10.8

A CONCEPT OF OPERATIONS FOR AN INTERACTIVE WEATHER BRIEFING

Dave Rodenhuis *
Federal Aviation Administration

1. INTRODUCTION

Adverse weather is the primary threat to safety of flight and efficiency of operations within the national airspace system (NAS). Weather hazards restrict the available airspace in the NAS so that demand for airspace often exceeds available capacity. The responsibility of aviation meteorologists is to transmit understanding of hazardous weather to their users and "customers" who subsequently use this information to make traffic management decisions.

Users of weather information always need forecasts, since "current" observations always contain latency between the time of observations and the particular application to traffic management, traffic control, and to aircraft operations. Therefore, the forecast is usually supplemented by "current" observations to improve credibility. The traditional method to communicate and rationalize conflicting weather information to users is a *weather briefing.* Frequently, however, this process fails to help the user when meteorologists do not understand the user's need, and users do not understand inherently uncertain weather processes.

Weather products and communications have radically changed in the past decade. Products are no longer limited to coded text messages such as the METAR and TAF. Weather observations are often graphical (eg, radar and satellite images), as are the forecasts (eg, GFA, CCFP, CIWS, NCWF, and RUC model output). Thus, future of modern weather forecasting services are moving on two different paths: (1) These graphical products have quick-glance value and hold out an expectation for automation and direct application by the user – but there is a burden on the user for training and sufficient time for interpretation. On the other hand, (2) these products are more ambiguous than text messages and require *more* interpretation, not less – but there is the burden on the meteorologist to learn the application so that forecast products are actually useful for decision-making. At this point automation seems to be winning.

Proposals of the National Weather Service (NWS, 2002, 2003, Johnston and Ladd, 2004) have focused on graphical products, capable workstations, universal data access, and integrated forecast processes. This strategy has led them to conclude (NWS, 2005) that automation will supplant the need for consultative weather services. For example, the Corridor Integrated Weather System (CIWS) was developed for direct application by end-users in TRACONs, towers, and at commercial airlines. Consequently the developers have invested heavily and effectively in CIWS training.

There is also a third path available that depends on development of Decision Support Tools (DST). This strategy would make the investment of time and training of users unnecessary, and would make a detailed knowledge of user needs by weather forecasters superfluous. However, the burden of development is now on the developers of the tools. Lacking sufficient knowledge of either weather forecasting or traffic management, developers may look for insight towards users or towards the *point of delivery* of weather services.

Traditional forecasting services have tried to compete with automation by attempting to create better products (NWS, 2005). This is a perilous strategy (Mass, 2003), since automation is turning out to be at least equal in quality (skill) and superior in quantity (frequency). The central question is, *How to improve the application of uncertain weather forecasts and utilize the improvements in quality and quantity available through automation?*

2. THE POINT OF DELIVERY

The Center Weather Service Units (CWSUs) are an example of the unresolved tension between weather forecast products and services to users. They are the *point of delivery* for the FAA (**Figure 1**); they deliver en route products from the Aviation Weather Center (AWC) and terminal forecasts produced by Weather Forecast Offices (WFOs) of the National Weather Service (NWS). The CWSU mission is to apply weather information and forecasts to support decision-making by ATC and air traffic management (ATM). Thus, they have the potential both to utilize new and more sophisticated weather forecasting products, and to provide the logic on which Decision Support Tools could be built.

