ARM-99-001

Site Scientific Mission Plan for the Southern Great Plains CART Site

January-June 1999

Prepared for the U.S. Department of Energy under Contract W-31-109-Eng-38

Site Program Manager Office
Environmental Research Division
Argonne National Laboratory
Argonne, IL 60439

DISCLAIMER

Publishing support services were provided by Argonne's Information and Publishing Division. (For more information, see IPD's home page: http://www.ipd.anl.gov.)

Reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831; prices available from (423) 576-8401.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

Distribution Category:
Environmental Sciences (UC-402)

ARM-99-001

Site Scientific Mission Plan for the Southern Great Plains CART Site

January-June 1999

January 1999

Randy A. Peppler[1], Douglas L. Sisterson[2], and Peter Lamb[1]

[1]Cooperative Institute for Mesoscale Meteorological Studies,
The University of Oklahoma, Norman, Oklahoma 73019

[2]Environmental Research Division, Argonne National
Laboratory, Argonne, Illinois 60439

Work supported by United States Department of Energy,
Office of Science,
Office of Biological and Environmental Research,
Environmental Sciences Division

SITE SCIENTIFIC MISSION PLAN FOR THE SOUTHERN GREAT PLAINS CART SITE JANUARY-JUNE 1999

1 INTRODUCTION

The Southern Great Plains (SGP) Cloud and Radiation Testbed (CART) site was designed to help satisfy the data needs of the Atmospheric Radiation Measurement (ARM) Program Science Team. This *Site Scientific Mission Plan* defines the scientific priorities for site activities during the six months beginning on January 1, 1999, and looks forward in lesser detail to subsequent six-month periods. The primary purpose of this document is to provide scientific guidance for the development of plans for site operations. It also provides information on current plans to the ARM functional teams (Management Team, Data and Science Integration Team [DSIT], Operations Team, and Instrument Team [IT]) and serves to disseminate the plans more generally within the ARM Program and among the members of the Science Team. This document includes a description of the operational status of the site and the primary site activities envisioned, together with information concerning approved and proposed intensive observation periods (IOPs). The primary users of this document are the site operator, the site program manager, the Site Scientist Team (SST), the Science Team through the ARM Program science director, the ARM Program Experiment Center, and the aforementioned ARM Program functional teams. This plan is a living document that is updated and reissued every six months as the observational facilities are developed, tested, and augmented and as priorities are adjusted in response to developments in scientific planning and understanding.

This report and all previous reports are available on the SGP CART site's World Wide Web home page at

http://www.arm.gov/docs/sites/sgp/sgp.html ,

at the link "Site Scientific Mission Plan."

2 SUMMARY OF SCIENTIFIC GOALS

2.1 Programmatic Goals

The primary goal of SGP CART site activities is to produce data adequate to support significant research addressing the objectives of the ARM Program. These overall objectives, as paraphrased from the *ARM Program Plan, 1990* (U.S. Department of Energy 1990), are the following:

- To describe the radiative energy flux profile of the clear and cloudy atmosphere

- To understand the processes determining the flux profile

- To parameterize the processes determining the flux profile for incorporation into general circulation models (GCMs)

To address these scientific issues, an empirical data set must be developed that includes observations of the evolution of the radiative state of the column of air over the central facility, as well as the processes that control that radiative state, in sufficient detail and quality to support the investigations proposed by the ARM Science Team. To address the entire 350-km × 400-km SGP CART site, the ARM Program also relies on models to compute the processes or properties that affect radiative transfer. This set of data includes measurements of radiative fluxes (solar and infrared [IR]) and the advective and surface fluxes of moisture, heat, and momentum occurring within the column and across its boundaries. Other entities to be described are cloud types, composition, and distribution (depth, fractional coverage, and layering); thermodynamic properties of the columnar air mass (temperature, pressure, and concentrations of all three phases of water); the state and characteristics of the underlying surface (the lower boundary condition); processes within the column that create or modify all of these characteristics (including precipitation, evaporation, and the generation of condensation nuclei); and radiatively significant particles, aerosols, and gases. Basic continuous observations must be made as often as is feasible within budgetary constraints. For limited periods of time, these observations will be supplemented by focused IOPs providing higher-resolution or difficult-to-obtain *in situ* data.

Beyond simply providing the data streams, determining their character and quality as early as possible in the observational process is imperative. This evaluation provides the basic operational understanding of the data necessary for an ongoing program of such scope. Although both reason and ample opportunity will exist to develop a further understanding of the ARM observations over the course of the program, the task of investigating and ensuring the data quality is extremely important. In this regard, routine instrument mentor and SST data quality assessments, definitive quality measurement experiments (QMEs), and value-added products (VAPs) help establish confidence in the measurements.

The SGP CART site is the first of three global locations chosen and instrumented for data collection. As summarized in the *Science Plan* for the ARM Program (U.S. Department of Energy 1996), the scientific issues to be addressed by using data from a midlatitude continental CART observatory include the following:

- Radiative transfer in cloudless, partly cloudy, and overcast conditions
- Cloud formation, maintenance, and dissipation
- Parameterizations of nonradiative flux
- The role of surface physical and vegetative properties in the column energy balance
- Other complications in the radiative balance in the atmosphere, particularly those due to aerosols, cloud condensation nuclei (CCN), and cloud-aerosol radiative interactions
- Feedback processes between different phenomena and different domains

The variety, surface density, and atmospheric volumetric coverage of the SGP instrumentation will be more comprehensive than those at any other ARM site, and the SGP site will experience a wider variety of atmospheric conditions than will the other sites. The resulting data will accordingly support a greater range and depth of scientific investigation, making it imperative for the ARM Program to develop and maintain a high-quality, continuous data stream from the SGP site.

The measurements required by Science Team proposals, the DSIT, and the science director are categorized into areas or groups of scientific applications within ARM. The DSIT and other teams coordinate activities to develop integrated, well-focused data sets for these groups. Focus areas include shortwave radiation, longwave radiation, water vapor, aerosols, clouds, surface fluxes, and the single-column model (SCM). A goal is to facilitate development of an algorithm that prescribes geophysical phenomena as products of multiple data streams.

2.2 Priorities for Site Activities

Priorities for site activities for January through June 1999 include the following:

- Facilitate all data quality assessment efforts, particularly those focused on the development of a full suite of data quality analysis tools, participation in the testing and further development of the Meta Data Navigator (MDN), implementation of QMEs and VAPs, and better dissemination of information on data quality.

- Continue assessment of the measurement capability of the SGP CART site relative to Science Team needs.

- Plan and implement key IOPs and campaigns.

- Finish implementation of the Okmulgee extended facility.

- Support the Instrument Development Program (IDP).

- Continue the review of routine site operations.

The IOPs focus on providing critical data sets on an episodic basis for the Science Team, as well as field support for instrument development and testing and for collaborative campaigns. The IOPs scheduled for this six-month period are detailed in Section 5.3.

Operation of the radiometer calibration facility (RCF) has matured, with site operations personnel, as trained by staff of the National Renewable Energy Laboratory (NREL), currently performing most of the work. Successful calibration was carried out in September 1996 and July-September 1997-1998, with the completion of two Broadband Outdoor Radiometer CALibrations (BORCALs). Achieving optimal use of the facility is an ongoing task, as more BORCALs will be performed in 1999.

The phased implementation of the Okmulgee extended facility (the wooded site) is nearly complete. The walk-up tower, shelter, and infrastructure were in place in spring 1998. Installation of instruments is planned for the spring or summer of 1999.

Four Vaisala 25-km ceilometers and four atmospherically emitted radiance interferometers (AERIs) were installed at boundary facilities in December 1998. However, one Vaisala ceilometer (Vceil) was operated at the central facility during the spring 1998 Cloud IOP. The whole-sky imager (WSI) was relocated to a different area within the optical cluster in December 1998 because of nighttime problems with light interference. Also in December 1998, a humidified nephelometer was added to the suite of instruments in the aerosol observation system (AOS). Two new radiometers (Eppley 8-48 and Eppley total ultravoilet [UV] radiometer, TUVR) will be added to the suite of instruments in the central cluster.

The Eppley 8-48 radiometer will replace the precision spectral pyranometer (PSP) in the solar and infrared radiation station (SIRS) testbed in January 1998. The TUVR will be added during the conversion of the baseline surface radiation network (BSRN) to the broadband radiometer station (BRS) sometime during late spring or early summer 1999.

The uninterruptable power supply (UPS) for the Raman lidar is to be installed by February 1999. This significant installation will ensure the continued operation of the lidar through power dips.

A commercially available temperature-humidity calibration chamber has been procured and will be installed in the calibration trailer by spring 1999. Bob McCoy (Colorado State University) has requested the installation of a scanning spectral polarimeter (SSP-3) at the central cluster for an indefinite period. The installation is expected to be complete before spring 1999. The Harrison UV spectral radiometer (developed with funding from the U.S. Department of Agriculture [USDA]) will be installed before the spring of 1999. Dave Bigelow (Colorado State University), USDA UV-B monitoring network, has requested that a full site be established at the central cluster. The full USDA site includes a multifilter rotating shadowband radiometer (MFRSR) identical to the one used by ARM, a Harrison design UV-B MFRSR, a Yankee UV-B broadband radiometer, and minimal meteorological support sensors (temperature, pressure, and snow cover). The UV-B site is to be installed by spring 1999. In addition, phased implementation of three storage trailers is taking place at IDP No. 4. This area, being proposed as the depot for general storage, instrument spare parts, and ready-to-deploy spare instruments for all three CART sites, could also be developed to accommodate IOP participants should the need arise.

Although an extended facility is not planned for Ft. Cobb at this time, the optimal location for another eddy correlation (ECOR) site is yet to be determined. This activity is on hold until the ECOR instrument is more stable operationally.

In summary, goals for this six-month period continue to be to provide the Science Team with a suite of measurements that will support a wide range of research, to establish solid procedures for instrument calibration and maintenance (particularly for broadband radiometry), to operate the series of VAPs and QMEs, to provide input for the scientific applications groups, and to install required instrumentation and facility support. Quality assessment efforts also remain central to the success of the entire program.

3 ROUTINE SITE OPERATIONS

3.1 Overview

The overwhelming majority of the measurements with the highest priority, on which the existing experimental designs are based, are regular routine observations, as specified in the *ARM Program Plan, 1990* (U.S. Department of Energy 1990). Scientifically and logistically, routine operations also serve as the basis and background for all nonroutine operations, including instrument development activities, IOPs, and collaborative campaigns directed toward obtaining difficult-to-gather or expensive *in situ* data. Consequently, development and validation of the basic observations remain high priorities. The site is sufficiently mature to support IOPs addressing key scientific areas of study.

The SST will continue to work to ensure the scientific productivity of the site by providing guidance to the site operations manager and his staff on scientific matters. This includes monitoring instrument performance via the analysis of the quality of the data stream, reviewing schedules and procedures for instrument maintenance and calibration, reviewing designs for the infrastructure supporting new instruments, contributing to the design of the standard operating procedures, reviewing and developing plans for IOPs, and helping to obtain near-real-time data displays during IOPs. The SST, in cooperation with instrument mentors and the DSIT, will continue to lead the data quality assessment effort at the CART site, an ongoing activity that includes monitoring of the CART data streams in collaboration with the staff at the central facility and the development of data quality performance metrics and graphic tools that address data quality. The site program manager will help coordinate these activities.

Routine operations are the activities related to the operation and maintenance of instruments; the gathering and delivery of the resulting data; and the planning for scientific investigations, including IOPs, campaigns, VAPs, and QMEs. Although the site is essentially complete, instrumentation will be evaluated continuously to assess the possible need to eliminate instruments or replace them with different or new sensors. This reevaluation is discussed in Section 7, "Looking Ahead." The process that leads to implementation of CART instruments continues to be the Pre-Readiness Review (PRR). The PRR includes the identification of requirements for instrument design and installation and the development of the documentation, procedures, and training needed to maintain CART instrumentation and integrate data streams into the site data system (SDS). The PRR also provides a forecast of when new instruments will be fully operational (i.e., ready for operational handoff to site operations via the Operational Readiness Review [ORR]) and delivering data to the Experiment Center and the Data Archive.

The design expectation for the routine operation of instruments is that they will continue to require servicing by site operators only once every two weeks. The exception to this is the central facility, which is staffed. If an instrument failed during a two-week period at an extended facility, data streams could be lost, although every effort is made to ensure adequate data-logging capacity at each such site. Such loss of data is unfortunate but is unavoidable because of manpower and budget constraints. The instruments at all extended, intermediate, and boundary facilities are polled frequently each day by the SDS at the central facility, and data are packaged and delivered to the Experiment Center and the Data Archive once daily. The Experiment Center generally delivers data to Science Team members and other data requesters once weekly via an Experimental Operations Plan and sends data sets to the ARM Data Archive as well. The VAPs and QMEs are implemented and operated at the Experiment Center.

Site operations staff conduct additional instrument “triage” during IOPs and campaigns. The triage plan calls for IOP scientists to identify instruments, individual sensors, and communication links that are critical to the operation and goals of the IOP, so that these instruments can receive more frequent servicing than is prescribed by the routine operational requirements mentioned above. The priority of triage efforts is determined by IOP scientists, the SST, and the site program manager, who take into consideration the scientific importance of a particular data stream and its expense. The triage plan has been very successful, as demonstrated during recent IOPs.

During the last six-month period, an electronics laboratory was set up in the staging trailer to expedite instrument and logger repairs that can be made on-site, thus saving both money and time. Instrument components can be diagnosed and replaced on-site within days instead of the four to six weeks required to return instruments to vendors for service. The electronics laboratory will also serve the other three CART sites.

Handling of instruments that must be returned to the vendor for calibration and servicing is also part of routine operations. Replacement instruments and sensors are rotated regularly to meet these requirements. Calibration and maintenance information is compiled, both to operate and maintain site instruments properly and to provide pertinent information to data users. Changeouts of all sensors and instrumentation are recorded in the site operations log.

A commercially available temperature-relative humidity chamber (Thunder Scientific Model 2500ST) was procured and will be installed by early spring in the calibration trailer. This chamber will allow temperature and humidity sensors to be checked and calibrated locally instead of being returned to the vendor. This capability will reduce turnaround time and expense. Furthermore, the chamber will allow comparisons of temperature and humidity sensors between the three CART sites.

Initial checks of data quality after instrument installation are provided by the instrument mentors. After the mentor reviews the data stream to ensure that the acquired instrument is performing properly and that the data are identified accurately by the Experiment Center, the mentor approves a “beta” release of the data. The beta release provides data to selected Science Team members who have requested them and are willing to work with the instrument mentor on data quality issues. Beta releases are established after the instrument mentor and an appropriate member of the DSIT have created a general statement on data quality for the Experiment Center. When the data quality relative to proper instrument functionality is consistently acceptable and well documented, the mentor approves a full release of the data.

3.2 Routine Operations

3.2.1 Functional Instruments and Observational Systems

Figure 1 is a map of the SGP site showing the locations of the developed extended, intermediate, and boundary facilities. The status of the systems and instruments anticipated by June 30, 1999, is summarized in Table 1.

Accomplishments in the area of site development are most evident at the central facility (Table A.1 in the Appendix), with its functioning power, fiber-optic infrastructure, and complete array of instruments. Of the 26 planned extended facilities (Table A.2 in the Appendix), 23 (including one at the central facility and one at the Cement location) are operational at the beginning of this period; one ECOR site (formerly Ft. Cobb, EF-23) is yet to be identified and is a placeholder site for possible expansion, if required.

ARM has developed an instrument Web site that provides detailed descriptions of each instrument and sensor used at each of the three CART sites. Information includes status and

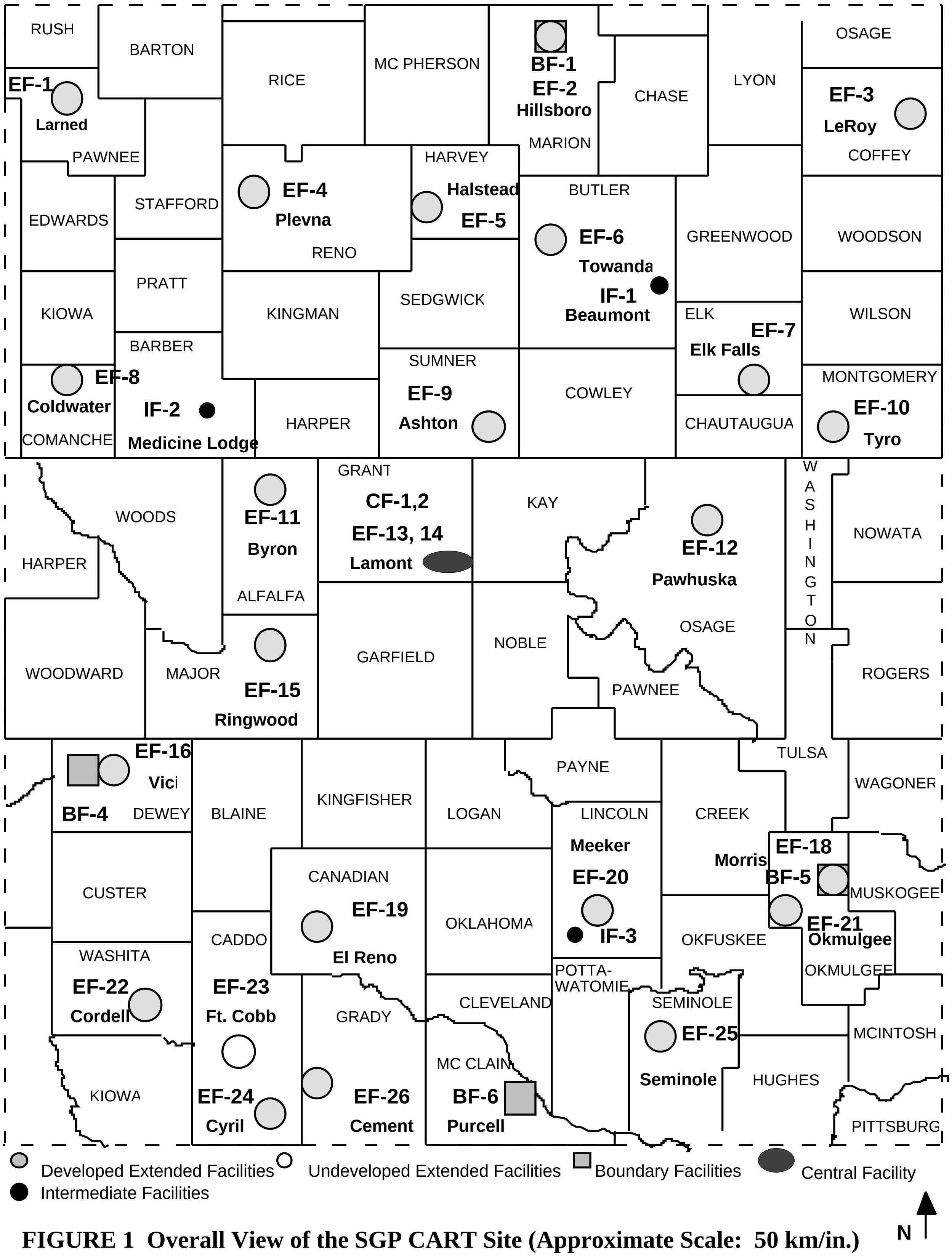

FIGURE 1 Overall View of the SGP CART Site (Approximate Scale: 50 km/in.)

