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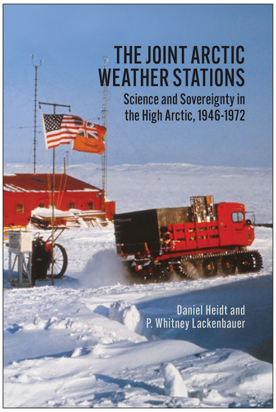

THE JOINT ARCTIC WEATHER STATIONS: SCIENCE AND SOVEREIGNTY IN THE HIGH ARCTIC, 1946–1972

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Science at the Stations

> The Joint Arctic Weather Stations are serving a two fold purpose, primarily as Arctic Observatories and secondly as advanced bases for scientific expeditions operating in the Queen Elizabeth Islands. It is gratifying to both Weather Services that the facilities and services provided at these stations are becoming ever more useful in the advancement of science.
>
> Patrick McTaggart-Cowan (1963)[1]

The Joint Arctic Weather Stations were primarily established to produce meteorological observations and to serve as bases for additional field science research. When outlining his weather station plans in early 1946, Charles Hubbard anticipated that "the establishment of meteorological stations will provide habitations, channels, communications, and transportation which will make it possible for us to penetrate the Arctic for other purposes." By laying the essential groundwork for Arctic activities, he felt "that probably in the long run the aggregate of all the scientific research that might be pursued may … represent the greatest benefit of the entire program."[2]

When Alan Innes-Taylor arrived at Isachsen two years later, he immediately noted the area's scientific value beyond meteorology. "It stirs my imagination and at the same time annoys me to think that man has neglected it for thirty years and then when he gets at it [he] doesn't do a well rounded scientific job," he reported, urging the Canadian government to send two field scientists to the station to conduct geological and botanical research.[3] Although Innes-Taylor left Isachsen more bitter than when he had arrived, this fervent proponent of an integrated Arctic science policy would have been pleased had he taken stock of the program in the decades that followed.[4]

Only a few years later, in 1953, Canadian External Affairs Minister Lester Pearson expounded upon how the network expanded science's vision into "Canada's Northern Horizon." The Arctic "is now a vital area of both defense and development," he suggested. He cited JAWS as a prime example of how "the northern frontier is being slowly but steadily rolled back, … not only from our concern for defense, but also from our determination to deepen and extend our knowledge of its economic and scientific secrets." Although he was initially apprehensive about the joint program and continued to promote Canadianization behind the scenes, Pearson now touted that "it was natural and sensible that the weather station program should become a cooperative venture," with meteorologists from both Canada and the US combining efforts "to get better observations from the far north which is the source of so much of our weather." The scientific benefits did not end there. He explained:

> The five new stations established in the northern Arctic since 1947 have also had great significance for scientists who have no connection with their primary function. The stations are laboratories for experts of every kind who come up for a week, a month or a season for field work and then return to their offices and laboratories in the south. Before the stations were established, this field work in the Arctic was enormously more difficult because of the lack of bases and the lack of transportation. Now the large aircraft which fly up on the spring resupply mission are filled with a varied assortment of men and equipment. A scientist from the Dominion Observatory travels from place to place with a little box which tells him much about the shape of the earth; a geodesist bearing cases of fragile and complicated equipment establishes fixed points astronomically in order to make Navigational charts and maps more accurate. A scientist from the Department

> of Agriculture spends a summer looking for insects; another, from the National Museum of Canada, is concerned with Arctic plants. Men in these fields of study return year after year to increase the knowledge of Arctic phenomena. But there are also special projects, such as research into the aurora borealis and the characteristics of permafrost, which have now become practicable with the establishment of the new permanent communities.[5]

Scholars regularly highlight the importance of JAWS infrastructure as scientific hubs in the High Arctic for southern field scientists and, in due course, surveyors of mineral and petroleum resources. This focus on visiting scientists, at the expense of their hosts, however, reveals comparatively little about the impact that these expeditions had on station resources, crews, and cultures.[6] The professional backgrounds of JAWS personnel, as well as their year-round Arctic residency, distinguished them from more transitory visiting scientists, and the station's inhabitants clearly differentiated themselves from these visitors. They generally welcomed new faces to the stations and did their best to assist visiting field parties with time, space, and resources — even though the additional requirements imposed by this hospitality taxed the stations and their crews.

Meteorological observations, however, remained the network's primary focus and the foundation of station life and culture. As historians Tina Loo and Meg Stanley note in their study of how local knowledge generates and flows in postwar development projects, plans and processes designed from afar required adjustment and modification once materials and practices "reacted in place and in real time." They also show how "place created and recreated practice."[7] Inspired by Sharon Traweek's work on cultural anthropology and the sociology of science, this chapter situates the JAWS community of scientific practitioners in their "domus" field stations, detailing what the men at the stations actually did, how they generated knowledge, as well as how place, professional backgrounds, and motivations contributed to local cultures that impacted scientific practices.[8] To date, historians of science investigating the production of knowledge have primarily focused on the collaboration and conflicts between two groups: scientists and amateurs.[9] Although a few scholars have begun to investigate technicians — one of the many categories of contributors between these two extremes — the diverse ways that this group reflects and shapes scientific knowledge and practice remain largely unexplored.[10] While field technicians embraced scientific objectivity and understood the importance of sound methodology, their careers did not rise or fall by developing new environmental insights. Unlike Arctic field scientists in the 1950s and 1960s who tried to advance their disciplines' stature by attempting to turn the Arctic into a laboratory-like environment where they could conduct controlled experiments,[11] JAWS technicians experienced no such pressure. Instead, they were "observers" who cultivated professionalism by accurately collecting synoptic data for scientists. Positioning technicians at remote field stations was especially efficient because it enabled comparatively costly scientists to focus on analyzing the incoming data.

Meteorological technicians — simply known as "met techs" — knew that southern meteorologists in North America and Europe used the data they collected to predict weather and to guide pilots crossing the Atlantic Ocean. Residing in the Arctic for a year or more, met techs helped to establish a scientific culture that differed from that imported by transient field scientists during their seasonal visits. Given the significant role the data they gathered played in forecasting, met techs emphasized precision, consistency, the importance of controlling variables whenever possible, and the timely transmission of their findings to southern meteorological centres. In contrast to the resupply efforts where participants generally adapted to seasonal environmental forces (see chapter 7), JAWS observers went to extreme lengths and endured hardships to conduct meteorological observations on schedule — almost regardless of the local weather conditions. Their daily routines consequently reflected a combination of established Western scientific methods, common sense, and acquired local knowledge — the latter accrued without the benefit of Indigenous people to guide them using traditional ecological knowledge or Inuit Qaujimajatuqangit.[12]

This dedication to collecting data in harsh conditions, however, had its limits. Local knowledge could be learned as well as forgotten, and technicians at the remote outposts lacked some of the insights of their scientist counterparts. Historian Vanessa Heggie explains that "field sites are often depicted as parts of hierarchical relationships, usually framed as centre-periphery," with information flows depicted "as unilateral, with data collection in the field feeding into more and more centralized, abstract and metropolitan sites."[13] Geissler and Kelly note that "through the day-to-day work of the field research, the global can be experienced and acted upon in any number of ways."[14] For the JAWS network, the tyranny of distance, isolation, and extreme polar conditions forced planners to provide field staff with agency and space to innovate and adapt international meteorological observation requirements to local conditions. When the analytic utility of certain observations came into doubt, JAWS personnel hesitated to continue braving the harsh local conditions. Within the JAWS program, planners were initially frustrated by the hesitancy of its personnel but, as Ted Binnema argues when discussing Hudson's Bay Company scientific networks from the eighteenth century, those requesting the services of field observers soon "understood the difference between networks peopled by grudgingly compliant subordinates, and those populated by men who thought of themselves as ardent and valued partners in research." Applying social intelligence and empathy generally led to stronger networks and more dedicated supporters.[15] JAWS planners, rediscovering this lesson, soon found that active dialogue with JAWS personnel was critical to obtaining the observations desired by southern scientists.

The Meteorological Program

The Canadian Interdepartmental Committee on Meteorology's recommendation in 1945 to set up the JAWS program for its initial five-year term stated two main purposes. First, officials anticipated that the stations would accumulate sufficient surface and upper air meteorological data to indicate the feasibility of scheduled air operations in the Arctic. Second, meteorologists would use the data for "extending the reliability of the forecast period from a few days to possibly a month."[16] The data required to fulfill these goals dictated the daily routine. Changes to local and international observation timing led to several adjustments to the stations' synoptic schedules in the decades that followed, but the types of meteorological observations undertaken remained consistent.

Met techs came to the stations with several months of intense observation training and prided themselves on overcoming harsh conditions on a regular basis to perform synoptic observations. In the early 1960s, an anonymous "Alert Poet" composed a "Northern Weather Station Prayer" that summarized the challenges that observers faced:

> Mighty Maker of this Earth
> Creator of the Universe
> Could you change your ice cold plan?
> Do away with the Arctic land?
> It's dismal cold and windy too!
> Good for What? of How? or Who?
> We try to solve your master Scheme,
> of wind and snow in a weather theme.
> We send the info to the south,
> By way of key and word of mouth.
>
> What earthly good can all this be,
> We can't decipher what we see.
> Can't you shed a little light,
> Let us plot to our delight.
> The answer that we seek and need,
> Is What? and How? and Who? Indeed![17]

Like all other Canadian weather observers, JAWS personnel followed the regulations set out in the *Manual of Standard Procedures and Practices for Weather Observing and Reporting* (*MANOBS*). This bible of Canadian meteorological procedure contained instructions for day and night observations; it also aligned Canadian synoptic observation procedures with international standards. Following its timetables also ensured that forecasting or climatic models considered JAWS observations alongside data from the rest of the continent or globe. The extreme environmental conditions of the archipelago, however, sometimes pushed these regulations and the men who followed them to the limit.

