Prototyping Aviation Collaboration Effort (PACE)
Ft. Worth ARTCC CWSU

Concept of Operations

A joint project between:

FAA Southwest Region
National Weather Service Southern Region Headquarters
National Weather Service Headquarters
Center Weather Service Unit (CWSU) Fort Worth
Warning Forecast Office Fort Worth
NOAA Forecast Systems Laboratory

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1. Background

Adverse weather conditions, especially those associated with thunderstorms, contribute significantly to disruptions in air traffic operations within the National Airspace System (NAS). The affects extend to every sector of the flying community and take the form of delays, re-routes, trip cancellations, and most importantly, a reduced margin of operating safety. When coupled with the dramatic growth being experienced throughout the industry, hazardous weather encounters are severely taxing an already overburdened traffic management system. Projections are for industry growth to outpace improvements to the traffic management system over the next five years.

To address the problems of weather on aviation the FAA in 1978 established the Center Weather Service Unit (CWSU) Program. This program was initiated by the FAA/NWS as result of an NTSB recommendation based on the findings from the crash of a Southern Airways in north Georgia. The CWSU program, since it's inception has slowly developed, only until the latter quarter of the 1990's did the CWSUs begin to receive newer technology that would enable the meteorologist to provide higher resolution forecasts and advisories to air traffic controllers and supervisors to mitigate the impacts of weather on the flying community.

Further progress toward achieving a more weather-responsive air traffic system is reliant upon a joint NWS and FAA commitment that places increased emphasis on aviation weather forecasting. The FAA, as the regulatory agency, is actively working toward establishing a more definitive set of requirements for weather forecast information. Once mutually agreed upon and finalized, the contents of a "FAA TMU Decision-Based Weather Needs
" should become requirements which will provide a starting point from which the NWS can launch appropriate initiatives aimed at satisfying those requirements.

PACE by definition was designed as a regional effort to begin to develop weather forecast products outlined by the "FAA TMU Decision-Based Weather Needs". The project has now taken on a broader scope and is working in parallel with "FAA TMU Decision-Based Weather Needs" work group at a national level, which is converting those needs to requirements.

During 2000 negotiations for the PACE facility began between FAA Southwest Region, NWS Southern Region Headquarters and Ft. Worth ARTCC management. NOAAs Forecast Systems Laboratory offered technical assistance to the project, predicated on receiving funding from the FAA Aviation Weather Research Program (AWRP). During 2001 and 2002 initial infrastructure and development work began as well communications of the projects intent with FAA and NWS national headquarters.

2. Purpose

The Prototype Aviation Collaborative Effort (PACE) will take place at the Ft. Worth ARTCC/CWSU, PACE is a rapid prototype facility designed to test and demonstrate the effective employment of developing science, technology and computer communication interfaces in developing new weather products for decision makers in the Traffic Management Unit (TMU).

Fort Worth ARTCC was selected for the following reasons, technical advances already in place at both the TMU and CWSU, high volume of traffic, working relationship between TMU and CWSU, communications and hardware infrastructure already in place, work space was a significant factor in selecting Ft. Worth CWSU since it is the largest of the 7 CWSU located within National Weather Service Southern Region Headquarters umbrella and finally, local and regional FAA/NWS support.

The PACE facility will initially develop a wide range of high- resolution forecast products specifically tailored to the ARTCC air traffic environment. PACE will build upon knowledge and experience gained from ongoing operations and testing such as the Collaborative Convective Forecast Product (CCFP) and Dallas-Fort Worth International Airport (DFW) Collaborative Aviation Forecast Study (D-CAFS). It is anticipated that an initial suite of graphical products would consist of convective forecasts followed by icing, turbulence, and ceiling and visibility forecasts, other parameters could then be addressed based on requirements outlined by the FAA.

3. Objectives

The primary goal of PACE is to establish procedures to generate automated guidance products, sharing common data sets amongst operational units and demonstrate how the employment of collaborative forecasting methodologies can lead to significant improvements in the accuracy and consistency of NWS-generated aviation forecast products. Accomplishing these objectives will in the end produce a more efficient use of the NAS, greater safety to the flying customer, and cost savings to the flying community.

The specific objectives of PACE are:

- Define a methodology of producing automated forecast guidance products, and it's role in support of TMU decision makers and the collaboration and forecast process.

