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ARM FY2021 Radar Plan

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ARM

DISCLAIMER

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Acronyms and Abbreviations

AMF	ARM Mobile Facility
ANL	Argonne National Laboratory
ARM	Atmospheric Radiation Measurement
ARSCL	Active Remote Sensing of Clouds
CACTI	Cloud, Aerosol, and Complex Terrain Interactions
COMBLE	Cold-Air Outbreaks in the Marine Boundary Layer Experiment
CSAPR	C-Band Scanning ARM Precipitation Radar
CSU	Colorado State University
DOE	U.S. Department of Energy
DQO	Data Quality Office
ENA	Eastern North Atlantic
HSRL	high-spectral-resolution lidar
Ka/W-SACR	Ka/W-Band Scanning ARM Cloud Radar
KAZR	Ka-band zenith radar
KDP	specific differential phase
LANL	Los Alamos National Laboratory
LASSO	LES ARM Symbiotic Simulation and Observation
LES	large-eddy simulation
MICROBASE	Cloud Microbase-KAZR Profiles (KA) Value-Added Product
MICROBASEKAPLUS	Improved MICROBASE Product with Uncertainties
MOSAiC	Multidisciplinary Drifting Observatory for the Study of Arctic Climate
MWACR	Marine W-Band ARM Cloud Radar
NSA	North Slope of Alaska
OGRE	Operational Ground-Based Retrieval Evaluation
PhiDP	propagation differential phase
PNNL	Pacific Northwest National Laboratory
Py-ART	Python-ARM Radar Toolkit
QVP	quasi-vertical profile
RF	radio frequency
SACRGRID	Scanning ARM Cloud Radar Grid Value-Added Product
SAIL	Surface Atmosphere Integrated Field Laboratory
SGP	Southern Great Plains
TRACER	Tracking Aerosol Convection Interactions Experiment
TWP	Tropical Western Pacific
VAD	velocity-azimuth display
VAP	value-added product
XSAPR	X-Band Scanning ARM Precipitation Radar

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1.0 Introduction

The fundamental objective of the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) radar facility is to provide high-quality radar observations to the scientific user community with an overarching goal of improving the treatment of clouds and precipitation in climate models. ARM has a complement of 32 scanning and zenith pointing radars, not including the radar wind profilers (Table 1). This large number of radars and deployment locales require an enormous commitment of effort to keep operational. It has been the experience in ARM that all these radars cannot be always operated at a high level, and priorities need to be developed to properly manage operations every fiscal year. This document provides an overview of the FY20 activities and documents the priorities for FY21.

Table 1. Inventory of ARM radars, including frequency, at each site. Frequencies are approximate and can be slightly different in the field.

	Radars	Frequency
SGP	3 - X-Band Scanning ARM Precipitation Radars (XSAPR) 1 - C-Band Scanning ARM Precipitation Radar (CSAPR) 1 - Ka/W-Band Scanning ARM Cloud Radar (Ka/W-SACR) 1 - Ka-band zenith radar (KAZR)	9.35 GHz 6.25 GHz 35.3/94.0 GHz 35 GHz
NSA	1 - X-Band Scanning ARM Precipitation Radar 1 - Ka/W-Band Scanning ARM Cloud Radar (2nd Generation) 1 - Ka-band zenith radar	9.35 GHz 35.3/94.0 GHz 35 GHz
ENA	1 - X-Band Scanning ARM Precipitation Radar (2nd generation) 1 - Ka/W-Band Scanning ARM Cloud Radar (2nd generation) 1 - Ka-band zenith radar (2nd generation)	9.5 GHz 35.3/94.0 GHz 35 GHz
AMF1 AMF2	2 - Ka-band zenith radar 1 - W-Band Marine ARM Cloud Radar 1 - Ka/W-Band Scanning ARM Cloud Radar (Rotational) 1 - Ka/X-Band Scanning ARM Cloud Radar (Rotational)	35 GHz 95 GHz 35.3/94.0 GHz 35.3/9.71 GHz
AMF3	1 - Ka-band zenith radar (2nd generation)	35 GHz
Other	1 - C-Band Scanning ARM Precipitation Radar (1st generation) 1 - C-Band Scanning ARM Precipitation Radar (2nd generation) 1 - Ka-band zenith radar (Spares) 2 - Ka/X-Band Scanning ARM Cloud Radar (Rotational/spares) 1 - Ka/W-Band Scanning ARM Cloud Radar (SGP)	6.25 GHz 5.7 GHz 35 GHz 35.3/9.71 GHz 35.3/94.0 GHz