Most JAWS observers worked twelve-hour shifts, seven days a week, and each station's daily routine revolved around the surface and upper air observations. Because these observations often overlapped, radio operators conducted most of the surface synoptic observations at the satellite stations in between other tasks. These radio operators also assisted with pilot balloon (PIBAL) flights. Met techs undertook some of the surface observations but were mainly responsible for the PIBAL and "radiosonde" balloon flights. OICs and ExOs scheduled all other station work — be it maintenance, clearing the airstrip, repainting, rebuilding, moving supplies, or emptying urinals and drums used as toilets — around the collection of these important meteorological observations.

Surface Observations

Satellite station personnel took eight daily surface observations at three-hour intervals, timed to start simultaneously at all the JAWS stations. Radio observers or met techs also took shorter hourly surface observations when the stations expected incoming aircraft. Given its high aviation traffic and larger staff, the Resolute station conducted regular hourly programs throughout the year.[18]

In the early 1950s, the first observations for a new day at the satellite stations began at 0215 GMT. Before consulting any instruments, the observer walked to a predetermined place where the entire sky was visible to record the type(s), number, height, and direction of movement of the clouds. He also determined the proportion of cloud cover by mentally dividing the sky in halves and then estimating the amount of cloud in each half by tenths. During the dark period, observers made the same observations by monitoring the visibility of stars or using a ceiling projector (a searchlight operated remotely by a person indoors that shot a high intensity beam of light into the sky).[19]

Observers also recorded the *cloud ceiling* height. If there was cloud cover during daylight hours, they usually made these measurements by visual estimation or by launching a small ceiling or slightly larger PIBAL balloon. The neoprene balloons for these ascents were usually red, though they also came in white and black to facilitate visibility against different coloured skies. During the dark period, JAWS personnel enhanced the visibility of these flights by attaching a light source to the balloon. *Vertical visibility*, which measured the distance that observers could peer into this medium, was a less precise measurement, but the information was still critical to pilots who would need to fly through cloud cover.[20] Another method to determine the cloud ceiling and vertical visibility involved placing a ceiling projector at a known distance from an alidade to triangulate

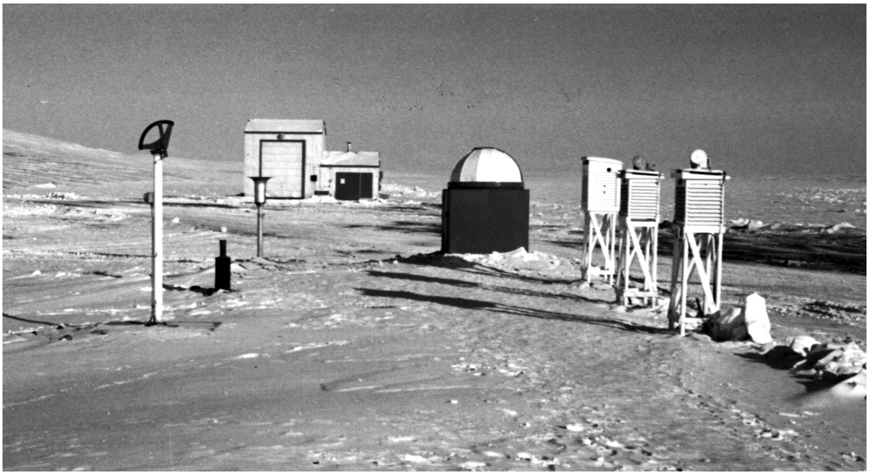

FIGURE 6-1. Most of Eureka's meteorological equipment, circa 1960s. On the right are the surface instrument shelters. An alidade for cloud height measurement is on the left. The large upside-down cone is the snow-gauge. The theodolite station with its rotatable dome is in the middle. The station's hydrogen production building and inflation garage are in the background. LAC (Winnipeg) Acc 2004-01213-7 AES Photographic Records of Arctic Weather Stations, Box 2, File Eureka ND.

height. Limited vertical visibility could also be determined by noting the brightness of the stars.[21] The popularity of these methods varied at each station and with each rotation of personnel.

In addition, these observers had to determine *horizontal visibility* during their surface observations. During daylight, this metric was determined by looking at pre-selected landmarks or items at various distances along the horizon. When it was dark, observers estimated horizontal visibility by looking at a light mounted on the top of the antenna mast or some other consistent light source. In unusual circumstances, one could observe whether the beam of light immediately above the ceiling projector was visible in order to approximate horizontal visibility.[22] Before proceeding, the observer recorded the present weather conditions according to the *MANOBS* definitions.[23]

Next, the observer turned his attention to the surface instrumentation located inside the cotton region screen instrument shelter (an American version of the Stevenson screen). The box's slatted walls sheltered the instruments from exposure to precipitation and direct solar radiation while allowing outside air to circulate through the enclosure. To foster consistent measurements across Canada, every box's base was 3 feet 9 inches above the ground and was positioned with its opening facing north. Even though cotton region screens sheltered surface instruments at each station, the extreme environmental conditions forced JAWS personnel to take several extra measures to ensure accurate readings. During severe storms, blowing snow would build up around the walls, or inside the structure itself, creating a layer of insulation that inhibited ventilation which caused the thermometers to produce skewed readings. Although personnel could cover the shelter with canvas during a storm to prevent it from filling with snow, this reduced the free circulation of air and thus affected the readings, so it was not recommended for stations like Isachsen that regularly faced high winds. Instead, personnel removed the floorboards from the shelter and constructed a special shelf for the temperature instruments.[24]

To avoid contaminating the results with human body warmth, observers approached the screens from the leeward side, held their breath, opened the box, and — keeping as much distance as possible — quickly noted the readings of the dry- and wet-bulb thermometers (the latter thermometer is covered by a cotton sock coated with a thin layer of ice), as well as the maximum and minimum temperatures recorded on separate, self-registering thermometers.[25] Only after recording these measurements could the observers take a new breath.

Even these additional measures were not always sufficient to ensure reliable readings. When temperatures dropped below -12°C (-10°F), the sock on the wet-bulb thermometer was useless and had to be removed. Instead, personnel had to approach the instrument shelter fifteen minutes before the scheduled observation, dip the wet-bulb thermometer directly into clean cold water to create an ice coating on it, return the thermometer, and then wait for the thermometers to stabilize before taking the measurements. Similarly, if frost had to be wiped from the thermometers, observers had to follow the same fifteen-minute rule to ensure reliable readings. When the temperature dropped below -39°C (-38°F) during the coldest months mercury-filled thermometers froze, so the stations switched to alcohol or mercury-thallium alloy thermometers.[26]

FIGURE 6-2. The inside of one of the cotton region screens shows the dry- and wet-bulb thermometers as well as a ventilation blower assembly. The horizontal mercury maximum-reading and the slightly tilted alcohol minimum-reading thermometers are above the blower. John Gilbert Collection.

Once an observer finished recording the thermometer readings he checked for precipitation. A rain gauge provided a reliable reading of rainfall, but snowfall was much more difficult to determine. Under normal conditions, each weather station set aside a flat area that was sheltered from the wind where personnel could take a series of snow thickness measurements, average them, and then sweep the snow away. On the archipelago, where drifting snow is endemic, it was "often difficult to tell whether snow is actually falling or not," R.W. Rae explained in 1952.[27] A decade later the use of snow-gauges, which did a better job of preventing drifting from skewing the results, partially resolved this issue. Even then, observers still reserved another sheltered area to try to ascertain accumulation, and ultimately had to draw upon their local experience to estimate how much of the snow was precipitation and how much had been picked up by the wind.[28]

The remaining observations concerned wind and atmospheric pressure. After checking the weathervane to determine its direction, the observer monitored the station's anemometer for one minute to ascertain windspeeds and record the average. Finally, the observer noted the barometric pressure and recorded separate corrective figures that considered the station's altitude, as well as the most recently observed temperatures.[29] Once these readings were complete and recorded, the observer resumed other work until his shift ended or the time arrived for the next observation.

