2.4 FORECASTS OF CONVECTION FOR AIR TRAFFIC MANAGEMENT STRATEGIC DECISION MAKING: COMPARISON OF USER NEEDS AND AVAILABLE PRODUCTS

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1. INTRODUCTION

Graphical forecasts of convection to support Air Traffic Management (ATM) decisions in the continental United States National Airspace System (NAS) have been manually produced collaboratively since 1998. The product is known as the Collaborative Convective Forecast Product (CCFP). It is designed to support decisions made in the strategic planning timeframe of 2 hours to 6 hours into the future and the geographical area covering the en route, cruise level phase of flight [Fahey et al 1999].

Traditionally, forecasts of convection for the airport terminal environment have been provided by the Terminal Aerodrome Forecast (TAFOR or TAF) and have been used to determine impact on aircraft operations at or very near the surface at or very near the airport. The domain of the TAF is defined as a 5 nautical mile (nm) radius around the center point of an airport (or aerodrome). The TAF option of using vicinity (VCNTY), extends the product's range to a 20 nm radius.

Commercial aircraft are in descent and climb phases of flight at distances greater than the TAF domain of 5 nm radius or even 20 nm around an airport. As a result, there currently is a gap in product coverage for the aviation weather decision maker. There is a need for an aviation weather product that can support the Air Traffic Management decision making process for the volume of airspace that falls between the geographical domain of the TAF and the geographical domain of the CCFP. And covers the strategic decision making time period of two to six hours into the future.

2. CURRENT CONVECTIVE FORECAST PRODUCTS

Aviation users of convective forecasts in the United States have a number of options available. Automated products include Regional Convective Weather Forecast (RCWF) as part of both the Corridor Integrated Weather System (CIWS) [Boldi et al 2002] and Route Availability Planning Tool (RAPT); the Terminal Convective Weather Forecast (TCWF) as part of Integrated Terminal Weather System (ITWS) [Dupree et al 2002]; and National Convective Weather Forecast (NCWF) which provide forecasts of convection for the tactical time frame of 0-2 hours in the future. Similarly, the National Weather Service (NWS) Aviation Weather Center's manually produced Convective SIGMETs address the same 0-2 hour period. Of the 5 tools mentioned above, the 3, CIWS, ITWS and RAPT are most likely to be used by ATM decision makers. All 3 are integrated weather information/traffic management tools.

Operational products currently being produced for the time frame of greater than 2 hours in the future are all manually prepared to some degree. And are not integrated into FAA air traffic management tools. The one exception is the CCFP, integrated with ETMS (Enhanced Traffic Management System). Examples of those not integrated include Severe Thunderstorm Watches, Tornado Watches and Convective Outlooks, all prepared by the NWS Storm Prediction Center (SPC) meteorologists and intended primarily for use by the general public (Figures 1,2 & 3).

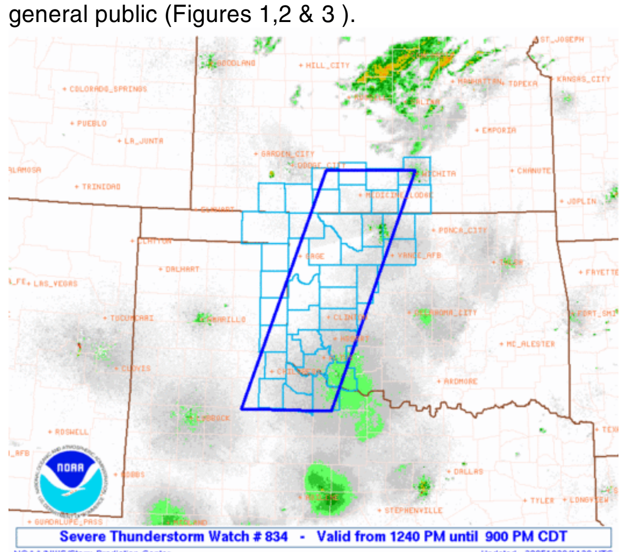

Figure 1. Severe Thunderstorm Watch #834, issued 1740z 19Oct'05 and Valid until 0200z 20Oct'05.

