technical note technical note

2002 Integrated Turbulence Forecast Algorithm (ITFA) Demonstration Report

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16. Abstract

This report summarizes the 2002 Integrated Turbulence Forecast Algorithm (ITFA) Demonstration conducted by ACB-630. The ITFA, developed at the National Center for Atmospheric Research (NCAR), combines several turbulence forecasting techniques into a single algorithm that produces a forecast of the potential for high-level, clear-air turbulence.

The demonstration was designed to evaluate ITFA for aviation operations. Participants included meteorologists from United Airlines and dispatchers from Comair Airlines. A usability study was employed to evaluate the extent IFTA was used, valued, and supported meteorological and dispatch operations. In addition, ITFA's ease of use, the extent the displayed data was interpretable, and accuracy perceptions in detecting and forecasting clear-air turbulence were measured. The demonstration also included a subjective meteorological study performed by ACB-630 meteorologists.

Demonstration results indicated interface characteristics were operationally acceptable for both meteorologists and dispatchers. However, dispatchers found the greatest utility in the 0-3 hour forecasts, while meteorologists were mostly interested in the 6-12 hour forecasts. Both groups noted a tendency for ITFA to over-forecast areas of turbulence.

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EXECUTIVE SUMMARY

This report summarizes the Integrated Turbulence Forecast Algorithm (ITFA) Demonstration conducted at Comair Airlines and United Airlines (UAL) from February 2002 through May 2002. Specific results, conclusions, and risks from the Demonstration are detailed within this report.

The ITFA, developed by scientists from the Research Applications Program (RAP) at the National Center for Atmospheric Research (NCAR), produces forecasts of turbulence by integrating the weighted output of several algorithms and indices that have proven strengths as turbulence predictors. The weightings are determined by comparing the output of the algorithms and indices to turbulence observations deduced from pilot reports.

The Demonstration was conducted by test personnel from the Federal Aviation Administration (FAA) William J. Hughes Technical Center (hereafter referred to as Technical Center), Weather Processors and Sensors Group, ACB-630. Participants included turbulence forecasters from UAL Weather Center Unit and dispatchers from Comair Airlines. A usability study was employed to evaluate the extent that the ITFA was used, valued, and supported meteorological and dispatch operations; as well as its ease of use, the extent the displayed data was interpretable, and perceptions of ITFA's accuracy in detecting and forecasting clear air turbulence (CAT). Data was collected in two phases in order to capture initial and overall impressions of the ITFA. Phase 1 occurred March 18 – 22, whereas Phase 2 was conducted from April 21-22, 2002. This report also contains a section on a subjective ITFA meteorological study performed by ACB-630 meteorologists.

Results from the two distinctly different aviation user groups (meteorologists versus dispatchers) revealed similar findings for some areas and mixed findings for others. For example, ITFA interface characteristics were considered operationally acceptable across both user groups. Based on user preferences, however, Comair dispatchers found the greatest utility in the ITFA 00 to 03-hour forecasts, whereas UAL forecasters were mostly interested in the 06 to 12-hour forecast depictions. One issue, noted by all users, was ITFA’s tendency to over forecast areas of CAT. Although both groups were favorably impressed with ITFA, Comair’s view of ITFA was more positive. UAL’s opinion of ITFA’s performance became less favorable over time.

1. INTRODUCTION.

1.1 BACKGROUND.

The Federal Aviation Administration (FAA) Aviation Weather Research Program (AWRP) has provided funding to the Research Applications Program (RAP) at the National Center for Atmospheric Research (NCAR) to develop a forecasting tool that mitigates the dangers to commercial and general aviation aircraft from unexpected, hazardous, clear air turbulence (CAT). This effort falls under the auspices of the Turbulence Product Development Team (PDT), which is made up of meteorological experts from private, government and academic organizations and receives its overall funding and direction from the AWRP. In response to the direction provided, NCAR/RAP has developed the Integrated Turbulence Forecast Algorithm (ITFA), which produces CAT forecasts for the contiguous United States.

In support of future ITFA development and to assess users' perceptions of the product, the FAA Technical Center, Weather Processors and Sensors Group (ACB-630) conducted a formal demonstration of the ITFA beginning in February 2002. The Demonstration included participation from one major and one regional airline; United Airlines (UAL) and Comair Airlines, respectively. Users included forecasters from UAL's Weather Center Unit and dispatchers from Comair's Flight Operations Center. A usability study was employed to evaluate the extent that the ITFA is used, valued, and supports meteorological and dispatch operations. Other aspects investigated included: ease of use; the extent the displayed data is interpretable; and perceptions of ITFA's accuracy and performance in detecting and forecasting CAT.

1.2 SCOPE.

This report addresses the user evaluation portion of the 2002 ITFA Demonstration.

1.3 PURPOSE OF REPORT.

The purpose of this report is to document activities, results, conclusions, and recommendations from the 2002 ITFA Demonstration. This report will be provided to NCAR/RAP to assist with future development of the ITFA and to the AWRP to facilitate decisions concerning the future direction of the product.

2. REFERENCE DOCUMENTS.

a. Acquisition Management System Test and Evaluation Process Guidelines, FAA, July 2001.

b. FAA/ACB-630, 2000, Integrated Turbulence Forecasting Algorithm (ITFA) Meteorological Evaluation Final Report.

c. FAA/ACB-630, 2002 Integrated Turbulence Forecast Algorithm (ITFA) Demonstration Plan and Procedures.

d. Gleim, I., 1999: Aviation Weather and Weather Services. 247-288.

e. Sharman, R., B. Brown, and S. Dettling, 2000: Preliminary Results of the NCAR Integrated Turbulence Forecasting Algorithm (ITFA) to Forecast CAT. *The 9th Conference on Aviation, Range, and Aerospace Meteorology*, American Meteorological Society, Orlando.

3. SYSTEM/PRODUCT OVERVIEW.

The ITFA produces forecasts of turbulence by integrating the weighted output of several algorithms and indices that have proven strengths as turbulence predictors. The weightings are determined by comparing the output of the algorithms and indices to turbulence observations deduced from Pilot Reports (PIREPs). The ITFA forecasting process is illustrated in figure 1. Table 1 contains the meteorological indices and algorithms that are currently included in the ITFA. A full description of each index is available from NCAR/RAP. The following sections describe ITFA inputs, processes and output.

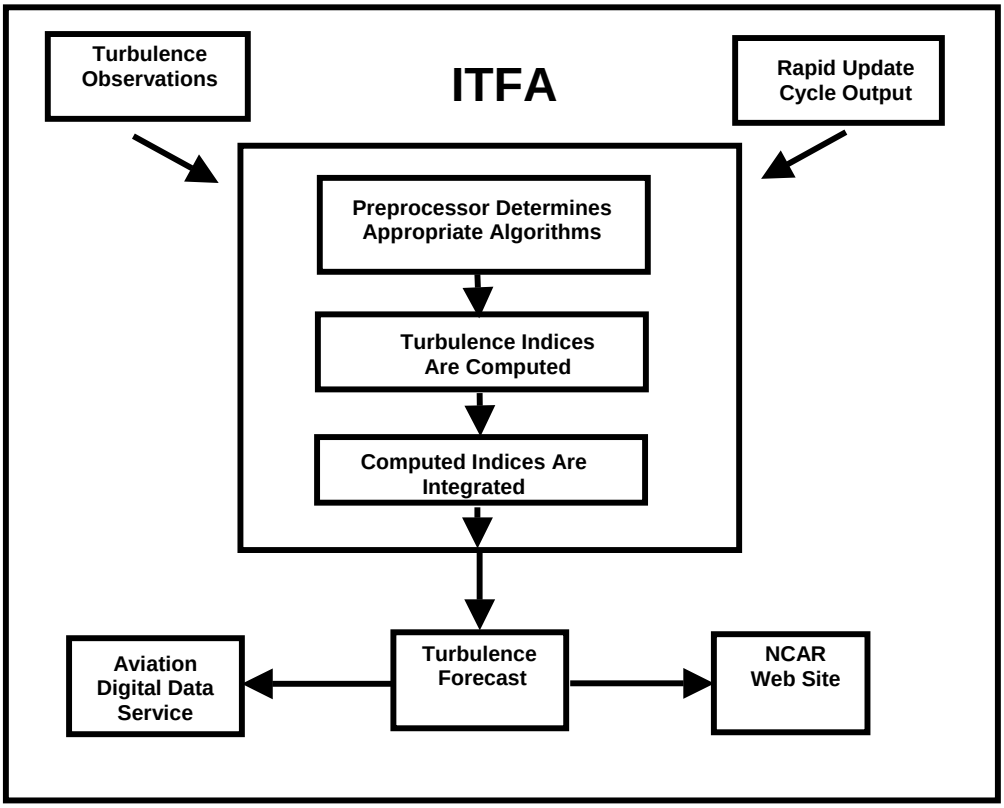


FIGURE 1. THE ITFA FORECAST PROCESS

TABLE 1. ITFA RESIDENT TURBULENCE INDICES

Richardson Number
Ellrod TI1 Index
Ellrod TI2 Index
Brown's 2 Index
Potential Vorticity Gradient
Colson-Panofsky Index
Endlich Empirical Wind Index
DTF3
DTF5
Anomalous Gradient Index
ABSIA
Vorticity Squared
Horizontal Shear
Divergence
Vertical Wind Shear
NGM1 Predictor

3.1 ITFA INPUT.

The ITFA uses the following data inputs:

a. Rapid Update Cycle (RUC) numerical weather prediction model output for levels above 15,000 feet.

b. Turbulence reports received from PIREPs.

3.1.1 Rapid Update Cycle (RUC).

The turbulence indices and algorithms within ITFA are calculated using the forecasted fields of the RUC. The RUC is a meteorological forecast model that was developed for the purpose of providing timely and accurate numerical weather predictions for the 0 to 12-hour range. The latest iteration of the RUC runs at the highest frequency of any forecast model at the National Centers for Environmental Prediction (NCEP), making it very useful for aviation forecasting. RUC 12-hour forecasts are generated every three hours with 3-hour forecasts produced hourly. Horizontal grid spacing of the RUC during most of the demonstration period was 40 kilometers (km).

3.1.2 PIREPs.

ITFA uses PIREPs to identify areas of turbulence, and to assign appropriate weighting factors to the output of ITFA's individual turbulence indices. A PIREP is a meteorological observation

received from the cockpit of an aircraft during flight. This information is vital to successful turbulence forecasting because a PIREP is usually the only direct means of observing turbulent conditions. A typical PIREP contains the location of the reporting aircraft, time of day, aircraft altitude, type of aircraft, sky condition, flight visibility, encountered weather, temperature, wind velocity, turbulence intensity and type, icing intensity and type, and general remarks.

The turbulence is documented in PIREPs by using standard contractions for intensity and type. Table 2 classifies each turbulence intensity level according to its effects on aircraft control, structural integrity, and articles and occupants within the aircraft.

TABLE 2. TURBULENCE INTENSITY REPORTING CRITERIA (GLEIM 1999)

Intensity	Aircraft Reaction	Reaction Inside Aircraft
Light	Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw). Reported as light turbulence or light CAT. Or Turbulence that causes slight, rapid, and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. Reported as light chop.	Occupants may feel a slight strain against belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little to no difficulty is encountered in walking.
Moderate	Turbulence that causes changes in altitude and/or attitude occurs but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed. Reported as moderate turbulence or moderate CAT. Or Turbulence that is similar to light chop but of greater intensity. It causes rapid bumps or jolts without appreciable changes in aircraft or attitude. Reported as moderate chop.	Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.
Severe	Turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Reported as severe turbulence or severe CAT.	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.
Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage. Reported as extreme turbulence or extreme CAT.	Occupants experience the same force as severe turbulence, though these forces may be more violent. Those who are not secured in their seats may become seriously injured.

3.2 ITFA OUTPUT.

The ITFA 0-12 hour forecasts are executed every 3 hours in conjunction with the RUC 12-hour model run. In addition, the 0-hour forecast is updated hourly, while all other forecasts are updated every 3 hours. Algorithm output consists of a mosaic of turbulence forecasts presented on a map of the contiguous United States that coincides with the RUC model domain. An example of an ITFA forecast product is presented as figure 2. The model run-time and the forecast level are displayed in the upper-right and upper-left corners of the product, respectively. In the lower left corner is the forecast valid time and date for that particular product. Finally, a color legend is presented at the lower-right quadrant of the product. The algorithm generates 0, 3, 6, 9 and 12-hour forecasts for flight levels between 15,000 and 45,000 feet. See table 3 for the available ITFA forecast levels.

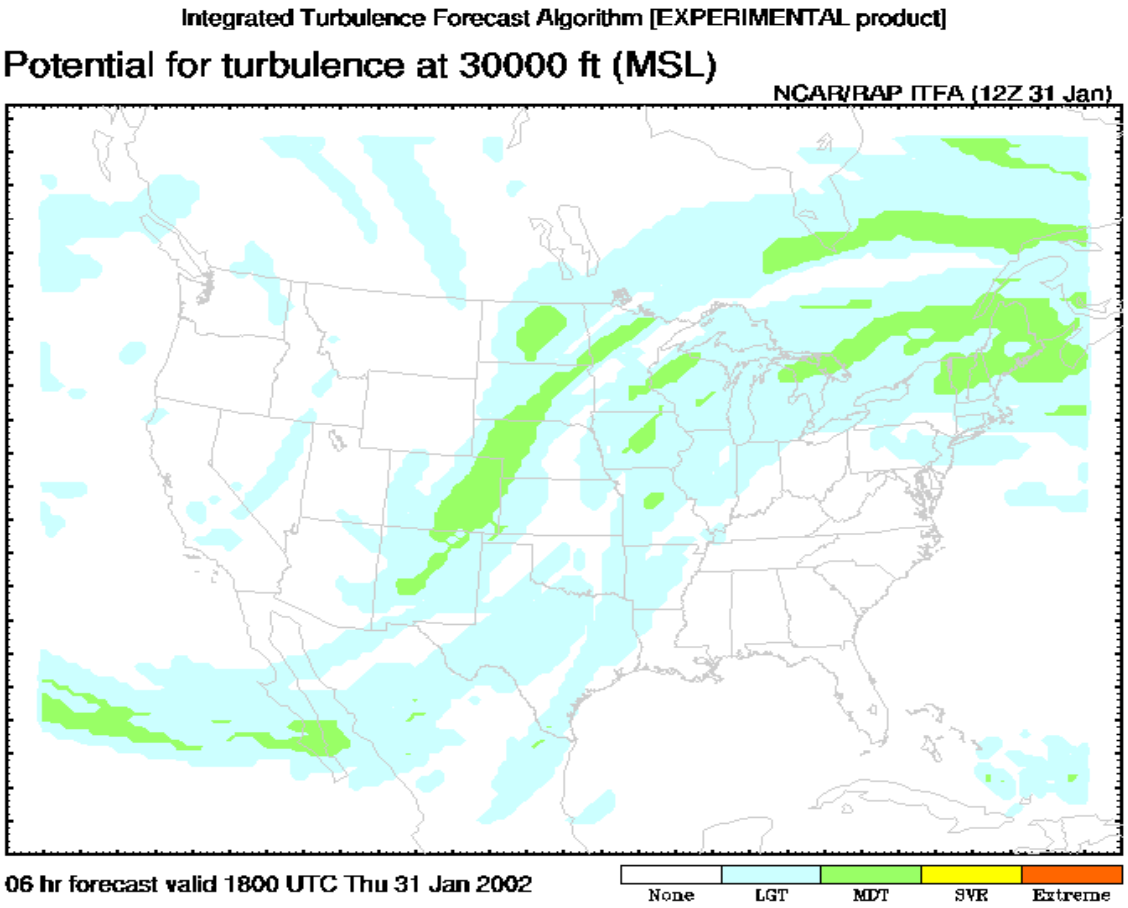


FIGURE 2. SAMPLE ITFA FORECAST PRODUCT

TABLE 3. THE ITFA FORECAST FLIGHT LEVELS

ITFA Forecast Flight Levels (In Feet)
45,000
42,000
39,000
36,000
33,000
30,000
27,000
24,000
21,000
18,000
15,000
Composite – All Forecast Levels

The ITFA display was accessible to users via the Internet from the Aviation Digital Data Service (ADDS) web page at the following Internet address: http://adds.aviationweather.noaa.gov/projects/adds/turbulence/.

3.3 THE ITFA FORECAST.

The ITFA CAT intensity forecast ranges from "none" to "extreme", represented by a color-coding scheme. Color-coding was as follows:

a. No coloring (white) = no turbulence
b. Blue = light turbulence
c. Green = moderate turbulence
d. Yellow = severe turbulence
e. Red = extreme turbulence

3.3.1 PIREPs Overlay.

Symbols that represent turbulence observations obtained from PIREP data are overlaid on the 0-hour forecast display. This information is based on data that are not more than 90 minutes old at the generation time of the ITFA. Turbulence observations derived from PIREPs are presented using the traditional turbulence symbols shown in figure 3.

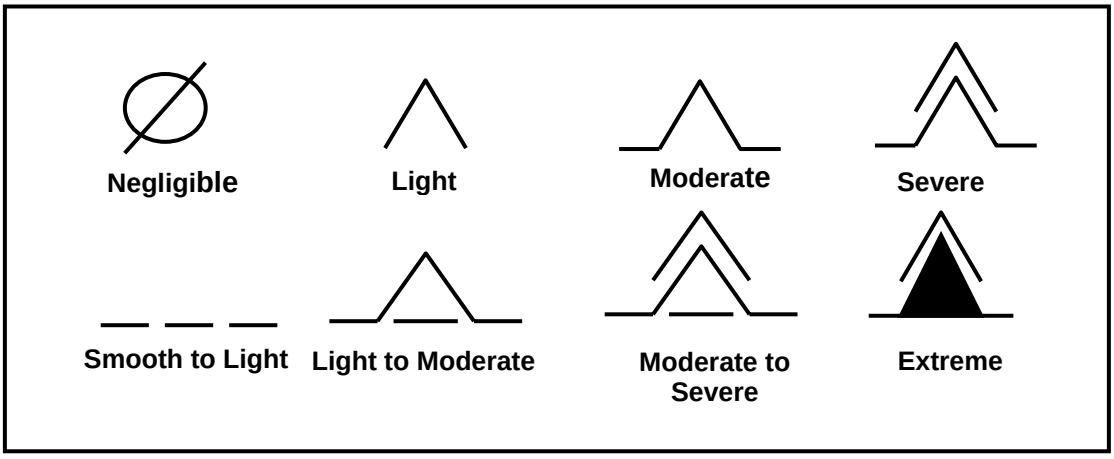


FIGURE 3. PIREP TURBULENCE SYMBOLS AND MEANINGS

4. DEMONSTRATION DESCRIPTION.

The 2002 Demonstration identified and assessed both positive and negative aspects of ITFA utility, data presentation, and perceived accuracy; as well as the extent the ITFA met job task and information requirements of the users.

