Metop's Antarctic Data Acquisition Project An International Partnership Success

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International partnerships can powerfully leverage the strengths of the participants to the benefit of all. This paper will discuss a unique collection of partnerships between four participants: The European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) along with three United States (US) agencies – the National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF). Together, EUMETSAT, NOAA, NASA and the NSF partnered to implement EUMETSAT's Antarctica Data Acquisition (ADA) capability for EUMETSAT's Metop series of polar-orbiting environmental satellites. These four organizations efficiently implemented a new capability connecting McMurdo Station, Antarctica to EUMETSAT's Darmstadt, Germany Control Centre for the purpose of improving (decreasing) the latency of Metop satellite data by fifty percent, from 130 minutes to 65 minutes. The improved latency provides both European and US weather services more frequent environmental observations for near-real-time mesoscale and mid/long-range global weather forecasts. The ADA capability was achieved by integrating organizationally independent components to form a working system for high-latitude southern hemisphere data acquisition and delivery. The ADA utilized the framework of existing cooperative relationships between EUMETSAT, NOAA, NASA, and NSF to the fullest extent possible, with new cooperative elements added where required. The international partners established clear understanding of each stakeholder's responsibilities, authorities, and accountabilities (RAAs) upfront. The RAAs allowed EUMETSAT, NOAA, NASA, and NSF to interact frequently and intensively with clarity – enabling each stakeholder to achieve their apportioned development effort on schedule. The clear RAAs and frequent communication then enabled a seamless and successful end-to-end integration, testing, and operational verification and validation campaign. EUMETSAT declared ADA operational for Metop on schedule in June 2011 and Metop became the first polar-orbiting environmental satellite to achieve 65-minute data latency operationally

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I. Introduction

THIS paper describes the process, benefits and reasons for success of an international cooperative effort to decrease the latency of Metop data to European and US meteorological services. This effort stands out as an example of multiple agencies and countries coming together with a common purpose and a shared enthusiasm to make what some thought impossible, a reality. The European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) along with three Unites States (US) agencies – the National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF) partnered to implement the Antarctica Data Acquisition (ADA) capability for EUMETSAT's Metop series of polar-orbiting environmental satellites. The Antarctica Data Acquisition (ADA) capability is the first operational system to provide half-orbit polar orbiting satellite data. The improved latency provided by ADA to European and US weather services delivers Metop data in half the time allowing for improved forecast products.

II. What is the Metop Antarctic Data Acquisition System and what does it do?

Together, EUMETSAT, NOAA, NASA and the NSF efficiently implemented a new capability connecting McMurdo Station, Antarctica to EUMETSAT's Darmstadt, Germany Control Centre for the purpose of improving (decreasing) the latency of Metop satellite data by fifty percent, from 130 minutes to 65 minutes. The improved latency provides both European and US weather services more frequent environmental observations for near-real-time mesoscale and mid/long-range global weather forecasts. Figure 1 below shows the multi-agency data flow from the Metop satellite, to the NASA antenna, through the NSF local communications network and the NOAA McMurdo Multi-mission Communications System (MMCS) and on to the EUMETSAT Control Centre in Darmstadt Germany.

