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**Report on Current Convective Weather
Processes and Product Requirements
at the Air Traffic Control System
Command Center (ATCSCC) and
Kansas City Air Route Traffic Control
Center (ARTCC)**

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March 2002

DOT/FAA/CT-TN02/13

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Technical Report Documentation Page

1. Report No. DOT/FAA/CT-TN02/13		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle REPORT ON CURRENT CONVECTIVE WEATHER PROCESSES REQUIREMENTS AT THE AIR TRAFFIC CONTROL SYSTEM AND KANSAS CITY AIR ROUTE TRAFFIC CONTROL CENTER				5. Report Date March 2002	
				6. Performing Organization Code ACT-320	
7. Author(s) Danny Sims; Cynthia Fidalgo, Raytheon Technical Services Company; Jeff Weinrich, Titan Systems Corporation				8. Performing Organization Report No. DOT/FAA/CT-TN02/13	
9. Performing Organization Name and Address U.S. Department of Transportation Federal Aviation Administration William J. Hughes Technical Center Atlantic City International Airport, NJ 08405				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No.	
				13. Type of Report and Period Covered Technical Note	
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration William J. Hughes Technical Center Atlantic City International Airport, NJ 08405				14. Sponsoring Agency Code	
15. Supplementary Notes					
16. Abstract This report summarizes current processes and information sources used when convective weather impacts Air Traffic Control (ATC) operations at the Air Traffic Control System Command Center (ATCSCC) and Kansas City Air Route Traffic Control Center (ARTCC). In addition, user needs for convective weather forecast products are presented. ACT-320 collected information from both facilities through site visits and interviews during the early summer of 2000. Based upon collected information, it is recommended that the integration of a convective weather forecast capability, for example, the National Convective Weather Forecast (NCWF), into the Traffic Situation Display (TSD) be investigated. In addition, further research should be conducted to extend the forecast period of current automated forecast products.					
17. Key Words Air Traffic Control Convective Weather Thunderstorms			18. Distribution Statement This document is available to the public through the Technical Center's Full-Text Technical Reports page: http://actlibrary.tc.faa.gov		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 24	22. Price

ACKNOWLEDGEMENT

This report on the current convective weather processes and product requirements at the Air Traffic Control System Command Center (ATCSCC) and Kansas City Air Route Traffic Control Center (ARTCC) could not have been completed without the assistance of several individuals. Specifically, Mark Libby, National Operations Manager, and Bill Failor at the ATCSCC and Tom Wray, Traffic Management Coordinator Manager, and Gary Ernst, Center Weather Service Unit Meteorologist-In-Charge at the Kansas City ARTCC were instrumental in coordinating site visits and providing feedback from operational Air Traffic Control personnel.

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EXECUTIVE SUMMARY

This report summarizes current processes and information sources used when convective weather impacts Air Traffic Control (ATC) operations at the Federal Aviation Administration (FAA) Air Traffic Control System Command Center (ATCSCC) and Kansas City Air Route Traffic Control Center (ARTCC). In addition, user needs for convective weather forecast products were ascertained and are presented.

The FAA William J. Hughes Technical Center, Weather Branch (ACT-320) collected information from both the ATCSCC and Kansas City ARTCC through site visits and interviews of ATC personnel at both facilities. The visits were conducted during the early summer of 2000, while convective weather was a major focus at both facilities.

Information indicated that the ATCSCC utilizes a Collaborative Decision Making (CDM) process. The primary weather products used at the ATCSCC for decisions regarding convective weather are national weather radar information on the Traffic Situation Display (TSD) and the Collaborative Convective Forecast Product (CCFP). The TSD information is current weather radar information along with individual aircraft information. It is predominantly used for short-term (0-2 hour), tactical decisions. The CCFP is a graphical forecast product developed collaboratively by forecasters at the Aviation Weather Center (AWC), airline and ARTCC Center Weather Service Unit (CWSU) meteorologists, and the ATCSCC Weather Unit. It is used for longer-term (2-6 hour), strategic decisions. In addition to the two graphical products, the ATCSCC decision makers rely upon the ACTSCC Weather Unit to provide weather information. The Weather Unit does not forecast the weather, but analyzes weather information and passes on pertinent information to decision-makers.

The Kansas City ARTCC also relies on the TSD and CCFP. However, since the ARTCC's mission is primarily tactical, a greater reliance is placed on TSD information, along with input from the ARTCC's CWSU meteorologists.

According to both facilities, a convective weather forecast product should include storm movement; growth and decay; storm tops; forecasts out to 6 hours; lightning data; and animation.

Based on information collected from the two facilities, it is recommended that the integration of a convective forecast capability into the TSD be investigated. The National Convective Weather Forecast (NCWF) developed under the FAA Aviation Weather Research Program, is a candidate for integration. The NCWF is a graphical 1-hour forecast product, maintained and operated by AWC. The TSD integration could be utilized by ATC personnel at the ATCSCC and ARTCCs. In addition, to ensure product availability to the ATCSCC Weather Unit and CWSUs, consideration should be given to have the NCWF available through existing Internet connections or integrated into the Weather And Radar Processor (WARP) system. Finally, in order to address additional user-stated requirements, further research should be conducted to extend the time period of current automated convective forecast products.

1. INTRODUCTION.

Convective weather (i.e., thunderstorms) has the greatest impact on air traffic delays in the summer months. Ground delays, ground stops, and sector overloading due to thunderstorms can cause major airport delays, compromise flight safety, and be costly in terms of money and air passenger satisfaction. Effectively avoiding thunderstorms as efficiently and safely as possible is an overriding concern of the Federal Aviation Administration (FAA).

