14.3

COLLABORATIVE DECISION MAKING (CDM) WEATHER EVALUATION TEAM (WET) OPERATIONAL BRIDGING FOR CONVECTIVE WEATHER: DEMONSTRATIONS AND IMPLEMENTATION PLANS

Tom Lloyd*
JetBlue Airways Corp., Forest Hills, NY

Kevin Johnston
Federal Aviation Administration, Warrenton, VA

Tom Fahey
Delta Air Lines, Atlanta, GA

Matt Fronzak
The MITRE Corporation, McLean, VA

Todd Harder
TASC Inc., Chantilly, VA

Larry Larkin
Federal Aviation Administration, Longmont, CO

Darin Meyer
MIT Lincoln Laboratory, Lexington, MA

Jeff Sarver
UPS Airlines, Louisville, KY

1. INTRODUCTION

The Weather Evaluation Team (WET) is a sub-team of the Collaborative Decision Making (CDM) organization. The CDM group consists of representatives from government, general aviation, airlines, private industry and academia, all of whom work together to create solutions to traffic flow problems that face the National Airspace System (NAS). The WET is responsible for addressing meteorological issues within the CDM community. Beginning in 2010, the WET undertook the process of investigating, developing and demonstrating the concept called *Operational Bridging*.

Operational Bridging (OB) is a set of weather forecasting processes, communication tools and engagement protocols between meteorologists and air traffic management (ATM) decision makers, all intended to accelerate the transition of aviation weather constraint forecasts from probabilistic to near-deterministic and enable more timely ATM decisions. This concept was developed as a result of a WET tasking from the CDM Stakeholders Group (CSG) to investigate improvements to convective forecasting in the National Airspace System (NAS), and has evolved based on a number of converging requirements.

In many respects, OB processes and protocols are neither new nor revolutionary. Many organizations that successfully manage aviation operations today practice one or more of the concepts that make up OB. What does make this effort unprecedented is the attempt to standardize the complete set of concepts for implementation at the national level. From the perspective of some groups, including the Federal Aviation Administration (FAA) Air Traffic Control System Command Center (ATCSCC), full OB implementation will result in some aviation meteorologists playing a different role than they do today.

While the overall concept of OB could appropriately be applied to all weather phenomena affecting the NAS, initial concept development and outreach activities, including the set of “Tabletop” demonstrations that occurred in the first half of 2011, have focused on convective weather impacts. This strategy will continue to be followed in the next major validation effort, a live demonstration of OB planned for the latter half of the year.

This paper provides an overview of the OB concept, details the demonstration and evaluation process, and discusses future plans for OB.

* *Corresponding Author Address:* Tom Lloyd, JetBlue Airways Corp., 118-29 Queens Blvd., Forest Hills, NY 11375; email thomas.lloyd@jetblue.com

1.1 *Collaborative Convective Forecast Product (CCFP)*

A critical precursor to the OB concept is the CCFP. The CCFP concept was tested in 1998 and introduced operationally in 1999 on a limited basis. This forecast product was developed based on requirements for a convective forecast to be applied to ATM decisions in the NAS (Rodenhuis et al., 1999). A requirement for consensus between the FAA and the aviation industry operators on the substance of the forecast led to the collaborative nature of the CCFP (Fahey et al., 1999).

After CCFP transitioned from a prototype product to an operational product in 2000, incremental changes to the forecast product were made to meet user needs (Fahey and Rodenhuis, 2004). In 2003, the predecessor to today's CDM WET, the Weather Applications Work Group (WAWG), was established. Under the stewardship of WAWG from 2003 through 2005, the CCFP was developed into the forecast product currently in use, although minor changes have been made to the visual presentation and forecast coverage threshold criteria of the CCFP since 2005.

CCFP is issued at a two-hour interval to coincide with the Strategic Planning Telcons (SPTs) hosted by the ATCSCC. CCFP collaboration is facilitated by the National Weather Service (NWS) Aviation Weather Center (AWC), resulting in a human-generated forecast of convection within the continental United States and a portion of eastern Canada. Forecast thresholds for depiction on the CCFP are defined in the CCFP Product Description Document[1].

CCFP can be considered to be the current "Single Authoritative Source" forecast for convective weather in the NAS. However, in recent years, numerous additional convective forecasts have been made accessible to ATM decision makers. Products such as the Corridor Integrated Weather System (CIWS) (Evans et al., 2002; Robinson et al., 2006), Consolidated Storm Prediction for Aviation (CoSPA) (Pinto et al., 2010), and Localized Aviation Model Output Statistics (MOS) Program (LAMP)/CCFP Hybrid (LCH)[2] have been introduced, offering arguably greater precision and more frequent updates than CCFP.

1.2 *Requirements*

Several converging requirements led to the development of OB in response to the CSG tasking noted above.

The CSG provided guidance to all CDM sub-teams, including the WET, to demonstrate key concepts of the Next Generation Air Transportation System (NextGen). In the weather arena, two areas in particular are applicable to WET activities: the Single Authoritative Source (SAS) concept and the Human-Over-The-Loop (HOTL) model, wherein forecasts are computer-generated but reviewed and approved by meteorologists prior to their issuance.

The WET, recognizing CCFP as the current SAS for convective weather forecasts, sought to evolve it in response to the CSG tasking. Among the requirements that initiated the development of the OB concept are the following:

- Reconcile the variety of convective forecasts available to ATM decision makers, now and in the future, with the SAS concept.
- Account for the evolving role of the meteorologist in forecast production, and move toward using the HOTL model in CCFP production.
- Explore methods of translating weather forecasts to ATM impact, as tasked by the CSG.
- Effectively use probabilistic weather forecast information in support of strategic TFM planning. (Note: an evaluation of the use of LCH indicated that ATM decision makers had difficulty applying the probabilistic forecast to operational planning.[3])

1.3 *Development*

With a focus on the above requirements, the WET investigated weather forecast and communication methods used in a variety of operational environments to examine how similar requirements were met in other organizations. Processes at the NWS Storm Prediction Center (SPC), NASA/NWS Spaceflight Meteorology Group (SMG) and several Airline Operations Centers (AOCs) were observed and discussed by the WET.

In September 2010 the team proposed the concept of OB to the CSG, requested and received approval to continue its development, which has been occurring since then. In January 2011, the OB concept was introduced to the larger meteorology community via a presentation at the 2nd Aviation, Range, and Aerospace Meteorology (ARAM) Special Symposium held as part of the 2011 American Meteorological Society Annual Meeting, and the subsequent publication of an associated manuscript (Fahey et al., 2011).

---

[1] The Product Description Document as well as the CCFP itself can be found at http://aviationweather.gov/products/ccfp.
[2] Deactivated as of November 1, 2010; formerly found at http://www.lampccfp-hybrid.com.
[3] The full report is viewable at http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/nextgen/research_tech_dev/awg/media/pdf/2010 CoSPA-LCH OpEval Results V1.1.pdf

2. CONCEPT

Few of the products and methods that make up OB are new. To varying degrees, OB processes have been exercised at many flight operations centers (FOCs) and air route traffic control centers (ARTCCs) between individual meteorologists and ATM decision makers for a number of years. The differences in this groundbreaking effort are the attempts to accomplish the following:

- Identify, bundle and nationally standardize the best aviation weather forecasting and dissemination characteristics and practices to be collected and standardized under the common name of Operational Bridging;
- Clarify assumptions and define associated terminology;
- Develop new forecast products and select communications tools and protocols, both of which enable the right information to be delivered to the right ATM decision makers at the right time;
- Ensure alignment with NextGen principles where appropriate; and
- Implement at the national level.

2.1 *Key Characteristics and Best Practices that define OB*

In the course of gathering information needed to develop the OB, the WET identified key characteristics of, or processes used by, successful practitioners of operational weather forecasting. Most of these are now considered to be part of the core OB concept. Several of the more important ones are further amplified below.

2.1.1 Forecaster Characteristics

Along with being a skilled meteorological prognosticator capable of continuously learning and leveraging advanced forecasting techniques, the OB meteorologist must also be an effective communicator, possess a solid understanding of NAS components and processes and have full awareness of the atmospheric conditions and thresholds which are critical to ATM decision makers.