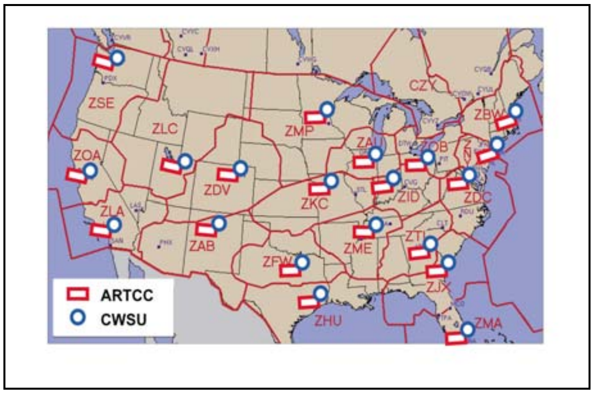

Figure 1 – National CWSU configuration

Several assessments and a functional analysis have been conducted by the FAA (1994, 1999), ATT (2003a,b), and SysOps (2006). Recommendations have been made by the National Research Council ((NRC, 1995) and the National Transportation Safety Board (NTSB, 1995, 2001). Regardless of opinions on deficiencies in CWSU services, there is nearly universal agreement on a preference for face-to-face weather briefings, even though the actual value remains intangible and uncertain. Regardless of value, the process is inefficient, and current personnel resources of CWSUs cannot simultaneously reach all users in their airspace that need weather services -- not only the ARTCC, but also TRACONS and Approach/Departure Control, and Traffic Management Units in selected towers.

Moreover, adverse weather does not respect the boundaries of center airspace, so that center-to-center communications would also be needed if weather briefings were to be used to bring a common understanding of weather conditions to the operators and users of the NAS. This seems to be an intractable problem that cannot be solved by traditional weather briefings.

Nevertheless, an attempt has been made (SysOps, 2004b). In response to the assessments that have been conducted, a new, national mission was described and a plan proposed (Rodenhuis and Sims, 2004) to improve the effectiveness of CWSU services. Several new products were identified, and provisions for continuous operations and training provided. As part of this plan, the traditional weather briefing was discarded in favor of an Interactive Weather Briefing (IWB) through on web-based teleconferencing. If so, at least a *concept* for the IWB is needed, since it lies at the core of a new mission and responsibilities. These sites—Joint Aviation Weather Sites (JAWS) in the notation of this paper --- would be collocated with the Traffic Management Units at selected ARTCCs, or at a single national site within the CONUS.

The success of an IWB depends critically on a capability to work nearly instantaneously and interactively with graphical products, voice communications, and video images. Such a capability would multiply the advantages of face-to-face communications to many operational centers at the same time. With the power of an IWB, the current CWSUs could move from the periphery to the center of operational aviation weather forecasting in support of traffic management (**Figure 2**).

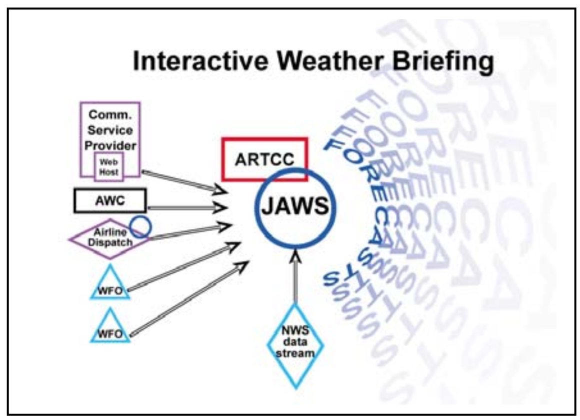

Figure 2 – The Joint Aviation Weather Site (JAWS) is the center and point of delivery of aviation weather services at FAA field sites.

In addition to developing a concept of operations for an IWB, it is important to test the concept with a tangible example, even if it is modified subsequently by new ideas or is changed in actual practice. These are the objectives of this paper — an operational concept for an IWB and an example.

3. MISSION

A CONOPS for an IWB is the cornerstone for modern operations of the JAWS. It must be designed to fit the designated mission for the point of delivery of aviation weather services.