TABLE 1 Instruments and Observational Systems Anticipated at the Central, Boundary, Extended, and Auxiliary Facilities on June 30, 1999[a]

Central Facility

Radiometric Observations

- AERI
- AERI X
- SORTI
- BRS (formally BSRN)
  - Pyranometer (ventilated)
  - Pyranometer (ventilated, shaded)
  - Pyrgeometer (ventilated, shaded)
  - NIP on tracker
  - MFRSR
- SIRS (formally known as SIROS)
  - Pyranometer (ventilated)
  - Pyranometer (ventilated, shaded)
  - Pyrgeometer (ventilated, shaded)
  - NIP on tracker
  - Pyranometer (upwelling, above pasture at 10 m)
  - Pyrgeometer (upwelling, above pasture at 10 m)
- MFRSR
- MFR (upwelling, above pasture at 10 m)
- Pyranometer (upwelling, above wheat at 25 m on 60-m tower)
- Pyrgeometer (upwelling, above wheat at 25 m on 60-m tower)
- MFR (upwelling, above wheat at 25 m on 60-m tower)
- CSPHOT
- RSS
- NFOV
- GRAMS
- SWS
- RCF instrumentation, including cavity radiometers
- UV spectrometer

Wind, Temperature, and Humidity Sounding Systems

- BBSS
- 915-MHz profiler with RASS
- 50-MHz profiler with RASS
- MWR
- Heimann IR thermometer
- Raman lidar
- THWAPS

TABLE 1 (Cont.)

Cloud Observations

WSI (daytime/nighttime)
BLC (interim)
MPL-HR
MMCR
TLCV

Others

Temperature and humidity probes at 25-m and 60-m levels on tower
Heat, moisture, and momentum flux instrumentation at 25-m and 60-m levels on tower
EBBR
ECOR
SMOS
AOS (samples at 10 m)
SWATS

Extended Facility Components

SIRS (formally known as SIROS)
- Pyranometer (ventilated)
- Pyranometer (ventilated, shaded)
- Pyrgeometer (ventilated, shaded)
- NIP on tracker
- Pyranometer (upwelling, at 10 m)
- Pyrgeometer (upwelling, at 10 m)

MFRSR
EBBR or ECOR
SMOS
SWATS

Auxiliary Facilities

None in preparation

Boundary Facilities

BBSS
MWR
THWAPS
Vceil
AERI

TABLE 1 (Cont.)

Intermediate Facilities	
	915-MHz profiler and RASS

[a] AERI, atmospherically emitted radiance interferometer; AOS, aerosol observation system; BBSS, balloon-borne sounding system; BLC, Belfort laser ceilometer; BRS, broadband radiometer station; BSRN, baseline surface radiation network; CSPHOT, Cimel sunphotometer; EBBR, energy balance Bowen ratio; ECOR, eddy correlation; GRAMS, ground-based radiometer autonomous measurement system; IR, infrared; MFR, multifilter radiometer; MFRSR, multifilter rotating shadowband radiometer; MMCR, millimeter cloud radar; MPL-HR, micropulse lidar–high resolution; MWR, microwave radiometer; NFOV, narrow-field-of-view zenith-pointing filtered radiometer; NIP, normal-incidence pyrheliometer; RASS, radio acoustic sounding system; RCF, radiometer calibration facility; RSS, rotating shadowband spectrometer; SIROS, solar and infrared radiation observing system; SIRS, solar and infrared radiation station; SMOS, surface meteorological observation station; SORTI, solar radiance transmission interferometer; SWATS, soil water and temperature system; SWS, shortwave spectrometer; THWAPS, temperature, humidity, wind, and pressure sensors; TLCV, time-lapse cloud video; UV, ultraviolet; Vceil, Vaisala ceilometer; WSI, whole-sky imager.

locations, theory of operations, calibration history, examples of data, quality assurance, citable references, etc. This information can be found at

http://www.arm.gov/docs/instruments.html .

In addition, ARM has developed a mission-critical Meta Data System (MDS) that enables all information to be provided at a common location (supplementing the instrument data streams). The MDS database enhances the scientific utility of the instrument data streams. Such information is available at the ARM MDS Web site at

http://www.db.arm.gov/MDS/ .

3.2.2 Launch Schedule for Balloon-Borne Sounding Systems

Until the full suite of remote sensing systems is deployed to perform deep, detailed soundings of the wind, temperature, and moisture of the troposphere under a wide range of conditions, the balloon-borne sounding system (BBSS) will continue to be an expensive workhorse. Because of budget constraints, the number of BBSS launches sitewide was reduced in 1997 to the minimum needed to support routine cross-checks on the remotely sensed measurements. The frequency of routine launches at the central facility was reduced from five per day to three, and routine launches were eliminated at all four boundary facilities. In December 1998, however, the midnight launch at the central facility was restored.

The new schedule for routine operations is in Table 2. The new routine radiosonde launch times, approved by the Science Team Executive Committee, were chosen to complement the National Weather Service (NWS) standard launch times of 0000 and 1200 UTC (universal time coordinated) and to support the daytime satellite advanced very-high-resolution radiometer (AVHRR) overpass at approximately 2030 UTC. In addition, the 2030 UTC launch during the maximum daytime boundary layer height, supports instantaneous radiative flux (IRF) and IDP research. The midnight launch provides the only deep tropospheric nighttime information. Remote sensing of virtual temperature profiles at all boundary facilities is performed by the nearby National Oceanic and Atmospheric Administration (NOAA) profilers, which are being outfitted with ARM-provided radio acoustic sounding system (RASS) units. The RASS units have already been installed at the Purcell, Oklahoma, and at the Haviland, Kansas, NOAA profilers. The Lamont, Oklahoma, NOAA profiler will not receive a RASS unit because it would be located too close to a residence, but the nearby SGP CART site central facility collects a relative abundance of thermodynamic data. In addition, global positioning system (GPS) instruments were recently installed at the Purcell, Vici, Haskell, Haviland, Lamont, Neodesha, and Hillsboro NOAA profiler locations to provide estimates of precipitable water. This information, along with the NOAA profiler data, has become available to the ARM Program as external data.

The central facility will be staffed from 0430 to 1630 and from 2230 to 0230 local time, Monday through Friday (including holidays), although staffing is limited. During appropriate SCM IOPs, the central facility and the four boundary facilities will be staffed 24 hours per day, 7 days per week (including holidays) to facilitate round-the-clock radiosonde releases every 3 hours, centered on 0000 UTC.

3.3 Instruments

A CART instrument is any instrument that is approved by the ARM Program and for which the site operations management has accepted responsibility for operation and maintenance. The PRR and ORR forms represent requests for information that facilitates the installation and operation of instruments or facilities at the SGP CART site. The purpose of

TABLE 2 Radiosonde Launch Schedule for January 1-June 30, 1999 (Times in UTC)[a]

Central Facility	Boundary Facilities
January 1-18, 1999 (Routine Operations, Monday-Friday)	
0000	
0600	
1200	
2030	
January 19-February 8, 1999 (Intensive Observation Period, Monday-Sunday)	
0000	0000
0300	0300
0600	0600
0900	0900
1200	1200
1500	1500
1800	1800
2100	2100
February 9-28, 1999 (Routine Operations, Monday-Friday)	
0000	
0600	
1200	
2030	
March 1-21, 1999 (Intensive Observation Period, Monday-Sunday)	
0000	0000
0300	0300
0600	0600
0900	0900
1200	1200
1500	1500
1800	1800
2100	2100
March 22-June 30, 1999 (Routine Operations, Monday-Friday)	
0000	
0600	
1200	
2030	

[a] UTC, universal time coordinated. Launch time is 30 min earlier; the stated time represents the approximate midpoint of the flight.

these reviews is to achieve an efficient handoff of instruments and facilities from instrument mentors to site operators. Figure 2, the SGP CART instrumentation implementation flowchart, represents information obtained from the PRR and ORR documentation. When all procedures, operation manuals, and training pertaining to an instrument have been completed, the instrument is accepted by site operations management. If sufficient documentation is available to operate an instrument, even though more will ultimately be required for full acceptance, the instrument may be operated in a degraded mode.

Instruments recently installed or expected to be installed include the following:

- *Narrow-Field-of-View Zenith-Pointing Filtered Radiometer (NFOV), Installed.* An uplooking, near-IR, shortwave radiance instrument (the NFOV) with a field of view overlapping or nearly coincident with that of the microwave radiometer (MWR) and possibly the cloud radar was installed in summer 1998. The wavelengths detected are in a fairly narrow band near 0.9 μm. Such a device is needed to improve understanding of the relationships between the liquid water path and shortwave radiation.

- *Chilled-Mirror Dew Point Hygrometer (CMDEWP) Instruments, Installed.* This instrument was originally loaned to ARM by Scott Richardson (University of Oklahoma) for past SGP CART site IOPs. ARM has procured three CMDEWPs and a logger for placement at the 25-m and 60-m levels on the 60-m tower and at the temperature, humidity, wind, and pressure sensors (THWAPS) location at the central facility. The CMDEWPs need to be installed only before specified IOPs and campaigns. These instruments are ready for deployment in 1999.

- *Scanning Spectral Polarimeter (SSP-3) Addition to the Optical Cluster at the Central Facility, Installed.* Graeme Stephens requested and provided this instrument in September 1998. The SSP-3 is not a CART instrument, but it does provide an opportunity for comparison with other instruments. The SSP3 will be treated as an IDP instrument and will be operated for an extended (indefinite) period.

- *Humidified Nephelometer Addition to Aerosol Observation System (AOS) at the Central Facility, Installed.* In December 1998, a second (humidified)

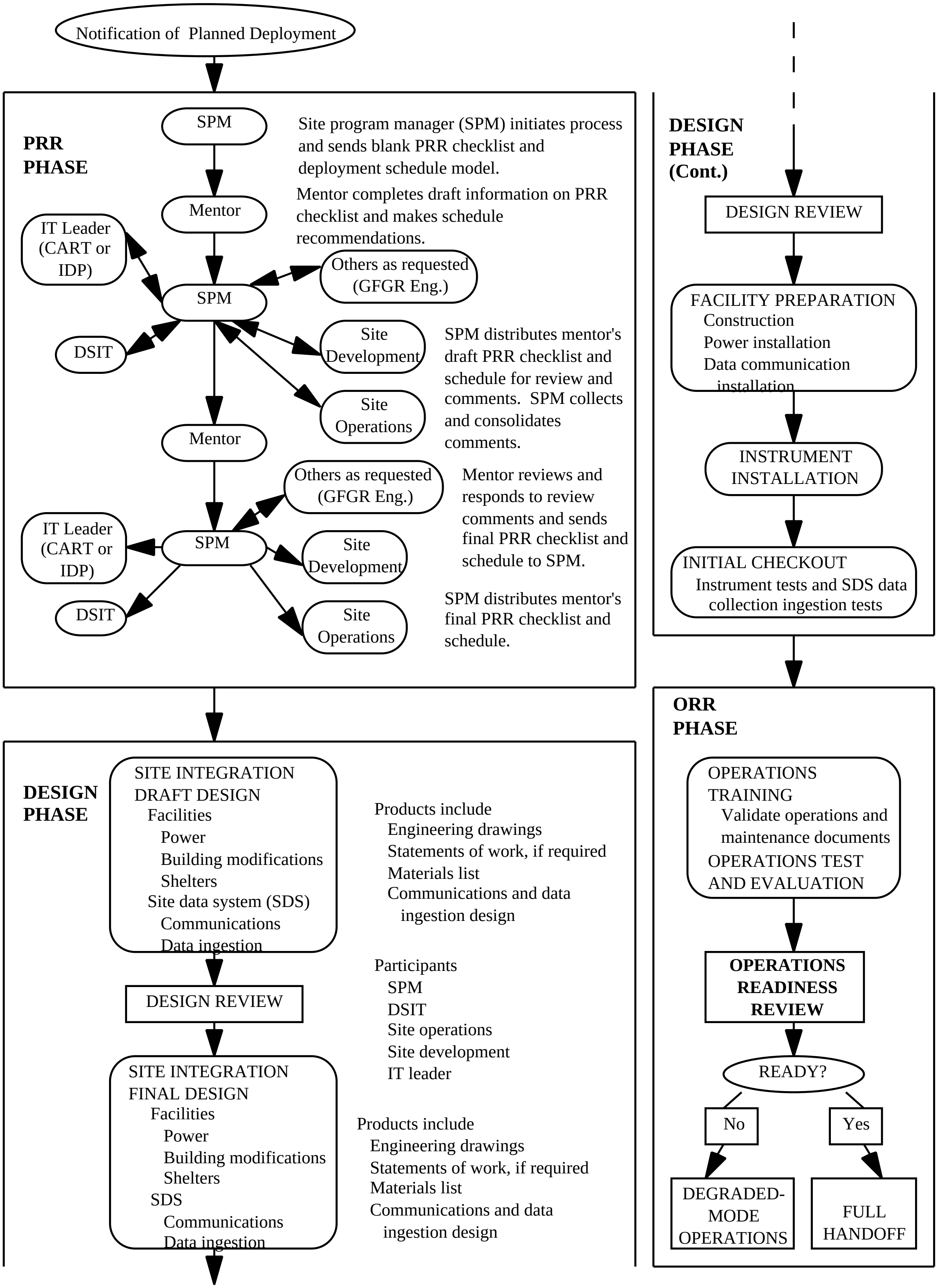

FIGURE 2 SGP CART Instrumentation Implementation Flowchart

nephelometer was added to the AOS to allow determination of the dependence on relative humidity of aerosol light scattering coefficients.

- *Humidified Nephelometer Addition to Aerosol Observation System (AOS) at the Central Facility, Installed.* In December 1998, a second (humidified) nephelometer was added to the AOS to allow determination of the dependence on relative humidity of aerosol light scattering coefficients.

- *Ceilometers and Atmospherically Emitted Radiance Interferometers (AERIs) at Boundary Facilities, Installed.* Vaisala ceilometers and AERIs were installed at the four boundary facilities in December 1998. The Vceils can detect cloud base to a height of about 2.5 km. They are intended primarily to provide data for algorithms to retrieve profiles of temperature and humidity in the lower troposphere from AERI data. Infrastructure modifications necessary for the new AERIs were made at the boundary facility trailers before either AERIs or Vceils were deployed. The AERIs were installed as delivered.

- *Eppley 8-48 (Black and White Pyranometer) Radiometer Added to the Solar and Infrared Radiation Station Testbed at the Central Facility, in Progress.* When it is used to measure diffuse radiation, the Eppley 8-48 does not exhibit the apparent daytime offsets observed by the CART PSP instrument in the SIRS. The Eppley 8-48 will be installed in the SIRS testbed at the central facility in early 1999.

- *Eppley Total Ultraviolet Radiometer Added to Baseline Surface Radiation Network at the Central Cluster at the Central Facility, in Progress.* The TUVR will measure total UV radiation and will be included in the conversion of the BSRN to a BRS platform in summer 1999.

- *Upgrades of the Balloon-Borne Sounding System, in Progress*. Steps have been taken to upgrade the CART BBSSs to use GPS-based rather than loran-based tracking for determining position, a necessity during the next few years as loran-C transmitters are phased out. In addition, a new type of Vaisala radiosonde, in which the RS-90 sonde replaces the RS-80 version presently used, is expected to become available this year. The humidity sensor on the RS-90 sonde is reported to have a faster response and to recover more quickly after it emerges from clouds. The temperature sensor is smaller and thus is probably considerably faster in response and less susceptible to the effects of heating by solar radiation. Reference THWAPS will be operational at each of the four boundary facilities by late winter 1999.

- *Ultraviolet Spectral Radiometer (UVSR), in Progress*. A UVSR (Lee Harrison, State University of New York-Albany, with funding from the USDA) should be available for installation in the spring of 1999. This instrument will measure total horizontal irradiance at 290-360 nm.

- *Installation of a USDA UV-B Radiation Monitoring Program Site at the Central Facility, in Progress.* Dave Bigelow (NREL) has requested and received approval for the installation of small array of instruments including an MFRSR (identical to those used by ARM), a UV-MFRSR (Harrison design), a Yankee UV-B broadband radiometer, various meteorological sensors, and a data logger. Installation is planned at the central cluster in spring 1999.

- *Establishment of Instruments on an Extended Facility at a Forested Site, in Progress.* A walk-up scaffolding tower (approximately 18 m) was erected in the summer of 1997 at the Okmulgee extended facility. The tower supports an ECOR system, a surface meteorological observation station (SMOS), and a SIRS above the forest canopy. All infrastructure support was completed in May 1998. Phased implementation of instrumentation is scheduled for late FY 1999.

