6.1 MODERNIZATION OF THE SPACE LAUNCH RANGES METEOROLOGICAL SUBSYSTEM ARCHITECTURE

T. Wilfong[1]

Lockheed Martin Mission Systems, Santa Maria, Ca

P. Conant

Space Launch Range Systems Contract, Patrick AFB, FL

K. Winters

45th Weather Squadron, Patrick AFB, Fl

C. Crosair

30th Weather Squadron, Vandenberg AFB, Ca

1 . INTRODUCTION

In the United States, there are two primary space launch locations -- the Western Range (WR) at Vandenberg Air Force Base, California and the Eastern Range (ER) encompassed by Cape Canaveral Air Force Station and Kennedy Space Center (KSC). The Air Force Space Command has the responsibility to operate both the ER and WR, providing common services and ensuring public safety. In addition to spacelift, the ER and WR also serve as launch ranges for ballistic missile and other tests. Figure 1 shows the extent of the ranges.

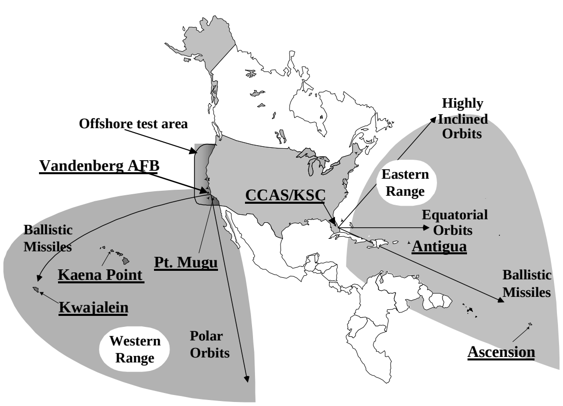

FIG. 1: The Eastern and Western Ranges cover large areas necessary to accommodate equatorial, high inclination and polar orbits as well as ballistic missile and other tests such as aircraft flights in the offshore corridor off the west coast.

Weather plays a critical role in the planning and execution of spacelift and other test operations. Each launch vehicle has specific tolerances for near surface winds and temperatures as well as winds aloft which must be considered immediately prior to launch. Cloud cover, temperature profiles, and the presence of convective activity in the vicinity of the range have significant impacts due to the potential for lightning strikes and electrostatic discharge. In the event of a launch mishap, toxic hydrazine clouds have the potential to endanger ground personnel. The launch decision process includes an evaluation of the threat. Toxic dispersion models are exercised which require wind and stability information as inputs. Results of these analyses are used as an emergency response planning tool. Weather data are also the most critical input to the blast overpressure model that provides pre-launch assessments of damage potential in the event of near-pad launch vehicle mishaps.

The Air Force provides comprehensive operational meteorological services to the ER and WR. These services include personnel and resource protection, pre-launch ground processing, and day-of-launch operations for launches by the Department of Defense, National Aeronautics and Space Administration (NASA), and commercial launch customers.

In the mid 1990s, The Air Force Space Command undertook an effort to modernize the two ranges. The Range Standardization and Automation (RSA) program is designed to improve efficiency and reduce costs by providing more automated, integrated and standardized systems. As part of this modernization effort, the Mission Systems division of Lockheed Martin is completing development and delivery of the infrastructure, instrumentation, communications and software applications necessary to operate the ranges.

[1]Corresponding author's address:
Timothy L. Wilfong
1111 Betteravia Rd
Santa Maria, CA 93454
e-mail: timothy.l.wilfong@lmco.com

2. RSA ARCHTECTURE OVERVIEW

The RSA architecture implements a common set of Automated Data Processing Equipment (ADPE) with a suite of layered services with the operating system services forming the base layer. For example, the Distributed Computing Services layer provides inter-communication services among all the processes. Figure 2 shows an overview of the architecture.

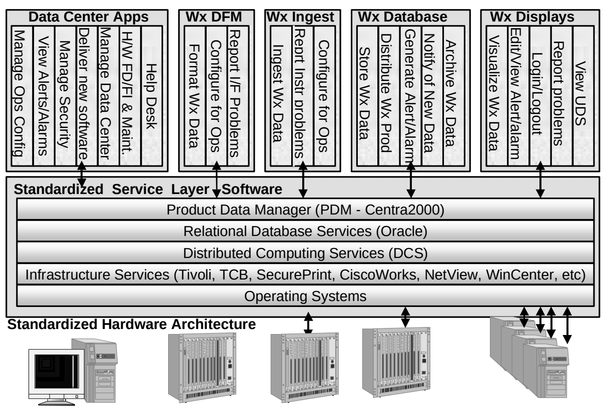

FIG. 2: The RSA architecture implements a common set of ADPE and operating systems. Layered on top of the operating systems is a common set of services or "middle ware". Applications such as the weather processes communicate with this layered service architecture.