The mission of the Joint Aviation Weather Sites (JAWS) is defined by the needs of the national system of traffic flow management to meet the objectives of safety, security, and capacity in the National Airspace System (NAS). This mission requires the JAWS to be cognizant of hazardous weather information covering all phases of flight, and to support the transition from strategic decisions to tactical operations. (Rodenhuis and Sims, 2004)

Based on this mission, a concept of operations will be built around the following responsibilities:

- Acknowledge national traffic flow management of the NAS, and translate this perspective consistently into weather support covering all phases of flight for regions of the national airspace that are the responsibility of the center(s);
- Collect hazardous weather information, applying it in the context of strategic planning of traffic flow management, and as time evolves, guiding the transition to short range products that are useful for tactical decisions;
- Work as an operational and technical extension of the national centers – the ATCSCC and the AWC (in Alaska: the AAWU).

The JAWS have the "*mission of transition*" and are responsible to support en route traffic management throughout the entire transition from Strategic to Tactical Adjustment, including the terminal weather environment. This usually spans the time scale from about 8 hours down to less than an hour. The transition from the en route domain to the airspace surrounding the TRACON area (gates, holding patterns, fixes) is most critical and approaches the shorter time scales associated with Arrivals and Departures at terminals. There are also en route or sector weather issues at flight level that routinely utilize weather forecasts, or require "tactical adjustments" (e.g., revisions or amendments to the CCFP) for which weather advisory services are needed to estimate capacity on preferred routings. Therefore, the JAWS forecasters must maintain an active Met Watch and acquire knowledge of observations and forecasts for the terminal and en route domain. They must maintain close weather collaboration with the AWC on the national scale, and with Weather Forecast Offices (WFOs) on a local scale. JAWS utilize all weather forecast information, especially the weather display from the WARP radar and satellite images, and short-range forecasts from ITWS and CIWS.

4. CONTEXT

The CONOPS for an IWB must also be designed to fit the context as well as the mission of the JAWS—support from other forecast offices of the NWS and mission support to FAA operational sites (**Figure 3**).

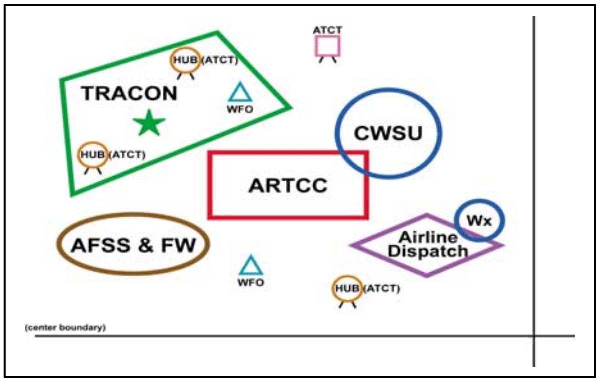

Figure 3 – Representative source and service elements for the delivery of aviation weather services.

<u>Strategic Planning</u> for traffic management is led by the ATCSCC, but is conducted collaboratively with traffic managers in TMUs at ARTCCs and Flight Dispatchers at commercial and business airlines. The daily strategic plan for traffic management is documented in the Operations Plan with a full knowledge of current weather and the weather forecasts of the CCFP and TAFs.

<u>En route forecasts and advisories</u> are produced by the Aviation Weather Center (AWC) in Kansas City. Their forecast mission starts with current observations and extends out to 6, 8, or even 24 hours in advance.

<u>Traffic Management Units (TMUs)</u> at ARTCCs, TRACONs and some towers require full knowledge of weather forecasts and the Operations Plan that will affect operations during the entire day. In this task they are assisted by the Weather Coordinator onsite at ARTCCs, and by interactive weather briefings (IWB) conducted by professional weather forecasters from remote sites.

Tactical Adjustment of air traffic is accomplished by the Air Route Traffic Control Centers (ARTCCs) and TRACONs with an awareness of the Strategic Plan of Operations updated and informed by the knowledge of current weather conditions. The discrepancy in the weather forecast or a deficiency in options for traffic management must be reconciled.

Tactical Air Traffic Control at the ARTCCs, TRACONs, and towers require weather information to be immediately at hand with minimum latency.