- *Absolute Solar Transmittance Interferometer (ASTI), in Progress*. Operation of the ASTI will continue in IOP mode as requested. A permanent location just south of the optical trailer at the central facility will be completed by the end of January 1999. The ASTI has been requested for the spring SCM IOP (March 1999).

Measurement issues currently under consideration but unresolved by ARM infrastructure include the following:

- *Optical Transmissometer, in Progress*. A commercially available transmissometer may be acquired to detect fog, dust, and drizzle too light to be recorded by rain gauges. Such phenomena are best detected by open-path devices rather than through a large sampling stack like that being used with the AOS. The data will be useful for evaluation of signals from radars, lidars, and the MWR.

- *Continuous Direct-Beam Solar Irradiance Measurements with a Cavity Radiometer*. Documentation for the BSRN specifies that an all-weather, windowless cavity radiometer be operated at a BSRN site. This task is not feasible at the SGP CART site central facility because of dusty conditions. Operation of a windowed cavity radiometer, one of which has already been purchased for this purpose, might be possible at the RCF, but considerable effort would be required for continuous operation. Some compromise for part-time or discontinuous operation might have to be developed. Cavity radiometers were operated during the Fall 1997 Integrated IOP and during BORCAL operations.

- *Local Observations of Surface Vegetative Conditions at Extended Facilities*. The interpretation of data on, and the modeling of, surface latent and sensible heat fluxes at extended facilities would be assisted by routine observation of leaf area index and surface optical reflectance properties, represented by the nondimensional vegetative index. Local leaf area index measurements might be too variable to be of much use, but local measures of nondimensional vegetative index are believed to be particularly important for interpretation of nondimensional vegetative index values derived from remote sensing data from satellites. The satellite data could then be used to help infer the values and variability of surface heat fluxes for the overall SGP CART site. Relatively simple devices that measure nondimensional vegetative index can be obtained at a modest cost and are currently being investigated.

- *Additional Extended Facilities at the SGP CART Site*. Some concern has been expressed that the spatial coverage of extended facilities for measuring air-surface exchange rates of heat and moisture seems to be incomplete, particularly to the south and southeast of the central facility. A review of the current site distribution is underway.

- *Surface Bidirectional Reflectance*. Measurements of surface bidirectional reflectance have been suggested at times for the SGP CART site. A commercial portable apparatus for rapid acquisition of bidirectional observations of the land and the atmosphere (PARABOLA) is available, but the system is not suitable for routine observations. Such observations would be quite useful in interpretation of solar reflectances seen from satellites. A Science Team project is now addressing this observational need.

- *Profiling with Passive Microwave Systems*. A passive MWR for obtaining profiles of temperature through clouds could augment or supplant profile measurements made with the AERIs at the boundary facilities. The primary advantage of microwave profiling is that it penetrates clouds, unlike any of the water vapor remote sensing systems currently in operation at the SGP CART site. Radiometrics has been developing such a system. Vertical resolution appears to be about 100 m near the surface, increasing gradually to more than 2 km at a height of about 10 km, near the maximum range. A less expensive Russian system with slightly greater vertical resolution and a maximum range of about 600 m is currently being evaluated. If funding were provided, a passive system for water vapor profiling might also be developed successfully.

3.4 Baseline Change Request

Once site operations personnel have accepted instruments, their design and configuration are "locked in" by using a configuration management system that is controlled by site operations. Any modifications to instruments or data systems that could affect more than one ARM functional group require a baseline change request (BCR). The BCR process is in a secure Web-based system. A BCR submittal form can be found at

http://www.arm.gov/docs/sites/sgp/forms/bcr.html .

The BCR requests usually come from instrument mentors. The site program manager, the control point for the BCR process, assigns infrastructure support for review and approval. Individuals participating in the review and approval process are given passwords for access to the BCR database. A critical BCR requires response within 24-48 hours, a very important BCR within 3-5 working days, and an important BCR within 5 working days.

3.5 Development of the Site Data System

Several installed instruments and all new instruments require software to transfer the data from the instrument platforms to the SDS via a pathway referred to as the integrated data processing circuit (IDPC). The IDPC handles communications between the instrument and data loggers and the data ingest system (described more fully in Section 4.1), transfers reports on instrument status to site operations staff and others, and transmits data to the Experiment Center and the Data Archive. Usually, data transfer is accomplished by coded switches at the extended facilities and intermediate facilities or by T-1 lines at the boundary facilities. Most of the ARM SGP instruments have their data collected (or delivered) to the SDS regularly, with data processed through the IDPC and passed on to the Experiment Center and the Data Archive. Some exceptions to this paradigm will continue to occur during the next six months.

The IDPC development schedule and the status of instruments can be found at the Web site

http://www.res.sgp.arm.gov/SDSMgtSite/application/idpc_status.htm .

Further work is in progress to facilitate routine operations, particularly to assess instrument performance, by including a broader suite of data display capabilities. When the SDS is near completion, procedures for system management and maintenance need to be written and transferred to site operations staff.

The SDS continues to address the need to make near-real-time data available through the Research System for instrument mentors, for selected scientists during IOPs and campaigns, and for educational outreach efforts in conjunction with outreach projects of the Oklahoma Climatological Survey (OCS).

3.6 Observations, Measurements, and External Data

External data being delivered to the ARM Program can be found on the Web at

http://www.xdc.arm.gov/ .

The availability of data from a particular platform on any given day is a function of the quality assurance process; some segments are temporarily unavailable during evaluation or correction of problems.

3.7 Site Development Activities

Full implementation of the permanent El Reno extended facility took place during the last six-month period with the final establishment of communications.

In anticipation of the need for additional IDP area facilities, IDP No. 4 was further developed. This 150-ft × 175-ft graveled area is located at the site formerly occupied by the farmhouse at the extreme southeast corner of the central facility. This area has a double-wide trailer (24 ft × 55 ft) for storage and a 12-ft × 50-ft office trailer. The storage facility will serve all three CART sites for ready-to-deploy spare instruments and instrument spare parts. Phased development will continue.

A major activity will be the replacement of 22 SMOS towers at the extended facilities and the central facility. The new towers are lightweight, single-mast, counter-weighted, tipping structures that require no guy anchors. The replacement activity has been led by Dan Nelson, and Wayne Meadows will be the technical safety representative in the field. A subcontractor will install the towers. The activity is expected to be completed by April 1999.

The Raman lidar (RLID) will be given a UPS to enable continuous operation through power dips. The RLID system shuts down the lidar when power dips below 110 V AC. On the basis of last year's operating statistics, providing continuous regulated power to the RLID would increase its operation by 40%. The three-phase UPS is large and requires an environmentally protected shelter that will be located to the west of the RLID. This activity is expected to be completed by March 1999.

The optical trailer, the RCF trailer, and the RLID cloud radar shelters are protected by an automatic carbon dioxide fire suppression system. A thorough review and testing of these systems occurred in August 1998, after an incident resulting in the accidental discharge of a carbon dioxide fire suppression system and a fatality at a DOE-managed facility in Idaho Falls. Although the SGP systems were in compliance, additional improvements were made to further reduce the risk to personnel and visitors. The need for carbon dioxide systems in the optical and RCF trailers is currently being reassessed.

4 DATA QUALITY

Data quality issues are addressed at several levels within the ARM Program and at the SGP CART site. One of the primary goals of the ARM Program is to provide data streams of known and reasonable quality. Maintaining data quality for a program of this size and complexity is a significant challenge. Data quality assurance within the ARM Program infrastructure has matured over the past few years and will continue to evolve, with the SST continuing to play a significant role. Data flagging issues, development of a mechanism for displaying information on data quality to data users, and addressing the data quality of new instruments continue to be the focus for this six-month period.

4.1 Instrument Mentors

Instrument mentors are charged with developing the technical specifications for instruments procured for the ARM Program. The instrument mentor then tests and operates the instrument system (either at his or her location or at the SGP CART site). In addition, the mentor works with SDS personnel on data ingest software requirements as part of the IDPC. Data ingest involves the conversion of data streams to the International System of Units (SI), as well as the acquisition of parameters that can be used to monitor instrument performance (e.g., monitoring an instrument's output voltage for a 5-V power supply or the continuity of the wire in a hot-wire anemometer). Data collection and data ingest, then, are the focus of the first level of data quality assurance. Quality at this level is monitored routinely by instrument mentors and site operators.

The next level of data quality assurance involves beta release of data streams from individual instruments. The mentor receives the data from the instrument to determine whether the technical specifications of the instrument are being met. When the mentor is satisfied that the instrument is functioning properly and that the technical specifications have been met, the data are formally released to the Science Team and other data users. After this release, the instrument mentor is charged with reviewing the instrument data streams at least once every two weeks, an action monitored at the Experiment Center. This information is forwarded to the SST.

Instrument mentors provide all calibration, operations, and maintenance documents and lists of spare parts to site operations. Typically, the mentor provides additional detailed documentation and hands-on training so that appropriate support can be offered by site operators. This activity is part of the ORR process.

4.2 Site Scientist Team

The SST helps to ensure that the scientific productivity of the SGP CART site is maximized by both the routine and special (IOP) operations at the site. The SST acts as a resource for the site operations manager and his staff on scientific matters by doing the following:

- Working with site operations personnel and instrument mentors on potential instrument problems

- Reviewing proposed instrument siting and deployment strategies, including the needs of the instrument mentors and instrument requirements for IOPs and campaigns

- Reviewing schedules and procedures for instrument calibration and maintenance

- Providing an early quality assessment of suspected instrument or data problems through the use of performance metrics, graphic display techniques, and data quality research investigations, as well as distributing the findings so that corrective actions can be taken

- Planning and conducting IOPs and campaigns

These activities require constant communication with site operations staff, including routine visits to the central facility and occasional trips to extended, intermediate, and boundary facilities. These activities are also highly coordinated with the site program manager and, when appropriate, with instrument mentors and DSIT personnel. Ongoing focus activities of the SST will contribute to the goals of data quality assessment for the SGP CART site and ensure that the operation of the site meets, as nearly as possible, the overall scientific goals of the ARM Program.

In the past, data quality assessment efforts of the SST largely involved evaluation of individual and multiple sets of data streams as needed, on an exploratory or developmental basis (data quality investigations); participation in QMEs; and participation in the creation and workings of the VAP Working Group.

Now that operational activities have shifted from deployment to support of ongoing, continuous operation of a wide variety of instrumentation at many locations, a more comprehensive, systematic data quality assessment effort has been undertaken by the SST. This effort is manifested in several ways, including the development of automated graphic display techniques for use by the SST in daily monitoring of data quality (initiated in October 1995), the development of performance metrics that systematically determine the percentage of the collected data falling within given quality tolerances (initiated in February 1996), and evaluation of the calibration and maintenance information.

The development of performance metrics is aimed at determining the quality of the site data via time series (numerical and graphic) of the metrics. In late 1996, the SST began issuing assessments of the data from several instruments, with the goal of quicker resolution of instrument and data quality problems. In 1998, a Web site containing graphic displays of performance metrics and other quality assessment techniques was established at

http://www.res.sgp.arm.gov/sst/dq_monitor/DISPLAYS.html .

Plans for this six-month period include continued development of graphic display techniques for more data streams, continued development and display of performance metrics, continued evaluation of the calibration and maintenance information, and continued participation in an ARM-wide data user interface (the MDN) initiative that will make information on data quality more readily available to data users. The SST will begin to construct summary statistics describing metrics performance during this six-month period. Thus, with the assistance of the site operations staff and instrument mentors, the SST will be able to serve the ARM Program goals better by laying a foundation for improving data credibility. See Peppler and Splitt (1998) for more detail about ARM SGP data quality techniques.

Revisiting the charge given to the SST and its roles and responsibilities within ARM will clarify SGP CART site operation and sources of help with issues related to the site. The SST's main role, as mentioned above, is to ensure the integrity of the scientific products of the SGP CART site. This role is embodied in the following broad task areas: (1) provide on-site scientific guidance for day-to-day operational decisions affecting ARM's research programs; (2) monitor, analyze, and document data quality and provide regular, frequent assessments of the results; (3) develop the site scientific mission; (4) conduct an ARM-approved research program focused on the SGP site and designed to further the objectives of the ARM Program; (5) participate as a full member to the ARM Science Team; and (6) direct an educational outreach program designed to interest precollege, undergraduate, and graduate students in scientific and technical disciplines.

The SST, defined as a “neutral” position within ARM, acts as the scientific liaison among the other parts of ARM, including science and infrastructure, to ensure the scientific integrity of SGP CART site operations. The SST must be proactive in communicating with ARM’s various science and infrastructure groups to collect information on issues and help determine optimal solutions. Maximizing the scientific potential of the SGP CART site, whether during routine daily operations or focused periodic experiments (IOPs), should be the main goal of the SST. The current makeup of the SST allows effective achievement of this goal.

The SST is the group within the ARM Program that assesses whether the site is providing the data that will allow the program to achieve its goals. This role involves evaluating the routine, daily operations, as well as suggesting and planning the most productive IOPs possible. Ensuring data quality is at the heart of the SST’s responsibilities. The SST achieves these goals by interacting with all of ARM’s various functional groups to collect information that will support informed decisions and appraisals.

This coordinated activity will be particularly important during the next three years, because the SGP CART site is essentially complete according to original plans. Now the SST must focus on a critical assessment of the current instrumentation suite at the SGP CART site. The important question is whether the SGP CART site is truly satisfying the needs of the ARM Science Team. The SST must also consider how ARM data will be compiled in a permanent record, and whether the data in their current state are of sufficient quality to satisfy researchers 10 or 20 years in the future. The SST must continue to plan and operate IOPs in the next three years that will help to solve the key scientific and measurement problems that the various scientific applications groups will encounter. The ARM Program, with strong participation by the SST, will address these priorities by operating a research facility (the SGP CART site) that can accommodate the evolving needs of the scientific community.

During the last six years, ARM Program participants have learned much that can be applied to future problems. The routine deployment of instrumentation has generated a tremendous amount of knowledge about what works and how to remedy problems. Routine operations have led to improved broadband radiometry and procedures for launching radiosondes. The focused IOPs have taught Science Team members much about the measurement of atmospheric state parameters such as water vapor. In the future, we must use our experience to better understand such issues as spectral radiometry and cloud radar measurements and must conduct IOPs that lead to further discoveries in the areas of solar radiation and aerosols and their relationships to clouds. By optimizing the operation of the SGP CART site during both routine and intensive operations, the SST can contribute to these goals.

The personnel making up the SST have various responsibilities. The site scientist, Peter Lamb, oversees the SST and contributes to the discussion and resolution of higher-level issues with ARM Program management. His interactions involve the development of both short-term responses to ongoing problems and longer-range planning to accomplish the ARM Program's overall scientific objectives. He does this by participation in the ARM Science Executive Committee and selected meetings and teleconferences, as well as by acting as a liaison for ARM to other federal and state agencies concerning the broader scientific and funding potential of the SGP CART site.

The associate site scientist, Randy Peppler, is the SST's primary daily contact point to the ARM Program at large. He oversees the tasks of the assistant site scientists and helps coordinate scientific issues facing the site with others in the ARM Program. He has primary contact with the site program manager and the site operations manager and has become part of the daily decision-making process at the site. He is also the SST's chief contact to the Science Team, IT, and DSIT. With the site program manager, site operations manager, and ARM technical director, he is a key part of the process of planning, developing, and operating IOPs.

The assistant site scientists (Mike Splitt and Chad Bahrmann) have the vital role of data quality analysts for the SGP site. They are focal points for the development of algorithms to perform data quality analyses, with the goal of achieving known quality (instruments are working to expectations) and reasonable quality (measurements are the best possible for a given geophysical parameter) for all ARM data streams. Splitt and Bahrmann also interface with others in the ARM Program who deal with data quality (particularly the IT and DSIT) and are part of a broad ARM initiative to build a data user interface that will communicate ARM data quality to anyone wishing to use the data. The senior assistant site scientist (Splitt) also helps to plan and implement IOPs and participates in decision-making discussions on science issues facing the site. The junior assistant site scientist (Bahrmann) works daily at the SGP central facility as the ARM Program's on-site scientific presence. He daily assists the site operations manager in running the SGP CART site smoothly. He also acts as the site's local goodwill ambassador, representing ARM to the local community.

The SST Research Team (Peter Lamb, Yefim Kogan, Zena Kogan, Mikhail Ovtchinnikov, Scott Richardson, Claude Duchon, Mike Splitt, and colleagues) conducts research on scientific and measurement issues facing the SGP CART site. This research is subject to approval by the ARM Program and is based on the stated goals and perceived needs within the program and on the expertise of the participating scientists. The areas of particular interest during the next three years include microphysics, radar meteorology, and measurement of the atmospheric state (particularly water vapor), soil moisture, and solar radiation.

The SST Educational Outreach Team (Ken Crawford, Renee McPherson, Andrea Melvin, and colleagues) directs the ARM SGP thrust pertaining to the U.S. Department of Energy's (DOE's) educational outreach priorities. This program is designed (1) to interest precollege and undergraduate and graduate students in scientific and technical disciplines and (2) to provide easy access to ARM data and to coordinated, pedagogically sound lessons. Over the next three years, this team will promote ARM outreach beyond Oklahoma and Kansas to the national educational community.

Scientific priorities for operation of the SGP CART site during the next three years include, in particular, the following:

- Continue facilitation of all data quality assessment efforts, particularly those focused on the development of a full suite of data analysis tools, participation in the development of an ARM data user interface, implementation of new QMEs and VAPs, and better dissemination of information on data quality

- Conduct a complete assessment of the measurement capability of the SGP CART site as it pertains to the needs of the ARM Science Team

- Conduct a complete assessment of current instrument calibration and maintenance procedures and the way they are implemented

- Finish the establishment of routine SGP CART site operations

- Plan and implement key IOPs and campaigns

- Continue beneficial collaboration with other national programs and explore new ones

- Support the IDP

To operate the site, numerous individual subtasks are performed daily by the SST, site program manager, and site operations manager. The purpose of these activities is to allow all scientific and infrastructure groups within ARM to achieve the goals and objectives the ARM Program has set for the SGP CART site in the years to come.