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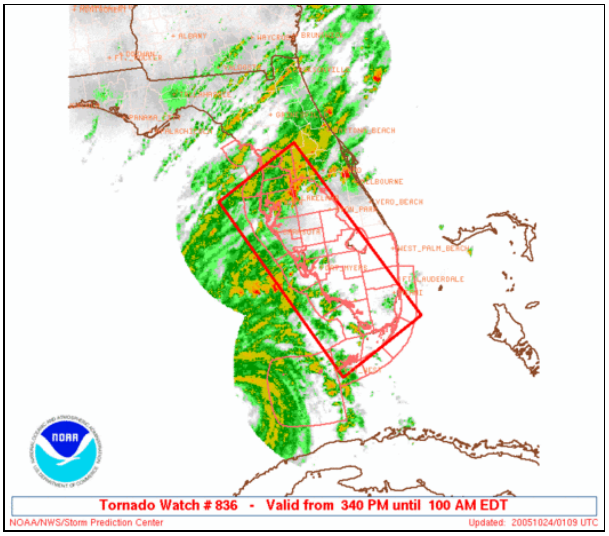

Figure 2. Tornado Watch #836, issued 2040z 23Oct'05 and Valid until 0500z 24Oct'05.

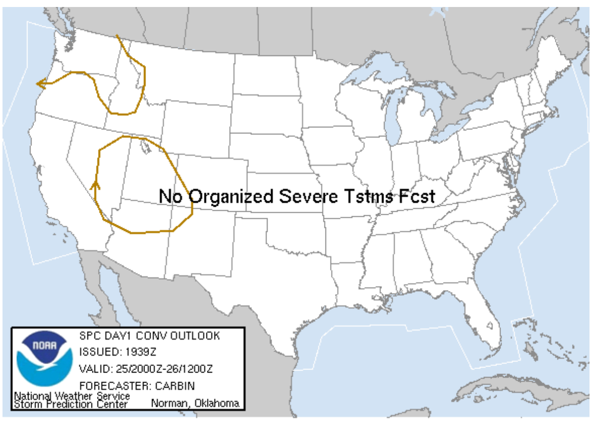

Figure 3. Day 1 Convective Outlook showing 2 areas of General Thunderstorm activity & valid for a 16 hr period.

The NWS Hydrometeorological Prediction Center (HPC) issues a 12 hour forecast of surface conditions which include areas of potential convection (see Figure 4). Similar to SPC products, this is intended primarily for use by the general public.

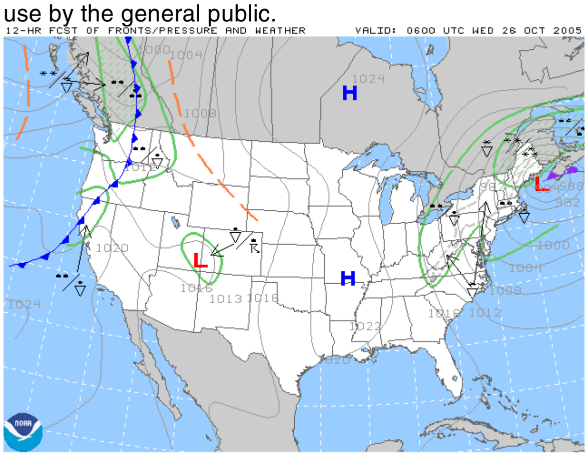

Figure 4. Potential convection shown in 4 corners area.

Two types of textual products, which may include forecasts of convection, are produced by NWS Center Weather Service Unit (CWSU) meteorologists. They are the Center Weather Advisory (CWA) and the Meteorological Impact Statement (MIS). The CWA is a short-term (within next 2 hours) warning of hazardous weather conditions causing or expected to cause an impact. It is provided to all aviation interests, including private pilots, towers, flight service stations, and commercial airlines. A CWA is an in-flight advisory and is similar to, but intended to be more localized than, the AIRMETs and SIGMETs issued by the AWC. In the case of convection, a CWA will usually be issued for a small scale event, covering less than 5000 square miles or a 8rapidly developing area not yet covered by a convective SIGMET.