2.1.2 Impact of Weather on Aviation Operations

It is clear that operational weather forecasters fully understand the impact of weather on the aviation operation they are supporting. This allows them to focus their forecasting resources in an optimal manner, as opposed to spending considerable effort on the forecast of low impact and therefore less important, weather phenomena.

2.1.3 ATM Decision Windows

By understanding the windows of time available to ATM decision makers to make critical decisions, forecasters are less concerned about scheduled forecast times and more focused on continuous watch of the progress of the weather relative to the current forecast and fine-tuning or amending the current forecast prior to ATM decision makers setting a course of action into motion.

2.1.4 Transition of Forecasts from Probabilistic to Near Deterministic

The WET determined that one of the common benefits associated with successful aviation weather forecast offices was the accelerated transition of aviation weather constraint forecasts from the low/medium confidence (probabilistic) category to the high confidence (near-deterministic) category. (Fahey et al., 2010) This allowed the customer ATM decision makers to devise, refine and implement their ATM plans in a timely manner.

The accelerated transition of forecasts from probabilistic to near deterministic, which is related to the amount of confidence that the forecaster has in the prognostication, is thought to be a key benefit of OB.

2.1.5 Collaborated Forecasts

While there may be times that a collaborated forecast results in less precision than what would have been produced by a particular individual forecaster, the scope, location and timing of many system weather forecast problems may be so broad as to make it impossible for any single meteorologist to properly ingest, correctly understand and accurately forecast the impact of the upcoming weather constraints. Moreover, when a forecast weather constraint results in the need to employ large scale Traffic Management Initiatives (TMIs), it is much easier to gain the concurrence of all NAS operators when each has had an opportunity to contribute to the definition of the problem. Finally, considering that this proposal has originated from a CDM sub-team, it should come as no surprise that the concept of collaboration is thought to be another key component of OB.

2.2 *Clarifying Assumptions and Terminology*

The ATM decisions the OB concept will support are those classified as being strategic, and usually related to traffic flow management (TFM). Tactical decisions are thought to be related to and made in support of Air Traffic Control (ATC). Ultimately, all ATM actions are implemented to support downstream or future ATC activities.

Aircraft dispatchers and operations managers/ATC coordinators are the strategic decision makers for an airline. Supervisory traffic management coordinators (STMCs) and ATM planners are the strategic decision makers for the FAA.

Although rigid timeframes are not explicitly used in the OB concept, tactical (ATC) decision making is generally thought to occur no more than 20 minutes from the expected event while strategic (ATM) decision making may occur from 20 minutes to days ahead of time. It is however tacitly understood that, depending on the decision maker, the type of facility, the type of weather constraint and other variables, the boundary between the two types of decision making may be a sliding, overlapping range of time values, as opposed to a specific lead time before the associated event. Figure 1, which illustrates the planning timeline for OB and ATM Decision Making for Convective Weather, is a depiction of the temporal relationship between the two types of decisions. It also notes examples of the convective forecast information available at various lead times prior to the weather event itself.

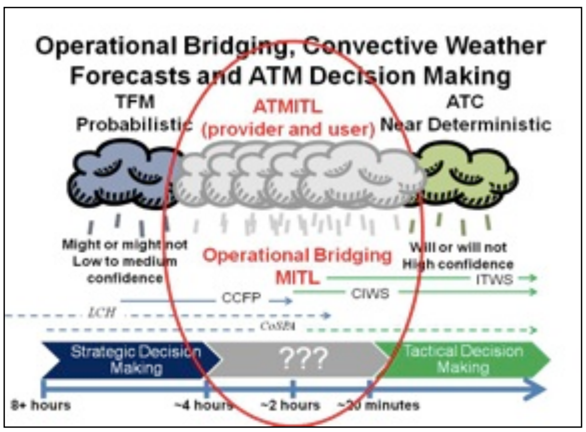


Figure 1. Graphical depiction of operational bridging for convective weather forecasts.

The OB concept can and should apply to any weather with the potential to impact ATM decisions. However, to make the initial development of the concept more manageable and meaningful, current OB focus will be limited to convection. Note in Figure 1 that, for convective forecasts, the primary OB activities are centered around two hours prior to the convective event.

When the focus of OB is expanded to include other, non-convective weather constraints, process engagement lead times will vary based on forecaster confidence and the class of weather constraint (e.g., low ceiling and visibility (C&V), surface winds or winter weather).

2.3 *New Forecast Products, Communications Tools, and Protocols*

Because OB is the combination of a national, standardized collaborated weather forecast and communications process, and because there do not currently exist forecast products or communications tools and protocols that would support all aspects of such an effort, the WET investigated a number of potential solutions. At least a portion of that analysis continues today.

The National Weather Service (NWS) Storm Prediction Center (SPC) produces an effective national convective forecast product called the Mesoscale Convective Discussion (MD). The MD provides benefits akin to what members of the WET envision from OB: a widely distributed, standardized method of accelerating the transition of probabilistic convective forecasts to near deterministic. Because the MD has a very broad target objective (i.e., the safety of all U.S. citizens), it does not necessarily have the clarity or focus needed by aviation users in industry or government. However, the WET understood the value in its general format, which combines text and graphics, and in its wide and effective communications method.

To fill the OB product void, the WET developed the Aviation Weather Statement (AWS). Modeled after the NWS SPC MD, the AWS is the vehicle through which unscheduled, event-driven updates to impacting forecast aviation weather constraints will be communicated in a standard process on a national basis. It will contain both text and graphics. An example of the AWS is found in Appendix B.

The AWS will be issued based on specific meteorological triggers or thresholds (e.g., some combination of location, mode and probability of forecast VIP Level 3 thunderstorm activity) identified by traffic managers as being key for their area. Any person identified as an OB collaborator may initiate the process which results in the publication of an AWS. For the purposes of ATM decision making, AWS information will be considered to supersede any other scheduled forecast product such as the Terminal Aerodrome Forecast (TAF).

With respect to communications tools and protocols, the WET determined a modern, web-based chat tool capable of supporting multi-user collaboration and relevant text, graphics and video should be identified and used in support of OB. A final determination of what this tool will be is yet to be decided by the WET.

2.4 *Alignment with NextGen Principles*

The WET identified at least two NextGen principles that OB would address:

- The use of a Single Authoritative Source (SAS) of weather to provide a common operating picture on which to base ATM decisions; and
- The use of the Human-Over-The-Loop (HOTL) process with automated forecasts.

Today, industry and government managers have multiple convective forecasts available to support their ATM decision processes. In addition to the officially recognized product, CCFP, new fully automated convective weather forecast systems such as the Corridor Integrated Weather System (CIWS) and CoSPA continue to be developed and fielded. The accuracy and precision of these products often exceeds that of CCFP, and users generally find them more effective and easier to use. Because they are digital, these products can be easily overlaid on traffic display systems and integrated directly into decision support tools, both actions of which are key steps in the evolution of the concept of ATM-Weather Integration. CIWS and/or CoSPA could potentially replace CCFP as the default SAS for convective weather, except for the lack of collaborated HOTL oversight of the forecast output.

The OB process is clearly capable of being the source of collaborated HOTL oversight of these or any other new forecast products. As such, it could be viewed, in combination with the new convective forecasts, as a natural evolution of today's CCFP.

2.5 *Implement at the National Level*

In addition to addressing the conceptual aspects of OB, actual operational implementation of the concepts on a national level is the final objective. The following sections will describe progress toward that ultimate goal.

3. CONCEPT VALIDATION/OUTREACH ACTIVITIES - TABLETOP DEMONSTRATION

To receive broader feedback on the OB concept and gauge its potential utility, the WET organized and executed a series of tabletop demonstrations of the concept in five separate breakout sessions at the 2011 CDM General Meeting in Atlanta in early May, 2011. A survey prepared by the WET was provided to members of the CDM community following each breakout session. More than 80 surveys were completed by CDM audience members. This section contains a description of the tabletop exercises, a review of the survey, an analysis of the results of the survey and a conclusion.