4.3 Value-Added Products and Quality Measurement Experiments

Unlike many other scientific projects, ARM collects data in an ongoing, continuous manner. Because of the volume of the perpetual data streams, traditional case study methods for analyzing the data are not very effective. To fit the need for an automatic analytical approach, the concept of a VAP (value-added product) has been defined. A VAP creates a "second-generation" data stream by using existing ARM data streams as input and applying algorithms or models to them. A VAP is run continuously in the ARM Experiment Center, and the output generated is treated as a new ARM data stream.

Many of the scientific needs of the ARM project are met through VAPs. Physical models that use ARM instrument data as input are implemented as VAPs and can help to fill some of the unmet measurement needs of the program. The VAPs in the special class called QMEs compare different data streams for consistency and allow for continuous assessment of the quality of the data streams. These data streams may come from direct measurements, measurements derived from instrument observations via other VAPs, or model output that is currently created by other VAPs.

New VAPs or suggestions for improvements or modifications to existing VAPs come from all areas of the ARM Program: the Science Team, instrument mentors, the DSIT, the Data Archive, the SST, etc. However, because of the limited resources available, VAP development must be prioritized to be meaningful. To this end, the VAP Working Group was established. This group consists of members of the infrastructure across the program, with representatives from each of the major scientific areas of ARM. This group discusses the scientific objectives of each VAP in the development queue, looks for common threads among the VAPs, assigns priorities, estimates completion dates, and assists in developing the VAPs. The SST is represented on the VAP Working Group. The VAPs currently available are listed in Table 3.

TABLE 3 Value-Added Products in Place at the SGP CART Site[a]

Value-Added Product	Description
LBLRTM	Line-by-line radiative transfer model; used for longwave and microwave radiance calculations
QME AERI/LBL	Comparisons of observed (AERI) vs. calculated (LBLRTM) longwave downwelling radiation
QME MWR/LBL	Comparisons of observed (MWR) vs. calculated (LBLRTM) microwave radiance at two frequencies
QME AERI/LBL CLOUDS	State-of-the-atmosphere data to facilitate QME AERI/LBLRTM analysis
RWP TEMP	Merged and quality-controlled RASS virtual temperature profiles
MWR PROF	Retrievals of water vapor, liquid water, and temperature profiles from a suite of ground-based instruments
QME MWR PROF	Comparisons of retrieved water vapor and temperature profiles from MWR PROF with BBSS profiles
AERI PROF	Retrievals of temperature and water vapor from the AERI data
QME AERI PROF	Comparisons of retrieved water vapor and temperature profiles from AERI PROF with *in situ* measurements
QME MWR COL	Comparisons of the MWR with an instrument performance model
RLID PROF	Profiles of water vapor mixing ratio, aerosol scattering ratio, and depolarization ratio from the Raman lidar
RLAER	Profiles of aerosol backscatter and extinction, together with "best-estimate" profiles of water vapor mixing radio, relative humidity, and aerosol scattering ratio
LSSONDE	Radiosonde profiles, where the moisture profile is scaled to match the MWR's total precipitable water vapor

[a] AERI, atmospherically emitted radiance interferometer; BBSS, balloon-borne sounding system; COL, column; LBL, line by line; LBLRTM, line-by-line radiative transfer model; MWR, microwave radiometer; PROF, profile; QME, quality measurement experiment; RASS, radio acoustic sounding system; RLID, Raman lidar; RWP, radar wind profiler; TEMP, temperature.

More information is available on the Web at

http://www.arm.gov/docs/research/vap_homepage/vap.html .

In September 1997, DSIT Experiment Center staff introduced, in beta release, the Shortwave Radiation Best Estimate data product for the central facility. The goal of this product is to create one data stream that holds all (or most) of the central facility data products of interest to the shortwave research community. Multiple measurements of the same parameter (e.g., SIRS and BRS sensors) are handled by designating one as the primary measure and using the other(s) to fill any gaps. Some data quality comparisons between like measurements are also included. Components of this tracking system cover ten measurement components: downward hemispheric flux, direct broadband component, diffuse broadband component, direct spectral component, diffuse spectral component, optical depth, net shortwave surface radiation, broadband albedo, spectral albedo, and calculated quantities (zenith angle, effective top-of-atmosphere horizontal flux). This data product remains under development as measurement areas are implemented. This shortwave data product will be followed by one for water vapor and then others for other key ARM geophysical parameters (Section 2.1). These products are available from the ARM Experiment Center.

4.4 ARM Information Architecture

The tasks of (1) incorporating what is known about data availability and data quality and (2) linking this knowledge directly to individual measurements in a way that is easily identifiable by data users, such as by data flagging, continue to be accomplished through development of the MDN, part of the ARM information architecture (AIA).

The first of four levels of data quality inspection is part of the data ingest routine, where minimum/maximum and delta limits, if exceeded, are stamped. The second level is provided by the instrument mentors. Although each mentor may have a unique methodology for data inspection, it is the mentor’s expert view that identifies suspect data points for a particular instrument. The third level of review looks for consistency of data between instruments by using data quality metrics and data stream comparisons. This level is provided by the SST. The fourth level of data quality inspection is the VAPs and QMEs, which have been driven by Science Team needs and implemented by the ARM Science Applications Working Group.

A communication interface about data availability will be established by color-coding measurements obtained from a particular instrument, with different colors to indicate the availability of data and the quality of the data for a daily aggregate. Pointers will be developed to direct the data user to details of the particular data quality inspection methodology for each measurement. For example, all existing data will be color-coded white. Missing data will be color-coded black. Data reviewed by an instrument mentor and judged to be of acceptable quality will be color-coded green. Suspect data values will be color-coded yellow. Data identified as not usable will be color-coded red. The color of the data will change to reflect the most current view of the quality of the measurement. The entire process is intended to be automated with a manual override capability. The first version of the MDN, scheduled for delivery in early 1999, will contain all of these features. In addition, a plan is being defined to assign a data quality flag to each existing data value. The flagging system will determine the color of the data and will be part of the MDN’s second version, scheduled for completion in 2000.

Quick-looks plots are currently under discussion. These plots are intended to provide the data user with a visual data inspection capability, especially if data are color-coded yellow and require further inspection and interpretation. They are scheduled for the second version of the MDN.

Activities that fall under the AIA address all three ARM CART sites. Milestones during this six-month period include the following:

- Data availability will be captured. (That is, available parametric data will be color-coded white; data that do not exist will be color-coded black.)

- The instrument mentors and SSTs will be able to color-code the parametric data manually.

- Data quality reports will be received along with parametric data.

Suspect measurements may still be usable data to some or even most of the data users. The ARM Program provides the searchable MDS database, which provides (1) information about the scientific utility of the data gathered at the SGP and the other two CART sites and (2) information to enhance the operation and assist in the maintenance of the SGP and other CART site systems. Information in the SGP MDS can be produced by the processes that collect data from instruments and generate ARM data streams, by site operators as they perform their duties, or by anyone in the ARM community via electronic mail messages that are forwarded to the MDS entry-processing software. Specifically, information provided by the SGP site operators includes hourly weather observations, general operator entries with subjects chosen from a list (data system, suspect data, site general, revision, other), general instrument maintenance reports on specific corrective maintenance for instruments, reports on surface conditions at extended facilities, weather alert status reports, and instrument preventative maintenance procedure summary reports. The contents of the MDS database and its location are discussed in Section 3.2.

4.5 Problem Review Board

A system for identification and resolution of problems has been established to permit anyone to easily report a real or perceived problem found to be affecting, or to have the potential to affect, the overall quality of an ARM data stream or product. The problem could be a faulty instrument; the way an instrument is sited, maintained, calibrated, or operated; or software errors in processing the instrument’s data or perhaps in some external data acquired for ARM data products from other programs. The person reporting the problem does not need to understand it or have a solution in mind. However, the person reporting the problem must be able to describe the symptoms or provide sufficient evidence to allow others to solve the problem. The overall goal is to identify problems in a timely way, so that they can be assessed, prioritized, and resolved as quickly as resources allow.

The problem-reporting system has several components. The process begins with the completion and submission of a Problem Identification Form (PIF). The PIFs are received by the Problem Review Board (PRB), which is composed of representatives from the DSIT and the IT, along with the site program managers. The PRB meets weekly via teleconference and assigns responsibility for analysis and resolution. Resolution is documented in a Corrective Action Report (CAR). A copy of the CAR is sent to the originator of the PIF to ensure that resolution of the problem is communicated.

In addition, a Data Quality Report (DQR) may be required. A DQR is a statement about the quality of data from a particular instrument. The information could be quite simple (e.g., stating that an instrument system was turned off and the data do not exist) or quite complex, giving detailed analyses and equations that should be used to adjust the instrument’s data. Hence, the description of the problem and the solution must be complete, so that someone can accurately correct the data.

The PIF, CAR, and DQR forms are accessible from multiple points on the ARM Web site. The PIF/CAR/DQR database can be found on the Web at

http://www.db.arm.gov/PIFCARDQR/ .

5 SCIENTIFIC INVESTIGATIONS AND OPPORTUNITIES

In 1994, the ARM Program identified a need for the creation of a Site Advisory Committee (SAC) to provide assistance to the ARM Program Science Team, the SGP CART SST, and the SGP CART site program manager. The SAC's charter is to

- Evaluate the SGP CART site's scientific mission,
- Provide scientific mission guidance for SGP CART site operations,
- Evaluate the research program of the site scientist,
- Evaluate the potential for collaboration with other research programs, and
- Provide recommendations for the SGP CART site's educational outreach program.

The seven-member SAC is composed of ARM and non-ARM Program scientists who meet formally at least once per year. The first such meeting was held in November 1995 at the University of Oklahoma (OU), and a follow-up meeting was held there in June 1996. Written reports summarizing the SAC's recommendations on the basis of these two meetings were distributed to the ARM Management Team, the SST, the site operations manager, and the site program manager. The SST responded in writing. Individual SAC memberships last for three years. A meeting is being planned for early during this six-month period.

5.1 Intensive Observation Periods

The SGP CART site operates a vast suite of instrumentation that routinely provides continuous data streams at a prescribed rate. These rates, however, can be changed upon request. Requests from inside and outside the ARM Program can be made through the SGP CART site program manager's office either (1) to operate an ARM instrument or instruments at a different data collection rate or in a different mode of operation or (2) to support and compare non-ARM instruments with ARM instruments. Such periods of special operation are referred to as IOPs.

Requests for IOPs can be made by the ARM Science Team, ARM Program infrastructure staff, or the scientific community at large. Preference for IOPs is given to the ARM Science

Team and infrastructure staff. The ARM Program has a limited budget for IOP support. However, funding from sources other than the ARM Program can be accepted to support IOPs or campaigns.

The BBSS is the instrument most frequently requested for operation at an accelerated data collection rate and is the primary driver for the timing of IOP requests. The SGP CART site has five locations where BBSS instruments are operated routinely. To achieve an accelerated data collection rate, simultaneous radiosonde launches can be made every three hours at all five locations for a 21-day period or longer.

The ARM Program provides funding for two or three of these three-week-long, accelerated BBSS launch periods per year, which are referred to as SCM IOPs. In the past, two SCM IOPs were held in fixed time periods, one in spring and one in summer. A third SCM IOP alternated between winter and fall. As the SCM Working Group's research has progressed, SCM IOP periods have become somewhat more selective, on the basis of research priorities at the time. Although the ARM Program supports and encourages multiple, concurrent IOPs during SCM IOP periods, IOPs involving accelerated BBSS launches at other times of the year are considered as the budget allows.

Requests for IOPs come through the SGP CART site program manager's office. The initial requests can be made informally, but an abstract of the goal(s) of the experiment(s) being requested, a list of the potential instruments and platforms involved, and the time period of the experiment(s) must be provided for approval. The requester must identify points of contacts for coordination.

Approval of an IOP is an external process that requires (1) review for resources and relevancy and (2) approval by the ARM Program technical director, the SGP CART site program manager, the SST, and site operations staff. After approval, the management of the detailed operational planning, setup, conduct, and shutdown of the IOP is the responsibility of the site program manager.

An IOP is given a title and assigned a DSIT representative, who has the responsibility to obtain the relevant scientific information about the proposed activity, typically in a science plan. The DSIT representative informs ARM Science Team members of the proposed activity for the purpose of potential collaboration. The SST has taken an increasing leadership role in this activity, beginning with the fall 1996 Water Vapor IOP.

The site program manager obtains from the DSIT representative a list of potential principal investigators (PIs) and the instruments or systems that are intended to be located at the SGP CART site. The site program manager then sends an IOP questionnaire to the PIs to collect information about the operational, safety, and data requirements of the IOP. The IOP questionnaire is returned to the site program manager's office and is distributed to the appropriate ARM infrastructure personnel for review. The IOP questionnaire can be entered electronically by a PI on a Web site at

http://www.arm.gov/stdocs/internal/iop_form.html .

The ARM infrastructure groups include the SGP CART site program manager, the SGP CART site SDS team, the DSIT representative, the SST, and site operations staff. Each of the ARM infrastructure groups has a specific role in the planning and implementation of the IOP.

The SDS representative assesses the data requirements, both those requested from ARM by the participating PI and those to be provided to ARM by the PI. A schedule of data delivery is established. The DSIT maintains a Web site that provides information about IOP planning and status, as well as day-to-day operations activities during the IOP; these data are provided by the SST. The main elements of the IOP Web site include a science plan, each PI's IOP questionnaire, the IOP operations plan, and a daily log during the IOP that identifies and discusses each day's scientific mission.

The SGP CART site SDS team assists PIs who have requested Internet connections at the SGP CART site's central facility. The SDS team assists in establishing the actual interface, as well as limits on the size of data files and the time of data file transfers, so that the PI's data transfers do not affect the SGP CART site's data transfer schedule.

The SST has overall responsibility for coordinating scientific interactions at the SGP CART site. The SST personnel work with the DSIT representative to identify IOP lead scientists. The SST assists the site program manager and site operations staff in locating instrumentation at the SGP CART site. The SST personnel assist in identifying real-time display requirements during IOP operations and identify mission-critical data streams that must be maintained during the IOP. The SST also assists in the creation of a science plan for the IOP and in making operational decisions during the IOP.

Site operations personnel provide IOP safety oversight and support installation of all guest instruments in accordance with requirements identified in the IOP questionnaire. The site operations personnel maintain the operational status of SGP CART site instrumentation and provide triage (quick-response maintenance) for instruments whose data have been identified as critical to the IOP. The operations staff provide PIs with additional logistic support (e.g., liquid nitrogen supplies, phone lines, safety briefings, and power) in accordance with requirements identified in the IOP questionnaire.

The site program manager's office coordinates all activities associated with the IOP. This office produces an IOP operations plan that (1) identifies all of the activities associated with IOPs, including roles and responsibilities; (2) specifies mission-critical instruments and outlines an instrument triage plan; (3) designates the locations of instruments and the SGP CART site facilities to be used; (4) specifies safety and emergency actions; (5) outlines IOP termination and start-up procedures; and (6) lists participants.

The progress of IOP planning activities is monitored via the weekly SST coordination teleconference that takes place on Tuesdays at 11:00 a.m. central time and through other conference calls with IOP participants and ARM infrastructure personnel as needed. The IOP Web interface page functions as a tool to facilitate the coordination and flow of information during all phases of IOP planning, implementation, and operation. The site program manager provides monthly updates in his internal monthly reports. Past, present, and known future IOPs are listed in Table 4.

5.2 IOPs and Campaigns Conducted during the Past Six-Month Period

The IOPs and campaigns that occurred during July-December 1998 are discussed below (see also Table 4).

JPL GPS Campaign. Steve Keihm (Jet Propulsion Laboratory [JPL]) brought a GPS receiver-antenna system, two water vapor radiometers (WVRs), one microwave temperature profiler (MTP), and a surface meteorological package to the central facility. The WVRs operated at frequencies of 20.7, 22.2, and 31.4 GHz. The MTP operated at specified frequencies in the range 51-59 GHz. The purpose of the experiment was to refine the model for atmospheric vapor absorption near 22 GHz by using the radiometer brightness temperature measurements in conjunction with the GPS path delay measurement. The GPS measurements provided a direct

TABLE 4 Intensive Observation Periods and Campaigns

Date	Name	Science Team Member[a]	DSIT Contact[b]	Description	Status
11/92	Field Test of NCAR Flux Profiler	D. Parsons (NCAR)	R. Cederwall	Enhanced soundings at the central facility and profiler site on 11/10-11/19; boundary layer flights on a few days	Completed; data available
4/93	AERI Field Test	H. Revercomb (UW)	J. Liljegren	Enhanced soundings at the central facility requested during the field acceptance test of the AERI instrument	Completed 4/29/93
5/93-6/93	Using the GPS for the Measurement of Atmospheric Water Vapor	Collaborative (UNAVCO and NCSU)	J. Liljegren	Intended to test the investigators' technique for inferring total precipitable water vapor in the atmosphere column by using GPS signals	Completed 6/8/93; data available
6/93	Warm-Season Data Assimilation and ISS Test	D. Parsons (NCAR)	R. Cederwall	Enhanced sampling (in time and space) of the SGP domain for a 10-d period with profilers and sondes; goals were (1) to study the performance of FDDA under thermodynamic conditions typical of the continental warm season and (2) to evaluate the estimates of divergence and vorticity from the prototype NCAR ISS with interferometric techniques, the triangle of three 915-MHz profilers, and the results of FDDA	Completed; all data available at the Experiment Center except for FDDA, which is available upon request at NCAR

TABLE 4 (Cont.)