- Demonstrate the utility of collaboration to achieve more accurate and consistent forecast product(s), initially amongst CWSUs and then expand to other operational units.

- Establish a methodology, using state-of-the-art or developmental collaboration technology, for promoting an efficient exchange of meteorological information among several operational elements.

  Explore advanced technology for collaborative generation of forecast products.

- Establish procedures, by which, each participating office, focusing on its area of expertise, adds value to the graphical forecasts.

  Assess whether the products developed can be ported to other aviation venues (e.g., TRACON, FSS)

- Demonstrate the importance of integrating common data sets into the forecast decision process.

- Develop automated graphical forecasts and improve graphical product generation and editing tools.

4. Operations Concept

This section discusses roles and responsibilities, the physical and functional characteristics of the PACE facility, local CWSU operations and sustaining environments for software and collaborative process development.

4.1 Roles and Responsibilities

To aid in development and understanding of the PACE facility 3 separate categories of personnel are defined.

4.1.1 Users

Users are personnel who utilize the resources and products from the PACE. These are categorized in two groups. More functional groups could be added later (i.e. TRACON, AFSS, and FSS personnel as products are refined).

The first group is that of the ARTCC Traffic Management Unit (TMU) controllers and supervisors. TMU will be the primary customer for the PACE products and will initially be designed, as decision making aids for air traffic control tactical and strategic planning. The second group is that of the meteorologists (AWC, CWSU and WFO). The meteorologist from the PACE will use automated "first guess" products graphical forecasts as guidance before finalizing the products for controller use.

4.1.2 Operators

Operators are defined as those persons who manage and monitor PACE systems resources in support of data and forecast product processing. These will include the PACE Chief, meteorologists initially from the CWSU (later expansion could involve AWC and WFOs) and systems personnel from FSL, again predicated, on receiving funding from AWRP. The PACE operations personnel will perform all of the activities needed to prepare for the execution of scheduled tests, monitor the status and accuracy of products and arrange for systems maintenance.

4.1.3 Developers

Developers are responsible for the design and development of PACE hardware and software. The development process is outside the scope of this Concept of Operations document. The developers will mainly consist of personnel from FSL, but may include NWS personnel. The developers will apply leading edge research and technology and document it's development as PACE develops and provides products to TMU.

The involvement of NOAAs Forecast Systems Laboratory, funded by the FAAs Aviation Weather Research Program is integral to the success of PACE. To date, significant infrastructure groundwork has been developed ensuring a March 2002 TMU evaluation support date.

4.2 PACE Physical Characteristics

4.2.1 CWSU Operations and Control Room

The CWSU selected for the PACE is located within the Fort Worth, TX ARTCC (ZFW). This site has been selected due to the high volume of air traffic, technological advances, location with respect to NWS/FAA regional headquarters and Fort Worth NWS WFO. The CWSU is located within the Display System Replacement Control Room next to the Operations Manager and TMU. This design facilitates the rapid flow of air traffic and weather data for use in tactical and strategic planning. Voice communications are conducted through Voice Switching and Communication System (VSCS), which provides managers, supervisors, or controllers direct access to CWSU meteorologists. The floor is divided into two main areas. First, the (Display System Replacement) DSR control room, equipped with DSR consoles for a radar and monitor position and areas for the TMU controllers and supervisors. Finally, the Operations Manager who oversees all facets of ZFW airspace. Second, is the Airways Facilities maintenance and control position to monitor radars, beacons, and radio frequencies. The CWSUs are an integral part of the nation's 21 Air Route Traffic Control Centers (ARTCCs) and are staffed 16 hours a day by NWS meteorologists. Their primary mission is to provide meteorological consultation, advisories, and forecasts to FAA traffic managers and controllers tasked with maintaining a safe and efficient flow of air traffic through the National Airspace System (NAS).

The weather support that the CWSUs provide is accomplished through a variety of products and dynamic verbal briefings that describe current and expected weather conditions and the impacts that these conditions may produce on traffic flow. The CWSUs' areas of responsibility are defined by the individual ARTCCs and may include special use airspace (e.g. military operations areas).

The primary text products produced by the CWSUs include the Center Weather Advisory (CWA) and Meteorological Impact Statement (MIS). The CWA is an unscheduled in-flight aircrew, flow control, and air traffic advisory. It is valid for up to two hours and often is issued for the same conditions that warrant issuance of SIGMETs or Convective SIGMETs.