For convective weather avoidance planning, methods and products are being developed, tested, and implemented. FAA initiatives such as strategic planning groups and Collaborative Decision Making (CDM) have been created to help avoid air traffic delays and contribute to flight safety. Additionally, convective forecast products that can provide accurate depictions of convection are being developed to help expedite planning and traffic management.

One convective forecast product, the National Convective Weather Forecast (NCWF), has been developed by scientists at the National Center for Atmospheric Research (NCAR) under FAA Aviation Weather Research Program (AWRP) funding and direction. The NCWF is a graphical depiction of current thunderstorm location and intensity, coupled with short-term forecasts of future locations. The FAA William J. Hughes Technical Center, Weather Branch (ACT-320) has conducted user assessments of different versions of the NCWF for the past three convective seasons (i.e., 1997, 1998, and 1999) involving aviation weather forecasters and dispatchers from regional and major airlines. One aspect of the assessments, especially from the airline dispatcher standpoint, was the desire for FAA Air Traffic Control (ATC) facilities to have access to the same or a similar product to assist in collaborative decision-making between the facilities and the airlines.

Before considering the possible implementation of the NCWF at ATC facilities, information on current processes and information sources used when convective weather impacts ATC operations was needed. In addition, ATC user needs for convective forecast products needed to be ascertained. Therefore, ACT-320 personnel visited two ATC facilities: 1) the Air Traffic Control System Command Center (ATCSCC) in Herndon, Virginia on June 19 - 20, 2000; and 2) the Kansas City Air Route Traffic Control Center (ARTCC) on May 9 - 11, 2000.

2. SCOPE.

This report summarizes information derived from site visits to the ATCSCC and Kansas City ARTCC specific to each facility's operational conduct during convective weather events. This report will also include convective forecast product requirements derived from information at each facility. Finally, based on conclusions derived from this report, recommendations for future convective weather product development are discussed.

3. ATCSCC.

3.1 ATCSCC OVERVIEW.

3.1.1 Mission Statement.

The ATCSCC's mission is to regulate air traffic when weather, equipment, runway closures, or other impacting conditions place stress on the National Airspace System (NAS). In these instances, ATCSCC specialists take action to modify traffic demands in order to remain within system capacity. This is accomplished in cooperation with the following:

- a. Airline personnel
- b. Traffic Management Specialists at affected ATC facilities
- c. Air Traffic Controllers at affected ATC facilities

The objective is to help minimize delays and congestion, and maximize the overall use of the NAS as safely and efficiently as possible. Further information on the ATCSCC is available at <http://www.atcsc.faa.gov>.

3.1.2 Units of Interest.

Operations at the ATCSCC are divided into separate functional units. For the purpose of this report, however, only those units directly involved with convective weather avoidance and planning will be discussed.

Most activity at the ATCSCC takes place in the Operations Center, which is divided into separate functional units. Flight specialists, responsible for each of the 21 ARTCCs, are located in the Operations Center. The 21 ARTCCs are divided into two regions, Eastern and Western. Specialists are geographically co-located according to Eastern Centers and Western Centers. The Weather Unit is also in the Operations Center, along with the Severe Weather Unit and Strategic Planning Team. At the front of the Operations Center, are eight large display screens, visible to all Operations Center personnel. These large-view screens fill the front wall and display the following information:

- a. ATCSCC Advisories, including Ground Delays and Ground Stops, accessed from the Operational Information System;
- b. Weather And Radar Processor (WARP) briefing terminal information, usually displaying national satellite images overlaid with radar reflectivity;
- c. National Traffic Situation Display (TSD) image; and
- d. The prototype Integrated Terminal Weather System (ITWS) image for Newark airport (EWR).

3.1.2.1 Weather Unit.

The Weather Unit is a separate functional ATCSCC area within the Operations Center. Staffed by Flight Service Station specialists (non-meteorologists), this unit provides weather information to the Eastern and Western Center specialists, the Severe Weather Unit and the Strategic Planning Team. The Weather Unit's role is not to forecast the weather, but to analyze weather information, filter it, and pass on pertinent information. According to the Weather Unit, major focus is on the national weather picture as well as individual high-volume airports such as Chicago's O'Hare; the New York area's LaGuardia, Kennedy and Newark; and Boston's Logan. Information provided included:

- a. Airways and airports that may be impacted by convective weather,
- b. When airways should be clear,
- c. When airports should be clear, and
- d. Duration of weather events.

There are two work-consoles in the Weather Unit, one for the Eastern Centers and one for the Western Centers. Each contains an individual WARP system. WARP is the primary weather information source for this unit. The most commonly used WARP products included:

- a. Radar mosaics depicting current reflectivity,
- b. Satellite images,
- c. Lightning data,
- d. Echo tops information,
- e. Fronts,
- f. Skew-T information (vertical profiles of temperature, moisture, and winds),
- g. Vorticity, and
- h. Various model data (such as Eta and Rapid Update Cycle [RUC]).

Other weather information sources used less frequently included:

- i. Weather products on the Internet,
- j. Discussions with Center Weather Service Unit (CWSU) meteorologists,
- k. Discussions with National Weather Service Forecast Office meteorologists, and
- l. ITWS (EWR only).

The WARP system has the capability for users to display individual NEXRAD radar sites, however, this option is rarely selected due to the length of time required to display the information. It often takes several minutes for a site to be displayed. This makes the feature virtually unusable by Weather Unit personnel.

