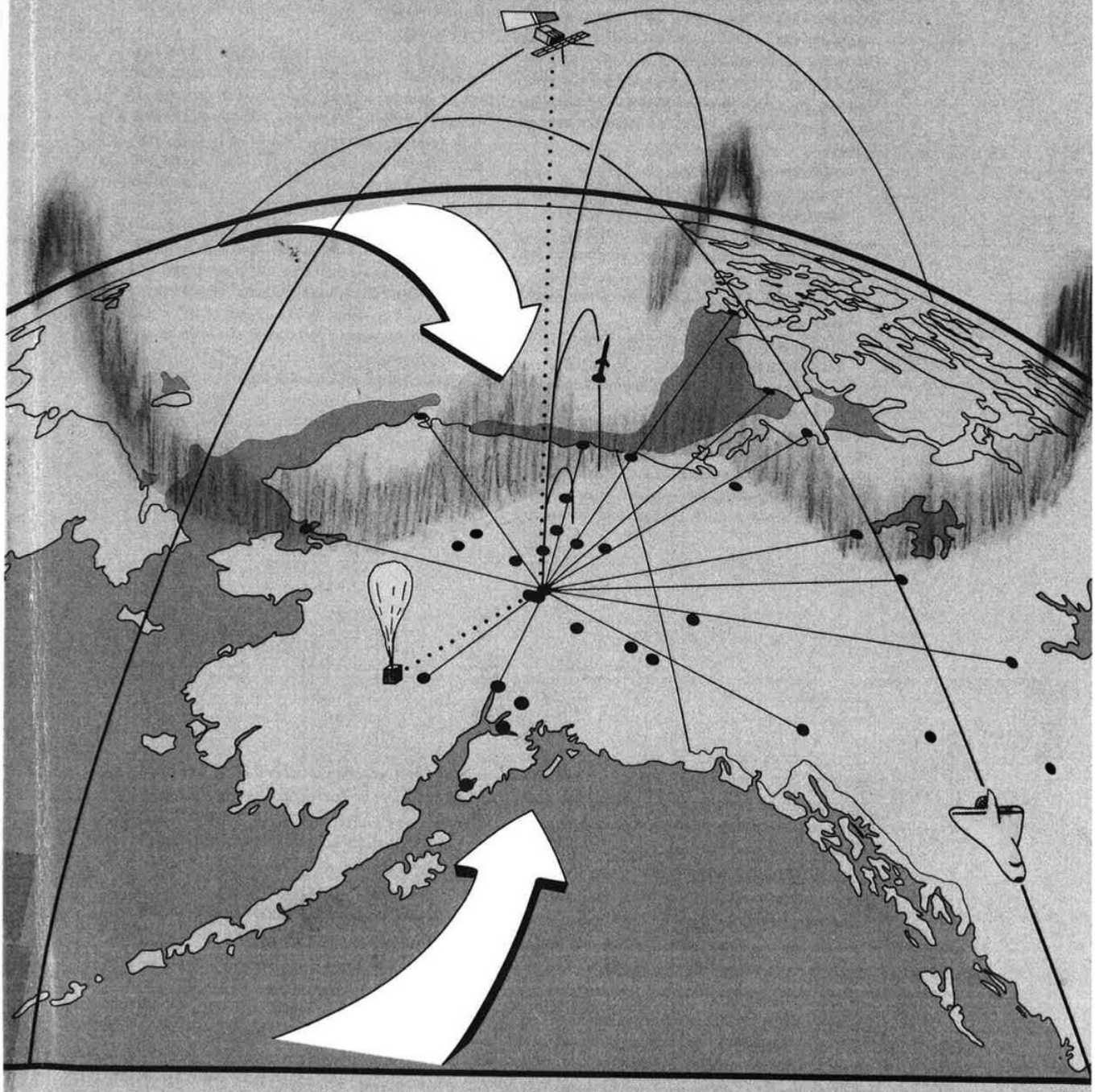
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Window on Space over the Western Arctic
The Poker Flat Research Range

CARLA A. HELFFERICH, CHARLES S. DEEHR, NEAL B. BROWN AND DOREEN FITZGERALD

Carla A. Helfferich, Charles S. Deehr, Neal B. Brown and Doreen Fitzgerald are all from the Geophysical Institute, University of Alaska, Fairbanks, Alaska 99775-0800.