3.1 *Tabletop Demonstrations*

The tabletop demonstrations consisted of scripted scenarios in which the potential utility of the OB process was demonstrated by the WET actors. Each scenario used weather data and graphics associated with recent convective weather forecast situations. The narrator led the audience chronologically through the process leading up to an air traffic management (ATM) decision being made in the face of uncertain weather forecasts. OB products such as the publication of an Aviation Weather Statement and an unsolicited briefing call from the OB meteorologist were demonstrated in logical places in the sequence of events. Appendix C contains the graphics used for one of the scenarios, along with the script used by the narrator.

Depending on available time, either two or three scenarios were performed for each breakout group. At the end of each scenario, the narrator paved the way for the survey by asking the audience, comprised primarily of either government or industry ATM decision makers, to think about the value of the OB processes that had been demonstrated, and whether or not they were helpful.

3.2 *Tabletop Demonstration Surveys*

Audience members were requested to complete a one-page survey containing six questions relative to the OB concept at the conclusion of each breakout session. The questions, designed to measure the perceived utility of OB, were to be answered from the perspective of either a government or industry ATM decision maker. The survey took less than five minutes to complete unless the respondent chose to include free text remarks on the back of the form. Respondents were only allowed to select a single answer for each of the first five questions. Multiple responses were allowed for question 6. A copy of the survey can be found in Appendix D.

A total of 85 surveys were completed. The following section contains the survey results displayed as a series of bar charts, and an analysis of those results.

3.3 *Survey Results*

Of the 85 survey respondents, 50 stated that they were U.S. Air Navigation Service Provider (ANSP) participants, 18 identified themselves as industry participants, and the remaining 17 indicated that they were either contractors or Canadian ANSP representatives. It is unclear whether this ratio of respondents corresponds to the makeup of the entire population which participated in the 2011 CDM Annual Meeting, or whether the U.S. ANSP (FAA) participants were particularly motivated to provide feedback on the OB process.

The first question asked the respondents to rate their level of understanding of the described weather situations prior to the use and demonstration of OB processes in the scenarios. Most respondents believed they understood the operational implications of the briefed weather situation fairly well, as is shown in Figure 2.

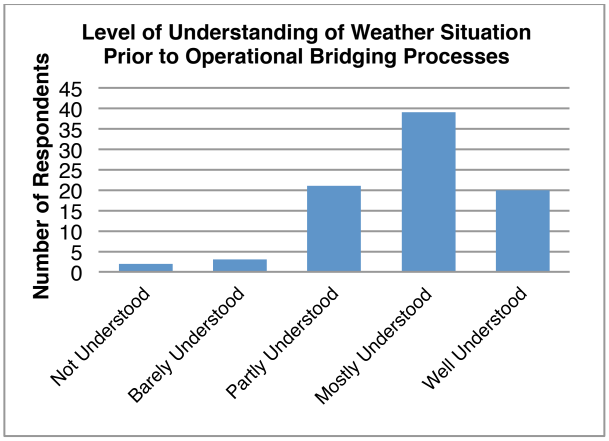


Figure 2. Operational Bridging Tabletop Demonstration Survey Results – Question #1.

Despite the fact that most participants indicated they had a good level of understanding of the underlying weather situation at the beginning of each scenario, a large majority felt their level of understanding improved after viewing the first operational bridging product, namely the Aviation Weather Statement (AWS). Also important was the fact that no respondents felt their level of understanding was reduced in any way by the AWS. Both of these conclusions are reflected in the responses to the second survey question, the results of which are displayed in Figure 3.

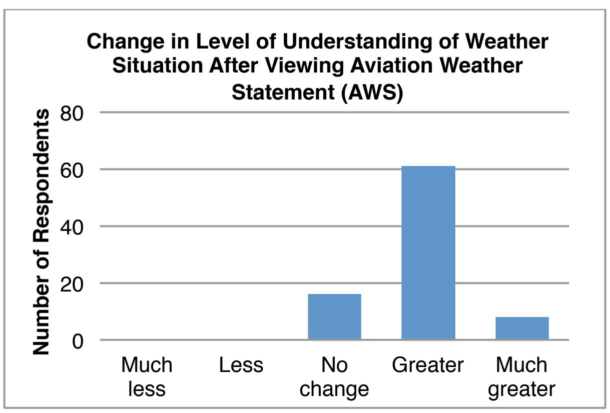


Figure 3. Operational Bridging Tabletop Demonstration Survey Results – Question #2.

Survey respondents reacted even more favorably to the second demonstrated OB process, the unsolicited briefing call from the OB meteorologist to the ATM decision maker. Figure 4 reflects this conclusion.

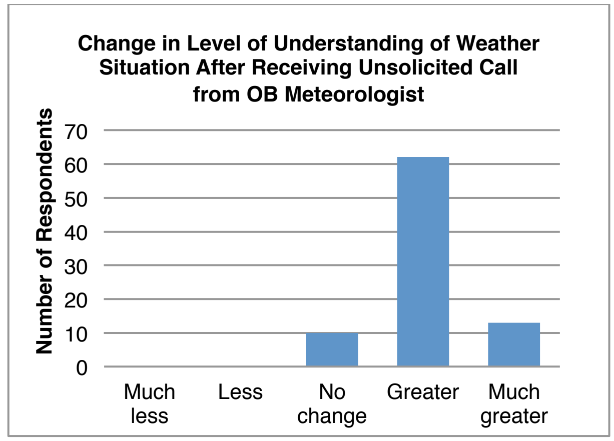


Figure 4. Operational Bridging Tabletop Demonstration Survey Results – Question #3.

The next two questions in the survey asked the respondents to assess the benefits of the AWS and the unsolicited OB briefing. Figures 5 and 6 display the results to these questions. Both products were thought to be either very or extremely beneficial by a majority of the participants, and none rated either product as being not beneficial.

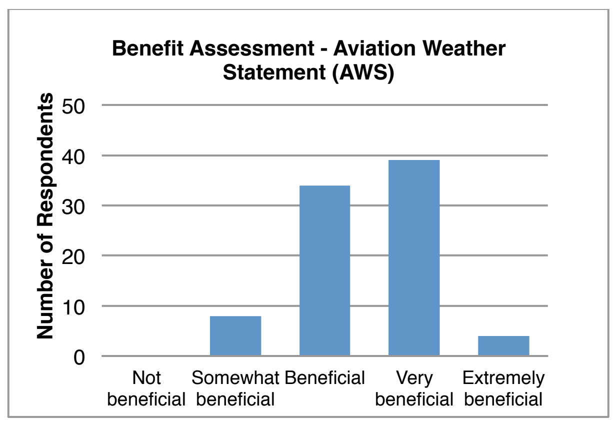


Figure 5. Operational Bridging Tabletop Demonstration Survey Results – Question #4.

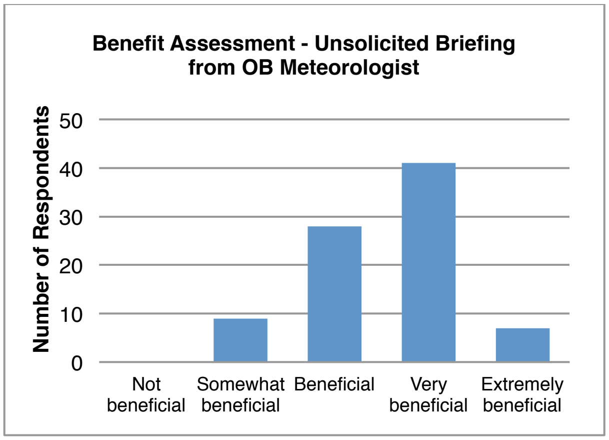


Figure 6. Operational Bridging Tabletop Demonstration Survey Results – Question #5.

The final question asked the respondents to identify one or more outcomes which, based on the tabletop demonstration, could be expected to be attributed to the OB process should it be implemented. Of the six specified outcomes, more respondents thought that OB would result in improved decision making quality than any other, followed very closely and in order by increased situational awareness, improved decision lead times and increased collaboration opportunities. Figure 7 displays these results.