Upper Air Observations

To observe, rapidly transmit, and accumulate upper air data that could be used by meteorologists and climatologists from around the world to predict continental weather patterns, JAWS met techs worked diligently to successfully release balloons at internationally established time intervals, obtain the maximum possible altitudes, and secure reliable data.[30] The mainstay of upper air observations was the radiosonde, a device containing temperature, humidity, pressure instruments, and a transmitter enclosed within a single box attached to a weather balloon. These ascents became rawinsonde (RAWIN) flights if the observers also extracted wind speed and direction for various altitudes by following the device's directional movements using a manual or automatic tracking antenna.[31] Regardless of the equipment used, station personnel colloquially referred to these balloon ascents as "radiosonde" flights. During the 1950s, each station released a radiosonde at 0300 and 1500 GMT.[32] Almost from the outset, the Alert, Eureka, and Resolute stations also possessed radio direction-finding rawinsonde equipment to track the radiosonde transmitter, regardless of cloud cover.[33] The exclusive reliance of the other two stations on aerial resupply explains why Mould Bay lacked rawinsonde capabilities until September 1953 and Isachsen until September 1954.[34]

Preparing, releasing, tracking, and encoding the data from the upper air flight required roughly two to three hours and two personnel (more if the first attempt at an instrument launch failed or if the attempt failed to attain minimum altitude requirements). One of the RAWIN observers (the "wind observer") began his preparations for the "run" by going into the observation dome and turning on the receiver to warm it up. He then turned the directional antenna to face where the surface winds would push the balloon shortly after launch. Next, he walked to the inflation building and began to secure the buoyant gas that would fill the balloon. Particularities of place significantly shaped these preparations. Each station received helium tanks as a backup gas supply during the winter when hydrogen production was most failure-prone, or for quick second releases. The noble gas was used sparingly at the stations, however, because the weight of the helium tanks made them "hellishly expensive" to airlift.[35]

Consequently, the stations used hydrogen produced on-site from a chemical reaction for nearly all their balloon flights. The stations' hydrogen buildings were small and detached (for safety reasons), but sufficient to house the gas generator — a boxy device shaped like a concrete mixer. Through an opening on the top of the tilted generator, the met tech deposited (in order) water, aluminum chips, and a caustic soda charge. Because purity was unimportant and water was so laborious to obtain during the winter months at the satellite stations, personnel sometimes reused bath or dishwater for this procedure. After capping the top, the technician spun the cylinder to mix the chemicals and water, and then ran "like hell! If she [the generator] doesn't blow, you have hydrogen."[36]

Accidents did happen. Lowell Demond recalled an incident at Mould Bay in 1956 when he put the aluminum chips and caustic soda into "the lunar lander" — his description of the generator — followed by a bucket of water. "I had failed to notice the valve from the water tank to the generator was opened, until the monster began to breath," he recounted. "I kicked the clean-out valve open and took off toward the airstrip. When I was about 100 feet from the inflation shack the safety valve blew. It was a strange load of debris which spewed across the tundra that day!" He recalled that the ceilings of the inflation buildings at Mould Bay and Eureka also bore the residue of past "massive splashing" above the high-pressure generators.[37]

Station personnel and southern planners took several measures to prevent such incidents and improve safety. Upper air observers' gear was designed to resist static buildup, but JAWS personnel nevertheless touched a grounded metal plate as they entered the hydrogen building to discharge any build-up that might ignite the explosive gas.[38] The same personnel also initially left the inflation sheds unheated to avoid any accidental explosions. These sheds consequently became bitterly cold and personnel at Alert during the early years sarcastically nicknamed their structure the "hell hole."[39] By 1953, each satellite station received new, low-pressure hydrogen generators, which, as their name suggests, diminished the threat of accidental rapid overpressure and violent releases. When the air temperature dipped below freezing, however, water often froze in the line and valve that linked the reservoir to the generating chamber, and thereby stopped the reaction entirely. Diligent cleaning helped to solve the problem, as did starting with heated reaction water and storing the most frost-prone parts in the heated rawinsonde or operations buildings between runs.[40] Shortly thereafter, station personnel secured permission to construct a small heating shed several feet away that pumped hot water mixed with antifreeze into the hydrogen and inflation buildings. As long as the hydrogen building's doors were not left ajar for more than a few seconds, this heat kept the building's interior temperature near the freezing point.[41] Despite these safety and environmental improvements, some personnel continued to prefer the high-pressure generator. According to Vaughn Rockney, Chief of the USWB's Observations Section in 1957, "Isachsen and Mould Bay much preferred the low-pressure generator and wanted nothing to do with the high-pressure type. At Alert, the opposite was true. However, all of the stations appeared to have the problem of hydrogen generation in Arctic temperatures well in hand."[42] Regardless of the hydrogen production device, the RAWIN observer used a hose to slowly inflate the latex balloon with the gas until the balloon filled most of the room.

JAWS personnel continued to use these hydrogen-generating systems into the 1960s. The leftover caustic sludge, which personnel typically dumped behind the hydrogen building or deposited in a nearby pit, built up over the years. By 1965, all of the stations received electrolysers, offering a much safer and environmentally-friendly method for producing hydrogen.[43] Thereafter, hydrogen production became more mundane.

While the RAWIN man prepared the balloon, the rawinsonde (RAOB) observer selected a radiosonde unit from storage and warmed up the RAOB receiving equipment. He then retrieved a battery from the sealed storage can and immersed the power unit in water. Next, he checked that all of the RAOB's instruments were properly connected to the transponder and performed a sensitivity check on the station's recorder. He then installed the battery in the radiosonde and placed the completed instrument

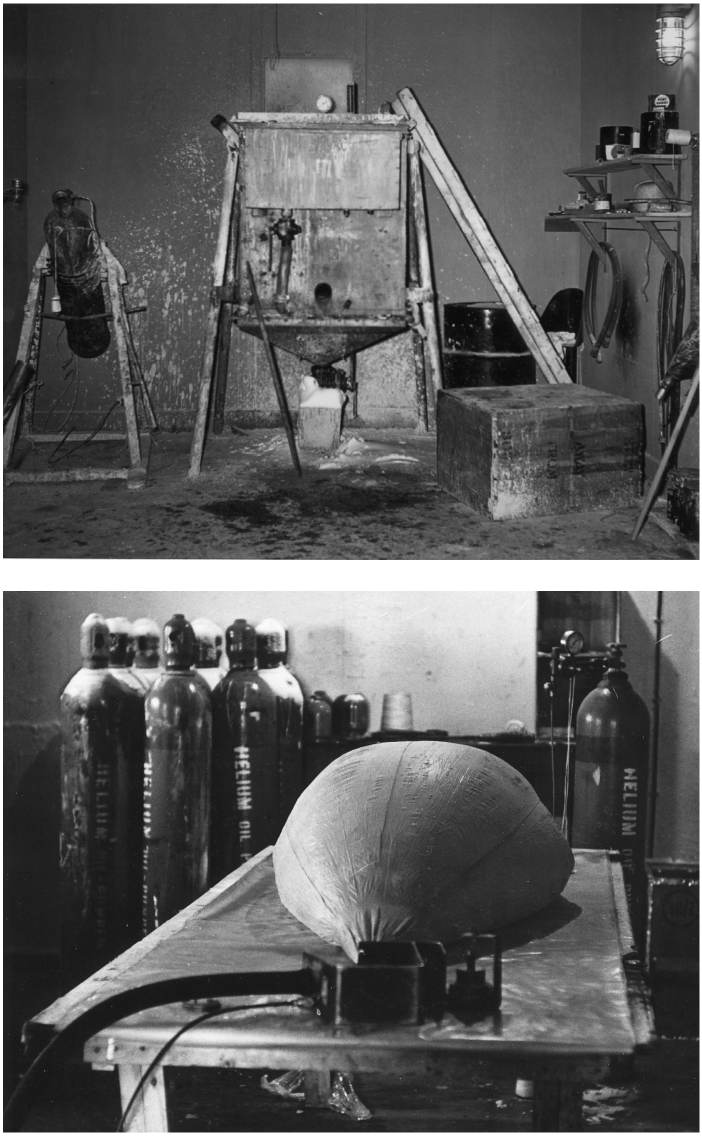

Figure 6-3. Preparing and launching a balloon was a multi-step process. All of the stations produced their own hydrogen. The photo (Top) shows the comparable low-pressure hydrogen generator at Sachs Harbour. Note the caustic soda splashes against the wall. LAC Winnipeg, Acc 2004-01213-7, file Low Pressure hydrogen generator - SACHS HARBOUR. (Bottom) After the chemical reaction, the RAWIN man inflated the balloon. Jim Jung Collection.

(Top) The crew then opened the inflation shed's doors and attached the instruments. Alan Faller Collection.

(Bottom) When all of the instruments were ready, the rawinsonde observer launched the balloon. LAC Winnipeg, Acc 2004-01213-7 AES Photographic Records of Arctic Weather Stations, Box 1, File Eureka.

in a "check box." After leaving the radiosonde in the box for five minutes, he turned on the RAOB recorder to establish a baseline and determine whether it matched the checkbox's own instrumentation and verified that all of the instruments' subsystems were working as expected. After confirming that they were, the observer then removed the radiosonde from the box and placed it in a surface instrument shelter with a hole cut in the bottom to accommodate the device's antenna (allowing the device to acclimatize to surface weather conditions). During the summer this acclimatization from indoor to outdoor temperatures was sometimes unnecessary, but during the winter it could require a half hour or more to adjust. In the meantime, the RAOB observer went inside the observation building to sharpen pencils and prepare paper charts for the flight.[44]

With the preparations complete, the RAOB observer then returned to the inflation building, opened the doors, and waited for his RAWIN counterpart to step outside from the nearby dome atop the rawinsonde building to flash the "launch" light. Most of the time, launching the balloon was simple. The launcher let out the balloon until the chord was taut, and then released the radiosonde. Winter storms could make this a difficult and dangerous activity. While serving as the RAWIN operator at Eureka in the mid-1950s, Lowell Demond recalled one particularly violent night:

> I flashed the light to Bob Frank [the RAOB observer] for at least four or five minutes and he couldn't see it because of the blowing snow. The wind was blowing directly toward the dome from the inflation building, I would guess at least 70+ MPH. I didn't see Bob release the balloon, but I heard the loud "SMACK" when the instrument hit the dome about two feet from where I was standing. If that would have hit me, you fellows would have had to plant me. The end result was a second release.[45]

With the balloon released, the "run" began. The RAWIN observer re-entered the unheated dome, which was made of plastic to permit the free transmission of radio waves. Then, during the 1950s, he assumed his seat on the American SCR-658 "radio theodolite." To track the balloon's path and receive the radiosonde's temperature, humidity, and pressure readings,

FIGURE 6-4. The rawinsonde building at Mould Bay in the mid-1950s. Note the light on the left side of the porch. Jim Jung Collection.