4.1 DEMONSTRATION OBJECTIVES.

Objectives for the Demonstration were derived after baseline data collection at both participating facilities: UAL's Weather Center Unit, and Comair's Flight Operations Center. Since both user groups are distinct aviation users (meteorologists versus dispatchers) and may have different uses and/or requirements for a turbulence forecast product, objectives, though similar, differed in some respects. Therefore, for the purposes of this report, demonstration objectives for each user group have been documented separately.

In addition to user feedback, ACB-630 personnel subjectively examined ITFA meteorological performance. User feedback identified times when ITFA tended to perform well or not. This data was further analyzed in regards to the meteorological environment.

4.1.1 Comair Demonstration Objectives.

The overall Demonstration objective for Comair users was defined as the demonstrated ability of ITFA to support flight planning in the strategic and tactical avoidance of CAT. To better evaluate the extent this objective has been met, specific “sub-objectives” were identified and included the following:

a. Assess flight planning task benefit.
b. Assess the value of ITFA compared to existing CAT information sources.
c. Assess the utility of ITFA for dispatcher operations.

d. Assess the reliability of ITFA.
e. Assess the perceived ITFA accuracy.
f. Assess the perceived ITFA performance.
g. Assess confidence in ITFA.
h. Assess the acceptability of ITFA interfaces.
i. Assess perceived operator mental workload.

4.1.2 UAL Demonstration Objectives.

The overall Demonstration objective for UAL users was defined as the demonstrated ability of ITFA to: provide airline meteorologists with accurate information on the intensity, duration and location of CAT; and support the detection and forecasting of CAT in an operational airline environment. This objective was further refined, and again, "sub-objectives" were identified and consisted of the following:

a. Assess CAT forecasting task benefit.
b. Assess the value of ITFA compared to existing CAT information sources.
c. Assess the utility of ITFA for meteorological operations.
d. Assess the reliability of ITFA.
e. Assess the perceived accuracy of ITFA.
f. Assess the perceived ITFA performance.
g. Assess confidence in ITFA.
h. Assess the acceptability of ITFA interfaces.
i. Assess perceived operator mental workload.

4.2 PARTICIPANTS.

ACB-630 conducted the ITFA Demonstration. Data collection took place at the operational sites listed in section 4.6.1. Participants included:

a. Comair Airlines Dispatchers – There are approximately 40 dispatchers involved in flight planning at Comair Airline's Flight Operations Center. Since all flight routes are randomly assigned, it is assumed that all dispatchers would encounter CAT along one of their lines of flight. Therefore, all dispatchers were able to participate in the Demonstration.

b. UAL Meteorologists – These included only meteorologists staffing the Turbulence Desk at UAL's Weather Center Unit. The Turbulence Desk is a new addition to the Unit. Approximately six meteorologists have been assigned to this Desk.

4.3 DEMONSTRATION ACTIVITIES.

4.3.1 Pre-Demonstration Activities.

In order to effectively compare current CAT forecasting and detection processes and the effect of ITFA on these processes, baseline data was collected prior to ITFA implementation. The following provides a brief overview of baseline data collection activities.

4.3.2 Baseline Data Collection.

In preparation for the usability portion of the ITFA Demonstration, an ACB-630 Human Factors Specialist visited the Flight Operations Center at Comair Airlines and the UAL Weather Center Unit to collect data on current Comair dispatchers' and UAL meteorologists' processes and procedures for forecasting and detecting CAT. These included: information sources used; types of weather phenomena that effectively factor into the forecast; methodologies used; and issues affecting the timeliness and accuracy of CAT detection. An initial understanding of users' requirements for an operationally useful CAT detection and forecast product was also solicited. Data from these visits formed the basis for the objectives of the ITFA 2002 Demonstration. See appendix A for baseline information collected from these visits.

4.4 DATA COLLECTION TECHNIQUES.

4.4.1 Phased ITFA Data Collection Approach.

The objectives of the ITFA Demonstration were achieved by obtaining feedback from airline dispatch and meteorological users. Data collection metrics were the same for both user groups, however, based on different user needs, tasking, functions, and expertise, questions were sometimes dissimilar.

The Demonstration period was divided into two data collection phases. Phase 1 data collection occurred from March 18-22, 2002, where preliminary impressions of the product's usefulness and performance were captured. Emphasis was also placed on identifying any issues that may have arisen over product use. Phase 2, the final data collection effort, took place from April 21-26, 2002.

4.4.2 Data Collection Metrics.

This section will describe Demonstration metrics, using the following techniques:

a. Questionnaires,
b. Structured interviews, and
c. Daily phone interviews.

4.4.2.1 Questionnaires.

Questionnaires were administered during Phases 1 and 2. Demonstration participants rated various aspects of the ITFA based on their perceptions of product utility, ease of use, readability, and accuracy. ITFA was rated on a 5-point Likert scale. The questionnaire also included open-ended questions that allowed users to identify aspects of ITFA products/components and CAT forecast/detection capabilities they felt needed improvement. Information on how frequently ITFA was used was also solicited. Examples of user questionnaires may be found in appendix B.

4.4.2.2 Structured Interviews.

ACB-630 personnel conducted structured interviews during both data collection phases. The goal of interviews during Phase 1 was to gain general feedback regarding the utility of the ITFA as well as identify issues or concerns that arose during this initial demonstration phase. Interviews during Phase 2 data collection were used as a supplementary data collection method to address issues resulting from Phase 1 data as well as capture users' perceptions of ITFA after a longer period of usage. Structured interview question responses are summarized in appendix C.

4.4.2.3 Telephone Interviews.

ACB-630 meteorologists monitored CAT conditions along UAL and Comair domestic flight routes. If significant CAT was expected, the ACB-630 Human Factors Specialist phoned Comair dispatchers (between 8:00 a.m. and 5:00 p.m. eastern time), and Turbulence Desk meteorologists at UAL. The interview consisted of a few short questions regarding the CAT event, information sources used to predict/detect the event, and perceived accuracy and performance of ITFA. This data was designed to identify specific performance scenarios of ITFA for further meteorological analysis. See appendix D for telephone interview questions.

4.5 DATA ANALYSIS.

Data was summarized and tabulated. Questionnaire ratings were analyzed using descriptive statistics, with the median as the measure of central tendency. Results are presented in tabular formats. Interview responses were summarized.

4.6 DEMONSTRATION ENVIRONMENT.

The ITFA Demonstration took place in the operational setting of each of the participating airlines. ACB-630 conducted interviews during normal working shifts, when dispatch and meteorological personnel were available. Data collection for Phases 1 and 2 were conducted on-site.

4.6.1 Demonstration Sites.

The ITFA product was available in both non-operational and operational settings. NCAR/RAP and FAA personnel monitored the ITFA in non-operational settings. Non-operational settings included:

a. NCAR; Boulder, CO and
b. FAA Technical Center, Atlantic City, NJ.

Users (dispatchers and meteorologists) utilized ITFA in operational settings. The Demonstration took place at the following operational sites:

a. Comair Airlines Flight Operations Center, Cincinnati/Northern Kentucky International Airport, Covington, KY, and;

b. UAL Operational Control Center, Weather Center Unit, Chicago, IL.

5. DEMONSTRATION MANAGEMENT.

ACB-630 had overall responsibility for the conduct and coordination of the ITFA Demonstration.

The principle organizations participating in the demonstration included:

a. AUA-430, Weather Sensors and AWRP Integrated Product Team, FAA Headquarters, Washington, DC;

b. ACB-630, FAA Technical Center, Atlantic City, NJ;

c. NCAR/RAP, Boulder, CO;

d. Comair Airlines, Cincinnati, OH; and

e. UAL, Chicago, IL.

5.1 ROLES AND RESPONSIBILITIES.

The following describes the roles and responsibilities of the organizations associated with the ITFA Demonstration.

a. AUA-430: AUA-430 funded and managed all demonstration efforts.

b. ACB-630: ACB-630 was responsible for the overall conduct and coordination of the user demonstration including: demonstration planning; data collection; compilation of results; completion of data analysis; and writing of the final report.

c. NCAR/RAP: NCAR/RAP was responsible for maintaining and running ITFA; implementing and/or updating the ITFA product when changes to the algorithm or ITFA interface were required; and conducting user training.

d. Comair Airlines and UAL: The participating airlines were responsible for providing access to equipment and personnel as needed to operate the ITFA web site. Personnel also provided input to the ACB-630 evaluators.

5.2 TRAINING.

NCAR developed and conducted user training prior to formal Demonstration conduct. Most participants received personalized ITFA training either individually or in small groups.

5.3 SCHEDULE OF DEMONSTRATION EVENTS.

The following lists dates of major Demonstration activities.

a. Demonstration Plan/Procedures complete - February 26, 2002
b. Daily Phone Interviews - February 11 - April 18, 2002
c. Phase 1 Data Collection - March 18 - 22, 2002
d. Phase 2 Data Collection - April 21 - 26, 2002
e. Complete Data Analysis - May 31, 2002
f. ITFA Final Report - June 30, 2002

5.4 PERSONNEL RESOURCES.

ACB-630 and NCAR/RAP provided all demonstration team members. Team members consisted of human factors specialists and meteorologists provided by ACB-630. Meteorologists and engineers provided by NCAR were responsible for maintaining ITFA and user training. The ITFA Demonstration also included the schedule and participation of users from the facilities listed in section 4.2.

6. RESULTS AND DISCUSSION.

This section presents the results of the ITFA Demonstration. Results for the two user groups, Comair dispatchers and UAL meteorologists, are reported separately.

6.1 COMAIR AIRLINES RESULTS.

The following sections will discuss the analysis and interpretation of ITFA Demonstration results from data collection Phases 1 and 2 at Comair Airlines.

6.1.1 Factors Affecting Comair Results.

User overload - Concurrent with the ITFA Demonstration, all dispatchers were directed to collect CAT and icing related data in the form of solicited PIREPs for NCAR researchers. Data was obtained by communicating with flight crews along a route of flight where icing and/or CAT may have been encountered. Logged data on these occurrences included such variables as location, altitude, visibility, sky conditions, temperature, and wind speed. Information from these dispatcher-solicited PIREPs were entered into a spreadsheet and forwarded to NCAR developers.

In addition to PIREPs, dispatchers were also required to fill out a daily “Comair Turbulence Evaluation – Winter 2002” form, developed by NCAR. For any number of turbulence events, the dispatcher was required to: classify turbulence activity; describe the turbulence based on severity, location (cloud versus clear air), altitude, time of onset, and duration of turbulence; and the perceived performance of ITFA during these turbulence events, e.g. accuracy of the severity depiction and tendencies to over or under-forecast a turbulence area.

Both of these data collection efforts were ongoing throughout the ITFA Demonstration period (February - April, 2002). These efforts required extra time, work, and mental effort beyond normal day-to-day dispatcher tasking. Dispatching aircraft for a large airline, like Comair, can be workload intensive, especially if weather, Air Traffic Control (ATC), or maintenance problems are encountered. The addition of ACB-630's data collection requirements for the ITFA Demonstration, such as daily phone interviews, structured interviews, and questionnaires, may have contributed to user overload, burdening the user with too many non work-related tasks. When overburdened beyond normal work requirements, responses to questions may not be as considered or forthcoming as desired.

6.1.2 Comair Questionnaire Results - Phase 1.

Questionnaires were divided into three sections. Section 1 addressed the ITFA interface in terms of the suitability of menu groupings, colors, and navigation. Section 2 evaluated the operational suitability of ITFA and its components based on the dimensions of utility, readability, ease of use, and accuracy. Section 3 measured the perceived frequency of use of ITFA components as well as other CAT information sources. The following sections will address each of the questionnaire sections.

6.1.2.1 Interface Suitability - Comair Phase 1.

Users were asked to rate the degree they either agreed or disagreed with a positive statement about a certain ITFA interface characteristic such as color-coding, navigation, and menu groupings. Median ratings were derived for each interface category, where "agree strongly" was the highest rating and "disagree strongly" the lowest. Median rating scores are shown in table 4.

TABLE 4. INTERFACE SUITABILITY - COMAIR PHASE 1

Median Ratings for ITFA Interface Suitability Comair - N=12							
ITFA Display	Meaningful Grouping on ADDS	Meaning-ful Menuing	Distinguish-able Flight Level Colors	Meaningful Titles	Distinguish-able Intensity Scale Colors	Meaningful Intensity Colors	Navigation
Median	4	4	4.5	4	4	4	4

Responses were based on the degree the user agreed to positive statements made about the suitability of a certain interface characteristic. 5=agree strongly; 4=agree; 3=neither agree nor disagree; 2=disagree; 1=disagree strongly.

Based on median rating scores, the overall perception of the ITFA interface was considered suitable in that colors were distinguishable and meaningful, menu groupings were meaningful and easy to identify, and navigation around the display was timely and efficient.

6.1.2.2 ITFA Component Operational Acceptability - Comair Phase 1.

All ITFA components, such as forecast options, displayed hour forecasts (e.g., 03 hour forecast display), and turbulence intensities were rated on the dimensions of utility, readability, ease of use and accuracy (when applicable). Not all components were rated on all dimensions, e.g., hourly forecast displays were not rated on readability and ease of use. Ratings ranged from 5, highly acceptable to 1, highly unacceptable. Table 5 contains median rating scores for each ITFA component rated.

TABLE 5. ITFA COMPONENT OPERATIONAL ACCEPTABILITY - COMAIR PHASE 1

Median Ratings for ITFA Product/Component Acceptability Comair - N=12				
Product	Utility	Readability	Ease of Use	Accuracy
Hour Forecast Options	4	4	4	N/A
Flight Level Options	4	4	4	N/A
Turbulence Display-All Forecast Hours	4	4	4	4
Turbulence Intensity Color Scale	4	4.5	4.5	N/A
Displayed Intensity Colors	4.5	4	4	4
00 Hour Forecast	4	N/A	N/A	4
03 Hour Forecast	4	N/A	N/A	4
06 Hour Forecast	4	N/A	N/A	3.5
09 Hour Forecast	4	N/A	N/A	3.5
12 Hour Forecast	4	N/A	N/A	3.5

Median ratings were derived from the following criteria: 5=Highly Acceptable; 4=Acceptable; 3=Neither Acceptable nor Unacceptable; 2=Unacceptable; 1=Highly Unacceptable.

For each of the dimensions of utility, readability, ease of use, and accuracy, the following was derived:

a. Utility of all ITFA components was considered operationally acceptable.

b. Readability of ITFA components rated, such as forecast options and color intensities, was operationally acceptable overall.

c. Ease of use of ITFA components rated was also considered operationally acceptable overall.

d. The 00 and 03-hour forecasts were rated as operationally acceptable, as were displayed color intensities. Median accuracy ratings of 3.5 for the 06, 09, and 12-hour forecasts were above the borderline (neither operationally acceptable nor unacceptable) criteria and below the operationally acceptable criteria. Since there is no defined standard for this rating, it may be assumed that accuracy perceptions were marginally operationally acceptable. Fifty percent of these ratings were borderline; the other fifty were operationally acceptable.

6.1.2.3 Frequency of CAT Resource Use - Comair Phase 1.

The frequency of use for ITFA forecasts as well as other CAT resources was evaluated. Frequency ratings ranged from 5, almost always (90% of the time), to 1, hardly ever (less than 10% of the time). Median scores were derived for each of the ITFA forecasts as well as other resources such as PIREPs, Airmen's Meteorological Information (AIRMET), and upper air maps. Results are presented in table 6.

TABLE 6. FREQUENCY OF USE - COMAIR PHASE 1

Median Ratings for CAT Product/Component Frequency of Use Comair - N=12	
Product	Frequency
00 Hour Forecast	4
03 Hour Forecast	3.5
06 Hour Forecast	2.5
09 Hour Forecast	1
12 Hour Forecast	1
ADDS PIREPs	4.5
AIRMETs	5
Significant Meteorological Information (SIGMETs)	5
Upper Air Maps	3
Jet Stream Analysis	4
Comair PIREPs	4.5
Satellite	4
Surface Analysis	4
Model Data	2.5

Criteria for frequency rating scores included the following: 5=Almost Always; 4=Frequently; 3=Now and Then; 2=Seldom; 1=Hardly Ever.

Results indicated the following:

a. CAT resources used almost always (90% of the time) were AIRMETs and SIGMETs.

b. Comair PIREPs as well as other PIREPs were used frequently (70% of the time). Frequent use was also reported for the ITFA 00-hour forecast, jet stream analysis, satellite depictions, and surface analysis.

c. Products used now and then (50% of the time) included the ITFA 03-hour forecast and upper air maps.

d. The ITFA 06-hour forecast and model data were seldom used (30% of the time).

e. The ITFA 09 and 12-hour forecasts were hardly ever used (less than 10% of the time).

Based on interview data (see sections 6.1.4 and 6.1.5) the infrequent use of the ITFA 06, 09, and 12-hour forecasts is probably a function of required use. Dispatchers do not plan flights more than 2 or 3 hours in advance. Reportedly, forecasts beyond that time are unnecessary.

6.1.3 Comair Questionnaire Results - Phase 2.

Phase 2 questionnaires were identical to those used in Phase 1. Each questionnaire section will be discussed separately.

6.1.3.1 Interface Suitability - Comair Phase 2.

Again, users were asked to rate the degree they either agreed or disagreed with a positive statement about a certain ITFA interface characteristic. Median ratings were derived for each interface category, where "agree strongly" was the highest rating and "disagree strongly" the lowest. Median rating scores are shown in table 7.