Date	Name	Science Team Member[a]	DSIT Contact[b]	Description	Status
1/94; 4/94; 7/94; 10/94; 4/95; 7/95; 9/95; 4/96; 7/96; 4/97; 6/97; 9/97-10/97; 1/98-2/98; 4/98-5/98; 1/99-3/99; 9/99-10/99	Seasonal SCM IOP	D. Randall (CSU)	R. Cederwall	Seasonal IOP with enhanced frequency of observations, particularly vertical soundings of temperature, water vapor, and winds at central facility and boundary facilities for periods of 21 d; the required sounding frequency of 8/d; data required for quantifying boundary forcing and column response	Winter and spring 1999 IOPs being planned
4/94; 9/95-10/95; 4/96; 9/96; 9/97-10/97; 9/99-10/99	ARM UAV	B. Ellingson (UoM)	D. Rodriguez	Clear-sky flux profiles acquired by a UAV and surface support data; measurements to be used to understand clear-sky heating rates and the ability of models to reproduce observations	First IOP conducted successfully in 4/94; flight for ARESE IOP in 9/95-10/95; first 24-h UAV flight in 10/96. Plans underway for ARESE Revisited in fall 1999

TABLE 4 (Cont.)

Date	Name	Science Team Member[a]	DSIT Contact[b]	Description	Status
4/94-5/94; 4/95-5/95	Remote Cloud Sensing Field Evaluation	R. McIntosh (UM); B. Kropfli (NOAA); T. Ackerman (PSU); K. Sassen (UU); A. Heymsfield (NCAR); J. Goldsmith (SNL); others	C. Flynn	Field evaluation and calibration of several remote sensing cloud-observing instruments (some from the IDP project); in situ cloud observations critical to success; enhanced soundings required at central facility	Completed; data analysis in progress
5/94	WB-57 Overflight for the Measurement of Atmospheric Water Vapor at High Altitude	Collaborative (Visidyne and Lockheed PARC)	J. Liljegren	Attempt to infer the vertical distribution of water vapor at high altitudes from solar transmission spectra	Completed; preliminary transmission spectra delivered to ARM
5/94	VORTEX IOP	E. Rasmussen (NSSL)	D. Slater	Special launches in support of VORTEX, testing hypotheses on the development and dissipation of severe storms	Completed 5/31/94
8/94	GEWEX/GCIP/GIST IOP	Collaborative	T. Cress	Special launches in support of GCIP and GIST as part of effort to improve climate models by improving parameterizations of hydrologic and energy cycles	Successfully conducted in 8/94
9/94-10/94; 6/95-7/95	Sampling of Coherent Structures with the 915-MHz profiler	R. Coulter (ANL)	R. Cederwall	Fluctuations in the vertical wind and index of refraction observed by operating the 915-MHz profiler with RASS in a special mode during the afternoon hours to sample convective plume structures	Completed

TABLE 4 (Cont.)

Date	Name	Science Team Member[a]	DSIT Contact[b]	Description	Status
4/95-5/95	Simultaneous Ground-Based, Airborne, and Satellite-Borne Microwave Radiometric and In Situ Observations of Cloud Optical Properties and Surface Emissivities	W. Wiscombe (NASA-GSFC); E. Westwater (NOAA-ETL)	D. Slater	Observations of cloud optical properties obtained over the CART site simultaneously from ground-based, in situ, and satellite-borne sensors; spatial variability of surface emissivities assessed to attempt retrieval of total precipitable water and cloud liquid water from the special sensor microwave imager	Completed; involved collaboration between Wiscombe and L. Fedor at NOAA
4/95-5/95	VORTEX-ARM	E. Westwater (NOAA-WPL); W. Wiscombe (NASA-GSFC); G. Stephens and P. Gabriel (CSU); J. Schneider (CIMMS-NSSL)	D. Slater	Joint VORTEX-ARM effort; 45 h of P-3 aircraft time to study stratocumulus clouds; work coordinated with Remote Cloud Sensing IOP	Data exchange completed 12/95
6/95-7/95	Surface Energy Exchange IOP	C. Doran (PNNL); R. Coulter (ANL); R. Stull (UBC)	R. Cederwall	Detailed observations of temperature and moisture profiles in the PBL, obtained within 75-125 km of the central facility by using airsondes and profilers, intended to evaluate the variations in the PBL structure in relation to underlying surface fluxes	Completed; airsonde data available as beta release from C. Doran

TABLE 4 (Cont.)

Date	Name	Science Team Member[a]	DSIT Contact[b]	Description	Status
9/95-10/95	ARESE	Collaborative	T. Cress	Intended to study the anomalous absorption of solar radiation by clouds, a phenomenon first noticed when satellite measurements of solar radiation absorbed by the surface atmosphere were compared with solar radiation measured at collocated surface sites	Completed; data available
4/96-5/96	SUCCESS	Collaborative	R. Peppler	Intended to determine the impact of the current and future subsonic aircraft fleet on Earth's radiation budget and climate	Completed
6/96-9/96	MSX Satellite Overflights	Collaborative	H. Foote	Intended to provide ground truth support for the MSX satellite, with nine MSX sensors operating in the range of 0.12-0.9 µm and with a spectral IR imaging telescope	Launched on 4/24/96; SGP CART site flyovers on 6/17, 7/15, 8/12, and 9/9
6/96-7/96	CLEX IOP	G. Stephens (CSU-CIRA); J. Davis (CSU-CIRA)	R. Cederwall	Intensified satellite data collection (by CSU), airborne cloud radar and in situ microphysical observations, and an array of ground-based measurements; intended to improve understanding of the nature and role of middle-level, nonprecipitating cloud systems	Completed; data exchange in progress

TABLE 4 (Cont.)

Date	Name	Science Team Member[a]	DSIT Contact[b]	Description	Status
7/96-8/96	BLX IOP	R. Stull (UBC)	R. Cederwall	Remote sensing surface fluxes measured with instrumentation on the University of Wyoming King Air; CASES site and NCAR mobile profiler involved; in conjunction with 7/96-8/96 SCM IOP	Completed; aircraft data to be available in 1997; BAMS article published June 1997 (Stull 1997)
7/96-8/96	LLJ IOP	D. Whiteman (PNNL)	R. Cederwall	Intended to investigate oscillations in the characteristics of the LLJ over the SGP	Completed; data from 915-MHz profiler run in modified mode ingested in 1997 (available now from R. Coulter at ANL); Wyoming King Air data, in collaboration with R. Clark (MSU), now available
9/96; 9/97-10/97	Water Vapor IOP	H. Revercomb (UW)	D. Turner R. Peppler M. Splitt	Measurement of water vapor profiles with many instrument systems; attempt to define water vapor profile of the site in support of IFR research efforts; first focused on the lowest kilmeter; second in series focused up to 12 km.	Completed; data analysis in progress; another planned for 1999

TABLE 4 (Cont.)

Date	Name	Science Team Member[a]	DSIT Contact[b]	Description	Status
12/96; 6/97	LMS/SITAC IOP	B. Dillman (Lockheed)	D. Slater	Intended to analyze approaches to atmospheric compensation for hyperspectral and ultraspectral image data obtained from satellite platforms	Completed
4/97	Cloud Radar IOP	B. Martner (ETL); P. Daum (BNL)	D. Rodriguez M.-D. Cheng	Designed to validate retrieval of cloud microphysics by newly installed ARM zenith-pointing MMCR (developed by NOAA-ETL); ETL operated collocated scanning NOAA K-band cloud radar; high-altitude and low-altitude sampling by two aircraft; aerosol components flown in clear-sky conditions by low-altitude aircraft	Completed
6/97-7/97; 7/99	SGP '97 (Hydrology) IOP; SGP99 Campaign	T. Jackson (USDA); M.-Y. Wei (NASA)	R. Cederwall	Part of USDA and NASA campaign to study three "recharge" events; additional ARM instruments installed at USDA El Reno extended facility; non-ARM aircraft with microwave radiometry sensed soil moisture	Completed; data analysis in progress; data meeting held 3/98; scaled-down experiment being planned for summer 1999

TABLE 4 (Cont.)

Date	Name	Science Team Member[a]	DSIT Contact[b]	Description	Status
9/97-10/97; 4/98-5/98; Spring 2000	Cloud IOP	G. Mace (UU)	D. Rodriguez	Designed to obtain on-site measurements of cloud and aerosol properties in cloudy and clear-sky conditions; single microphysics aircraft to be flown in conjunction with ARM UAV high-low set of airborne platforms (1997) measuring radiometric properties; unprecedented opportunity to quantify cloud-aerosol-radiation interactions	Completed; data analysis in progress; next IOP planned for spring 2000
9/97-10/97; 8/98; Winter 2000	Aerosol IOP	P. Daum (BNL); S. Schwartz (BNL)	M.-D. Cheng P. Daum (aircraft coordinator)	Same as Cloud IOP	Completed; data analysis in progress; next IOP planned for winter 2000
9/97-10/97; 8/98; 3/99	Shortwave Radiation IOP	W. Wiscombe (NASA-GSFC); G. Stephens (CSU)	D. Slater B. McCoy	Focused on both broadband and spectrally resolved shortwave measurements, with emphasis on instrument calibration and intercomparison; also evaluated GRAMS and had UAV/aircraft component (1997)	Completed; data analysis in progress; mini IOP planned for spring 1999

TABLE 4 (Cont.)

Date	Name	Science Team Member[a]	DSIT Contact[b]	Description	Status
9/97-10/97	Fall 1997 Integrated IOP	G. Mace (UU)	R. Peppler	Ensemble of UAV, SCM, Water Vapor, Cloud, Aerosol, and Shortwave Radiation IOPs	Completed; data analysis in progress
3/98	MOPITT Campaign	J. Wang (NCAR)	D. Slater	Validation of airborne instrument that measures tropospheric CO and CH_4	Completed; data analysis in progress
6/98	NASA DC-8 Cloud Radar Campaign	B. McIntosh (UM); S. Sekelsky (UM)	D. Rodriguez	Comparison of airborne 95-GHz cloud radar with ground-based radars; about 20 flight hours available	Completed
6/98-10/98	JPL GPS Campaign	S. Keihm (JPL)	D. Turner	Calibration of JPL GPS retrieval algorithms in moist climate	Completed; data analysis in progress
8/98	BDRF Campaign	D. Cahoon (NASA Langley)	D. Slater	BDRF function measurements over the major scene types in and around the central facility; in conjunction with Shortwave Radiation and Aerosol IOPs	Completed; data analysis in progress
3/99	AES Campaign	F. Murcray (UD); D. Rider (NASA-JPL)	C. Flynn	Demonstration of AES that could give an independent comparison of the AERI and AERI-X	Planning underway

TABLE 4 (Cont.)

Date	Name	Science Team Member[a]	DSIT Contact[b]	Description	Status
3/99	ETL GPS	M.J. Post (NOAA-ETL)	D. Turner	Joint NOAA-ETL and Russian study to acquire GPS and water vapor data	Planning underway
Spring 1999 and 2000	TIMEX Campaign	E. Rasmussen; C. Ziegler; J. Schneider (NSSL)	R. Peppler	Investigation of boundaries causing thunderstorm initiation through use of airborne and ground-based mobile DIAL and many other mobile platforms	Planning underway
Spring or Summer 1999 or 2000	MCS Campaign	P. May (BoM)	R. Peppler	Investigation of precipitation microphysics and convective dynamics of MCSs through use of wind profilers and dual polarmetric scanning radar	Planning underway
9/99-10/99	International Pyrgeometer Intercomparison Campaign	T. Stoffel (NREL); Ells Dutton (NOAA) J. Michalskey (SUNY-Albany)	D. Slater	International intercomparison and cross-calibration of working-standard or standard pyrgeometers at the RCF	Planning underway
Fall 1999	Mini-MOPA Campaign	V. Wulfmeyer (UCAR); W. Eberhardt (NOAA-ETL)	D. Turner	Demonstration of new, compact DIAL capable of high-resolution water vapor measurements	Unknown
Fall 1999 or 2000	AFWEX Campaign	H. Revercomb (UW)	D. Turner	Focus on absolute calibrations and upper tropospheric measurements	Planning underway
Fall 1999	CO_2 DIAL IOP	J. Jolin (LANL)	D. Turner D. Slater	CO_2 DIAL on aircraft to fly over the site; potential benefit for water vapor and aerosols measurements	Unknown

TABLE 4 (Cont.)

Date	Name	Science Team Member[a]	DSIT Contact[b]	Description	Status
Summer 2000	Soil Sampling Campaign	J. Happell (UoMi)	R. Cederwall	Intended to test whether soils are a significant global sink of atmospheric CCl_4 and CH_3CCl_3	Unknown

[a] Affiliations: ANL, Argonne National Laboratory; BNL, Brookhaven National Laboratory; BoM, Australian Bureau of Meteorology; CIMMS, Cooperative Institute for Mesoscale Meteorological Studies; CIRA, Cooperative Institute for Research in the Atmosphere; CSU, Colorado State University; ETL, Environmental Technology Laboratory; GSFC, Goddard Space Flight Center; JPL, Jet Propulsion Laboratory; LANL, Los Alamos National Laboratory; MSU, Millersville State University; NASA, National Aeronautics and Space Administration; NCAR, National Center for Atmospheric Research; NCSU, North Carolina State University; NOAA, National Oceanic and Atmospheric Administration; NREL, National Renewable Energy Laboratory; NSSL, National Severe Storms Laboratory; PARC, Palo Alto Research Center; PNNL, Pacific Northwest National Laboratory; PSU, Pennsylvania State University; SNL, Sandia National Laboratories; SUNY, State University of New York; UBC, University of British Columbia; UCAR, University Corporation for Atmospheric Research; UD, University of Denver; UM, University of Massachusetts; UNAVCO, University NAVSTAR Consortium; UoM, University of Maryland; UoMi; University of Miami; USDA, U.S. Department of Agriculture; UU, University of Utah; UW, University of Wisconsin; WPL, Wave Propagation Laboratory.

[b] Other definitions: AERI, atmospherically emitted radiance interferometer; AES, airborne emission spectrometer; AFWEX, ARM-FIRE Water Vapor Experiment; ARESE, ARM Enhanced Shortwave Experiment; ARM, Atmospheric Radiation Measurement (Program); BAMS, *Bulletin of the American Meteorological Society*; BDRF, bidirectional reflectance functions; BLX, Boundary Layer EXperiment; CART, Cloud and Radiation Testbed; CASES, Cooperative Atmosphere-Surface Exchange Study; CLEX, Cloud Layer EXperiment; DIAL, differential-absorption lidar; DSIT, Data and Science Integration Team; FDDA, four-dimensional data assimilation; FIRE, First ISLSCP Regional Experiment; GCIP, GEWEX Continental-Scale International Project; GEWEX, Global Energy and Water Cycle Experiment; GIST, GEWEX Integrated System Test; GPS, global positioning system; GRAMS, ground-based radiometer autonomous measurement system; IDP, Instrument Development Program; IOP, intensive observation period; IR, infrared; IRF, instantaneous radiative flux; ISS, integrated sounding system; LLJ, Low-Level Jet; LMS, Lockheed Missile and Space; MCS, Mesoscale Convective System; MMCR, millimeter cloud radar; MOPA, Master Oscillator Power Amplifier; MOPITT, Measurements of Pollution in the Troposphere; MSX, Midcourse Satellite Experiment; PBL, planetary boundary layer; RASS, radio acoustic sounding system; RCF Radiometer Calibration Facility; SCM, single-column model; SGP, Southern Great Plains; SITAC, Spectral Imagery Technology Applications Center; SUCCESS, Subsonic Aircraft: Contrail and Cloud Effects Special Study; TIMEX, Thunderstorm Initiation Mobile Experiment; UAV, unmanned aerospace vehicle; VORTEX, Verification of the Origins of Rotation in Tornadoes Experiment.

estimate of the total atmospheric delay, independent of modeling assumptions about the absorption properties of water vapor. The function of the radiometers was to measure the atmospheric water vapor content, temperature profile, and related wet-path delay. The GPS data also provided for retrieval of the wet-path delay after subtraction of the dry delay obtained from a surface barometer measurement. The experiment began at the end of June 1998 and will be completed by the end of October 1999.

Shortwave Radiation IOP-Aerosol IOP-BDRF Campaign. A comprehensive exercise focusing on shortwave radiation, aerosols, and the bidirectional reflectance function (BDRF) was conducted at the central facility and surrounding areas on August 3-28, 1998. The IOP combined shortwave ground instrumentation, aerosol flights of the Gulfstream-1 aircraft, and a BDRF Campaign conducted by the National Aeronautics and Space Administration (NASA), Langley Research Center, involving both ground and air operations. The Shortwave Radiation IOP was the second in a series of three such IOPs concentrating on measurement of the shortwave spectrum, both broadband and spectrally resolved.

The emphasis of the combined IOP was on clear sky, because no true cloud physics aircraft were available. (The Gulfstream-1 can make only a limited number of cloud physics measurements.) The Gulfstream-1 aircraft, available for 20 flight hours on August 11-21, carried a large variety of state-of-the-art aerosol instrumentation, including a three-wavelength integrating nephelometer, an instrument for measuring aerosol absorption, and aerosol and cloud probes. Flights were stepped over the central facility starting at 500 ft above ground level (AGL) and going up in 500-ft increments to the top of the boundary layer, then in larger increments up to 17,000 ft AGL. Descent was in a spiral over the central facility. The Shortwave Radiation IOP, coordinated by Tom Charlock of NASA, relied on uplooking spectrometers covering the ranges 0.4-1.0 μm and 0.4-2.5 μm, with the ARM shortwave spectrometer (SWS) and rotating shadowband spectrometer (RSS/RSS-2) participating, along with the Colorado State University SSP. An enhanced level of broadband activity also occurred on the RCF deck, including the completion of BORCAL (Broadband Outdoor Radiometer Calibration) 98-02.