Planning is both tactical and strategic. Weather Unit personnel are primarily concerned with current weather and 1 to 3 hours into the future. However, personnel also participate in the Collaborative Convective Forecast Product (CCFP) generation process, which is concerned with forecasts out to 6 hours.

3.1.2.2 Severe Weather Unit.

The primary function of the Severe Weather Unit is to strategically plan alternate flight routes when normal routes are or will be impacted by convective weather activity. Typically, Severe Weather Unit personnel will:

- a. Assess the extent of the weather and area(s) affected;
- b. Assess flight routes that may be affected;
- c. Look-up flights filed through the affected area and check flight plans, especially for those using a National Route Plan (NRP) (see section 3.2.2.4);
- d. Check alternate routes;
- e. Discuss routes with affected ATC facilities and ensure routes are feasible;
- f. Advise facilities, if necessary to restrict traffic using either miles-in-trail or altitude; and
- g. Issue a Severe Weather Route Advisory and enter it into the Enhanced Traffic Management System (ETMS) for dissemination to all air traffic facilities and airports.

It was reported that the CCFP is the only convective weather product used for strategic planning by the Severe Weather Unit. For tactical considerations, it was noted that personnel observed radar reflectivity information provided on the TSD. The radar information is a national mosaic.

3.1.2.3 Strategic Planning Team (SPT).

The purpose of the SPT is to reduce the impact of convective weather on FAA and NAS users as well as facilitate transition to normal operations after weather events via collaborative planning. The SPT acts as a focal point for the development of a collaborative Strategic Plan of Operation (SPO). The SPO results from the CDM process and specifies consensually derived reroutes that are necessitated by operationally significant convective weather activity. In addition to the personnel at the ATCSCC, the SPT includes airline strategic planners, ARTCC and Terminal Radar Approach Control (TRACON) traffic management representatives, and military airspace coordinators in developing a SPO.

In the event that convective weather impacts existing flight routes, the SPT provides planning information for airlines and ATC facilities in order to expedite air traffic within the NAS in an organized and equitable manner. The goal is to accomplish air traffic diversions with the least impact on other sectors or Centers' airspace. The CCFP is the primary weather information source used by the SPT, along with current national radar information on the TSD. The SPT is concerned with planning within a 2-8 hour time frame.

3.2 CONVECTIVE WEATHER PLANNING – ATCSCC.

Information regarding convective weather planning was the focus of the ACT-320 site visit. The following sections describe components and processes utilized during convective weather events.

3.2.1 CDM Process.

CDM is the planning process where members of the SPT and other affected participants consensually agree on alternate flight routes. The ATCSCC is lead on this collaborative effort. All SPT members participate via teleconferencing (telecons). CDM telecons begin at 7 am EST and continue every 2 hours, until 9 pm. ATCSCC staffing and preparation begin at 5 am. The ATCSCC is responsible for connections to and maintenance of the communication's bridge.

The ATCSCC opens each telecon with a short discussion of current NAS conditions and presents an initial or amended SPO if one already exists. CDM participants then provide input into the SPO. When consensus is reached, the SPO is briefed to the ATCSCC Operational Supervisors, posted on the ATCSCC web page, and issued as a numbered advisory over the ETMS. The SPO is both a short- and long-term operating plan.

All ATC facilities and airlines are invited to participate; especially those affected by convective weather and planned reroutes. Depending on weather impacts, telecons can last from 30 minutes to over an hour and include several participants, especially if convective weather will be significant in high volume sectors or over a large geographical area.

Performance of the CDM process is measured by MITRE Corp, via performance metrics that produce "report card" type reports available to FAA decision-makers. ACT-320 personnel have not reviewed these reports.

During the site visit, ACT-320 personnel observed an afternoon CDM telecon. During this telecon, convective weather was occurring over the southeastern US. Impacted were major routes over the Northeast, Dallas, Florida, and Atlanta. Traffic to Miami airport was to anticipate miles-in-trail restrictions. ATC personnel concerned with Dallas traffic could not identify any usable Playbook scenarios for deviating traffic (see Playbook description in section 3.2.2.3). In this instance, the ATCSCC facilitator left rerouting decisions up to Dallas. New York Center wanted to reroute traffic over Atlanta. The SPT decided to split traffic flows. Consensus for this decision was attained from both Washington and Atlanta ARTCCs. Other options were to maximize use of the Atlantic Ocean routes to the greatest extent possible. Also, first tier flights out of Atlanta would be at a low altitude, thereby maximizing airspace. Alternate flight routes were chosen, when J48 (a jet flight route) was shut off, flights were diverted to J6. However, to accommodate the increase in traffic flow on this latter route, Ground Delay Programs, Ground Stops, and miles-in-trail were invoked. In total, the CDM telecon lasted approximately 45 minutes.

The SPT issues the SPO within an hour after every CDM telecon. One specialist noted that strategic planning is a process and not an end within itself. The process forces participants to come to an agreement even if it is not the optimum solution. The advantage is that all parties agree to a solution, thus everyone is operating under the same guidelines.

A major issue identified at the ATCSCC was the location of convective weather. According to some ATCSCC Severe Weather Specialists, convective weather that affects Northeastern airports and jet routes has a significant impact on traffic flow. The Northeast contains the heaviest air traffic volume in a relatively small amount of space. Thunderstorms occurring in these high volume areas will affect other sectors and airports, especially if traffic is rerouted into adjacent, congested airspace. In contrast, similar size thunderstorms may not have the same impact in the Midwest or West where the range of maneuverable airspace is more plentiful and congestion is less prevalent. It was noted that a line of thunderstorms in the Midwest would have less impact on the NAS than a relatively small amount of convection affecting the Northeast.