TABLE 7. INTERFACE SUITABILITY - COMAIR PHASE 2

Median Ratings for ITFA Interface Suitability Comair - N=10							
ITFA Display	Meaning-ful Grouping on ADDS	Meaning-ful Menuing	Distinguish-able Flight Level Colors	Meaning-ful Titles	Distinguish-able Intensity Scale Colors	Meaning-ful Intensity Colors	Navigation
Median Rating	4	4	4	4	4	4	4

Responses were based on the degree the user agreed to positive statements made about the suitability of a certain interface characteristic. 5=agree strongly; 4=agree; 3=neither agree nor disagree; 2=disagree; 1=disagree strongly.

Consistent with Phase 1 results, the overall perception of the ITFA interface was considered suitable in that colors were distinguishable and meaningful, menu groupings were meaningful and easy to identify, and navigation around the display was timely and efficient.

6.1.3.2 ITFA Component Operational Acceptability - Comair Phase 2.

ITFA components were again rated on the dimensions of utility, readability, ease of use and accuracy (when applicable). Not all components were rated on all dimensions. Table 8 contains median rating scores for each ITFA component rated.

TABLE 8. ITFA COMPONENT OPERATIONAL ACCEPTABILITY - COMAIR PHASE 2

Median Ratings for ITFA Product/Component Acceptability Comair - N=10				
Product	Utility	Readability	Ease of Use	Accuracy
Hour Forecast Options	4	4	4	N/A
Flight Level Options	4	4	4	N/A
Turbulence Display-All Forecast Hours	4	4	4	4
Turbulence Intensity Color Scale	4	4	4	N/A
Displayed Intensity Colors	4	N/A	N/A	4
00 Hour Forecast	4	N/A	N/A	4
03 Hour Forecast	4	N/A	N/A	4
06 Hour Forecast	4	N/A	N/A	4
09 Hour Forecast	4	N/A	N/A	4
12 Hour Forecast	4	N/A	N/A	4

Median ratings were derived from the following criteria: 5=Highly Acceptable; 4=Acceptable; 3=Neither Acceptable nor Unacceptable; 2=Unacceptable; 1=Highly Unacceptable.

All ITFA components were rated operationally suitable on every dimension. Some of these results are inconsistent with Phase 1 results in that perceptions of the accuracy of the 06, 09 and 12-hour forecasts were more positive. Perceptions of the remaining components such as the turbulence intensity color scale, the displayed turbulence colors, and flight level options, were again rated operationally suitable, and were consistent with Phase 1 results.

6.1.3.3 Frequency of CAT Resource Use - Comair Phase 2.

The frequency of use for ITFA components as well as other CAT resources was again evaluated. Results are presented in table 9.

TABLE 9. FREQUENCY OF USE - COMAIR PHASE 2

Median Ratings for CAT Product/Component Frequency of Use Comair - N=10	
Product	Frequency
00 Hour Forecast	4.5
03 Hour Forecast	4
06 Hour Forecast	3
09 Hour Forecast	3
12 Hour Forecast	3
ADDS PIREPs	5
AIRMETs	5
SIGMETs	5
Upper Air Maps	4
Jet Stream Analysis	3.5
Comair PIREPs	4
Satellite	4
Surface Analysis	4
Model Data	1.5

Criteria for frequency rating scores included the following: 5=Almost Always; 4=Frequently; 3=Now and Then; 2=Seldom; 1=Hardly Ever.

Results indicated the following:

a. CAT resources used almost always were AIRMETs, SIGMETs, and ADDS PIREPs.

b. Frequently used resources included Comair PIREPs, 00 and 03-hour ITFA forecasts, satellite depictions, surface analysis, and upper air maps,

c. Products used now and then included the ITFA 06, 09, and 12-hour forecasts and jet stream analysis.

d. Model data was hardly ever used.

Results were somewhat consistent with Phase 1 in that AIRMETs and SIGMETs were used most frequently as CAT sources.

Frequency of use of the ITFA 06, 09, and 12-hour forecasts increased significantly. There was some increase of reported frequency of use for PIREPs. Frequency of jet stream analysis use decreased somewhat, whereas use of upper air maps increased.

6.1.4 Comair Structured Interview Results - Phase 1.

The following summarizes responses from structured interview sessions at Comair Airlines where 10 dispatchers were interviewed. Complete interview responses may be found in appendix C.

1. What is your overall impression of the ITFA product?

All responses were positive. Typically, users liked the ITFA and found it useful.

2. Did you use ITFA information for any aspect of flight planning for flight routes affected by CAT?

Overall ITFA was used, to some extent, as another CAT resource. It was mostly found to be useful in the areas of flight planning, pre-flight planning self-briefings, and some intermittent use throughout the day for enroute monitoring. AIRMETs, SIGMETs, and PIREPS are typically used for CAT information in flight planning.

3. How did the ITFA output compare to traditional sources of CAT information such as SIGMETs and PIREPs?

ITFA compared favorably to other resources. Most users liked ITFA's graphical presentation of CAT.

4. ITFA Performance/Accuracy. Please describe ITFA performance, conditions under which it performed well and/or poorly, how it handled CAT coverage and intensities, and confidence level in its output.

Accuracy of predictions were somewhat questionable. Many noted a tendency to over-forecast. Perceptions of ITFA CAT intensities were mixed, with some noting higher intensities than actually existed and others lower. Confidence in ITFA ranged from moderate to high.

5. Which of the hour forecasts were most beneficial? Is the forecast range adequate?

Almost all users indicated that they do not require a forecast range beyond 3 hours since flight plans are never issued more than 2 hours in advance of flight time.

6. Are flight level ranges of 15,000 to 45,000 feet adequate?

Flight levels were acceptable, although many would like finer gradations between flight levels. Some would prefer a lower altitude depiction. Flight levels corresponding to those used by Comair would be preferable.

7. Did ITFA have any effect on your perceived mental workload associated with flight planning in relation to CAT?

There was an overall perception of some small decrease (if any) in workload.

8. Did you ever experience any problems in accessing ITFA products?

There were no reported data retrieval problems, with the exception of the screen not refreshing automatically from time to time.

9. Is there anything that could be changed or added to the ITFA product to make it more useful to you?

There were a few suggestions which included:

a. Change increments of altitude to 2,000 ft between flight levels.

b. Integrate PIREPs in a more timely manner (PIREPS are sometimes over an hour old).

c. Use PIREP overlays on ITFA hour forecasts.

d. Flight levels should correspond to flight levels used by Comair, e.g., 29,000 to 31,000 feet.

6.1.5 Comair Structured Interview Results - Phase 2.

Twelve Comair dispatchers were interviewed during the Phase 2 data collection effort. Phase 2 responses, although consistent with Phase 1, were more positive overall.

The following summarizes these responses. All responses may be found in appendix C.

1. What is your overall impression of the ITFA product?

Again the overall impression of ITFA was favorable. Users found it useful, helpful, and worthwhile.

2. Did you use ITFA information when flight planning?

Reportedly, ITFA was used mostly as a self-briefing at the beginning of the user's shift, and then checked intermittently, as needed, throughout the day. Users commented that ITFA gives a good, broad, graphical overview of current CAT conditions.

3. How did the ITFA output compare to traditional sources of CAT information such as PIREPs and SIGMETs?

Comparisons, overall, were favorable. Reportedly it was mostly used in conjunction with standard CAT resources such as AIRMETs, SIGMETs, and PIREPs. It was also used as another checkpoint to verify the existence of CAT.

4. ITFA Performance/Accuracy. Please describe ITFA performance, conditions under which it performed well and/or poorly, how it handled CAT coverage and intensities, and confidence level in output.

Most users indicated that ITFA had a tendency to over-forecast areas of turbulence. Some noted that ITFA would indicate areas of turbulence not confirmed by PIREPs. There were no specific recollections of ITFA performance. Perceptions of ITFA accuracy in the vertical (altitude) were mostly positive. However comments regarding the accuracy of ITFA CAT intensities (e.g., ITFA intensity is showing "light" when moderate is reported and vise versa) were mixed.

5. Overall, what was your confidence level in the ITFA CAT Potential forecasts?

Overall confidence in ITFA was somewhat high. Although ITFA output is not relied on 100% and is used in conjunction with other CAT products, users were confident enough to use it operationally, and felt it should be approved for that purpose.

6. Which of the hour forecasts were most beneficial?

Consistent with Phase 1 results, the 00 and 03-hour forecasts were used mostly due to flight planning requirements.

7. Are flight level ranges of 15,000 to 45,000 feet adequate?

Responses were similar to Phase 1, where finer gradations between flight levels and flight levels consistent with Comair flight ranges were desired.

8. Did ITFA have any effect on your perceived mental workload associated with flight planning where CAT was a factor?

Again, users reported little to no effect on workload. Mostly the perception was that workload decreased. Some users, however, found it increased workload since it was another source to look at, and had to be accessed in order to fill out the NCAR forms.

9. Did you ever experience any problems in accessing ITFA products?

No access problems were reported.

10. Is there anything that could be changed or added to the ITFA product to make it more useful to you?

Suggestions for improvement were similar to those in Phase 1 and included:

a. Overlay flights, jet routes, and locators such as cities and Very High Frequency (VHF) Omnirange Navigation System (VOR) sites.
b. Change flight levels to those used by Comair.
c. Use 1,000 feet intervals between flight levels.

6.2 UAL RESULTS.

The following sections will discuss the analysis and interpretation of ITFA Demonstration results from data collection Phases 1 and 2 at UAL.

6.2.1 Factors Affecting UAL Results.

Infrequency of ITFA Use – A small number of meteorologists staff the UAL Turbulence Desk. Sometimes forecasters from other desks are rotated through the Turbulence Desk for a short period of time, to cover personnel who may be on leave or unavailable. Feedback was solicited from forecasters who had worked the Desk for a short period of time and whose use of ITFA was infrequent. Although feedback from these forecasters was valuable, their impressions of ITFA may not be as considered as those who staff the Turbulence Desk on a more regular basis.

6.2.2 UAL Questionnaire Results - Phase 1.

With minor differences, the UAL questionnaire was the same as the Comair questionnaire, and was also divided into three sections (see section 6.1.2). The following sections will address each of the questionnaire sections.

6.2.2.1 Interface Suitability - UAL Phase 1.

Users were asked to rate the degree they either agreed or disagreed with a positive statement about a certain ITFA interface characteristic. Median ratings were derived for each interface category, where "agree strongly" was the highest rating and "disagree strongly" the lowest. Median rating scores are shown in table 10.

TABLE 10. ITFA INTERFACE SUITABILITY - UAL PHASE 1

Median Ratings for ITFA Interface Suitability UAL - N=8							
ITFA Display	Meaning-ful grouping on ADDS	Meaning-ful Menuing	Distinguish-able Flight Level Colors	Meaning-ful Titles	Distinguish-able Intensity Scale Colors	Meaning-ful Intensity Colors	Navigation
Median	5	5	5	4	4.5	4.5	4

Responses were based on the degree the user agreed to positive statements made about the suitability of a certain interface characteristic. 5=agree strongly; 4=agree; 3=neither agree nor disagree; 2=disagree; 1=disagree strongly.

Based on median rating scores, the overall perception of the ITFA interface was considered suitable.

6.2.2.2 ITFA Component Operational Acceptability - UAL Phase 1.

All ITFA components were rated on the dimensions of utility, readability, ease of use and accuracy (when applicable). Not all components were rated on all dimensions; e.g., hourly forecast displays were not rated on readability and ease of use.

Ratings ranged from 5, highly acceptable to 1, highly unacceptable. Table 11 contains median rating scores for each ITFA component rated from Phase 1 UAL data.

TABLE 11. OPERATIONAL ACCEPTABILITY - UAL PHASE 1

Median Ratings for ITFA Product/Component Acceptability UAL - N=8				
Product	Utility	Readability	Ease of Use	Accuracy
Hour Forecast Options	4	4.5	5	N/A
Flight Level Options	4	4.5	4.5	N/A
Turbulence Display-All Forecast Hours	4	4	4	4
Turbulence Intensity Color Scale	4	4	4.5	N/A
Displayed Intensity Colors	4.5	N/A	N/A	4
00 Hour Forecast	4	N/A	N/A	4
03 Hour Forecast	4	N/A	N/A	4
06 Hour Forecast	4	N/A	N/A	4
09 Hour Forecast	4	N/A	N/A	4
12 Hour Forecast	4	N/A	N/A	4

Median ratings were derived from the following criteria: 5=Highly Acceptable; 4=Acceptable; 3=Neither Acceptable nor Unacceptable; 2=Unacceptable; 1=Highly Unacceptable.

Results indicated that all ITFA products and components were perceived operationally acceptable on all dimensions.

6.2.2.3 Frequency of CAT Resource Use - UAL Phase 1.

The frequency of use for ITFA components as well as other CAT resources was evaluated. Results are presented in table 12.

TABLE 12. FREQUENCY OF USE - UAL PHASE 1

Median Ratings for CAT Product/Component Frequency of Use UAL - N=8	
Product	Frequency
00 Hour Forecast	4
03 Hour Forecast	4
06 Hour Forecast	4
09 Hour Forecast	4
12 Hour Forecast	3.5
ADDS PIREPs	4
AIRMETs	2.5
SIGMETs	3
Turbulence Index	5
Upper Air Maps	5
Jet Stream Analysis	5
UAL PIREPs	5
Satellite	5
Bulk Richardson Number	3
Model Data	4.5

Criteria for frequency rating scores included the following: 5=Almost Always; 4=Frequently; 3=Now and Then; 2=Seldom; 1=Hardly Ever.

Results indicated the following:

a. Items used almost always included: the UAL Turbulence Index; UAL PIREPs; upper air maps; jet stream analysis; and satellite. (Note: none were ITFA products).

b. Items used frequently included: all ITFA forecasts from the 00 to 09-hour forecasts; and model data.

c. Items used now and then included: the ITFA 12-hour forecast; SIGMETs; and the Bulk Richardson Number.

d. Items used seldom included: AIRMETs.

6.2.3 UAL Questionnaire Results - Phase 2.

Questionnaires used in Phase 2 were identical to those in Phase 1. Each questionnaire section will be discussed separately.

6.2.3.1 Interface Suitability - UAL Phase 2.

Users were asked to rate the degree they either agreed or disagreed with a positive statement about a certain ITFA interface characteristic. Median ratings were derived for each interface category, where "agree strongly" was the highest rating and "disagree strongly" the lowest. Median rating scores are shown in table 13.

TABLE 13. INTERFACE SUITABILITY - UAL PHASE 2

Median Ratings for ITFA Interface Suitability UAL - N=4							
ITFA Display	Meaning-ful grouping on ADDS	Meaning-ful Menuing	Distinguish-able Flight Level Colors	Meaning-ful Titles	Distinguish-able Intensity Scale Colors	Meaning-ful Intensity Colors	Navigation
Median	4	4	4	4	4	4	3.5

Responses were based on the degree the user agreed to positive statements made about the suitability of a certain interface characteristic. 5=agree strongly; 4=agree; 3=neither agree nor disagree; 2=disagree; 1=disagree strongly.

All interfaces were suitable with the exception of navigation, which received a near borderline (neither acceptable nor unacceptable) rating. Median scores were somewhat lower than those for Phase 1.

6.2.3.2 Operational Acceptability - UAL Phase 2.

All ITFA components were rated on the dimensions of utility, readability, ease of use and accuracy (when applicable). Not all components were rated on all dimensions, e.g., hourly forecast displays were not rated on readability and ease of use.

Ratings ranged from 5, highly acceptable to 1, highly unacceptable. The median was used as the measure of central tendency. Table 14 contains median rating scores for each ITFA component rated.

TABLE 14. ITFA OPERATIONAL SUITABILITY – UAL PHASE 2

Median Ratings for ITFA Product/Component Acceptability UAL - N=4				
Product	Utility	Readability	Ease of Use	Accuracy
Hour Forecast Options	4	4	4	N/A
Flight Level Options	4.5	4.5	5	N/A
Turbulence Display-All Forecast Hours	4	4	4	3
Turbulence Intensity Color Scale	4	4	4	N/A
Displayed Intensity Colors	4	N/A	N/A	4
00 Hour Forecast	4	N/A	N/A	4
03 Hour Forecast	4	N/A	N/A	4
06 Hour Forecast	4	N/A	N/A	3
09 Hour Forecast	4	N/A	N/A	3
12 Hour Forecast	4	N/A	N/A	3

Median ratings were derived from the following criteria: 5=Highly Acceptable; 4=Acceptable; 3=Neither Acceptable nor Unacceptable; 2=Unacceptable; 1=Highly Unacceptable.

All items were operationally acceptable on the dimensions of utility, readability and ease of use. Accuracy of CAT color intensity indications and 00-hour and 03-hour forecasts were also acceptable.

Accuracy of the 06, 09, and 12-hour forecasts were rated borderline (neither acceptable nor unacceptable). Accuracy perceptions of these items decreased from UAL's Phase 1 perceptions where these components were rated acceptable.

6.2.3.3 Frequency of CAT Resource Use - UAL Phase 2.

The frequency of use for ITFA components as well as other CAT resources was again evaluated. Results are presented in table 15.

TABLE 15. FREQUENCY OF USE - UAL PHASE 2

Median Ratings for CAT Product/Component Frequency of Use UAL – N=4	
Product	Frequency
00 Hour Forecast	1.5
03 Hour Forecast	3
06 Hour Forecast	4
09 Hour Forecast	4
12 Hour Forecast	4
ADDS PIREPs	3
AIRMETs	3
SIGMETs	3
Turbulence Index	5
Upper Air Maps	5
Jet Stream Analysis	5
UAL PIREPs	4.5
Satellite	4.5
Bulk Richardson Number	3
Model Data	4.5

Criteria for frequency rating scores included the following: 5= Almost Always; 4=Frequently; 3=Now and Then; 2=Seldom; 1=Hardly Ever.

Results indicated the following:

a. Items used almost always included: UAL's Turbulence Index; upper air maps; and jet stream analysis. (Note: none were ITFA products).

b. Items used frequently included: Satellite; all ITFA forecasts from 06 to 12-hours; model data; and UAL PIREPs.

c. Items used now and then included: AIRMETs; SIGMETs; Bulk Richardson Number; ADDS PIREPs; and the 03-hour ITFA forecast.

d. Items used hardly ever included: 00-hour ITFA forecast. This is a significant difference from Phase 1, where 00-hour forecast use was frequent.

6.2.4 UAL Structured Interview Results - Phase 1.

The following summarizes responses from structured interview sessions at UAL where 8 forecasters were interviewed. Complete interview responses are in appendix C.