The BDRF campaign, led by Dan Cahoon (NASA-Langley Research Center), had surface and airborne components. Focusing on surface BDRF under clear skies, it represents a Clouds and Earth's Radiant Energy System (CERES) validation experiment. Surface instruments were placed in the vicinity of the central facility in "targeted fields" (at Tonkawa and Pawhuska, Oklahoma) and at the central facility itself, areas representing a variety of vegetation types. Instruments included a number of different broadband and spectral radiometers, photometers, lidars, and radiosondes. In the airborne portion of the campaign, a helicopter from White Sands Missile Range flew over target sites in conjunction with satellite overpasses, with a downlooking Analytical Spectral Devices (ASD) spectrometer, downlooking broadband radiometers, and a scanning radiometer that can track a particular pixel in flight. Chad Bahrmann of the SST wrote daily IOP updates and assisted visiting scientists with ARM data available on the R1 computer. Nightly planning meetings held at the Marland Mansion in Ponca City included NASA, ARM, and Gulfstream-1 staff. At these meetings, analyses of activities conducted during the just-completed day were discussed, and plans were made for the next day. The SST acted as an information conduit between ARM staff and the visiting scientists. In addition, the SST participated in BDRF soil sampling activities with local 4-H youth volunteers. This sampling, conducted in the fields over which the BDRF helicopter flew, was highly successful.

5.3 Future IOPs and Campaigns

The IOPs and campaigns planned for the first half of 1999 and beyond are discussed below. (See also Table 4.)

ARM SCM IOPs. The SCM Working Group has proposed two SCM IOPs for this six-month period. The Winter SCM IOP will be held on January 19- February 8, 1999, and will focus on the sampling of cold, sympotically driven conditions. The Spring SCM IOP will be held on March 1-21, 1999, and will focus on cool, stratus conditions. The SCM Working Group is focusing on deriving SCMs with retrievals of atmospheric state from remote sensing instrumentation rather than from radiosondes. The SCM Working Group has proposed an SCM IOP in September-October 1999 to look at conditions driven by local convection without strong sympotic forcing.

Mini-Shortwave IOP. The Shortwave Working Group has proposed a mini-shortwave IOP overlapping the Spring SCM IOP in March 1999. The early springtime gives visiting instrumentation a better chance of studying stratiform clouds without harsh winter conditions. The only non-CART instruments participating at the central facility will be the Pilewski (NASA-Ames) solar spectral flux radiometer (SSFR) and the ASTI.

ETL GPS Campaign. M.J. Post (NOAA-Environmental Technology Laboratory [ETL]) has expressed interest (with Russian colleagues) in jointly acquiring GPS and water vapor data at the central facility in the spring of 1999. Post hopes to be ready to participate in the Spring SCM IOP discussed above.

Airborne Emission Spectrometer (AES) Campaign. Dave Rider (NASA-JPL) will lead an exercise to demonstrate the operation of a version of the tropospheric emission spectrometer (TES), a device similar to AERI-X that could be used for side-by-side comparisons with the latter. This exercise is proposed for March 1999, to coincide with the Spring SCM IOP. The TES is an Earth Observing System (EOS) chemistry platform instrument. A demonstration version of the TES, the AES, would be used during the campaign. The AES has made airborne measurements previously and would offer ARM independent comparison of the AERI and AERI-X (because calibration sources for the AERI-X came from the AERI).

SGP99 Campaign. Tom Jackson (USDA-ARS Hydrology Laboratory) has tentatively planned for a reduced effort in July 1999 as part of an ongoing hydrology experiment. Results of the SGP ’97 IOP indicate that the advanced microwave scanning radiometer (AMSR) holds the greatest promise for soil moisture measurements. Soil moisture retrieval algorithms for AMSR have been proposed but not rigorously evaluated. A joint project between an EOS soil moisture process (Tom Jackson) and an EOS AMSR Instrument Team (Ehi Njoku, JPL) is being planned. The goals of this effort are to understand how to effectively interpret and use the less-than-optimal sources of satellite microwave data that are available now or will be available in the near future and to explore new approaches that might enhance the ability to measure soil moisture from space. The AMSR instrument will be launched in the 2000-2001 time frame on the Earth Observing System-Afternoon Crossing (Descending) Mission (EOS-PM) and Advanced Earth Observation Satellite-II (ADEOS-II) platforms.

Mini-MOPA Campaign. Alan Brewer (NOAA-ETL) will lead the mini-MOPA campaign, tentatively scheduled for fall 1999. The mini-Master Oscillator Power Amplifier (MOPA) is a compact differential-absorption lidar (DIAL) capable of high-resolution water vapor measurements. An earlier airborne version was deployed during the SUCCESS (Subsonic Aircraft: Contrail and Cloud Effects Special Study) Campaign of April 1996. The main goal of this activity would be to demonstrate the performance and capabilities of the mini-MOPA for improving water vapor measurements and perhaps for eventual incorporation into the SGP instrumentation suite or use during Water Vapor IOPs.

The CO_2 DIAL IOP. John Jolin (Los Alamos) anticipates conducting a DOE-funded experiment at the SGP CART site with a 10-kHz tunable-frequency lidar system for the 9- to 11-μm wavelength region of interest. This CO_2 DIAL system can be mounted in aircraft or be ground based. Currently, the aircraft system is being considered. The CO_2 DIAL system will be used to identify trace chemical species, as well as to measure water vapor. The system aboard a

U.S. Air Force KC-135 aircraft can be used to make spectrally resolved albedo measurements. This IOP has been scheduled tentatively for 1999.

International Pyrgeometer Intercomparison Campaign. The Longwave Working Group has proposed an International Pyrgeometer Intercomparison Campaign for September-October 1999. The intercomparison would be hosted at the central facility, and the activity would be planned and operated by Joe Michalsky (State University of New York-Albany), Tom Stoffel (NREL), and Ellis Dutton (NOAA). The intercomparison would be limited to working standards or standard instrumentation (rather than field instruments) to keep the number of participants to a practical size. The activities would center around the use of the RCF.

ARM UAV IOP. An ARESE (ARM Enhanced Shortwave Experiment) Revisited IOP is proposed for September-October 1999. This activity would include an unmanned aerospace vehicle (UAV) and the Twin Otter aircraft. The intent would be to repeat the 1995 activities associated with ARESE.

ARM-FIRE Water Vapor Experiment (AFWEX) Campaign. The Water Vapor Working Group has proposed a Water Vapor IOP for the fall of 1999 or the year 2000. The group has suggested that the IOP focus on absolute calibrations of instruments, upper-tropospheric measurements, and an international radiosonde intercomparison. For the upper-tropospheric measurements, the group strongly recommended the participation of DIAL, NASA, Lidar Atmospheric Sounder Experiment (LASE), and high-resolution interferometer spectrometer (HIS) systems, as well as aircraft-based (NASA DC-8) radiance observations. Jens Bosenberg is willing to bring his DIAL. Scheduling issues need to be worked out.

Mesoscale Convective System (MCS) Campaign. Peter May, Australian Bureau of Meteorological Research Centre (pmay@numbat.colorado.edu) has proposed an MCS Campaign for late spring or early summer in 1999 or 2000. This yet unfunded study would investigate precipitation microphysics and convective dynamics of MCSs in both a tropical climate (Australia in 1999) and midlatitudes (potentially the SGP CART Site area) in 1999 and 2000 by using a combination of wind profiler and dual polarimetric scanning radar data. Specific objectives include (1) development of profiler hydrometer distribution retrieval techniques in the ice-phase and mixed-phase regions of MSCs and (2) investigation of the precipitation, kinematic, and dynamic characteristics of deep convection at each site. The second objective will include a comparison of hydrometer size distribution vertical structure, as well as latent heat effects and potential vorticity production from MCSs, in both the midlatitude and tropical environments. The MCS Campaign will make use of wind profilers and dual polarimetric scanning radar.

Thunderstorm Initiation Mobile Experiment (TIMEX) Campaign. The National Severe Storms Laboratory (NSSL) is planning to have ground-based and airborne DIAL systems, as well as other instrumentation, over various parts of the SGP CART site during the 1999-2001 convective seasons. Erick Rasmussen, Conrad Ziegler, and Jeanne Schneider (NSSL) are involved with this activity. For now, Randy Peppler (Cooperative Institute for Mesoscale Meteorological Studies, OU) is the primary ARM contact. TIMEX will make use of airborne and ground-based mobile DIAL, as well as Doppler weather radars.

Cloud IOP. The Cloud Working Group has proposed a Cloud IOP in the spring of FY 2000. The group recommended that the IOP include, at a minimum, the Wyoming King Air and the North Dakota Citation aircraft, to examine multilayer and deep cloud systems. The group also identified a need to image ice crystals in a wide size range from 10 μm to several thousand microns. Because the spring of FY 2000 will be in the EOS era, some coordination with NASA should be planned to allow a more thorough experiment with participation by the NASA ER-2 and the NASA DC-8.

Soil Sampling Campaign. A Soil Sampling Campaign is tentatively proposed for the summer of 2000. This yet unfunded study would investigate the possibility that soils are a significant global sink of atmospheric CCl_4 and CH_3CCl_3. Sampling would involve taking soil gas samples over the top 50 cm of soil with a small probe and analyzing the samples by gas chromatography at the central facility.

Aerosol IOP. The Aerosol Working Group has proposed an Aerosol IOP in the winter of FY 2000. Wintertime clouds tend to be more stratus-like, and therefore clouds and aerosol properties are easier to work with and characterize. To date, only the more complex properties of clouds and aerosols in the fall and spring have been studied. This IOP would include aircraft support (the Pacific Northwest National Laboratory G-1).

5.4 Collaborative Investigations

Argonne National Laboratory has developed a new research facility (Wesely et al. 1997; Coulter et al. 1998) within the existing boundaries of the SGP CART site, to be devoted to studies of the planetary boundary layer (PBL). The Argonne Boundary Layer Experiments

(ABLE) facility covers an area of approximately 50 km × 50 km within the Walnut River watershed in Butler County, Kansas, about 50 km (30 mi) east of Wichita and near ARM's Towanda extended facility. New techniques of observation and data fusion are being developed and used to study the nocturnal low-level wind maximum and its relation to synoptic jet features; to develop methods for spatial integration of air-surface exchange of heat, gases, and momentum; and to study horizontal and vertical dispersion in the PBL. The initial set of instrumentation currently available at ABLE includes two 915-MHz profilers with RASS, three minisodars, one surface ECOR flux station, one soil moisture and temperature station, three automated weather stations (AWSs), and one satellite data receiver processor. One central location houses data collection equipment and instrumentation and provides accommodations for visiting scientists. The data obtained are being provided in real time to a user community of atmospheric scientists and ecologists, at the location

http://www.atmos.anl.gov/ABLE .

The 915-MHz profilers with RASS and the minisodars have been installed at Oxford and Whitewater, Kansas. A minisodar and an AWS have been added to the ARM Program's Beaumont, Kansas, intermediate facility, which is shared by and provides data streams for both the ARM Program and ABLE encompasses. A surface flux site was installed at Smileyburg, Kansas. In addition, an extensive automated high-spatial-resolution soil moisture and temperature network will be installed and remain in place in the Towanda subbasin. A second network (not automated) with larger spacing may also remain in place. All are within the footprint of the Wichita next-generation radar (NEXRAD).

The Cooperative Atmosphere-Surface Exchange Study (CASES) is a collaborative effort to obtain measurements over the entire Walnut River watershed (approximately 100 km × 100 km), over a somewhat larger domain than ABLE encompasses. CASES will include hydrologic, ecological, and atmospheric chemistry studies, in addition to ABLE research. The principal contacts for CASES are Peggy LeMone (National Center for Atmospheric Research) and Bob Grossman (University of Colorado). Several proposals have been submitted to the NASA Land Surface Hydrology Program to conduct experiments over the CASES-ABLE domain. Information can be found at

http://www.joss.ucar.edu/cases .

5.5 Scientific Working Groups

The ARM Program has formed groups concentrating on the study of geophysically significant phenomena such as water vapor (atmospheric state), aerosols, clouds, and radiation. Algorithm development that describes these phenomena is currently a primary focus.

One goal of these groups is to produce algorithm products that represent a merging of appropriate instrument measurements into a cohesive product defining a particular geophysical state, for use by the Science Team. These products specifically address problems posed in the *Science Plan* and by the various science applications working groups. One product currently under construction prescribes water vapor over the SGP CART site, information sought by the IRF Working Group. As noted in Section 4.3, this an effort involves three IOPs obtaining multiple water vapor measurements at the central facility (e.g., additional measurements on the 60-m tower; use of tethered systems; use of guest instruments and additional instruments, such as chilled-mirror and frost-point hygrometers; use of aircraft; and comparison of these measurements with routine BBSS, Raman lidar, MWR, and 915- and 50-MHz RASS water vapor profiles). The end result of such comparisons will be the generation of an ensemble, site-representative water vapor profile for use in GCMs. Section 4.3 describes a recently constructed product for shortwave radiation at the central facility.

5.6 Educational Outreach

The educational outreach program for the SGP CART site, coordinated by Dr. Ken Crawford, Director of the OCS, combines a range of resources available at OU. Outreach is focused at the precollege, undergraduate, and graduate levels. Efforts in this six-month period will concentrate on professional development activities, staff support for teacher participants, scientific mentorship of students, development of data analysis tools for students and teachers, and application of data in the classroom (McPherson and Crawford 1996; Melvin and McPherson 1998). A two-week workshop involving five Kansas and two Oklahoma teachers was held at OU in July 1997. Instruction on how to use ARM data and related software was given, along with lessons on atmospheric radiation, energy transfer, meteorological data, telecommunications, data visualization, the Web, and the ARM Program. Six EARTHSTORM teachers attended the workshop as the “Storm Team,” helping instruct participants and offering insight on ways to modify existing lessons and materials to incorporate ARM data. The five Kansas teachers were given Power Macintosh 5400 computers for their classrooms. The Storm Team and some of our other ARM teachers will be making presentations at the 8th Symposium on Education, which is part of the 79th Annual Meeting of the American Meteorological Society, to be held in Dallas, Texas, in January 1999. Schools can access ARM data on the Web at

http://www.arm.gov/docs/education.html .

An SGP-only outreach site can be reached from this location through the link “Outreach Sites,” by selecting “Southern Great Plains.”

6 DISTRIBUTION OF DATA

Most of the data being requested are received from the SGP CART site or external data sources and are then repackaged for daily and weekly distribution to individual users. In some special cases, users can log into the Experiment Center or the R1 computer at the central facility and extract data by anonymous file transfer protocol (FTP). All data are sent to the Data Archive, where they are accessible to the public on the Web at

http://www.archive.arm.gov .

The status of data streams from CART instruments and external sources has been classified as releasable (released upon request for the data stream), developmental (released only to SDS personnel for development of ingestion programs), under evaluation (released to an investigator for an initial data quality check), beta release (for releasable data of known and reasonable quality), collecting (when raw data are being collected for future processing and distribution), mentor only (provided only to the instrument mentor at the request of the mentor), analysis (released for further processing or analysis, such as for graphic display), or defunct (due to replacement of a prototype instrument data stream with the CART instrument data stream).

7 LOOKING AHEAD

The SGP CART site now provides a full range of data streams needed to support the broad spectrum of Science Team research. Research activities are increasingly drawing on multiple SGP data streams to focus on geophysically significant phenomena (water vapor profiles, clouds, aerosols, temperature profiles, radiation, surface fluxes). The operational challenges that will be of greatest importance during 1999 and beyond will therefore include maintaining the performance of the basic instrumentation suite at the highest possible level and improving that performance where possible, enhancing the original CART design through the permanent addition of new instruments, evaluating current instrumentation as to its effectiveness, and mounting focused IOPs and campaigns involving temporary additional instrumentation. Through this mix of activities, the evolving scientific requirements, challenges, and opportunities for the SGP CART site can be met. The present chapter outlines the path ahead, to the extent that it can be identified in late 1998.

7.1 The Overall Future View

A key development expected at the central facility during the present six-month period is the installation of the UV spectrometer. It is scheduled for an early 1999 deployment, about 50 m east of the central cluster. Another central facility measurement issue now under consideration is the possibility of acquiring continuous direct-beam solar irradiance measurements with a cavity radiometer. Cavity radiometer measurements were made successfully under close supervision during the Shortwave Radiation IOP in fall 1997. Additional work is continuing on the refinement of millimeter cloud radar (MMCR) returns to eliminate the effects of insects and other particles (“atmospheric plankton”) in the boundary layer. A scanning polarimeter from Colorado State University will be installed indefinitely at the central facility, giving the SGP site another spectrometer. Deployment is slated for early 1999. The USDA UV-B network will also expand to place one of its full sites at the central facility. This would include an MFRSR identical to ARM’s, a Lee Harrison-designed UV-B MFRSR, and a Yankee UV-B broadband radiometer, plus some meteorological support sensors and data loggers. This deployment should also occur early in 1999 and is being spearheaded by Dave Bigelow of Colorado State University.

An electronics laboratory that has been established at the central facility will allow site technicians to service and repair CART instruments and sensors without vendor intervention and associated costly service contracts, saving approximately $50,000 per year. Turnaround time will be days instead of weeks or months. In addition, a commercially available temperature-humidity calibration chamber will be installed at the central facility in 1999 to provide calibrations and checks for all three CART sites. Scott Richardson of the SST will be the mentor for the chamber.

The completion of BORCAL 98-02 at the RCF allowed for the deployment of fresh radiometers for the SIRS in fall 1998. The RCF has been used successfully for this purpose for two summer seasons. A plan for more comprehensive use of the RCF is being prepared by NREL.

Use of a hand-held ozone meter at the central facility is being considered. The instrument, used successfully during the Fall 1997 Integrated IOP, can make daily observations of ozone and is easy to operate.

