Attachment 1
United States Antarctic Program
McMurdo Station, Antarctica
Communications Mission Needs Assessment

Division of Polar Programs
Geosciences Directorate
National Science Foundation
Arlington, VA 22230

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1 Summary

The National Science Foundation (NSF), as Executive Manager of the United States Antarctic Program, operates three science research stations in Antarctica. The largest of these, McMurdo Station, Ross Island, currently utilizes wideband satellite communications provided in partnership with a sister federal agency, the National Oceanic and Atmospheric Administration (NOAA), to meet all communications requirements for NSF USAP operations and for NOAA and NASA tenants operating space data reception facilities at McMurdo. Out year forecasts for McMurdo bandwidth requirements indicate that mission changes by NOAA and its sub-tenants and increased demand by NSF USAP operations will require enhancement to the existing wideband satellite communications. NSF will assume the lead role as communications provider and will seek to implement enhanced capability.

2 Mission Need Summary

The following factors describe the essential elements of the NSF mission need:

1. Relocate Antarctic (McMurdo Station) satellite teleport operations from a remote, isolated facility (Black Island Telecommunications Facility) to a new infrastructure immediately adjacent McMurdo Station to reduce risk from age/obsolescence, address increased sustainment costs due to age and isolation, and address service availability risks due to remoteness.[1]
2. Increase communications bandwidth capability, both outbound from McMurdo Station and inbound to McMurdo Station, to address increase outbound requirements by NSF mission partner NOAA/JPSS and its international collaborator EUMETSAT. A worst case need-date for increased capability in proven operational condition is 3 months prior to the launch of the initial EUMETSAT Polar Satellite-Second Generation satellite (Metop SG-A1), nominally planned for mid-calendar year 2021.
3. Increase outbound and inbound USAP general operational mission, science and health/welfare communications capability serving year-round operations at McMurdo Station.

3 Statement of Objectives

The goals of this request for information are as follow:

1. Alert industry to an enduring U.S. Government wideband satellite communications requirement planned for the close of this decade to allow industry time to factor the Government's requirements into business planning, system architectures and satellite deployment planning
2. Gather relevant technical and cost data to support Government program planning lead time required for budgeting, space segment acquisition and Antarctic earth station acquisition/construction

[1] NB: The design and implementation of the earth station replacing the Black Island Telecommunications Facility is not the focus of this RFI, with the exception that antenna sizing information needs to be understood based on space segment offerings.

3. Conduct a capability risk assessment to determine the degree of alignment of future Government Antarctic communications requirements, need timelines and the availability of commercial satellite industry resources and services

4 Motivation

Modern satellite communications have developed into mission-essential logistics infrastructure for the United States Antarctic Program (USAP). USAP mission communications between Antarctica and the U.S., within Antarctica and in the surrounding Antarctic waters are completely dependent upon satellite communications.

The National Science Foundation (NSF) has teamed with sister Federal agencies (NOAA, NASA) to capitalize on the unique high latitude southern location of the largest USAP research station, McMurdo, to enable low latency space data capture for current and future polar low earth orbit environmental monitoring and science research satellites. High reliability, wideband communications satellite services are essential for the success of these activities.

Recent executive program reviews of the United States Antarctic Program have identified the importance of pervasive modern digital communications at increasing capacity and availability as important to the success of future scientific research activities in Antarctica.[2] NSF recognizes the essential value of modern digital network based communications for the success of the NSF science program supported via McMurdo Station, as well as for the efficient operations of this logistical hub and for the morale/well-being of the personnel assigned there. Thus, NSF has a strategic goal of expanding wideband communications for McMurdo Station for the future of the USAP.

Further, the primary means for supporting wideband satellite communications for McMurdo Station has been identified as a single point of mission failure due to its age, location and associated support logistics.[3]

Satellite earth stations were established at the Black Island Telecommunications Facility,[4] 20 miles distant from McMurdo, to support McMurdo Station at a time when there were fewer options for satellite space segment in the Pacific Ocean Region and where footprint coverage for McMurdo was dominated by C-Band global beams on satellites in the 174°E to 180°E section of the orbital arc. The selection of the Black Island location was driven in large part by the need to circumvent a significant northern horizon obscura of this portion of the GEO arc by the largest geographic feature on Ross Island, the location of McMurdo – the 12,448 ft active volcanic mountain, Mt. Erebus.

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[2] National Research Council (U.S.). 2011. *Future science opportunities in Antarctica and the Southern Ocean*. Washington, D.C.: National Academies Press. http://site.ebrary.com/id/10520715. http://www.nap.edu/catalog/13169/future-science-opportunities-in-antarctica-and-the-southern-ocean .

[3] United States Antarctic Program. 2012. *More and better science in Antarctica through increased logistical effectiveness report of the U.S. Antarctic Program Blue Ribbon Panel at the request of the White House Office of Science and Technology Policy and the National Science Foundation*. Washington, D.C.: White House Office of Science and Technology Policy. http://purl.fdlp.gov/GPO/gpo26025. Pp. 137-138

[4] See Section 12 GEO SATCOM Operations (pg. 21)

In the modern era, more options currently exist and are anticipated to exist in the future for wideband communications satellites operating in the 150°E to 176°E section of the GEO arc that have direct visibility from McMurdo Station. Additionally, technology development within the satellite industry favors the implementation of high throughput satellites (HTS) with regional or targeted beams operating at higher power densities and higher frequencies (thus favoring ground station antenna sizing). Space segment replenishment programs by regional and international operators are expected to provide greater opportunities for addressing the expanding future requirement for McMurdo. Refer to Section 10 (pg.15) below for more discussion on orbital arc requirements.

5 Statement of Requirements

5.1 Orbital Arc Location

Bounded by ~ 150°E on the West and ~ 176°E on the East.

See Orbital Arc Requirements (pg. 15) for more in depth information for ground station site selection dependencies on local terrain obscura influencing the usable orbital arc segment.

5.2 Bandwidth

Table 1 - Bandwidth Requirements, Broken Out by Mission Service

Mission	Outbound [a]		Outbound		Inbound [a]		Inbound	
	Min. [b]	Priority [d]	Max. [c]	Priority	Min.	Priority	Max.	Priority
NSF	20 Mbps	1	30 Mbps	1	45 Mbps	1	60 Mbps	1
JPSS	2 Mbps	1	43 Mbps	1	2 Mbps	1	2 Mbps	1
NASA	1 Mbps	1	2 Mbps	2	512 kbps	1	512 kbps	2
DMSP	5 Mbps	1	7 Mbps	4	256 kbps	1	256 kbps	4
EUMETSAT	15 Mbps	1	68 Mbps	3	256 kbps	1	256 kbps	3
TOTAL	**43 Mbps**		**150Mbps**		**48 Mbps**		**63 Mbps**	

Notes:

[a] McMurdo Station is the reference for traffic direction.

[b] Minimum refers to the Threshold Requirement for bandwidth

[c] Maximum refers to the upper-bound Objective Requirement for bandwidth

[d] Priority refers to network Layer 2/Layer 3 traffic prioritization that may be used for committed and burst information rate bandwidth management among mission users to permit instantaneous sharing of underutilized bandwidth.

Bandwidth requirements may vary over the duration of the joint missions. The ability to scale bandwidth, either to increase or to decrease, from the values of Table 1 is desired.

The selection of operational spectrum is at the discretion of the service provider. NSF intends to build the requisite Antarctic teleport earth station to suit the available space segment. However, a practical upper bound of ground station antenna aperture of 13 m is presently estimated and would thus be a factor in spectrum selection such that the needed earth station G/T would be met given the inbound data rates in Table 1.

5.3 Description of Service

Table 2 - Description of Service

Term Item	Description
Combination of Services	Space segment, terminating teleport, and terrestrial backhaul to service delivery point desired
Space Segment Type	At the discretion of the service provider (e.g., leased transponder, managed throughput services, etc.)
Service Start *(Nominal)*	Early Start: January, 2020 Late Start: March, 2021
Service End *(Estimated)*	Enduring – through 2040
Period	Continuous Service (Full Period)
Priority	Dedicated, Non-Preemptible
Availability	High – 99.5% or better
Restoration	On-satellite required; Alternate satellite desired
Service Delivery Point	Continental U.S. (CONUS) – Denver, CO metro area
Terminating Teleport	Combined with the space segment, and is at the discretion of the service provider, although CONUS/Hawaii preferred. Should the service provider not provide the terminating teleport, this would be Government Furnished.
Terrestrial Backhaul	Preferred as combined with space segment but may be excluded from service if CONUS/Hawaii terminating teleport provided. Foreign teleports require bundling of terrestrial backhaul to the CONUS service delivery point.
Customer Data	Digital transport stream (e.g., TCP/IP encapsulated in MPLS, GRE tunnels, L2TP/VPN, etc.), to include jitter and latency sensitive applications (VoIP telephony, video conferencing, etc.)
Required BER *(un-degraded)*	$\mathbf{10^{-7}}$ or better (optimal is $\mathbf{10^{-9}}$ or better with error correction, clear sky)
Service Management	Service Level Agreements for all components of service provided (space segment, terminating teleport, terrestrial backhaul). Integration of supplier's 24x7 operations management and supplier's subcontractors with the customer's operations management process is required (which includes Antarctic teleport operations, Antarctica-to-CONUS demarc circuit performance management, etc.)

6 Acquisition Concept

NSF intends to serve as the lead U.S. Government procurement authority. Detailed acquisition planning will occur following the receipt and analysis of industry input to this request for information. As an option, NSF may assign all aspects of the acquisition and post-procurement

to its Antarctic Support Contractor, providing logistics, transportation, science support and IT/communications services to NSF for the operations of the USAP.

NSF is seeking to understand the feasibility and costs of the various modes of acquisition. The factors for consideration could result in the formation of a trade-space for future RFP development.[5] It is assumed that the current and future marketplace conditions in the Pacific Ocean and Southeast Asia markets will have a bearing on the range of acquisition modes available. The acquisition factors under consideration could include the following (Table 3).

