U.S. DEPARTMENT OF ENERGY | Office of Science

DOE/SC-ARM-13-022

Atmospheric Radiation Measurement (ARM) User Facility Management Plan

September 2020

ARM

DISCLAIMER

DOE/SC-ARM-13-022

Atmospheric Radiation Measurement (ARM) User Facility Management Plan

September 2020

Work supported by the U.S. Department of Energy,
Office of Science, Office of Biological and Environmental Research

Acronyms and Abbreviations

AACT	ARM-ASR Coordination Team
AAF	ARM Aerial Facility
ADC	ARM Data Center
ADO	Associate Director for Operations
AMF	ARM Mobile Facility
ANL	Argonne National Laboratory
ARM	Atmospheric Radiation Measurement
ARS	Access Request System
ASR	Atmospheric System Research
ASST	Architecture and Services Strategy Team
CL850	Challenger 850
CPMSG	Cloud and Precipitation Measurement and Science Group
DOE	U.S. Department of Energy
DQM	Data Quality Manager
EESD	Environmental and Earth System Science Division
ENA	Eastern North Atlantic
G-1	Gulfstream 159
HPSS	High-Performance Storage System
IMB	Infrastructure Management Board
LASSO	Large-Eddy Simulation (LES) ARM symbiotic Simulation and Observation
LES	large-eddy simulation
netCDF	Network Common Data Form
NSA	North Slope of Alaska
OMB	Office of Management and Budget
ORNL	Oak Ridge National Laboratory
OSS	Operations Status System
PI	Principal Investigator
PNNL	Pacific Northwest National Laboratory
SGP	Southern Great Plains
TBS	tethered balloon systems
TWP	Tropical Western Pacific
UAS	unmanned aerial systems
UEC	User Executive Committee
USGCRP	U.S. Global Change Research Program
VAP	value-added product

Contents

Figures

1.0 Mission and Vision

Mission and Vision Statements for the U.S. Department of Energy (DOE)'s Atmospheric Radiation Measurement (ARM) user facility

Mission

The ARM user facility, a DOE scientific user facility, provides the climate research community with strategically located in situ and remote-sensing observatories designed to improve the understanding and representation, in climate and earth system models, of clouds and aerosols as well as their interactions and coupling with the Earth's surface.

Vision

To provide a detailed and accurate description of the Earth's atmosphere in diverse climate regimes in order to resolve uncertainties in climate and earth system models toward the development of sustainable solutions for the nation's energy and environmental challenges.

2.0 Introduction

ARM is a DOE Office of Science user facility. ARM was created in 1989 to provide an observational basis to improve the understanding of cloud processes and their interaction with radiation and aerosols and to improve the representation of these processes in earth system models and numerical weather prediction models (Stokes and Schwarz 1994). These goals continue to reflect ARM's current mission (Mather and Voyles 2013).

ARM began collecting measurements in 1992 at its longest-operating observatory in Oklahoma. Today, the ARM facility provides measurements of atmospheric properties and properties of the underlying land surface through the continuous operation of approximately 400 ground-based instruments. These instruments are distributed across three fixed-location atmospheric observatories and three mobile facilities that have been deployed to diverse locations ranging from the Arctic to the tropics to Antarctica. The ARM facility also includes aerial platforms that are typically used to augment measurements from the ground-based observatories. The ARM mobile facilities and aerial platforms are deployed on a proposal-driven basis. Data from ARM instruments are automatically collected and transferred to the ARM Data Center where they are processed, archived, and made openly available to the research community through a sophisticated data discovery portal.

This collection of measurement capabilities and supporting data infrastructure represents a unique set of capabilities that enable high-impact science aligned with the DOE Environmental and Earth System Science Division (EESSD) as well as with the science interests of the broader atmospheric research community. ARM measurements contribute to a wide range of interdisciplinary science in areas such as meteorology, atmospheric aerosols, cloud processes, radiation, hydrology, and biogeochemical cycling and are used for satellite validation and the validation and development of atmospheric processes in earth system models. To facilitate the application of ARM data to earth system models, ARM has developed the Large-Eddy Simulation (LES) ARM Symbiotic Simulation and Observation (LASSO) framework, which combines high-resolution model simulations with ARM observations. ARM has also developed a

wide array of value-added data products, which aid in the application of ARM measurements by providing derived higher-order parameters, sophisticated quality assessment, and merging of parameters across multiple instruments.

The ARM facility is managed and operated by nine DOE laboratories. ARM staff at these laboratories are responsible for day-to-day operations of the ground-based and aerial ARM observatories, engagement with the user community, and the ongoing development of new measurements, data products, and data management capabilities. This document provides a brief description of the components of the ARM facility and the ARM management structure. Additional information can be found at the ARM website (www.arm.gov) and in a monograph that describes many aspects of ARM's first 20 years (Turner and Ellingson 2017).

3.0 Oversight and Reporting Requirements

Oversight of the ARM facility is provided by the DOE/ARM Program Managers within the DOE Office of Biological and Environmental Research. Through that office, a review panel of scientists, engineers, and program managers are selected to review the structure, interactions, and overall performance of the facility. This review is nominally chartered on a 3-year cycle.

As a matter of government policy, all DOE user facilities, including ARM, have a number of reporting requirements. ARM is required to report to the DOE ARM Program Manager where accountabilities are established by DOE's Office of Biological and Environmental Research, and to the White House Office of Management and Budget (OMB). A primary requirement for ARM is the documentation of unique science users. Scientific users of the ARM facility are categorized as onsite, remote, or data users depending on how they make use of ARM resources for their scientific research.