The MIS is a 2 to 12 hour forecast of weather conditions expected to impact the safe and/or efficient flow of air traffic in an individual Air Route Traffic Control Center's (ARTCC) air space. The MIS is intended to be used for planning purposes by Air Traffic Control and Air Traffic Management staff at an individual ARTCC (see Table 1).

ZAB MIS 01 VALID 251510-260310 ..FOR ATC PLANNING PURPOSES ONLY...
UPR LO MOVG INTO NW AZ THRU DAY... WITH JET OV SRN ZAB. AREA OF TS SRN NV MOVG E INTO NE AZ BY 00Z. TS TOPS TO FL370. OCNL MOD TURB FL290-410 AZ/NM...FL240-410 TX PRTN OF ZAB.=

Table 1 MIS issued by ZAB CWSU 25Oct05 valid 12 hrs.

3. AIRLINE AIR TRAFFIC MANAGEMENT NEEDS and BENEFITS

High density airports utilize static structures of flight paths to be followed by arriving and departing flows of traffic to keep aircraft trajectories de-conflicted with manageable levels of direct intervention by air traffic controllers. Until more flexible arrival and departure structures can be adopted to flex flows around convective weather dynamics, in today's NAS these static structures are closed or subjected to reduced capacity and throughput of traffic flows as weather impacts them. Similarly, recapture of capacities to nominal levels after convective weather clears or diminishes over critical terminal airspace structures, suffers from a lack of planning supported by an adequate forecast.

Although CIWS, RAPT and other weather tools are available in the tactical (one to two hour) event horizon, current forecasts in the two to six hour timeframe do not address impacts to the entirety of these terminal airspace structures. Neither TAF nor CCFP were designed to forecast weather impacts of sufficient granularity and scope to provide useful guidance during severe weather impacts.

3.1 *Dispatch and Strategic Planning Team Needs*

Both Dispatchers and Airline ATC Coordinators have need for a Terminal Area Forecast that addresses impact to the arrival and departure structure including Departure Procedures (DP's) and Standard Terminal Arrival Routes (STAR's), and arrival transitions. Dispatchers have both legal mandates to avoid severe weather and economic imperatives to preclude congestion impacts in routing choices. Unfortunately, lack of an adequate forecast of sufficient precision and granularity leaves opportunities to increase operational efficiency unapprised and introduces inefficiencies due to the need to never compromise safety. The resulting Traffic Management Initiatives (TMI's), applied in a reactive manner in the tactical (one to two hours) timeframes are among the most costly to operators. These include Ground Stops, Departure Stops, Ground Delays Programs and Reroutes that are more circuitous than needed, if better pre-planned avoidance was possible.

If a new forecast could provide such guidance, dispatchers and airline ATC coordinators together with traffic managers could collaborate to more effectively reduce demand in a preplanned fashion on terminal route structures which are likely to be impacted by both severe weather and significant volume. While these forecasts are unlikely to provide the desired level of precision for the operators, the pivotal questions concerning actual value of the forecast are:

1. Is the forecast precision and geographic coverage sufficient to allow route decisions which reduce the scale of the congestion problems at reduced levels of capacity in the strategic (two to six hour) event horizon?

2. Does the forecast precision and geographic coverage create enough confidence and predictability to better plan for and execute recovery of capacity and throughput after clearing and diminishment of the convective weather?

The effective geographic area of coverage for the terminal area needs to capture the departure gates and the arrival cornerposts of the airspace. Clearly the greater the radius of the coverage area, the greater the value of the forecast to the decision-maker. Similarly however, the greater radius of coverage for the forecast, the greater the difficulty; the lower the accuracy and the less the realized benefits. Therefore, the operator needs for geographic coverage must be tempered to some extent by the challenge of providing a forecast of sufficient integrity. Ideally dispatchers, ATC coordinators and traffic managers would like to extend this to 75 or even 100 NM. However, 40-60 nautical miles would capture the majority of the relevant terminal area airspace structure.