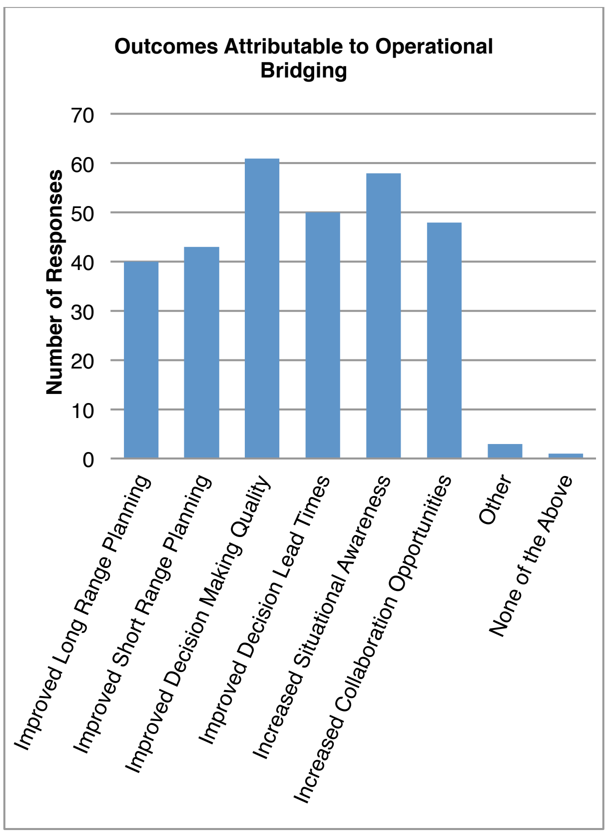


Figure 7. Operational Bridging Tabletop Demonstration Survey Results – Question #6.

3.4 *Conclusion*

Survey results strongly suggest the members of the CDM community who responded to the survey viewed the OB process as capable of providing significant benefits to ATM decision makers, regardless of whether they represented government or industry aviation concerns. Conversations with several key ATC provider representatives during the remainder of the CDM Annual Meeting not only confirmed the results of the survey, but also added a sense of urgency to the further development and implementation of the OB process.

4. LIVE DEMONSTRATION PLAN

In August of 2011, the WET has plans to perform a live demonstration of OB. The intent is to demonstrate the capability and usability of the OB process (including the AWS) within a live, operational setting with a focus on convection.

This live operational demonstration is dependent on convective weather impacting the New York Metroplex during the month of August. WET meteorologists will be responsible for making the decision regarding which week in August convective activity is forecasted to occur resulting in the demonstration. Once the decision is made, teams will be deployed to the locations identified below and the OB demonstration will begin. Personnel will remain at their designated locations based on the predetermined length of the weather event, expected to be no more than one week. Due to limited resources, only a targeted audience will be used for this demonstration. This targeted audience will include the Command Center (ATCSCC), New York Center (ZNY), Washington Center (ZDC), New York TRACON (N90), Aviation Weather Center (AWC), and the airlines.

4.1 *Expected Results*

The goal of the live demonstration is to verify and validate the process of accelerating the transition of aviation weather constraint forecasts in sufficient time to enable ATM decision makers to devise and refine better ATM decisions for TMIs in a timelier manner. The WET is also expecting the AWS will prove to be a critical tool for keeping ATM planners up to date on weather critical to TMI decisions in the 0-4 hour time period.

Another expected result is improved weather information will be available for traffic managers and Flight Operations Centers (FOCs).

This will be accomplished by having OB meteorologists merge their solid understanding of NAS components and processes with their full awareness of critical atmospheric conditions for ATM decision makers, and by utilizing advance forecasting techniques and communication skills.

The overall result of OB should be a reduction in fuel costs as well as a reduction in the expenses associated with flight delays, cancellations, and diversions due to timely adjustments to the forecast weather. These adjustments may include previously unforeseen weather that is now expected to develop or has already begun to develop. Conversely, the adjustment may also address forecast weather that now is expected to either not develop at all or expected not to develop to the extent previously forecast.

4.2 *Measurements of success*

This demonstration will be focused on answering two very high-level, fundamental questions:

1. Is there value to OB? and
2. Are decisions made with more confidence?

To answer these two questions and further assess the potential benefits from OB, a designated team of observers will be deployed to the various participating facilities. Their distinct role will be to document all interactions/conversations occurring in the facility regarding TMI implementation and revisions. The observers will also document any other comments or feedback relevant to the use of OB and the AWS. While the observer is expected to capture all decisions during the day, particular attention will be focused upon the following elements:

- The issue time of the TMI;
- The initial TMI parameters (start time, end time, scope, and AAR);
- The issue time of any subsequent TMI revisions;
- The TMI parameters of any subsequent revisions;
- For any initial TMI or revision, if the manager is recommending parameters other than those recommended by OB, the rationale behind the selection should be included; and
- Any cases where the OB information seems questionable

Following each day of the demonstration, the observers will create a quick look report that will answer the following ATM specific questions (the questions answered in the quick look report will be dependent on the reason the AWS and OB process were implemented):

- Was the TMI initiated earlier?
- Was the TMI start time more appropriate/accurate?
- Is the convective weather active and verifying?
- How many times was the rate adjusted after TMI issued?
- Was the adjustment more appropriate/accurate?
- Is the convective weather active?
- Weather active, but convection not verifying?
- How many times was the rate adjusted after TMI issued?
- Was the adjustment appropriate/accurate?

The WET will use all of the data from the questions listed previously to measure the level of success of OB processes and specifically the AWS tool.

4.3 *Reporting on findings*

After the demonstration is complete and notes from the observers have been reviewed, the WET will produce a post-demonstration evaluation report. The report will focus on the level of success of the demonstration in its entirety while specifically addressing the following:

- Utilization of OB in ATM;
- Additional/supplemental value over the CCFP, CIWS, and CoSPA;
- Ease of reading, understanding, and interpreting the AWS;
- Sufficiency of training;
- Forecast skill/quality with respect to CCFP, CIWS and CoSPA;
- OB accuracy correlated to time frames; and
- Possible standardized implementation across the NAS for ATM decision processes.

This report is scheduled to be released no later than a month after the demonstration is finished.[4]

5. FUTURE ACTIVITIES

The plan for OB is incorporation of the OB process and procedures in the NAS and to continuously improve the traffic management decision process. For this to occur, there are required activities and actions to be performed. Several actions have already occurred such as the OB Tabletop Exercise and the development of an OB Concept of Operations (ConOps). The next critical step is to perform a live OB demonstration and to analyze the results from various perspectives, and produce a report. The report information may determine several possible actions and/or alternatives such as:

- Proceed forward with the OB concept as is;
- Make modifications to the OB process and/or procedures and perform another OB live demonstration;
- Make modifications to the OB process and/or procedures without the need for another OB live demonstration and proceed forward; or
- Take no further actions regarding possible NAS implementation of the OB concept

With the understanding that OB will be successful, the WET will provide a position paper with support documentation to the CSG after a positive report is

[4] Findings will be available at the WET web site: http://flycdm.org/Workgroups/weather_eval.html

available. The CSG would provide the OB concept and any support documentation to the FAA liaison to provide to the FAA Vice President of System Operations to initiate OB into the NAS as a new procedure. As with any new process and/or procedures introduced to the NAS, all the required actions and activities will be determined, and completed, for successful implementation of the OB process into the NAS. Items such as resources, schedules, training, documentation, communications, and milestones will need to be addressed prior to utilizing OB within the NAS.

As the OB process is being utilized in the NAS for convective weather, there will be a continuing evaluation of the benefits of this tool. This is paramount in these times when new products are continuously emerging and may have related (positive) impacts to the OB process and/or procedures. It is envisioned that OB will expand into other areas of weather, other than convective, that may have impacts on ATM decisions. This will be a natural evolution of the OB concept. As with any future changes, all the requisite actions will need to occur to revise the appropriate documentation and logistical information to support the implementation into the NAS.

6. ACKNOWLEDGEMENTS

The CDM WET wishes to acknowledge the work of Pat Murphy and Jason Levit of NOAA/NWS and John Huhn of MITRE in development of the AWS product and “Tabletop” demonstration scenarios, and the participation of WET participants Kory Gempler of FedEx Express, John Kosak of the National Business Aviation Association and Matt Lorentson of NOAA/NWS in development of the Operational Bridging Test Plan. All of their efforts have greatly contributed to the continued development of Operational Bridging.