4.0 Atmospheric Observatories

ARM operates long-term, fixed-location observatories in three different climatic regimes: (1) Southern Great Plains (SGP), (2) North Slope of Alaska (NSA), and (3) Eastern North Atlantic (ENA). Respectively, these sites address a range of climatic conditions: (1) variable midlatitude climate conditions, (2) land and land-sea-ice arctic climate, and (3) marine stratocumulus. In addition, two ARM Mobile Facilities (AMF1 and AMF2) are deployed for short-term field campaigns (approximately 1 year) at sites around the world. AMF2 is designed for deployments in a marine environment. A third mobile facility (AMF3) is currently deployed for an extended period at Oliktok, Alaska. The AMF3 is slated to end operations at Oliktok in 2021 in preparation for relocation to the southeastern United States, where it will begin operating in its new location in 2023. Between 1996 and 2014, ARM operated instruments at three sites in the Tropical Western Pacific (TWP). While these sites no longer operate, their data are available at the ARM Data Center. In addition, ARM includes aerial measurement capabilities that are typically deployed to augment the ground-based observatories. ARM is currently in transition between piloted aerial platforms. The Gulfstream 159 (G-1) aircraft, was retired at the end of 2018 and a Challenger 850 (CL850) regional jet was purchased in 2019. The CL850 is expected to be ready for research operations in 2023. The locations of the ARM fixed-location observatories along with mobile and aerial facility deployments are shown in Figure 1. The characteristics of the ARM observatories are summarized below.

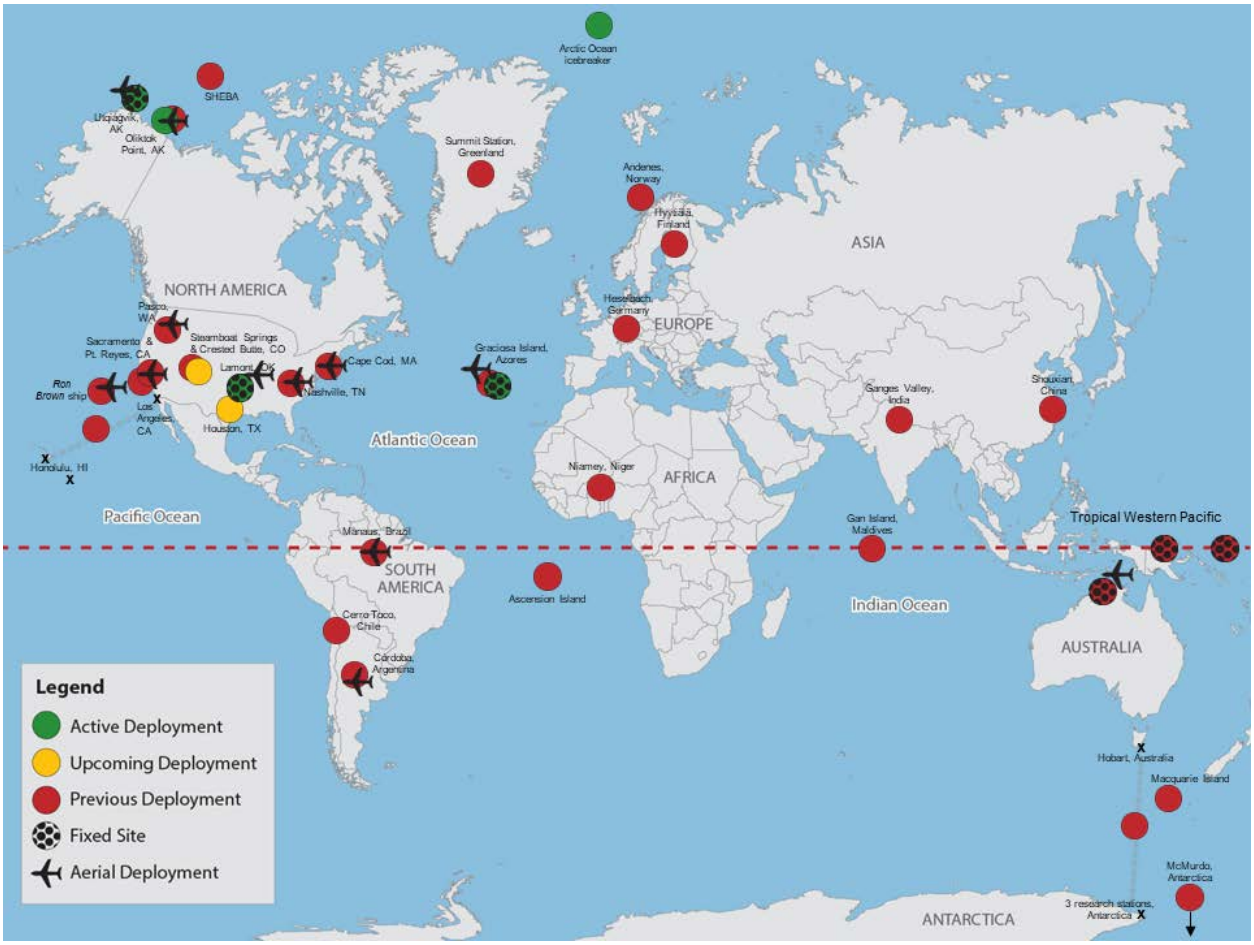

Figure 1. Locations of ARM fixed sites and mobile facility deployments.

Each ARM observatory includes an extensive set of instruments that provide measurements of the surface energy balance and the atmospheric properties that impact that balance, with a particular emphasis on cloud and aerosol measurements. A list of core instruments that is provided at each of the ARM fixed-location observatories and with most mobile facility deployments is provided below.

- Surface meteorological sensors (T/RH/wind)
- Balloon-borne sounding system
- Weighing gauge and tipping bucket precipitation sensors
- Broadband solar and terrestrial infrared radiometers (up- and down-looking)
- Microwave radiometer; 2-channel (23/31 GHz) or 3-channel (23/31/90 GHz)
- Atmospheric emitted radiance interferometer (infrared spectral radiances)
- Total sky imager
- In situ aerosol sensors including condensation particle counter and nephelometer
- Ceilometer (range of ~7km)
- Micropulse lidar (dual-polarization, backscatter-only)

- Doppler lidar
- 35 GHz profiling cloud radar
- 915 GHz or 1290 GHz radar wind profiler.

Details on the specific nature of these and additional site-specific instrumentation can be found on the ARM website at http://www.arm.gov/instruments/. The ARM instruments page also includes information about instruments deployed on the ARM aerial platforms. These include an extensive array of in situ probes for observing cloud and aerosol properties along with the atmospheric state.