Table 3 - Acquisition Considerations

Funding	Regulatory and Federal Acquisition Regulations Issues	Acquisition Methods and Policy Considerations
Total Life Cycle Cost	Interplay between FAR-based procurement and Funding issues	Conventional lease (base year + option years
Budget affordability: up-front outlay v. annual incremental costs	Contracting options for long-term lease contracts accommodating FAR requirements	Long term lease
Federal budget formulation timeline	Cost savings for long-term lease commitments	Capital lease with operation by commercial satellite operator
	NTIA requirements for other than a standard leased services acquisition	Purchase/ownership with operation by commercial satellite operator
		Hosted Payload
		Anchor tenant for leased services
		Pre-construction/launch investment opportunities

7 Concept of Operations

7.1 Antarctic Teleport and Telecommunications

NSF provides all Antarctic satellite earth station and terrestrial telecommunications infrastructure, hardware, maintenance and operations support. All earth station operations and maintenance are provided by NSF and may include any combination of collaboration with tenants, international Antarctic program operators, the NSF Antarctic Support Contractor, or independent contractors.

7.2 Tenant Services Architecture

NSF provided satellite telecommunications services will support multiple users: USAP operations and science as well as multiple tenants hosted at McMurdo Station. System

[5] An additional consideration is the degree to which NSF needs to position a commitment to assure service providers to invest in future capacity. The duration of commitment, nature of commitment, etc. would need to be understood in order to assess feasibility.

architecture at Layer 2/3 will establish a specific demarcation for tenant telecommunications service interface that serves as the information security accreditation boundary between NSF and tenant systems. NSF traffic management provides independent transport of tenant and USAP data streams between the McMurdo Station demarcation and a similar demarcation point to be defined in CONUS. Between the demarcation points, NSF is responsible for traffic and operations management. Tenant traffic transiting the NSF satellite communications service will be segregated at Layer 2/3 to ensure the integrity of the information security accreditation boundary isolation. If required, NSF will employ modern traffic management technology (e.g., WAN optimization appliances, packet shaping, other Quality of Service techniques) to manage bandwidth allocations among all user traffic streams.

7.3 Services Management

NSF serves as the responsible Government agency. Tenant services are managed via Interagency Agreements that define terms of service and cost recovery. NSF serves as the single-payer for all commercial services with cost reimbursements from tenant users. Service Level Agreements (SLA) are established with tenant users that address tenant requirements, such as: interconnect points of presence, outage notification protocols and points of contact, service restoration procedures, service metrics reporting, etc. Tenant SLA quality of service metrics will be derived from the equivalent contracted terms of the satellite and terrestrial telecommunications services providers that support the end-to-end link between Antarctica and CONUS.

Overall end-end services management, local McMurdo terrestrial telecommunications services, McMurdo and CONUS demarcation point management, and operational services management coordination with tenant users are provided by NSF via its Antarctic Support Contractor. The Antarctic Support Contractor has overall responsibility for tactical coordination of services management with all tenant users.

8 Mission Needs Discussion

8.1 McMurdo Station Overview

McMurdo Station is the largest of the three year-round U.S. Antarctic stations and is located on the southern tip of Hut Point Peninsula, Ross Island, Antarctica. McMurdo serves as the main logistical gateway for the majority of U.S. program activity within Antarctica, providing port and aerodrome facilities supporting research programs conducted at McMurdo Station, the deep interior of Antarctica and South Pole Station. Station populations can reach ~ 1200 personnel during the peak of the austral summer season (Oct. – Feb.), while reducing to ~ 150-200 during the austral winter season (Mar. – Sep.)[6].

[6] For more information on McMurdo Station, see: http://www.usap.gov/videoclipsandmaps/mcmwebcam.cfm

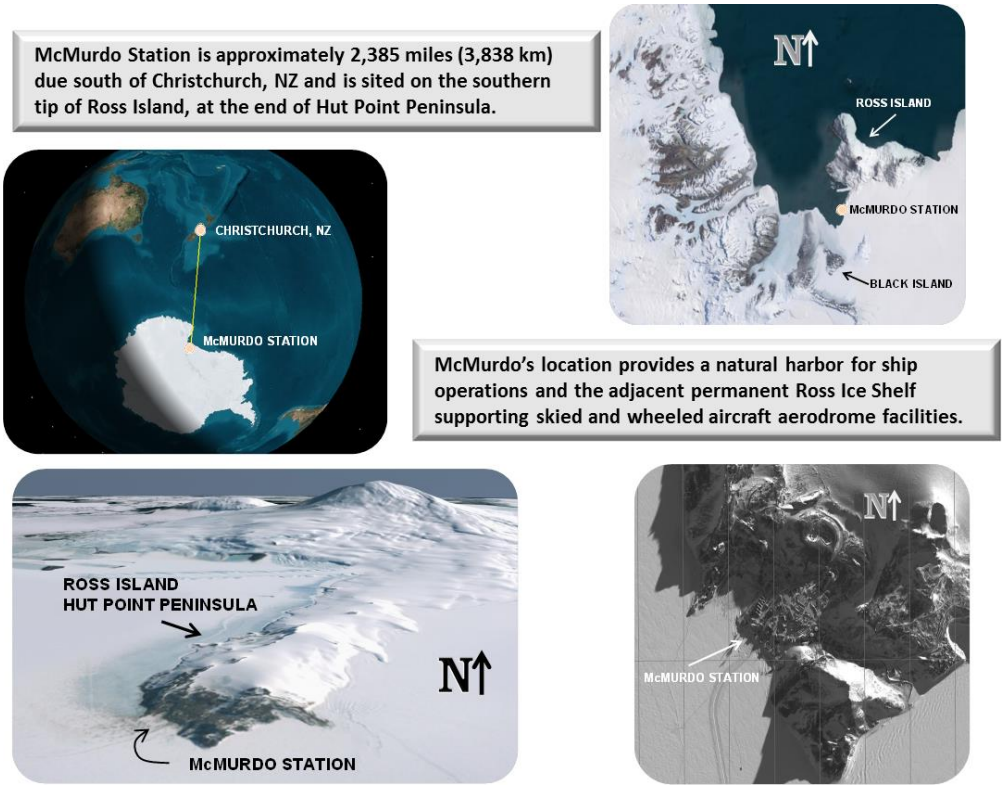

Figure 1 - Geographic Location of McMurdo Station

Figure 2 - McMurdo Station, as Seen Looking North from Winter Quarters Bay

8.2 Inter-Agency Space Data Collaboration

McMurdo Station hosts two major U.S. Federal agency tenants who conduct data communications intensive operations: NASA Ground Networks (NASA/GN) and the NOAA Joint Polar Satellite System (JPSS). As part of a multi-agency collaboration, NSF hosts two JPSS receptor earth stations that will collect data from the new civil operational environmental satellite system replacing the NOAA Polar Orbiting Environmental Satellites.

As a continuation of a collaboration begun in the early 1990's to support data acquisition during the RADARSAT-1 synthetic aperture radar Antarctic Mapping Mission, NSF also hosts the NASA/Near Earth Networks (NEN) McMurdo Ground Station (MG1) and its potential expansion (MG2)[7]. Jointly, these space data earth stations will collect data from the present U.S. Air Force Defense Meteorological Satellite Program (DMSP), the forthcoming JPSS-1&2 civil operational environmental satellites, the EUMETSAT MetOp satellite system[8], and various NASA polar low earth orbit and launch support activities.

NOAA, NASA and NSF have teamed resources to produce the Multi-Mission Communications System (MMCS)[9] that supports these activities via NSF provided satellite communications earth station infrastructure at its Black Island Telecommunications Facility, located approximately 20 miles south of McMurdo to permit an unobstructed view of the Pacific geosynchronous satellite arc[10] westward from 183°W longitude. Due to McMurdo's high latitude of 78°S, satellites appear no higher than 3.5° above the horizon.

The Black Island Facility supports two satellite earth stations, an 11 m Ku-Band (active) and a 7.2 m Ku-Band (inactive). Via leased Ku-Band transponder services on the SingTel Optus D1 satellite, a 60 Mb/s outbound/20 Mb/s inbound service is provided by the 11 m earth station beginning in January, 2011.

Future mission needs from NOAA, NASA and their respective supported clients (EUMETSAT, future NASA polar LEO science missions) are projected to outstrip the capacity of the outbound bandwidth available to the MMCS. McMurdo Station has the potential to evolve into a Southern Hemisphere equivalent of the major polar LEO space data acquisition and command service that has developed at Svalbard in the Northern Hemisphere. Access to greater broadband communications for real-time forwarding of data and commands currently constrains the greater utilization of McMurdo Station's high southern latitude for polar LEO satellite operations support.

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[7] See: http://antarcticsun.usap.gov/features/contenthandler.cfm?id=2392

[8] Product and Services News, Improving the Timeliness of Metop-A Global Data UPDATED 07/04/2011, EUMETSAT, March 31, 2011; http://www.eumetsat.int/Home/Main/News/ProductServiceNews/805204?l=en , retrieved April 11, 2011

[9] Paciaroni, J.; Higgins, C.; Jamilkowski, M. L.; NPOESS McMurdo Multimission Communications System, American Geophysical Union, Fall Meeting 2010, abstract #IN43B-1405; December 2010; http://adsabs.harvard.edu//abs/2010AGUFMIN43B1405P , retrieved April 11, 2011

[10] See: http://antarcticsun.usap.gov/features/contenthandler.cfm?id=2114

8.3 Operational Mission Needs Discussion

Modern telecommunications and remote management provided by broadband satellite communications and IP networks enable permanent O&M and sustaining engineering staff located in the U.S. to compensate for the challenges of annual staff rotations. Technical experts from the various manufacturers/suppliers of critical systems are able to support McMurdo staff via remote diagnostics. This is of specific importance to the critical power generation and facilities environmental control systems.

Broadband communications also play an increasingly important role in the health and safety of all station personnel through the implementation of modern telemedicine capabilities. High-resolution digital video transmissions enable remote radiologists to guide real-time ultrasound diagnostic procedures administered by local staff. High-resolution digital video transmissions streamed via Internet-2 have supported real-time specialist supervision of locally administered clinical procedures when necessary. A 24-hour/day, 7-day-per-week broadband capability will increase current telemedical capabilities, permit transmission of vital diagnostic information at any time, day or night, and leverage on-site medical staff with virtually unlimited access to specialized medical expertise in the United States. Enhanced off-site support in medical emergencies facilitates positive patient outcomes in such a remote, hostile environment.

IP network services enabled by broadband satellite service permit station staff to remain connected with family, transact personal business, and continue personal activities that they enjoy at home. Satellite communications, coupled with the Internet, have dramatically diminished the psychological impacts of the remoteness, harsh environment, extended isolation, and monotony of living and working for a year at McMurdo Station. As the challenges for managing a complex technical presence at McMurdo increase for both the science program and for station operations, the well-being needs of station staff increase as well. Access to music, news, video, telephone calls and video chats with family/friends, personal e-mail, social networking contacts, etc. all compensate for the difficulties of living and working at the station.