the RAWIN observer had to closely follow the balloon with the radio array that he moved himself by turning two handwheels.[46] The RAOB operator, seated at a station a floor below, monitored the radiosonde's readings. Most runs lasted approximately one hour. As the balloon ascended, the atmosphere thinned, and the balloon expanded to a diameter of thirteen to twenty feet before bursting.[47] The balloon had to reach a minimum of 100 millibars (approximately 50,000 feet) or a second launch was required. Most launches easily surpassed this minimum, and met techs followed the balloon until it attained its maximum height.[48]

In order to expedite post-run data processing, some RAWIN and RAOB operators swapped information as the flight progressed. Rockney observed the process during his September 1957 tour of the stations:

> The job of completing the rawin as quickly as possible, when only two men are available to make the observation, requires two particular techniques. First, the man working the raob must begin to supply height data to the man at the rawin mount as quickly as such data can be computed. This means,

FIGURE 6-5. The SCR-658 "radio theodolite" inside each JAWS RAWIN dome was the same as the setup shown here at Sachs Harbour. Note the large pad on the observer's lap to mark down the minute-by-minute direction information used to determine upper wind directions. Environment Canada.

for example, that as soon as a few minutes of record have been obtained, the adiabatic chart must be plotted and the height data computed so that the rawin operator can begin calculations of the horizontal distances as soon as possible. Second, a plotting board must be located at the SCR-658 mount so that the rawin operator can work up the rawin while the sounding is progressing. At Alert, for example, where I watched a rawinsonde observation that went to 9 millibars, the rawin operator came down from the dome when the balloon burst, lacking only the last few minutes of height data to complete the entire rawin.[49]

FIGURE 6-6. The radiosonde room at Eureka, n.d. The flight's readouts arrived at the chart recorder on the left, and the met techs are processing data from the run. LAC Winnipeg, RG 93, Acc 2004-01213-7, Box 2, File Eureka, n.d.

Not all observation teams practiced this method, however, as some preferred to share their data after the run terminated.[50]

With the flight complete, the RAWIN and RAOB operators rejoined on the first floor of the rawinsonde building to check their work for errors and to finish plotting the run. Here the two met techs encoded the data from their run so that it could be transmitted south. This process converted the data into a series of five-figure groups that could be more easily transmitted via Morse code. It took about half an hour to encode the observations. The met techs then walked the coded messages to the radio room.[51]

This upper air workflow continued throughout the JAWS program, although several technological advancements shortened or eliminated certain portions of the work. Between 1960 and 1962, an electronics technician (with the assistance of station personnel) swapped each of the station's SCR-658s for the GMD-1: a radio theodolite that automatically tracked the radiosonde, thus removing human error from the tracking process. It also had a wider angle of tracking (6 degrees vs. 15), allowing observers to track the balloon to even higher altitudes. Automation also permitted the RAWIN observer to monitor paper tape readouts in the comfort of the observation room, alongside his RAOB counterpart.[52]

The transmission of each flight's observations underwent a similar transformation. The timely transmission of the gathered data was crucial to forecasters. Initially, radio operators at the satellite stations transmitted their surface and upper air observations by Morse code to Resolute. This hub station called each satellite station (as well as Sachs Harbour) at appointed times each day to receive the data. If the satellite station was not ready to transmit, it had to wait until all the other stations completed their transmissions. The length of the transmission varied with the duration of the radiosonde's flight, but it usually required ten to fifteen minutes to complete. In the early years of the program, Resolute's radio operators then relayed the entire set of observations in Morse code to Edmonton. The process proved reliable, achieving nearly 90% consistency. Beginning in 1958, the stations gradually received radio teletype machines that enabled met techs to assume more and more responsibility for transmitting their observations.[53] Within a half hour of receiving the coded observations from the stations, Edmonton's radio operators put the observations on teletype circuits that quickly fed the information to civilian and military forecast centres across Canada, the United States, and Europe, which entered the data onto maps and passed them on to their respective forecasters.[54]

Station personnel also employed smaller and simpler flights to conduct meteorological observations that used less sophisticated tracking tools and methods. Although pilot balloons were sometimes used to determine cloud ceilings for surface observations, their main purpose was to measure wind currents in the upper atmosphere. In the 1950s, most JAWS launched PIBALs within a half hour of 0900 and 2100 GMT each day.[55] One individual worked in the "comfortable, warm" observation building at the plotting table, listening to a second individual who sat outside manually tracking the balloon with a theodolite — a scoped device used to monitor an object's spatial direction by following its vertical and horizontal (azimuth) movements — and calling out the readings every minute when a buzzer sounded until the balloon was obscured by clouds, burst, or disappeared from sight.[56] After noting the vertical and azimuth angles as well as the duration of the flight, the observer then re-entered the rawinsonde building to plot the course of the balloon and to determine the wind's speed and direction throughout the balloon's ascent.[57] Although PIBALs were not as revealing as radiosondes, they were less expensive, simpler to prepare, and provided upper air wind direction and speed data. Furthermore, PIBALs provided a simple means to check the accuracy of radiosonde flights.

The Arctic environment often hampered this additional type of balloon flight. During the late summer and early fall, low cloud cover limited the number of occasions when observers could obtain data over 3,000 feet. In the winter dark period, PIBALs were even more difficult to complete. The extreme cold sometimes froze and burst the balloons before they reached a satisfactory altitude, requiring a second launch.[58] Tracking the balloon with a theodolite during the dark period also necessitated attaching either a candle inside a paper lantern or a water-activated battery to the PIBAL balloon. Griff Toole, who worked as a radio operator in 1950 under Alert's typically calm wind conditions, remembered this comparatively primitive candle system working quite well. On the station's occasional windy days, he recalled watching "the balloon and candle do a couple of full double loops right after release and still not catch fire." The candles sometimes went out prematurely, but it was still the station's preferred illumination method during his tenure.[59] Other observers, such as Don Ware (who worked at the more consistently windy Mould Bay), found both methods to be futile because the candle's flame expired and the battery tended to freeze after ascending only a few thousand feet.[60]

Regardless of the lighting technology employed, tracking PIBALs as they rose through the night sky remained difficult. From time to time, the observer would note three or four identical azimuth and elevation readings before realizing that he had lost the PIBAL and had instead fixed on a star. "This always brought about a few curses," Demond recalled, and required a second release if the balloon had not attained the required minimum altitude.[61] John Gilbert claimed that "PIBALs were the toughest job of all" his duties at the stations.[62] The theodolite at each station was not designed for Arctic use, so personnel had to manipulate the metallic instrument

FIGURE 6-7. The PIBAL dome at Isachsen in 1953. Despite the dome, the unheated space meant that PIBALs remained among the least-liked observations that station personnel had to conduct. Bill Nemeth Collection.

with their bare hands in extreme cold. Furthermore, the observer's breath frosted the theodolite in frigid conditions. Michael Young, the OIC at Isachsen, complained in 1952 that "the observer is forced to continually be wiping off one part or another of the theodolite while attempting to follow the balloon. This is especially vexing in regard to the azimuth [horizontal] reading as the glass covering the numbers is sunken a little and only vigorous rubbing with the bare hand will clear off the frost long enough to make a proper reading."[63] This exposure of the observer's bare hands to the cold air and metallic theodolite was often painful.[64] Even after each station received, by the 1950s, a fibreglass dome that was designed to protect the observer from the wind while he took theodolite readings through a slit, the continued exposure to the elements and the lack of a heater did little to resolve the frosting issues. The dome, moreover, had to be manually turned like an observatory to follow the PIBAL, and observers often had to wrestle it into position when it froze to its mountings during the colder parts of the winter.[65] "It was not the most pleasant observation I had to take," Don Ware concluded sarcastically.[66]

Additional Scientific Observations at the Joint Arctic Weather Stations

Although the meteorological program represented the primary focus of a station's scientific observations, JAWS personnel regularly performed additional work for other scientists, government departments, and agencies. Some of these projects were confined to a single station, while others were performed at several or all of the stations. Through these contributions, station personnel identified themselves as members of a broader scientific community working to produce expert knowledge. These purposeful activities also provided personnel with a welcome opportunity to diversify their routines and skills, enhance their sense of reliability and trustworthiness, and embed the JAWS cultures and personnel in scientific exchange networks beyond the weather services that paid their salaries.