4.1 Southern Great Plains

The SGP observatory is managed by Argonne National Laboratory and consists of in situ and remote-sensing instrument clusters arrayed across north-central Oklahoma and south-central Kansas. The ARM SGP site is the largest and most extensive climate research field site in the world. The site includes a Central Facility with extensive instrumentation for studying clouds, aerosols, precipitation, and their interaction with the surface energy balance. The site also includes a network of ancillary sites that provide spatial information about surface properties, the surface energy balance, boundary-layer structure, and hydrometeor distributions.

https://www.arm.gov/capabilities/observatories/sgp

Because the SGP site contains one of the largest collections of ground-based remote sensors and continuous measurements for atmospheric research in the world, it is an ideal and popular site for field campaigns, which range from hosting individual guest instruments to major collaborative field projects. Since 2015, measurements at the SGP site have been augmented with large eddy simulation (LES) model runs targeting shallow convection. These LES runs are coupled with ARM observations with automated diagnostics and facilitate the application of ARM observations to global-scale model evaluation and development.

4.2 North Slope of Alaska

The NSA site is managed by Sandia National Laboratories and provides data about cloud and radiative processes at high latitudes. Routinely operating instruments include millimeter-wavelength cloud radar, micropulse lidar, a number of radiometers, and other instruments for atmospheric profiling and measurements of surface meteorology (https://www.arm.gov/capabilities/observatories/nsa). Data from these instruments are being used to understand cloud processes in the Arctic and to refine models and parameterizations as they relate to arctic climate. The site consists of a facility at Utqiagvik, Alaska, which includes a subset of the instruments available at the SGP Central Facility.

The NSA site provides a test bed for studies of climate change at high latitudes. In this region, ice (including snow) is the predominant form of condensed water most of the year, both in the air and on the surface. Ice and snow scatter, transmit, and absorb sunlight and radiant heat much differently than water. There is very little water vapor in the atmosphere, changing the impact of the atmosphere on the propagation of radiant energy, particularly radiant energy propagating upwards from the surface, and on the performance of some atmospheric remote-sensing instruments. The major "pumps" for the global

ocean currents are at high latitudes, and there is good reason to believe that those pumps will be affected by climate-related changes in the atmosphere. High-latitude atmospheric processes over both land and sea must be characterized for incorporation into global climate models.

4.3 Eastern North Atlantic

The ENA site is located on Graciosa Island in the Azores archipelago (Portugal) and is managed by Los Alamos National Laboratory. The Azores is located in the northeastern Atlantic Ocean, a region characterized by marine stratocumulus clouds. Response of these low clouds to changes in atmospheric greenhouse gases and aerosols is a major source of uncertainty in global climate models. The ENA fixed-site facility is located near the site of a previous ARM mobile facility deployment. The previous Azores deployment lasted approximately 20 months beginning in May 2009 and illustrated the scientific importance of measurements in this region (https://www.arm.gov/capabilities/observatories/ena).

4.4 ARM Mobile Facilities

The ARM mobile facilities (AMFs) were created to explore science questions beyond those addressed by ARM's current fixed sites. With instrumentation and data systems similar to the fixed sites, the AMFs are deployed to locations around the world for campaigns lasting 6 to 24 months. They are designed to operate in any environment, from the cold of the poles to the heat of the tropics. The AMF1 and AMF2 are deployed on a proposal-driven basis with proposal calls open to the general science community. Proposed deployment sites are logistically reviewed by the ARM Infrastructure Management Board (see section 6.2) and scientifically peer reviewed by the ARM Science Board.

The first ARM Mobile Facility (AMF1) was initially developed in 2005 and has been deployed to Point Reyes, California; Niamey, Niger; Heselbach, Germany; Shouxian, China; the Azores, Portugal; Nainital, India; Cape Cod, Massachusetts; Manacaparu, Brazil; Ascension Island; Cordoba, Argentina; and Andenes, Norway. The AMF2 has similar capabilities to the AMF1 but was designed to be more modular with a specific objective of being deployable in difficult environments, including onboard ships. The second ARM Mobile Facility (AMF2) was first deployed in 2010 to the Storm Peak Laboratory near Steamboat Springs, Colorado and has subsequently been deployed to the island nation of the Maldives; on the cargo vessel, *Spirit*, operating between Los Angeles and Hawaii; on the NOAA Research Vessel *Ron Brown*; McMurdo Station, Antarctica; on the Australian Antarctic supply ship *Aurora Australis* in the Southern Ocean; and on the German icebreaker *Polarstern* for a year-long deployment in the Arctic Ocean. AMF1 and AMF2 are managed by Los Alamos National Laboratory.

A third ARM Mobile Facility (AMF3) is managed by Sandia National Laboratories and is intended for intermediate-length deployments of approximately five years. The AMF3 was originally deployed at Oliktok, on the North Slope of Alaska, approximately 300 km southeast of Utqiagvik, in 2013. At Oliktok, the AMF3 has provided arctic measurements in a region that experiences higher-than-normal levels of aerosols due to the adjacent Prudhoe Bay oil fields and has enabled development of Unmanned Aerial Systems (UAS) and Tethered Balloon Systems (TBS) capabilities because DOE manages a region of restricted air space over Oliktok as well as an adjacent warning area. In keeping with the mission of intermediate-length deployments for the AMF3, the observatory will end operations at Oliktok in the spring of 2021 and then will be relocated to the southeastern United States where it is expected to begin operations in 2023. The selection of the new location was made by DOE management based on science

priorities and a 2018 workshop (U.S. Department of Energy 2019). An AMF3 southeastern U.S. science team was selected based on peer-reviewed proposals to develop a science plan for the new AMF3 deployment and provide scientific guidance to ARM on site selection, site layout, and instrumentation needs to address science questions.

4.5 ARM Aerial Facility and Tethered Balloon Operations

As an integral measurement capability of the ARM Facility, the ARM Aerial Facility (AAF), including piloted aircraft and fixed-wing UAS, is managed by Pacific Northwest National Laboratory (PNNL) and provides airborne measurements required to answer science questions proposed by the Atmospheric System Research (ASR) Science Team and the external research community. A G-1 aircraft served as the primary aerial platform for the AAF from 2010 through 2018. During that time, the G-1 flew missions in the United States, Brazil, Portugal, and Argentina. The G-1 was retired at the end of 2018 and a Challenger 850 regional jet has been procured to replace the G-1 as the primary ARM aerial platform. The Challenger 850 will be undergoing modifications, equipment integration, and testing over the next several years and is expected to be ready for research flights in early 2023.