7. DISCLAIMER

The content of this document reflects the views of the individual authors and does not necessarily reflect the views of JetBlue Airways, Delta Air Lines, UPS Airlines, the Federal Aviation Administration, the MITRE Corporation, MIT Lincoln Laboratory or TASC, Inc. None of these organizations makes any warranty of guarantee, expressed or implied, concerning the content or accuracy of these views.

8. REFERENCES

Evans, J. E., K. Carusone, M. Wolfson, B. Crowe, D. Meyer, and D. Klingle-Wilson, 2002: The Corridor Integrated Weather System (CIWS). *10th Conference on Aviation, Range and Aerospace Meteorology,* American Meteorological Society, Portland, OR, pp. 210-215.

Fahey, T. H., D. Branch, W. Failor, C. Knable, W. Leber and D. Rodenuis, 1999: Thunderstorms & Air Traffic vs. Safety and Economics – Is Collaboration The Answer? *8th Conference on Aviation, Range and Aerospace Meteorology,* American Meteorological Society, Dallas, TX, pp. 33-37.

Fahey, T. and D. Rodenhuis, 2004: Continual Evolution of CCFP – User Needs for Extended Range Prediction. *11th Conference on Aviation, Range and Aerospace Meteorology,* American Meteorological Society, Hyannis, MA, P3.7.

Fahey, T. H., K. Johnston, M. Fronzak, J. Huhn, P. Murphy, T. Lloyd, D. Meyer, and T. Harder, 2011: Collaborative Decision Making (CDM) Weather Evaluation Team (WET) Past and Planned Weather Integration Efforts with Convective Forecasts. *Second Aviation, Range and Aerospace Meteorology Special Symposium on Weather-Air Traffic Management Integration,* Seattle, WA, 3.4.

Pinto, J., W. Dupree, S. Weygandt, M. Wolfson, S. Benjamin and M. Steiner, 2010: Advances in the Consolidated Storm Prediction for Aviation (CoSPA). *14th conference on Aviation, Range and Aerospace Meteorology,* American Meteorological Society, Atlanta, GA, J11.2.

Robinson, M., J. E. Evans and T. R. Hancock, 2006: Assessment of Air Traffic Control Productivity Enhancements from the Corridor Integrated Weather System (CIWS). *MIT Lincoln Laboratory Project Report ATC-325,* p. 302.

Rodenhuis, D.R., F. Mosher, and T. Fahey, 1999: Report on a Task Force to Commercial Aviation – Rapid Prototyping of Experimental Products. *8th Conference on Aviation, Range and Aerospace Meteorology,* American Meteorological Society, Dallas, TX, pp.125-129.

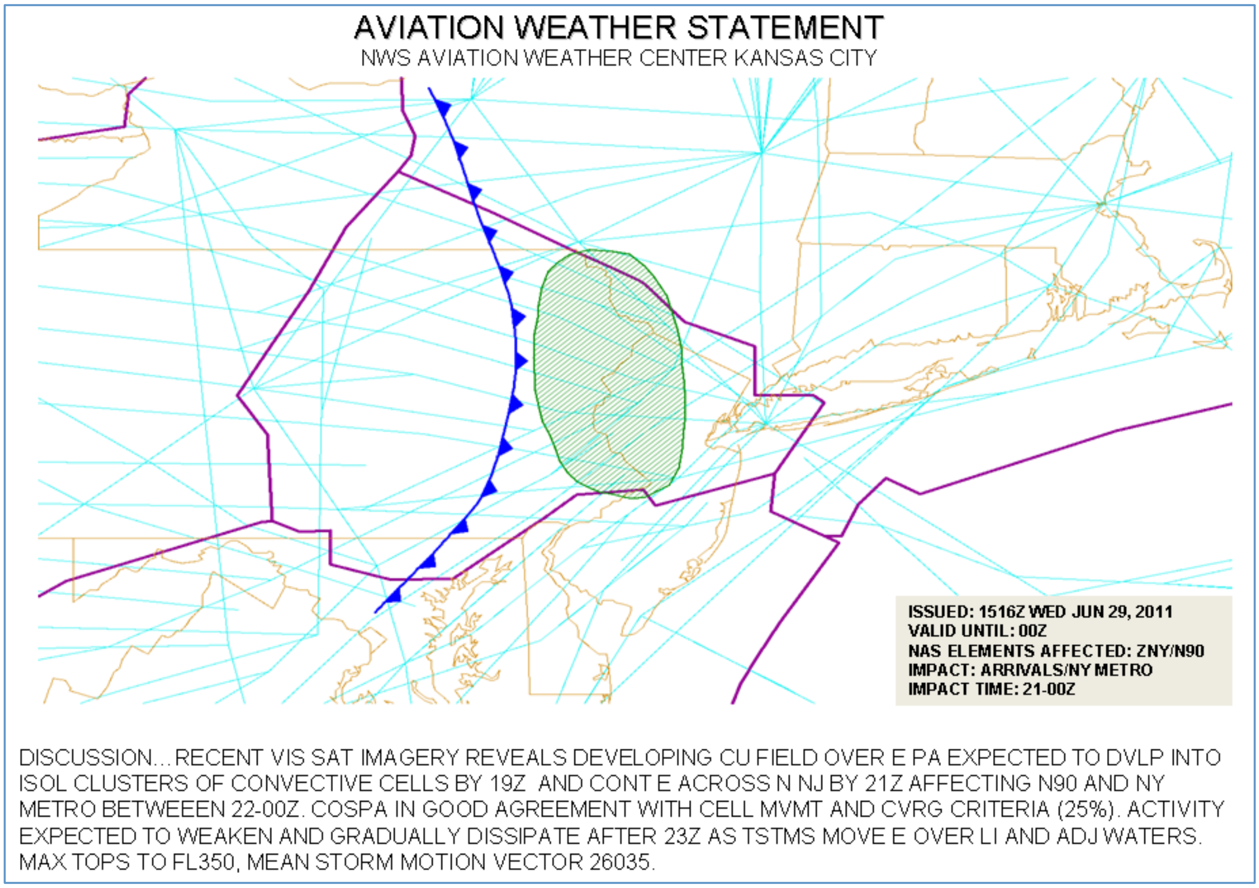
APPENDIX A.

LIST OF ACRONYMS

AAR: Aircraft Arrival Rate
ANSP: Air Navigation Service Provider
AOC: Airline Operations Center
ARAM: Aviation, Range, and Aerospace Meteorology
ARTCC: Air Route Traffic Control Centers
ATC: Air Traffic Control
ATCSCC: Air Traffic Control System Command Center
ATM: Air Traffic Management
AWC: Aviation Weather Center
AWS: Aviation Weather Statement
C&V: Ceiling and Visibility
CCFP: Collaborative Convective Forecast Product
CDM: Collaborative Decision Making
CIWS: Corridor Integrated Weather System
ConOps: Concept of Operations
CoSPA: Consolidated Storm Prediction for Aviation
CSG: CDM Stakeholders Group
FAA: Federal Aviation Administration
FOC: Flight Operations Center
HOTL: Human-Over-The-Loop
LAMP: Localized Aviation Model Output Statistics (MOS) Program
LCH: Localized Aviation Model Output Statistics (MOS) Program (LAMP)/CCFP Hybrid
MD: Mesoscale Convective Discussion
MOS: Model Output Statistics
NAS: National Airspace System
NASA: National Aeronautics and Space Administration
NextGen: Next Generation Air Transportation System
NOAA: National Oceanic and Atmospheric Administration
NWS: National Weather Service
OB: Operational Bridging (OB)
SAS: Single Authoritative Source
SMG: Spaceflight Meteorology Group
SPC: Storm Prediction Center
SPT: Strategic Planning Telcon
STMC: Supervisory Traffic Management Coordinator
TAF: Terminal Aerodrome Forecast
TFM: Traffic Flow Management
TMI: Traffic Management Initiative
TRACON: Terminal Radar Approach Control
VIP: Video Integrator and Processor
WET: Weather Evaluation Team

APPENDIX B.

AVIATION WEATHER STATEMENT (AWS) EXAMPLE



Note: This sample AWS has been designed to illustrate the general format and appearance of the product. Its contents are not intended to reflect an actual or hypothetical weather impact situation.

APPENDIX C.