3.2 *Dispatch and Strategic Planning Team Benefits*

Both independent routing decisions implemented by dispatchers and by ATC as well as collaborated route decisions of operator's ATC Coordinators and Traffic Managers could be brought to bear on the controllable variable of volume when the uncontrollable variable (weather) creates an impact within the terminal area structures. These strategic volume reductions would reduce the scale of the overall problem in a more economic fashion than the present reactive TMI's and procedures. They would also scale down the tactical problem to a level of solubility which does not exist today. Therefore significant benefits could be gained by the elimination of TMI's and replacement with less costly routes adjustments.

Similarly, adequate forecast guidance to decision-makers could allow more focus and better planning on the recapture of capacity and throughput for forecast clearing and diminishment of the convective activity. Better communication and execution of plans for ramping up the throughput in previously impacted terminal areas implies significant delay and cancellation reductions. These delay and cancellation reductions also could result in significant levels of cost and revenue benefits over present day NAS procedures.

3.3 *Operations Planning and Strategic Planning Team Needs*

Of the many problems that can impact an airlines' scheduled operation, convective activity, whether it disrupts flight routes or directly impacts a terminal, is one of the more difficult problems that Operations Planners and the Strategic Planning Team have to solve.

When a problem affects an airline's scheduled operation, there are a limited number of decisions that can be made. A flight can depart on schedule, it can be delayed, or it can be canceled. The ultimate goal of any decision is to preserve passengers and revenue, while providing the best possible service, given the circumstance. These decisions are often made through a combination of factors impacting multiple flights, rather than using a single flight to obtain a solution. Before any decision is made a host of information about the flight(s) has to be gathered and evaluated. The Operations Planner needs specific information about passengers/revenue, pilots, flight attendants, aircraft, airports, station capabilities, etc.

3.4 *Operations Planning and Strategic Planning Team Benefits*

Operations Planners decisions are limited by the resources needed to conduct a flight. These include pilots, flight attendants, aircraft, station personnel, and time. Some of these resources are governed by specific Federal Air Regulations (FARs), employee contracts, or other restrictions. Aircraft have maintenance schedules that must be followed, pilot and flight attendant schedules are limited by time and contract restrictions, airports have aircraft specific limitations, the airport terminals and airport property have a limited number of gates or available parking spots, and some airports have curfews. When an airline creates a schedule it allocates all the necessary resources as efficiently as possible, within the aforementioned limitations. Because of those restrictions an impact to any one flight can affect future flights at a multiple equal to the discontinuity of the pilots, flight attendants, and the aircraft. When an economic decision is made by an operations planner, those same resources are reallocated within their constraints, while limiting the impact to future flights.

The most beneficial resource for solving a problem is time. Strategic planning allows the airline to weigh its decisions against a larger cast of resources. As time passes, resources disappear and with them the number of possible solutions. When a tactical solution is imposed, operations become more chaotic and the ability to adjust to the situation is limited because of the relative position of the resources needed to solve the problem. Pilots, flight attendants, and passengers have boarded, or are in the process of boarding the flight; station resources are in position to push from the gate in anticipation of the next arriving flight. Tactical planning eliminates time and efficiency. Solutions no longer favor passengers/revenue, but rather the problem dictates the solution, and answers become reactionary.