Towers and Flight Watch Offices are adequately equipped with textual and graphical weather products. In order to maintain a regional awareness of both the observations and the forecast, they will access the IWB in a passive mode. More specific and local weather information and forecasts are available at the local NWS Weather Forecast Office (WFO).

NWS Weather Service Forecast Offices (WFOs) are responsible for continuous Met Watch and issues forecasts and warnings to fulfill their responsibility to protect life and property. Specifically, terminal forecasts (TAFs) are produced by the WFOs.

5. INTERACTIVE WEATHER BRIEFING (IWB)

The IWB is an opportunity to provide further clarification to the weather context (en route weather forecasts and traffic management decisions). The focus for the IWB is estimates of traffic capacity for TRACONs and Routes with a weather forecast to back it up. And the foundation for the TRACON Forecasts is an hourly HUB Forecasts presented in a concise display with their TDAs for terminal capacity. (Rodenhuis, 2006)

The presentation of an interactive weather briefing requires weather information and forecasts incoming to the JAWS, and supplementary products and forecasts developed by the JAWS forecasting team, including TRACON and ENROUTE Forecasts and their TDAs.

Users of the IWB are located in all FAA operational field facilities—centers, TRACONs, and some towers. The assumption of a remote proxy to face-to-face communications places higher demands on the communications system, and this question needs to be evaluated during prototyping and testing. An interactive graphics capacity (light pen or mouse) is required to give the briefing forecaster full capability to utilize graphical products during interaction with users.

Within the area of responsibility of each JAWS, the IWB must connect to all the users, either interactively, or passively. This can be accomplished by utilizing federal communications services, currently FAA Firmnet. There is also an opportunity for commercial or contract services if they are needed. (**Figure 4**)

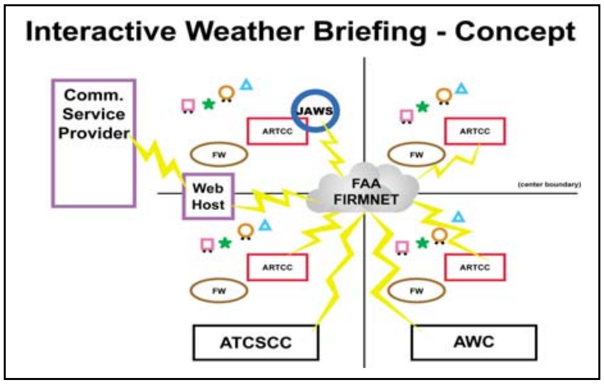

Figure 4 - A conceptual diagram of the connections required to deliver an Internet Weather Briefing (IWB) to the users of weather information in ATC and ATM.

5.1 *CONOPS for an IWB*

Therefore, *the IWB is an integrating mechanism between en route and terminal operations*. This is the operational concept.

In addition to the delivery of textual and graphical products from the AWC and WFOs, the IWB is the means of communicating a consistent interpretation of weather forecasts in terms of the needs of the FAA users: *capacity*. The context for the IWB is terminal weather information (current observations and the terminal forecasts) that all FAA facilities already have on hand: TAFs, NEXRAD observations and ITWS forecasts. At major TRACONS and terminals, products are the Hub Forecast and its TDA; the TRACON Forecast and its TDA; and ITWS and CIWS forecasts where they are available. For the en route environment the national weather forecast products include the traditional advisories, the CCFP, and experimental forecasts of other weather hazards (NCWF, GTG, GFA, and CIP/FIP).

The output products of the JAWS are TRACON Forecasts and the professional advisory services of the Interactive Weather Briefing (IWB). In support of this mission the JAWS require Hub Forecasts with TDAs of capacity estimates (AARs). (In the future, TRACON forecasts will be augmented by weather forecasts for sectors and routes, accompanied by TDAs that present empirical estimates of capacity.)