ARM is developing unmanned aerial system (UAS) capabilities to gather in situ atmospheric measurements on a more routine basis than is possible from a piloted aircraft. ARM has collected measurements from small UAS and is currently testing a midsize UAS that will provide greatly expanded capabilities in terms of payload, elevation, and endurance.

The ARM facility also includes a TBS that is managed and operated by Sandia National Laboratories. The TBS provides an efficient and effective mechanism to obtain vertical profiles of atmospheric state, aerosol, and cloud properties over an ARM site. To date the TBS has been operated at Oliktok and the Southern Great Plains but plans are underway to deploy the TBS at other locations including mobile facility sites in the coming years.

Both the AAF platforms and the TBS are deployed on a proposal-driven basis. Each platform is typically also able to include a small number of guest instruments. Data obtained from aerial platforms are documented, checked for quality, integrated into the ARM Data Center, and made available in a timely and consistent manner for use by the scientific community.

5.0 Data Services

ARM Data Services are managed by Oak Ridge National Laboratory (ORNL) and provide facility-wide leadership, management, and operations of end-to-end data management in order to make data collected at ARM facilities available and accessible. Data Services staff at Oak Ridge are supported by software developers across the ARM facility. ARM data are processed to a standard Network Common Data Form (NetCDF) format and are available to anyone. Many ARM data products are available to the science community within about a day of collection at field sites. The following functional groups ensure that ARM data processes stay current with modern computational technologies and best practices in earth system data management.

The Site Data Systems team is responsible for the deployment, sustainability, operations, and maintenance of a high-performance, secure, computing and communications environment that bridges

measurement collections from instruments to the ARM Data Center (ADC). The site data system also provides onsite processing and early access to preliminary data plots and metrics for special deployments and field campaigns.

The data flow software team is responsible for software and tool development that supports data flow and data flow monitoring, which includes collections, site transfer, and tools.

The ADC team provides overall cyberinfrastructure and the data processing environment for ARM infrastructure and science users. The ADC team also provides data processing and analytical platforms for research users.

The ADC data ingest and processing team is responsible for the timely collection, processing, value-added processing, and delivery of data products from ARM research sites to the ADC. These operations and engineering activities are closely coordinated with the ADC archival team and Site Data Systems team to optimize data transfer and storage rules, data collection metrics, and overall processing performance.

The ADC archival team validates and verifies data released by the ADC data ingest team. After the data are validated, they are sent to deep archive within the ORNL High-Performance Storage System (HPSS). A backup copy is also sent to Argonne National Laboratory (ANL) HPSS to preserve the archive in case of a catastrophic event. A subset of the data is available on spinning disk for quick access and distribution to end users.

The data reprocessing team is responsible for timely and accurate data product reprocessing to resolve data quality issues, automation of reprocessing workflow, and effective use of ARM high-performance computing resources for large reprocessing tasks.

The metadata workflow and field campaign data management team manages metadata operations for baseline, value-added product (VAP), principal investigator (PI), evaluation, and field campaign data products. The metadata team is responsible for developing tasks, milestones, and priorities associated with metadata workflow and standards across ARM processes and data products.

The database and workflow design team provides technical leadership in the design and implementation of database development that improves functionality of ARM databases across ARM processes and data products. This includes mitigating redundancies and improving efficiencies in the metadata workflow. The ADC database development team works with cross-laboratory development teams to understand database needs including ingests and value-added products, website, user services, data discovery, data quality, asset management, site operations, field campaigns, and staff and user information.

The instrument management, data, and metadata tools team develops and operates user web tools related to generation of metadata, metadata management, user registration, operations system status, access requests, data citation, data quality and corrective maintenance reporting tools, and data discovery and retrieval.

The ARM Data Services − systems and hardware team is responsible for operations and maintenance of ADC hardware, network configuration, deployment of software packages, license management, user account management, adhering to DOE cybersecurity policies and procedures, evaluation and adaptation

to new storage, computing, network, and software solutions, providing system admin support to data product generation teams and data services teams, interfacing with the site data systems team to support end-to-end data flow and monitoring, interfacing with the Oak Ridge high-performance computing and information technology groups for administration and operations of ARM clusters, and interfacing with Argonne's high-performance storage systems group for offsite backup.

The ADC compute clusters team is responsible for the design, implementation, and operation of the ARM Next-Generation Computing facility, support development, optimization and porting of ARM computational workflows to a high-performance computing environment, and providing operational support to ARM high-performance computing projects such as the LASSO framework.

6.0 Management Structure

The ARM management structure is designed to provide representation of the diverse facility components and representation of the user community (see Figure 2). Components of the facility are managed and operated by nine DOE national laboratories: Argonne, Brookhaven, Lawrence Berkeley, Lawrence Livermore, Los Alamos, National Renewable Energy, Oak Ridge, Pacific Northwest, and Sandia. The facility components are managed on a day-to-day basis by the Infrastructure Management Board, with oversight by the ARM DOE Program Managers. The ARM facility serves the broad international climate research community; however, there is a particularly close link between ARM and the DOE ASR program.

6.1 DOE ARM Program Manager

The DOE Program Manager directs and empowers the ARM budgeting, planning, coordination, and management of activities within the ARM structure.

6.2 Infrastructure Management Board

The Infrastructure Management Board (IMB) consists of the Technical Director, Associate Director for Operations, the Engineering and Process Manager, Data Services Manager, Instrument Operations Manager, Aerial Facility Manager, and the Site Managers for each of the ARM observatories. These positions are described below. The members of the IMB are responsible to DOE management for their respective ARM facility components and serve as the primary points of contact for their respective areas. The IMB meets with the DOE Program Managers (usually via teleconference) on a weekly basis to discuss a broad range of matters pertaining to the management of the ARM facility. The IMB is responsible for the overall ARM budget that is proposed to the DOE Program Managers for review and approval. The IMB assesses the impacts of all requests for use of the ARM facility and screens science requests for such use prior to consideration by the Science Board. It also provides information regarding the feasibility, cost, and facility impact associated with each request. The IMB works with DOE management on strategic planning using input from the user community as guidance for how to best configure the facility to serve research needs.