1. What is your overall impression of the ITFA product?

Although UAL forecasters reported use of ITFA was infrequent, the overall impression was favorable.

2. Did you use ITFA information when forecasting domestic CAT?

ITFA was typically used to compare to forecasts already derived. It was mostly used for guidance and to confirm existing forecasts.

3. How did the ITFA output compare to traditional sources of CAT information such as the UAL Turbulence Index and upper air charts?

Little comparisons were made. Those that were, indicated that ITFA was not considered a use-alone product, but, it did compare somewhat favorably to other CAT sources.

4. ITFA Performance/Accuracy. Please describe ITFA performance, conditions under which it performed well and/or poorly, how it handled CAT coverage and intensities, and confidence level in output.

Responses were mixed. There was a general perception of over-forecasting, where ITFA would indicate areas of CAT that did not exist. ITFA seemed to perform well when depicting CAT in the vertical dimension (altitude detection). There was also some perception of under-stating CAT intensities, e.g., indications of light turbulence when moderate or higher was reported.

Conditions where ITFA was perceived to perform well were reported by some forecasters and included:

a. Upper level rapidly moving systems, and

b. Distinct systems with significant patterns.

5. Which of the hour forecasts were most beneficial? Is the forecast range adequate?

Forecasters would typically use most forecast ranges out to 12 hours. The forecast ranges were adequate for operational use.

6. Are flight level ranges of 15,000 to 45,000 feet adequate?

Flight level ranges are adequate. Some forecasters would like user selectable ranges and finer granularity between flight levels.

7. Did ITFA have any effect on your perceived mental workload associated with forecasting and issuing advisories on domestic CAT?

Overall, there was some perception of a decrease in workload.

8. Did you ever experience any problems in accessing ITFA products?

There were no reported data access problems.

9. Is there anything that could be changed or added to the ITFA product to make it more useful to you?

Suggestions for improvement included the following:

a. Use of discernable colors for color-blind users. For the color-blind, differentiating between blue and green is difficult.

b. Fine-tune the algorithms to decrease their sensitivity and tendency to over forecast.

c. Provide an indication of weights used for algorithm inputs to show which parameters are being used in a particular forecast.

d. Allow user-selected output for forecast times and altitudes.

e. Allow the user the ability to window multiple images.

f. On the 03-hour forecast display, overlay actual PIREPs.

6.2.5 UAL Structured Interview Results - Phase 2.

Four UAL core Turbulence Desk meteorologists were interviewed during the Phase 2 data collection effort. Phase 2 responses were less positive than Phase 1. The following summarizes these responses. All responses may be found in appendix C.

1. What is your overall impression of the ITFA product?

Opinions were less favorable than Phase 1 impressions. Reportedly, this was due to ITFA's tendency to over-forecast.

2. Did you use ITFA information when forecasting domestic CAT?

Similar to Phase 1 perceptions, ITFA was mostly used for confirmation of derived forecasts and guidance.

3. How did the ITFA output compare to traditional sources of CAT information such as the UAL Turbulence Index and upper air charts?

ITFA compared favorably with other information sources, but was not considered a great asset. It is another tool used mostly to compare to other sources.

4. ITFA Performance/Accuracy. Please describe ITFA performance, conditions under which it performed well and/or poorly, how it handled CAT coverage and intensities, and confidence level in output.

ITFA's potential for over-forecasting areas of CAT led to questionable perceptions of its overall accuracy. Perceptions on CAT intensity accuracy were mixed. Either the intensity was perceived to be above or below the actual CAT intensity or reported turbulence intensities. Although perceptions differed, most users felt that ITFA's intensity depictions were, at times, inaccurate.

Confidence in ITFA was questionable. The overall perception was that ITFA was nice to have, but not reliable enough to rely on. Confidence in ITFA appears to have decreased over time. Reportedly, more use of the system is required.

5. Which of the hour forecasts were most beneficial? Is the forecast range adequate?

Forecasters usually used forecast hours beyond 3 hours. Some looked out to the 12 hour ranges, although most used the 03 to 06-hour forecast ranges. Some reported looking at all forecasts to derive an indication of CAT trending.

6. Are flight level ranges of 15,000 to 45,000 feet adequate?

Flight levels are adequate overall.

7. Did ITFA have any effect on your perceived mental workload associated with forecasting and issuing advisories on domestic CAT?

There was mostly an imperceptible effect on workload. There may have been some slight decrease.

8. Did you ever experience any problems in accessing ITFA products?

There were no reliability issues that were product specific. There was a problem with morning forecast updates due to the RUC model grid change to 20 kilometers which occurred near the end of the demonstration. However this problem was beyond the scope of ITFA and was resolved once the RUC grid was successfully transitioned.

9. Is there anything that could be changed or added to the ITFA product to make it more useful to you?

a. Use different colors or annotations (like cross hatching, etc.) for black and white print outs, to differentiate CAT intensity.

b. Overlay PIREPs.

c. Improve turbulence detection and placement. There is too much areal coverage and intensity.

6.3 SUBJECTIVE METEOROLOGICAL EVALUATION.

6.3.1 Meteorological Observations.

As part of the ITFA Demonstration, ACB-630 meteorologists monitored CAT conditions along UAL and Comair domestic flight routes. When CAT conditions were expected the meteorologist informed the ACB-630 human factors specialist and they phoned one or more Comair dispatchers (between 8:00 a.m. and 5:00 p.m. eastern time), and the morning and afternoon shift Turbulence Desk meteorologists at UAL.

During the monitoring period, ACB-630 meteorologists also subjectively examined ITFA meteorological performance. Trends in ITFA performance were observed during the demonstration period. The following subsection will explain the data used, trends found during the monitoring period, and examples of those trends and their associated meteorological environment.

6.3.1.1 Data.

There were several data sets used in conjunction with analyzing the ITFA output. ITFA forecast output during the demonstration was viewed via ADDS, while all ITFA forecast output was archived by NCAR. This archived output was subsequently made available to ACB-630 in a slightly different format than what was available on ADDS. Additional data used were the 500 millibar (mb), 300 mb, and 250 mb constant pressure level upper air charts archived by the Storm Prediction Center (SPC). PIREPs were viewed via ADDS.

6.3.1.2 Trends.

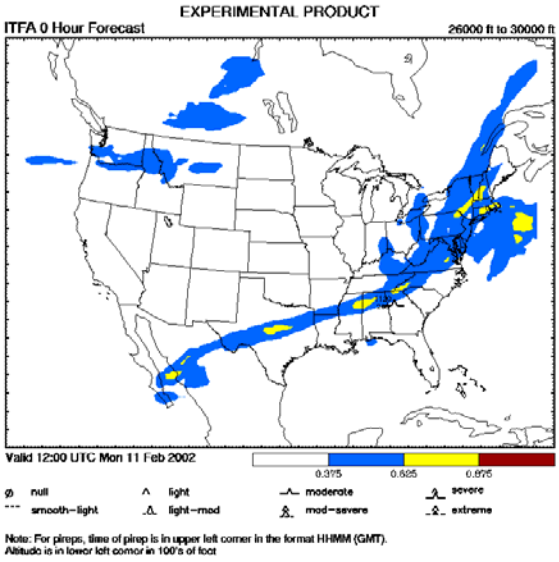
The turbulence forecasted by ITFA during the demonstration period appeared to be associated with upper level troughs and the speed and directional shear associated with these systems. Generally, it was observed that ITFA followed the jet stream patterns. Overall, ITFA tended to forecast more areas than was observed through PIREPs. This is in agreement with users' perceptions that ITFA tends to over-forecast. While PIREPs can confirm where pilots have observed turbulence, it cannot be assumed that turbulence is not present if no PIREP is reported.

While over-forecasting was the general trend, some ITFA forecasts focused on specific areas of turbulence. Section 6.3.1.3 gives some examples of ITFA trends and performance during the demonstration period.

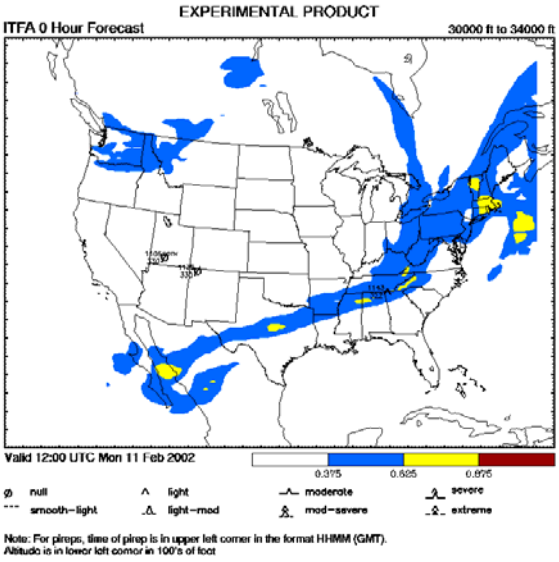
6.3.1.3 Examples.

On February 11, 2002, it was observed that ITFA was forecasting moderate and severe turbulence across parts of the eastern United States. ITFA 00-hour forecasts produced at 1200 and 1500 Universal Time Coordinated (UTC) are presented as figures 4a-d. As seen in these figures, ITFA produced forecasts up to 0.875 (which is moderate and severe turbulence, as identified by NCAR/RAP) from Texas through the Appalachians to the Northeastern United States. Figures 5a-b are the 1200 UTC 500 mb and 300 mb analyses, respectively, from February 11, 2002. These charts show ITFA forecasts were associated with speed shear along a trough over the eastern United States, especially on the north side of the jet stream in figure 5b. At 1335 UTC, a severe PIREP was reported in the Atlanta region at 28,000 feet, near where ITFA is forecasting 0.625 to 0.875 (severe turbulence, see figure 4c). In the Northeast, ITFA is also forecasting up to 0.875, however, there are no PIREPs to verify these forecasts.

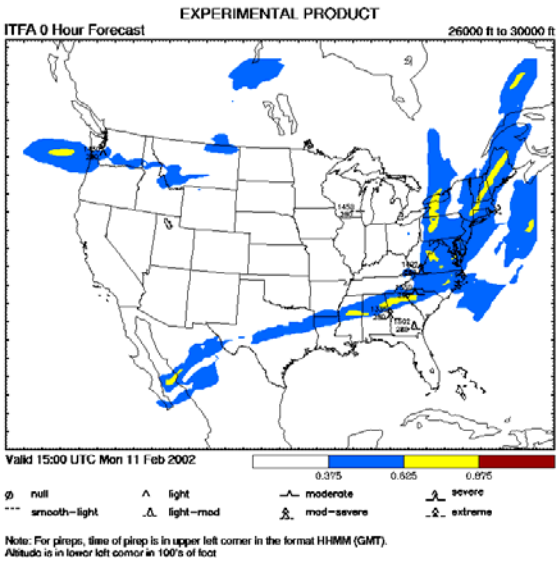
A



B



C



D

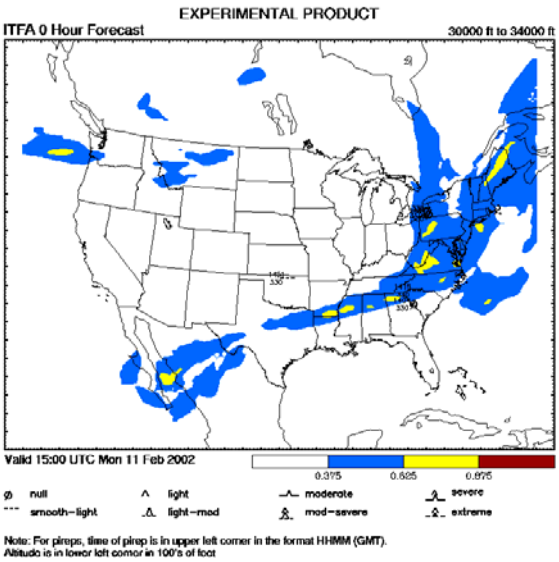


FIGURE 4A-D. ITFA 00-HOUR FORECASTS FOR 26,000 TO 30,000 FEET AND 30,000 TO 34,000 FEET, VALID 1200 UTC (A AND B) AND 1500 UTC (C AND D)

A B

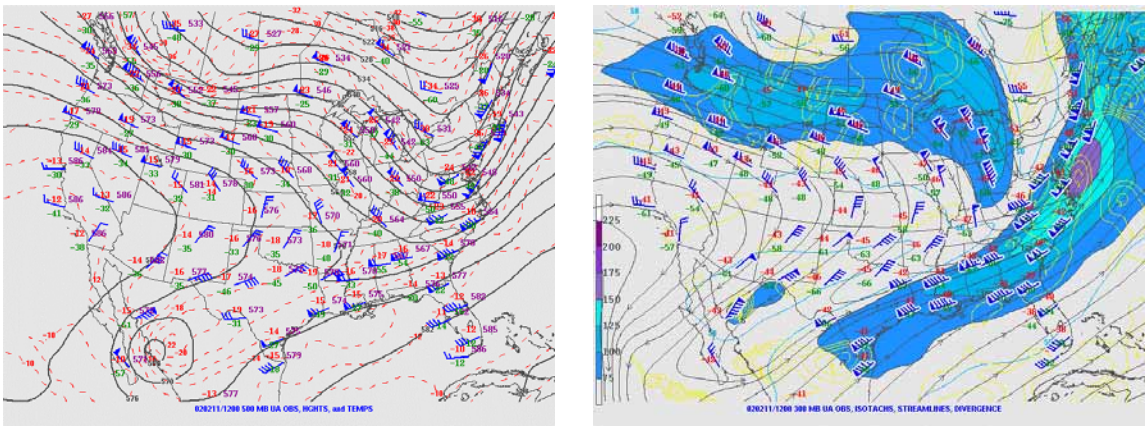
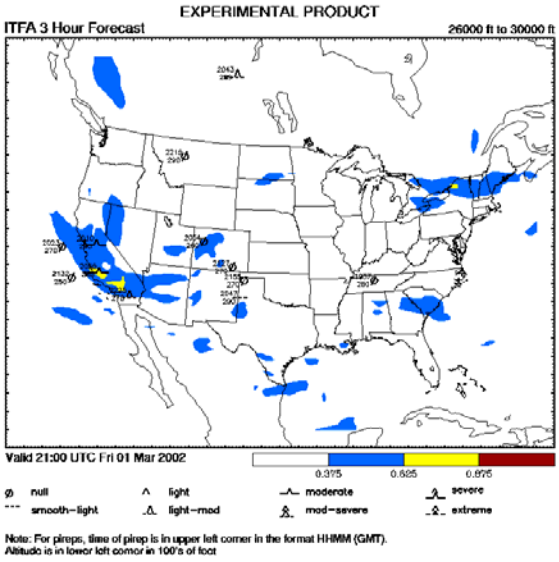


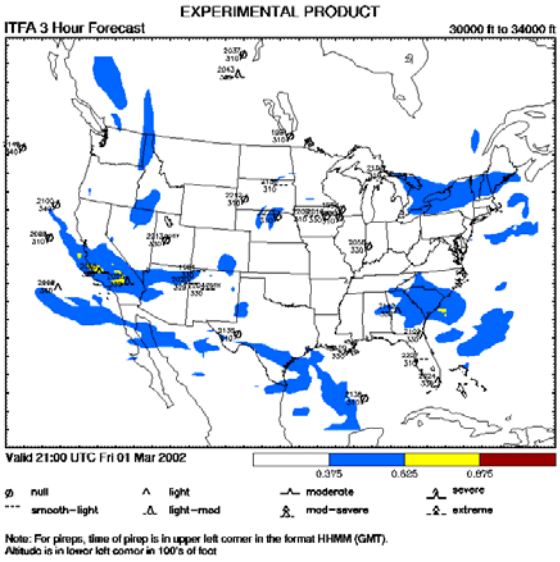
FIGURE 5A-B. FEBRUARY 11, 2000, 1200 UTC 500 MB (A) AND 300 MB (B) UPPER-AIR ANALYSES

On March 1, 2002, ITFA was forecasting moderate and severe turbulence over portions of California (see figures 6a-d). As seen in the figures, ITFA produced forecasts up to 0.875 (moderate and severe turbulence) over Southern California. Figures 7a-b are the 0000 UTC 500 mb and 300 mb analyses, respectively, from March 2, 2002. These charts show ITFA forecasts were associated with speed shear on the backside of a trough over the Western United States. Several moderate PIREPs confirm the presence of turbulence in the forecasted region. ITFA does well in pinpointing the region of concern without over-forecasting areas in the rest of the country.