3.2.2 SPT Products.

The following products and options are used by the SPT when dealing with convective weather:

3.2.2.1 CCFP.

The CCFP is a graphical weather product depicting a convective area (defined as an area with echo tops at or above 25,000 feet with at least 25% coverage). An example of the CCFP product is shown in figure 1. The map display is divided by ARTCC boundaries. Forecast graphics are for 2, 4, and 6 hours. Area coverage is identified as either LOW (25 - 49%), MED (50 - 74%), or HIGH (75 - 100%). Maximum tops are identified in hundreds of feet. Within each convective area, growth rates are identified as negative (-), no change (NC), positive (+), and fast positive (++). Probability of convection is given as HIGH (70 - 100%), MED (40-69%), or LOW (1-39%).

The CCFP originates from the Aviation Weather Center (AWC). The first-guess forecast is made available via a website to airline and CWSU meteorologists, as well as to the ATCSCC Weather Unit. These participants evaluate the initial forecast and provide feedback, via an Internet chat room, on their interpretation of forecasted convective activity. The AWC forecaster evaluates the feedback and creates the final CCFP. The forecast is then issued to all CDM participants and is used for routing discussions and decisions. The final CCFP depicts a convective forecast at 2-hour intervals out to 6 hours (i.e. 2, 4, and 6 hour presentations). The first forecast is issued at 1500 Universal Time Coordinated (UTC) and is valid through 2100 UTC. CCFPs are issued every 4 hours until 0300 UTC.

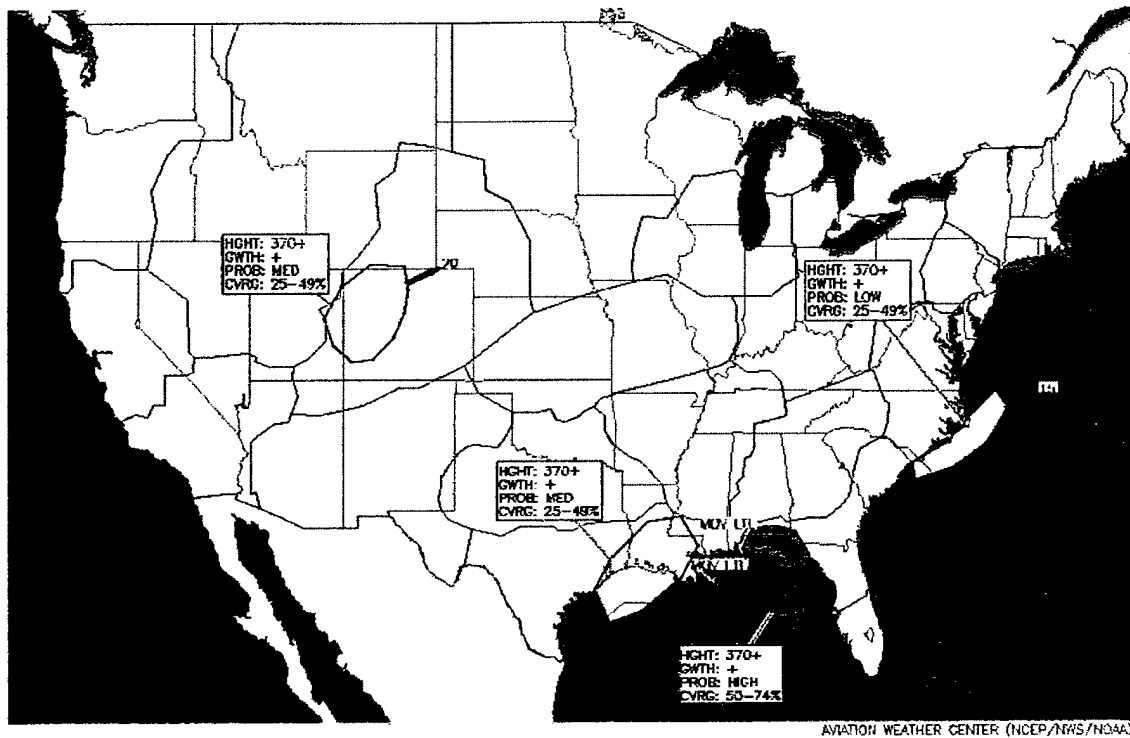


FIGURE 1. COLLABORATIVE CONVECTIVE FORECAST PRODUCT IMAGE

Some criticism of the CCFP involved the broad-brush depiction of forecasted convection. ACT-320 personnel observed the CCFP issued the morning of the site visit covered approximately 1/3 of the country (not represented in figure 1). Because of this broad coverage, effectiveness of the CCFP as a strategic planning tool has been questioned by some ATCSCC users.

3.2.2.2 Traffic Situation Display (TSD).

The TSD graphically displays current aircraft positions on a national scale superimposed on maps of geographical boundaries or NAS facilities. It also displays national weather radar reflectivity. All Instrument Flight Rule (IFR) aircraft and other flights tracked by ARTCCs nationwide are available for display. Due to the large number of aircraft available, a user can filter out unwanted aircraft or color code types of flights that are of interest. The TSD can query the ETMS data base for lists of flights that will be affected by the implementation of convective weather routes and can display and broadcast all valid Severe Weather Avoidance Plan routes. The ETMS performs flight data collection, monitoring, management, maintenance, and analysis via computers, communications systems and traffic management software programs. Monitor Alert, a part of ETMS, analyzes traffic demand for all airports, sectors, and airborne reporting fixes in the continental United States, then automatically displays an alert when the demand exceeds capacity in a particular area. Traffic levels are displayed using red and yellow areas representing actual (yellow) and predicted (red) traffic volume. An example of a zoomed-in display of the TSD with alert areas is presented in figure 2.