4. AIR TRAFFIC MANAGEMENT NEEDS FROM THE USER PERSPECTIVES

In order to better understand the needs of the users, the FAA sponsored an effort throughout the 2005 convective season, which visited both government and airline industry operations centers in order to determine the needs of the users. A team visited seven Air Route Traffic Control Centers (ARTCC), a major Terminal Radar Approach Control (TRACON) facility, the Air Traffic Control System Command Center (ATCSCC) (see Table 2) and six airlines (see Table 3) in order to determine the needs of the Traffic Management Unit (TMU) operational personnel, as well as the needs of the airline dispatch operational users. The goal of this effort was twofold. 1) To collect user feedback from traffic management specialists who utilize the CCFP for traffic flow decisions and 2) Collect producer feedback from the CWSU and airline meteorologists who participate in the production of CCFP.

The overall purpose of the effort was to collect information from government and industry users in order to evaluate several changes in the CCFP product from the 2004 version to the 2005 (see figure 5) and assess any effect on TFM decisions based on the changes made. In addition, the information collected from the visits will help populate the 2006 "CCFP Statement of User Needs", which helps build the NWS requirements for the product. The information and feedback from the users will also help in the development of the first "CCFP Concept of Use" document, which will give users a common set of standard operating practices. Lastly, the data will be used to evaluate the need for product improvement or the requirement for any procedural changes.

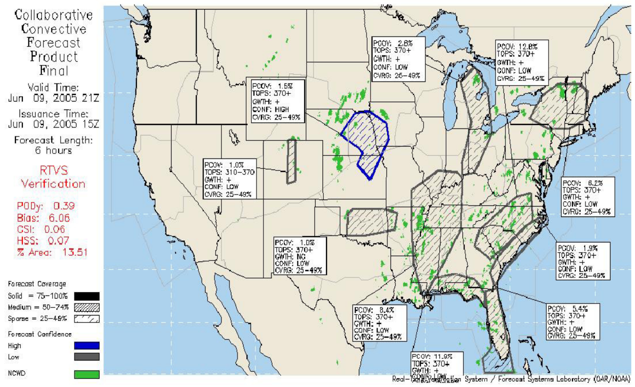

Figure 5. 2005 CCFP Intuitive Graphics

FAA Facilities visited	
Air Traffic Control System Command Center	ATCSCC
Potomac TRACON	PCT
Washington Center	ZDC
Fort Worth Center	ZFW
Houston Center	ZHU
Cleveland Center	ZOB
Minneapolis Center	ZMP
Memphis Center	ZME
Jacksonville Center	ZJX

Table 2 FAA Facilities Visited

Airlines Visited	
American Airlines	AAL
Continental Airlines	COA
Federal Express	FED
Northwest Airlines	NWA
Southwest Airlines	SWA
US Airways	USA

Table 3 Airlines Visited

4.1 *FAA ARTCC Facility Perspectives*

FAA user needs for weather information are numerous and vary depending on the domain, scope and location of the FAA facility. Specific weather information needs vary depending on the time horizon under consideration and the traffic management initiatives being monitored or under consideration; for example real time NEXRAD information verses the 6- hour CCFP forecast polygon.

Defining the needs from the perspective of a time horizon and TFM events provide us with a method of evaluating what weather information is available and identify where the gaps in information reside. An initial dividing point that has been used over the past few years exists in the definition of the terms tactical and strategic. These terms can vary depending on the individual's perspective, but with respect to the CCFP the terms have been defined in a recent white paper as:

Tactical: Traffic management initiatives within the 0-2 hour timeframe, the “short-term” effort that was not strategically coordinated through the planning telcon.

Strategic: Traffic management initiatives within the 2-6 hour timeframe, the “long-term” effort that was strategically coordinated through the planning telcon. [WAWG, 2005b][1].

Assuming these definitions meet most TFM behaviors; what are the needs based within these periods?

Based on the feedback from this year’s review of the CCFP we can identify some areas where needs are not being met or where there is inadequate weather information available.

A common theme throughout all of the facilities visited was the request for better accuracy—meaning, a precise, scientifically accurate CCFP forecast is needed. The users felt that if they had a more accurate forecast they could make better predictions in their route selection, which would help in the overall management of the NAS.