2.0 Fiscal Year 2020 Results

FY20 priorities were mainly oriented towards the ARM Mobile Facilities (AMF) deployments. An overview of the radar operations and the processing of the data to a calibrated b1-level product from the Cloud, Aerosol, and Complex Terrain Interactions (CACTI) campaign can be found in the ARM technical report DOE/SC-ARM-TR-244 (https://arm.gov/publications/brochures/doe-sc-arm-tr-244.pdf). A Ka/W-SACR and KAZR operated successfully for the entire deployment in Norway as part of the Cold-Air Outbreaks in the Marine Boundary Layer Experiment (COMBLE). A Ka/X-SACR, KAZR, and MWACR were deployed on ship as part of the Multidisciplinary Drifting Observatory for the Study of Arctic Climate (MOSAiC) campaign. The Ka-band worked properly for the entirety of the campaign, but the X-band transmitter failed during installation and the mentors did not have enough time on deck to troubleshoot the issue effectively. In a synergistic effort with these arctic campaigns, the North Slope of Alaska (NSA) XSAPR was brought into an operational phase and operated for a majority of FY2020. These data were also pulled into the Arctic Domain Awareness Center. Other notable efforts include that of Eastern North Atlantic (ENA) site operations bringing the Ka/W-SACR and XSAPR2 into an operational state Both instruments are awaiting additional assessment from the mentors before becoming fully operational. On the opposite end of the spectrum, ARM has officially started the process to retire the Tropical Western Pacific (TWP) CSAPR, which has been in storage. Working parts and parts of potential use in the future will be kept and the rest excessed.

The framework to process ARM's radar data from raw data to a1 level and then to calibrated and corrected b1 level was completed, and as noted earlier, used for the first time in the processing of the CACTI radar data. Additionally, work was started on the adaptive scanning capabilities that are necessary for CSAPR2 in support of the Tracking Aerosol Convection Interactions Experiment (TRACER).

3.0 Fiscal Year 2021 Priorities

ARM's radar mentorship is undergoing a transition to better align the personnel with the priorities. Priorities will be set by the ARM Infrastructure Management Board with input from the science community and the radar mentor team. The mentorship will be split into a hardware engineering component and a data analysis and processing component. The hardware engineering mentors will oversee the preparation of the hardware based on priorities. The data mentor(s) and radar science liaison will assess the quality of the data, working closely with the engineering team, translators, and others in ARM, to ensure ARM is providing routine calibrated and corrected data sets.

The timeline for the primary, and some secondary, activities described below is shown in Table 2.

Table 2. Timeline of FY21 radar activities.

			October-2020	November-2020	December-2020	January-2021	February-2021	March-2021	April-2021	May-2021	June-2021	July-2021	August-2021	September-2021
TRACER Campaign Operations (AMF1)	10/1/21	9/30/22												
CSAPR2 Preparations and Operations	9/1/20	9/30/22												
Cell Tracking Capability Development (BNL)	10/1/20	9/30/22												
Ka/X SACR Preparations and Operations	10/1/20	9/30/22												
SAIL Campaign Operations (AMF2)	9/1/21	6/15/23												
CSU X-Band	10/1/20	12/31/23												
KAZR Preparations	3/1/21	6/30/21												
AMF3 Activities to Support the Southeast U.S.	3/1/23	3/1/28												
CSAPR Refurb	2/1/21	2/28/23												
Technical Review	5/1/21	5/30/21												
Maintain KAZR Operations	10/1/20	9/30/21												
COMBLE Data Processing	1/1/21	4/30/21												
MOSAiC Data Processing	5/1/21	9/30/21												
NSA SACR	7/1/21	9/30/21												
ENA SACR and SAPR	5/1/21	8/1/21												
XSAPR Magnetrons	3/1/21	9/30/21												
SACR Measurement Review	4/1/21	6/1/21												
Primary Activities														
Secondary Activities														

3.1 Primary Activities

3.1.1 TRACER Campaign Operations (AMF1)

Timeframe: 10/1/2021–9/30/2022

The top priority for FY21 is the preparation of the CSAPR2, SACR, and KAZR for the upcoming TRACER campaign. TRACER is focused on deep convection and the scanning radars play a central role in achieving the science goals for the campaign.