The MIS also is an unscheduled product but is concerned primarily with flight operations planning. It details expected weather conditions that will significantly impact the flow of traffic in the time period beyond two hours but within 12 hours of issuance.

4.2.2 PACE Test-bed

The primary tool for use in the PACE will be a Pentium computer running the Linux operating system with software based on FX Connect software based on D2D AWIPS and JAVA. The hardware footprint required for this configuration will be that of a standard tower PC and that of a 21inch monitor. Communications will be performed through Internet links that have already been implemented at Ft. Worth CWSU, NCEP/AWC and Ft. Worth WFO. Additional links will likely follow to demonstrate collaborative technology between CWSUs.

Hardware and communications for the PACE FX Connect platform were purchased through the National Weather Service Southern Region Headquarters Aviation Implementation Plan funds.

1. dual 800 mHz Pentium 3 processors
2. 21-inch SVGA color monitor
3. 30 gb hard drive
4. 500 Mb RAM
5. 512K piped cache
6. Redhat LINUX Version 6.2 operating system (loaded configured by FSL)
7. AWIPS D2D and FX-Connect display application software (installed by FSL)
8. DSL high-speed communications line.

4.2.3 Phased Approach to Product Development

The PACE work group has developed a phased approach to developing products that could address those outlined by the “FAA TMU Decision Based Needs Document”.

Convective Forecasts **PACE Phase I Step I**	**1 Hour convective forecast for the ARTCC**
Time:	1 hour
Start Date	March 2002
Product Description:	Automated TMU display depicting NCWF and Convective SIGMETs
CWSU role:	Monitor automated generation.
TMU role:	provide feedback regarding utility and recommend enhancements.

Current Tasks to meet March milestone:

1. Display NCWF at CWSU/TMU stand-up briefings
2. Evaluate capability to have forecasters collaborate using FX-connect
3. Implement Web server at Forecast Systems Laboratory
4. Enable FX Connect to acquire NCWF from NOAAport instead of AWC
5. Transition to the latest version of FX Connect based on AWIPS 5.2.2
6. Transition to LINUX 7.1 for greater stability and security
7. Train CWSU forecasters and familiarize TMU staff with the new product
8. Develop evaluation procedures
9. Enable RTVS to verify products for the ARTCC domain

PACE Phase I Step II	**1-6 Hour convective forecast for ARTCC and TRACON**
Time:	1 to 6 hour
Start Date:	April 2002
Product Description:	The 1 hour plan-view of graphical forecast will be based on NCWF and Convective SIGMETs. A 2-6 hour plan-view graphical forecasts based on CCFP.
CWSU role:	Monitor automated generation of 1 hour forecast. Add value as needed to CCFP by generating complementary graphical forecast that shows additional detail
TMU role:	Provide feedback regarding utility and recommend enhancements

Current Tasks to meet the April milestone:

1. Enable FX Connect to display the TRACON boundary, CCFP with graphic forecast enhancements, and FAA Playbooks.
2. Enable forecasters to generate graphical forecasts that complement the CCFP
3. Enable FSL TMU Web server to acquire forecaster input products from the CWSU.

PACE Phase I Step III	**Enhancing 1-6 hour convective forecasts for ARTCC and TRACON**
Time:	1 to 6 hour
Start Date:	Late summer 2002
Product Description:	The 1 hour plan-view graphical forecast will be base on NCWF, TCWF and Convective SIGMETs. Develop a 2-6 hour plan-view graphical forecasts based on CCFP. Test methods for the Fort Worth and Houston CWSUs to collaboratively generate prototype convective products in a real-time environment.
CWSU role:	Monitor automated generation of 1 hour forecast. Add value as needed to 2-6 hour forecast
TMU role:	Provide feedback regarding utility and recommend enhancements

Current Tasks to meet the April milestone:

1. Enable FX Connect to acquire and display 1-min ASOS observations from WARP WINS server
2. Enable FX Connect to acquire and display layer composite reflectivities from WARP WINS server
3. Develop and test prototype products for high and ultra-high sectors that have lower reflectivity thresholds
4. Enable FX Connect to acquire and display TCWF

Icing Forecasts
PACE Phase II

Fall 2002
Integrated Icing Detection Algorithm
Integrated Icing Forecast Algorithm

ARTCC and TRACON domain 0 to 6 hour forecast depicting detection and forecast areas of icing.