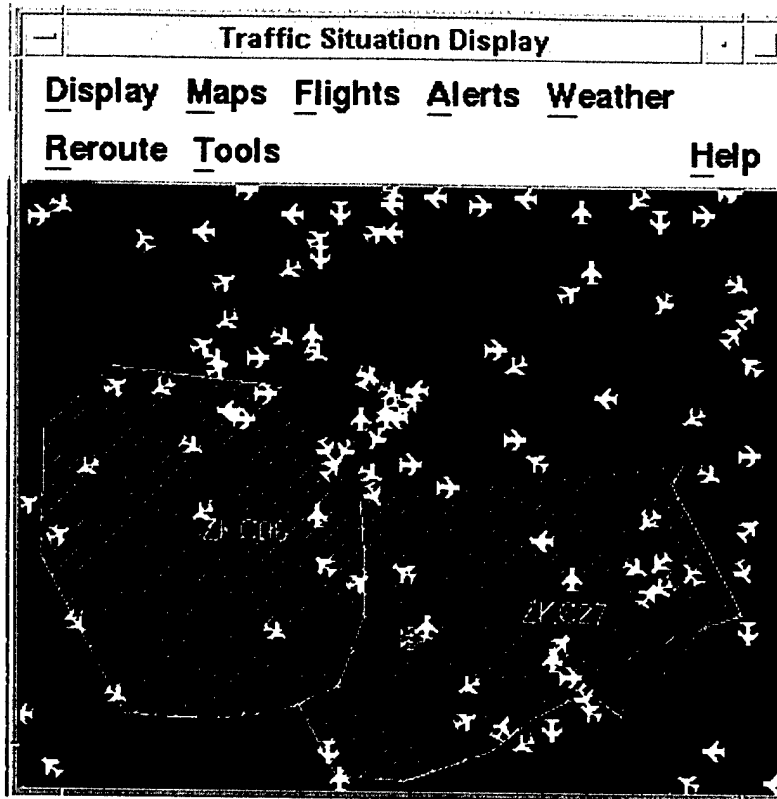


FIGURE 2. TRAFFIC SITUATION DISPLAY

3.2.2.3 National Severe Weather Playbook.

The Playbook is a compilation of Severe Weather Avoidance Plan routes to be used in the event of convective weather. The pre-planned routes were developed collaboratively between the ATCSCC and other ATC facilities. These routes are used by the SPT whenever possible and are intended to facilitate rerouting decisions and save time. While the routes form the basis of flight rerouting, they are often modified to fit the current weather situation.

3.2.2.4 National Route Plan (NRP).

A NRP allows aircraft between selected cities to choose their own routes in order to fly more direct, fuel-efficient paths in enroute airspace (above 29,000 ft. and further than 200 miles from departure and arrival locations). Standard routes are not always the most expedient. For example, a flight traveling westward may want to fly south of the jet stream to avoid head-winds. Conversely, when flying west to east, aircraft may prefer a route that provides a good tail wind. NRP flights usually route themselves around convective weather. Centers will avoid issuing route and/or altitude changes for aircraft that display the remarks "NRP" on flight plans unless extensive rerouting is required due to weather or sector volume issues. Under these latter conditions, ATCSCC will suspend flights from being designated as NRP.

3.2.2.5 Canadian Airspace.

When weather impacts northeast corridor flight routes, Canadian airspace may be utilized. This must be coordinated in advance and approval obtained from Toronto Center. It was noted, however, that Toronto Center often cannot handle the extra traffic volume due to understaffing or other issues. Therefore, use of Canadian airspace is not always an option.

3.2.2.6 Controller Chart.

A high altitude controller chart is near the Severe Weather Unit. The chart provides a graphical overview of airways, facility boundaries and navigational aids. This is used by Severe Weather personnel to see affected airspace and identify alternate jet routes.

3.3 ATCSCC CONVECTIVE WEATHER FORECAST PRODUCT REQUIREMENTS.

When queried, SPT and Severe Weather Unit personnel responded with requirements for convective weather forecast products. It was recognized that the CCFP fills the longer-term forecast requirement. Improvements in forecast accuracy were requested, however, it was recognized that measurable improvements to a 6-hour forecast may not be realized for several years. However, for short-term forecasts (i.e., 0-3 hours) there are no apparent viable forecast products in use at the ATCSCC, except for some overlap with the CCFP 2-hour forecast. Thus, ATCSCC personnel stated that a convective weather product should provide information on:

- a. Where convection will develop,
- b. How long convection will last,
- c. Storm movement,
- d. Storm coverage,
- e. Storm intensity,
- f. Storm tops, and
- g. Forecasts from 1 to 3 hours.

If a product were available to the ATCSCC, higher than normal workload constraints during the convective season would prevent any evaluation activities until the late October, early November time-frame.

4. KANSAS CITY ARTCC.

4.1 ARTCC OVERVIEW.

4.1.1 ARTCC Mission Statement.

The Kansas City ARTCC is responsible for the safe, orderly, and expeditious flow of enroute aircraft over all or portions of 9 states in the Midwest (KS, CO, NE, IA, MO, AR, IL, OK, and TX). The facility also serves as the approach and departure control for hundreds of "satellite" airports in the region that have no control towers. The ARTCC handles an average of 7000 aircraft operations daily.