This concept is illustrated in **Figure 5** with a list of products and service customers.

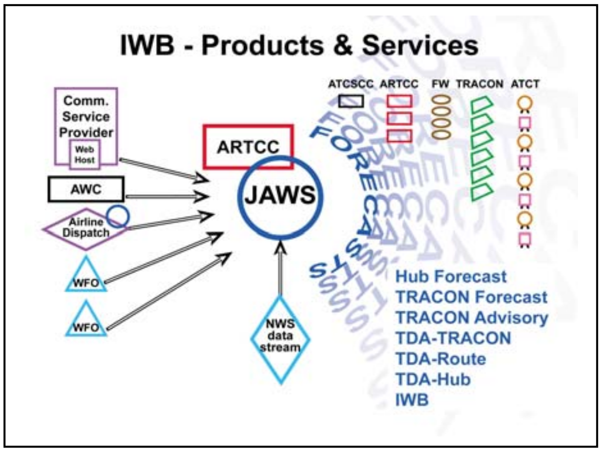

Figure 5 – The Joint Aviation Weather Site (JAWS) is the center for assimilating current weather information and forecasts and generating forecast products of capacity and weather (lower right). The Users of the JAWS products are the operational sites for ATC and TFM of the FAA/ATO (upper right).

The purpose of the IWB is to rationalize estimates of capacity with weather forecasts. The forecaster is expected to reduce the 4-dimensional weather forecast to a product for aviation users: a 1-dimensional time-sequence of capacity for selected locations/elements of the airspace (terminals, TRACONs, and routes), and to include a description of the cause of restrictions in capacity (adverse weather). The goal of the IWB is to advise on air traffic capacity that is implied by the weather forecast, and to bring all users to the common viewpoint and appreciation of the forecast, its skill, as well as its uncertainty. From this information traffic flow managers at the TMU will make their decisions.

The delivery of the IWB requires an interactive video conferencing system that is able simultaneously to display reference weather products, output products, graphical interactions (with light pen or equivalent), the image of the IWB forecaster and the recipients/users with voice communications. A full description of input/output products and the technical requirements for an IWB are given by SysOps, 2004b.

6. INPUT DATA AND PRODUCTS

The traditional weather data and products that are currently used by the CWSUs are assumed to continue to be available. These products are viewed on a several different display systems: WARP, AWIPS Remote Display, IDS, and ADDS Internet products.

In addition, it is assumed that the JAWS will have access to products that are currently available to traffic managers at FAA centers. Examples are:

- Integrated Terminal Weather System (ITWS) that forecasts convection out to an hour in the terminal area
- Corridor Integrated Weather System (CIWS) that forecasts convection within the ORD-LGA corridor out to 2 hours in advance
- Weather forecast products used by the FAA operational centers that come from the research community or from by private industry that address weather hazards to aviation.
- Traffic management tools: demand and capacity parameters on the Traffic Situation Display (TSD).
- Hub Forecasts every hour out to 8 hours in advance for a limited set of (approximately) 30 hub terminals in the CONUS. The forecast includes a Tactical Decision Aid (TDA) that estimates the Airport Arrival Rate (AAR) from the weather forecast. (Rodenhuis, 2006)

7. OUTPUT PRODUCTS AND SERVICES

The operational products expected from the JAWS weather forecasters are directed towards the needs of their users. Those needs are safety due the potential threat of hazardous weather, and estimates of capacity. A detailed content of the JAWS forecast products is expected from the NWS in consultation with users in the FAA/ATO/System Operations. The output products are:

- TRACON Forecasts for the TRACON and surrounding area (gate posts, holding patterns, choke points, etc). The forecast covers 3 spatial dimensions and time and is associated with a TDA for traffic volume. The forecast variables, frequency of the forecasts, lead-times, and the nature of the TDA are unspecified at this time.