8.4 Additional Geographical Needs Considerations

While the primary emphasis of this RFI pertains specifically to McMurdo Station, the NSF activity in Antarctica and its surrounding oceans is broad and there are additional geographic areas in need of modern broadband and wideband communications, per **Error! Reference source not found.**. The scope of USAP activity in Antarctica spans nearly the entire continent as described in Figure 17 and depicted in the Appendix – *Total Antarctic Region Communication Coverage Requirement*.

Table 4 - Geographic Coverage Mission Needs

Geographic Coverage Mission Needs		
Coverage Region	**Description**	**Coverage**
1	South Pole Station	Spot
2	West Antarctica	Zone
1	McMurdo Station	Spot
4	East Antarctica & Interior	Zone
2	Palmer Station	Spot
3	West Palmer Peninsula	Zone
n/a	Full Continent & Surrounding Ocean (vessels)	Continental

These is interest in any synergy that can be obtained by combining solutions for McMurdo Station that could include some or all of the remaining geographic coverage requirements. While dated, a sense of the bandwidth needs for these regions can be gained from prior announcements. [11]

9 Schedule

The primary schedule drivers are:

1. NOAA and Partner Agency satellite deployment schedules – The introduction of the EUMETSAT Polar Satellite-Second Generation (Metop-SG) follow-on mission is the primary driver for bandwidth increase. EUMETSAT is in the process of finalizing its out-year program plan, however a fair representation of its deployment schedule can be depicted in Figure 3. EUMETSAT has the following ground system communications readiness targets:

   Table 5 - EUMETSAT Ground Communications Readiness Targets

Requirement	Event	Readiness
Threshold	Metop SG-A1 Launch	Launch minus 3 months
Objective	"	Launch minus 1 year

   Refer to Figure 3 for the current estimated flyout schedule.[12]

2. Logistics constraints for transport and construction of earth station infrastructure in McMurdo Station – Based on the assumption that up to a 13 m scale earth station with radome enclosure may be required (worst case planning assumption), the earth work preparation, international cargo transport via the single annual resupply vessel, and coordination of shared labor resources on-site dictate a standard/nominal three-season schedule timeline.

[11] Satellite Based Broadband Communications Services, Solicitation Number NSF_SATCOM_RFI_2011, Division of Acquisition and Contract Support, National Science Foundation, FedBizOpps, Apr 29, 2011; https://www.fbo.gov/spg/NSF/DACS/DACS/NSF_SATCOM_RFI_2011/listing.html

[12] See: http://noaasis.noaa.gov/NOAASIS/images/POES_Flyout_Chart_08_06_14.jpg

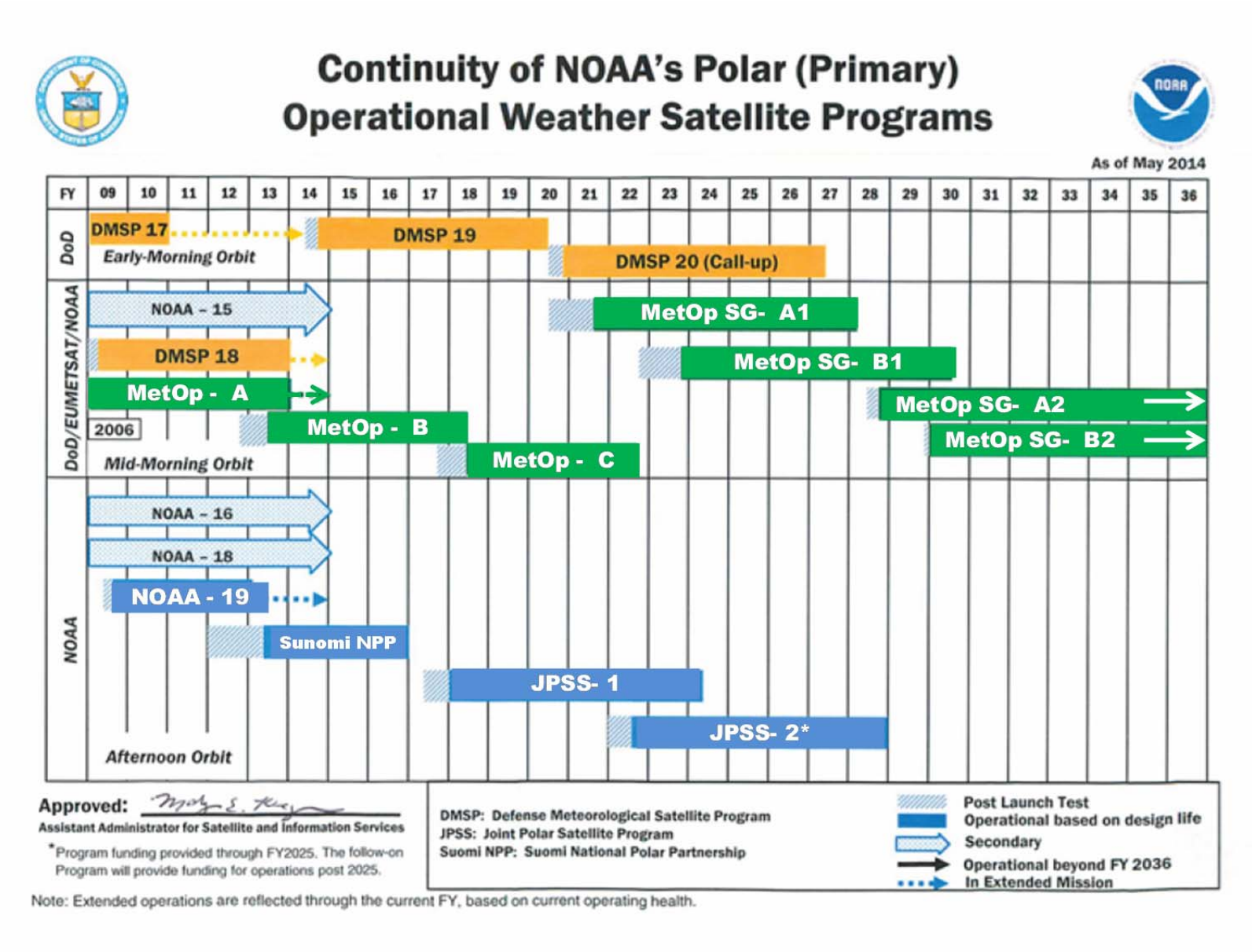

Figure 3 - NOAA NESDIS Flyout Schedule - Polar Weather Satellite Continuity

Notional Development Schedule

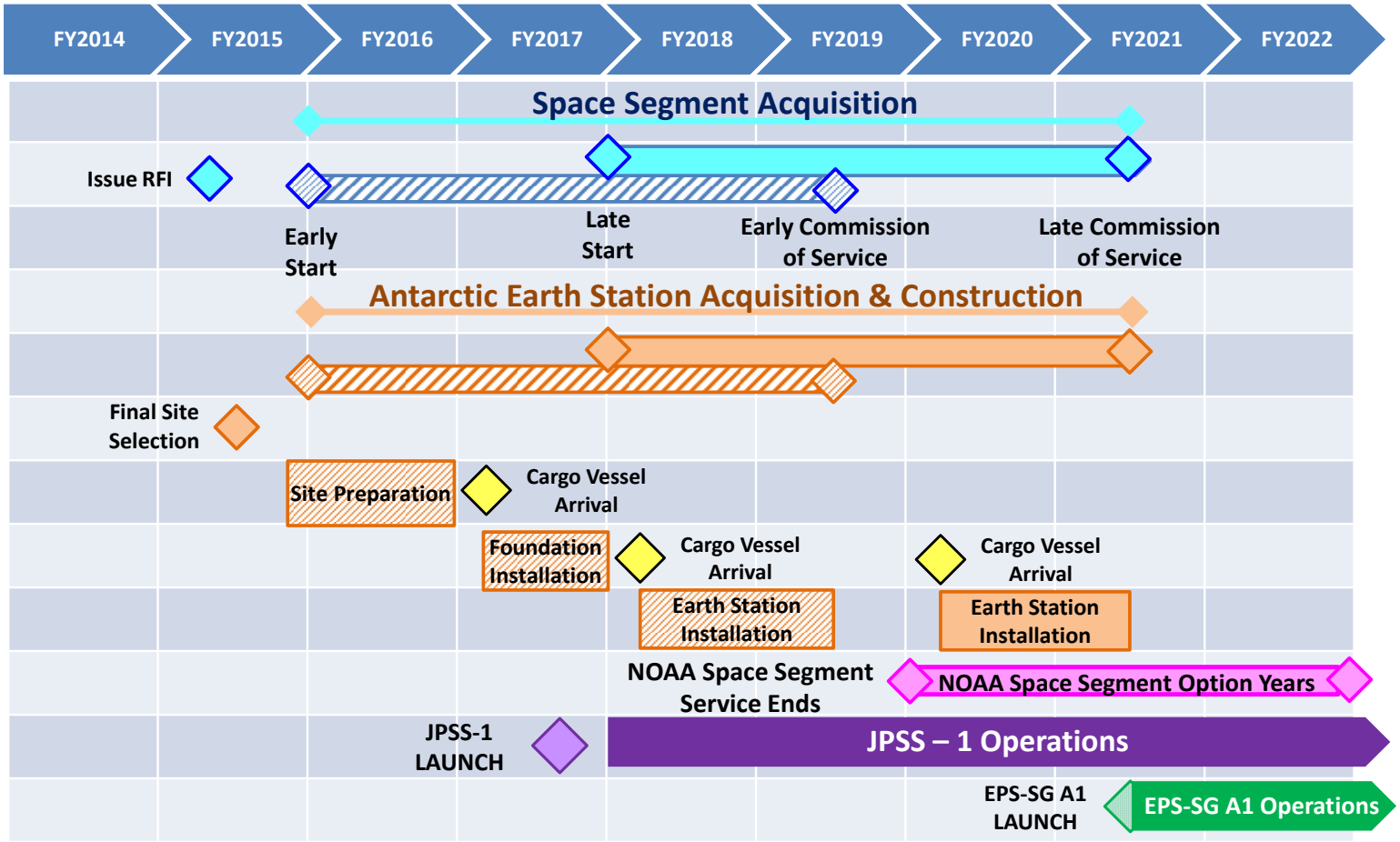

Figure 4 - Notional Service Development Timeline

10 Orbital Arc Requirements

Site evaluation assessments have identified two candidate ground station locations:

- Site 1 – Northern mid-slope of Observation Hill (Observation Hill Site)
- Site 2 – Northwestern edge of a flat plateau at the base of Crater Hill that supports an HF radio transmitter facility (T-Site)

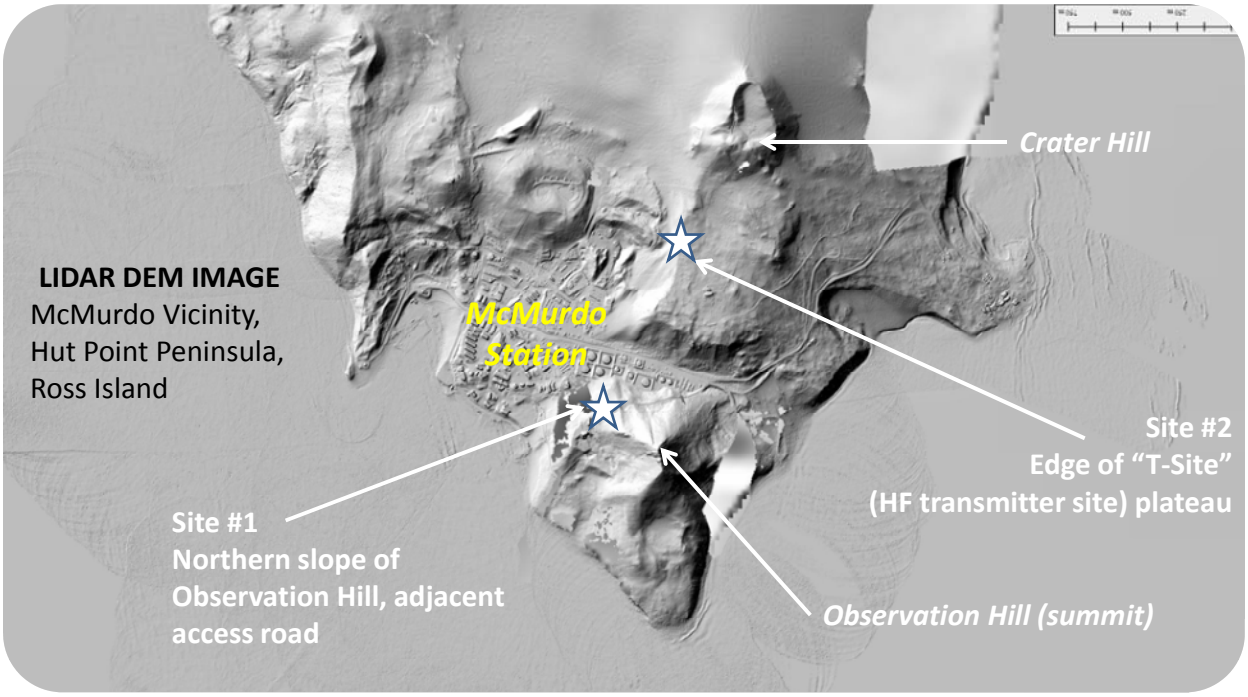

Figure 5 - Candidate Ground Station Locations

Table 6 - Candidate Ground Station Lat. and Lon.

Site Name	Lat.	Lon.	Elevation (AMSL) from DEM	Description
Site #1: Observation Hill	77.8503° S	166.682° E	95.55 m	Location of former water distillation plant on northern slope of Observation Hill
Site #2: T-Site	77.8427° S	166.712° E	189.1 m	Western edge of "T-Site" (HF Transmitter Site) plateau

A combination of geographic information system (GIS) terrain analysis using high resolution LIDAR digital elevation models produced by science research programs, 3D Analytical Graphics Systems Tool Kit™ view predictions and in situ observations have validated the GEO arc viewing horizons for exploitation as depicted in the following horizon profile plots:

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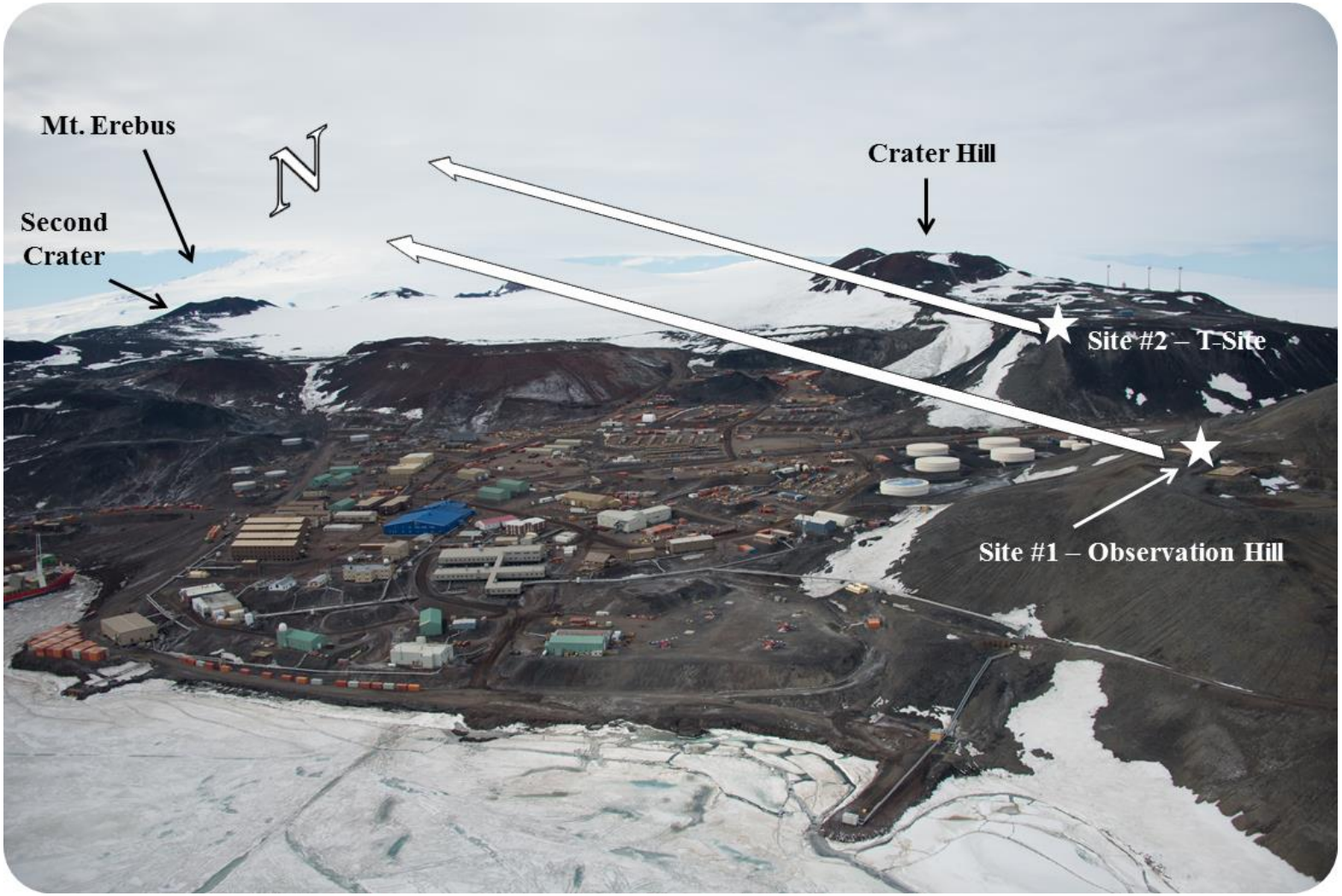