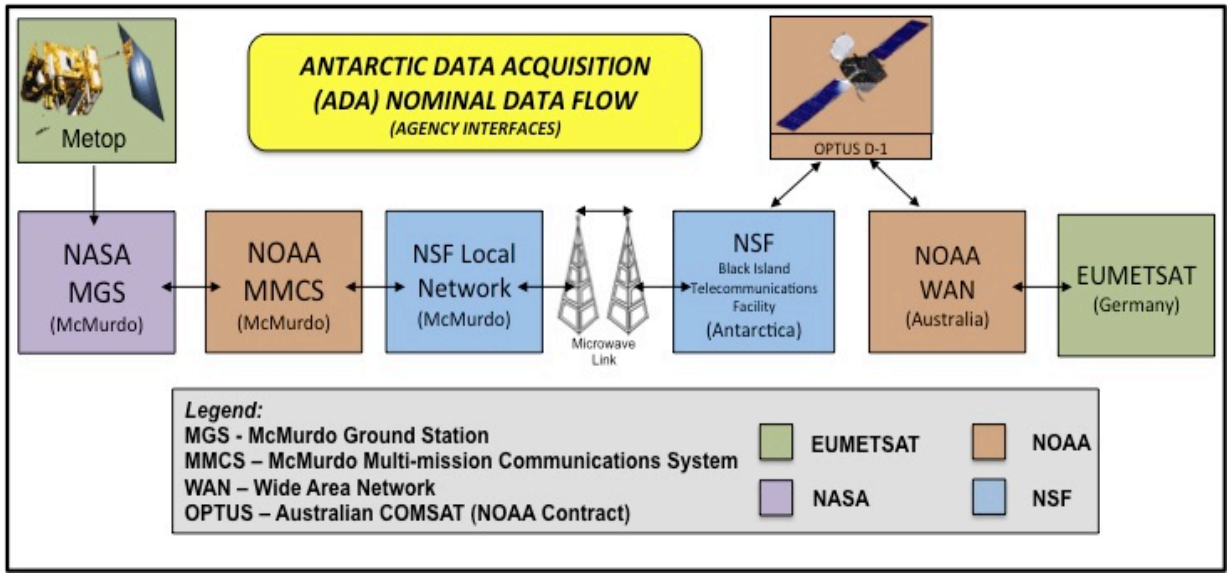

Figure 1. Antarctic Data Acquisition Nominal Data Flow with Agency Interfaces

Figure 2 depicts the flow of Metop data to EUMETSAT before the ADA and after the addition of the ADA. In addition to the nominal full orbit dumps of data over the northern polar station in Svalbard, the Metop satellite now dumps additional half orbits of data over the MGS in McMurdo. The data dumped over McMurdo is transmitted back to Darmstadt for real-time processing, and is transferred in parallel to NOAA in Suitland via the existing communications infrastructure. Receiving the half orbits of data from McMurdo avoids having to wait an extra 50 minutes to receive the same data from Svalbard, and is the key in halving the Metop data latency from 130 minutes to 65.