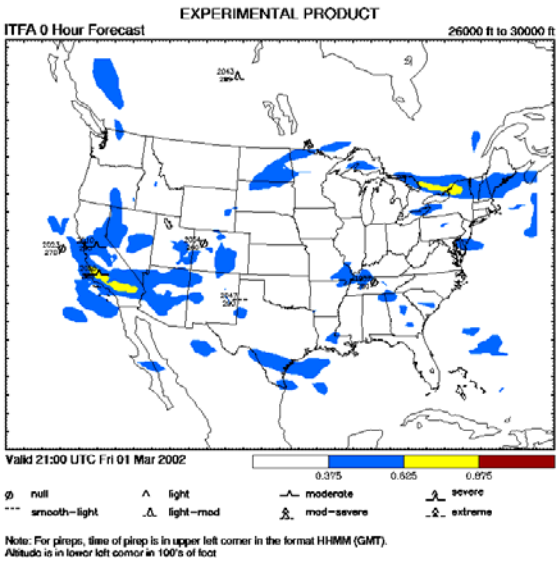
A



B



C



D

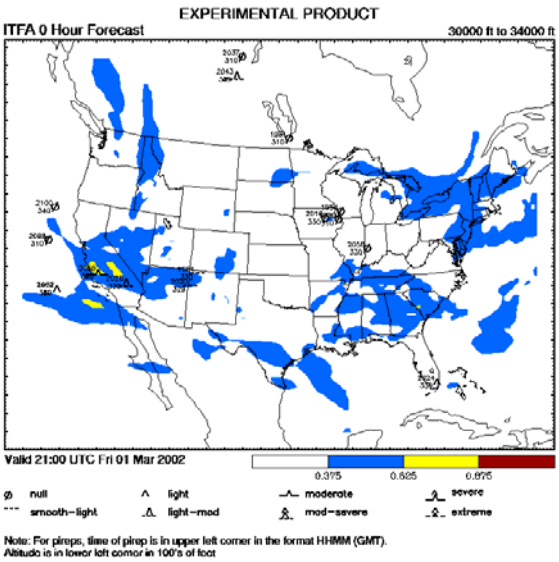
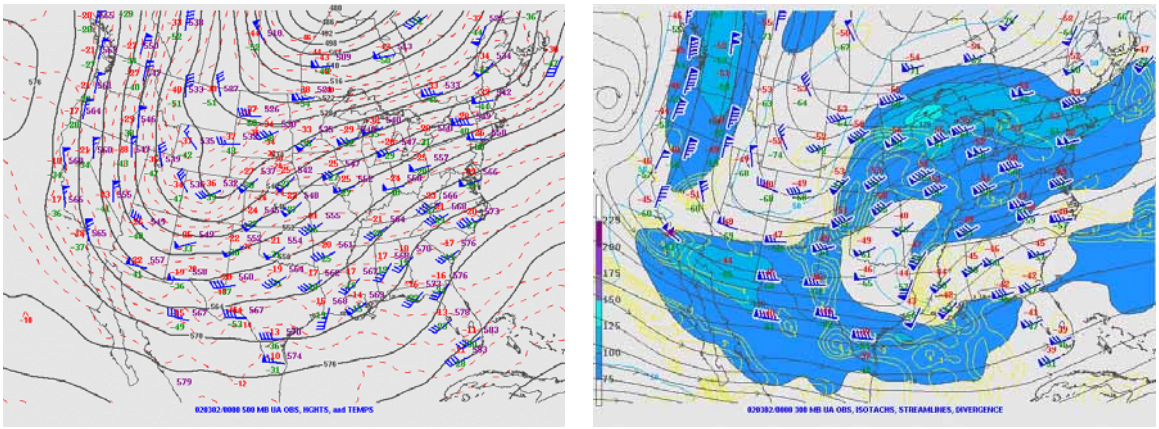


FIGURE 6A-D. ITFA FORECASTS VALID AT 2100 UTC FOR 26,000 TO 30,000 FEET AND 30,000 TO 34,000 FEET, 03-HOUR FORECASTS (A AND B) AND 00-HOUR FORECASTS (C AND D)

A B



FIGURES 7A-B. MARCH 2, 2000, 0000 UTC 500 MB (A) AND 300 MB (B) UPPER-AIR ANALYSES

7. CONCLUSIONS.

7.1 USABILITY.

Conclusions derived from data analysis and results will be discussed within the context of each of the stated Demonstration objectives (see sections 4.1.1 and 4.1.2). The following will address each objective to discern the extent Integrated Turbulence Forecast Algorithm (ITFA) affected each of these objectives. Objectives for each user group will be the same, unless noted that it applies specifically to Comair or United Airlines (UAL) users.

1. Assess ITFA Flight Planning Task Benefit and Utility for Dispatcher Operations (Comair).

Utility of an item or component typically connotes benefit within the realm of job tasking. Comair questionnaire results from both Phases 1 and 2 regarding the utility of ITFA products and components were positive. Users rated the utility of ITFA components, including forecasts, turbulence intensity indicators and other options, to be operationally acceptable for use in flight planning.

Structured interview responses (Phases 1 and 2) also supported the perception of ITFA usefulness and benefit in supporting flight planning decision making where clear air turbulence (CAT) may be a factor. Overall impressions of ITFA were favorable. Users tended to like the graphical presentation of CAT at various flight levels. Reportedly ITFA was used as a self-brief at the beginning of a shift to provide an overall indication of the presence of CAT. Since flight planning is seldom accomplished more than 2 hours in advance of flight time, dispatchers were mostly interested in the 00 to 03-hour forecasts. Due to this operational factor, other forecast options were unnecessary and rarely used.

Questionnaire data assessing the frequency of use of ITFA and other CAT informational sources also support the infrequent use of the ITFA 06, 09, and 12-hour forecasts where frequency of use was rated as seldom, or hardly ever.

2. Assess CAT Forecasting Task Benefit and the Utility of ITFA for Meteorological Operations (UAL).

For Phases 1 and 2, UAL questionnaire utility ratings on all of the ITFA components rated were considered operationally acceptable. Therefore, UAL meteorologists found ITFA useful for forecasting and deriving alerts for CAT.

Phase 1 structured interview responses indicated an overall favorable view of ITFA as a useful guidance tool, used mostly to confirm forecasts already derived. In Phase 2, this overall impression was less favorable, although ITFA was still reportedly used as a CAT guidance tool and confirmation source. The overriding reason for this less favorable view was attributed to ITFA's tendency to over-forecast CAT. Due to this limitation, forecasters did question ITFA's usefulness and accuracy.

3. Assess the Value of ITFA Compared to Existing CAT Information Sources.

Comair: Questionnaire data (Phases 1 and 2) assessed the frequency of use of ITFA as well as other CAT information sources. The most frequently used sources of CAT information (almost always used, or 90% of the time) were Significant Meteorological Information (SIGMETs), Airmen's Meteorological Information (AIRMETs), and Aviation Digital Data Service (ADDS) Pilot Reports (PIREPs).

ITFA product use increased significantly from Phase 1 to Phase 2. For Phase 1, Comair users only reported using the ITFA 00-hour forecast frequently The 03-hour forecast was used now and then, whereas the 06, 09 and 12-hour forecasts were rarely used. For Phase 2 however, the 00, and 03-hour forecasts were used frequently, and use of the 06, 09, and 12-hour forecasts increased significantly to now and then (about 50% of the time). Although ITFA 00 and 03-hour forecasts were used somewhat less frequently than traditional sources of CAT such as AIRMETs and PIREPs, it did compare favorably (used at least 70% of the time) to these other sources. Less frequent use may also be attributed to the newness of the product and its experimental status.

Phase 1 and 2 structured interview responses also indicated favorable comparisons of ITFA to CAT information sources already used. Although many users stated that they would not use ITFA output by itself, it was considered a valuable addition to resources already available.

UAL: Frequency of use questionnaire data indicated that the most frequently used CAT resources were upper air maps, jet stream analysis, and the UAL Turbulence Index. The next frequently used items were PIREPs, model data, and satellite depictions. ITFA hour forecasts, used frequently in Phase 1, decreased in Phase 2, particularly use of the 00-hour forecast, which was used hardly ever (less than 10% of the time). Use of the 03-hour forecast also decreased (now and then).

Based on structured interview results, comparisons of ITFA to other CAT information sources were mixed. Although considered an adequate guidance tool, it was no better than other Internet products or resources. It would never be used in and of itself, but in conjunction with other products or indicators.

4. Assess the Reliability of ITFA.

During the upgrade of the Rapid Update Cycle (RUC) grid near the end of the demonstration (not an NCAR software change), one UAL meteorologist noted that the early forecasts were not updating. Otherwise, there were no reported data reliability problems.

5. Assess the Perceived ITFA Accuracy/Performance.

Comair: For Phase 1, questionnaire results assessing the operational acceptability of the accuracy of the displayed CAT intensities and hour forecasts were mixed. Although the CAT color intensity indications and 00 to 03-hour forecasts were considered operationally acceptable for accuracy, the ITFA 06, 09, and 12-hour forecasts were operationally borderline (neither acceptable nor unacceptable). The less positive perception of accuracy for these particular forecasts may be a function of infrequent use. Reportedly, these forecast options were rarely used by dispatchers.

Comair Phase 2 questionnaire results were more favorable in terms of ITFA accuracy. Accuracy for all ITFA components rated was operationally acceptable.

ITFA accuracy perceptions based on interview responses (Phases 1 and 2) were mixed, with the exception of one over-riding perception. Most users perceived a tendency in ITFA to over-forecast areas of CAT, in that ITFA painted too large a picture of turbulence activity, especially when these areas were not confirmed by PIREPs.

Accuracy of the colored CAT intensities was questioned. Some noted ITFA tended to indicate higher intensities when CAT was lower. Conversely, others perceived the opposite, in that CAT intensities were understated (e.g., indicating light turbulence when moderate was reported). Overall perceptions on the accuracy of the vertical CAT indications, at various flight levels, were positive.

UAL: Based on questionnaire results, the operational acceptability of the accuracy of the ITFA hour forecasts decreased significantly from Phase 1 to Phase 2. Phase 1 data indicated that UAL meteorologists found all intensity depictions and each of the hour forecasts to be operationally acceptable. In Phase 2, accuracy of the 06, 09, and 12-hour forecasts were rated borderline, neither operationally acceptable nor unacceptable. Over time and with greater product familiarity, UAL perceptions of ITFA accuracy decreased, going from a positive perception to a neutral one.

Structured interview responses from both Phases 1 and 2 also support this perception. Like Comair users, a tendency for ITFA to over-forecast was typically noted. The accuracy of the

CAT intensity colors was questioned, although some noted a tendency to over-forecast, others thought it under-forecasted.

Conditions where ITFA seemed to perform well were derived during Phase 1 interview sessions. These conditions included: upper-level, rapidly moving systems; and distinct systems with significant patterns. Therefore, it may be assumed that if these conditions are not prevalent, then ITFA performance may diminish.

6. Assess Confidence in ITFA.

Comair: Structured interview responses from Phases 1 and 2 indicated that confidence in ITFA output increased over time. For Phase 1 responses, confidence was moderate to high. In Phase 2, almost all respondents indicated perceptions of high confidence in ITFA output. In fact, many users stated that they would like to see ITFA approved for operational use.

UAL: Conversely (to Comair perceptions) confidence in ITFA for UAL meteorologists decreased over time. Although confidence was never high, perceptions of ITFA's tendency to over-forecast and miss CAT intensity levels were cited as the major components to lower confidence in its output. It was considered no better than any other Internet-based product.

7. Assess the Acceptability of ITFA Interfaces

For both Comair and UAL users, all ITFA interface characteristics that were evaluated, e.g., color distinguishability and effective item groupings, were operationally suitable.

8. Assess Perceived Operator Mental Workload

Comair: Perceptions of workload for Comair users were mixed. Although many saw ITFA as a benefit and therefore helped in decreasing workload, others perceived it to increase workload, especially when directed to evaluate the product and fill out forms.

UAL: Perceptions of workload effect were slight, especially for Phase 2. In Phase 1, there was some perceptible workload decrease, but the effect on workload appeared to be insignificant.

9. Suggestions for Improvement

Although not a stated objective, areas for improvement are always an inherent goal within any product demonstration. Suggested ITFA improvements should benefit development of ITFA in a direction that is user-oriented.

Comair users suggested:

a. Overlay flights, jet routes and locators such as cities and Very High Frequency (VHF) Omnirange Navigation System (VORs).
b. Change flight levels to those used by Comair.
c. Use 1,000 feet intervals between flight levels.

UAL users suggested:

a. Use of discernable colors for color-blind users. For the color-blind, differentiating between blue and green is difficult.

b. Fine-tune the algorithms to decrease their sensitivity and tendency to over-forecast.

c. Provide an indication of weights used for algorithm inputs to show which parameters are being used in a particular forecast.

d. Allow user-selected output for forecast times and altitudes.

e. Allow the user the ability to window multiple images.

f. On the 03-hour forecast display, overlay actual PIREPs.

g. Use cross hatching or another form of redundant coding to indicate CAT intensity for black and white printing.

7.2 METEOROLOGICAL OBSERVATIONS.

It was observed during the demonstration that turbulence forecasts appeared to be associated with upper level troughs and the speed and directional shear associated with these systems. The forecasts generally followed the jet stream patterns. Some ITFA forecasts appeared to focus on specific areas of turbulence confirmed by PIREPs, however, a tendency to over-forecast was apparent.

8. RISKS.

The following describe the risks or potential for risk as it applies to the ITFA Demonstration and operational use of the ITFA product.

1. Meteorological Expertise and ITFA Use - Dispatcher meteorological expertise may be limited. Although many have been trained meteorologically, and some are more expert than others, a thorough understanding of weather phenomena is not within the dispatcher domain. A risk exists if too much dependence is placed on an experimental weather product such as ITFA. Subjective analysis has indicated that there appears to be a considerable margin for error for ITFA CAT depictions and forecasts (due to the over-forecasting tendency). Until ITFA has undergone more rigorous testing and verification, users should be made aware of product inconsistencies and/or limitations.

2. Use for Airline Meteorologists - One of the targeted user groups for ITFA was airline meteorologists. Although UAL's impressions of ITFA were somewhat favorable, the question remains whether ITFA would be a worthwhile addition, or used to any great extent within the domain of an airline meteorological department. The full utility of ITFA for this user group is not clear. Additional investigation in the utility for meteorologists should be conducted before fielding an operational ITFA for meteorological use.

9. ACRONYMS.

ACB-630	FAA Technical Center Weather Group
ADDS	Aviation Digital Data Service
AIRMET	Airmen's Meteorological Information
AWC	Aviation Weather Center
AWRP	Aviation Weather Research Program
CAT	Clear Air Turbulence
FAA	Federal Aviation Administration
ITFA	Integrated Turbulence Forecast Algorithm
km	kilometer
mb	millibar
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
PDT	Product Development Team
PIREPs	Pilot Reports
RAP	Research Applications Program
RUC	Rapid Update Cycle
SIGMET	Significant Meteorological Information
SPC	Storm Prediction Center
UAL	United Airlines
UTC	Universal Time Coordinated
VHF	Very High Frequency
VOR	VHF OmniRange Navigation System

APPENDIX A

COMAIR AND UAL BASELINE INFORMATION

Comair Baseline Information

1. Background:

In order to plan effectively and understand current processes and perceptions on detecting and avoiding Clear Air Turbulence (CAT), baseline data was collected at Comair Airlines, one of the airlines slated to participate in the Integrated Turbulence Forecast Algorithm (ITFA) Demonstration. Participants will be dispatchers in Comair's Flight Operations Center. The baseline data collection was started the week of September 10, 2001, but due to the September 11 tragedy, this effort was curtailed.

Cynthia Fidalgo, ACB-630 Human Factors Engineer, Raytheon Technical Systems Co. traveled to Cincinnati from October 9 -11, 2001 to complete data collection. The data collection metric used, structured interview questions, consisted of a number of questions specific to dispatcher tasking and how CAT entered into this process, e.g., weather information sources used, planning required, and typical avoidance strategies.

John Burrows, Duty Manager, Flight Control, coordinated the visit and provided preliminary information regarding Comair operations. Although Comair had participated in the FAA's 1999 National Convective Weather Forecast (NCWF) Demonstration, there had been some significant changes within Comair's infrastructure; most importantly the relocation of their operations center to a new facility. Therefore an understanding of current Comair operations was required.

The following is a summary of information regarding Comair operations in general, and the effects of CAT both procedurally and perceptively on dispatcher flight planning.

2. Comair Operations:

The Comair Systems Operations Control Center (SOCC) is located at Comair headquarters, a new building adjacent to the Cincinnati/Northern Kentucky International Airport (CVG) Control Tower. Previously, Comair was headquartered in a much smaller suite of offices within one of the CVG airport terminals. The entire SOCC is broken down into five functional sub-units. The largest of these is Dispatch Operations. Other units include: Crew Scheduling, Main Control, Flight Control, and Customer Service.

Currently, Comair's fleet consists of 100 turbojets (Canadair Regional jets, or CRJs) and nine Embraer Brasilias, or EM2s. More turbojets are anticipated to be acquired in November 2001, and again in June 2002. The Comair expansion includes the planned retiring of all turboprop airplanes. For every turbojet acquired, two Brasilias are retired from the fleet. Comair maintains the same flight routes it had in 1999 with flights between 80 cities in 28 states and 2 countries (the Bahamas and Canada). Flight routes encompass Montreal, Canada to the North; Key West and Nassau to the South; Bangor, Maine to the East; and Colorado Springs to the West. Most flight routes take an hour or less.

Currently there are 32 dispatchers, three dispatchers in training, four assistant dispatchers, and six lead dispatchers. Individual dispatch responsibilities are broken out by a randomly computer generated roster of lines of flight. Generally each dispatcher handles 40 to 50 flights a day. Shifts are broken out as follows: 4 am – 2 pm; 6:30 am – 4:30 pm; 5 am – 3 pm; 8:45 am – 5:45 pm; 1:30 pm – 11:30 pm; 2:45 pm – 12:45 am; and 6:30 pm – 4:30 am. Operations typically end at 1:00 am and resume at 5:30 am. There are a few overnight charters.

The same weather information sources exist for each dispatcher. They are consolidated on one PC for each workstation. Internet access is also available. Weather information sources are provided via Deltamatic, an internal Delta Airlines application providing flight information, such as flight times and payloads. Jeppensen, the flight planning application, uses Kavouras as the major weather vendor providing graphical weather depictions and textual information such as radar, base maps, and National Weather Service Terminal Area Forecasts (TAFs). WEXAIR, the application used to generate automatic flight plans, is also derived from Jeppensen. Dispatchers can also receive e-mail messages over the airline's intranet. Most internal information/messages are disseminated in this manner. The Aircraft Situation Display (ASD) capability is also available on each dispatcher's PC, known as the RLM Flight View. This application is used to follow all commercial flights and is useful in determining how Air Traffic Control (ATC) is routing traffic.

Although dispatchers receive weather training, there is little formal training on CAT detection or forecasting. Dispatchers are more familiar with convective turbulence.

3. Dispatcher Interview Summary:

A total of fourteen dispatchers were interviewed. Of these, nine were dispatchers, four were lead dispatchers, and one was a dispatcher in training. Dispatch experience ranged from 2 months to 12 years. Questions concerned flight planning in general, types of weather sources used, the affect of CAT procedurally in flight planning, criteria for avoiding CAT, significance of CAT compared to other weather phenomena, and perceived benefit and requirements for a CAT forecast product.

4. Flight Planning:

Most dispatchers reported preparing flight releases about 1½ hours prior to the aircraft's anticipated departure. The release must be in the automatic WEXAIR system 1 hour before departure. Some planning may be accomplished up to 3 hours before scheduled takeoff if there is little or no operationally significant weather along a flight path. Weather information is either derived over the WEXAIR system or on the Internet via either the Aviation Digital Data Service (ADDS) web site or the Airline Dispatch Federation (ADF) site.