In the 6-hour period the only product that provides common National TFM outlook guidance is the CCFP. The fact that all facilities have a common picture of the expected weather was noted as a positive attribute of the product. However, there were some drawbacks voiced on the product, namely, the skill of predicting exactly where the weather will materialize and the ability of the product to forecast small areas that will impact a facility but resides outside the envelope of the CCFP criteria. Most felt the criteria could be lowered in certain geographical areas of the NAS, which could help capture some of the small, air mass type convection that does not meet current CCFP criteria but causes impact to the system when handling traffic issues and re-routes.

Also, in some cases it was noted that a 6-hour product is not a long enough outlook horizon and possibly a product that extends up to 8 hours would be useful. The 8-hour lookout would be useful for when the morning personnel are trying to plan for the mid afternoon events, or for early afternoon to evening planning.

The 4-hour forecast period, was identified as an important period for the planning of the facilities initiatives. From a planning perspective the, 4-hour horizon is a key focus period for forming TFM actions and developing route planning options. Increased accuracy in the 4-hour forecast envelope would appear to have larger benefit potential for the customer and facility stand point. One attribute identified as missing in the CCFP is the transition or trend information between the 4- and 6-hour polygons. The users would like to see how the forecast periods connect, similar to RADAR looping only for the forecast product. Connecting the polygons in sequenced graphic was a common improvement comment.

A large component of the angst and discontent with the CCFP product comes from the 2-hour CCFP polygon. This discontent can be derived from the misconception of what confidence means to the user of the product. This is especially apparent when RADAR products depict convection in the area of a CCFP polygon that is depicting low confidence areas in the vicinity. Many TFM specialists mentally estimate and predict movement of the convection from experience or by utilizing other short term forecast products. So when the CCFP seems to contradict what their experience tells them, then there is reluctance to acceptance of the forecast. Similarly, if no CCFP is depicted in an area that appears to be ripe for convection but falls outside the scope of the criteria for identifying the area with a forecast polygon. The 2-hour CCFP forecast panel is an area where a change in the current criteria might warrant further discussion within the industry. The 2-hour panel is also a key transition point from the strategic application of weather to the tactical application. A renewed look at the time horizon and information available to effect change from strategic applications to tactical applications requires further study. Currently, there appears to be a gap in weather information between the 1-2 hour forecast periods. The exception to this is the area covered by the 0-2 hour CIWS product, which bridges that gap.

As mentioned above, the misconception of the forecaster confidence level has been a common theme among the users throughout past convective seasons. With hope of improving this misconception, there was a change from three confidence levels; low, medium and high to two confidence levels; low and high from the 2004 to 2005 convective season. There seems to be different interpretations of what the producers’ confidence level really means for the users. The 2005 Statement of Needs defines forecaster confidence to be, “For each area of convection, a subjective statement of confidence is required. This parameter is the forecaster’s confidence that convective weather, as defined by the minimum CCFP criteria, will occur in the forecast polygon at the specified time and place. The confidence value will be identified in one of two classes and depicted graphically for each CCFP polygon, as detailed below:

- Low 25 -- 49% (polygon border and fill in gray)
- High 50 – 100% (polygon border and fill in slate blue)

Note regarding confidence: the subjective opinion of the forecaster is stated in probabilistic terms (%) and is only addressed to the question of the existence of the forecast polygon that meets the minimum CCFP criteria ---regardless of any other properties of the forecast convection; i.e., for any configuration (lines and areas); for any growth rates; for any coverage; and for any category of growth/decay rate, speed/direction, or tops. The confidence is NOT a probability of occurrence unless and until an empirical probability has been calculated, post-facto, from a comparison of a substantial record of forecast confidence with actual observations.” . [WAWG, 2005a]

The discrepancies and mis-interpretations of forecaster confidence level is one area that could be cleared up with the “CCFP Concept of Use” document as well as additional training.

[1] CCFP White paper, Phaneuf; Fox

Another recommendation from the user community is to improve the echo top information in the CCFP product. This could improve the predictability and use of the airspace at higher levels for routing aircraft above certain convective activity.