3.1.1.1 TRACER CSAPR2 Preparations and Operations

Timeframe: 9/1/2020–9/30/2022
Mentor staffing: Andrei Lindenmaier, Tim Wendler

The CSAPR2 was deployed to the Southern Great Plains (SGP) site for maintenance, testing, and upgrades. The vendor was contracted to upgrade the radar control software to allow for external inputs to control the radar in support of cell-tracking science goals for the campaign. The radar will be uninstalled from SGP in July 2021 and sent for installation at TRACER. A vendor service contract will be implemented during TRACER to support radar operations and troubleshooting in the field.

3.1.1.2 TRACER Cell Tracking Capability Development

Timeframe: 10/1/2020–9/30/2022
Staffing: Pavlos Kollias, Ed Luke, Mariko Oue, Bernat Puigdomenech

The development of the automated adaptive scanning will be a major upgrade to this radar. Coordination between the mentor team, vendor, adaptive scanning software team lead by Pavlos Kollias from Brookhaven National Laboratory, and others will be vital to ensure the successful implementation of this capability for the TRACER campaign. Testing of this capability will take place at SGP prior to the uninstallation of the CSAPR2.

3.1.1.3 TRACER Ka/X SACR Preparations and Operations

Timeframe: 10/1/2020–9/30/2022
Mentor staffing: Andrei Lindenmaier, Tim Wendler

The engineering team will prepare the Ka-X SACR hardware at Pacific Northwest National Laboratory (PNNL) and ship the system directly to TRACER. A service contract with the vendor has been set up to help with software upgrades.

3.1.2 SAIL Campaign Operations

Timeframe: 9/1/2021–6/15/2023

The AMF2 will be deployed for a little under two years in Colorado for the Surface Atmosphere Integrated Field Laboratory (SAIL) campaign (September 1, 2021–June 15, 2023). The KAZR will be deployed as part of the AMF and Colorado State University (CSU) will deploy their X-Band radar for ARM in place of an ARM scanning cloud radar system (both items detailed below).

3.1.2.1 SAIL CSU X-Band Radar

Timeframe: 10/1/2020–12/31/2023
Staffing: Dr. Chandrasekar

A scanning cloud radar was not included in the AMF2 call for proposals. In order to support the science objectives of SAIL, a scanning, polarimetric, X-band radar from CSU was contracted to provide radar measurements for the entire SAIL campaign. This radar will be deployed on Crested Butte Mountain (GUC S3) on a roughly 20-foot tower to provide adequate views of the area.

3.1.2.2 SAIL KAZR Preparations

Timeframe: 3/1/2021–6/30/2021
Mentor staffing: Peter Argay, Tim Wendler, Andrei Lindenmaier

A KAZR will be deployed at Los Alamos National Laboratory (LANL) during the SAIL beta test to prepare it for the campaign. As part of these preparations, the high-spectral-resolution lidar (HSRL) will

be incorporated into the KAZR container. This will include modifications to the container to add a window in the roof. General operations are tracked under the Maintain KAZR Operations below.

3.1.3 AMF3 Radar Activities to Support the Southeast U.S.

Timeframe: 2/1/2021 Onward
Mentor staffing: Andrei Lindenmaier

As part of the AMF3 move from Oliktok Point, Alaska to the Southeast United States, radar needs are actively being planned for. Options for the deployment of a C-band precipitation radar and a X-band radar are being analyzed and discussed. A design review for the proposed plan (in development) will be reviewed in late-spring 2021.

3.1.4 Maintain KAZR Operations

Timeframe: Continuous
Mentor staffing: Tim Wendler, Andrei Lindenmaier

The KAZRs are workhorses for ARM's radar measurements and are a continued high priority at each of the sites. All KAZRs are operational at the time of writing and as travel and time permits, the KAZR receivers will undergo periodic calibration. The radar data team, led by the radar data mentor, is responsible for monitoring operational radar data sets with support from the ARM Data Quality Office (DQO) and other members of ARM's Infrastructure. In preparation for the radar data mentor, and to properly support through their transition, Infrastructure is going to coordinate and leverage resources across ARM in support of ARM's radar. This is discussed further in the Coordination of Non-Engineering Radar Activities section below.

3.1.5 COMBLE and MOSAiC Data Processing

Timeframe: 1/1/2021–9/30/2021
Staffing: Jennifer Comstock, Scott Giangrande, Karen Johnson, Alyssa Matthews

Production of high-quality calibrated and corrected radar data from COMBLE and MOSAiC is a high priority. This effort is being led by members of the radar data mentor team and overseen by the cloud radar translator.