Turbulence Forecasts
PACE Phase III

Spring 2003
Integrated Turbulence Forecast Algorithm

ARTCC and TRACON domain 0 to 6 hour forecast depicting detection and forecast areas of icing.

Ceiling & Visibility Forecasts
PACE Phase IV

2004

Collaboration

In addition to this phased approach to product development it is the intent of PACE rapid prototype facility to begin testing the collaborative capabilities of FX Connect. Collaboration testing is already underway between FSL and the Ft. Worth CWSU exploring the drawing tools and system capabilities for application to PACE. In parallel to product development, PACE should also explore collaboration between CWSUs in support of the TMU mission.

This collaboration could begin in 2002 providing the initial milestones are met and funding, logistics and product development are not impeded. Some initial contacts have started with the Houston CWSU as a possible candidate for collaboration testing.

4.2.4 Methodology

The planned technology to be employed by the PACE has been developed by NOAAs Forecast Systems Laboratory (FSL). The system, FX Connect, is ideal for rapid prototyping because it provides the full suite of AWIPS data and function-yet it resides outside the AWIPS firewall (thereby, avoiding bureaucratic/operational restrictions and enabling us to make rapid enhancements based on user feedback. The user can generate freehand and icon-based graphical forecast products in a common window that includes basic AWIPS weather displays. Essentially, FX-Connect opens an AWIPS-look-alike window on all participating systems and enables participants to access the AWIPS database and basic AWIPS functions, such as animation, zooming, and overlaying and the following items listed below:

1. Collaborative display of several meteorological data sets, including output from the FAA Weather Research Product Development Teams (PDT)
2. User-friendly access to these same data sets; via FSL developed web page.
3. Simultaneous display of forecast products addressing convection, icing, turbulence, ceiling and visibility threats.

It is anticipated that FX-Connect will mature sufficiently in the next year to undergo limited testing of the collaborative software. It is envisioned that PACE participants in the collaborative mode will:

1. View the same AWIPS weather data;
2. Viewing first-guess graphics (overlain on AWIPS weather graphics, if desired) in real-time as those graphics are generated;
3. View enhancements to forecast graphics in real-time as those enhancements are generated by participants (FX-Connect);
4. Agreeing on a final graphic(s); and
5. Ability to produce hard copies of the demonstration products and save those products on the participant's system for later recall or verification.

4.2.5 Daily PACE Operations

Since ZFW CWSU is not operational 24 hours a day, the PACE facility and CWSU will rely heavily on computer generated first guess graphics as a starting point for each days operations. The PACE facility will operate Monday through Friday 0600 – 2100 local time. This time frame will capture 1) the heaviest flow of traffic for a given day and 2) large portion of the day usually impacted by thunderstorms.

Beginning with real-time operations of PACE Phase I Step I in March 2002. it is foreseen that the initial set of forecast graphics will be completely automated relying on NCWD/NCWF with the CWSU staff or Chief will only monitoring products. The Chief of PACE will gather comments and feedback from TMU. Based on the users feedback enhancements will be made to tailor the convective forecast graphics to users needs.

Daily PACE operations for PACE Phase I Step I:

1. The team has come to consensus that the first convective products will include the NCWD with polygons from the NCWF. Added to this product will be convective SIGMETs, speed and movement vectors, and echo tops data. The forecast resolution will be at the ARTCC level.

2. FSL production of the NCWD/NWCF forecast display will be automatic and the product will be updated once every 5 minutes. The Convective forecast product is then distributed at the CWSU and TMU web display.

3. There will be no impact on the CWSU meteorologist work conditions in Phase I.

Daily PACE operations for PACE Phase I Step II:

The team approach has defined a 1 to 6 hour forecast product for Phase II. FSL will produce and initial 1 hour NCWF forecast with Convective SIGMETs. FSL will generate a display of the 1 hour NCWF forecast (that also shows Convective SIGMETs) and a separate display of the CCFP with valid times of 2, 4 and 6 hours.