The RSA weather subsystem is one of several subsystems – all integrated into a common operating environment. There are three major elements, called segments, comprising the architecture: Instrumentation, Network and Control & Display. Figure 3 shows the major components of each segment.

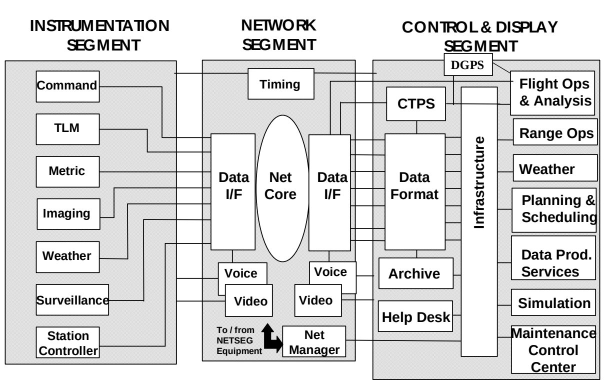

FIG. 3: The RSA architecture consists of three major segments integrated into a common operating environment in which various products such as weather operate.

The weather subsystem is planned for delivery in three phases. The first phase planned for completion at both the WR and ER this year implements a basic capability to perform mission support. Included are the common instrumentation sets at both ranges along with the communication and ADPE infrastructure to acquire, quality control, distribute, and archive local data. Also included in the first delivery is an implementation of AWIPS 5.1.2 that will be used for interactive display of local and NOAAPort data as well as decision product preparation (Davis et al. 2000). Meso-scale analysis and forecast models complete the tools implemented in the first delivery. Two future deliveries are planned over the following two years to enhance the basic capability and enable deactivation of current systems. Future enhancements include (1) an alert monitoring system, (2) enhancements to upper air data quality control, (3) improvements to the meso-scale modeling system necessary to produce more precise toxic and sound focusing hazard decision products, (4) extensive upgrades to the current toxic modeling systems, (5) data acquisition from lightening related instrumentation, and (6) enhancements to the AWIPS to include display of three dimensional data sets as well as the capability to acquire and display NexRad level II and III data.

3. RSA WEATEHR SYSTEM ARCHITECTURE

3.1. Instrumentation Segment

The first delivery of the RSA weather subsystem includes instrumented towers, 915 MHz and 50 MHz Doppler radar wind profilers, and mini-sodars. In addition, the system will interface to the Air Force Real Time Automated Meteorological Profiling System (RT-AMPS), which provides data from AMPS, a GPS based balloon sounding system (Divers, et al., 2000, Wilfong et al. 2000). Table 1 shows the classes of instrumentation supported in the first delivery. Subsequent deliveries will include interfaces to NexRad level II and III data, as well as interfaces to lightening detection systems.

Table 1: Instrumentation included in the first delivery

	ER	WR	Update	Data
Towers	39	25	1 min	Average wind, temp, RH, Soil Moisture
Mini-Sodar	6	6	1 min	Wind 15m -150m
915 DRWP	5	6	15 min	Wind 120m - 3Km RASS 100m -1.5Km
50 DRWP	1	1	3 min	Wind 2Km-20Km
RT-AMPS interface	1	1	Regular + Launch	Wind, temp, RH, pressure Surface – 30Km

Interfaces to the lightning systems planned for future deliveries include (Boyd et at. 2002)

- Lightning Location and Prediction (LLP) systems on both ranges also known as the Cloud-to-Ground Lightning Surveillance System (CGLSS) on the ER

- Launch Pad Lightning Warning System (LPLWS), a network of 31 field mills on the ER

- The Lightning Detection and Ranging (LDAR) system consists of a network of seven time-of-arrival radio antenna receiver sites, which provides a three-dimensional depiction of the lightning, including: in-cloud, cloud-to-cloud, cloud-to-air, and cloud-to-ground lightning.

3.2 Network Segment

The RSA network segment includes all the communications lines and equipment required to transport instrument data, support communications between various locations on the ER and WR, and provide links with external data sources**.**

3.3 Control and Display Segment

As shown in Figure 4, the weather infrastructure is implemented on two separate local area networks (LANs). The Operations Control Center (OCC) LAN interfaces to all local instrumentation and is used to acquire, quality control, and archive local data, as well as to distribute instrumentation data, mesoscale model data, and decision products. The AWIPS LAN is implemented in much the same way as the NWS installations and uses the new Linux based architecture. Local data acquired by servers on the OCC LAN are formatted and sent to the AWIPS LAN where they are combined with NOAAPort and NexRad data acquired directly by the AWIPS.