4.2 *Airlines Operations Center Perspectives*

In general, some similarities exist between the customers and FAA TFM facility personnel with respect to the CCFP. Common to both is the opinion that a product which provides common situational awareness is critical for facilitating productive discussions during the collaborative planning telcons. Another common point noted was the need for a good training program for any new weather product, including changes, which was the case for the CCFP. These training programs need to be timely, providing a definition of the product and its indented use, including its strengths and limitations.

One notable difference of opinion between the customer and the FAA facilities was with the CCFP criteria for plotting a polygon area. A common opinion of the FAA TFM personnel was the need to lower the criteria to ensure "hot spot" areas get adequate attention in planning, while the general customer opinion was to increase the criteria so that large low confidence areas can be reduced.

Some customers use the CCFP 4- and 6-hour panels as the big picture look at what will be needed in the operations, including possible changes in the staffing levels. Some will consider changes in fuel loading but typically the customer will not want to adjust preferred routings based solely on low confidence, low coverage polygon areas in the 4-6 hour time horizons.

The problem of confidence in the 2-hour CCFP polygon is viewed with similar skepticism when other weather products contradict the forecast, as noted earlier. Showing transition, trend, direction, development or decay may improve how the CCFP is viewed for the 2-hour CCFP period when existing weather is present.

5. RECOMMENDATIONS

The CDM (Collaborative Decision Making) Steering Group [CSG], a group made up of FAA and Industry representatives has requested that CCFP Granularity; CCFP Verification; and a Terminal Area Weather Forecast Need be addressed by the Weather Applications Work Group (WAWG). The WAWG has historically been responsible for CCFP development. While much of the focus in this document is on the CCFP, it is clear that the CCFP can not be the only weather product solution for ATM decision making in the strategic time frame. Recommendations listed below are from the FAA and Operator needs identified in this document.

5.1 *Lower CCFP Minimum Threshold*

Since FAA facilities and Operators/Customers have proposed reducing and increasing the minimum threshold respectively, no change to the CCFP is recommended. Rather, a new product, focusing on the Terminal/Congested Airspace environment, is recommended to be developed. This recommendation is consistent with the CSG request.

5.2 *CCFP Accuracy*

As stated in section 3.1, the perceived need for accuracy by the users is virtually unlimited. While this is not unique to the CCFP nor to the proposed Terminal Area Weather Forecast, it does force the question of degree of accuracy which must be achieved. Once again as stated in 3.1, if the answer to the two questions posed is affirmative, then operators will accrue benefits:

1. Prior to and During a Convective Event: Is the Forecast precision and geographic coverage sufficient to allow effective anticipation such as alternate routing decisions?

Effective Anticipation, being defined as a documented reduction in congestion problems due to initiatives taken to reduce levels of capacity in the affected airspace in the strategic (2 to 6 hour in advance) time period.

2. During and immediately after the convective event: Does the forecast precision and geographical coverage instill enough confidence to enable an Effective Recovery?

Effective Recovery, being defined as a collaborative effort, implemented as planned with capacity and throughput maximized immediately after clearing and/or diminishment of the convection.

5.3 *Extend CCFP to an 8hr Forecast*

It is recommended that the WAWG address this issue and expand the existing CCFP to add an 8 hour or 9 hour forecast. It is not one of the current CSG recommendations, however continued focus is needed based on direct user feedback.

5.4 *Indication of Trend between 4Hr & 6Hr CCFP*

This appears to be a display issue that can be addressed by technology. Introducing a method for users to loop the 2, 4 and 6 hour forecasts may satisfy this request. It is recommended that the WAWG address this issue. Since it is currently outside of the scope of CSG recommendations, as mentioned above in 5.3 continued focus is needed in this area as well.

5.5 *2Hr CCFP Issues*

Additional information will need to be collected before a solution can be proposed to address the issue of weather forecasts to support the transition from tactical to strategic decision making. The two most likely solutions rest with:

1. Technology: Continued efforts in the area of integration of automated weather information

products with traffic management tools such as CIWS.
2. Human-in-the-Loop: Utilization of meteorology staff resources at the CWSU facilities and redefinition of the CWA product.