Reportedly, AIRMETs, SIGMETs, and PIREPs were the primary information sources in deriving the current and probable future existence of CAT for flight planning purposes. AIRMETs and SIGMETs provided a very broad view of where CAT may most likely be encountered. Although helpful in defining a large, general, geographical location, AIRMETs and SIGMETs were not as effective in determining specific areas of CAT. PIREPs, however, helped dispatchers to more effectively hone in on specific areas of

CAT occurrence. Two dispatchers indicated that other information sources used for detecting and forecasting CAT included winds aloft, and upper air analysis of the jet stream. Although many dispatchers reportedly looked at the turbulence products on the ADDS or ADF page, these resources were rarely, if ever, used for flight planning.

5. Effect of CAT on Flight Planning:

For any given flight route, the WEXAIR system will automatically generate the most expedient altitude for speed and fuel burn. If a pilot experiences significant (moderate to severe) turbulence, he/she will radio in to Dispatch and either request a new altitude or recommend one. The dispatcher will then recalculate fuel burn at this new altitude to ascertain whether or not fuel supplies are sufficient. Typically there is enough fuel to compensate for this change. Reportedly, rerouting due to turbulence is a very rare occurrence. Each dispatcher interviewed indicated that changing altitude to get below or above CAT was almost always employed.

A number of PIREPs indicating CAT along any specific flight route will cue the dispatcher in planning other flights along that route, i.e. choosing different altitudes than those already automatically generated. The size of the plane reporting the turbulence is also another consideration. The larger the aircraft, the more attention is paid to the report, since smaller planes traversing the same airspace may experience significantly more turbulence than larger aircraft.

Flying into moderate turbulence was not a major concern to most dispatchers, although avoided when possible. Severe turbulence, however, must always be avoided.

6. Perceived Aviation Weather Hazard of CAT:

Almost all dispatchers reported that compared to aviation weather hazards such as thunderstorms and icing, CAT posed less of an operational threat. However the unpredictability of CAT (inability to see it and unexpected encounters) was cited as a major concern. When flying through moderate to severe CAT, passenger safety and comfort may be compromised. To ensure the continuance of airline revenue and in the interest of safety, customer comfort and satisfaction are airline priorities.

7. Perceived Benefits and Requirements for a CAT Forecast Product:

Most dispatchers interviewed reported that a CAT forecast product would be a benefit to dispatch operations. Those who did not see a benefit in this type of product indicated it was not needed and would only contribute to information overload.

Requirements for a CAT forecast product were solicited and included the following:

a. Altitude of CAT;
b. Upper and lower limits of CAT;
c. Areal coverage of CAT;
d. Severity of CAT;
e. Direction of movement of CAT;
f. Forecast of CAT from 3 to 6 hours;
g. Overlays of detected and forecasted CAT on an ASD type display;

h. A vertical cross-section of CAT along a flight route, like the one displayed on the Integrated Icing Diagnostic Algorithm (IIDA);
i. A 3-D depiction of CAT;
j. Overlay of PIREPs with the CAT depictions; and
k. On the job training on the CAT product, to best show how this information can be applied operationally.

UAL Baseline Information

1. Background:

Prior to ITFA Demonstration conduct, baseline data was collected from the United Airlines (UAL) Weather Center Unit by Cynthia (Fidalgo) Grzywinski, ACB-630 Human Factors Engineer, Raytheon Technical Systems Co. and Jeffrey Weinrich, Meteorologist, Titan Corp., on December 17 and 18, 2001. The weather unit is located at UAL Operations Center in Chicago, IL. Data was collected to ascertain user requirements for a CAT forecast product, and to understand current CAT forecasting processes and procedures. Garry Hinds, UAL's Weather Center Operations Manager, coordinated the visit and discussed his perspective on the effect of CAT on airline operations. Structured interview questions specific to the detection and forecasting of CAT, e.g., weather information sources used and forecasting techniques applied, were asked of individual meteorologists responsible for turbulence forecasting. The following summarizes information derived from these discussions and interview sessions.

2. CAT and UAL Operations:

UAL runs 645 flights per day from 7:00 a.m. - 9:00 p.m. EST. To date, over 40% of UAL's flights are international. Reportedly, this percentage will increase as UAL expands its international markets. The airline is also expanding its longer haul domestic flights and cutting back on shorter flights (those less than two hours). It is expected that this refocusing of resources to international and longer domestic flights will help maintain UAL's viability in the competitive airline market. With the expansion of flight routes, UAL is also interested in enhanced (more accurate and timely) weather information. Adverse weather affecting a UAL route of flight is carefully monitored to ensure the most expeditious means of avoidance. The ability to accurately pinpoint, forecast, and detect operationally significant weather would allow for better strategic flight planning.

The detection and prediction of turbulence is of particular interest to UAL. According to G. Hinds, turbulence has a significant impact on flight operations. UAL is especially sensitive since a turbulence related fatality that occurred in a 1997 UAL flight from Tokyo to Honolulu. This concern was evidenced by the newly formed Turbulence Desk, devoted to turbulence monitoring within the Weather Center Unit (see section 3). Although UAL's primary concern is passenger safety, there are, at times, trade-offs between safety and comfort. For example, keeping passengers strapped in their seats throughout the duration of a long flight may be safer if turbulence is anticipated, but passengers will be unhappy without food, drink or bathroom breaks. Knowing when turbulence may be significant enough (or not significant enough) to initiate a "no cabin activity policy" is expected to enhance passenger satisfaction without compromising safety.

Another CAT related operational issue concerns pilot's turbulence reports (PIREPs), a major source of turbulence information. Although PIREPS are updated continuously, turbulence intensity is open to interpretation. Light turbulence in the cockpit can be experienced as moderate turbulence in the back of the aircraft. Additionally, some aircraft, due to size or design, are more sensitive to turbulence than others. Therefore moderate turbulence may be interpreted as "severe". Once an area of severe turbulence is identified, the affected airspace is no longer usable and considered a "no fly zone". This is in accordance with the FAA's Federal Aviation Regulations (FARs) on avoidance of severe weather situations such as severe turbulence. Avoidance of these areas is typically costly in terms of additional fuel, longer flight times, and customer dissatisfaction. A forecast of moderate turbulence with occasional severe turbulence would still afford the airline usable airspace. From an operational standpoint, a CAT prediction product that can accurately discriminate "severe" from "moderate" from "light" turbulence based on a standard linear scale (e.g., 8 -10 = severe turbulence), would obviate subjective interpretations.

3. UAL Weather Center Overview:

The UAL Weather Center is divided into five sections, or desks. It is located within UAL's Operational Control Center, adjacent to dispatch and other flight operations services such as Air Traffic Control (ATC) liaisons and maintenance coordinators.

Although there is some rotation between desks, personnel are typically permanently assigned to one desk and one of three shifts (morning: 6:30 a.m. - 2:30 p.m.; afternoon/evening: 2:30 p.m. - 10:30 p.m.; and mids: 10:30 p.m. - 6:30 a.m.). Each desk is staffed 24 hours a day, 7 days a week. Currently there are 21 meteorologists on staff.

The weather desks are delineated by function and/or geographical location and include:

1. Air Traffic Control (ATC) Desk - It was reported that UAL was the only airline to have a dedicated forecaster to staff the ATC Desk. The ATC forecaster serves as the weather expert when interacting with the Air Traffic Control System Command Center (ATCSCC), specifically during Strategic Plan of Operations (SPOs) telecons between the airlines, ATC, and the ATCSCC. Focus is on weather at and enroute between all of the UAL hubs, which include: Chicago's O'Hare International Airport (ORD), Washington Dulles International Airport (IAD), Denver International Airport (DEN), San Francisco International Airport (SFO), and Los Angeles International Airport (LAX). Weather phenomena of interest include: significant surface winds, clouds, visibility and any significant weather affecting or potentially affecting operations at the airport.

2. East Desk - The primary task of the East Desk forecaster is to provide forecasts for flights into and out of the two eastern UAL hubs: ORD and IAD. Forecasts are also provided for other major eastern airports such as Boston Logan International Airport (BOS), New York LaGuardia International Airport (LGA), and Philadelphia International Airport (PHL). Tracking major weather events occurring in the Eastern US, such as thunderstorms, is also a primary concern.

3. West Desk - The West Desk forecaster focuses on weather affecting UAL's western hubs: DEN, LAX, and SFO. For other major western airports such as

Reno International (RNO), low-level turbulence and wind shear is also closely monitored.

4. International and Polar Desk - Formerly, this desk was combined with turbulence forecasting (see "5." Below), although turbulence is still monitored from this position. The primary responsibility of the International Desk forecaster is to monitor weather events that may affect international flights. Weather phenomena most closely watched would include, but not be limited to: volcanic activity, hurricanes and typhoons, and turbulence. Additionally there are two polar flights per day from Chicago to southeastern Asia. The polar region is data poor due to a lack of weather resources and reporting stations. Therefore, forecasting for this region is very difficult.

5. Turbulence Desk - The Turbulence Desk is a new addition to the Weather Center Unit and is dedicated to monitoring any turbulence that may affect UAL flights worldwide (domestic and international). All turbulence events, including CAT, mountain wave and convective turbulence are monitored. Alerts are issued whenever these events are significant (severe to moderate/severe) and may impact known UAL flight routes. Forecasters attempt to narrow down the area of turbulence to the greatest extent possible so that areas of operational maneuverability along a flight route may be utilized.

4. Meteorologists Interview Summary:

Only those forecasters who work the Turbulence and International/Polar Desks were interviewed (N=5). Questions concerned methodologies for detecting and forecasting turbulence, weather phenomena or variables that made CAT more or less difficult to forecast, associated workload in predicting CAT, and perceived benefit and requirements for a CAT forecast product.

All meteorologists interviewed reported that CAT is a major weather concern at UAL and that much emphasis is placed on the accurate forecasting of CAT location and intensity. Compared to other aviation weather hazards such as convection, icing, and volcanic ash, CAT was considered the most difficult to forecast since there is less meteorological information available (e.g., CAT can not be seen or picked up on radar).

Turbulence forecasts are issued every 8 hours to dispatchers over UAL's internal flight planning application (Unimatic System). A polygon is manually drawn over any geographical location where UAL flights may encounter moderate to severe turbulence. Briefings are updated and reissued whenever turbulence conditions change.

4.1 Methodology:

Typically the turbulence meteorologist employs a top-down approach for deriving turbulence forecasts. An initial weather picture is formed by looking at weather maps, briefings, and satellite imagery. The satellite shows a signature or overall pattern indicating where current weather disturbances are occurring. Turbulence PIREPs, considered one of the most valuable CAT information sources, are also reviewed. These reports serve to guide the forecaster to areas of potential or existing CAT as well as confirm forecasts already derived. Once this overall picture is formed, other information sources are utilized. A turbulence index, developed by a UAL meteorologist,

was used extensively as a guide for initiating turbulence alerts. The index factors in 500 millibar (mb) wind direction and speed, thermal patterns, and surface winds and gradients. Each of these factors is weighed, and an overall index is derived. Upper air maps showing variables such as wind direction and speed, temperatures, and pressure gradients were also used for CAT prediction. Since CAT is oftentimes caused by steep gradients in wind velocity (either vertical or horizontal), the greater the change in speed and direction, the more severe the turbulence. This commonly occurs in the vicinity of the jet stream, especially at the jet stream's front and core. Therefore, areas of directional and speed shear near a strong jet core are generally good indicators of turbulence. Of greatest interest were the 200 mb, 250 mb, and 300 mb levels, covering areas where turbulence may occur enroute. Other levels such as 500 mb and 700 mb were used to determine turbulence potential at lower altitudes. One meteorologist reported using the Bulk Richardson Number, a ratio indicating the degree of shear instability, as another CAT predictor.

Forecasters also reported using weather models such as the Aviation Model (AVN), the Eta model, the Nested Grid Model (NGM), and a Canadian model available on the Internet. Model data provided additional meteorological information such as pressure gradients, winds, temperatures, and heights. Pattern recognition and experience were also considered important components in forecasting CAT, especially when meteorological data was limited.

The Rapid Update Cycle (RUC) model was rarely used, reportedly due to unfamiliarity with the model. SIGMETs and AIRMETs, issued by the Aviation Weather Center (AWC), were not considered helpful operationally because they cover too large a geographical area.

4.2 CAT Forecaster Workload:

Forecasting CAT was perceived to be more difficult than forecasting other aviation weather phenomena such as convection or icing. A factor contributing to this perception is the limited number of CAT meteorological indicators available. When one or more of these indicators are missing, e.g. an unbalanced atmosphere, strong vertical velocities, or strong thermal patterns, it is difficult to justify a CAT alert. Due to these difficulties, all meteorologists associated high operator mental workload with CAT forecasting.

4.3 Perceived Benefits and Requirements for a CAT Forecast Product:

All meteorologists indicated that a CAT forecast product would be a benefit to overall forecast operations as an additional information source.

Requirements for a CAT forecast product were solicited and included the following:

a. Altitude of CAT;
b. Upper and lower limits of CAT;
c. Severity of CAT;
d. Continuous updates;
e. Forecast range from 3 to 12 hours;
f. Interactive overlays of forecasts with other meteorological information such as winds, temperatures, and satellite imagery;
g. Interactive PIREP overlays color coded for severity;

h. Definitions of numbers, colors, and symbols on the forecast display;
i. Display of moderate or greater turbulence forecasts only;
j. Regional plots of turbulence forecasts;
k. Animation;
l. International turbulence forecasts; and
m. Access to each index's output.

APPENDIX B

PHASE 1 QUESTIONNAIRES FOR COMAIR AND UAL

2002 INTEGRATED TURBULENCE FORECAST ALGORITHM (ITFA) DEMONSTRATION QUESTIONNAIRE

PHASE 1

COMAIR AIRLINES DISPATCHERS

Prepared by:

Weather Processors and Sensors Group, ACB-630
William J. Hughes Technical Center
Federal Aviation Administration
Atlantic City International Airport
Atlantic City, NJ 08405

Instructions

The purpose of this questionnaire is to obtain feedback from users regarding the Integrated Turbulence Forecast Algorithm (ITFA). Feedback from users is a very important component of the Federal Aviation Administration (FAA) William J. Hughes Technical Center's Demonstration of the ITFA product. Your responses to this questionnaire will provide important information for future use of the ITFA. Therefore, please respond to all questions as honestly and thoroughly as possible.

Responses to this questionnaire will remain ANONYMOUS and CONFIDENTIAL. A report will be written on the results of this questionnaire, summarizing respondents' comments; however no one will be identified or associated with any specific comment. **Please return the questionnaire to the FAA Technical Center Evaluator.**

To investigate various aspects of the ITFA product and components, this questionnaire is divided into 3 parts. Part 1 will address the product's interface design. Part 2 will focus on your perceptions of the ITFA's operational suitability, specifically the utility of the ITFA and it's components in forecasting and detecting clear air turbulence (CAT). Finally, Part 3 will address frequency of use for the products/components listed.

Definition of Terms

Utility - This refers to how useful the ITFA products/components are to you as a CAT forecasting/detection tool. One overall element of utility would include the perceived usefulness of ITFA on tasking involved in flight planning.

Ease of Use - This refers to how easy the ITFA is to use (i.e. navigation, data retrieval). For example, a user may consider a feature easy to use if it can be readily accessed or not confused with another feature.

Readability - This refers to the extent the information displayed is easy to see, readable, meaningful, and understandable. For example, overlaid text may be too small to read or obscured by other overlays.

Accuracy - This refers to the degree you perceive the accuracy of the ITFA Potential for Turbulence product in detecting and predicting CAT.

Part 1 - ITFA Interface Characteristics

Instructions: Please read each statement below and circle the response that most closely agrees with your assessment of each of the statements. The comment space is provided for clarification of your response, e.g., why you strongly disagreed with one of the statements.

1. Items on the ADDS Turbulence page, such as Forecast Hours and Flight Levels are grouped meaningfully, and are easy to identify.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

2. All menu items on ITFA Forecast Hours and Flight Levels presented on the ADDS Turbulence page, are grouped meaningfully, and are easy to identify.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

3. Colors used in menu groupings for Flight Levels aid in distinguishing between menu items.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

4. All items on the ITFA forecast display, such as: the main map display, titles, time labels, and the turbulence intensity color scale, are grouped meaningfully, and are easy to identify.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

5. Colors used on the turbulence intensity color scale, e.g. blue for light intensity and green for moderate intensity, are distinguishable and easy to identify.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

6. Colors used for the turbulence intensity color scale, e.g. blue for light intensity and green for moderate intensity, are meaningful and clearly represent the turbulence intensity potential.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

7. Navigation between the web pages, e.g. from the ADDS turbulence page to the IFTA forecast display, is timely and efficient.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

8. Is there anything about the ITFA display interfaces that you would like to change?

_____

Part 2 - **Utility, Ease of Use, Readability, and Perceived Accuracy**
Instructions: The five-point scale below should be used to rate the utility, readability, and ease of use of each of the ITFA products and components. For items regarding the ITFA Turbulence Potential displays, perceived accuracy will also be rated.

Rating Scale Definitions

5 – Highly Acceptable. This response indicates the dimension (e.g. ease of use) for the product/component being rated is highly suitable operationally for flight planning involving CAT avoidance.

4 – Acceptable. This response indicates the dimension (e.g. ease of use) for the product/component being rated is suitable operationally for flight planning involving CAT avoidance.

3 –Neither Acceptable nor Unacceptable. This response indicates the product/component being rated is "borderline" providing neither benefit nor negative affect operationally for flight planning involving CAT avoidance.

2 – Unacceptable. This response indicates the dimension (e.g. ease of use) for the product/component being rated is not suitable operationally for flight planning involving CAT avoidance.

1 –Highly Unacceptable. This response indicates the dimension (e.g. ease of use) for the product/component being rated is highly unsuitable operationally for flight planning involving CAT avoidance.

NA - you have never used the product/component in question.