TABLETOP DEMONSTRATION SLIDES AND SCRIPT

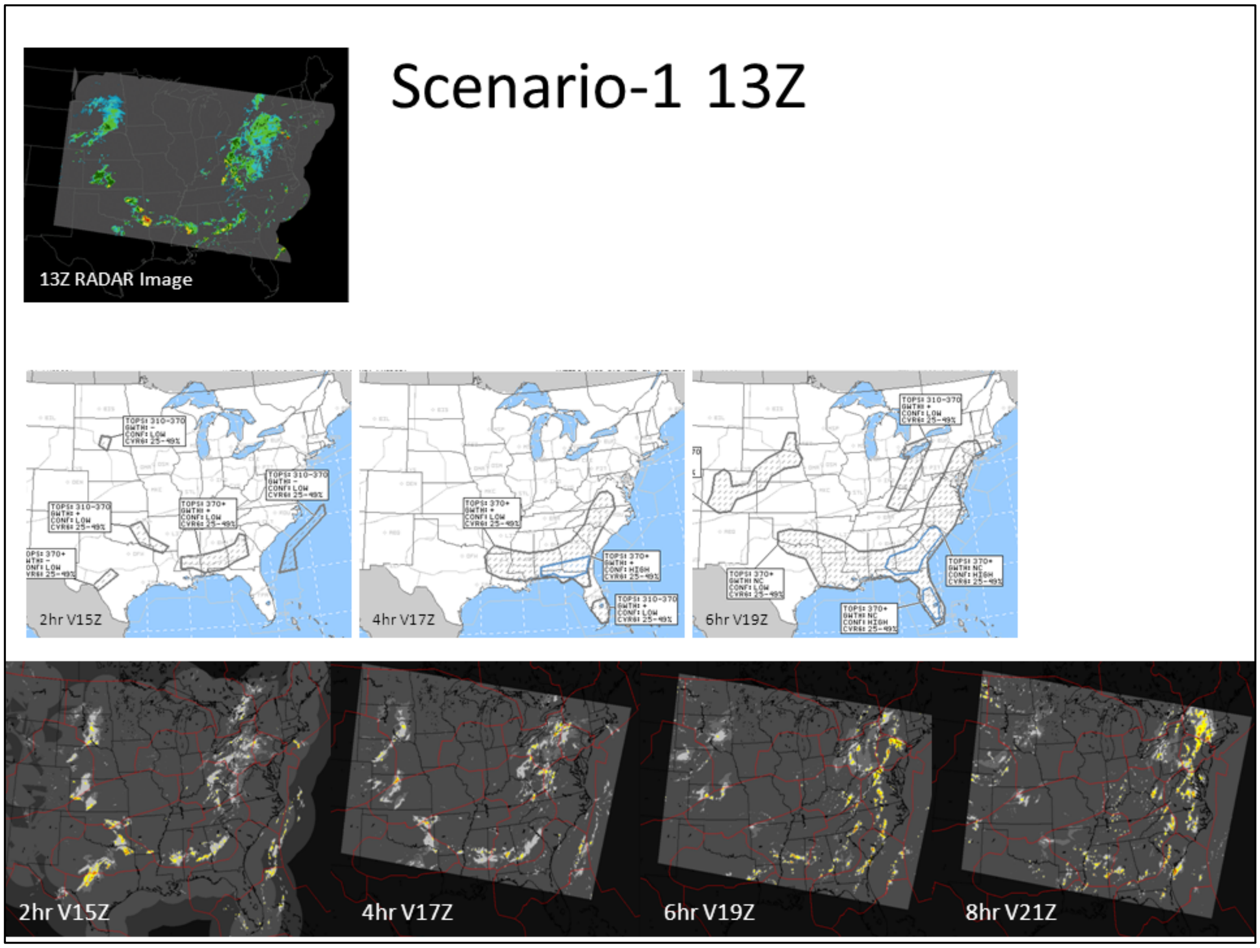


Figure A-1. Operational Bridging Tabletop Exercise Scenario 1, Slide 1

Facilitator: This is what you see at 13Z. What would you anticipate for the day?

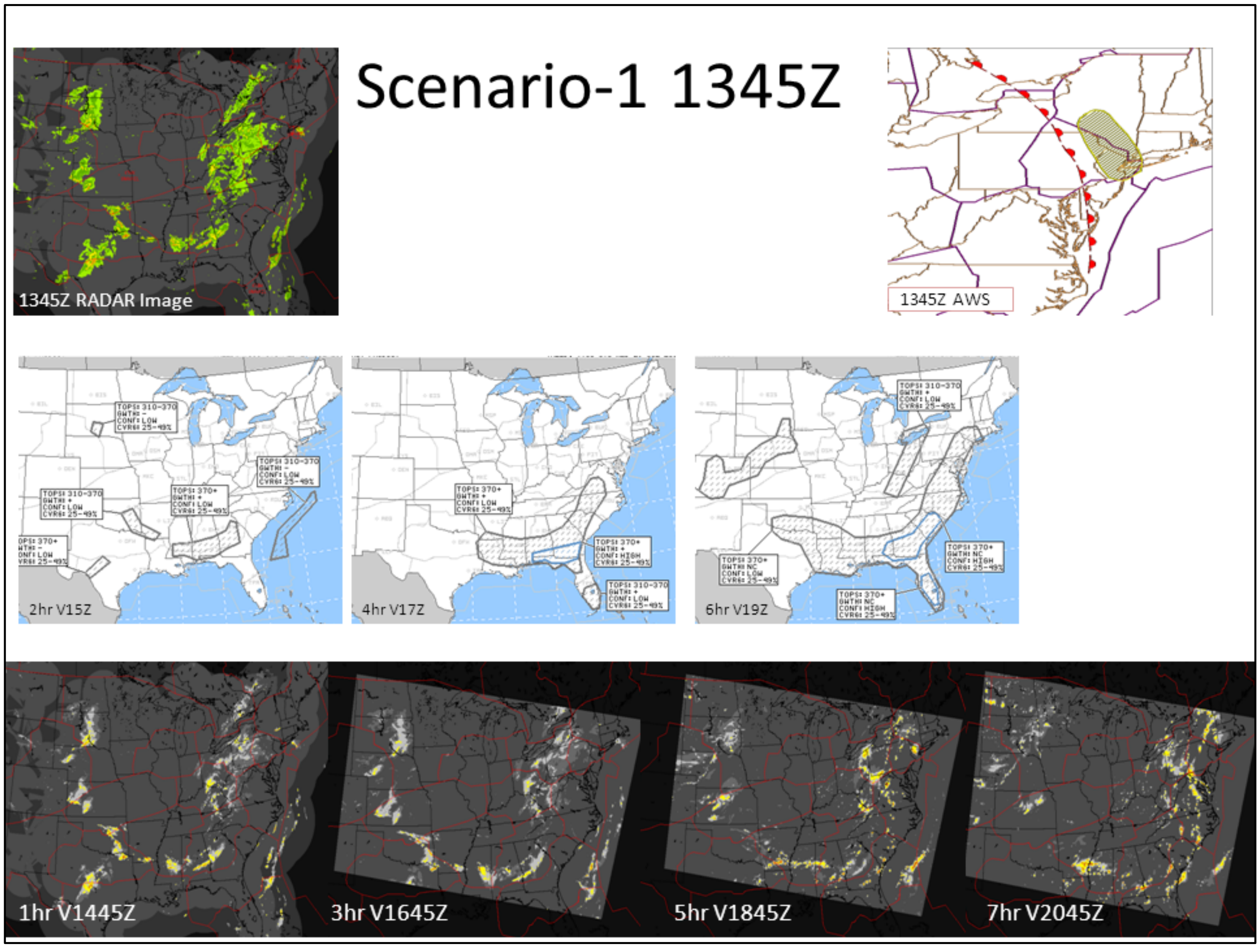


Figure A-2. Operational Bridging Tabletop Exercise Scenario 1, Slide 2

Facilitator: 45 minutes later an "Aviation Weather Statement" (AWS) is issued. It indicates an area of concern over southeast PA, NJ and into the NY metro areas. Convective development is possible over the next 1-3 hours, but well below CCFP coverage criteria. Neither CoSPA nor CCFP indicate something like this so early. If this occurs as depicted in the AWS, but not in CCFP/CoSPA, it could significantly impact NY area arrivals.