- TRACON Advisories (a.k.a. Center Weather Advisory) directed to FAA facilities to alert them to hazardous weather or whenever a significant change of weather is expected to occur that would change their capacity or operating conditions. The threshold conditions that trigger a TRACON Advisory have not be specified.

- ENROUTE Forecasts and associated TDAs that apply AWC forecasts to specific routes and sectors within the designated area of responsibility. None of the characteristics of these forecasts or its related TDAs are specified at this time.

- Consulting and Advising at the initiative of the users and available 7x24. The primary users are: TMUs in ARTCCs, TRACONS, ATCT (towers) and Flight Watch Offices within their domain of responsibility. Consulting and advising can be conducted by any means available: IWB, telephone, or face-to-face (at host ARTCCs).

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- Interactive Weather Briefings (IWB) that presents estimates of capacity with supporting weather forecasts information. The IWB will operate on a cycle of 4 hours, congruent with cycles of the Weather Chatroom and the production of the CCFP. The duration of the IWB will be 3-5 minutes, exclusive of interaction. Separate IWBs will be scheduled for different parts of the CONUS that have different weather or traffic management interests, needs, or problems.

8. EXAMPLE

With this concept of operations is it possible to reconfigure the current CWSUs into a network of Joint Aviation Weather Sites (JAWS) that could actually do the work and satisfy the mission? This question cannot be answered without making some detailed assumptions about the national configuration and workload. Nevertheless, these calculations are useful as an example.

8.1 *National Configuration*

The CONUS is divided into six contiguous regions of airspace. Each of the JAWS is assumed to be collocated with an ARTCC within an associated airspace of responsibility as identified in **Figure 6** and **Table 1**.

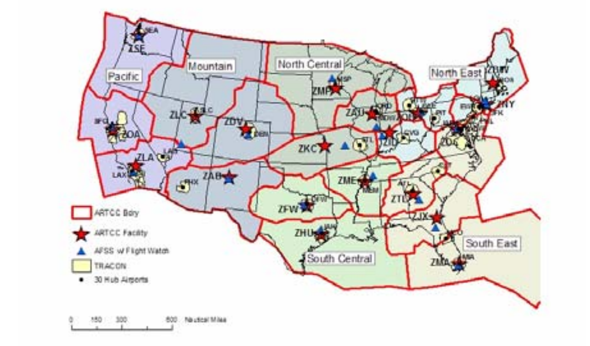

Figure 6 – Distribution of ARTCCs and designated regions for the JAWS

8.2 *IWB Forecast Team*

The *IWB Forecast Team* (Positions 1 and 2) is the cornerstone of the JAWS operations. Depending on the JAWS location (West, Central, or East), the distribution of personnel (Positions 1, 2, 3) is adjusted to meet the responsibilities at each site. When Position 3 is active, it supports the team effort. (Positions 4 covers a portion of the night shift; Position 5 is a fractional management position.)

REGION (CONUS)	ARTCC	TRACON	HUBS	FW	TOT FAC
North East	4	7	9	4	***24***
South East	4	5	7	4	***20***
North Central	3	3	4	3	***13***
South Central	3	3	3	3	***12***
Mountain	3	3	3	3	***12***
Pacific West	3	4	4	3	***14***
Weather Office	6	---	---	---	***6 + NWS***

Table 1 – Distribution of FAA field sites that are potential users of JAWS weather products and services.

The IWB Forecast Team members are identified with their primary tasks:

Position 1 - IWB Lead

- Hazards Briefing on Hub Forecasts (weather and capacity)
- Briefing on TRACON Forecasts
- Briefing the CCFP (summer season)
- Briefing the turbulence forecast (TBD)
- Rationalize and explain the current weather and the forecasts
- Respond to questions
- Support Position 2 during downtime.