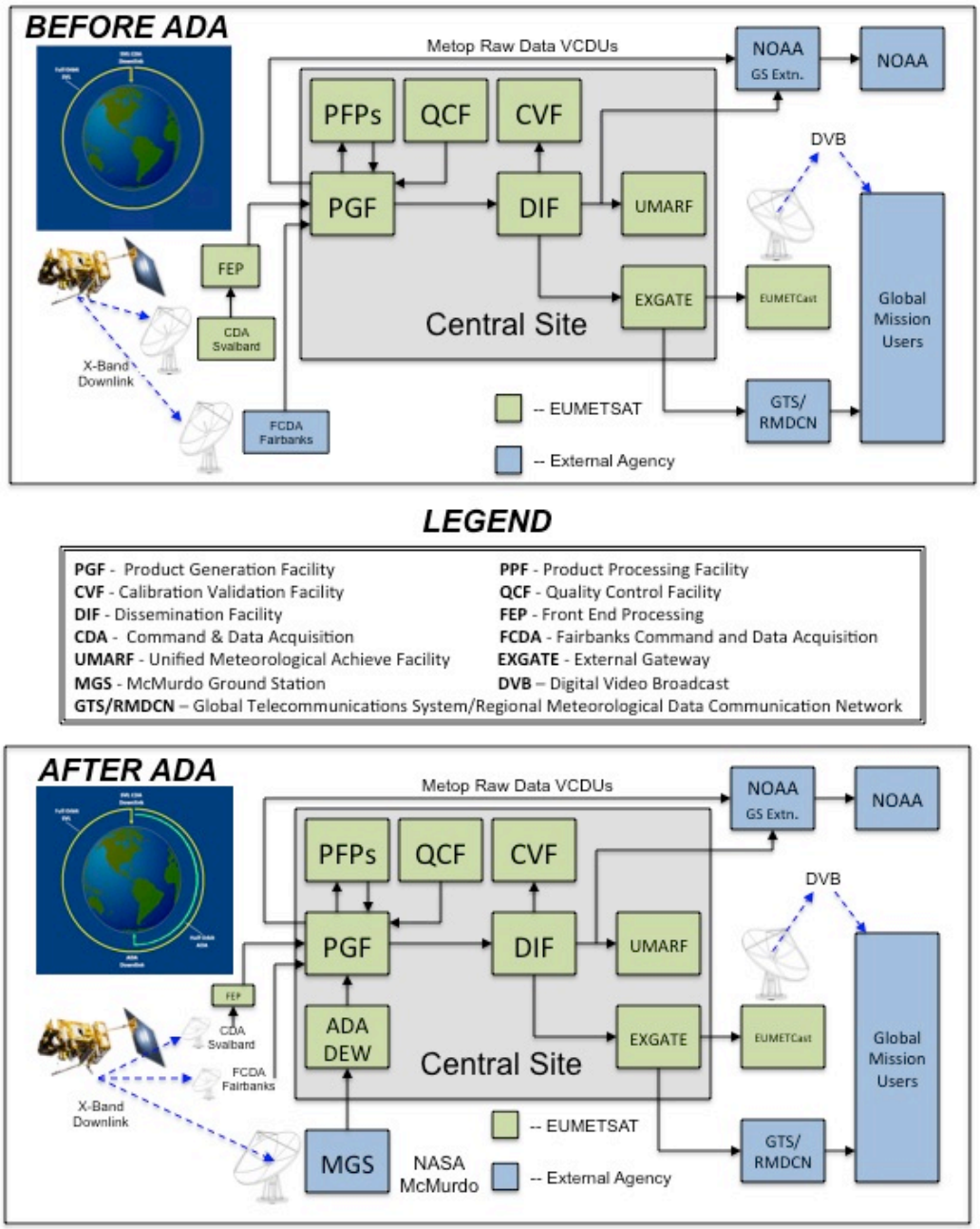

Figure 2. Before ADA and After ADA Diagram of Metop Data Flow

III. Who are the Stakeholders/Partners and what is their contribution?

The primary stakeholders in the Antarctic Data Acquisition project are EUMETSAT and NOAA. These Agencies formally partnered in 1998 when the Initial Joint Polar System (IJPS) collaboration was established. Under IJPS, NOAA and EUMETSAT agreed to provide and share meteorological data for "Mid-Morning" and "Afternoon" orbits by complementing each other's polar satellite global coverage.

In the early part of the 21st Century, NOAA was pursuing a new polar-orbiting satellite constellation in cooperation with the US Department of Defense and NASA. The US system, designated the National Polar-orbiting Operational Environmental Satellite System (NPOESS), was designed to fly in each of the early-morning, mid-morning, and afternoon orbits. The NPOESS Program encountered numerous developmental challenges and as a result, in 2006 the US Government decided to not deploy a satellite into the mid-morning orbit. This decision was made primarily because EUMETSAT was already providing data for the US from that orbital location via Metop-A under the IJPS partnership. The expectation was that data from Metop-B and Metop-C would continue to meet the US needs for the next 10-15 years. However, a nuance to the decision resulted in the retention of the US requirement for low data latency. To meet this latency requirement, NOAA looked to EUMETSAT to fulfill the data requirement and re-examine methods to achieve the latency requirement for the data. At the same time, EUMETSAT was investigating methods to improve the data latency of Metop and to address a technical issue with the direct broadcast downlink on Metop-A. After a series of meetings in mid-2006 and early 2007, NOAA and EUMETSAT agreed the most economical means to meet the both organization's goals for improved data latency from the mid-morning orbit was to expand NOAA's planned use of McMurdo Station, Antarctica. NOAA agreed to provide a satellite ground station capability and a Multi-Mission Communications System for acquiring Metop Global Data Sets (GDS) and transporting them to EUMETSATs Metop Control Centre. EUMETSAT agreed to modify the Metop system to downlink their GDS to the NOAA-provided resources at McMurdo Station and to combine processing of the McMurdo GDS stream with their existing GDS stream from Svalbard, Norway.

Through a series of incremental steps, NOAA and EUMETSAT expanded their partnership by first agreeing to begin work on ADA via an exchange of letters in 2007. The final terms were agreed to in 2009, and the formal agreement, known as the *Supplement to the Program Implementation Plan (PIP) for the Cooperation between the NOAA and EUMETSAT on Metop Data Downlink at McMurdo Station, Antarctica* was signed in 2011.