Improved specifications of the water vapor, temperature, and cloud conditions above the boundary facilities are expected to result from several observational enhancements and additions during 1998 and 1999. First, the addition of ceilometers late in 1998 was intended primarily to provide data for algorithms that will retrieve lower tropospheric temperature and humidity profiles from the output of new AERI instruments, also deployed in late 1998. Second, higher-quality BBSS soundings should result from a planned upgrade of the Vaisala sensors being used (from RS-80 to RS-90). The RS-90 humidity sensor has a faster response time and thus recovers more quickly than its predecessor after the sun emerges from clouds. The temperature counterpart of the RS-90 is also smaller and has a faster response time than does the RS-80 and, in addition, is less susceptible to solar heating. An identical BBSS upgrade will occur at the central facility. Temperature, humidity, wind, and pressure sensors (THWAPS) were also added recently at the boundary facilities for better characterization of surface conditions for BBSS launches. Under consideration for the boundary facilities is a capability to profile with passive microwave systems, which would augment the AERI measurements. Locations and status of the boundary facilities and intermediate facilities are summarized in Table A.3 and A.4 in the Appendix. New collection software was installed and activated in fall 1998 to allow for automated tip-mode calibrations on the MWRs, which should improve future calibration of MWR values.

The anticipated completion of the wooded extended facility at the Okmulgee site in 1999 will improve the basis for spatial integration of turbulent and radiative fluxes over the entire SGP CART site. Measurement issues under consideration at the extended facilities include local observations of surface vegetative conditions and measurements of surface bidirectional reflectance. Stabilization of ECOR data collection and communication is an ongoing issue. Work is underway to solve this problem.

The nighttime offset frequently seen in the signals from the Eppley precision spectral pyranometers (PSPs) in use at extended facilities is under investigation. Testing of Eppley 8-48 (black and white) pyranometers at the central facility is being considered. The placement of the temperature sensors makes these pyranometers less susceptible to the offset. This offset is particularly noticeable in our shaded PSPs, used to measure diffuse irradiance.

The SST, DSIT, and Instrument Team will continue to play a strong role in the area of data quality, including the ARM-wide effort that will see the creation of a formal data user interface (the MDN) to allow data users to view data quality information when they obtain ARM data sets.

During 1998, the SGP CART site observational capabilities continued to benefit from ongoing interactions between the ARM Program and several other federal and state research programs having an interest in the SGP in general. The federal agency interactions, which until now have particularly involved the GEWEX (Global Energy and Water Cycle Experiment) Continental-Scale International Project (GCIP), were broadened through the leadership of NASA and the USDA in the SGP ’97 (Hydrology) IOP. These interactions are also manifest in the approximately biannual meeting of a Joint ARM-GCIP-ISLSCP (International Satellite Land-Surface Climatology Project) Working Group (on which ARM is represented by J.C. Doran, R.G. Ellingson, and P.J. Lamb); the implementation of the soil and water temperature system (SWATS) at the ARM extended facilities, with significant financial support from GCIP; and the USDA’s facilitation and partial funding of the El Reno extended facility. The Joint Working Group will be concerned not only with fostering the most cost-effective and efficient observational strategies for the SGP CART site in the future, but also with formulating the best possible scientific use of the resulting data among their programs. Consistent with this latter goal, the Joint Working Group’s May 1997 meeting focused on “Value-Added Science,” which is likely to be a continuing theme of that forum.

Interactions with the Oklahoma Mesonet (OKM), which has been an important source of external data on the SGP for several years, increased with the OKM’s parallel deployment of approximately 60 SWATSs. Through a joint effort of the NWS and ARM, ARM radiosonde data became available to the meteorological community at large via the Global

Telecommunications System. This availability will be especially valuable for the NWS short-range-prediction efforts during the tornado seasons of the next few years.

Throughout 1999, the scientific operation of the SGP CART site will benefit from guidance provided by the SAC. The fundamental role of the SAC is to ensure that the operation of the site addresses the goals and objectives of the ARM Program (published in the 1996 *Science Plan*) to the fullest possible extent, including through successful adaptation to changing circumstances and opportunities. Such performance will ensure that the flows of data to the Science Team members are appropriate to their needs, of consistently high quality, and as continuous as possible. For example, the recent redoubling of efforts by the SST to help ensure the quality of SGP data is consistent with the strong encouragement offered by the November 1995 SAC review. Because the membership of the SAC is divided approximately equally between ARM Science Team members and nonmembers, its guidance reflects both the inherently more parochial concerns of the ARM Science Team and the broader global-change perspective of the others. The recommendations from the November 1995 and June 1996 SAC meetings are now being acted upon by the SST and will be reflected in the scientific capability of the site during 1999 and beyond. Those recommendations included the need for increased attention to quality assurance and quality control of the SGP instruments and data streams; the necessity to make midcourse corrections (including personnel assignments and funding priorities) to ensure that the configuration and operation of the SGP CART site are in full consonance with the ARM *Science Plan* priorities; the desirability of converting the *Site Scientific Mission Plan* into an article for publication in the *Bulletin of the American Meteorological Society* that would publicize the scientific potential of the site (to be completed during the present six-month period); and the inauguration of an SST Visitor Program that would particularly involve cloud and radiation data analyses and simulations, with the goal of enhancing the site's observational capabilities in those crucial areas. Thus, the SAC guidance will have a continuing effect on the scientific mission of the SGP CART site.

7.2 The 1998 Assessment of Capabilities and Needs

The last *Site Scientific Mission Plan* (July-December 1998) (Peppler et al. 1998) contained a review of the SGP CART site's operational and instrumentation requirements in light of increasingly constrained budgets. These issues were placed on the table for discussion by the Science Team Executive Committee, the SAC, and the ARM Management Team. All issues remain open. They are listed below to remind the reader:

- Do we need the early and late radiosonde launches at the central facility and the noontime radiosonde launches at the boundary facilities during non-IOP/campaign periods?

- Do we need three SCM IOPs per year at the SGP CART site?

- Do SCM IOPs need to be 21 days long?

- Do we need all 24 extended facilities to adequately assess surface characterization for GCMs?

- Do we need to visit extended facilities every two weeks?

- Do we need to maintain the radar wind profilers at the central facility and the three intermediate facilities?

- Do we need to operate the Raman lidar continuously?

- Does the AOS provide sufficient information to study the role of aerosols in radiative transfer in GCMs?

- Should MFRSR instrumentation be removed from the SGP CART site extended facilities?

- Should ECOR instruments be decreased or eliminated at extended facilities?

This list represents issues regarding operation of the SGP CART site that have significant costs. These issues should be couched in the context of activities that could be eliminated to lessen operational expenses, making an opportunity to address new issues and concerns relative to the goals of the ARM Program.

7.2.1 The Assessment Procedure

In spring and summer 1998, the SST conducted an assessment of the measurement capability of the SGP CART site relative to Science Team needs. Members of ARM's scientific working groups and others in the ARM Program were polled to determine their level of satisfaction relative to both the current routine SGP measurement suite and the site's IOP measurement capability, including heretofore unmet measurement needs. A previous measurement review in 1995 was documented in the *Science Plan for the Atmospheric Radiation Measurement Program (ARM)* (U.S. Department of Energy 1996). Section 6 of that report ("Instrument Development") contains information about current and planned (at that time) measurement capabilities. Section 6.4 describes "Concerns and Unmet Needs," including clear-sky measurements and retrievals, radiosondes, RLID operation, RASS operation, surface meteorological instruments, MWRs, cloudy-sky measurements and retrievals, and optimal operating strategies for current instruments. IRF Group measurement needs at that time were expressed in Section 3.3 of the document (under the categories of radiation, radiative properties, and cloud variables).

The 1998 SST polling was aimed at updating the 1995-1996 effort to give the STEC and AMT new information for planning. The following scientific working groups were polled: Cloud, Shortwave Radiation, Longwave Radiation, Aerosol, Water Vapor (Atmospheric State), Surface Flux, SCM, and UAV. (The hope was that IRF concerns would be captured within the responses received from the Shortwave and Longwave subgroups.) Input was solicited from each group in the following two areas:

- Adequacy of the current, routine SGP CART site measurement suite for each scientific group's needs.

- IOP ideas and plans for 1999 and 2000.

Relative to the first area, answers to the following questions were sought:

- Is the current instrument suite adequate for your group's needs? Which instruments are the "absolutely crucial" ones for your success?

- If the current suite is not adequate, why isn't it? Is the problem the quality of the data now being produced (including instrument performance, calibration, and maintenance), unmet measurement needs, or current sampling rates?

- How would you suggest that we improve the current suite? What are your unmet instrument needs, if any, and do you have a particular instrument in mind to satisfy any unmet need?

- Would you like to see particular instruments run in an IOP mode for short periods of time to help meet unsatisfied needs?

Relative to the second area, because the ARM infrastructure is beginning to plan IOPs over a two-year horizon in view of tightening budgets and the inherent difficulty in scheduling aircraft, the following questions were asked:

- What are your plans and suggestions for IOPs in 1999 and 2000? Include, what, when, and where, as well as ground-based instrumentation guests you might want.

- What aircraft would be needed (if any) to make these IOPs work?

7.2.2 Unmet Measurement Needs and Desires

Below are the recommendations from the working groups regarding measurements and future IOPs. In some cases, the chief scientist and DSIT contact apparently polled members of the group to generate a consensus response. In other cases, the opinions expressed seem to be mainly those of the chief scientist. Regardless, ARM scientists and management can use this information to guide the SGP CART site down the most scientifically sound path possible. Prioritizing the needs expressed here would be useful. The SAC should be instrumental in this regard.

Cloud Working Group

- Central facility: Optimally, launch 6 sondes per day, 7 days per week.

- Raman lidar: Add a calibrated, operational water vapor product. Use the RLID as a cloud/aerosol sensor to obtain depolarization information on hydrometeors.

- Cloud base observations: Reconcile differences between the Belford laser ceilometer (BLC) and micropulse lidar (MPL). (Differences of up to 150 m have been observed; this need is urgent.) The addition of Vceils is also desired.

- MMCR: Solve or mitigate the “atmospheric plankton” problem (bugs and other materials that have been contaminating boundary layer returns). Switch from collection of the moments of the Doppler spectrum to the spectrum itself. Radome moisture is a concern.

- WSI: Add a minute-by-minute, continuous time series of cloud cover.

- Cloud observations away from the central facility: Add cloud fraction information at boundary and extended facilities. Perhaps install hemispheric sky imagers at those sites.

- Micropulse lidar−high resolution (MPL-HR): Install the MPL-HR permanently.

- MWR: Install the new collection software to perform automatic tip-mode calibrations.

- Weather Surveillance Radar (WSR-88D) data: Continue investigation of the use of WSR-88D data for cloud and cloud water definition for the SGP site, to help define a sitewide three-dimensional cloud structure.

- Cloud optical depth: Make computation of cloud optical depth a higher priority. This quantity, which links cloud properties to radiation, is not available as a routine product. The quantity can be retrieved from the MFRSR (and likely other instruments), and candidate algorithms exist.

CERES Working Group

- Vertical microphysics profiles: Add continuous lidar/radar/radiometer vertical profiles of cloud microphysics with a sampling interval of roughly one minute. Such profiles would be invaluable for CERES cloud retrievals needing thousands of surface-satellite matches.

- Aircraft microphysics measurements: Add *in situ* aircraft microphysical measurements over a complete range of water and ice types.

- Cloud fractional coverage: Adopt scanning lidar as the best means for determining cloud fractional coverage.

- Cloud volumes: Adopt as a long-range goal a scanning version of nadir cloud retrievals to obtain three-dimensional cloud volumes.

- Aerosol optical depth: Develop continuous aerosol optical depth measurements covering the near-IR, UV, and visible ranges.

- Shortwave radiation: Sample shortwave radiation more densely with a direct/diffuse spectrometer or a radiance scanning spectrometer (good for aerosol/cloud investigations).

- SSA: Measure aerosol single scattering albedo (SSA) at more wavelengths. Deploy a new system for measurement of SSA. There are doubts about the present system in the AOS (filter impaction).

- Processing of aerosol and cloud measurements: Enhance ARM processing of aerosol and cloud-related measurements (e.g., inversions for aerosol size distribution, cloud optical depth, and cloud screening).

Shortwave Working Group

- RLID: Install and operate the new aerosol extinction profile product being developed by Rich Ferrare. Use lidar to identify regions with relative humidity of about 70%.

- MMCR: Resolve the “atmospheric plankton” problem. The Aerosol Working Group could help.

- WSI: Calibrate radiance as a function of angle.

- Cimel Sunphotometer (CSPHOT): Record more angular information. The instrument now scans up to 40 degrees on each side of the sun.

- Broadband radiometry: Accelerate the progress of the ground-based radiometer autonomous measurement system (GRAMS).

- Spectral radiometry: Ensure that the SWS and RSS are both running. The SWS and the Colorado State SSP can act as a cross-check on the RSS.

- Ultraviolet: Add a broadband UV radiometer that measures at wavelengths of 0.3-0.4 µm.

- MWR: Validate values for liquids in low stratus clouds, possibly by using hot-wire liquid-water probes on a tethersonde.

- Platform northeast of the optical trailer: Use this platform to house future radiometers; install an elevated walkway for access from the trailer.

- Hand-held ozone meter: Consider whether data from this device, used during the Fall 1997 Integrated IOP, should become a “weather observation” measurement or a formal, ingested measurement.

Aerosol Working Group

- Aerosol chemical composition and aerosol relative humidity data: Collect or analyze these quantities.

- 60-m tower nephelometer: Add this instrument to obtain a sense of the vertical profile of aerosols in the lowest 60 m above the central facility.

- Routine *in situ* measurements of boundary layer aerosols over the central facility: Investigate the feasibility of making these measurements at regular intervals from a small local aircraft.

- CCN spectrum: Add CCN and CNN spectrum plus aerosol composition as a function of size during IOPs.

- New 180 degree backscatter nephelometer: Add this device (a standard one-wavelength TSI nephelometer with a laser added to get the 180 degree scattering coefficient).

Water Vapor Working Group

- MWR: Install new collection software (strongly endorsed to take tip-mode curves routinely and to automatically monitor and update calibrations). Periodically perform same-site instrument comparisons.

- RLID: Assign a high priority to the remaining issues of down time and continuing nonlinear calibration (pulse pileup and overlap corrections). The periodic comparisons of the lidar with the NASA Goddard Space Flight Center scanning RLID are "invaluable."

- Vaisala relative humidity sensors: Continue comparisons to well-calibrated independent sensors such as the chilled-mirror hygrometers on an IOP basis.

- AERI + GOES (Geostationary Operational Environmental Satellite) water vapor and temperature retrievals: Implement this as the best avenue for continuous profiling of water vapor and temperature during clear skies at the boundary facilities.

- Central facility radiosondes: Implement 4 launches per day at equal intervals (0000, 0600, 1200, 1800 UTC) during non-IOP periods; keep 8 launches per day during IOPs.

- GPS: Except perhaps during IOPs, discontinue use of the GPS installation at the central facility, which is not required because the Lamont GPS operates so well.

- Absolute standards: Continue the study of ways to use absolute standards (e.g., MWR, 60 m tower, GPS) to help reduce bias and variability in profiles measured by the RLID and the sondes. The primary question still to be addressed is whether scaling of profiles to agree with values from the tower at a point (60 m) or with precipitable water vapor from the MWR is the correct course of action.

Surface Flux Working Group

- ECOR: Establish a reliable set of ECOR measurements for both sensible and latent heat fluxes, perhaps at a half dozen reliable sites. Establish an IDPC for the ECOR display data in near real time, allowing better diagnosis of problems.

- Non-Dimensional Vegetative Index (NDVI): Obtain supporting data for the EBBR and ECOR stations, possible from the hand-held NDVI (representing leaf area index and surface optical reflectance properties), to assist in interpretation of sensible and latent heat fluxes.

SCM Working Group

- Sitewide cloud characterization: Install ceilometers and hemispheric sky imagers at boundary facilities in order to estimate cloud fraction as a function of height and time across the CART site. The MMCR does this at the central facility, but the SCM Working Group is looking to the Cloud Working Group to provide a best estimate of the macrophysical characterization across the CART site. Other critical cloud properties for SCMs include cloud boundaries, cloud overlap, particle size, cloud droplet and cloud ice number concentration, cloud optical depth, and horizontal advective tendencies of liquid and ice.

- Remote sensing: Implement whatever remote measurements are needed to obtain the best possible retrievals of the atmospheric state in the column above the SGP site for parameters now obtained from radiosondes.

- SCM IOPs: Extend the time periods for forcing SCMs beyond the present three-week SCM IOPs.

- Surface flux over cropland: Aim toward continuous measurements with ECOR systems.

7.2.3 Future IOP Desires

SCM Working Group

- For 1999, implement the following SCM IOPs: Winter (mid January to early February), early spring (March stratus), and summer/fall (local convection).

- For FY 2000, consider driving SCMs with remote sensing retrieval capabilities. If this is not possible, retain a more traditional SCM IOP schedule.

UAV Program

- ARESE Revisited is under discussion.

Aerosol Working Group

- Another Aerosol IOP in either winter 1999 or winter 2000 is desired, featuring the Gulfstream-1 aircraft sampling low-level stratus clouds.

Shortwave Working Group

- Another shortwave IOP in either spring 1999 or spring 2000 would be desirable, focusing on stratiform cloud events. Wintertime cloud conditions would probably be more desirable, but weather conditions then are likely to be too harsh for special IOP deployments.

Longwave Working Group

- An International Pyrgeometer Intercomparison is being planned by Tom Stoffel and Joe Michalsky for the central facility during September 1999.

Water Vapor Working Group

- A 1999 Water Vapor IOP is desired, probably in September-October. This IOP would focus on upper-level water vapor, boundary layer distributions, and absolute calibrations. DIALs (the NASA and LASE), an interferometer sounder, and aircraft-based radiance measurements would be key for this third Water Vapor IOP.

- In FY 2000, an Arctic IOP might be planned, focusing on cold, dry conditions.

Cloud Working Group

- A spring 2000 Cloud IOP would be desired, focusing on multilayered and deep cloud systems, along with cirrus ice crystals. The North Dakota Citation and Wyoming King Air would be needed, along with the NASA ER-2 and DC-8, as this would be well into the EOS era.

8 REFERENCES

Coulter, R.L., G.E. Klazura, B.M. Lesht, J.D. Shannon, D.L. Sisterson, and M.L. Wesely, 1998, “Using the ABLE Facility to Observe Urbanization Effects on Planetary Boundary Layer Processes,” in *Reprints, 10th Joint Conference on the Application of Air Pollution Meteorology with the Air and Waste Management Association, January 11-16, 1998, Phoenix, Arizona*, American Meteorological Society, Boston, pp. J76-J79.