Poker Flat, the world's largest overland rocket range, is based 30 miles north of Fairbanks, Alaska, and extends to the coast of the Arctic Ocean. The only high-latitude rocket range on U.S. soil, the Poker Flat Research Range has an impact zone larger than Indiana. The range is an important facility for maintaining the highest level of auroral research, for national security support, for observing global climate, and for support in the National Science Foundation's program on Coupling, Energetics, and Dynamics of Atmospheric Regions (CEDAR).

Poker Flat is owned and operated by the Geophysical Institute of the University of Alaska–Fairbanks under contracts with the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center, Wallops Flight Facility. The range has also received contracts from the Defense Nuclear Agency, the U.S. Air Force Geophysics Laboratory, the National Oceanic and Atmospheric Administration, and the National Science Foundation.

Since the first launch 20 years ago, more than 220 high-altitude rockets have been launched from Poker Flat. Among the records set during these two decades are the heaviest parachute-recovered payload (2300 pounds), the heaviest vehicle (5985 pounds) to an altitude of 113 km, and a payload recovery far exceeding that of launch facilities with impact areas at sea. The current apogee record for a Poker Flat launch is 1400 km.

The range is located on land owned by the University of Alaska. Permission to let expended rocket motors and payloads fall on the designated 14-million-acre impact zone extending north and north–northeast to the Beaufort Sea is secured periodically from the Bureau of Land Management, the U.S. Fish and Wildlife Service, the State of Alaska Division of Lands, the Doyon Ltd. Native Corporation, and other entities. The Federal Aviation Administration reviews requested rocket flight zones and coordinates airspace operation during launches; the Alaska Department of Transportation authorizes range personnel to stop traffic on the nearby Steese Highway during launches. Soviet authorities are informed shortly before each launch via NORAD in Colorado Springs.

As the Poker Flat facility begins its third decade of service, it must modernize to be effective, because vital scientific support is lacking. In accordance with the recommendations of the *U.S. Arctic Research Plan* and the U.S. Arctic Research Commission, a plan is being developed for a major upgrade of Poker Flat. Features include



Poker Flat Research Range flight zones.

Partial List of Range Users (1969–1988)

United States:
Advanced Research Projects Agency
Aerospace Corporation
Air Force Geophysics Laboratory
Cornell University
Defense Nuclear Agency
Florida Atlantic University
Geophysical Corporation of America
Geophysical Institute, Unersity of Alaska–Fairbanks
Lincoln Laboratory, MIT
Los Alamos Scientific Laboratory
National Aeronautics and Space Administration
National Oceanic and Atmospheric Administration
onal Science Foundation
Pennsylvania State University
Sandia Corporation
Science Applications Inc.
Space Data Corporation
Rice University
United States Air Force, Space Division
United States Air Force, BMO
United States Army, BMD
University of California at Berkeley
University of California at San Diego
University of Colroado
University of Denver
University of Michigan
University of Minnesota
University of New Hampshire
University of Rhode Island
University of Houston
University of Washington
University of Wisconsin
Utah State University

Foreign:
Denmark
Japan
Sweden
United Kingdom

improvements in ground- and space-based support, launch facilities, range support and background atmospheric indicators of global climate change. A unique feature of the modernized range will be a network of Alaska village observatories, providing important synoptic data to the range command center, as well as educational and job opportunities to the villages.

History of Poker Flat

Auroral studies began on a small scale at Fairbanks as early as 1929; 20 years later, the Geophysical Institute, authorized by an act of Congress, was under construction. Auroral studies were a major part of the institute's program, and by the 1950s, American scientists were interested in using sounding rockets as a major means for studying the aurora.

By 1956 North America's first northern sounding-rocket range had been built at Ft. Churchill, Manitoba, as a joint U.S.–Canadian venture. Ft. Churchill was an important facility, but it had some disadvantages. Its chief problem was that only some kinds of auroral forms occur there, and only certain kinds of experiments can be performed. Nevertheless, the Canadian site was valuable to many experimenters. Among them, in the 1960s, was Neil Davis of the Geophysical Institute. After one campaign there, he conceived the plan for an Alaska research range. By 1964 NASA was interested enough to commission Davis to find the best sounding-rocket launch site in Alaska.

His first choice lay on the southern boundary of the quiescent auroral zone, the best vantage point from which to study the aurora. It was in a sparsely populated area from which rockets could be launched without interfering with major highways or population centers, yet it had easy access to a highway connecting it with the amenities and transportation facilities of Fairbanks. The site could also be integrated with the University of Alaska, where the Geophysical Institute had achieved a distinguished record of auroral and other relevant high-latitude research. Numerous ground-based observation sites that could support sounding rockets already existed throughout Alaska, and most of them were under the auspices of the institute. Because mammoth gold dredges had once operated near this now-bare tract, old electric power lines, standing since the 1920s, could easily be refurbished.