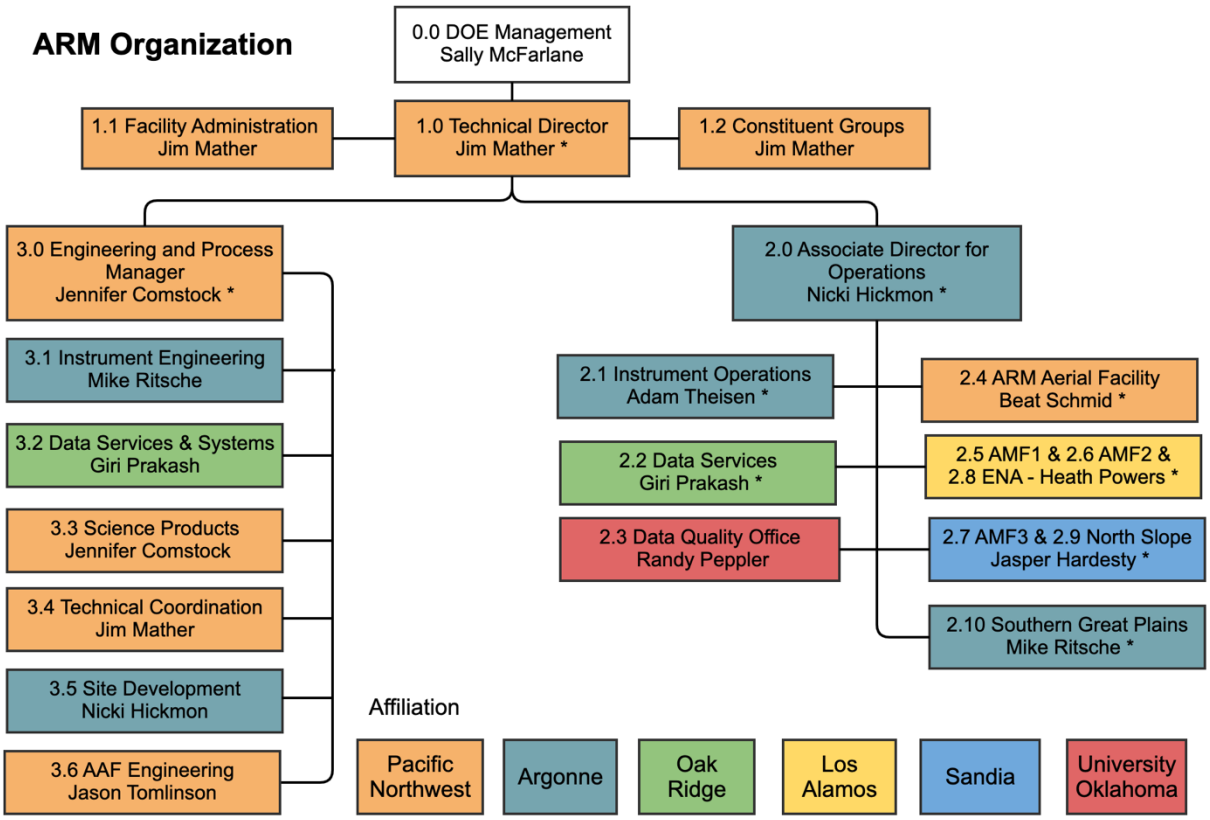

Figure 2. ARM user facility management structure. Asterisks (*) represent roles that are members of the Infrastructure Management Board. Box colors indicate institution affiliation.

6.2.1 Technical Director

The Technical Director is the chair of the IMB, reports directly to the ARM Program Manager, and is responsible for ARM day-to-day technical activities, strategic planning, budgeting, engineering development, contracting, property management, and interactions with the science community. The Technical Director provides scientific leadership and is responsible for leading the development of the ARM vision and the strategy to achieve that vision. This office oversees the implementation of user requirements with the Associate Director Operations for the operation and enhancement of the facility. The Technical Director coordinates with the Engineering and Process Manager for the implementation of engineering services required for the operation and enhancement of the facility. Responses to review committees are coordinated through this office, as well as working with the DOE Program Manager to coordinate, plan, and implement communications with the science community, and ensuring DOE user facility policies and reporting requirements are followed. To develop and advance the ARM vision, the Technical Director oversees the ARM User Executive Committee, participates on the AACT, and engages with the user community through a variety of forums. The Technical Director is the primary point of contact for ARM.

6.2.2 Associate Director for Operations

The ARM Associate Director for Operations (ADO) is responsible for ensuring efficient, effective, and continuous operation of instruments and data systems. The ADO reports to the ARM Technical Director. The ADO is responsible for coordinating the overall field campaign screening process within the IMB and for resolving user issues that might arise regarding external science projects conducted at the ARM facility. The ADO serves as the communication link between the ARM IMB and the ARM Science Board. The ADO works with the Technical Director to promote the use of the ARM facility by the external scientific community. The ADO will work with the Technical Director to develop and implement the facility operational strategy. While the Facility Operations Managers report directly to the ARM Technical Director and are responsible for the operation of their facilities, the ADO is empowered and authorized to provide oversight to operational activities to ensure that the facilities are operated consistently and appropriately to serve the ARM user community and that field operations are conducted in accordance with applicable safety and security policies.

6.2.3 Engineering and Process Manager

The Engineering and Process Manager is responsible for the oversight of all ARM engineering tasks. The Engineering and Process Manager reports directly to the Technical Director and is responsible for developing priorities within and across the engineering areas and communicating priorities to each of the engineering area leads. The Engineering and Process Manager is responsible for tracking the progress of engineering tasks and communicating progress to the Technical Director. She/he works with the leaders of each of the engineering areas to establish and track performance metrics that measure progress of tasks toward goals and provide a mechanism to feed improvements back into the engineering system. The Engineering and Process Manager also works to define and refine engineering workflows for the facility and assure that the fundamentals of the engineering process are consistently applied across ARM.