1. The CWSU or PACE Chief will monitor the 1 hour automated product. Upon receipt of the 2 to 6 hour CCFP forecast the CWSU personnel can generate a complementary prototype product using the drawing tools. These results are then mounted on the FSL web server for distribution to TMU.

2. The PACE FX Connect system will provide a nearly seamless platform to perform this activity. This can be demonstrated by the fact that the original collaboration for the CCFP product can be accomplished at the FX Connect system using a web browser in conjunction with the systems, graphic forecast display capability. The complementary product will be a logical extension to the CCFP by covering thunderstorms below the lowest coverage threshold (less than 25%) covered by the CCFP. FX Connect essentially brings all the tools for the meteorologist into one system streamlining the process and eliminating the need for the forecaster to use multiple systems to aid in analysis and forecasting.

3. Although, the CWSU meteorologist will be performing graphical editing in Phase II, we don't see this as a workload item since part of the duties encompass participating in the CCFP discussions. In fact, performing the chat room discussions at the FX Connect system will actually streamline and enhance the current operations as stated above. Adding value to the 2 to 6 hour CCFP product is a logical extension covering thunderstorms below the threshold (<%25 coverage) of the CCFP product.

Daily PACE operations for PACE Phase I Step III:

1. The team approach will again use a 1 to 6 hour forecast product as in Phase II. FSL will produce and initial 1 hour NCWF with the addition of the (TRACON Convective Weather Forecast) TCWF and Convective SIGMETs. The 2 to 6 hour plan-view product will be based on the CCFP forecast. The forecast resolutions will be at the ARTCC and TRACON domain levels.

2. As with Phase II the CWSU will only monitor the 1hour forecast product. And, when appropriate will add value at the ARTCC and TRACON domains using the drawing tools provided through FX Connect. Those results are then distributed to the TMU web display through the FSL web server.

4.2.6 Product Requirements

The generated graphic(s), as mentioned before have not been determined as of yet. The output must meet the users need for tactical and strategic "go, no go" decision-making. Approach and departure are the most critical phases of flight. Therefore, weather information must be of sufficient detail to support the decision-making responsibilities of the Traffic Management Unit (TMU). Thus, the forecast graphic(s) should incorporate as much mesoscale observational information as possible.

4.2.7 Support Systems

Support to PACE will be provided through NWS Southern Region Headquarters, FSL, NCAR, NWS HQ Office of Science and Technology and Aviation Services Branch. Some of these support mechanisms will come in the form of hardware and software support for PACE operations funded by NWS Southern Region and FSL. Support for science, technique development and applications, would be provided by the NWS Office of Science and Technology (OST), FSL, and AWC.

4.2.8 Operations Management

Management of PACE will be performed by the CWSU MIC at Ft. Worth who has accepted this added responsibility. As Chief of the prototyping facility he shall be a liaison between all participants with PACE, and responsible for arranging all tests and assigning work. It is envisioned that the facility would be populated by temporary employ assignments of personnel from FSL. These assignments would bring expertise from a certain field to aid in product processing.

4.2.9 Product Controls & Verification

The CWSU shall maintain control of all products to support TMU air traffic operations and will be the direct interface with TMU. It is proposed that Real Time Verification System (RTVS), be used as a metric for forecast accuracy, however, the use of RTVS will be based on FAA Aviation Weather Research Program funding. RTVS has been applied to CCFP and is currently being used at AWC for forecast verification.

5. Cooperative Arrangements

Negotiations have initiated between NWS Southern Region Headquarters and FAA Southwest Region for the development of PACE. Communications have already taken place with ZFW Airways Facilities and

Air Traffic authorizing installation of communications lines, and hardware delivery. Coordination has to taken place at ZFW for building access and familiarization for FSL temporary employees.

5.1 Interagency Living Document

It has been recommended by FAA Southwest Region that this "Concept of Operations" document serve as a "living document" authorizing the establishment of the PACE facility at Fort Worth ARTCC. This document outlines operations of the PACE facility and interactions between the parties involved with the rapid prototype facility.

6. Timeline

NWS Southern Region Headquarters proposes the following timeline to spin-up the PACE to operations.