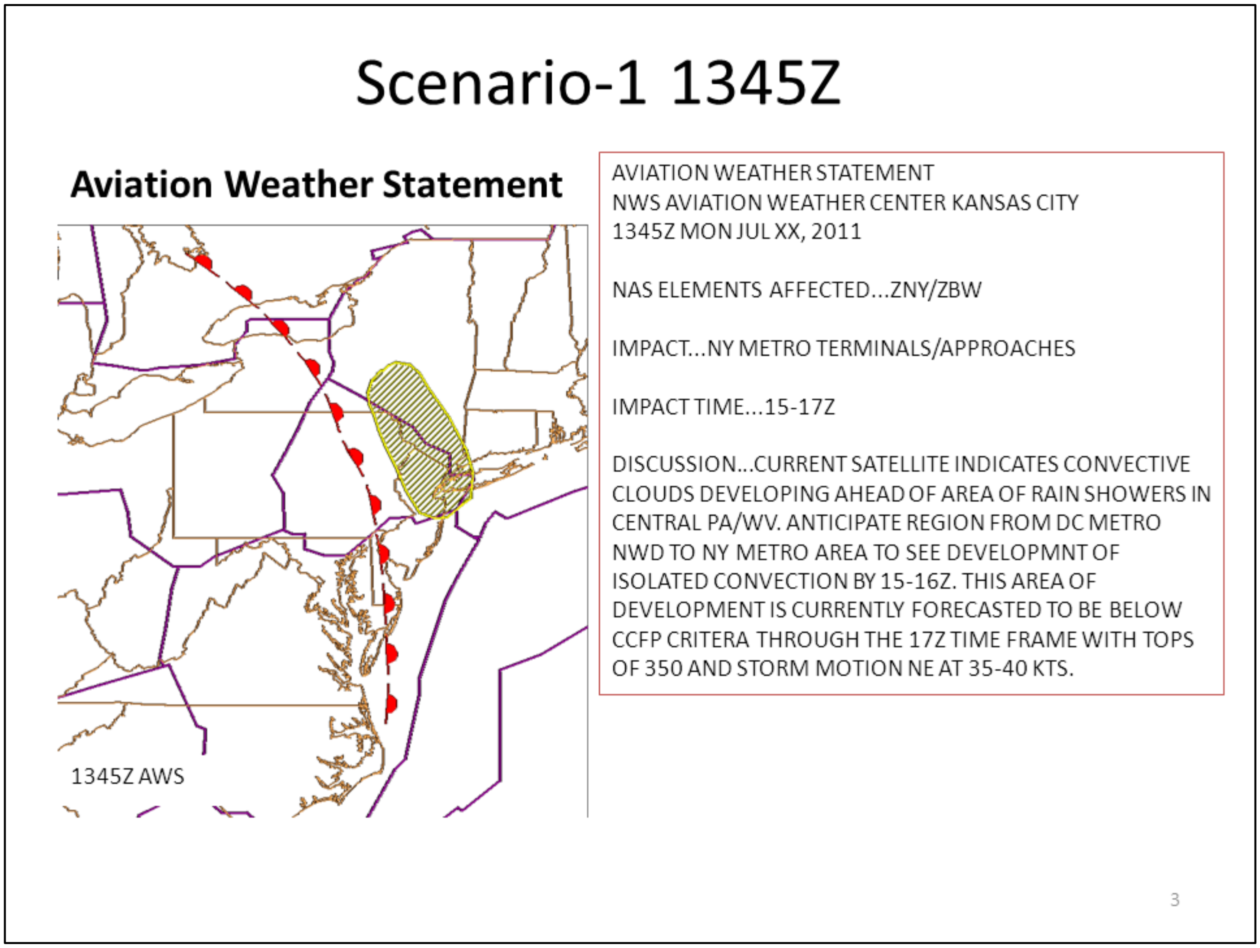


Figure A-3. Operational Bridging Tabletop Exercise Scenario 1, Slide 3

Facilitator: Here's a close up view of the AWS issued at 1345Z.

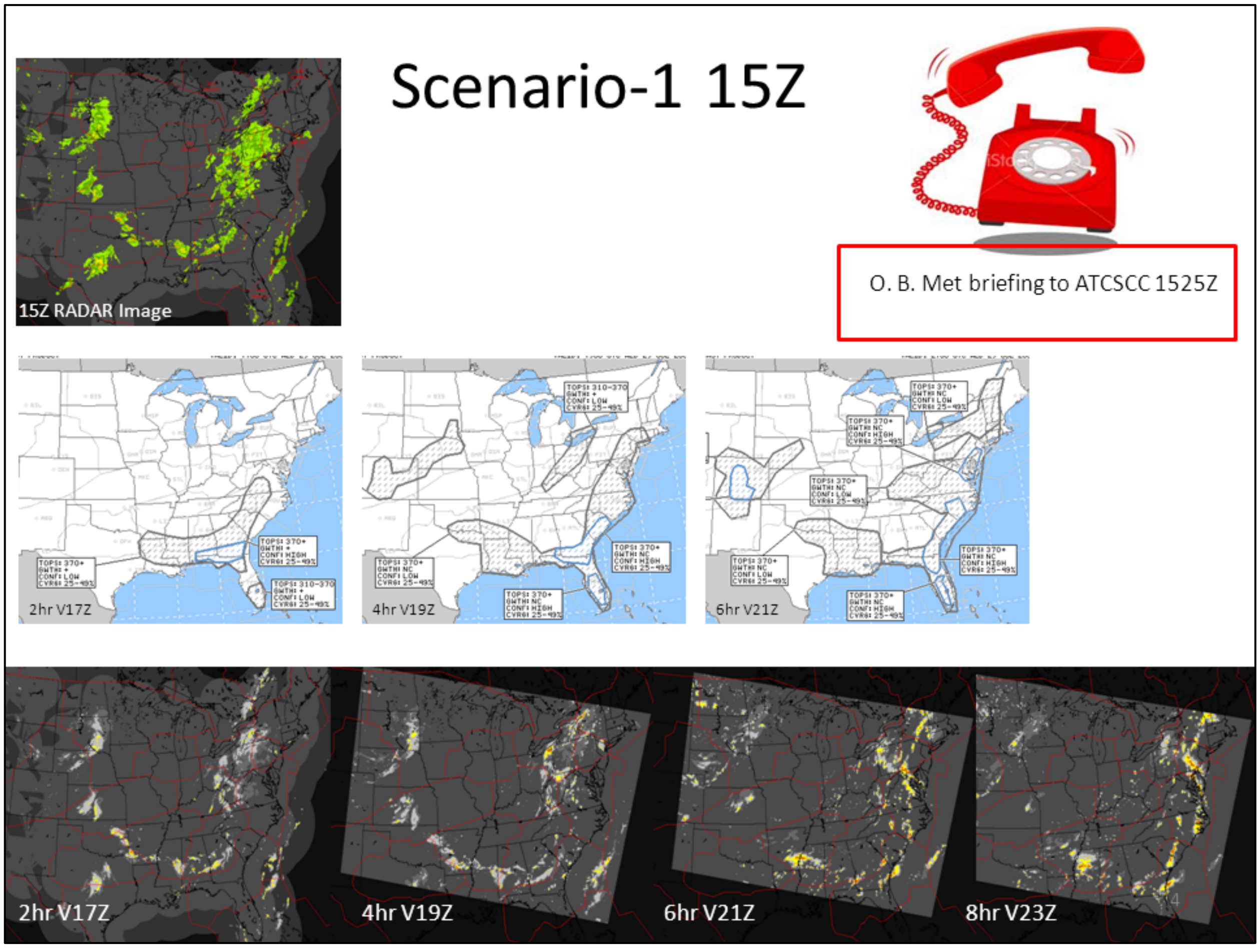


Figure A-4. Operational Bridging Tabletop Exercise Scenario 1, Slide 4

Facilitator: The 15Z CCFP indicates that low coverage, low confidence areas have expanded from the 13Z issuance, but still does not indicate anything significant in the DC-NYC areas until 21Z. Remember the AWS issued at 1345Z described below CCFP criteria there by 15-16Z. Since this is still expected to be below CCFP criteria, it is not depicted on the 15Z CCFP maps. CoSPA seems inconsistent here. It shows some TS near the NY Metro at 19Z, but only at 19Z. Then it re-introduces thunderstorms impacting NY Metros around 23Z.