McMurdo station is the southern-most, largest, and most logistically capable of the national Antarctic operators collaborating in the Antarctic Treaty system that is within reach of conventional geosynchronous communications satellites. This is an ideal combination to maximize the objectives of low-latency data return held by NOAA and EUMETSAT. However, the commercial satellite industry does not consider Antarctica a market, and thus does not provide the kind of enhanced service offerings that would be needed to support the required data flow from McMurdo.

While NOAA was developing its data sharing relationship with EUMETSAT, NOAA was also collaborating with NSF for the implementation of two NPOESS receptor earth stations at McMurdo as an important component of the global NPOESS command/control/communications network. NSF is the executive agent for all US activities on the Antarctic continent, and in this role manages the United States' Antarctic Program (USAP), a critical function the NSF has carried out since 1970[7]. In its role as executive agent, the NSF provides logistics support, along with all infrastructure services to operate and maintain McMurdo Station. Additionally, the NSF is a key stakeholder in the NOAA-led partnership for communications services that link Antarctica to the other continents. The NSF in return provides local (on-ice) networking and microwave communications services from "downtown McMurdo" on Ross Island to the satellite uplink station the NSF operates on near-by Black Island to obtain unobstructed viewing of critical communications satellite orbit slots in the Asia-Pacific region.

NSF informed NOAA of a close working relationship that NSF had cultivated with the Australian satellite communications operator, Optus, while exploring the potential to re-purpose a legacy inclined-orbit Optus satellite

[7] President Nixon assigned NSF as the budgetary lead via National Security Decision Memorandum 71 (July, 1971), which has received continued authorization via subsequent Presidential administrations, most notably Presidential Memorandum 6646 issued by President Reagan (February, 1982). Prior to 1971, NSF was the lead Federal sponsor for U.S. scientific research programs in Antarctica dating back to the legendary International Geophysical Year of 1958/59, the precursor to the modern-day Antarctic Treaty system. The Nixon memorandum began the integration of the logistical operation and science program under NSF leadership.

for Antarctic communications (to the NSF Amundsen-Scott South Pole Station, located at 90°S). Optus had, at the time, a replenishment satellite for its operational fleet under construction by Orbital Sciences. NSF brokered an introduction between Optus and NOAA to explore the potential of modifying the new satellite's service plan/antenna beam pattern to incorporate service to McMurdo. A successful match was made, resulting in the reconfiguration of the Optus D1 satellite (and its later on-orbit backup, Optus D2) to project high-gain Ku-Band service to McMurdo. This provided the missing link needed to capitalize on McMurdo's unique southern high latitude.

Although NOAA operates and maintains several Command and Data Acquisition Stations (CDAS) in the United States and at Svalbard, Norway, NOAA did not operate or maintain a CDAS at McMurdo Station at the time NOAA signed the Supplemental PIP to add ADA. In order for NOAA to provide data acquisition and data transport services per the new Supplement PIP, NOAA needed to secure the assistance from two additional US Agencies with existing assets at McMurdo Station – NASA and the NSF.

Fortunately, NOAA had partnered with both NASA and the NSF prior to ADA, and the three agencies were able to build upon previous successful collaborative efforts to enable NOAA to meet its commitment to EUMETSAT.

Since the long lead times needed to deploy the necessary infrastructure at a remote location such as McMurdo precluded NOAA from independently procuring and installing a new X-band antenna system to support Metop, NOAA asked its long-time partner, NASA, to secure use of the 10-meter McMurdo Ground Station (MGS) to support Metop X-band data acquisition. In early 2008, NOAA and NASA began negotiations on an agreement for NASA to provide NOAA the ground station services necessary to meet NOAA's commitment to the ADA partnership. This agreement identified the major activities that NASA would undertake to meet a commitment to support the Metop series through Metop-C flyout. The long-term agreement was executed in 2011.

Early in 2008, NOAA reached out to its partner NSF for additional assistance. For NOAA and EUMETSAT to achieve ADA, NSF participation was essential. In order for NASA to complete the required modifications to the MGS, NASA was dependent on NSF support for cargo prioritization and on-ice civil works, including construction site preparation and heavy equipment operations.