The ARTCC controls all aircraft operating under IFR conditions within its airspace. Like most enroute centers, Kansas City airspace is split into sectors separated both vertically and horizontally. Vertical sectors either cover an area from the ground to 23,000 feet, or 23,000 feet and above.

Within Kansas City airspace, St. Louis' Lambert International Airport is a major hub and has far more traffic volume than any other surrounding airport. Therefore, air traffic flow into, around, and out of this airport is a major concern to traffic managers. During the summer months, this area often experiences air-mass type convection.

4.1.2 Units of Interest.

4.1.2.1 Traffic Management Unit (TMU).

The function of the TMU is to monitor and balance air traffic flow within the ARTCC's airspace. Traffic Management Coordinators (TMCs), who work in the TMU, are responsible for:

- a. Communicating with adjacent center TMUs to optimize traffic flow within the NAS,
- b. Developing arrival strategies and delivering arrival aircraft to achieve the Airport Acceptance Rate in conjunction with TMUs at TRACON facilities, and
- c. Utilizing the TSD and Monitor Alert function of the ETMS to adjust traffic flows on a proactive basis.

Typically there are two to three TMCs and one supervisor on each shift. The TMU is staffed 24-hours a day.

4.1.2.2 Center Weather Service Unit (CWSU).

The CWSU provides daily weather briefings to TMCs and Center supervisors at 7:45 am, 12 pm, 3:30 pm, and 8:30 pm CST. Generally, the CWSU discusses weather conditions within the ARTCC airspace likely to affect aviation operations. Briefings usually include current and forecasted weather conditions at major hub airports and along airways throughout the ARTCC airspace. An outlook is also provided which extends into the following shift or through the overnight off-duty hours. Briefings contain weather advisories in effect at the time of the briefing; a synopsis of weather systems and movements; an enroute flight outlook; terminal weather for St. Louis and Kansas City Airports; and jet stream location. Using the WARP Briefing Terminal, the CWSU illustrates:

- a. Weather expectations for the midnight shift,
- b. Position of the jet stream,
- c. Current and forecast weather at major airports, i.e. St. Louis and Kansas City,
- d. Turbulence,
- e. Icing,

- f. Areas of convection,
- g. Weather advisories, and
- h. Satellite images (visible and infrared).

There are four meteorologists at the CWSU and one Meteorologist-In-Charge (MIC). Only one meteorologist is on duty during a shift and will work either the morning shift, starting at 5 am (5:30 am in the summer), or the evening shift, which ends at 9 pm (9:30 pm in the summer). Between the hours of 9:00/9:30 pm and 5:00/5:30am, there is no CWSU meteorological support. The CWSU is located adjacent to the TMU.

4.2 CONVECTIVE WEATHER PLANNING - KANSAS CITY ARTCC.

Procedures and products used by the Kansas City ARTCC when dealing with convective weather were collected through a combination of interviews and observations of TMCs in the TMU and CWSU meteorologists.

During the ACT-320 visit, convective storm activity in the form of a major squall line was affecting airspace from Canada to Northern Mississippi and almost every airport east of the Mississippi. This line was predicted to move to the Northeast.

For Kansas City airspace, two arrival fixes to St. Louis were cut off and arrival sequencing for Chicago and St. Louis was in place (15 miles-in-trail). One of the Playbook scenarios was modified to accommodate reroutes. Due to the heavy workload imposed by this convective weather, data collection was informal. Most information was gathered when feasible and consisted of comments and observations in both the TMU and CWSU areas. The following sections summarize information derived from this visit.

Individually, three TMCs were interviewed. Interview questions were open-ended to solicit general information. Questions were directed at procedures, information sources used, difficult situations encountered, and requirements for additional weather sources. Questions were based on high-level tasks most impacted by convective weather. These tasks included:

- a. Planning aircraft reroutes and deviations;
- b. Anticipating miles-in-trail restrictions;
- c. Opening, closing, or reconfiguring Arrival Transition Areas and Departure Transition Areas; and
- d. Determining holding areas.

Generally, interview responses were the same or very similar for each task area. In other words, convective weather seemed to affect each task area equally.

4.2.1 CDM Process.

A CDM telecon (see section 3.2.1) is conducted every 2 hours (6 am - 8 pm CST). TMU personnel participate in the telecon when the ARTCC airspace is affected by convective weather or it appears other centers will need to off-load traffic into Kansas City's airspace. Playbook routes (see section 3.2.2.3) are used initially to determine the most expedient, consensual reroute. (Note: One of the TMCs at the Kansas City ARTCC was part of the working group who developed the Playbook scenarios). Although there was some criticism of CDM, e.g., length of time and large number of participants, most TMCs felt that the process was useful.

In-between CDM telecons, reroutes or other issues are dealt with tactically by the TMU as they occur. In these situations, the TSD is monitored and utilized for decision-making. If convective weather is building, the TMCs will consult with the CWSU meteorologist to identify if and when weather will impact a flight route.

4.2.2 Convective Weather Products.

4.2.2.1 CCFP.

As discussed in section 3.2.2.1, the CCFP is a graphical weather product that is used for CDM planning and decisions. One TMC noted that the CCFP helps to average out various forecasts and shows general convective tendencies. Another reported that it is sometimes helpful in coming to consensus where weather planning is concerned. Others, however, reported that the product is only used as a backup since the CWSU provides all pertinent weather information. For CDM, the CCFP helps with broad-brush planning, but, overall was not considered a useful weather information source.

Although the CWSU monitors the CCFP generation process (chat room), the CWSU will not participate in CCFP generation unless ARTCC airspace is or will be affected by convective weather.