The JAWS scientific observation program included the first synoptic records of sea ice and snow conditions in the Canadian High Arctic, collected for the American Snow, Ice and Permafrost Research Establishment (SIPRE) and the National Research Council of Canada. Founded in 1949 by the US Army Corps of Engineers, SIPRE and its successor, the Cold Regions Research and Engineering Laboratory (CRREL), collected snow and ice information from the polar regions to better understand how the military could operate in polar environmental conditions.[67] Once the ice was thick enough to permit safe passage, JAWS personnel were supposed to determine its thickness on the first and fifteenth of each month.[68] To do so, teams of two initially used special long-handled chisels to cut holes in the ice — an arduous task when the latter was several feet thick. In 1949, a Resolute crew improvised a measuring device consisting of a 9-foot length of 3-inch pipe which they embedded in the ice. They then filled the pipe with fuel oil, displacing the water so that it did not freeze. They then rigged 3/8-inch pipe as a measuring rod.[69] In 1951, personnel at Isachsen also experimented with cutting steps down into the ice, but the drilling method ultimately prevailed.[70]

A few JAWS personnel found the ice work interesting, but most found the work unappealing. At Isachsen in 1951, for example, OIC Vlad Jelinek led the station on a full schedule of observations and Jelinek personally reported at length about his plans to compare ice thickness under snowdrifts with a spot that station staff would artificially keep clear with a bulldozer.[71] For most personnel, however, these observations remained one of the least-liked in their station's regimen. "The job of cutting a hole in the ice to measure it's [*sic*] thickness at this time of year becomes quite a chore," Isachsen OIC Michael Young wrote in April 1953:

> Since the ice has passed the four foot mark[,] usually the three Radiosonde men and the Mechanic do the chipping. It has been found that the ice chisels sent in last spring are very poor for the job. The holes go so deep that it is usually cut about four feet long and about two to three feet wide at the top so as to allow a little swinging room when standing in the hole. A sharp pickaxe is used to chip the ice and a large pail to bail out the holeful [*sic*] of ice after a few lusty swings. Anyone who thinks you don't sweat at forty below zero should swing a pickaxe through five feet of ice once in a while. What a job as winter goes on becoming colder and colder. It usually takes three or four hours to do the ice cutting after the five foot level of thickness is accumulated which falls early February.[72]

By the 1960s, the effort required to obtain ice thickness observations eased considerably. JAWS personnel deployed new kits consisting of a 40-inch-long auger bit that snapped onto a carpenter's hand-brace turning tool to drill a small hole through the sea ice. A cloth measuring tape with a steel bar was then dropped through the hole and the tape was pulled up till the steel bar caught on the ice at the bottom of the hole.[73]

Snow observations, which JAWS personnel began conducting for SIPRE in 1952, were less tiring but equally frustrating. Each snow collection kit included a triple beam balance, a balance tube, five sample tubes, a hand lens, a plastic crystal cup, a thermometer, a metal cutting plate, a black spool of thread, observation forms, and a manual.[74] Station staff were supposed to conduct observations each week during the snow season, twice a month beginning in December for the rest of the dark period, and resume weekly observations in March until the end of the snow season.[75] Observations required one to two hours to complete. As Derek Challis (Alert OIC 1958–59) recalls, the observations:

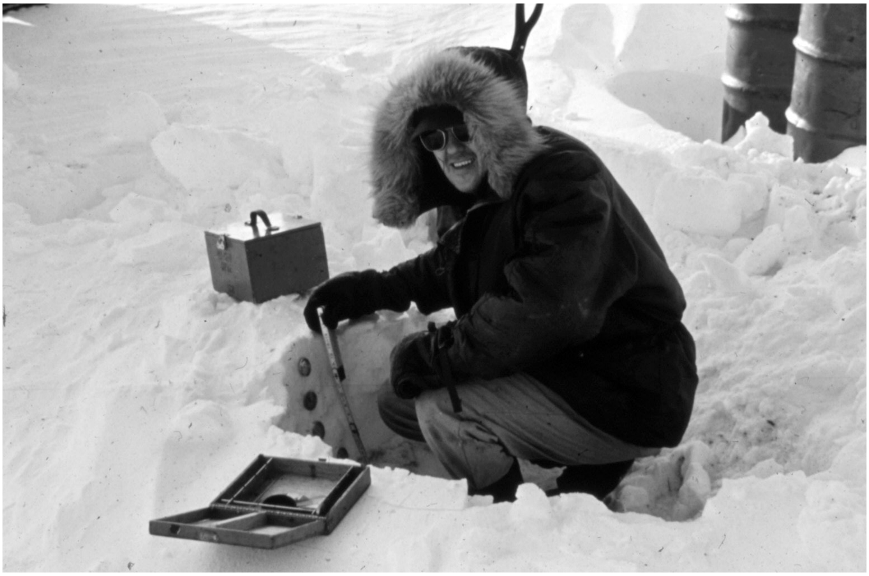

FIGURE 6-8. A SIPRE snow kit in use. One observer later recalled that station personnel "called it by a lot of other names that are unprintable." Jim Jung Collection.

> entailed digging a trench in snow cover to expose a profile of snow down to ground. Identify and measure thickness of the different snow layers. Insert the thermometers and measure temp. of each layer. Measure the density of each layer. This is the killer. Sprinkle snow flakes (granules) from each layer onto the metal plate to record shape and size. Can you imagine doing one of these observations at 40 or so below, on your hands and knees, with a flashlight and a breeze blowing[?][76]

Indeed, personnel so disliked the work that Challis threatened to assign the job to met techs who posted the highest upper air error count.[77] The development of simplified snow survey kits eased these efforts by the 1960s.[78]

Some of the additional observations collected at the joint stations required specially designed and constructed facilities. The seismic building was a "scientific vault ... buried into the hillside so that it was basically underground," Mould Bay geophysicist David Weston explained. The seismic instruments were "set on concrete piers built down into the permafrost so that they could accurately record any seismic motion from anywhere around the world."[79] Each neighbouring JAWS compound provided the seismic stations with electrical power, vehicle support, recreation, and food for one geophysicist.[80] JAWS met techs were trained to operate the seismometers for short periods, but geophysicists from the Dominion Observatory best handled each building's long-term operation. Because these geophysicists lived with JAWS personnel at Mould Bay and Alert for a year at a time, and because the geophysicists regularly assisted with station maintenance and participated in base activities, they were deeply integrated into the life and culture of the hosting satellite stations.[81]

None of the JAWS stations were located in major earthquake zones, yet it was "almost impossible to exaggerate the importance" of the data the JAWS seismic stations collected, because their readings could be used to triangulate events with any other two stations in the Northern Hemisphere.[82] Mould Bay's observations were particularly valuable, Weston explained, because it was one of the "quietest" seismic stations in the world. Far from avalanches, oil drilling, aircraft landings, and highway traffic that reduced the sensitivity of seismometers, this low background noise allowed Mould Bay to measure movements as small as 1/76,000th of 1/10th of a millimetre. Consequently, "when events were too small to be recorded anywhere else, people [seismologists] were very interested in what Mould Bay was able to record."[83]

Resolute also hosted an ionospheric research station and a magnetic research station beginning in the summer of 1948. At extremely high latitudes, the proximity of the magnetic north pole makes traditional compasses ineffective. By the same token, geoelectric storms (solar flares and solar mass ejections) can trigger communication blackouts at the poles that sometimes last for days. The joint stations' locations made them ideal places to collect data that civilian and military departments could use to determine how to navigate and communicate in the region, as well as how these conditions could complicate detecting incoming Soviet bombers.[84] When the American military approached the Canadian government about constructing these observatories in the North, however, the Americans "gracefully" accepted the insistence of the Department of Transport and the Defence Research Board (DRB) that "observations of this kind were considered to be solely a Canadian responsibility."[85] Historian Edward Jones-Imhotep notes that the program subsequently contributed to "key national aims: territorial and epistemic sovereignty, northern development, international cooperation, distinction, identity, and influence vis-à-vis Britain and the United States."[86] Constructed in 1948, these observatories were purpose-built. The ionospheric station had its own engine room, covered passage, storeroom, laboratory, and accommodations for up to seven observers. The magnetic observatory was built entirely from wood and other non-magnetic materials. The area immediately surrounding the magnetic observatory was also kept clear of all materials and vehicles.[87] In 1961, the Canadian government expanded its network of magnetic observatories to Mould Bay and Alert. To save costs and ease operational requirements, Canada constructed the new seismic and magnetic observatories as separate units that shared heating and other resources.[88]

Science Hubs

Although the JAWS network was built to provide meteorological observations, the stations served as ready hubs for diverse field research on the archipelago. During the early years of the program, southern planners carefully managed which researchers had the opportunity to benefit from the remote stations' limited resources. Station resources were very limited, and the spring resupply required most of their guest accommodations. Consequently, each satellite station could only host two additional transient visitors.[89] Indeed, for much of their existence, the satellite stations were more like transit hubs than operation support bases, and visiting science teams, though welcomed, had to be largely self-reliant.

Most science research programs did not construct their own buildings at the stations, and visiting scientists had to limit their reliance on local resources and contribute to the JAWS operations. Dr. John Tener, for example, visited Eureka to study muskox biology and ecology during the spring and summer of 1951. The station provided him "with a Jamesway hut, washing, laundry and library facilities, and food, and radio schedules when we were in the field."[90] In return, he assisted with various tasks, such as helping the mechanic to remove an engine from the station weasel and baking cakes.[91]

Visiting parties who planned to work at the stations were warned against relying on the JAWS personnel who were already preoccupied with meteorological, communication, or construction work. When the Los Angeles County Museum secured permission from the Canadian government to kill one muskox bull, two cows, and a calf to be stuffed for a display in 1959, they inquired whether JAWS personnel would be available to assist with skinning, butchering, and packing the animals. Dyer's response was clear:

> There will be about 12 to 14 employees at the Eureka Station during the time of your visit. It is not very likely that any of these individuals could afford much time to assist you in your work, because of their prior duties and scheduled observational work. It might be possible, however, to locally make arrangements for one or two of the men to double up on routine duties, allowing possibly one or two to assist you for short periods. Such arrangements for doubling up work would, of course, have to be acceptable to the individuals involved and in no case would it have any deleterious affect [*sic*] on the routine operations of the station and observational program.[92]

In the end, Eureka only provided "a few pieces of camping equipment" and the use of the station's weasel.[93]

Larger field parties that utilized the stations were also generally "self-supporting."[94] In 1959, McGill University (an academic hub for Arctic scientific research) commissioned an expedition headed by glaciologist Fritz Müller and George Jacobsen of Canada's Tower Company to select a site on Axel Heiberg Island for long-term geographic study. Eureka provided the ideal jump-off point for the expedition, serving as a base for the chartered flights used to select a research site and as a relay point for radio communications. The following year, when McGill began construction of the new research station (which became the McGill Arctic Research Station or MARS), JAWS personnel helped to unload materials from CGS *D'Iberville*, provided "refreshments" when the construction crew of twenty-two arrived in May 1960, and allowed the visitors to use the station bulldozer to dig out their cache. The self-sufficient McGill crew brought their own tents and meals, but they relied on the weather station to relay their communications to the south and to meet aircraft throughout the summer.[95] Without this assistance, geographer William Wonders wrote, "most" of the expedition's research "would have been severely handicapped if not impossible."[96]