6.2.4 Data Services and Operations Manager

The Data Service and Operations Manager provides management and leadership for the ARM computing environment, product delivery, facility user account database, and process and science user interaction. This includes the end-to-end definition and operational execution of collection, processing, and delivery of quality-assured measurement data products from our research sites to the ARM Data Center and discovery and distribution to the scientific user community.

The Data Service and Operations Manager leads the Architecture and Services Strategy Team (ASST; see section 7.2).

6.2.5 Aerial Facility Manager

The ARM Aerial Facility (AAF) Manager is responsible for the safe and effective operation of aerial measurements, including manned and unmanned fixed-wing aircraft and associated measurement systems, as well as coordination with ARM management, ASR science, and the general science community to define and adapt aerial measurement strategies for approved field campaigns and the Next-Generation ARM concept. Responsibilities also include the timely processing, quality assessment, and delivery of aerial measurements data to the science community.

6.2.6 ENA, AMF1, and AMF2 Site Manager

The Eastern North Atlantic (ENA), ARM Mobile Facility (AMF1, and AMF2) Site Manager is responsible for the safe and effective management of the ENA, AMF1, and AMF2 research facility assets. This includes the instrumentation, data systems, facilities, and personnel, as well as the ground-based and aerial support for ARM field campaign activities. An important responsibility is the cooperative relationship with local and regional stakeholders.

6.2.7 NSA and AMF3 Site Manager

The North Slope of Alaska (NSA) Site Manager is responsible for the safe and effective management of the Utqiagvik and AMF3 research facilities. This includes the instrumentation, data systems, facilities, and personnel, as well as the ground-based and aerial support for field campaign activities. An important responsibility is the cooperative relationship with local and regional stakeholders.

6.2.8 SGP Site Manager

The Southern Great Plains (SGP) Site Manager is responsible for the safe and effective management of the SGP research facility and assets. This includes instrumentation, data systems, facilities, and personnel, as well as the ground-based and aerial support for field campaign activities. An important responsibility is the cooperative relationship with local and regional stakeholders.

6.2.9 Instrument Operations Manager

The Instrument Operations Manager is responsible for the effective planning and mentorship of ARM instrumentation. Such efforts include management of mentorship activities, development of the ARM instrument plan, coordination of new instruments with engineering, and effective tracking of instrument information.

6.3 IMB Support

This section describes a variety of support roles that facilitate the work of the IMB.

6.3.1 Technical Administrator

The ARM Technical Administrator has a variety of responsibilities associated with the operation of the ARM Technical Coordination Office. The Technical Administrator manages communications through the Technical Coordination Office including the management of group affiliations and email lists within ARM's People Database, delivering ARM e-newsletters and other facility messages, and management of the ARM mail moderator. The Technical Administrator is also responsible for maintaining facility records in the PNNL electronic records database and managing travel and other logistics for members of the Technical Coordination Office. The Technical Administrator reports to the Technical Director.

6.3.2 Field Campaign Administrator

The ARM Field Campaign Administrator is responsible for coordinating the overall field campaign screening process within the IMB. This is the communication link between ARM and the PI and the IMB and the Science Board. The ARM Field Campaign Administration works with the IMB to promote the use of the ARM facility by the external scientific community and to resolve user issues that might arise regarding external science projects conducted at ARM. The Field Campaign Administrator reports to the Associate Director for Operations.

6.3.3 Financial Coordinator

The Financial Coordinator maintains the integrated budget, develops and maintains routine and special financial reports, and manages funding flow for ARM sub-contracts. The Financial Coordinator reports to the Technical Director.

6.3.4 Contracting and Procurements Manager

The Contracting and Procurements Manager is responsible for managing the contracting process for procurements and service contracts that are placed through the ARM technical coordination office. These include all capital procurements, instruments, and computers outside the ARM Data Center. They also include a variety of service contracts including inter-laboratory contracts. Responsibilities include maintaining regular contact with PNNL contracting staff to ensure continued progress on contracts from the request for proposals through to contract close-out, maintaining tracking documentation for contracting actions, and working with the Technical Director and the IMB to ensure consistency between the integrated budget and contracting actions. The Contracting and Procurements Manager reports to the Technical Director.

6.3.5 Property Manager

The Property Manager is responsible for tagging new equipment as it comes into the ARM facility and maintaining records for ARM property in the PNNL property database and the ARM Operations Status System (OSS). The Property Manager coordinates with mentors and staff at the observation facilities to ensure that property information in OSS is up to date. The Property Manager reports to the Technical Director.

6.4 ARM-ASR Coordination Team (AACT)

As a user facility, ARM serves the broad climate research community. However, ARM has a particularly close relationship with the ASR program, a sister organization within the DOE Office of Science, Office of Biological and Environmental Research (http://science.energy.gov/ber/research/cesd/). The ASR program supports basic research related to clouds, aerosols, and precipitation interactions based on observations from the ARM user facility, laboratory experiments, and process modeling (http://asr.science.energy.gov).

DOE has established the AACT, which includes members from ARM and ASR leadership, to foster communication between ARM leadership and users, ASR scientists, and DOE program managers:

(https://www.arm.gov/connect-with-arm/organization/aact)

A key role of the AACT is to help plan the annual Joint ARM User Facility/ASR Principal Investigator Meeting.

7.0 Additional ARM Facility Roles

The ARM user facility spans the full range of activities associated with atmospheric observations from the operation of instruments at field sites to the distribution of processed data. Functions associated with the ARM facility are carried out at nine DOE laboratories and a variety of collaborating institutions. The high-level organization was summarized in Figure 2. There are too many roles to describe in this document; however, a subset of roles that are particularly important for engagement with external stakeholders are described in this section. These roles are organized into four main areas:

- DOE management and groups reporting directly to DOE
- Technical coordination
- Operations
- Engineering.

The distinction between Engineering and Operations can sometimes seem blurred because often the same people are involved. However, the basic distinction between these areas is simply that Operations relates to the day-to-day activities associated with existing capabilities while Engineering involves developing new capabilities.