4.2.2.2 TSD.

As discussed in section 3.2.2.2, the TSD graphically depicts current aircraft positions, routings, and airspace volume. During the site visit, TMCs were observed utilizing the Monitor Alert portion of the TSD. The TSD was used extensively to assess sector loading and to see if a sector was becoming overloaded due to rerouting. For example, when Atlanta handed traffic off to the Memphis ARTCC, capacity overload in Memphis' airspace was predicted. To address an overloaded sector, ground stops, miles-in-trail, or aircraft holds may be implemented. According to TMCs, the TSD with aircraft and traffic flow depictions, overlaid on radar reflectivity, provides an effective picture of current air traffic and areas to avoid.

In addition, TMCs check the TSD to see where aircraft are getting through or deviating around weather. This is done because TMCs need to know how solid a line of storms will be and if reroutes are possible. If storm tops are below 30,000 feet, aircraft should be able to fly over the convective weather. If tops are above 30,000 feet, then rerouting is unavoidable. New routes are

introduced by using the Playbook (see section 3.2.2.3). If there is a high probability that routes will be closed, TMCs will ask airlines to start filing flight routes around the impacted area. If weather unexpectedly changes, then TMCs must react to the developing situation.

4.2.2.3 Miles-in-trail.

Miles-in-trail are a specified interval between aircraft expressed in nautical miles. They are invoked as a means to slow down air traffic to avoid sector overloading due to rerouting. TMCs will use the TSD to check air traffic volume in order to base miles-in-trail requirements. Normally, spacing is at 10 nautical miles and will increase as demand increases. In extreme cases, up to 40 miles-in-trail may be invoked.

4.2.2.4 Other Weather Sources.

The CWSU is the primary source of weather information and is used extensively by the TMU. CWSU information is either derived via the WARP briefing terminal, at scheduled weather briefings, or face to face with CWSU meteorologists. TMCs indicated that current information required from the CWSU for tactical and strategic planning included:

- a. Jet stream location,
- b. Weather at major airports,
- c. Turbulence,
- d. Icing,
- e. Weather advisories, and
- f. Visible and infrared satellite images.

The CCFP product is used as a basis for a broad weather picture and CDM telecons, but its use is infrequent. Unlike the ATCSCC, there is currently no ITWS display in either the CWSU or TMU. Thus, TMCs have had little exposure to graphical forecast products. One meteorologist noted that an ITWS display is scheduled to be installed in November 2000.

4.2.5 Worst-case Convective Scenarios.

TMCs noted the following concerning worst-case convective weather situations:

- a. Weather impacting St. Louis airport, especially fast moving and rapidly developing air mass situations. When caught unprepared in this scenario, flights are not able to depart.
- b. At least three TMCs noted that worst-case convective scenarios involved lines of convective weather with an opening over Kansas City ARTCC airspace or with traffic off-loaded onto the ARTCC. These scenarios do not necessarily involve convective weather within Kansas City ARTCC airspace, but are situations where convective weather in other regions results in increased volume and workload for the ARTCC.

4.3 KANSAS CITY ARTCC CONVECTIVE WEATHER FORECAST PRODUCT REQUIREMENTS.

TMCs' responses indicated a graphical convective forecast should include the following:

- a. Storm movement projection,
- b. Animation,
- c. Growth and Decay,
- d. Lightning data,
- e. Storm top heights, and
- f. Forecast of 2 to 6 hours.

In addition, TMCs noted that regardless of the presence or absence of convective weather, turbulence and upper level wind information was needed.

5. CONCLUSIONS.

Based upon information collected from the ACT-320 site visits to both facilities, the following sections summarize information on convective weather procedures, products, and product requirements at the ATCSCC and the Kansas City ARTCC.

5.1 CONVECTIVE WEATHER PROCEDURES.

5.1.1 ATCSCC.

Convective weather procedures revolve around the CDM process. Telecons with ATC field facilities and airlines are conducted every 2 hours. Planning occurs for the 2-6 hour time frame, however, tactical decisions (0-2 hours) were also observed. The telecons use the CCFP as the basis for planning and decisions in regards to convective weather for the 2-6 hour time frame. Tactical decisions are based upon current radar information as displayed on the TSD.

The impact of convective weather is primarily reroutes. Where airspace is abundant, e.g., in the Western US, reroutes are not problematic. However, in the Eastern US, even small areas of convection cause significant impacts on the NAS. Thus, convection in the Eastern US receives considerable attention.

5.1.2 Kansas City ARTCC.

While Kansas City ARTCC TMU personnel participate in the CDM telecons conducted by the ATCSCC, the main focus of ARTCC activities are short-term, tactical (0-2 hour) decisions when operations are impacted by convective weather. The basis for many of these tactical decisions is the current radar information on the TSD and input from the CWSU meteorologists. The CCFP is referenced for the CDM telecons and longer range planning that may impact the ARTCC's airspace. However, due to the rapidly changing nature of convective weather, situations must be dealt with as they occur. Therefore, the longer range planning and the CCFP are secondary convective weather considerations in the ARTCC.

5.2 CONVECTIVE WEATHER PRODUCTS.

5.2.1 ATCSCC.

As stated, the CCFP is the primary convective weather product used by the ATCSCC Severe Weather Unit and Strategic Planning Team. The product is used in conjunction with the CDM telecons for the 2-6 hour strategic planning. Other products used include the current radar information on the TSD. This information is used for tactical decisions during the CDM telecons. In addition, the ATCSCC Weather Unit provides updates on convective weather to the Severe Weather Team (responsible for reroute planning) and the Strategic Planning Team (responsible for the CDM telecons). The updates consist of discussions of the CCFP prior to the conduct of the telecons, and information from the WARP briefing terminals. The WARP information is primarily the current radar overlaid on a national satellite image.