Additional scientific observations peaked at the High Arctic weather stations during the United Nations' International Geophysical Year (IGY) from 1 July 1957 through 31 December 1958. Two previous polar years (in 1882–83 and 1932–33) had established the feasibility and utility of international cooperation in polar studies, and the 1957–58 IGY research program grew to encompass eleven earth sciences, including geomagnetism, meteorology, seismology, aurora activity, and solar activity, with a special emphasis on the earth's polar regions. Sixty-seven countries participated in the vast research and data-sharing program,[97] and more than ninety research stations across Canada participated. Every day, Resolute, Eureka, and Alert each flew one "very high" rawinsonde balloon, and Resolute launched an additional rawinsonde (bringing its daily total to four). Beyond this expanded meteorological program, several JAWS stations hosted other research programs, such as new 12x12-foot buildings at Resolute and Alert to support ozone and solar radiation monitoring. The National Research Council also constructed a 100-foot tower at Resolute to monitor vertical temperature gradients.[98]

These additional activities strained the JAWS program's human resources. Resolute received a few more met techs to undertake the additional upper air flights, but coordinating the activities of eight to ten extra personnel who were coming and going from the south was a "bit of a nightmare" according to the station's senior meteorological technician Archie Asbridge. When the IGY program ended in 1959, Resolute's met techs "breathe[d] a sigh of relief." Although Canada sent two scientists to Alert and Resolute to manage the ozone and temperature gradient monitoring programs during the IGY, its decision to continue these programs after it ended forced the scientists to train Asbridge to continue their work. Maintaining the temperature gradient tower program, which was gradually phased out in succeeding years, required unusually strong courage. Asbridge recalled:

> One task was to calibrate the thermopiles [devices that convert thermal energy into electrical energy] on the 100' tower. The process was done by immersing the thermopiles in a pail of water containing copious chunks of ice. This wasn't too difficult at the 10' level but became an onerous and somewhat risky business at the 100' level. Fortunately, the tower dimensions were such that it was possible to climb to the top inside the framework and [Anatol] Rutenburg [a visiting physicist] had rigged up a rope and pulley system anchored on the top. So it was possible to hoist up the ice bucket from ground level before starting the climb. The major problem was that the thermopile was on the end of a boom that extended six feet from the top of the tower. To get around this dilemma, Rutenburg's solution had been to anchor a very sturdy plank about 10 inches wide and 3 inches thick on which I very gingerly inched myself along with the ice bucket towards the thermopile. The plank was previously used by Rutenburg and he was at least as heavy as I was so I felt confident wearing a safety belt but I refused to look down to the ground.[99]

The IGY was not the only reason JAWS personnel undertook additional observations. For extra pay, JAWS personnel sometimes "moonlighted" by carrying out auxiliary research programs at the stations. Neither Canadian nor American personnel were permitted to undertake this work without permission from their headquarters because "there is a very strong tendency for extracurricular work to sometimes pre-empt and often interfere with the primary duties."[100] David Weston, for example, took on the operation of an "all-sky camera" throughout the dark period at Mould Bay from 1970–72 for the Geophysical Institute of the University of Alaska. The camera, designed to record the aurora borealis, took a picture approximately once every minute. "I was never involved in the data-reduction or conclusions of this work," Weston recalled. "I was merely a carbon life-form on the ground in a remote location whose responsibility it was to change the film, keep the dome cleared of snow, and maintain the equipment."[101]

FIGURE 6-9. David Weston in front of Mould Bay's all-sky camera during the early 1970s. David Weston Collection.

Despite the successful use of the JAWS network as sites for additional sensors or bases for largely self-sustaining field parties, southern planners recognized at an early stage that expanding the JAWS program's support infrastructure would facilitate the dramatic expansion of scientific research on the archipelago. This desire to expand northern science infrastructure conformed with an international postwar and decolonization shift that increasingly privileged science over exploration as a means to justify sovereignty claims.[102] In November 1952, Robert Sykes advocated developing the stations on a "cellular" basis by constructing semi-separate "plants" that included their own housing, kitchens, and mess halls. "Thus a unit would come in, quarter and ration themselves, obtain certain assistance from the station, including power and, of course, a number of personal services." Such autonomy, Sykes believed, would ensure that the day-to-day routine of JAWS personnel "would not be so disrupted by the addition of personnel, as so often seems to be the case now."[103]

Resolute's facilities were the first to expand. To project its operating capabilities into the High Arctic, the RCAF took advantage of the existing airfield at Resolute Bay and opened its own base in 1949, which quickly expanded to house over 200 Canadian personnel during the summer months. All of this growth produced redundant capabilities and "consolidation" — as it became known — reduced operating costs by eliminating duplicate supply and communications facilities, and ensured the immediate availability of meteorological data for RCAF operations. The Canadian government chose to close the original weather station in 1953 and moved the entire enterprise to the new RCAF base, two and a half miles away. Under this arrangement, the RCAF OIC oversaw the entire base and the airstrip, leaving the weather station OIC to supervise JAWS operations.[104] Thereafter, the Canadians at Resolute dwarfed the tiny American contingent attached to the weather station, and this shift alleviated some of the concerns in Ottawa about the presence of American personnel in the High Arctic.[105]

All of the stations shared some common characteristics, but local conditions also fostered unique station subcultures. Resolute's status as a transportation and communication hub made it unique. Its personnel appreciated amenities such as running water and a septic system, which the other stations initially lacked.[106] By the mid-1950s, a janitor cleaned parts of the JAWS station frequented by transients, and personnel had access to a nurse at the nearby military station.[107] Archie Asbridge, who transferred from Isachsen to become senior met tech at Resolute in 1958, recalled how:

> Living and working at the Resolute Bay weather station in the late 1950's [*sic*] was a breeze by comparison with a tour of duty at one of the very isolated stations such as Mould Bay, Alert, Eureka and Isachsen. To begin with there was frequent contact with the outside world, namely the weekly military flights from southern Canada carrying fresh provisions and mail. After working at the isolated Isachsen station for seven months I'll never forget the absolute pleasure at being able to walk into the Resolute military cook shack and order a breakfast of "three eggs over easy with bacon and hash-brown spuds" knowing that the eggs were really fresh and the bacon

had not been living in an underground reefer at an isolated station for several months.

Asbridge also enjoyed interacting with the much broader array of fifty RCAF and twenty DoT personnel who worked at Resolute. Despite its many amenities, however, Resolute remained "one of the worst places to launch a balloon in inclement weather," Asbridge recalled. Overhead wires limited where the met techs could release balloons, and JAWS personnel bore "the brunt of many admonitions and foul language after we had torn down the complex fire alarm wires inter-connecting the station buildings."[108]

A less integrated relationship between DoT, the USWB, and the Canadian military developed at Alert. The formation of the North Atlantic Treaty Organization (NATO) in 1949 and the outbreak of the Korean War in 1950 highlighted the imperative of collecting signals intelligence from the USSR. The RCAF took advantage of the existing JAWS airstrip and operating infrastructure at Alert to establish a one-hut signal intelligence unit 500 yards north of the weather station. This listening post, which was closer to Moscow than Ottawa, proved effective and the Canadian Army assumed command of the wireless station three years later. The Signals Corps continued to expand its facility at Alert in the ensuing decades,[109] and personnel at the military and weather stations co-existed separately and amicably for just over two decades, loaning vehicles and other equipment to each other, inviting each other to parties, and cooperating during the resupply season.[110]

Given their close proximity to military installations, Resolute and Alert eventually received mail every other week as well as fresh produce much more regularly than the other stations, and this accessibility reduced the sense of isolation at those places.[111] These conveniences also brought additional responsibilities for JAWS personnel. Because Resolute was the hub for the resupply, its OIC spent much of his summer preparing meteorological forecasts, while the ExO supervised the unloading of the sealift and the reloading of transport aircraft bound for the satellite stations. When this logistical work proved too complex and extensive for the ExO to manage alone, the USWB sent a "storekeeper" to Resolute to sort the supplies for each of the stations.[112]

Isachsen and Mould Bay were the most isolated of the High Arctic stations. Environmental conditions compounded the remoteness, leading a climate severity index to identify Isachsen as the least hospitable place in Canada to live.[113] Although both of these stations hosted the Polar Continental Shelf Project (PCSP) (see below), they attracted substantially fewer transient scientists than Eureka or Resolute. At first, old structures were simply re-tasked to accommodate visitors. Isachsen and Mould Bay could house up to eight additional "permanent" (or sixteen temporary) residents by 1959, while Eureka had room for ten. Scientific parties numbering "more than a few men" were still instructed to bring a cook to assist the resident JAWS cook with feeding the extra mouths. Even with these supports in place, accessing the satellite stations proved difficult. Visiting strip mechanics and construction personnel typically occupied four to six of these beds during the construction season, leaving room to host no more than two scientific guests in certain years.[114]