NASA might have ignored Davis's survey and the selected site, but distant international developments began to play a role. The early 1960s had witnessed the race between the U.S.S.R. and the U.S. in atomic weapons testing, and the Defense Atomic Support Agency (DASA) had gone all out in purchasing launchers, missiles, ships and aircraft to monitor nuclear tests. By 1966 the test ban treaty was ready for signing, and DASA needed a new way to do its research. The barium clouds created by chemical releases from sounding rockets resemble atomic bomb debris, and DASA grasped this opportunity to work with—in effect—simulated bombs. Aurora scientists suddenly had access to surplus launchers, boosters, money, new facilities and friends in the military.

There was still no Alaska launch facility, and there might never have been one except for an accident in Greenland. A major series of barium-release experiments sponsored by the Department of Defense was scheduled for Thule, Greenland, in the spring of 1968. Just before the launches an American B-52 with nuclear weapons aboard crashed off the coast near Thule. The Danish parliamentary elections were in progress, and "ban-the-bomb" sentiment was at its peak. Public indignation, mixed with political prudence, dictated that no U.S. weapons-related experiments be held on Danish protectorate territory.



Initial construction at Poker Flat—a rocket assembly building—in the fall of 1968.

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Assembling the first rocket launcher, in the winter of 1968.

DASA was left with six barium-release rockets and a crew, ready and waiting, but no launch site. Fort Churchill was unsuitable; after the Greenland accident, no one would consider anything but American soil for a launch. At the urging of Neil Davis, who enlisted the help of Peter Haas of DASA, Robert Frosch of the Advanced Research Projects Agency (ARPA, and especially Lt. Col. Mike Dowe, also of ARPA), the site survey was reconsidered. It was agreed that the location near Chatanika, north of Fairbanks, could house a so-called minimal launch facility, designed specifically for the mission bumped from Greenland, SECEDE III. It was rescheduled for March 1969.

Minimal though it may have seemed to Federal officials, building the launch facility stretched the Geophysical Institute's resources to their limits. The first task was to obtain the necessary permissions: a long-term lease for 7000 acres from the State, permission for airspace use from the FAA, and permits from the Bureau of Land Management for rocket impacts on Federal lands. Finally, in July 1968, construction began.

Eldon Thompson, Larry Sweet, other institute staff, Army and Air Force personnel, and technicians and scientists from Space Data Corporation began with a budget of $90,000—a meager sum since they were starting from scratch. The site was called Poker Flat, in honor of nearby Poker Creek and the Bret Harte short story "The Outcasts of Poker Flat."

Construction continued throughout the fall and winter. In March the DASA and ARPA crews arrived with their six barium-release rockets. They found a rail-type launcher, complete with a 60-ft A-frame movable cover, a corrugated aluminum rocket assembly building, and a trailer to house scientific equipment and personnel that was shielded from the launch pad by a fortress of what the crew called Alaska cement (55-gallon drums filled with ice). An array of storage and single-purpose portable structures and tents completed the picture. Poker Flat was open for business.

The Defense Department had envisioned it to be highly limited business. Once SECEDE III was complete, they planned to pack up and move away, leaving Poker Flat to return to scrubby black spruce forest.

Davis had other plans. The SECEDE experimenters needed ground support for their payload observations, and they requested stations at Fort Yukon, Bettles, Tok and Ester Dome—a fair expanse of interior Alaska. Davis agreed that the stations would be provided, on one condition. He also had a rocket experiment planned, a NASA-funded launch to make auroral measurements from Ft. Churchill, but Davis wanted to make the launch from Poker Flat.

Thus it was seven rockets, not six, that lifted off from Poker Flat during the spring of 1969. Radio stations throughout Alaska carried the live countdown of the first launch, and thousands of Alaskans hurried outside to catch a glimpse of the first barium release. The Department of Defense had what it wanted. They packed up and left, even rolling up the communications cables that had linked the range headquarters to Pedro Dome, where communications had been established to the temporary control center for SECEDE III at Fort Wainwright near Fairbanks. With a budget of less than $500, Davis, Thompson and Sweet saw that the grounds were kept up while they tended to their duties at the institute. They even managed to install a communications system at Poker Flat, built entirely with surplus military equipment.