7.1 Instrument Mentors

ARM currently operates more than 400 instrument systems that provide ground-based observations of the atmospheric column. To keep ARM at the forefront of climate observations, the ARM infrastructure depends heavily on instrument scientists and engineers, also known as instrument mentors. Lead mentors must have an excellent working knowledge of their instrument systems as well as an understanding of instrument applications to studying relevant processes to ensure research-quality instrument performance. Instrument mentors report to the Instrument Operations Manager.

http://www.arm.gov/instruments/contacts

7.2 Architecture and Services Strategy Team

The Architecture and Services Strategy Team (ASST) provides facility-wide vision, strategy, and leadership for the ARM computing environment to provide a flexible and extensible computing architecture and resources for high volume, high processing rates, and complex relationships between data elements.

The ARM software development and operations team is distributed across all nine DOE laboratories associated with the ARM facility. The ASST is responsible for representation of and communication with the software development and operations team members. The ARM ASST Manager is tasked to effectively coordinate the participation and contributions of ASST.

7.3 Data Quality Office

The Data Quality Manager (DQM) and staff, making up the Data Quality Office, provide overall guidance and management of a program to assure that the data collected at ARM sites meet the data quality objectives and tolerances as defined by the science user community and ARM and make estimates of that assurance publicly available (http://www.arm.gov/data/quality).

7.4 Translators

The ARM science translators are liaisons between the ARM science community and ARM infrastructure and are responsible for understanding community needs related to value-added products. The primary responsibility of the translators is to work with scientists and software developers to implement scientific algorithms to create robust data products that can be applied to ARM data on a routine basis. ARM translators develop project plans that follow the VAP workflow, use ARM standards for each data development project, are required to host design reviews, and report progress to the lead translator. Translators report to the Engineering and Process Manager.

8.0 Constituent Groups

Beginning with the radar science and operations group in 2012, several groups have been formed over the past few years for the purpose of facilitating communications between ARM and the ARM user community. Three of these groups are focused on particular measurement areas (clouds and precipitation and aerosol) while the User Executive Committee includes representation that is intended to span the range of science user areas of interest. In each case, the group reports to the ARM Technical Director with the expectation of providing feedback to improve the ARM facility and its service to the user community.

8.1 User Executive Committee

The User Executive Committee (UEC or Committee) is an independent body charged with providing objective, timely advice and recommendations to the leadership of the ARM facility with respect to the user experience. The Committee reports directly to the Technical Director in his/her capacity as chair of the ARM Infrastructure Management Board (IMB) and serves as the official voice of the user community in its interactions with ARM management. The charter cited here (see link above) defines the membership, responsibilities, and structure of the UEC.

8.2 Cloud and Precipitation Measurements and Science Group

The ARM Cloud and Precipitation Measurements and Science Group (CPMSG) brings together members of the ARM instrument operations, engineering, and translator teams with the ARM science community

to improve the performance and science impact of ARM's measurements of clouds and precipitation. The members of the CPMSG work toward this goal by confronting science needs from the broader research community with operational constraints of the ARM facility (https://www.arm.gov/publications/programdocs/doe-sc-arm-19-001.pdf).

A driving consideration for the group should be how resources can best be applied to measurements of cloud and precipitation properties and the development of associated data products to increase the scientific impact of these measurements.

The CPMSG reports directly to ARM's Technical Director and is charged with providing constructive recommendations regarding the operation, characterization, and development of instruments yielding cloud and precipitation measurements along with the development of data products derived from these instruments and the identification of measurement gaps.

8.3 Aerosol Measurement and Science Group

The Aerosol Measurement Science Group (AMSG) is responsible for leading the identification of scientific performance goals, objective task prioritization, measurement gaps, data products, data processing algorithms, approaches to quality assessment, and metrics necessary to couple measurement products to the needs of the climate science community and for reporting progress toward these goals and objectives to DOE ARM and ASR management. The AMSG as a whole will be responsible for working with the ASR and ARM science communities to identify the measured parameters and the architecture of these parameters required at the ARM user facility to improve understanding of the impact of aerosol and trace gases on climate processes that affect climate and related model simulations and forecasts. The role of the AMSG is not to set scientific priorities or objectives in aerosol research, but to provide expertise on the measurements and processes required to best meet the aerosol science objectives of the ARM facility and the ASR program.

9.0 Logistics for Users

ARM is managed as a DOE user facility despite its geographic displacement from major DOE installations. DOE guidelines for visitors and access are followed in all cases. Formal procedures are used to accommodate users at the ARM sites. Activities at the ARM facility fall under the DOE's safety and security policies. Therefore, requests for visits and data accounts on user data systems by foreign nationals require substantial lead-time for approval.

Users conduct several major types of activities, including:

- A request for data from the ARM Data Center
- A visit to a site (real or virtual)
- A field campaign.

All user requests are managed through the unified User Registration process.

9.1 Requests for Archived Data

Any scientist can request data from the ARM Data Center. The request process includes the creation of an "ARM user account." using the interface available on the ARM website. This account creation provides ARM with information about how to contact users (email, phone number, etc.) and their affiliation (educational status, institutional status, etc.), area of research, and a few other details. The ARM Data Center keeps detailed records about data requests that enable future reports about "who uses how much of which data types from where and what time periods." Data from both routine and field campaign measurements are accessible, and data access is monitored by ADC operations.

9.2 Site Visits (Real or Virtual)

A request for a site visit or an account on a site data system is submitted using the Access Request System (ARS; https://armcrf.servicenowservices.com/nav_to.do?uri=%2Fhome.do). The ARS provides advance notice of onsite visits to site managers in order to coordinate support. The system also provides the means for applicants to request, and for administrators to manage, access to onsite and offsite computer facilities (virtual access). Submitting an ARS request allows users to easily communicate their needs to ARM site managers and operations staff for site support and network or remote access. It also provides a method of continuing communications with ARM personnel if requirements change or if unforeseen complications or issues arise. There are several types of Site and Computer Access Requests that can be made. All forms are found on the ARM website and should be submitted online.

9.2.1 Physical Onsite Visit Request

A physical request submission (ARS form) is required to visit an ARM site. Advance notice of a site visit through this form is necessary to ensure the safety of onsite visitors, to help provide whatever support is needed during the visit, and to make the experience of the visitor as productive and pleasant as possible. This form also is necessary for scheduling the activities of site staff.

9.2.2 Request to Connect a Visiting (Onsite) Device (PC or Instrument) to an ARM Network

A special form is used for requesting access to an ARM network. An ARS form is also used for requesting permission to connect a personal computer, instrument, or other device to an ARM site network whether the requester will be present at the site or not.