Visiting scientists' access to each station's equipment and personnel continued to be strictly limited through the 1960s, and all "tourists" were warned to be as "self-sufficient" as possible when operating away from the stations.[115] At the same time, DoT continued to expand guest accommodations at the satellite stations. Heavy traffic led to the construction of additional dormitories at Alert in 1961 and the rebuilding of Eureka in 1963. Mould Bay and Isachsen, however, were still generally limited to accommodating no more than two visiting scientists. DoT planned to construct additional storage facilities at all of the stations, and dormitories at both Mould Bay and Isachsen in 1962, so that all of the stations would be capable of supporting at least twenty "scientific and exploration personnel." Even these plans suffered delays, and it appears that limited airlift resources, in addition to the increased use of Mould Bay by PCSP scientists, delayed the construction of its new facilities until at least 1968.[116]

The PCSP developed too early to benefit from most of these infrastructure improvements, and it severely taxed Isachsen's resources when leveraging it as a support base.[117] Created in 1958 to conduct "hydrographic, oceanography, geophysical, and biological studies of the entire Canadian Polar Continental Shelf and, if it is so desired later, the Canadian Arctic Basin,"[118] the PCSP (run by the Canadian Department of Energy, Mines and Resources) sought to address the acute lack of knowledge about Canada's continental shelf at a time of heightened geostrategic and resource interest in the polar basin. The Soviet launch of *Sputnik* signalled the dawn of the satellite era and highlighted the need to learn more about the earth's gravity at the poles. When these concerns were coupled with nuclear-powered submarines and questions about maritime sovereignty in Arctic waters, the continental shelf became an important area for further field science research.[119] The 1957 United Nations conference on the Law of the Sea confirmed that all coastal states had "the rights to mineral and other resources on their continental shelves as far as 200 miles off shore," but Canada knew "virtually nothing" about the extent of its polar shelf and its resources.[120] The PCSP, as an innovative commitment to polar field science launched during the International Geophysical Year (1957–58), not only enabled sustained research but also resonated with the Canadian political nationalism promoted by Prime Minister John Diefenbaker in his "Northern Vision."[121]

PCSP scientists spent most of their time in the field studying the continental shelf as a series of "research blocks,"[122] but the project required a staging base as well as accommodations for transient scientists. As the only locations with buildings and airstrips on the northwest edge of the archipelago, the JAWS stations were the logical transportation hubs for the program,[123] with Resolute serving as the PCSP hub and Isachsen (1959–63) and Mould Bay (1964–68) as its main bases. By 1959, the program's heavy reliance on Resolute had motivated W.E. van Steenburgh, the chairman of the ACND Scientific Research Subcommittee, to exclaim that "during the past ten years Resolute has become the most important scientific station north of 60°N in Canada."[124]

Scholars Richard Powell and Stephen Bocking have analyzed the PCSP's research activities *from* these stations, but the program's impact *on* Isachsen and Mould Bay has received little attention. Given the rush to field the PCSP, it is not surprising that the project "severely strained" Isachsen's limited resources, and the introduction of weekly mail carried by PCSP aircraft could not compensate for these challenges.[125] The two satellite stations were only designed to accommodate fifteen individuals, and the addition of the usual strip mechanics as well as the unusual despatching of telecom, construction, and twelve to eighteen PCSP personnel brought the station's total population to forty-five during July and August.[126] During the summer of 1960, for example, Isachsen's cook complained that the PCSP personnel used the hot water that he required to wash dirty dishes. Lounge furniture also suffered from the additional traffic, and the JAWS washing machine and dryer required repairs because they were "inadequate for such a large crew" of both PCSP and JAWS personnel. Consequently, OIC M.A. MacAulay and ExO W.V. Greco insisted that the PCSP "install their own washing facilities" at the station.[127]

The PCSP laboured hard to rectify this problem in succeeding years and gradually managed to reduce its reliance on JAWS facilities. Laundry remained a problem in 1961 and the PCSP continued to rely on the station's airfield, radio operators, accommodations, and garage. In return, however, PCSP personnel were told to do "their equitable share of general camp maintenance duties, such as garbage and water haul, snow removal, and fire hazard inspection[s.]"[128] The situation improved the following year. Having established its own camp near the Isachsen weather station, the PCSP stationed a caretaker there throughout the winter who was well liked by JAWS personnel and "volunteered his help on many occasions in the performance of station duties."[129] That spring, the JAWS complex accommodated up to twenty PCSP personnel while the camp was open for operations. The PCSP continued to use JAWS radiomen to send up to ten messages a week south, and used the station's power, water supply, and darkroom, but these requirements did not significantly strain Isachsen's human and material resources.[130]

Mould Bay benefitted from the lessons learned at Isachsen. The PCSP's shift to the more westerly base was planned several years in advance and, in 1963, the Canadian government constructed a separate mess and recreation building, garage, and other non-permanent structures at the station.[131] Support for the PCSP resembled that provided at Isachsen in 1962 and included use of the station's tractors, forklifts, darkroom, communications facilities, and airstrip.[132] A similar list of requirements from 1968 suggests that the PCSP had a comparatively minimal impact on JAWS resources at Mould Bay by that time.[133]

Private companies also used the stations' land strips to explore natural resources on the Arctic Archipelago. Government surveying during the 1940s and 1950s confirmed the high probability of oil and mineral resources in the region, and a few companies drilled unsuccessful wells during the early 1960s. However, the discovery in 1968 of massive oil reserves in Prudhoe Bay, Alaska, bolstered demand for further oil exploration using the joint stations as staging points, which the JAWS program supported in various ways. First, Resolute's size and location made it the ideal hub for commercial airlift and sealift operations, and two oil companies established a general supply base there in 1970. Its airport also served as a hub for regular flights for extraction companies sending personnel to or from sites all over the archipelago.[134] In addition, several of the sites served as "anchor points" for exploration activities by allowing aircraft and ships to land company equipment at the stations and transport it via tractor train or helicopter to research or drilling sites.[135] The stations also offered weather data to aircrews operating in the High Arctic.[136] JAWS personnel generally welcomed this traffic, which brought additional connections with the south and temporary guests who helped to relieve the monotony of station life.

Scientific Cultures

The presence of PCSP personnel, visiting scientific teams, and individual scientists contributed to the scientific culture that characterized each joint station. Despite the stations' resource and capacity limitations, as well as their different training backgrounds, JAWS personnel (especially met techs) felt a sense of camaraderie with the transient scientists at their stations. Station personnel often talked with these new arrivals about the Arctic, science, and other subjects of interest over dinner or a drink. "It was an interesting intellectual environment," David Oldridge remembered, "because most of the people [JAWS personnel] there were fairly educated … maybe not with degrees, but at least able to converse with people with degrees. We had scientists coming in: geologists and even astrophysicists."[137] JAWS personnel were keenly interested in their guests' research. Bruce Weaver, for example, befriended seismologist Walter Piche:

> I remember him trying to do triangulation when we had [detected] what was obviously a nuclear blast. He showed it to me on the photographic paper and said "lets see if we can figure out where this is …." We talked to the other stations by HAM radio and took a map and laid some lines down and said "un

> hunh," central China. And then we waited. I guess it was about two weeks later that the government announced [that China had detonated another of its early atomic devices]. So we were sort of sitting there not wanting to say anything until it was officially announced.[138]

Although trained to operate the seismograph, Weaver could not interpret the results. He, like other JAWS personnel, appreciated the analytical skills of visiting scientists who shared insights about the practical applications of the data being generated at the stations.

Despite their shared experiences, scientists and JAWS observers acknowledged their different professional and transitory statuses. Practical jokes highlighted their different occupations in a jovial spirit. In the mid-1950s, a visiting scientist ran into the Resolute station and announced: "hey there's a couple of bear[s]" by the shore. The station's personnel leapt into action. As Howard Wessbecher recounts:

> we always had rifles on the station because of the bears so here about 12 guys jump up, grab rifles and start advancing which was about 500–600 ft. from where we were in the lounge down at the beach. Start advancing toward these two bears and we could definitely see them.… Polar bears in the wild are kinda yellow, they're not pure white … and we could see the yellow tinge to the fur. We could see the black eyes and so they're blasting away. Twelve of us. It was like a frontal squad, moving, blasting away. We got down there.… We couldn't figure out why those bears didn't drop. And we weren't missing them, we knew that.…We had a couple of 15,000 gallon oil tanks off to one side and I kept eyeballing the ladder going up them and I thought, that's what I'm heading for if those bears charged. Got down there and it turned out he'd made them out of snow and had sprinkled them with farina and put coal — we used coal for heat. He had made the eyes out of that and those bears were totally riddled. They were riddled!