Figure 6 - McMurdo Station Aerial View Showing Evaluation Sites

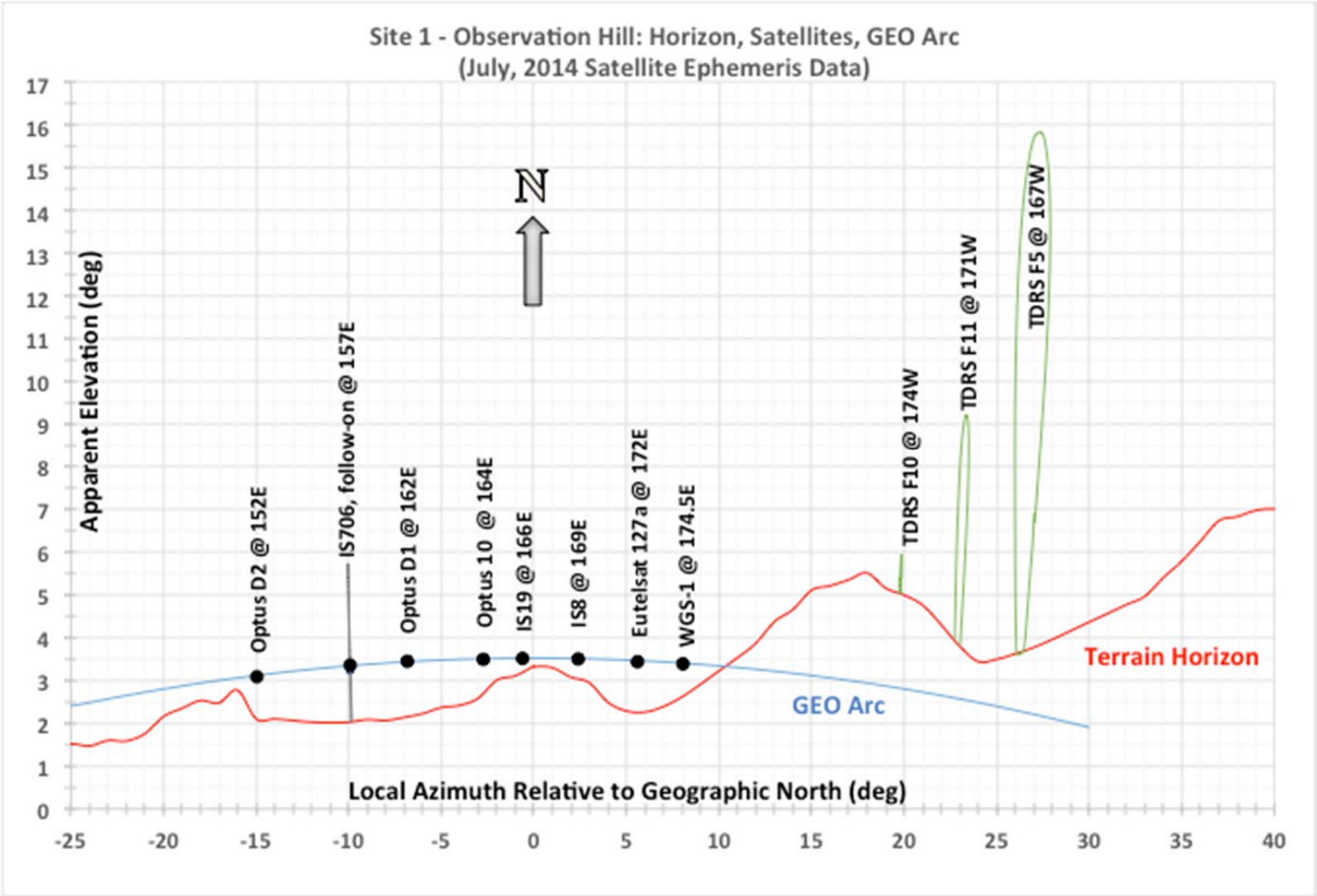

Figure 7 - Site #1, Observation Hill Horizon View Plot

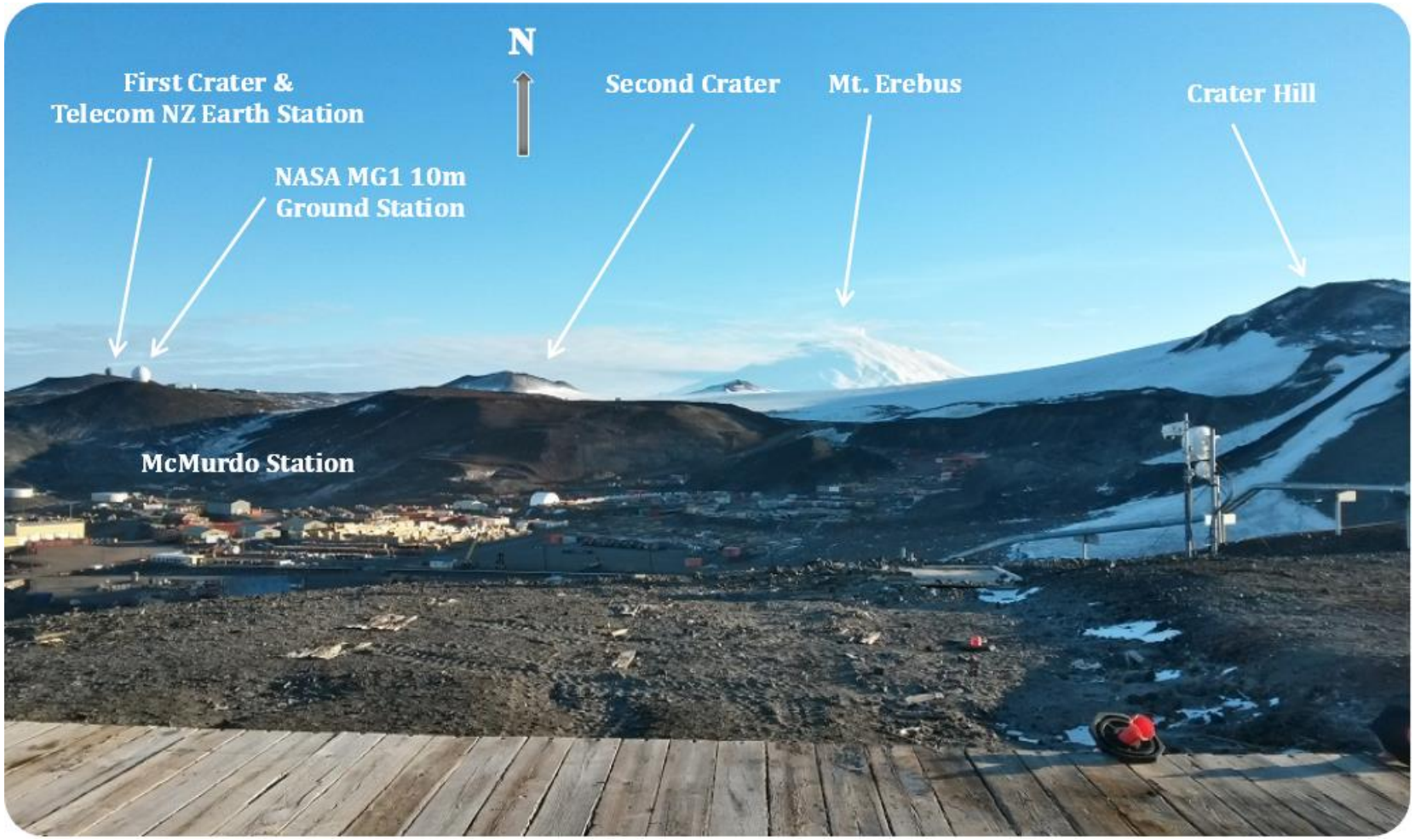

Figure 8 - Site #1, Observation Hill Horizon Photograph

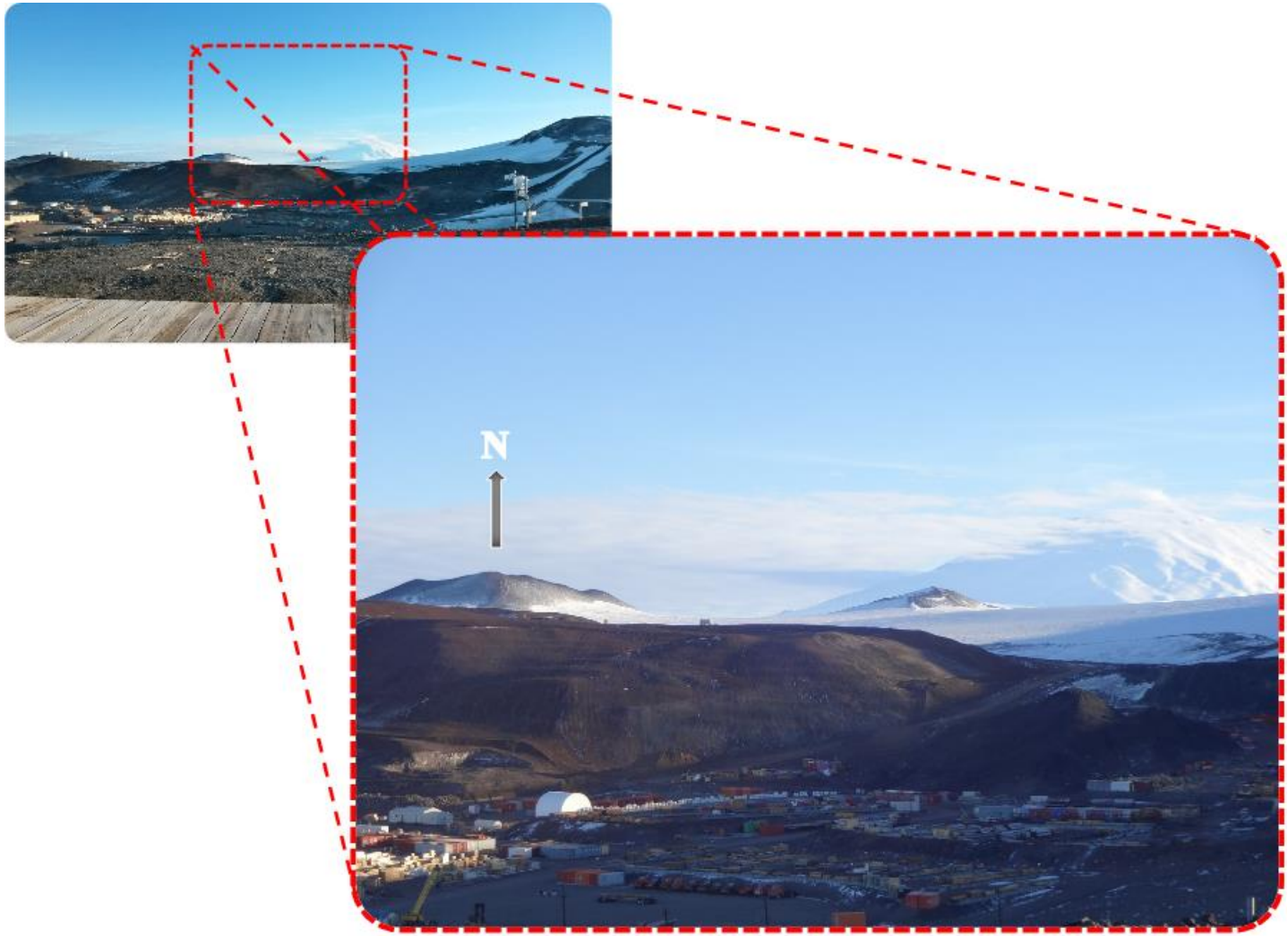

Figure 9 - Site #1, Observation Hill, Zoom of Horizon Major Obscura

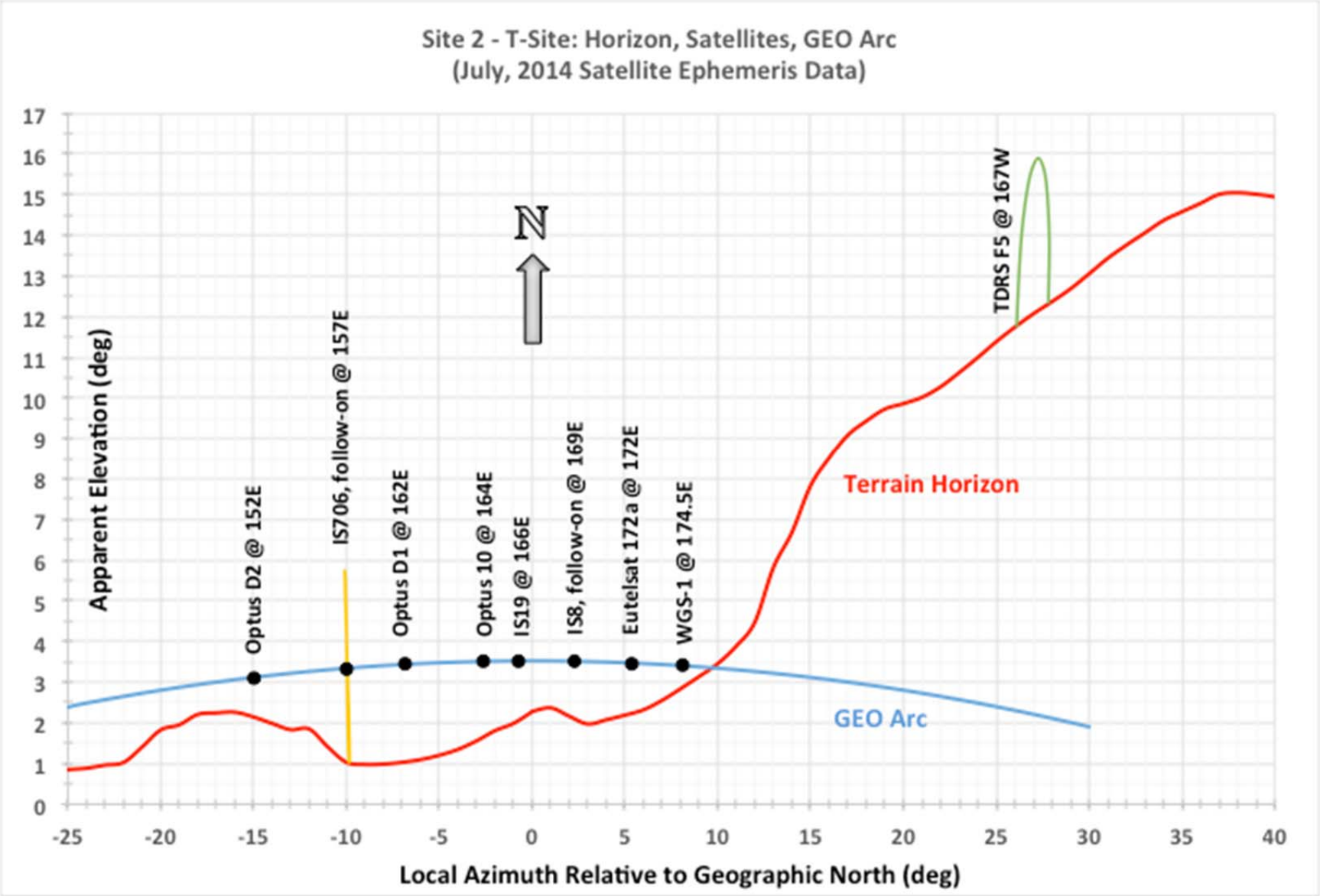

Figure 10 - Site #2, T-Site Horizon View Plot

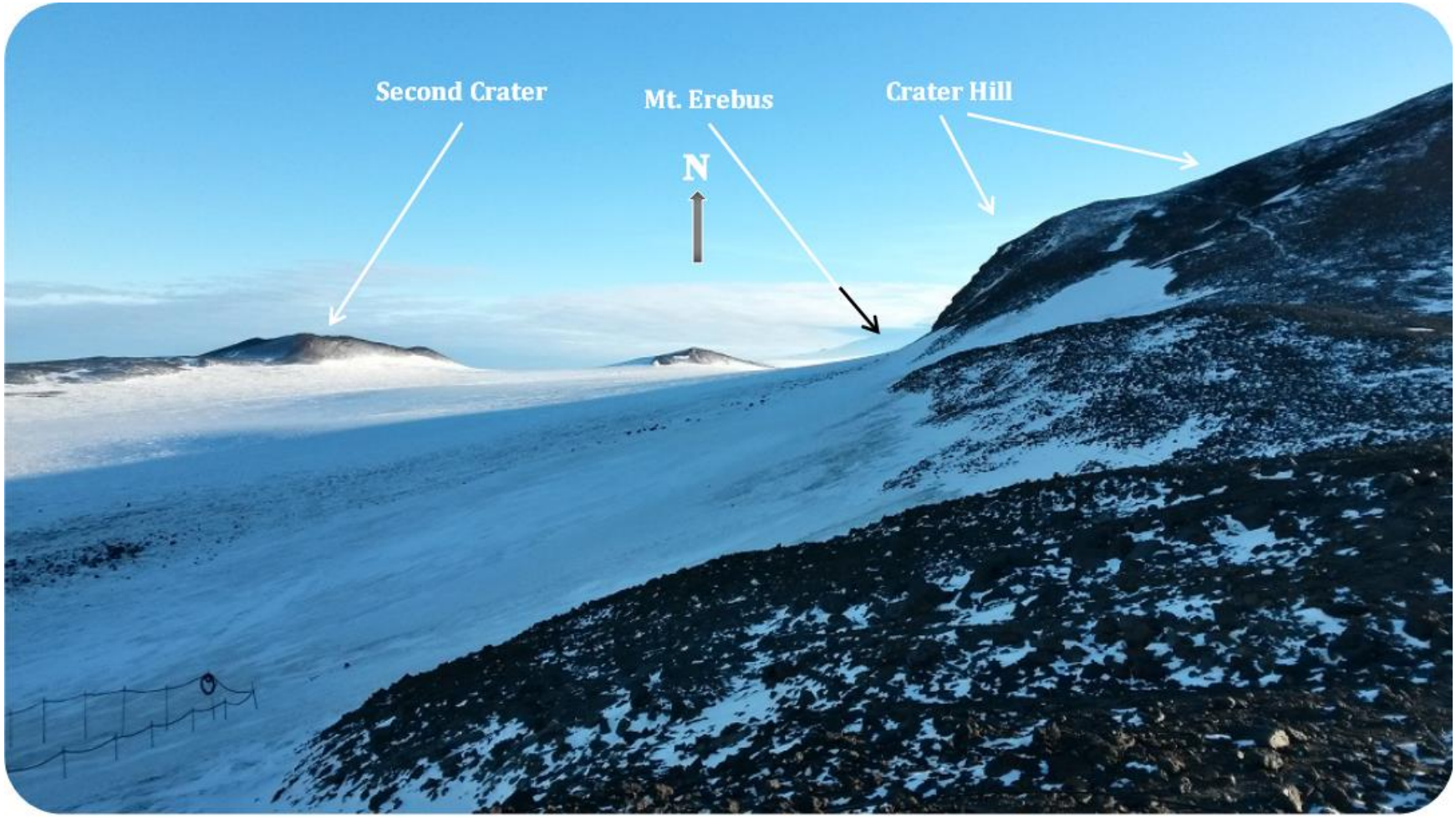

Figure 11 - Site #2, T-Site Horizon Photograph

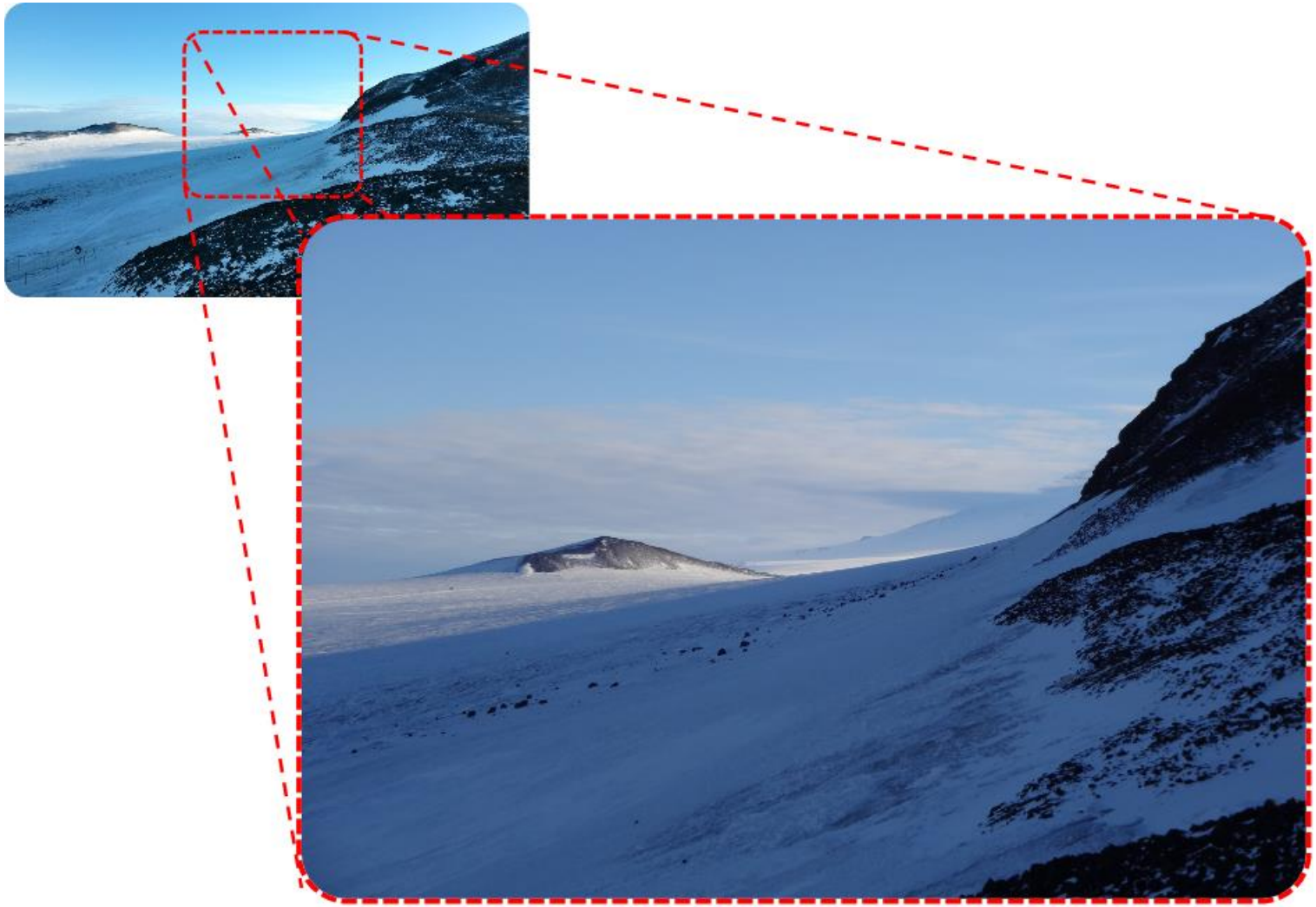

Figure 12 - Site #2, T-Site, Zoom of Horizon Major Obscura

11 NSF/USAP Mission Overview

The National Science Foundation has been designated the executive manager of the United States national program in the Antarctic – the U.S. Antarctic Program (USAP), via Presidential decision memorandum[13]. It is United States policy to maintain an active and influential presence in the Antarctic as expressed via the conduct of science research activities. The National Science Foundation provides management and operations of the funding of science research[14] pertaining to the polar regions, to include the management, operations and development of necessary infrastructure within the Antarctic. The National Science Foundation serves as the central clearing house and national lead for all U.S. agency activities pertaining to Antarctica. As such, NSF maintains an active working relationship with the U.S. Department of State with regard to the U.S. obligations under the international Antarctic Treaty Consultative system.