It needs to be determined if these solutions are within the realm of the charter of the WAWG.

5.6 *Concept of Use & Verification*

The CSG identified CCFP verification as a priority. Verification of the accuracy of the CCFP has been an on-going effort of the WAWG. Identifying methods to measure the value of the CCFP from a FAA ATM and Operator/Customer perspective has been a 2nd verification goal. This second goal can not be realized until a CCFP Concept of Use is finalized.

A well organized and successful training effort was undertaken in preparation for the 2005 CCFP season. But with the lack of a terminal area convection forecast product, and in spite of the training, there is a tendency to misuse the CCFP as a tool for estimating terminal area impacts. It is recommended that a project be undertaken to develop a Concept of Use document for both the existing CCFP and for the yet to be defined terminal area convection forecast product. It is also recommended that the 2005 CCFP training module be used as the starting point for the CCFP component. And that the Concept of Use document be the initial starting point for the terminal area product. Expertise from Operators' Dispatch and ATC Coordination organizations as well as from FAA Traffic Flow managers will need to be collected. Documentation of independent as well as collaborative use of these two products will need to be addressed.

While the WAWG would certainly be involved in such an effort, the expertise and resources necessary to successfully accomplish such a task reside in the FAA's Aviation Weather Requirements organization.

5.7 *Convection Tops Information*

DeLaura & Allan, 2003 in their RAPT case study conclude that "two dimensional forecast products do not supply sufficient information about the operational impact of hazardous weather".

Tops information will need to be a key weather variable in any terminal environment weather product.

In addition, the WAWG has identified in the past, the need to focus on tops information in the CCFP based on feedback from Operators/Customers. Two separate but complimentary efforts have been discussed: Tops forecasting and Tops verification. The majority of the previous WAWG discussion regarding Tops forecasting involved greater vertical resolution (e.g. FL250-310, FL310-350, FL350-390, and FL 390 & above vs. current 3 layers) but it is recommended that additional horizontal resolution be also addressed. Since the WAWG has addressed these issues in the past; since this issue includes both CSG recommended CCFP Granularity and CCFP Verification; and since the literature documents the importance, it is recommended that this be addressed by the WAWG for the 2006 season if possible, but definitely by the 2007 and 2008 seasons.

6. CONCLUSIONS

Development of forecasts for Air Traffic Management decisions in the strategic time frame (valid 2 hours or more into the future) and for the geographical volume of air space within approximately 100 miles of the airport have been studied [FAA, 1999]. There have also been attempts at rapid prototyping. The Prototype Aviation Collaborative Effort (PACE) developed a plan to demonstrate convective weather products for Traffic Management Unit (TMU) decision makers at Forth Worth ARTCC [NOAA, 2002].

The two areas of development noted above are the areas where gaps currently exist in strategic convective weather forecasts. It appears that there is a need for a product covering the spatial coverage gap of the areas outside of the immediate terminal environment that includes all of the arrival and departure structure. The second area is in the temporal coverage spanning the period from tactical to strategic operations (i.e., around the 2 hour time frame).

With significant past investment in collecting user needs and prototyping, the time is now ripe to begin the necessary work to implement an new operational product, while at the same time continuing to strive to improve the existing CCFP. Resources will need to be identified, including staff, tools and communication capability. Access to the product will need to be provided to both FAA and Operator traffic management decision makers. It remains to be identified who will take on the task of coordinating the continued efforts and new development. Perhaps a work group under the FAA-industry Collaborative Decision Making (CDM) framework would be most appropriate.

The Weather Applications Work Group (WAWG), which has overseen the evolution of the CCFP, is one potential organization that could take on some of the tasks. But additional resources will need to be identified if it is agreed to begin the task of rapid prototyping a terminal environment convection forecast.

7. ACKNOWLEDGEMENTS

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