3.1.6 Coordination of Non-Engineering Radar Activities

Timeframe: Ongoing
Mentor staffing: ARM Infrastructure Staff

A large contingent of people in ARM devote effort towards non-engineering radar activities, such as data ingest developer, value-added products, data quality, and more. Efforts are underway to bring together those groups in a more coordinated fashion to contribute to radar data monitoring, quality control, and other topics as necessary. This will include regular calls and communication across these ARM Infrastructure groups, prioritizing needs when appropriate.

3.2 Secondary Activities

These activities could result in operational systems but are lower priority.

3.2.1 NSA SACR

Timeframe: Late summer 2021
Mentor staffing: Tim Wendler, Todd Houchens

The NSA SACR would benefit from characterization. The recommended approach would be to ship the radio frequency (RF) unit to PNNL where it can be characterized in a climate-controlled environment (the receiver calibration would not be meaningful if conducted with the components exposed to arctic cold because it would not be representative of operating conditions).

3.2.2 ENA SACR and SAPR

Timeframe: Summer 2021
Mentor staffing: Andrei Lindenmaier, Tim Wendler, Vagner Castro

The SACR RF units and their auxiliary parts were shipped to PNNL for repair and calibration. Once complete, these parts will be shipped back to ENA for installation by site technicians. The XSAPR is operating but awaiting further review before collections are enabled.

3.2.3 XSAPR Magnetrons

Timeframe: Spring/summer 2021
Mentor staffing: Andrei Lindenmaier

The SGP XSAPRs have been down for an extended period due to nearing end of life for the magnetrons. The first of the new magnetrons have been received. The new magnetrons will be tuned with the transmitters during spring/summer FY21. Field calibration of the XSAPRs will be postponed until after TRACER or until a field campaign need requires it.

3.2.4 SACR Review

Timeframe: Spring 2021
Staffing: Jennifer Comstock

The lowest priorities for ARM are SACRs at several of the sites as follows. The AMF2 SACR will not be deployed for SAIL as previously noted. The SACRs at SGP have proven not to be as useful at SGP for shallow convection. They could be used for deep convection but undertaking a study at SGP would be a significant effort. The W-band SACR at ENA has proven not to be useful for boundary-layer clouds at ENA. Furthermore, it has been a challenge to maintain this system in a remote environment. The ARM SACR systems will undergo a review in spring 2021.

3.3 Translator and Data Product Activities

3.3.1 Community Radar Software Support

Timeframe: Ongoing
Staff: Zachary Sherman, Jason Hemedinger, Scott Collis

Support and further development of the Python-ARM Radar Toolkit (Py-ART). Py-ART is used by internal and external stakeholders and is specifically engineered to work with ARM radar data. Py-ART has supported well over 100 publications and is used across academia, government, and industry. Py-ART is also the main tool used for value-added product (VAP) development on the precipitation radars. Py-ART also acts as a conduit to get science codes back into infrastructure.

3.3.2 Precipitation Radar Advanced Products

Timeframe: Ongoing
Staff: Robert Jackson, Zachary Sherman, Jason Hemedinger, Scott Collis

Application of retrieval codes to b and, where appropriate, simpler-level datastreams includes PhiDP processing, KDP retrieval, attenuation correction, and dealiasing. And, where none exists, clutter detection and calibration offset application. The current focus is on historical data from the SGP and NSA and will pivot in 2022 to TRACER C-SAPR2 and, if appropriate, additional value-adding to data from the CSU SAIL X-Band deployment.

FY22 activities will look to application of codes that move away from natural radar coordinates. This includes mapping to Cartesian grids, quasi-vertical profiles (QVP), and velocity-azimuth display (VAD). Designs for SAIL and TRACER will commence in the latter part of FY21 and product plans will rely on the operational modes of the radars.

3.3.3 Cloud Radar Advanced Products

Timeframe: Ongoing
Staff: Lynn Ma, Karen Johnson, Meng Wang, Scott Giangrande

The Active Remote Sensing of Clouds (ARSCL) data product will continue with upgrade and maintenance to ensure streamlined production. Data sets from ARM Mobile Facility campaigns will be processing (CACTI, COMBLE, and MOSAiC). The Scanning ARM Cloud Radar Grid (SACRGRID) VAP, which provide cloud radar moments on a Cartesian grid, will be processed for CACTI, COMBLE, and MOSAiC. The MICROBASEKAPLUS VAP, which provides four primary microphysics quantities, will restore MICROBASE capabilities to an operational state, incorporating OGRE improvements and uncertainty quantification. FY21 will start by adding SGP and ENA records to evaluation. Additional efforts include efforts on KAZR spectral decluttering at SGP, aligning with LASSO activities, and the incorporation of CloudSat calibration offsets into a calibrated ARSCL product.

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