. Great keynote speakers.
- I like that the topics were relevant to most of the issues we currently have – power and data transfer.
- Wide range of topics.
- UAS was nice. Iridium always good to catch up on.
- Met with colleagues & friends; learned current techniques & new technologies, catering certainly decent; frequent breaks were appreciated.
- Keynote talks; Lockheed & Iridium development.

12. Describe the PTC in one word [Okay, no more than three words.]

- Interesting & informative.
- Polar Tech!
- Useful
- Informative exciting, collaborative
- Informative
- Valuable
- Vibrant
- Nerd Party
- Great discussions
- Informative!
- Problem prevention
- Collaborative thinking
- Up & coming
- Make it bigger
- Enthusiastic, informative, different kind of conference
- Good pace
- In-depth
- Nicely hands on
- Educational
- Excellent
13. Any Final Thoughts? Comments, Suggestions, Questions? Suggestions for the PTC2017 venue?

- Contact Andrew Gerrard at New Jersey Institute of Technology for 2017 venue
- Madison/IceCube would be happy to host.
- Here [Denver] is good for 2017
- Rewards, incentives for documented / shared results of testing, lessons learned; discussion of issues listed by Jen Mercer
- Great job!
- Publish agenda in advance of meeting—2-4 weeks.
- Great location and hosting! Better lighting controls would help visibility of presentations. Small-group discussions may produce more opportunity for interaction? Overall, an excellent conference. Thank you!
- Agenda out earlier. Keep the audience small so open discussion is possible.
- Would like to see if this conference could engage more researchers with what’s suited and what’s worked. Also, more federal agency participation would raise awareness and help the conference grow. Earlier registration
- You nailed it! I like the mix of old, new & really cutting edge. Start the planning & housekeeping earlier & you’ll be all set.
- Email list of everyone for easy follow up collaboration.
- Enjoyed it!
- Poster session is not that much of a benefit.
- I like moving around, but boy, Denver is easy. I would have trouble going to a ‘boondoggle’ location like Hawaii.
- Some of the talks aren’t very technology focused.
- A pleasure to be a part of PTC. It seems like UAS will be a revisited theme. PTC2017 in MP, CA?

A word cloud created from survey responses to question 12.
Appendix D: About the PTC

STATUS OF PLANNING FOR PTC2017

Prospective dates: 11-12 April 2017

Meeting location: Denver area

   Polar Field Services Headquarters
   Denver Colorado
   8100 Shaffer Parkway #100
   Littleton, CO 80127

PTC STEERING COMMITTEE

   • Todd Valentic, SRI International, (todd.valentic@sri.com)
   • Robbie Score, Polar Field Services, (robbie@polarfield.com)
   • Satish Chetty, Beyond 66, (satish@suburbia.org.au)
   • Tracy Dahl, Polar Field Services, (tracy@polarfield.com)
   • Kyle Hoppe, Antarctic Support Contract, (kyle.hoppe.contractor@usap.gov)
   • Joe Pettit, UNAVCO, (pettit@unavco.org)
   • Kip Rithner, Polar Field Services, (kip@polarfield.com)

DISCLAIMER:

This report describes work supported by the National Science Foundation under Contract No. NSFDACS11C1675. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.