It was not long before the station's personnel got even with the prankster. The transient scientist was an ornithologist who collected bird eggs, Wessbecher recalled, "so we took some chicken eggs and painted little brown dots all over them and laid them out there and kind of helped him find them and he came back all excited because he had found these weird eggs he couldn't identify."[139]

JAWS personnel also created their own brand of scientific culture that blended investigative values with observer training and embodied experiences from working at the stations. Both the USWB and DoT emphasized the importance of accurate readings.[140] JAWS meteorological observers rarely needed such encouragement. "We were always trying to be extremely accurate with everything we did … on the meteorological end of it," Lowell Demond remembered. An error would be quickly picked up "by meteorologists down south, who plotted the weather data from all of the stations on a single map" and reported inconsistencies. Professional pride meant that "you just didn't want that to happen." Station personnel understood how their observations contributed to forecasting and the importance of creating a permanent record of environmental conditions for future scientists. "We felt that that was very beneficial to forecasting, to aviation," Demond recalled, "but we also believed that some of the work that we were doing, for example ice and snow observations … was going into climatology and it was going to be there as a permanent record … and that would be significant."[141]

Even under harsh conditions, met techs thus went to extreme lengths to launch their balloons. "We were proving that people could do work in harsh conditions on an on-going basis with pretty good regularity," Weaver later explained.[142] At Alert, consistently low wind speeds made balloon releases easy[143] compared to Isachsen, where high winds regularly endangered upper air observations by violently pushing launched balloons sideways, pulverizing the instrument package on the ground.[144] Over time, the teams developed different techniques to ensure successful results in high winds. The most common solution was the two-person launch. Wessbecher explained how one person walked downwind with the radiosonde and, when his partner released the balloon, ran further downwind with the radiosonde until the balloon carried its cargo aloft. "Sometimes we tried two, three releases and I'd say … less than 5% of the time we didn't make it" and had to concede that "hey, we can't get her up."[145] One JAWS poet, who signed his name "DW," captured the focus and dedication of these runners:

> I think that I shall never see,
> A release as lovely or as free:
> To run along, to feel the breeze,
> To hold the string with supple ease.
> A look of triumph on my face,
> I hold the prize, I run the race.
> At proper time, tho wind does blow,
> To clear the way, and let it go.
> To watch it rise, ahh crafty fox:
> To watch my pal run with the box.
> Then smile upon my face is lit,
> Cause he fell in the caustic pit.[146]

In one extreme case, personnel at Isachsen launched five balloons because the first four "burst upon hitting the sides of the door on the way out" under heavy winds.[147] Weaver bragged that during his fourteen months as a met tech at Mould Bay from 1965–66, he and his fellow observers missed only two upper air flights due to weather out of a total of 730 launches.[148]

There were exceptions to this precision culture. The USWB and DoT checked the observations closely, and each station received monthly accuracy reports. OICs or senior met techs also checked all upper air observation report hard copies with a red pen before they were sent south on airlifts. All of the stations frequently achieved perfect scores.[149] An acceptable average count was three errors per station per month, but at some stations during the early and mid-1960s the error counts crept to ten, and by the mid-1960s they were sometimes closer to twenty. The problem was not exclusive to the JAWS program; by the mid-1960s most Canadian upper air stations committed an average of 21.2 errors per month. The error count was exaggerated by vague criteria that failed to distinguish between "serious errors" and "trivial ones" that did not affect forecasting, but the problem had to be rectified.[150] At Resolute, the senior met tech introduced a "stringent program of checking," and all of the met techs were soon engaged in "healthy competition with one another, each endeavouring to succeed in obtaining the highest sounding and the lowest error count."[151] Similarly, the outgoing ExO at Alert, David Thornton, reported that "thorough checking and re-checking have been the rule for all personnel and the results are now showing up. Pride in the work is increasing continually."[152] Although error counts still occasionally spiked, they were repeatedly brought back to within acceptable limits.[153]

JAWS observers were also innovative. To protect latex radiosonde balloons against puncturing or stretching during release in high winds, met techs at Resolute devised a "shroud" to protect the balloon. The danger of static from the friction of the balloon rubbing against the shroud meant that it could only be used with helium-filled balloons, which initially limited their use to Resolute (where the use of helium started in 1952). The following year, the satellite stations received limited quantities of helium to quickly inflate balloons when necessary, and personnel promptly adopted the shroud to improve launch performance in high-wind conditions. Isachsen ExO John Llewellyn noted "with satisfaction" in his December 1965 monthly report that his team had "never failed to get a balloon and instrument aloft."[154]

JAWS personnel also experimented to improve the low burst altitudes of their flights during the dark period, when extreme cold at high altitudes made the balloons brittle and caused them to burst prematurely. Although heating the balloon before expansion helped, the altitudes that these balloons attained remained unsatisfactory. Met techs at Eureka began experimenting with alternative treatments in the early 1950s by soaking the balloons in diesel oil, which coagulates into a honey-like consistency at low temperatures. Specific procedures varied over time and from station to station, but observers achieved flights as high as seven millibars (111,000 feet) during the winter months after "conditioning" their balloons.[155] One inspector objected to these practices during his 1967 tour because "the diesel fuel would rub off on a person's clothes and before long the odor would permeate all of the living quarters and would additionally be another fire hazard."[156] These warnings do not appear to have had any lasting effect, however. JAWS personnel continued to express excitement when their diesel-soaked balloons achieved higher altitudes in the early 1970s,

Figure 6-10. The “shroud” in use at Mould Bay in 1959. LAC Winnipeg, Acc 2004-01213-7 AES Photographic Records of Arctic Weather Stations, Box 2, File Mould Bay Picture Album.

and a few JAWS veterans may have exported this practice to US Antarctic weather stations.[157]

Despite their dedication to accuracy and consistency, JAWS met techs did not always follow the instructions or wishes of distant weather bureau officials, particularly when station personnel did not understand the significance of the observation programs. Eureka’s archival record and oral histories reveal, for example, how southern planners struggled to convince JAWS personnel at all of the stations to persist with synoptic PIBAL flights, which they were supposed to conduct twice per day. JAWS personnel generally completed these flights until 1957, when a rumour that the Canadian Meteorological Service no longer used these reports began to circulate. (This assumption may have arisen because the daily rawinsonde flights collected the same data without personnel needing to operate a freezing theodolite.) As uncertainty grew about the value of the flights, more and more observation reports listed "PISO" ("no pilot balloon observation, snowing") and "PIWI" ("no pilot balloon observation, high or gusty surface wind"). The USWB and DoT reacted by refuting "in no uncertain terms" the rumour that they no longer valued PIBALs and insisted that the reports remained essential. Accordingly, Eureka's personnel resumed their "100% record, no matter what the weather!" Other stations followed suit, but divergent perceptions about the usefulness of PIBALs did not end there. Don Shanks noted that PIBALs were rare at Isachsen and Eureka during his tenure from 1962–65,[158] and Larry Petznick (Isachsen's OIC from 1964–65) reported that all station personnel continued "to question the value of Pibal observations" and wondered "if the useage [*sic*] and end results from Pibals are worth the amount of time and work put into them." Petznick assured DoT and the US Weather Bureau that "the Pibal program continues to slog on,"[159] but it was not long before the stations ceased these PIBAL flights as part of a synoptic program.[160]

The meteorological services' more active responses to similar concerns about snow and ice observations demonstrated how respect for on-the-ground perceptions and effective communication could overcome station workers' doubts. The frequency of SIPRE observations at the stations ebbed and flowed. In 1953, Thomson conceded that "the regularity of ice thickness reports from the Joint Arctic Weather Stations would improve if the back-breaking labour involved in chopping an ice hole were minimized."[161] Despite a few attempts to train JAWS personnel during the 1950s, personnel rotations eroded local appreciation of the value of SIPRE work.[162] In November 1960, Eureka's OIC R.J. Grauman described his team's frustrations:

> Snow observations appear to be about nine tenths guess work. An observation made ten feet from another would give completely different results. This is a very miserable job, especially when the wind is blowing and the temperature is low. Personnel have never been told what value these observations are, and it is felt that masses of data are being collected to keep a staff of filing experts busy. Frozen hands and fingers, and noses and ears seem to be the only reward for these observations.

> If value of work were pointed out to observer, observations would be made with more regularity and diligence, such … is the attitude toward ice thickness observations now.[163]

This time, senior officials responded more thoughtfully. Despite privately believing that Grauman's remarks "would not have been included in a letter from a mature individual,"[164] the director of Canada's Meteorological Branch informed the men at Eureka that the "SIPRE observations are required by the US Army Engineers and the information thus obtained is proving of great value." The ice thickness measurements, for example, were used to produce tables "which remove the guess work" when determining whether it was safe for an aircraft to land on a particular ice strip at a given place and time of year.[165] The data that the men collected also helped scientists better understand the cycle of ice formation from freeze-up to break-up, including accretion rates for new ice forming each year. The results were mixed and some gaps persisted, but station personnel persevered with the snow and ice observations. Don Shanks, who worked as a met tech at Isachsen from 1962–63 and then served as the OIC at Eureka the following year, noted the variations. Isachsen conducted regular snow and ice observations, while Eureka did not have a snow kit and only conducted a half-dozen ice thickness measurements.[166] The detailed response, however, helped remove northern doubts about the value of the practice, and weather station personnel continued to conduct snow and ice monitoring into the 1970s.[167]

The dual purpose of the stations as hubs and meteorological observation sites influenced station cultures. JAWS personnel were immersed in science. The importance of consistency and accuracy permeated their culture of observation. Met techs went to extreme lengths to develop the localized knowledge and strategies necessary to launch balloons according to internationally-standardized schedules. As the PIBAL and SIPRE programs demonstrate, however, a basic understanding of the value of these activities proved essential to keep observers motivated. When station personnel doubted the utility of their work, simple commands from southern officials were inadequate motivators over the long term. Maintaining robust support for unpopular observations at the isolated stations required dialogue, and it was critical for southern officials to repeatedly explain why JAWS personnel needed to endure physical hardships to complete these tasks.

Acquiring "common sense" field knowledge required more than a few weeks' stay in the Arctic, and JAWS station personnel developed a strong group identity based upon common experiences and amassed expertise. Despite differentiating themselves from scientists, most met techs and other station personnel embraced their station's dual roles as logistical hubs for government and corporate research on subjects ranging from geology to zoology. The flurry of activity and insights that scientist visitors brought to the stations provided a welcome break from the monotony of station life. As installations that conducted direct research and served as sites of general logistical support for other environmental science, the weather stations were hubs for creating expeditionary *spaces* as well as inhabited *places*.[168] Despite their dedication to undertaking meteorological observations in prohibitively difficult conditions, the station personnel knew their limits — particularly when the seasonal cycle dictated the tempo of station life beyond synoptic scientific observations.