6.1 Negotiating the operation of a prototyping test facility at the Fort Worth ARTCC with the regional FAA

Target: Complete
Resources: None

6.2 Publishing a Living Document (PACE Concept of Operations).

Target: Complete updates to document annually
Resources: Minimal, if any

6.3 Assessing the need for acquiring new or upgrading existing technology and/or communications for the PACE facility

Target: Completed September 2000
Resources: Minimal, if any, for the assessment

6.4 Researching staffing options for the PACE facility

Target: Completed November/December 2000
Resources: Minimal, if any

6.5 Implementing a staffing plan and beginning first training/familiarization session

Target: June/July 2001

6.6 Begin operations of the PACE

CWSU capability to monitor NCWD/NCWF product with echo top and movement vectors. New ARTCC map backgrounds for VORs and jetroutes. FSL and CWSU tests of FX Connects collaborative and drawing tool software.

Target: Started December 2001
Resources: Minimal, if any

6.7 Posting comparative verification statistics on the regional aviation website, in compliance with agency policy regarding privacy issues

Target: TBD
Resources: Minimal, if any

6.8 Establishing the responsibilities and confirming the participation of interested organizational elements in PACE facility operations

Target: Completed
Resources: Minimal, if any

6.9 Accelerating development of computer-generated forecast guidance

Target: May 2001
Resources: Software/hardware upgrade/maintenance $2,500

6.10 Ongoing tests of collaboration process with FSL to determine future application of this technology.

Target: Started December 2001

6.10.1 Develop and test a methodology for conducting wide-scale collaboration among NWS offices

6.10.2 Develop technique(s) for revising the database and producing a collaborative forecast graphic

6.10.3 Develop methodology/software for generating customized forecast products

Resources: Software/hardware upgrade/maintenance $2,500

6.11 Posting of products on the TMU website for review and comments

Target: April 2002
Resources: Minimal

6.12 Posting of products on the regional aviation website for review and comments

Target: Summer 2002
Resources: Minimal, if any, Possible SRH ROC assignment

6.13 Integrated Icing Detection and Forecasting Algorithm

Target: Fall 2002
Resources: FSL Programming, predicated on funding from FAA Aviation Weather Research Program

6.14 Integrated Turbulence Forecasting Algorithm

Target: Spring 2003
Resources: FSL Programming, predicated on funding from FAA Aviation Weather Research Program

6.15 Ceiling / Visibility Forecasts

Target: 2004
Resources: FSL Programming, predicated on funding from FAA Aviation Weather Research Program

The products produced by the PACE will eventually be tailored to meet the FAA driven "Weather Requirements" document currently being developed. It will take sustained effort by programmers and operational personnel to meet the needs both temporal and spatially outlined by the FAA's "requirements" document. Refinements to methodologies and product prototypes as we move closer to achieving the goal of an accurate and efficient forecast system will obligate the sustained activities of the PACE facility for an unknown period of time.

7.0 Evaluation

Rigorous evaluation (via RTVS and customer feedback) of this entire collaborative forecast and product development process can be accomplished through the establishment of the PACE facility. It is of the utmost importance that such a facility be established in an operational environment, where customers can interact directly with the development and testing process, and provide immediate feedback. The CWSU appears best suited to house such a prototyping facility.

Feedback will be gleaned immediately from both the CWSU and PACE facility staff as to whether the output provides useable decision making information for TMU personnel. It is also proposed that FSL maintain product verification database for the PACE facility. Quarterly or semi-annual meetings should take place between the FAA, NWS and FSL to evaluate product development and assess their operational value.

8.0 Path to Operations: Migration of PACE to Real-time Operations

Assuming that PACE is successful, after a period of evaluation at ZFW it is expected this type of real-time, automated and collaborative forecasting method could be reproduced nationwide to provide higher quality forecasts to the NAS. To accomplish this will require a path-to-operations along with a science and technical overview of the products developed by PACE.

The PACE products should go through the same technical review that the FAA and NWS have applied to other operational products such as NCWD and NCWF. The National Weather Service Office of Science and Technology should review the PACE products to certify them as operational. Post certification, the FAA and NWS should determine the most logical and expeditious method to provide a path-to-operations for the newly developed products. Currently, the only approved weather display platform for the CWSU and TMU at the nations 21 ARTCCs is the Weather and Radar Processor (WARP) system and it's briefing terminals. Other avenues that could be explored are Enhanced Traffic Management System (ETMS) located in the ARTCC TMU and the Advanced Weather Interactive Processing System (AWIPS) Remote Display located in the ARTCC CWSU.