Facilitator: At 1525Z the Operational Bridging Meteorologist calls Command Center:

OB Meteorologist: Radar is beginning to show thunderstorm cells over eastern PA and central NJ. Will expect several isolated thunderstorms along PA/NY and NJ/NY border by around 16Z, and for these to increase and form a line from northeast PA to central NJ by around 17Z with tops around FL400-450. CoSPA is not yet picking up on this, but once storms are detected by CoSPA it should start depicting them and forecasting their movement. Movement of these thunderstorms should be to the northeast, impacting NY metro arrivals through 19Z and beyond.

Facilitator: Would this prompt you to make a decision earlier or differently than you thought?

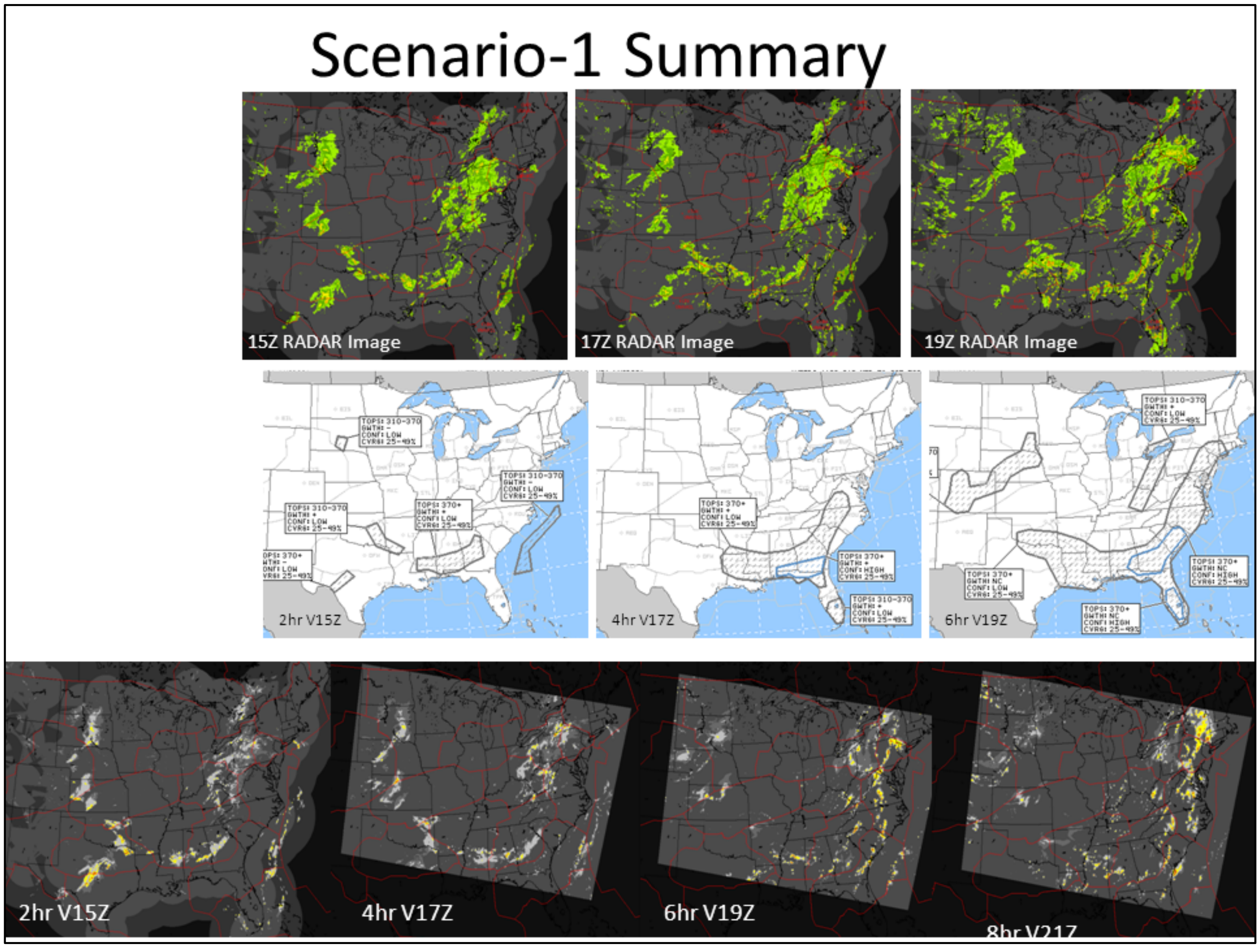


Figure A-5. Operational Bridging Tabletop Exercise Scenario 1, Slide 5

Facilitator: In review we see that a broken line of thunderstorms developed southwest of the NY Metro area by 17Z. At 13Z both CCFP and CoSPA gave no indication of this high Impact event. Even by 15Z CoSPA and CCFP were indicating that convection would be impacting the Northeast and be active between DC and NYC, but were inconsistent and indicated the threat to be 19Z and later. Through Operational Bridging, information concerning the developing impact to the NY terminals and arrival routes was made available as early as 1345Z via the issuance of an "Aviation Weather Statement" with a graphic and text describing the threat. This AWS mentioned the possibility of isolated to widely scattered thunderstorms over portions of eastern PA and NJ as early as 1530-16Z, much earlier than both CCFP and CoSPA. Later as the threat was more imminent, and the impact more clear, the Operational Bridging Meteorologist verbally briefed the Command Center.

Scenario-1 Summary Questions

- What did you think initially?
- Did your thinking change as new information was provided? If so, what information?
- Did you think “Operational Bridging” was beneficial to advanced planning and situational awareness?
- Do you think Operational Bridging (AWS and on demand briefing/consultation) would help you make better decisions at greater lead times?"

6

Figure A-6. Operational Bridging Tabletop Exercise Scenario 1, Slide 6

APPENDIX D.

OPERATIONAL BRIDGING SCENARIO FEEDBACK SURVEY

CDM Weather Evaluation Team (WET) - Operational Bridging Scenario Feedback

Your Current Organization ____
[e.g., Government, Industry, Other (if Other, please specify)]

Your Current Role ____
[e.g., Staff manager (8-5), Line manager (shift worker), Line staff (shift worker), Other (please specify)]

Please answer the following questions as if you were an NTMO/TMS at the ATCSCC, an STMC/TMC at an ARTCC, TRACON or ATCT or an industry Ops Manager/ATC Coordinator, **EVEN IF NONE OF THESE ARE YOUR CURRENT ROLE**.

Q1. Indicate the level of your understanding of the IMPACT of the forecast convective situation(s) at the beginning (after the first slide[s]) of the scenario(s).

1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
Not understood	Barely understood	Partly understood	Mostly Understood	Well Understood

Q2. Indicate the change in the level of your understanding of the IMPACT of the forecast convective situation(s) after receiving the Aviation Weather Statement(s) (AWS).

1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
Much less	Less	No change	Greater	Much greater

Q3. Indicate the change in the level of your understanding of the IMPACT of the forecast convective situation(s) after receiving the Operational Bridging briefing.

1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
Much less	Less	No change	Greater	Much greater

Q4. Rate the benefit provided by the Aviation Weather Statement(s) (AWS) used in the scenario(s).

1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
Not beneficial	Somewhat beneficial	Beneficial	Very beneficial	Extremely beneficial

Q5. Rate the benefit provided by the Operational Bridging briefing(s) used in the scenario(s).

1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
Not beneficial	Somewhat beneficial	Beneficial	Very beneficial	Extremely beneficial

Q6. Please indicate which if any of the following outcomes may be attributable to Operational Bridging.

- ☐ Improved long range planning (4-6 hours ahead)
- ☐ Improved short range planning (2-4 hours ahead)
- ☐ Improved decision making quality
- ☐ Improved decision making lead times
- ☐ Increased situational awareness
- ☐ Improved collaboration opportunities
- ☐ Other (specify)______________________
- ☐ None of the above

Thank you for your participation. Please write any additional comments on the back of this sheet.