NSF executes the USAP to foster cooperative research with other nations, protect the Antarctic environment, and develop measures to ensure only equitable and wise use of resources. The program comprises research by scientists selected from universities and other research institutions and operates with support by a contractor and other agencies of the U.S. Government. NSF sponsored USAP research has three goals: to understand the region and its ecosystems; to understand its effects on (and responses to) global processes such as climate; and to use the region as a platform to study the upper atmosphere and space.

U.S. national policy for Antarctica calls for an active and influential presence, which is expressed via a vibrant science research program supporting research in the basic sciences, as well as hosting other U.S. Government agency activities in Antarctica. To accomplish this, NSF operates and maintains three U.S. stations in Antarctica, as well as various remote camps and vessels.[15] The largest research facility is McMurdo Station, essentially a small town with populations peaking between 1000 to 1200, where 90 percent of approximately 3000 USAP participants pass through on their way to research sites, including Amundsen-Scott South Pole Station at the geographic South Pole.

[13] Reagan, Ronald W., Presidential Memorandum 6646, "United States Antarctic Policy and Programs," February 5, 1982; http://www.nsf.gov/geo/plr/ant/memo_6646.jsp

[14] The National Science Foundation was created by an Act of Congress in 1950. Its founding charter and purpose are defined in 42 U.S.C. § 1861 et. seq. Its purpose is (in part) defined as "to initiate and support basic scientific research and programs to strengthen scientific research potential and science education programs at all levels in the mathematical, physical, medical, biological, social, and other sciences, and to initiate and support research fundamental to the engineering process and programs to strengthen engineering research potential and engineering education programs at all levels in the various fields of engineering, by making contracts or other arrangements (including grants, loans, and other forms of assistance) to support such scientific, engineering, and educational activities and to appraise the impact of research upon industrial development and upon the general welfare." NSF is the federal government's primary source of funding for academic basic science and engineering research and the second-largest federal source (after HHS) of R&D funds for universities and colleges. (http://www.nsf.gov/statistics/seind14/index.cfm/chapter-4/c4s6.htm#s2).

[15] Reagan, Ronald W., Presidential Memorandum 6646, op. cite

12 GEO SATCOM Operations Background

12.1 Historical Information

The era of modern satellite communications at McMurdo Station began in 1983 when two INMARSAT Standard-A land earth stations were established on Ross Island on the northern slope of Observation Hill. Providing ready access to the main station for power, terrestrial communications connections, and maintenance, this site enabled visibility to the early generation maritime communication satellite systems of the era.

As the maritime communications satellite space segment evolved over the decade, the service was reposition to an orbital longitude blocked by the terrain of Ross Island, which in turn lead to a search for an alternate ground station location that resulted in the creation of the Black Island Telecommunications Facility, approximately 20 miles south of McMurdo Station.

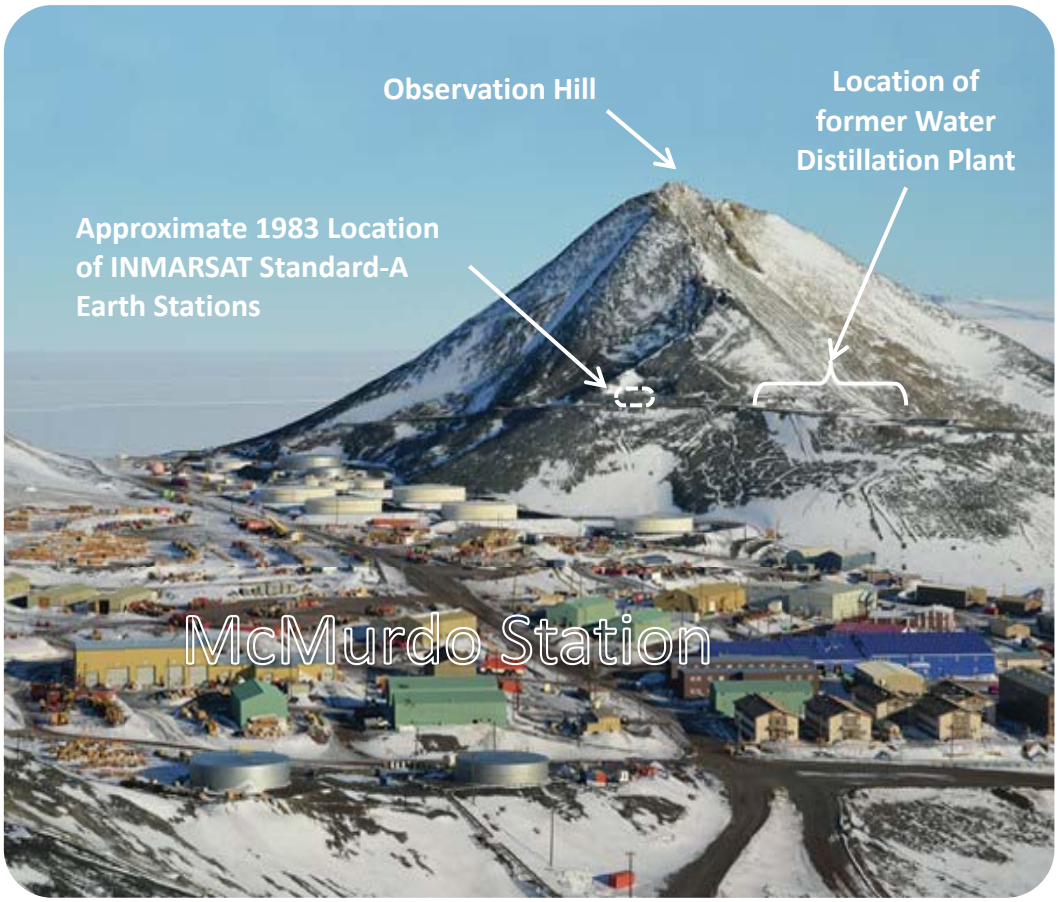

Figure 13 - Early Inmarsat Standard A Earth Station Location, Observation Hill

Table 7 - McMurdo Station Communications Satellite History

Date	Event
Feb-1982	Inmarsat operations established. COMSAT Marisat satellite fleet used for the initial service deployment; Pacific service provided by COMSAT Marisat F3 located at 176.5E
Jan-1984	ITT/Antarctic Services constructs/commissions two Inmarsat Standard-A ship earth terminals on the slope of Observation Hill to establish satellite communications via Marisat F3
Mar-1984	ITT/Antarctic Services submits proposal to NSF Polar for proposal for remoting the Inmarsat earth terminals to accommodate a planned satellite constellation change in Pacific service. Daily Islands were the primary site selected, followed by Marble Point as a secondary choice
Nov-1984	ITT/Antarctic Services determines both primary and secondary site selections were unfeasible. Ad hoc decision to utilize Black Island made.
Nov-1984	European Space Agency MARECS B2 launched; located at 177.5E. Assumes role as POR primary satellite Jan-1985. Not visible from Observation Hill.
Feb-1985	Black Island remote Inmarsat Standard-A earth terminal installation completed and commissioned
Jul-1985 to Dec-1991	Satellite swaps, with all primary satellites not visible from Observation Hill: • MARECS B2 moves from Pacific to 345E; MARECS A moves from the Atlantic to the Pacific (177.5E) • Intelsat V F8 with MCS-D maritime comm. package launches Dec-1985 and stationed at 180E in Spring-1986, becoming primary; MARECS A serves as spare at 179.9E; Marisat F3 as spare in Dec-1989 at 176.1E • Inmarsat-2 F3 launched Dec-1991; positioned for service in the Pacific at 178E
Feb-1992	A two week trial of C-Band service from Black Island via a newly installed 7.2 m earth station (Intelsat Standard F3) working Intelsat 503 @ 174E
Jan-1993	Full period C-Band service at 1.5 Mb/s via the Black Island 7.2 m temporary antenna working Intelsat 511 @ 177E
Feb-1995	Permanent service begins via a newly completed 11 m C-Band earth station providing 1.5 Mb/s via Intelsat IS-703 @ 177E
Feb-2006	Black Island 11m C-Band service increased to 3 Mb/s working Intelsat IS-701 @ 180E
Jan-2008	Black Island 7.2 m earth station modified to Ku-Band and commissioned for 10 Mb/s service working Optus D1 at 160E
Jan-2010	Black Island 11m earth station modified to Ku-Band and commissioned for 20 Mb/s service working Optus D1 at 160E
Jan-2011	Black Island 11m earth station asymmetric 60 Mb/s outbound, 20 Mb/s inbound service begins via Optus D1 at 160E

12.2 Black Island Telecommunications Facility (BITF)

The BITF is sufficiently south and west of Ross Island so as to have an unobstructed view of the geosynchronous arc as far east as the 183°E GEO orbit slot before Mt. Erebus blocks the view.

From it's humble beginnings[16], the facility has evolved over the years 1991-present into a rather complex operation that encompasses a hybrid solar/wind/diesel-electric autonomous power plant, two satellite communications earth station antennas (7.2 m and 11 m) enclosed by metal space frame radomes, 20,000 gallons of fuel tankage, living quarters for seasonal maintenance personnel, a helicopter landing pad, and miscellaneous support resources.