Because the launch facility had shown itself to be workable and scientifically useful, the institute wouldn't let it be abandoned. To forestall any possibility of premature closing, the first two full-time range employees were hired, launch officer Car-

Historical photograph colorized; colors are interpretive.

roll Coe and windweighter Jim Wolff. Institute scientists also put together their own payload experiment, to which Jim Heppner of NASA/Goddard added three barium-release rockets. Remarkably, a second launch season took place.

By the summer of 1970 the U.S. research community was convinced of Poker Flat's value. But the facility was not prepared for sudden popularity: 13 sounding rocket launches were scheduled between November 1970 and March 1971. With this show of support, construction had to begin again.

A second launcher was installed; permanent telemetry and radar stations were established, with the long-term loan of a portable Sandia telemetry station and the NASA Very Long-Range Tracking (VERLORT) radar, which had been used early in the manned space flight program and was capable of tracking a rocket to the moon.

NSF funded construction of a 40- by 40-ft blockhouse to shelter most major functions: range and payload control, telemetry and windweighting. Other improvements included new roads, better on-site communications, a microwave link to Pedro Dome for both telephones and scientific data, and several wooden storage and work buildings.

The 1971 construction season was even more hectic. After several years of negotiations, including one memorable visit to the range by a site selection committee whose members were greeted by a freshly cleaned moose carcass hanging from one of the launchers, an 88-ft-diameter incoherent scatter radar was installed a mile from the launch site. Operated by SRI International, this radar provided valuable data for years in conjunction with optical, radio and rocket techniques. It was moved to Sondrestrom, Greenland, in 1982.

To provide more prelaunch data, ground support instrumentation was upgraded at the Fort Yukon and Ester Dome field sites by Hugh Anderson of Rice University and Neal Brown of the institute. Two new launcher support buildings were built, and protective, heated clamshell covers were installed to keep rockets and payloads from freezing while they awaited launch. Communications at the site and between the range and field sites were improved. To ameliorate the poor rocket-storage situation (rockets were being stored in boiler-heated tents), a 30- by 40-ft rocket assembly and storage building was erected.

Poker Flat had become a big business, employing 18 people full time—mostly for construction and scientific instrumentation—during the summer of 1971. It now needed an overall coordinator more than a scientist with a wild idea. Davis had seen the range through, but he had visions of returning to science. In the fall of 1971, Neal Brown was named the first full-time Poker Flat range supervisor.

Brown started work in the spring of 1972, just in time to oversee the biggest year yet in range construction. The budget was $1.2 million, the staff numbered 50, and the launch support capa-



The A-frame rocket launcher cover, built in the winter of 1968.

Historical photograph colorized; colors are interpretive.

bility effectively doubled. Two new launchers were built, both specially designed and funded by the Defense Nuclear Agency to accommodate the complex payloads charged with liquid helium needed for project ICECAP (Infrared Chemistry Experiment Coordinated Auroral Program).

The old A-frame launcher cover was demolished with carefully placed explosives. In keeping with the Flat's traditional spirit, 90% of its materials were salvaged and recycled, mainly into a new payload assembly building, a 2500-square-ft structure with a class-100 clean room for assembling dust-sensitive payloads. A warm-storage warehouse went up, as did a partially buried rocket storage bunker. All aspects of range communications were improved, and three television camera systems were installed for launch pad surveillance.



Assembling rocket motors onto the launcher for a Talos–Sergeant launch in 1978.

The scientific capacity also improved. The telemetry system was expanded from P-band to include S-band with autotrack. Too large and sophisticated to fit in the blockhouse, it was relocated in the new payload assembly building. A 260-ft-high instrumented meteorological tower was installed; along with a minicomputer, this helped with windweight calculations for launches. Another invaluable addition was an all-sky, low-light-level television camera for determining auroral and launch conditions. With the suspension of NASA rocket operations at Point Barrow, the Tone Ranging Trajectory System, which tracks rocket paths by radio waves, was moved to Poker Flat. A final 1972 improvement was the Meteorological Rocket Network Facility, another pad with three launchers for smaller rockets (Lokis, Super-Lokis and Arcas) used to collect wind and temperature data, and still more technical and scientific support capability.

By this time the basic facility was essentially complete. The next major addition was in 1974, when construction began on the Poker Geophysical Observatory. It would house riometers, magnetometers and other instruments used in routine institute experiments, plus all-sky cameras and meridian-scanning photometers to support rocket launches.