Figure 3 shows an expanded view of each stakeholder's contributions to ADA.

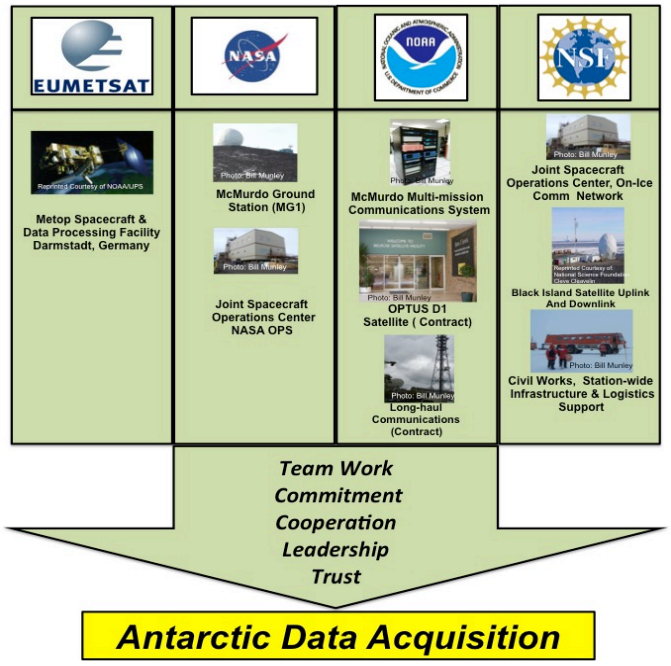

Figure 3. Interagency Cooperation and Participation

IV. Why were the partnerships successful?

The ADA capability was achieved by integrating organizationally independent components and leveraging existing capabilities both on- and off-ice in an unprecedented display of international cooperation. Figure 4 describes the attributes for the ADA success story.

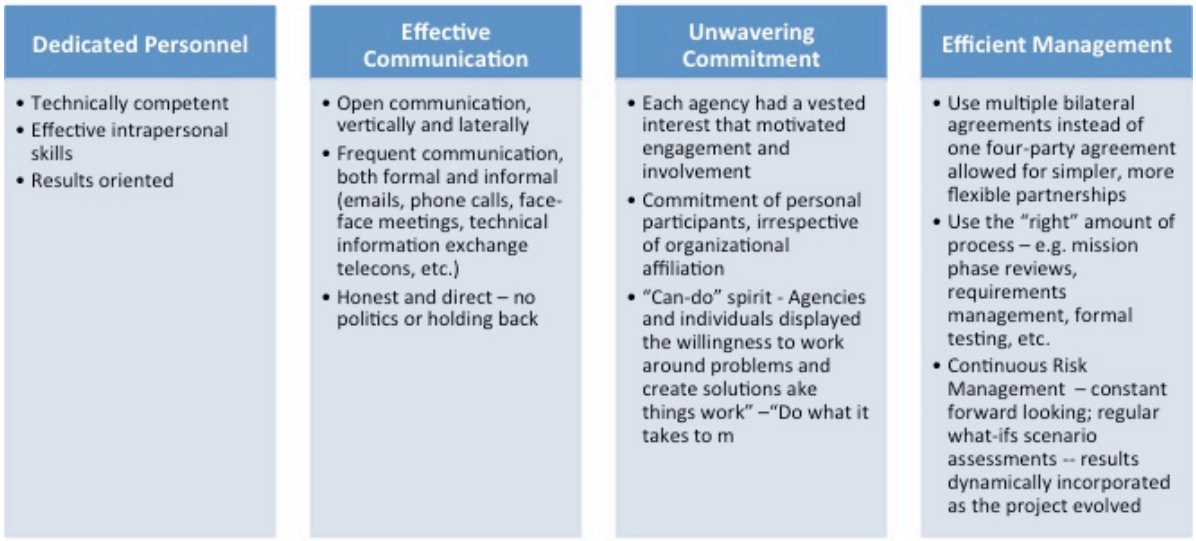

Figure 4. Partnership Attributes for ADA Success

To implement the ADA, NOAA and EUMETSAT utilized the framework of their existing relationship to the fullest extent possible. Then NOAA reached out to its partners, NASA and the NSF, and offered "win – win" scenarios for each of the stakeholders. In each of the bilateral agreements, the stakeholders took the time to establish clear, discrete roles, accountabilities, and authorities (RAAs) at the onset – in each agreement; roles were clarified, discussed, and agreed to before the partnerships were executed. Furthermore, these partnerships were founded upon open communication and information sharing in that although NOAA served as the linchpin for the cooperation, all four partners met regularly to ensure that each stakeholder understood their own RAAs as well as those of the other partners. Table 1 lists the Agency-Unique and Common Benefits the ADA Project provides to each stakeholder.