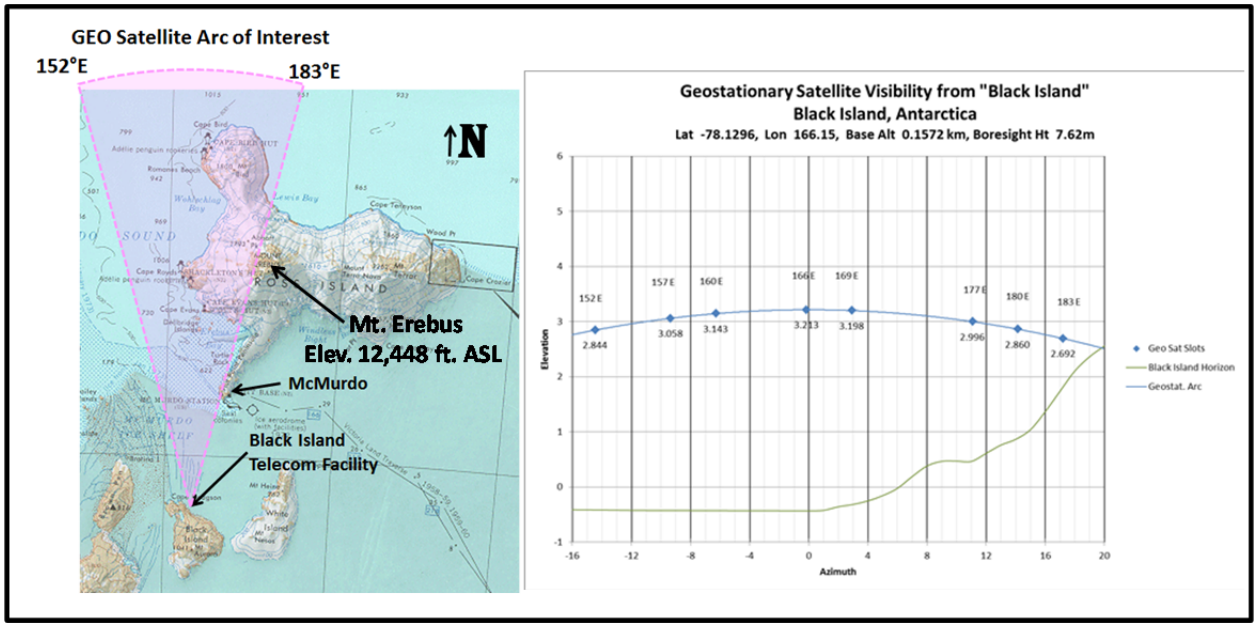

Figure 14 - Black Island Telecom Facility Location and GEO Arc View

The BITF operates as an unattended facility during the austral winter months (typically late February – October) with only infrequent staff visitations for preventative or corrective maintenance. Winter access is only via surface vehicle, and depending on the weather and surface conditions, the time to access the site could be delayed by up to a week. The winter overland route between McMurdo Station and the BITF is approximately 72 miles (116 km), and when surface conditions are poor (large ice melt pools from austral summer melting, large snow drifts, etc.), slow moving tracked vehicles or equally slow moving overland transporters with oversized balloon tires are required, resulting in lengthy transit times (18 hours or more).

The BITF is routinely pummeled by hurricane-force storms that take a toll on the physical integrity of the antenna radomes, towers, and the facility infrastructure. The island is covered by a fine-grained volcanic grit and small rocks that become airborne during storm events, causing abrasion wear and small missile hazard damage.

[16] Kueffner, John H., "Wind Hybrid Power System for Antarctica Inmarsat Link," Telecommunications Energy Conference, 1986. INTELEC '86. International , vol., no., pp.297,298, 19-22 Oct. 1986
doi: 10.1109/INTLEC.1986.4794440

The BITF has grown incrementally since its inception, with numerous expansions in the facility and changes in the power systems design and earth station electronics complements. The facility has become cramped and cluttered in the key telecommunications and power systems areas, complicating maintenance and systems upgrades.

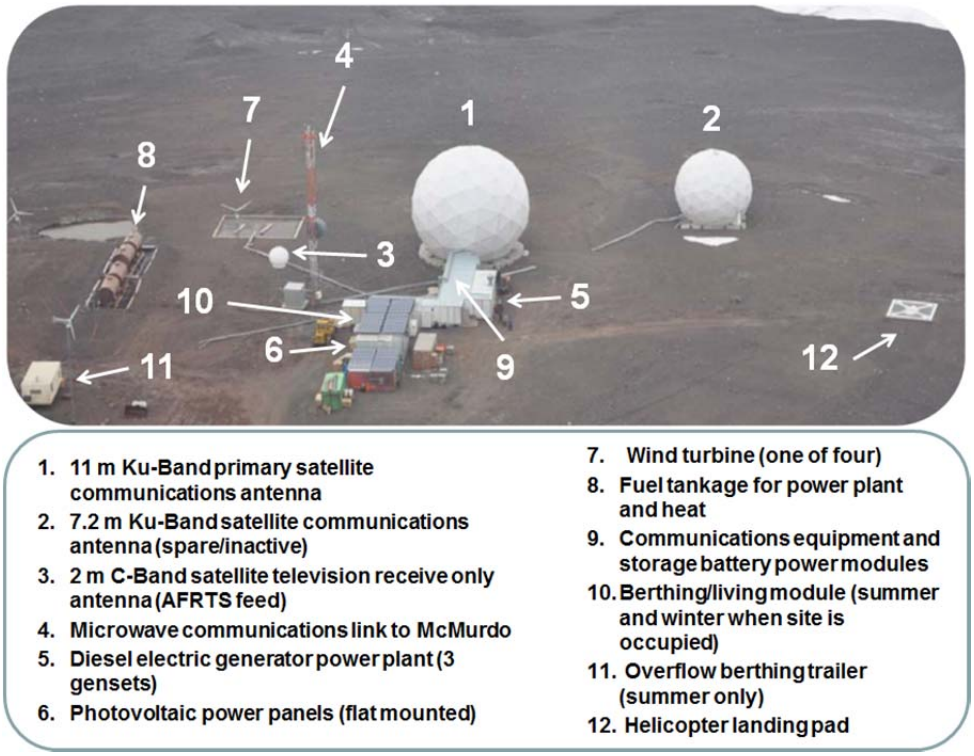

Figure 15 - Black Island Telecommunications Facility

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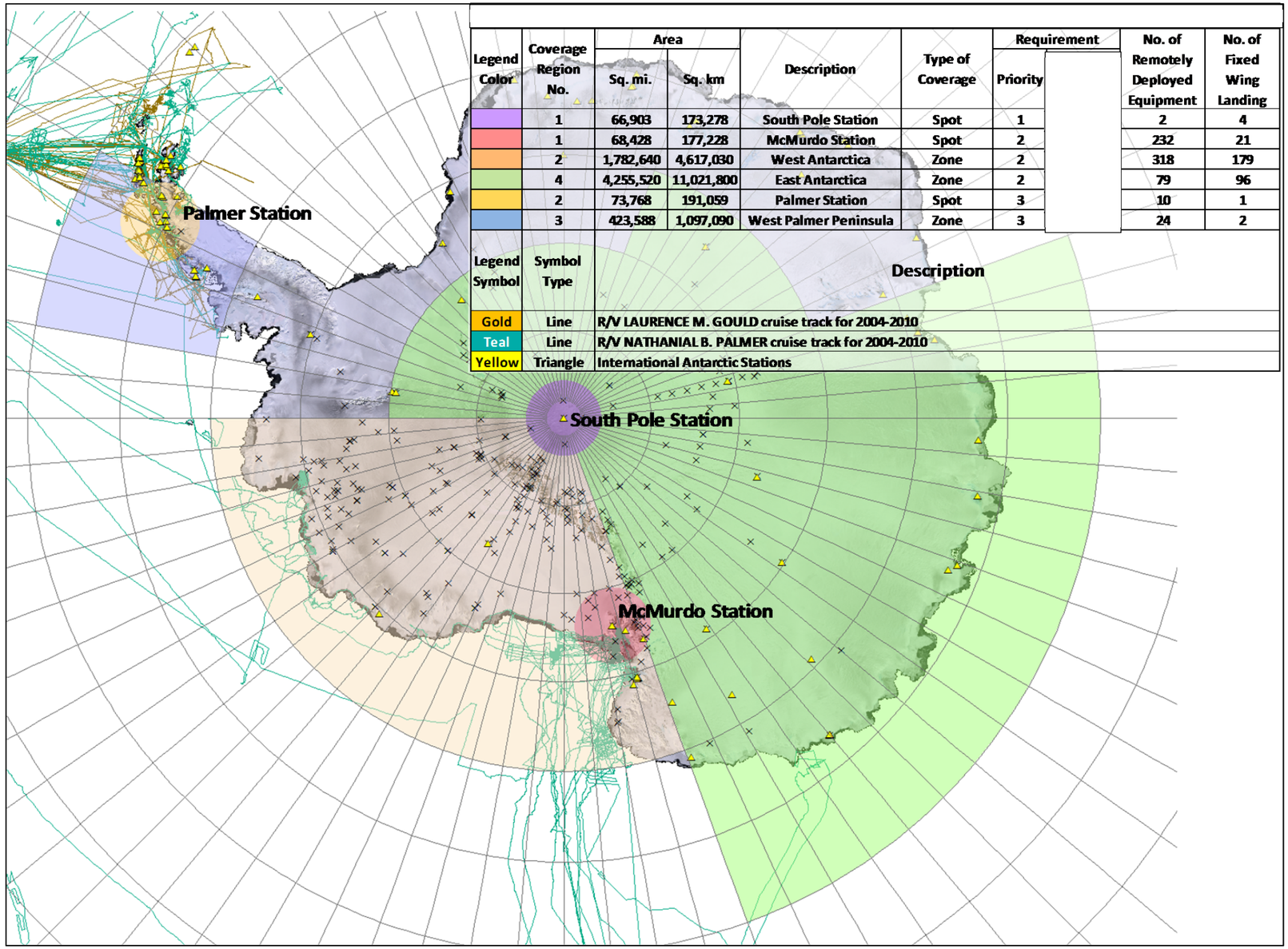
Figure 16 - Black Island Telecommunications Facility As Seen From a Servicing Helicopter Approaching From McMurdo

Appendix – Total Antarctic Region Communication Coverage Requirement



Legend Color	Coverage Region No.	Area Sq. mi.	Area Sq. km	Description	Type of Coverage	Requirement Priority	No. of Remotely Deployed Equipment	No. of Fixed Wing Landing
	1	66,903	173,278	South Pole Station	Spot	1	2	4
	1	68,428	177,228	McMurdo Station	Spot	2	232	21
	2	1,782,640	4,617,030	West Antarctica	Zone	2	318	179
	4	4,255,520	11,021,800	East Antarctica	Zone	2	79	96
	2	73,768	191,059	Palmer Station	Spot	3	10	1
	3	423,588	1,097,090	West Palmer Peninsula	Zone	3	24	2

Legend Symbol	Symbol Type	Description
Gold	Line	R/V LAURENCE M. GOULD cruise track for 2004-2010
Teal	Line	R/V NATHANIAL B. PALMER cruise track for 2004-2010
Yellow	Triangle	International Antarctic Stations

Figure 17 - Full U.S. Antarctic Program Geographic Mission Needs Scope

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