Products/ Components	Highly Acceptable	Acceptable	Neither Acceptable Nor Unacceptable	Unacceptable	Highly Unacceptable	NA
9. ITFA Hour Forecast Options (ADDS Turbulence Page)						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
10. ITFA Flight Level Options (ADDS Turbulence Page)						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA

Products/ Components	Highly Acceptable	Acceptable	Neither Acceptable Nor Unacceptable	Unacceptable	Highly Unacceptable	NA
11. Potential for Turbulence Display (Forecast Display) – For All Forecast Hours						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
d. Accuracy	5	4	3	2	1	NA
12. Turbulence Intensity Color Scale						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
13. Displayed Turbulence Intensity Colors						
a. Utility	5	4	3	2	1	NA
b. Accuracy	5	4	3	2	1	NA
14. 00-Hour Forecast Display						
a. Utility	5	4	3	2	1	NA
b. Accuracy	5	4	3	2	1	NA
15. 03-Hour Forecast Display						
a. Utility	5	4	3	2	1	NA
b. Accuracy	5	4	3	2	1	NA
16. 06-Hour Forecast Display						
a. Utility	5	4	3	2	1	NA
b. Accuracy	5	4	3	2	1	NA
17. 09-Hour Forecast Display						
a. Utility	5	4	3	2	1	NA
b. Accuracy	5	4	3	2	1	NA
18. 12-Hour Forecast Display						
a. Utility	5	4	3	2	1	NA
b. Accuracy	5	4	3	2	1	NA

Part 3 - Frequency of ITFA Product/Component Use

Instructions: Please use the definitions below as guidance to describe your frequency of use of the identified product for CAT avoidance in flight planning.

Frequency Rating Scale Definitions

5 - Almost Always. This response indicates that for dispatch operations involving CAT, the ITFA product/component was used about 90% of the time.

4 – Frequently. This response indicates that for dispatch operations involving CAT, the ITFA product/component was used about 70% of the time.

3 – Now and Then. This response indicates that for dispatch operations involving CAT, the ITFA product/component was used about 50% of the time.

2 – Seldom. This response indicates that for dispatch operations involving CAT, the ITFA product/component was used about 30% of the time.

1 – Hardly Ever. This response indicates that for dispatch operations involving CAT, the ITFA product/component was used about 10% of the time.

NA - You have never used the ITFA product operationally for domestic CAT forecasts.

Frequency of Use	Almost Always	Frequently	Now and Then	Seldom	Hardly Ever	NA
ITFA FORECAST PRODUCTS – ADDS TURBULENCE PAGE						
19. ITFA 00-Hour Forecast	5	4	3	2	1	NA
20. ITFA 03-Hour Forecast	5	4	3	2	1	NA
21. ITFA 06-Hour Forecast	5	4	3	2	1	NA
22. ITFA 09-Hour Forecast	5	4	3	2	1	NA
23. ITFA 12-Hour Forecast	5	4	3	2	1	NA
OTHER ADDS TURBULENCE PAGE PRODUCTS						
24. Pilot Reports of Turbulence	5	4	3	2	1	NA
25. AIRMETS – Current Turbulence Advisories	5	4	3	2	1	NA
26. SIGMETS - Current Turbulence Advisories	5	4	3	2	1	NA
OTHER TUBULENCE PRODUCTS						
27. Upper air maps	5	4	3	2	1	NA

Frequency of Use	Almost Always	Frequently	Now and Then	Seldom	Hardly Ever	NA
28. Jet Stream Analysis	5	4	3	2	1	NA
29. Comair Pilot Reports	5	4	3	2	1	NA
30. Satellite Depictions	5	4	3	2	1	NA
31. Surface Analysis Charts	5	4	3	2	1	NA
32. Model Data, e.g. AVN, ETA, and NGM	5	4	3	2	1	NA
33. Other_____	5	4	3	2	1	NA

Additional Comments: _____

_____

2002 INTEGRATED TURBULENCE FORECAST ALGORITHM (ITFA) DEMONSTRATION QUESTIONNAIRE

PHASE 1

UNITED AIRLINES METEOROLOGICAL DEPARTMENT

Prepared by:

Weather Processors and Sensors Group, ACB-630
William J. Hughes Technical Center
Federal Aviation Administration
Atlantic City International Airport
Atlantic City, NJ 08405

Instructions

The purpose of this questionnaire is to obtain feedback from users regarding the Integrated Turbulence Forecast Algorithm (ITFA). Feedback from users is a very important component of the Federal Aviation Administration (FAA) William J. Hughes Technical Center's Demonstration of the ITFA product. Your responses to this questionnaire will provide important information for future use of the ITFA. Therefore, please respond to all questions as honestly and thoroughly as possible.

Responses to this questionnaire will remain ANONYMOUS and CONFIDENTIAL. A report will be written on the results of this questionnaire, summarizing respondents' comments; however no one will be identified or associated with any specific comment. **Please return the questionnaire to the FAA Technical Center Evaluator.**

To investigate various aspects of the ITFA product and components, this questionnaire is divided into 3 parts. Part 1 will address the product's interface design. Part 2 will focus on your perceptions of the ITFA's operational suitability, specifically the utility of the ITFA and it's components in forecasting and detecting clear air turbulence (CAT). Finally, Part 3 will address frequency of use for the products/components listed.

Definition of Terms

Utility - This refers to how useful the ITFA products/components are to you as a decision-making CAT forecasting tool. Elements of utility would include: 1) impacts on decision making; 2) impacts on workload; and/or 3) impacts on tasking involved in issuing CAT alerts.

Ease of Use - This refers to how easy the ITFA is to use (i.e. navigation, data retrieval). For example, a user may consider a feature easy to use if it can be readily accessed or not confused with another feature.

Readability - This refers to the extent the information displayed is easy to see, readable, meaningful, and understandable. For example, overlaid text may be too small to read or obscured by other overlays.

Accuracy - This refers to the degree you perceive the accuracy of the ITFA Potential for Turbulence product in detecting and predicting CAT.

Part 1 - ITFA Interface Characteristics

Instructions: Please read each statement below and circle the response that most closely agrees with your assessment of each of the statements. The comment space is provided for clarification of your response, e.g., why you strongly disagreed with one of the statements.

1. Items on the ADDS Turbulence page, such as Forecast Hours and Flight Levels are grouped meaningfully, and are easy to identify.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

2. All menu items on ITFA Forecast Hours and Flight Levels presented on the ADDS Turbulence page, are grouped meaningfully, and are easy to identify.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

3. Colors used in menu groupings for Flight Levels aid in distinguishing between menu items.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

4. All items on the ITFA forecast display, such as: the main map display, titles, time labels, and the turbulence intensity color scale, are grouped meaningfully, and are easy to identify.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

5. Colors used on the turbulence intensity color scale, e.g. blue for light intensity and green for moderate intensity, are distinguishable and easy to identify.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

6. Colors used for the turbulence intensity color scale, e.g. blue for light intensity and green for moderate intensity, are meaningful and clearly represent the turbulence intensity potential.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

7. Navigation between the web pages, e.g. from the ADDS turbulence page to the IFTA forecast display, is timely and efficient.

Agree Strongly	Agree	Neither Agree Nor Disagree	Disagree	Disagree Strongly

Comment _____

8. Is there anything about the ITFA display interfaces that you would like to change?

_____

Part 2 - **Utility, Ease of Use, Readability, and Perceived Accuracy**
Instructions: The five-point scale below should be used to rate the utility, readability, and ease of use of each of the ITFA products and components. For items regarding the ITFA Turbulence Potential displays, perceived accuracy will also be rated.

Rating Scale Definitions

5 – Highly Acceptable. This response indicates the dimension (e.g. ease of use) for the product/component being rated is highly suitable operationally when forecasting domestic CAT.

4 – Acceptable. This response indicates the dimension (e.g. ease of use) for the product/component being rated is suitable operationally when forecasting domestic CAT.

3 –Neither Acceptable nor Unacceptable. This response indicates the product/component being rated is "borderline" providing neither benefit or negative affect operationally when forecasting domestic CAT.

2 – Unacceptable. This response indicates the dimension (e.g. ease of use) for the product/component being rated is not suitable operationally when forecasting domestic CAT.

1 –Highly Unacceptable. This response indicates the dimension (e.g. ease of use) for the product/component being rated is highly unsuitable operationally when forecasting domestic CAT.

NA - you have never used the product/component in question.

Products/ Components	Highly Acceptable	Acceptable	Neither Acceptable Nor Unacceptable	Unacceptable	Highly Unacceptable	NA
9. ITFA Hour Forecast Options (ADDS Turbulence Page)						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
10. ITFA Flight Level Options (ADDS Turbulence Page)						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA

Products/ Components	Highly Acceptable	Acceptable	Neither Acceptable Nor Unacceptable	Unacceptable	Highly Unacceptable	NA
11. Potential for Turbulence Display (Forecast Display) – For All Forecast Hours						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
d. Accuracy	5	4	3	2	1	NA
12. Turbulence Intensity Color Scale						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
13. Displayed Turbulence Intensity Colors						
a. Utility	5	4	3	2	1	NA
b. Accuracy	5	4	3	2	1	NA
14. 00-Hour Forecast Display						
a. Utility	5	4	3	2	1	NA
b. Accuracy	5	4	3	2	1	NA
15. 03-Hour Forecast Display						
a. Utility	5	4	3	2	1	NA
b. Accuracy	5	4	3	2	1	NA
16. 06-Hour Forecast Display						
a. Utility	5	4	3	2	1	NA
b. Accuracy	5	4	3	2	1	NA
17. 09-Hour Forecast Display						
a. Utility	5	4	3	2	1	NA
b. Accuracy	5	4	3	2	1	NA
18. 12-Hour Forecast Display						
a. Utility	5	4	3	2	1	NA
b. Accuracy	5	4	3	2	1	NA

Part 3 - Frequency of Turbulence Product/Component Use
Instructions: Please use the definitions below as guidance to describe your frequency of use of the identified product for domestic CAT forecasts.

Frequency Rating Scale Definitions

5 - Almost Always. This response indicates the turbulence product/component was used about 90% of the time for decisions regarding domestic CAT forecasts.

4 – Frequently. This response indicates the turbulence product/component was used about 70% of the time for decisions regarding domestic CAT forecasts.

3 – Now and Then. This response indicates the turbulence product/component was used about 50% of the time for decisions regarding domestic CAT forecasts.

2 – Seldom. This response indicates the turbulence product/component was used about 30% of the time for decisions regarding domestic CAT forecasts.

1 – Hardly Ever. This response indicates the turbulence product/component was used less than 10% of the time for decisions regarding domestic CAT forecasts.

NA - You have never used the turbulence product operationally for domestic CAT forecasts.

Frequency of Use	Almost Always	Frequently	Now and Then	Seldom	Hardly Ever	NA
ITFA FORECAST PRODUCTS – ADDS TURBULENCE PAGE						
19. ITFA 00-Hour Forecast	5	4	3	2	1	NA
20. ITFA 03-Hour Forecast	5	4	3	2	1	NA
21. ITFA 06-Hour Forecast	5	4	3	2	1	NA
22. ITFA 09-Hour Forecast	5	4	3	2	1	NA
23. ITFA 12-Hour Forecast	5	4	3	2	1	NA
OTHER ADDS TURBULENCE PAGE PRODUCTS						
24. Pilot Reports of Turbulence	5	4	3	2	1	NA
25. AIRMETS – Current Turbulence Advisories	5	4	3	2	1	NA
26. SIGMETS - Current Turbulence Advisories	5	4	3	2	1	NA
OTHER TUBULENCE PRODUCTS						
27. UAL Turbulence Index	5	4	3	2	1	NA

Frequency of Use	Almost Always	Frequently	Now and Then	Seldom	Hardly Ever	NA
28. Upper air maps	5	4	3	2	1	NA
29. Jet Stream Analysis	5	4	3	2	1	NA
30. UAL Pilot Reports	5	4	3	2	1	NA
31. Satellite Depictions	5	4	3	2	1	NA
32. Bulk Richardson Number	5	4	3	2	1	NA
33. Model Data, e.g. AVN, ETA, and NGM	5	4	3	2	1	NA
34. Other_____	5	4	3	2	1	NA

Additional Comments: _____

_____

APPENDIX C

COMAIR AND UAL STRUCTURED INTERVIEW RESPONSES

ITFA PHASE 1 STRUCTURED INTERVIEW RESPONSES

COMAIR AIRLINES

1. What is your overall impression of the ITFA product?

User	Response
1	Very valuable.
2	Good.
3	Impressed by it. Compared to PIREPs it did better than expected.
4	Useful for me.
5	I like it.
6	I sometimes use it. I like it.
7	I like it. It gives a lot of information.
8	Very good.
9	Used as a back-up to PIREPS and SIGMETs to confirm what they are showing.
10	I am a high proponent of new weather information. A picture is worth 1,000 words. ITFA is beneficial.
11	I like it.
12	Like it.

2. Did you use ITFA information for any aspect of flight planning for flight routes affected by CAT?

User	Response
1	Uses entire ADDS page: ITFA, PIREPs and SIGMETs. Used during pre-briefing (self). If there is a large AIRMET, will go to ITFA to see where the heaviest turbulence will be. It's a good tool to pick altitude. I also use it real time for enroute monitoring. Then I look at PIREPs as a cross reference.
2	Yes, to get an overall view. It was not accurate this morning. There were no PIREPs to confirm CAT it was predicting. I look at it in the morning. If there is CAT, I will look at it intermittently.
3	Would use if CAT was a factor based on the 300 mb charts. Would also look at PIREPs and AIRMETs.
4	I used it as another piece of information to derive altitude to plan flights.
5	If there is a potential for CAT to effect flights, derived from AIRMETs, SIGMETs, and PIREPs, I will then look at the ITFA. I will look at it periodically throughout the day depending on the weather and if PIREPs are confirming the output.
6	Yes. I look at it in the morning and bring it up out of habit. It's useful.
7	In the morning, it's one of the first things I check. I use it for planning. Also used for enroute monitoring.
8	Used for flight planning. I look at it in the morning when I come in then half way through the day. It's very useful.
9	When CAT is bad, I will use the ITFA information, especially for Florida routes. I will also pick altitudes based on it. It's useful.

10	I use it every day. It helps me plan proactively and has improved pilot/dispatch relations. It helps to show that we're more aware of the actual conditions. It also helps with the enroute portion of flight. I integrate it in my decision making.
11	I use it every day to determine how I'm going to plan for CAT. I usually check it before planning each block of flights.
12	I used it as a self-briefing in the morning. Would sometimes update myself with it throughout the day. Very useful.

3. How did the ITFA output compare to traditional sources of CAT information?

User	Response
1	Valuable addition.
2	Compares well since I don't have to mentally draw SIGMETs for myself.
3	Another good tool.
4	It compared favorably. Gave an overall view and was useful in conjunction with PIREPs and SIGMETs. ITFA is a valuable addition.
5	It's more helpful than regular sources. It gives an immediate picture of what's happening.
6	Favorably compares. It's much easier to read and understand. Valuable.
7	Very favorably. Valuable addition.
8	Compares wonderfully. It's quick and easy to use. A valuable tool.
9	Favorable comparison. Valuable.
10	Valuable addition.
11	Better than AIRMETs and SIGMETs. I like the visual component.
12	Compares favorably. It's more specific than the SIGMETs or AIRMETs, which cover too broad an area. It gives me a much better idea of where turbulence might be.

4. ITFA Performance/Accuracy. Please describe ITFA performance, conditions under which it performed well and/or poorly, how it handled CAT coverage and intensities, and confidence level in output.

User	Response
1	Overall accuracy was fair to good. With widespread areas it tends to over forecast. It seems to nail where the heavier CAT will be. Very helpful. Confidence is moderate.
2	Accuracy is fair to good. One day I noticed ITFA didn't pick up CAT farther north. It doesn't pin point CAT. Seems to under forecast. Performs better in the vertical (altitude). I have some confidence in it, although I would not use it by itself. It's a good tool as a supplement. PIREPs are primary.
3	It sometimes over forecasts on area location and CAT intensity (ITFA shows intensity is more than it actually is). 80% of the time, ITFA is confirmed by PIREPs. I can't tell when it performs well or not (which prevailing conditions). It detects the vertical pretty well. Onset and offset of CAT is not important.
4	PIREPs are the basis for what's actually happening. It did a good job of locating CAT. Areal and vertical coverage seems pretty accurate.

5	It tends to over forecast area locations and coverage. Vertical coverage seems adequate. ITFA intensities are sometimes more severe than what's actually out there. It seems to do well when there's a strong, dynamic jet. Confidence in ITFA is moderate. It's a good advisory tool.
6	Location of CAT is generally accurate. Sometimes it shows CAT where it's not confirmed by PIREPs. It seems to capture altitude of CAT well. My confidence in ITFA is fairly high. I do use it to avoid CAT areas.
7	Location of CAT is usually accurate. It sometimes seems to over forecast. This is based on verification with PIREPs.
8	It's accurate for a few hours, then the reliability goes down during the day. It's good at locating large areas of CAT. It tends to over forecast. Altitude coverage seems accurate, but if there's no PIREP to confirm, it's hard to make judgments on ITFA's accuracy. It sometimes over-does the intensity, e.g. reporting moderate when CAT is actually light. My confidence is pretty high.
9	It tends to over forecast the location of CAT. Within a general area, altitude forecasting is typically good. Intensity is sometimes understated. ITFA will sometimes report light CAT when moderate is reported. I am fairly confident in its output.
10	Sometimes it would completely miss areas of CAT, but overall could tell me where to expect problems. It captured altitude of CAT well. Sometimes ITFA CAT intensities were understated.
11	Location of CAT always seems to be accurate. Altitude of CAT is also accurate. No problem with the intensity indicators. Confidence is high.
12	CAT location is fairly accurate, although it over forecasts, giving a broad view of CAT. Seemed OK in the vertical.

5. Which of the hour forecasts were most beneficial? Is the forecast range adequate?

User	Response
1	I use the 0 – 4 hour forecasts. Beyond that it's not helpful.
2	I need to plan 2 hours in advance. 6-8 hours is not necessary.
3	I look out between 3 and 6 hours.
4	Only look at the current CAT detection. Don't look at the other forecast times. I use PIREPs and SIGMETs for predicting CAT.
5	I look out to 3 hours.
6	I look 3 hours out since releases need to be prepared 2 hours ahead of the flight. 0-3 hour forecasts are the only ones I need.
7	0-3 hours.
8	Under 4 hours. Will sometimes look farther out to see trending.
9	00 hour. forecast. Beyond 3 hours it's not necessary.
10	0-3 hours only required.
11	00 hour forecast depictions only.
12	0-3 hours.