As part of a modernization program, the National Weather Service (NWS) has spent many years creating an interactive analysis and forecasting tool for weather forecast offices. The RSA project is effectively leveraging this work for use at the ranges. Working with the National Oceanic and Atmospheric (NOAA) Forecast Systems Laboratory (FSL) , the RSA project is expanding the capability of AWIPS. Specifically, general purpose functions are being expanded or created to visualize site specific data. These functions will be integrated into the AWIPS baseline so that they can be used by all weather forecasting offices within the NWS in future versions of AWIPS. For example, range operations require extensive use of vertical data sets. AMPS balloons, Mini-Sodars, 915 MHz profilers and 50 MHz profilers are used at the ranges to formulate decision products. The standard AWIPS system is used to ingest and display local data at every NWS office, but the data sets are limited to surface "mesonet" type data. FSL enhanced the local data ingest for RSA by creating a capability to ingest and display data with a vertical dimension such as profiler and rawinsonde data.

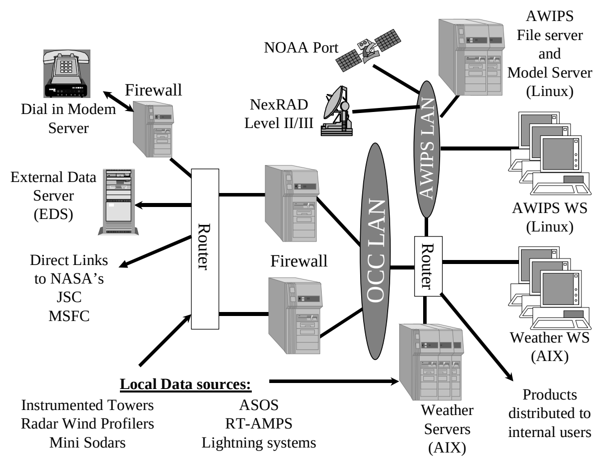

FIG. 4: The weather support subsystem consists of local instrumentation, communication and the automatic data processing equipment required to acquire and process data. The AWIPS LAN is implemented in the same manner as other National systems to maintain compatibility.

The AWIPS LAN also supports a mesoscale model server used to run a local area analysis and forecast model (Shaw et al. 2002). Lockheed Martin in partnership with FSL has implemented an assimilation and forecast system using the Local Analysis and Prediction System (LAPS, Albers et al. 1996). In principle, LAPS can be coupled with any mesoscale NWP model. The NCAR/PSU fifth-generation mesoscale model (MM5, Grell at al. 1995) has been selected for use as the forecast component for the RSA project. FSL's close working relationship with NCAR and extensive experience with the MM5 model, combined with its public domain nature, make it a logical choice. Additionally, the selection of MM5 as the forecast component places the RSA program on a direct track for upgrading to the emerging Weather Research and Forecast (WRF) model in the future. MM5 Version 3, Release 4 (MM5v3-4) is the version implemented within the RSA program. It is a non-hydrostatic model utilizing a terrain-following pressure coordinate and offers a wide variety of boundary layer schemes, cumulus parameterizations, microphysical schemes, and longwave radiation formulations. Minor modifications have been made to accommodate the diabatic initialization technique. The RSA implementation of AWIPS uses Linux PC and NFS servers. Mimicking the NWS' proposed hardware upgrades, the RSA program is implementing high-end IBM IntelliStation PCs for data display with an IBM eServer series 350 network file server for data ingest, decoding, and storage.

4. SUMMARY AND FUTURE WORK

In addition to the personnel and resource protection missions that are shared by National Weather Service offices throughout the country, the spacelift ranges support a variety of operations culminating in a launch. During the launch countdown, the Launch Weather Team (LWT) monitors conditions and evaluates the Launch Commit Criteria (LCC). The LCC are each determined to be either red if the criterion is violated or green if not violated. Frequent briefings of the LCC status are provided to the Launch Director who uses the information to make Go/No Go determinations for the launch.

A primary goal of the RSA program is to implement a completely integrated solution to reduce costs and provide assured access to space. The weather subsystem reflects this overall philosophy. Significant life cycle cost reduction will be achieved by integration of a government-off-the-shelf system (AWIPS) into the space launch range architecture. Delivery of the weather subsystem is planned to take place over the next three years, with the first delivery occurring this year. Future work will concentrate on implementing an alert monitoring system, implementing common toxic hazard evaluation systems, enhancing the meso-scale modeling system, implementing complete upper air data quality control, and expanding the AWIPS capability to include display and fusion of sources of lightening threat data.

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