Position 2 – Weather Hazards and Capacity (WHC) Forecaster

- Continuous Met Watch
- Produce the TRACON Forecast
- Reconcile forecast discrepancies within the NWS (CCFP, TAFS, en route products)
- Support the IWB Lead

Position 3 – Collaborative Forecaster and Augmentation

- Primary CCFP coordinator on Weather Chat room
- Support the Hazards and Capacity Forecaster
- Assigned tasks as they arise (dynamic)

8.3 *Workload Estimate*

The workload to deliver full weather services requires the positions at each site with the identified responsibilities. (Note that 21 shifts per week for 7x24 operations. (hrs/day x 7 / 8 = shifts/week)

Position 1 - Monitoring of current weather (Met Watch) and operate the Interactive Weather Briefing (IWB), (20 hrs/day): 17.5 shifts/week

Position 2 - Develop TRACON forecasts and prepare Advisories (20 hrs/day): 17.5 shifts/week

Position 3 - Augmentation; support CCFP participation (8 hrs/day): 7.0 shifts/week

Position 4 - Night coverage; maintain Met Watch; IWB standby, (4 hrs/day): 3.5 shifts/week

Position 5 - Management (half time, 5/week): 2.5 shifts/week

SUBTOTAL: 48.0 shifts/week

Training (5%): 2.4 shifts/week

TOTAL Workload
(7x24 operations): ***50.4 shifts/week***

NET individual workload available after subtracting personnel benefits: 4.2 shifts/week

NET personnel required
(full service): ***12 FTEs per site.***

8.4 *Distribution*

The estimate of a full-service workload with an estimate of 12 FTEs per site. However, the personnel should be distributed to match the highest traffic density and most frequent adverse weather.

The most severe and persistent adverse weather that presents a challenge for safety of flight and for air traffic management is convection. The preferred location of intense convection is in the Eastern 2/3rd of the CONUS. The largest fraction of en route air traffic and the most congested air space is located in the Eastern 1/3rd of the CONUS. For that reason, personnel are distributed as shown in **Table 2**:

Region	Number of Personnel (FTEs)
Pacific	10
Mountain	10
North-Central	11
South-Central	11
Northeast	12
Southeast	12
TOTAL	**66**

Tab le 2 – The regional distribution of FTEs in the JAWS

8.5 *Operational Schedule*

A briefing cycle can be designed to cover 3 distinct areas of responsibility on a 4-hour cycle. In fact, there may be as many as 4 ARTCC regions within the responsibility of each JAWS (Table 1). However, each site may choose to structure their IWB to fit their user's needs within their jurisdiction. Thus, it is expected that three independent IWBs or less would simultaneously satisfy the needs of users and fit within the practical limits of time available. A detailed schedule is presented in SysOps, 2004b.

The IWB Forecast Team and their support (Position 3, if on-duty) are also expected to respond to inquiries—either on by phone or through the IWB teleconferencing system. These are identified as "dynamic interrupts". Incoming calls should be considered a priority except during IWB broadcasts or during the preparation of advisories on weather hazards (the TRACON Advisory). Conflicts with other operational responsibilities (eg, CCFP Weather Chatroom) are expected to be worked out in practice just as phone calls are handled currently.

9. CONCLUSIONS

The concept of operations for an Interactive Weather Briefing appears to be feasible and to be able to meet the requirements of a new mission that would to provide full weather services that are needed by all the users in the NAS.

The next step is to describe the technical requirements for web conferencing system to support an operational IWB. Subsequently, these concepts need to be proved by performing a prototype test consisting of 3 components: terminal products, TRACON products, and the communications/hardware/software system. All these issues are defined in SysOps, 2004b. At this time 1 element has already been completed (Rodenhuis, 2006).

Based on this concept, user needs have been described (SysOps, 2004c) which have the force of requirements for the evolution of the present system of CWSUs. However, the proposed configuration (6 sites) and the use of forecasters from the National Weather Service are simply design choices and were proposed to minimize costs and maximize the quality of services. Other configurations and service providers are also capable of meeting the expectations of users in the Air Traffic Organization, System Operations.

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