9.2.3 Remote (Offsite) Network Access to any Instrument or Computer System at an ARM Observatory

This type of submission should be used to request network access to a system located on an ARM facility from a location outside the facility.

9.3 Field Campaign

A field campaign is a research activity that is proposed, planned, and implemented at one or more research sites. ARM facility activities that require an augmentation or change in the routine data acquisition operation of a site are designated field campaigns unless they are judged by the IMB to be primarily for the purpose of developing a new facility capability. Activities that are focused on developing new facility capabilities are tracked via the ARM Engineering Change Management System. Field campaigns range from small activities such as deployment of guest instrumentation at a research site, changes in instrument sampling strategies, or extra radiosonde launches to major activities such as an aircraft campaign or deployment of an ARM mobile facility.

9.3.1 Field Campaign Proposals

Field campaigns may be proposed by any member of the scientific community. Information and guidelines about proposing field campaigns can be found at https://www.arm.gov/research/campaigns. All field campaign proposals first require submission of a preproposal. The IMB is responsible for reviewing preproposals and related facility infrastructure needs, assessing the feasibility and costs associated with the preproposal, determining whether the proposed activities fit within ARM's mission, and making recommendations on whether a full proposal should be requested. Preproposals are categorized based on the level of logistical and financial support requested and the extent to which the request might impact ongoing scientific activities.

Activities with minimal cost and impact to ARM may be approved by the IMB based on the preproposal. Campaigns that exceed a certain cost threshold, including AMF and AAF deployments, require submission of a full proposal and are reviewed by the ARM Science Board. The Science Board is an ad hoc review panel that is convened each year by the DOE Program Manager to review proposals for use of the ARM facility. Panel members consist of both DOE-funded scientists and members of the broader scientific community and are chosen to cover the broad range of scientific research areas supported by the ARM facility. Intermediate-level campaigns may require an abbreviated proposal and be subject to peer review. The lead scientist on a preproposal is notified several weeks after submitting the preproposal as to whether a full or abbreviated proposal will be requested. Full and abbreviated proposals are peer-reviewed, with criteria including scientific and technical merit of the proposed project and appropriateness of the proposed method or approach.

9.3.2 User Responsibilities

The PI of an accepted field campaign is required to provide an abstract for the ARM website. PIs of AMF and AAF deployments and smaller field campaigns with a higher-than-normal level of complexity are required to provide a campaign science plan that defines experiment goals, participant roles, critical measurements, and other campaign details. Typically, a field campaign results in the generation of one or more new data sets beyond the standard ARM data sets. These field campaign data sets may be produced by a guest instrument or may be a product from an ARM instrument operated in a non-standard way at the PI's request. PIs are required to submit their field campaign data sets to the ARM Data Center within six months of the completion of the campaign. The PI is also required to submit a final report within six months of the completion of the field campaign. The level of detail expected in final reports depends on

the level of complexity of the campaign but should describe what occurred and provide a summary of the field campaign outcomes including the degree to which campaign objectives were achieved.

9.4 User Account Request

A user account is required to access ARM data, sites, and computing resources. Field campaigns sometimes require near-real-time access to ARM datastreams, thus requiring access to a site research system. Access to ARM site research systems or networks is intended to provide local onsite support for visiting scientists and engineers using the facilities for scientific research, for ARM infrastructure staff, or for users requiring access to local instruments. These accounts are approved for a limited time.

10.0 Data Policies

DOE has established a policy for data management that emphasizes the importance of data management for scientific discovery. The policy underlines the importance of sharing and preserving data. All scientific data and data products that result from ARM-supported research are required to be submitted and are archived (with appropriate documentation) in the permanent ARM Data Center. All ARM data, including data originating from ARM-supported field campaigns, are available on a free and open basis and are publishable on receipt with acknowledgment of ARM as the source. ARM's data policy was originally derived from the data policies established by the U.S. Global Change Research Program (USGCRP) in 1991, which encourage "full and open" access to data and research results (http://www.gcrio.org/USGCRP/DataPolicy.html).

11.0 Communications and Outreach

The ARM facility supports outreach efforts to the science community, communities located near its research sites, and the general public. The ARM Communications Team is responsible for managing the ARM website, publishing ARM documents, and raising awareness in the community of ARM activities and the ARM facility and to relay scientific results and successes to the scientific community and to DOE management. The Communications Team regularly updates the ARM website to include current events and activities at ARM sites, new research results, and a compilation of summaries of published ARM research results or other significant ARM accomplishments. The Communications Team facilitates prompt and comprehensive responses to inquiries and information requests from scientists and agency personnel and publicizes successful ARM research stories in appropriate venues. Communication specialists develop materials that provide up-to-date information on instrumentation, data, and project results from ongoing science at the ARM sites. The Communications Team makes presentation materials available for ARM users to employ at meetings and other scientific venues. The Communications Team also engages in local outreach at each of its extended deployments (fixed sites and mobile facility deployments). The mission of local outreach is to raise the level of awareness in the local community of ARM and its purpose for deploying in a particular area.

12.0 References

Mather, JH. and JW Voyles. 2013. "The ARM Climate Research Facility: A Review of Structure and Capabilities." *Bulletin of the American Meteorological Society* 94(3): 377–392, https//doi.org/10.1175/BAMS-D-11-00218.1

Stokes, GM, and SE Schwartz. 1994. "The Atmospheric Radiation Measurement (ARM) Program: Programmatic background and design of the cloud and radiation testbed." *Bulletin of the American Meteorological Society* 75(7): 1201–1221, https://doi.org/10.1175/1520-0477(1994)075<1201:TARMPP>2.0.CO;2

Turner, D.D. and R.G. Ellingson, 2017. "The Atmospheric Radiation Measurement (ARM) Program: The first 20 years." Online: American Meteorological Society. AMS Monographs Vol. 57.

U.S. Department of Energy. 2019. Atmospheric Radiation Measurement (ARM) User Facility ARM Mobile Facility Workshop Report. DOE/SC-0197.

www.arm.gov

U.S. DEPARTMENT OF
ENERGY

Office of Science