5.2.2 Kansas City ARTCC.

The Kansas City ARTCC TMU uses the CCFP during the CDM telecon. However, the product's use for tactical decision-making, the primary focus of ARTCC activities, is limited due to the broad-brush approach of the product and its time frame (2-6 hours). Most convective weather decisions are made based upon the current radar information on the TSD along with briefings and forecasts provided by the CWSU meteorologists. The CWSU uses radar information from the WARP system, however the system has no convective weather forecast component.

5.3 CONVECTIVE WEATHER PRODUCT REQUIREMENTS.

According to input from both facilities, a convective weather product should include the following:

- Storm movement,
- Growth and decay in order to identify areas of new convection,
- Storm tops,
- A forecast of 0-6 hours,
- Animation, and
- Lightning data.

Historically, requirements for a graphical, convective weather forecast product reflect those reported most often from previous base-line data collection efforts at other aviation facilities such as dispatch operations at major and regional airlines (see ACT-320's two reports: National Convective Weather Forecast [NCWF] Product Demonstration Report, March 2000, and National Convective Weather Forecast [NCWF] 1999 Assessment Report, May 2000). Future product development should include these requirements to the greatest extent possible.

5.4 EVALUATIONS.

While both facilities were open to future evaluations of new convective products, limitations exist at both facilities. ATCSCC personnel stated that any evaluation activity would have to occur after the convective season. Workload during the convective season itself is too high to divert personnel to evaluation purposes. Kansas City ARTCC personnel seemed reluctant if an evaluation required additional equipment or information sources. It appeared that most TMCs were satisfied with the status quo and that current weather sources were adequate for ATC operations.

6. RECOMMENDATIONS.

6.1 TRAFFIC SITUATION DISPLAY (TSD) INTEGRATION.

Because both ATCSCC and Kansas City ARTCC personnel monitor the TSD frequently, the integration of a convective forecast component may be a viable means of providing convective forecast information. Justification for this integration includes:

- a. Previous use and familiarity of the TSD with ATC users;
- b. Optimal juxtaposition of overlays such as geographical locators, jetways, and navigational aids;
- c. Air Traffic depictions and location of aircraft;
- d. Alleviates the need for additional monitors in space-limited ATC facilities; and
- e. Capability to access other TSD components such as the ETMS database and Monitor Alert function.

Therefore, it is recommended that integration of the National Convective Weather Forecast (NCWF) with the TSD be investigated. The investigation should include discussions with the Volpe National Transportation Systems Center (VNTSC), Aviation Weather Center (AWC), and NCAR. VNTSC is responsible for operating and maintaining the ETMS; AWC maintains the operational running of the NCWF; and NCAR has been responsible for development of the NCWF. It may be that integration of the NCWF would include portions of the forecast product, for example, the forecast fields rather than the detection field. However, this would have to be determined in coordination with the different involved agencies.

Further justification for integration of the NCWF into the TSD is the shared situational awareness between airline users and ATC facilities. Previous ACT-320 assessment efforts (National Convective Weather Forecast [NCWF] 1999 Assessment Report, May 22, 2000) identified the usefulness of the NCWF for airline dispatch operations. Dispatcher comments from the assessment included the desire for ATC facilities to have the NCWF in order to facilitate coordination between airlines and ATC personnel. If NCWF is integrated into TSD, then further evaluation should be conducted in order to ensure user requirements and needs are met.

6.2 WEATHER AND RADAR PROCESSOR (WARP) INTEGRATION.

ATC decision-makers at the ATCSCC and Kansas City ARTCC rely upon the Weather Unit and CWSU, respectively, for weather information. These weather information providers utilize the WARP system and Internet-based products. Therefore, in order to have shared situational awareness with ATC decision-makers, consideration should be given for ensuring the ATCSCC Weather Unit and CWSUs have access to the NCWF, if the product is integrated into the TSD. The access could either be through available Internet capabilities or integration into WARP.

6.3 FURTHER RESEARCH.

Due to user-stated requirements for longer-term forecasts, research is needed to extend the time period of current automated convective products (e.g., the NCWF currently forecasts only to 1 hour). The Convective Weather Product Development Team, funded by the FAA Aviation Weather Research Program, includes efforts for improving the accuracy and forecast time of convective weather products. Conduct of these efforts should receive high consideration.

7. ACRONYMS.

ACT-320	FAA William J. Hughes Technical Center, Weather Branch
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATCSCC	Air Traffic Control System Command Center
AWC	Aviation Weather Center
AWRP	Aviation Weather Research Program
CCFP	Collaborative Convective Forecast Product
CDM	Collaborative Decision Making
CWSU	Center Weather Service Unit
ETMS	Enhanced Traffic Management System
FAA	Federal Aviation Administration
IFR	Instrumented Flight Rules
ITWS	Integrated Terminal Weather System
NAS	National Airspace System
NCAR	National Center for Atmospheric Research
NCWF	National Convective Weather Forecast
NRP	National Route Plan
RUC	Rapid Update Cycle
SPO	Strategic Plan of Operation
SPT	Strategic Planning Team
TMC	Traffic Management Coordinator
TMU	Traffic Management Unit
TRACON	Terminal Radar Approach CONTROL
TSD	Traffic Situation Display
UTC	Universal Time Coordinated
VNTSC	Volpe National Transportation Systems Center
WARP	Weather And Radar Processor