Since then various significant additions have appeared. The University of Rhode Island installed air sampling equipment in 1979, a program that continues with funding to the University of Alaska–Fairbanks. NOAA, in conjunction with the Environmental Protection Agency and under the auspices of the World Meteorological Organization Global Ozone Research and Monitoring Project, in 1984 installed and began operating an automated Dobson ozone spectrophotometer meteorological measurement station at Poker Flat. This station is part of a global array of similar stations collecting data on the status of stratospheric ozone.

Radar equipment continues to be important. Site preparation for NOAA's Mesospheric–Stratospheric–Tropospheric (MST) radar began at Poker Flat in 1978. This experimental radar measured the upper-atmospheric wind direction, speed and turbulence. It began gathering data in 1979, gradually coming up to full power over the next few years. During the summer of 1986, site preparation and construction got underway for a stratospheric–tropospheric radar funded by Federal agencies and the State of Alaska through scientists at the Geophysical Institute. Completed in the fall of 1987, it has a 150-ft-diameter spherical dish with a 120-ft tower.

The range now incorporates rocket assembly and launching capabilities, along with telemetry receiving stations and ground-based diagnostics needed for launch decisions for space, aeronomy and atmospheric science experiments. The ground-based instrumentation allows auroral activity, magnetic storms, ionospheric perturbations and other space disturbances to be monitored as they happen. The facility now incorporates eight rocket launchers up to 20,000 pounds; S-band and P-band telemetry; 100-m precision radar and transponder tracking; and 200-m optical beacon tracking.

The Poker Flat location offers several advantages: overflight and landing rights on a large land area; economical, fail-safe payload recovery; easterly launches as far as the Alaska–Canada border; northerly launches with no downrange limit; a safe polar-orbit satellite launch track; a complete meteorological rocket launch, track and data facility;

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Poker Flat personnel preparing a rocket for launch in 1981.

an extensive network of Geophysical Institute observatories; university academic and research facilities; access to nearby military and civilian air fields; and range operators with the experience of many launches behind them.

Poker Flat also plays a supporting role in research on the ground. The Caribou–Poker Creeks Research Watershed, cooperatively established in 1970 by Federal and State agencies and the University of Alaska, lies north of the Chatanika River within the prime booster impact area. The area is managed by the U.S. Forest Service's Institute of Northern Forestry. Users look to Poker Flat for occasional support, and cooperation and coordination between range and watershed personnel is continuing.

Some Results from Poker Flat

Rocket experiments at Poker Flat fall into three categories: ballistic tests of rocket systems, single experiments on the high-latitude upper atmosphere, and series of experiments involving single or multiple techniques that are refined over several years. The last of these is by far the largest category. Fully half of the large rockets flown at Poker Flat carried payloads designed on the basis of experiments flown previously. These experiments, or series of experiments, have also been by far the most productive in terms of scientific results.

One of the more important results involved the discovery and mapping of vertical electric fields and field-aligned currents associated with an auroral arc. Predicted from auroral television data, the low-altitude portion was observed with rocket-borne magnetometers in the early 1970s, and the morphology beyond 10,000 km was studied by using shaped-charge barium by the mid-1980s. These results were of key importance to the theories of the formation of auroral arcs and the acceleration of auroral primary electrons. Correlation with plasma drift measurements by the Chatanika incoherent scatter radar were also made to increase the scale of the measurements.

Among the optical measurements, both the ultraviolet and the infrared portions of the aurora's spectrum have been measured. The results have related the spatial extent of these emissions to the visible aurora. In addition to the barium releases, chemicals such as lithium, water and aluminum have been used to map neutral and ionized winds. In the lower atmosphere the Meteorological Rocket Network provided neutral wind, temperature and density measurements as ground truth for SAGE and SAM satellites, among others.

One of the more extensive programs has been the tracing of field lines and production of aurora emissions with rocket-borne electron accelerators. The aurora created by these electron beams has been observed immediately under the rocket and after the beam has traveled to the conjugate region in the southern hemisphere and back.

Among the successful single shots was a measurement of the ozone depletion due to X-rays from the aurora. Others include the measurement of the UV oxygen energy transfer in an optically thick medium and noctilucent cloud studies.

The increasing sophistication of the experiments conducted at Poker Flat has demanded that range facilities improve accordingly.

Future Development

As the Geophysical Institute prepares to enter a new century, there is a heightened interest, both national and international, in the Arctic. The U.S., through the International Geosphere–Biosphere Program, the Arctic Research Commission, and the Interagency Arctic Research Plan, has identified vital needs for improved knowledge of space and the upper atmosphere as a component of the Earth as a system.