AGENCY	*UNIQUE BENEFITS*	*COMMON BENEFITS*
EUMETSAT	• Strengthened IJPS partnership- with NOAA • Minimal changes to Metop system	• Low cost solution for improving Metop data latency from 130 mins to 65 mins on average • Access to NOAA's McMurdo Multi-mission Communications System (MMCS)
NOAA	• Strengthened IJPS partnership- with EUMETSAT • Meets commitment via strategic partnerships with NSF and NASA • Gained cost-sharing partner for McMurdo Multi-mission Communications System (MMCS)	• Low cost solution for improving Metop data latency from 130 mins to 65 mins on average
NSF	• International recognition for McMurdo Station's role for high latitude space data acquisition as a conjugate to Svalbard in the Northern Hemisphere • Leveraging the NSF mission in Antarctica with NOAA and NASA missions to provide greater return on the U.S. national investment • Low overhead/simplified management for NSF (only 1 bilateral agreement needed – NSF-NASA for MGS hosting and logistical support • Infrastructure upgrades at McMurdo (MGS road access, local area network improvements, etc.)	• Improved forecasting and weather predictions for flight and search/rescue operations in Antarctica as a result of improved latency and local access to data • Affordable communications enhancements for NSF's science program via access to the McMurdo Multi-mission Communications System (MMCS)
NASA	• Gained Long-term customer for MGS • Refurbished aging antenna system and upgraded ground station electronics for MGS with remote operability and increased capability to support future NASA missions • Cost-sharing partner for MGS, upgrades, operations and maintenance • Infrastructure upgrades at McMurdo (MGS road access, local area network improvements, etc.)	• Affordable communications enhancements for NASA's space data ground network via access to the McMurdo Multi-mission Communications System (MMCS)

Table 1. Agency benefits of ADA

V. Conclusion

In the end, through leveraging existing partnerships, NOAA was able to meet its requirements to utilize Metop data in the mid-morning orbit and to reduce the latency to acquire the data. Each of the other partners also directly benefited from the ADA cooperation. EUMETSAT was able to cut delivery of its Metop data in half; NASA was able to upgrade its MGS and have a guaranteed long-term user of MGS; and NSF was able to increase the forecast accuracy of the South Pole as well as increase the volume of data able to go in and out of McMurdo. This significant new operational capability now provides Metop meteorological and environmental data to US and European weather services approximately twice as fast as they receive it at present by reducing the amount of time that meteorological sensor data stored on the satellite's on-board recorders must wait before being downlinked to the ground for processing.

Appendix A
Acronym List

ADA	Antarctic Data Acquisition
ADA DEW	Antarctic Data Acquisition DIF Extension Workstation
CDA	Command & Data Acquisition
CDAS	Command & Data Acquisition System
CVF	Calibration Validation Facility
DIF	Dissemination Facility
EUMETSAT	European Organisation for the Exploitation of Meteorological Services
EXGATE	External Gateway
FCDA	Fairbanks Command & Data Acquisition
FEP	Fronte End Processing
GDS	Global Data Set
GTS/RMDCN	Global Telecommunications System/Regional Meteorological Data Communications Network
IJPS	Initial Joint Polar System
Metop	Polar-orbiting Meteorological Satellite
MGS	McMurdo Ground Station
MMCS	McMurdo Multi-mission Communications System
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NSF	National Science Foundation
PGF	Product Generation Facility
PIP	Program Implementation Plan
PPF	Product Processing Facility
QCF	Quality Control Facility
RAA	Responsibilities, Authorities, and Accountabilities
UMARF	Unified Meteorological Archive Facility
US	United States
USAP	United States Antarctic Program