McPherson, R.A., and K.C. Crawford, 1996, “The EARTHSTORM Project: Encouraging the Use of Real-Time Data from the Oklahoma Mesonet in K-12 Classrooms,” *Bulletin of the American Meteorological Society* 77:749-761.

Melvin, A.D., and R.A. McPherson, 1998, “Southern Great Plains Atmospheric Radiation Measurement (ARM) Educational Outreach Program,” in *Preprints*, *Seventh Symposium on Education, January 11-16, 1998, Phoenix, Arizona*, American Meteorological Society, Boston, pp. 23-26.

Peppler, R.A., and M.E. Splitt, 1998, “ARM Southern Great Plains CART Site Data Quality Assessment Activities,” in *Preprints, 10th Symposium on Meteorological Observations and Instrumentation, January 11-16, 1998, Phoenix, Arizona*, American Meteorological Society, Boston, pp. 355-358.

Peppler, R.A., D.L. Sisterson, and P. Lamb, 1998, *Site Scientific Mission Plan for the Southern Great Plains CART Site, July-December 1998*, ARM-98-003, U.S. Department of Energy, Washington, D.C.

Stull, R., 1997, “Boundary Layer Experiment 1996 (BLX 96),” *Bulletin of the American Meteorological Society* 78:1149-1158.

U.S. Department of Energy, 1990, *ARM Program Plan*, *1990*, DOE/ER-0441, Washington, D.C.

U.S. Department of Energy, 1996, *Science Plan for the Atmospheric Radiation Measurement Program*, DOE/ER-0670T, Washington, D.C.

Wesely, M.L., R.L. Coulter, G.E. Klazura, B.M. Lesht, and D.L. Sisterson, 1997, “A Planetary Boundary Observational Capability in Kansas,” in *Reprints, 1st Symposium on Integrated Observing Systems, February 2-7, 1997, Long Beach, California*, American Meteorological Society, Boston, pp. 169-171.

APPENDIX:

STATUS AND LOCATIONS OF INSTRUMENTS

TABLE A.1 Actual and Planned Locations of Instruments at the Central Facility[a]

Instrument	Elevation[b] (m)	Latitude, Longitude (deg)	Surface Type	Location
AERI	316	36.606 N 97.485 W	Pasture	Optical trailer
AERI X	316	36.606 N 97.485 W	Pasture	Optical trailer
SORTI	316	36.606 N 97.485 W	Pasture	Optical trailer
MWR	316	36.606 N 97.485 W	Pasture	Optical trailer
WSI	316	36.606 N 97.485 W	Pasture	Optical trailer
BLC	316	36.606 N 97.485 W	Pasture	Optical trailer
MPL-HR	316	36.606 N 97.485 W	Pasture	Optical trailer
SWS	316	36.606 N 97.485 W	Pasture	Optical trailer
NFOV	316	36.606N 97.485W	Pasture	Optical trailer cluster
GRAMS	316	36.606 N 97.485 W	Pasture	Optical trailer cluster
TLCV	316	36.606 N 97.485 W	Pasture	Optical trailer cluster
SSP	316	36.606N 97.485W	Pasture	Optical trailer cluster
RSS	316	36.606 N 97.485 W	Pasture	Optical trailer cluster
BSRN/BRS	318	36.605 N 97.485 W	Pasture	Central cluster
MFRSR	318	36.605 N 97.485 W	Pasture	Central cluster

TABLE A.1 (Cont.)

Instrument	Elevation[b] (m)	Latitude, Longitude (deg)	Surface Type	Location
SIRS	318	36.605 N 97.485 W	Pasture	Central cluster
MFR (10 m)	318	36.605 N 97.485 W	Pasture	Central cluster
CSPHOT	318	36.607 N 97.489 W	Pasture	Central cluster
EBBR	318	36.605 N 97.485 W	Pasture	Central cluster
SMOS	318	36.605 N 97.485 W	Pasture	Central cluster
SWATS	318	36.605 N 97.485 W	Pasture	Central cluster
BBSS	313	36.609 N 97.487 W	Grass	Central compound
THWAPS	313	36.609 N 97.487 W	Grass	Central compound
CMDEWP	313	36.609 N 97.487 W	Grass	Central compound
USR (25 m)	314	36.607 N 97.489 W	Wheat	60-m tower
UIR (25 m)	314	36.607 N 97.489 W	Wheat	60-m tower
MFR (25 m)	314	36.607 N 97.489 W	Wheat	60-m tower
T/RH (25 m)	314	36.607 N 97.489 W	Wheat	60-m tower
CMDEWP (25 m)	314	36.607 N 97.489 W	Wheat	60-m tower

TABLE A.1 (Cont.)

Instrument	Elevation[b] (m)	Latitude, Longitude (deg)	Surface Type	Location
T/RH (60 m)	314	36.607 N 97.489 W	Wheat	60-m tower
CMDEWP (60 m)	314	36.607 N 97.489 W	Wheat	60-m tower
ECOR (25 m)	314	36.607 N 97.489 W	Wheat	60-m tower
ECOR (60 m)	314	36.607 N 97.488 W	Wheat	60-m tower
ECOR	315	36.606 N 97.488 W	Wheat, pasture	Aerosol trailer
AOS	315	36.607 N 97.488 W	Pasture, wheat	Aerosol trailer
RCF	313	36.608 N 97.488 W	Pasture, wheat	Calibration trailer
RWP (915 MHz)	312	36.601 N 97.487 W	Shale, pasture	Profiler trailer
RWP (50 MHz)	312	36.600 N 97.487 W	Shale, pasture	Profiler trailer
MMCR	316	36.606 N 97.485 W	Pasture, wheat	IDP 2
RLID	311	36.609 N 97.487 W	Pasture, wheat	IDP 3

[a] AERI, atmospherically emitted radiance interferometer; AOS, aerosol observation system; BBSS, balloon-borne sounding system; BLC, Belfort laser ceilometer; BRS, broadband radiometer station; BSRN, baseline surface radiation network; CMDEWP, chilled-mirror dew point hygrometer; CSPHOT, Cimel sunphotometer; EBBR, energy balance Bowen ratio; ECOR, eddy correlation; GRAMS, ground-based radiometer autonomous measurement system; IDP, Instrument Development Program; MFR, multifilter radiometer; MFRSR, multifilter rotating shadowband radiometer; MMCR, millimeter cloud radar; MPL-HR, micropulse lidar–high resolution; MWR, microwave radiometer; NFOV, narrow-field-of view zenith-pointing filtered radiometer; RCF, radiometer calibration facility; RLID, Raman lidar; RSS, rotating shadowband spectrometer; RWP, radar wind profiler; SIRS, solar and infrared radiation station; SMOS, surface meteorological observation station; SORTI, solar radiance transmission interferometer; SSP, scanning spectral polarimeter; SWATS, soil water and temperature system; SWS, shortwave spectrometer; THWAPS, temperature humidity wind and pressure sensors; TLCV, time-lapse cloud video; T/RH, temperature and relative humidity sensors; UIR, upwelling infrared radiometer; USR, upwelling solar radiometer; WSI, whole-sky imager.

[b] Above sea level.

TABLE A.2 Locations and Status of Extended Facilities[a]

Site	Elevation[b] (m)	Latitude, Longitude (deg)	Surface Type	Flux Station[c]	SWATS[c]	SMOS[c]	SIROS + MFRSR[c]	SIRS + MFRSR[c]	Comment
Larned, KS EF-1	632	38.202 N 99.316 W	Wheat	ECOR 9/1/95	Yes 6/96	Yes 9/1/95	Yes 9/1/95	Yes 11/20/97	Power and communication center installed 10/95
Hillsboro, KS EF-2	450	38.306 N 97.301 W	Pasture	EBBR 10/96	Yes 6/96	No	Yes 9/7/95	Yes 11/5/97	Power and communication center installed 8/95
LeRoy, KS EF-3	338	38.201 N 95.597 W	Wheat and soybeans (rotated)	ECOR 12/7/95	Yes 9/96	Yes 12/7/95	Yes 12/7/95	Yes 11/4/97	Power and communication center installed 9/95
Plevna, KS EF-4	513	37.953 N 98.329 W	Rangeland (ungrazed)	EBBR 4/3/93	Yes 3/5/96	Yes 3/28/95	Yes 3/28/95	Yes 11/7/97	Power and communication center installed 3/95
Halstead, KS EF-5	440	38.114 N 97.513 W	Wheat	ECOR (on hold)	Yes 9/96	Yes 5/31/96	Yes; broad-band only 5/31/96	Yes 11/6/97	Power and communication center installed 11/95

TABLE A.2 (Cont.)

Site	Elevation[b] (m)	Latitude, Longitude (deg)	Surface Type	Flux Station[c]	SWATS[c]	SMOS[c]	SIROS + MFRSR[c]	SIRS + MFRSR[c]	Comment
Towanda, KS EF-6	409	37.842 N 97.020 W	Alfalfa	ECOR 12/14/95	Yes 9/96	Yes 12/14/95	Yes 12/14/95	Yes 11/5/97	Power and communication center installed 8/95
Elk Falls, KS EF-7	283	37.383 N 96.180 W	Pasture	EBBR 8/29/93	Yes 3/12/96	Yes 3/9/95	Yes 3/9/95	Yes 10/31/97	Power and communication center installed 2/95
Coldwater, KS EF-8	664	37.333 N 99.309 W	Rangeland (grazed)	EBBR 12/8/92	Yes 6/96	Yes 3/4/93	Yes 5/9/95	Yes 8/20/97	Power and communication center installed 5/95
Ashton, KS EF-9	386	37.133 N 97.266 W	Pasture	EBBR 12/10/92	Yes 2/27/96	Yes 3/13/90	Yes 10/5/93	Yes 2/5/98	Power and communication center installed 10/93
Tyro, KS EF-10	248	37.068 N 95.788 W	Wheat	ECOR 7/21/95	Yes 7/96	No	Yes 7/21/95	Yes 10/30/97	Power and communication center installed 6/95
Byron, OK EF-11	360	36.881 N 98.285 W	Alfalfa	ECOR 6/26/95	Yes 6/96	Yes 6/26/95	Yes 6/26/95	Yes 8/22/97	Power and communication center installed 6/95

TABLE A.2 (Cont.)

Site	Elevation[b] (m)	Latitude, Longitude (deg)	Surface Type	Flux Station[c]	SWATS[c]	SMOS[c]	SIROS + MFRSR[c]	SIRS + MFRSR[c]	Comment
Pawhuska, OK EF-12	331	36.841 N 96.427 W	Native prairie	EBBR 8/29/93	Yes 9/97	No	Yes 6/30/95	Yes 10/29/97	Power and communication center installed 6/95
Lamont, OK EF-13, 14	318	36.605 N 97.485 W	Pasture, wheat	EBBR 9/14/92; ECOR 5/30/95	Yes 2/5/96	Yes 4/9/93	Yes 10/15/93; BSRN 5/15/92	Yes 8/19/97	Power and communication center installed 6/93
Ringwood, OK EF-15	418	36.431 N 98.284 W	Pasture	EBBR 9/16/92	Yes 2/21/96	Yes 3/29/93	Yes 10/12/93	Yes 8/23/97	Power and communication center installed 10/93
Vici, OK EF-16	602	36.061 N 99.134 W	Wheat	ECOR 5/30/95	Yes 7/96	No	Yes 5/30/95	Yes 8/21/97	Power and communication center installed 5/95
EF-17[d]	—	—	—	—	—	—	—	—	—
Morris, OK EF-18	217	35.687 N 95.856 W	Pasture (ungrazed)	EBBR 7/97	Yes 9/96	No	Yes; broad-band only 5/24/96	Yes 9/30/97	Power and communication center installed 10/95

TABLE A.2 (Cont.)

Site	Elevation[b] (m)	Latitude, Longitude (deg)	Surface Type	Flux Station[c]	SWATS[c]	SMOS[c]	SIROS + MFRSR[c]	SIRS + MFRSR c	Comment
El Reno, OK EF-19	421	35.557 N 98.017 W	Pasture (ungraze d)	EBBR	Yes	No	Yes	Yes 6/16/98	Implementatio began 5/97
Meeker, OK EF-20	309	35.564 N 96.988 W	Pasture	EBBR 4/5/93	Yes 2/8/96	Yes 4/2/93	Yes	Yes 2/12/98	Power and communicatio center installed 10/94
Okmulgee, OK EF-21	240	35.615 N 96.065 W	Forest	ECOR FY99	Yes FY99	Yes FY99	No	Yes FY99	Lease signed 2/97; tower, phone, and power installed 5/98
Cordell, OK EF-22	465	35.354 N 98.977 W	Rangela nd (grazed)	EBBR 4/5/93	Yes 2/15/96	No	Yes 4/26/95	Yes 11/24/97	Power and communicatio center installed 3/95
EF-23[d]	—	—	—	—	—	—	—	—	—
Cyril, OK EF-24	409	34.883 N 98.205 W	Wheat (gypsum hill)	ECOR 8/25/95	Yes 7/96	Yes 8/25/95	Yes 8/25/95	Yes 11/25/97	Power and communicatio center installed 7/95

TABLE A.2 (Cont.)

Site	Elevation[b] (m)	Latitude, Longitude (deg)	Surface Type	Flux Station c	SWATS[c]	SMOS[c]	SIROS + MFRSR[c]	SIRS + MFRSR c	Comment
Seminole, OK EF-25	277	35.245 N 96.736 W	Pasture	EBBR 12/97	Yes 12/97	Yes 12/97	No	Yes 12/10/96	Power and communication center installed 11/96; SIRS + MFRSR installed 12/10/96, activated 4/9/97
Cement, OK EF-26	400	34.957 N 98.076 W	Pasture	EBBR 6/10/92	No	No	No	No	Phone line (only) installed 10/92

[a] BSRN, baseline surface radiation network; EBBR, energy balance Bowen ratio; ECOR, eddy correlation; EF, extended facility;
MFRSR, multifilter rotating shadowband radiometer; SIROS, solar and infrared radiation observing system; SIRS, solar and
infrared radiation station; SMOS, surface meteorological observation station; SWATS, soil water and temperature system.

[b] Above sea level.

[c] Date indicates actual or scheduled installation date.

[d] This extended facility is a placeholder site for possible expansion, if required.

TABLE A.3 Locations and Status of Boundary Facilities[a]

Site	Elevation[b] (m)	Latitude, Longitude (deg)	Surface Type	BBSS[c]	THWAPS	MWR[c]	Vceil	AERI	Comment
Hillsboro, KS BF-1	441	36.071 N 99.218 W	Grass	Yes 1/18/94	No	Yes 1/18/94	No	No	Temporary power and communication installed 12/93
Hillsboro, KS BF-1	447	38.305 N 97.301 W	Grass	Yes 9/28/94	Yes 4/16/98	Yes 9/28/94	Yes 12/10/98	Yes 12/15/98	Relocated and temporary power and communication installed 9/94; permanent power, communication, and grounding mat installed 3/96; T-1 line installed 4/96
BF-2	—	Unspecified	—	—		—	—	—	—
BF-3	—	Unspecified	—	—		—	—	—	—
Vici, OK BF-4	648	36.071 N 99.218 W	Grass	Yes 1/18/94	No	Yes 1/18/94	No	No	Temporary power and communication installed 12/93

TABLE A.3 (Cont.)

Site	Elevation[b] (m)	Latitude, Longitude (deg)	Surface Type	BBSS[c]	THWAPS	MWR[c]	Vceil	AERI	Comment
Vici, OK BF-4	622	36.071 N 99.204 W	Grass	Yes 10/3/94	Yes 4/17/98	Yes 10/3/94	Yes 11/18/98	Yes 11/18/98	Relocated and temporary power and communication installed 9/94; permanent power, communication, and grounding mat installed 3/96; T-1 line installed 4/96
Morris, OK BF-5	18	35.682 N 95.862 W	Grass	Yes 1/18/94	No	Yes 1/18/94	No	No	Temporary power and communication installed 12/93

TABLE A.3 (Cont.)

Site	Elevation[b] (m)	Latitude, Longitude (deg)	Surface Type	BBSS[c]	THWAPS	MWR[c]	Vceil	AERI	Comment
Morris, OK BF-5	217	35.688 N 95.856 W	Grass	Yes 10/6/94	Yes 4/21/98	Yes 10/6/94	Yes 12/4/98	Yes 12/14/98	Relocated and temporary power and communication installed 9/94; permanent power, communication, and grounding mat installed 3/96; T-1 line installed 4/96
Purcell, OK BF-6	344	34.969 N 97.415 W	Grass	Yes 9/23/94	Yes 4/20/98	Yes 9/23/94	Yes 11/11/98	Yes 11/11/98	Permanent power, communication, and grounding mat installed 3/96; T-1 line installed 4/96

[a] AERI, atmospherically emitted radiance interferometer; BBSS, balloon-borne sounding system; BF, boundary facility; MWR, microwave radiometer; THWAPS, temperature, humidity, wind, and pressure sensors; Vceil, Vaisala ceilometer.

[b] Above sea level.

[c] Date indicates actual installation date.

TABLE A.4 Locations and Status of Intermediate Facilities[a]

Site	Elevation[b] (m)	Latitude, Longitude (deg)	Surface Type	915-MHz Profiler and RASS[c]	Comment
Beaumont, KS IF-1	525	37.626 N 96.538 W	Rangeland	Yes 9/96	Power and communication installed 9/96
Medicine Lodge, KS IF-2	585	37.280 N 98.933 W	Rangeland	Yes 9/96	Power and communication installed 9/96
Meeker, OK IF-3	300	35.550 N 96.920 W	Grass	Yes 9/96	Power and communication installed 9/96

[a] IF, intermediate facility; RASS, radio acoustic sounding system.

[b] Above sea level.

[c] Date indicates actual installation date.