Thus the institute expects sounding rocket programs to remain an important component of experimental research because rocket programs can support various scientific needs: cost-effective studies of plasma processes in space; studies of solar-variability-controlled energy depositions in the upper atmosphere and their downward flow through the middle atmosphere; and studies of the behavior and dynamics of minor constituents such as ozone in the Arctic upper atmosphere for global studies. The upper atmosphere studies are proposed by the NSF programs CEDAR and GEM (Geospace Environmental Modeling) and the international Solar–Terrestrial Energy Program. One

Historical photograph colorized; colors are interpretive.

of the four items in *Findings and Recommendations of the U.S. Arctic Research Commission* is that the U.S. should "upgrade the only high-latitude sounding rocket launch facility on U.S. soil and related logistics systems to support expected needs in upper atmosphere research in the Arctic."

Responding to the identification of specific needs, the Geophysical Institute has proposed a major upgrade to develop the existing range into a national space and environmental research facility that can support the U.S. Arctic research effort. The institute plan calls for redeveloping the range payload assembly and launching facility for modern guided and ballistic sounding rockets. This entails rebuilding launch pads and providing an improved, refitted payload assembly building. Launching more-powerful rockets requires strengthening the blockhouse building to ensure safety of the facility and personnel. Longer rail launchers are required for better control over unguided rockets.

Also planned is the integration of the range command center and the optical observatory within a new structure. The observatory is the source of information essential for launch decisions and is the hub of communications to networks of downrange and cross-track stations that telemeter their data for collation and assembly at Poker Flat. It would be equipped to serve the next generation of rocket and balloon experiments, as well as ground-based observers.

It is also important to integrate an air sampling station with the data-handling capability of the research range. This will create a center for expanded efforts to measure stratospheric and tropospheric ozone, greenhouse gases and Arctic aerosols. This station in continental boreal tundra would provide sensitive indications of processes leading to global climate change.

The planned installation and upgrades include

- A satellite receiving and command network to interrogate and command satellite observations of near-Earth space in real-time to establish magnetospheric conditions;
- Incoherent Scatter Radar, an instrument for measuring the spatial distribution of ion density and velocity;
- Resonant Scatter Lidar, an optical radar to measure the density and temperature of certain ions and neutral atoms as a function of altitude between 70 and 110 km, with a possible extension to 150 km;
- Rayleigh Scatter Lidar, an optical radar to measure the density and temperature between the ground and 70 km;
- High-speed imaging systems of auroral phenomena, both at the observatory and in the downrange area;
- An improved meridian-scanning photometer system for real-time quantitative measurements of auroral brightness and position;
- An imaging riometer to delineate areas of high-energy electron and proton precipitation;
- A magnetometer network for real-time quantitative measurements of the location of auroral electrojets leading to atmospheric heating, etc.;
- An optical interferometer network for measuring mesospheric and thermospheric, neutral and ionized wind fields;
- An air-sampling station to expand the capability for measuring stratospheric and tropospheric ozone, greenhouse gases and Arctic aerosols; and
- A village observatory network to incorporate rural Alaskans in near-Earth space research.

Through the Geophysical Institute, the University of Alaska has pioneered the Poker Flat facility, which is unique in the United States. Poker Flat's past has been distinguished, and the institute looks ahead with high hopes to future accomplishments.

Publications

Readers may obtain further information on some of the research described in this article from the following publications:

Poker Flat Research Range: A ten year history, by N.B. Brown: Geophysical Institute, Annual Report 1978-79, University of Alaska–Fairbanks, p. 15–33, 1980.

A new understanding of the aurora, by T.N. Davis and D.W. Swift: Geophysical Institute, Annual Report 1976-77, University of Alaska–Fairbanks, 1977.

United States Arctic Research Plan, by the Interagency Arctic Research Policy Committee, NSF 87-55, 1987.

National needs and Arctic research: A framework for action, by the U.S. Arctic Research Commission: Report to the President and the Congress of the United States, 1986.

Statement of goals and objectives to guide United States research: Findings and recommendations of the U.S. Arctic Research Commission, by the U.S. Arctic Research Commission, 1988.

What we have learned from the fireworks: Advances in plasma and magnetospheric physics, by E.M. Wescott: Research Report 1985–87, University of Alaska–Fairbanks, 1989.

The dynamic aurora, by Syun Akasofu: Scientific American, May, p. 90, 1989.



Colorized interpretation of the original A-frame launcher cover photograph, page 21.



Color reference supplied for the Poker Flat landscape.