6. Are flight level ranges of 15,000 to 45,000 feet adequate?

User	Response
1	More than adequate. Would like 2K intervals between flight levels.
2	Adequate. 2K increments between levels would be better.
3	Adequate.
4	Adequate. Would prefer 1K increments between flight levels.
5	Adequate. It would be better if it corresponded to the flight levels we use, e.g., 29-31K, 31-33K.
6	Adequate. No need for further refinement.
7	Adequate. Better if intervals were 2K instead of 3K.
8	Would like to see flight levels begin at 8K.
9	Would like 1K increments between flight levels.
10	Would like intervals between flight levels to match ours, e.g. 20k, 21k, etc.
11	Would like to see surface to 45,000 ft for flight levels for Brasilias and some short range jets. Intervals would be better at 1K.
12	It didn't line up with the flight levels. In the composite you would find areas of severe CAT, but nothing severe in any of the other flight levels.

7. Did ITFA have any effect on your perceived mental workload associated with flight planning in relation to CAT?

User	Response
1	Depending on the day, it would occasionally reduce my workload. It's good for a general picture but not for details.
2	Little positive effect.
3	No difference.
4	A little. It was good to access the information quickly and it's easy to look at. Another piece of information.
5	Helped. It's nice to see the SIGMET and AIRMET options on the same page.
6	It helped, especially when flight crews would call in. It's all right there and I can answer questions in a timely manner. It simplified my job.
7	Beneficial effect. Less workload. It cleared the mind for other duties.
8	Will decrease workload if the information conforms to other information sources.
9	Positive effect.
10	Positive increase in workload.
11	Positive effect.
12	It gave a good view to what was out there. A good mental picture, although not a good tool for pinpointing CAT.

8. Did you ever experience any problems in accessing ITFA products?

User	Response
1	No.
2	OK.
3	No
4	No, although sometimes I need to refresh the screen manually.

5	No
6	No
7	No
8	No
9	No. Although it doesn't seem to refresh itself.
10	No. Needed to hit refresh manually.
11	A few times. It wouldn't pull up the Java tools.
12	No.

9. Is there anything that could be changed or added to the ITFA product to make it more useful to you?

User	Response
1	Change increments of altitude to 2,000 ft between flight levels.
2	No.
3	No
4	Nothing specific. Change increments between flight levels.
5	Improve the forecast accuracy.
6	No
7	Reduce intervals between flight levels.
8	Lower flight level altitudes and 2K increments between flight levels.
9	Nothing.
10	Good tool. Integrate PIREPs in a more timely manner. Some PIREPs are too old. Use PIREP overlays.
11	Lower flight levels and more intervals in between (1K).
12	Flight levels should correspond to ours.

ITFA - Comair Phase 2 Interview Summary

1. What is your overall impression of the ITFA product?

User	Response
1	ITFA was worthwhile. Usually confirms what other sources are saying.
2	I liked it. Especially the separation of different altitudes. Visualization was good. I didn't have to look at the mb charts at all.
3	A good product. 80% accurate. But I didn't see a lot of CAT.
4	I haven't used it since last month. It gives me a broad view of the possibility of turbulence. I also like the other ADDS products. It's convenient.
5	Helpful. Good to use to avoid CAT.
6	Useful tool. I've been using it more frequently.
7	Good product
8	Over the last 2 weeks it seems more accurate.
9	It's mostly useful. I like it. I don't like to use it early in the morning since there are no PIREPs to support it. It's most beneficial as the day goes on.

10	It's all right. Sometimes hit or miss. I use it as an advisory tool. If I see anything, I will notify the flight crews. PIREPs do not always confirm ITFA output.
11	I'm beginning to use it more. I like the different altitude indicators. My impression of it is favorable.
12	Excellent product.

2. Did you use ITFA information when flight planning?

User	Response
1	I use it for avoiding CAT and as a self-brief. If flight crews call in, it's a quick way to report on CAT conditions.
2	Yes, especially in conjunction with the jet stream. It helps in planning altitude and fuel requirements
3	I haven't used it a lot due to the lack of CAT activity. I mostly used it to fill in NCAR's forms. I feel it's the same as an AIRMET in providing a big picture of turbulence. It's a good tool to have, but not built into my present flight planning methodology. It's more user-friendly than the AIRMET.
4	It gives me a broad overview for the current time frame. I don't use it for predictions. I check it periodically and it's useful to a certain extent.
5	I look at it initially to see where turbulence is. I will use it intermittently on an as need basis.
6	I first look at it in the morning as a self-brief. I check it throughout the day.
7	Used as a self-brief in the morning. Would occasionally check it during the day.
8	I use it for an initial self-briefing. Sometimes look at it throughout the day. It's useful.
9	I use it as a pre self-brief. If called for, I may use it frequently throughout the day.
10	I monitor it during the day, like the SIGMETs and AIRMETs. PIREPS are the most important source.
11	I first look at it in the morning and then intermittently throughout the day. It's a very useful resource.
12	I use it for pre planning flight releases, at last 2 or 3 times a day.

3. How did the ITFA output compare to traditional sources of CAT information such as the PIREPs and SIGMETs?

User	Response
1	I've used it more than any other CAT information source. It's easy to use.
2	I used it almost exclusively.
3	It's valuable and used in conjunction with SIGMETs, AIRMETs, and PIREPs.
4	I can do well without it. I use my own methods
5	It's valuable in conjunction with other sources. It gives me an idea of what's actually happening. I use PIREPs to cross-check.
6	Used as another check for confirmation of CAT.
7	It's useful, especially when there's a lot of significant turbulence.

8	I use it in conjunction with PIREPs. SIGMETs are too big. As turbulence develops I will check the ITFA product.
9	Used in conjunction with PIREPs, SIGMETs, and AIRMETs. It fits in well. A valuable addition.
10	PIREPs are the most important source of information. ITFA is a "feel good" tool. An added piece of information.
11	I use it in conjunction with PIREPs, AIRMETs, and SIGMETs. I find it a valuable addition.
12	Valuable addition to PIREPs, SIGMETs, AIRMETs.

4. ITFA Performance/Accuracy. Please describe ITFA performance, conditions under which it performed well and/or poorly, how it handled CAT coverage and intensities, and confidence level in output.

User	Response
1	I will keep flights out of severe turbulence. If the CAT forecast is moderate I will still send someone in with the canned altitude to test the waters. If CAT is prevalent, I will change the altitude.
2	I can't think of any situation. It made me feel more knowledgeable about the location and intensity of CAT. I thought it was accurate. I didn't notice any tendencies to under or over-forecast.
3	I didn't notice. It sometimes over-forecasted.
4	It seemed to reflect CAT conditions and was usually confirmed by PIREPs. Sometimes the forecast is broad. And, it sometimes under-does the intensity, e.g. PIREPs were reporting moderate, whereas ITFA indicated light.
5	Accuracy is mostly good. Coverage and altitude is usually fairly accurate. It sometimes over-forecasts.
6	I thought it was mostly accurate. It sometimes missed areas.
7	I have no accuracy issues. I really can't tell. The turbulence intensity seems to be a little high.
8	It seems to correlate with PIREPs. It tends to over forecast. Intensities and altitude coverage seem accurate.
9	Accuracy is very good. It does tend to over-forecast, but PIREPs generally confirm areas it is forecasting. It seems to err on the conservative side. I like a conservative bias. It captures the vertical well. Typically intensity levels seem to be in sync.
10	It didn't seem to miss areas. It usually detected CAT in areas where no PIREPs were associated with it.
11	It tends to be more conservative and over-forecasts. Sometimes it reports areas of light turbulence but there is no turbulence reported. It seems to be accurate with altitude depictions of CAT and is preferable to the SIGMETs.
12	It's too conservative and over forecasts. Reported CAT intensities are too high, e.g. reporting moderate when turbulence is light. Altitude depictions are usually accurate.

5. Overall, what was your confidence level in the ITFA CAT Potential forecasts?

User	Response
1	I have high confidence in ITFA. I would use it operationally.
2	High confidence. I wouldn't feel comfortable without it.
3	Fairly high. It should be approved for operational use.
4	Moderate confidence. I would not feel comfortable if it were all I had to use. I need to use it more.
5	I'm 75% confidant in it. I would like to see it become operational.
6	Fairly high confidence. Yes to operational use.
7	I have some confidence in it. I need other information to back it up. I feel it can be used operationally.
8	75% confident.
9	I have high confidence in ITFA. I would like to see it used operationally.
10	There was some increase in confidence. It helps with guidance. It probably should be approved for operational use.
11	Confidence is fairly high. I would not use ITFA by itself, but as another resource. I would like to see it as an operational product.
12	High confidence.

6. Which of the hour forecasts were most beneficial?

User	Response
1	I only use the current out to 3-hour forecasts. I don't look for trending.
2	No more than 3 hours.
3	Never beyond 6 hours.
4	Current depiction.
5	Out 2-3 hours.
6	I look out to 10 hours. I like to see CAT trends, especially for my return flights.
7	0-3 hours.
8	3 hours out.
9	2 hours out.
10	1-2 hours out.
11	3-4 hours out.
12	2 to 2 ½ hours out.

7. Are flight level ranges of 15,000 ft. to 45,000 ft. adequate?

User	Response
1	OK. 3,000 feet intervals are adequate.
2	Adequate.
3	Adequate.
4	It would be better if the intervals between flight levels were broken down to 1,000 feet increments.
5	I would like to see it correspond to our fights levels, i.e. 29 or 31K feet.
6	Adequate, but would like to see flight levels correspond to our flight levels.
7	Yes.

8	1K feet intervals between levels would be better. 15 to 22K are not needed.
9	Flight levels are ok. Would like to see smaller increments in between.
10	Would like to see flight levels lower than 15K feet, especially for areas like Akron and Dayton. More intervals in between would also be better.
11	Adequate.
12	Flight levels are adequate, though I would like to see them below 15K feet.

8. Did ITFA have any effect on your perceived mental workload associated with forecasting and issuing advisories on domestic CAT?

User	Response
1	Some reduction of workload. It's convenient.
2	Workload is lessened. I don't need to look at many sources.
3	Workload increased due to NCAR's reports.
4	Increased workload. Another product to look at.
5	It helps reduce workload.
6	Decreased workload. Easier to plan ahead.
7	No effect on workload.
8	Reduced workload a little. It's good to see the whole picture when I'm busy.
9	Decreased workload. It helped with pre-planning and took a lot of the guess work away.
10	No effect on workload.
11	No effect on workload.
12	Decreased workload. Provides a good quick look at CAT for flights. Allows me to plan more proactively

9. Did you ever experience any problems in accessing ITFA products?

User	Response
1	No.
2	No problem.
3	No problem.
4	It didn't automatically refresh.
5	No.
6	Reliable.
7	OK.
8	No.
9	The AIRMET java tool sometimes bogs down.
10	No.
11	No.
12	No.

10. Is there anything that could be changed or added to the ITFA product to make it more useful to you?

User	Response
1	N/A
2	Overlay flights and jet routes.
3	N/A
4	1K ft. intervals between levels.
5	Change flight levels to those used by COMAIR.
6	N/A
7	Overlay locators such as cities, VORs, jet routes.
8	Have flight levels correspond to Comair levels.
9	N/A
10	N/A
11	N/A
12	N/A

ITFA PHASE 1 STRUCTURED INTERVIEW RESPONSES

UNITED AIRLINES

1. What is your overall impression of the ITFA product?

User	Response
1	Haven't used very much. Have only recently been transferred to the Turbulence Desk. It's good to check my CAT forecast against.
2	It's very good visually. I like the color coding and the 3 hour RUC updates. A very good presentation over the US.
3	Good. It's very readable. Nice presentation of Bulk Richardson Number. By itself I would not rely on it to put out an alert.
4	Good
5	Used as a tool along with satellite and PIREPs.
6	Nice additional guidance compared to other Internet sites. Output was easier to read and user friendly. It tends to over forecast (like most models). In case of CAT, it's better to err on the side of over forecasting.
7	It's a good tool to see if I'm on the right track. However, I'm already used to how I have always forecasted CAT. ITFA doesn't seem to differ from other Internet sites that are already out there.

2. Did you use ITFA information when forecasting domestic CAT?

User	Response
1	Yes. But I never used it as my sole source of information. Typically used in combination with other products. These include upper air maps, 4 panel model data, and PIREPs.
2	It's a good guidance tool and I use it as a self-brief when I come on shift. I also look to see how it matches other sources of information. The product seems to typically concentrate on areas that are indicating moderate and above CAT.

3	I use it for both forecasting and now-casting. I use it frequently, with the PIREPs display for back-up to our own internal system of PIREPs. This is a numerical product and it typically corroborates my hunch on where to issue CAT alerts. On a scale from 1 to 5, I would give it a 4.
4	I've used it for CAT alerts, but I rarely work the Turbulence Desk.
5	I don't use it as verification, but as a confirmation. Is it telling me what I believe is happening? I have more confidence in my forecast if it confirms what I'm thinking.
6	Yes, although I've only been on the Turbulence Desk for 4 shifts. The times I've put out CAT alerts I've always used it.
7	Would sometimes used to compare to my forecast.

3. How did the ITFA output compare to traditional sources of CAT information such as the UAL Turbulence Index and upper air charts?

User	Response
1	I think it was close. The same general accuracy.
2	I can't compare it. It's a separate entity. I need to understand the color scale more, i.e. should I be concerned with blue areas?
3	Better. It is directly related to CAT and uses the same parameters for forecasting CAT that I would use. So, it does it (CAT forecasting) for me.
4	I like the ITFA choices. It's more comprehensive and compares favorably to other sources of information.
5	I can't compare it. It's another tool.
6	Can't really compare it. It's easier to use, but doesn't have enough of a track record. It doesn't seem to have a particular bias, despite the over forecasting. It's a valuable addition.
7	Among other Internet products it compares well. It is not as important as my traditional analysis.

4. ITFA Performance/Accuracy. Please describe ITFA performance, conditions under which it performed well and/or poorly, how it handled CAT coverage and intensities, and confidence level in output.

User	Response
1	I don't think I've used ITFA enough to give an informed opinion. It depends on the situation. The CAT intensities seem to under forecast, i.e. sometimes blue can be moderate turbulence. As far as confidence, I'll have to wait and see. I need to use it more to establish confidence in it.
2	I need to use it more and how it performs under a significant CAT event. There weren't enough of them. Today it did not perform well. It showed turbulence in the upper northeast, although no turbulence was reported, whereas ITFA did not indicate CAT in the southern Great Lakes, where CAT was reported. My confidence is high in that it provides guidance by showing me a visual picture of where I should be looking. However, the color intensities may be under rated. When indicating blue, it may be higher (moderate).

3	It tends to over-forecast. PIREPs don't always confirm areas were ITFA is predicting CAT. I think it has a high FA rate. We need to understand its idiosyncrasies. It may need to be tweaked to be less sensitive. However, I haven't seen any other numerical product that is better. It fills a void. In general it performs well in raising confidence (where indicating CAT) that CAT will be anticipated in this area. It does tend to over forecast somewhat. I am not confident enough in it to use exclusively.
4	It performed better with upper level rapidly moving systems. When the pattern slowed down, it seemed to over forecast.
5	It seems to have a tendency to over forecast with both areal coverage and intensity levels. It seems OK in picking location and altitude.
6	Not sure. It seems to do a better job with more distinct systems with significant patterns. i.e. 1 event I noticed had an anti cyclonic curvature (jet). ITFA seemed to really pick up on that. Onset and offset of CAT is not an issue, since I don't use the product that way. It seems to pick areas where turbulence would be present and errs on the side of conservatism (over forecasts). Confidence is not low. Can't really comment on ITFA intensities, since PIREPs are subjective. Comparing PIREP intensity with ITFA intensity doesn't have much meaning for me.
7	It handles a more defined, dynamic set-up well. But, so can I.

5. Which of the hour forecasts were most beneficial? Is the forecast range adequate?

User	Response
1	I rely on the 0, 3, and 6 hour forecasts (relative to my shift). Sometimes the later model data seems unreliable. The range is adequate.
2	Will look at separate forecasts to give an indication of trending. Will always look at the latest 3 hour update.
3	I look at all the forecast times to see tendencies in turbulence. Range is adequate.
4	Between 1500 and 0300 when most flights are in the air. Adequate range.
5	No more than 12 hours out. 3-12 hours is a good range.
6	Depends on the time of day. I usually look 6 hours out. Adequate forecast range.
7	09 and 12 are forecasts I typically look at. I try to look between 6 and 12 hours ahead.

6. Are flight level ranges of 15,000 to 45,000 feet adequate?

User	Response
1	Prefer 3,000 ft, intervals.
2	Range is adequate. I don't like to issue CAT alerts any more than 6 to 8 hours.
3	Range is good. A finer calibration between flight levels would be good, but not necessary.
4	Yes, adequate.

5	Adequate. Would like to see thinner layers between flight levels, e.g. 1,000 ft instead of 3,000.
6	The composite image from 15 – 45k was useless. Would like the ability to pick my own flight levels, e.g. 36 – 42k.
7	Yes, adequate. 3k intervals are fine.

7. Did ITFA have any effect on your perceived mental workload associated with forecasting and issuing advisories on domestic CAT?

User	Response
1	I don't know.
2	Probably helped with workload as an extra source of information to look at.
3	It helps. It's the best numerical product we have. A very important tool.
4	It helped somewhat.
5	Slight improvement. Easy to use.
6	Made it easier. It helped with the geographic extent of turbulence over time. It also helped to get a better handle on how turbulence will behave over time.
7	Yes. It helped me to narrow down CAT areas in the vertical. It handles altitude better than area.

8. Did you ever experience any problems in accessing ITFA products?

User	Response
1	Have not experienced any problems.
2	No
3	No problems. However it needs to refresh the screen more frequently and I must remember to reload it. This is especially true for the PIREPs display.
4	No.
5	No.
6	No. If slow loading, it's probably UAL's intranet.
7	No access problems.

9. Is there anything that could be changed or added to the ITFA product to make it more useful to you?

User	Response
1	I am somewhat color blind and can't always tell the difference between blue and green. Changing the colors would help me to differentiate. I really like this site.
2	Not at this time. Need more use and good turbulence days.
3	Not really. Fine tune the algorithms to decrease sensitivity and tendency to over forecast.
4	Improve the over forecasting tendency. It would be nice to know which parameter is being weighted at one time, for a particular forecast.
5	Nothing.
6	Allow forecaster to define output in range of time and altitudes.
7	Ability to have composite of user selected flight levels and times. Ability to window multiple images. On 3 hour forecast, overlay actual PIREPs. Show windows with PIREPs next to the 3 hour forecasts.

ITFA PHASE 2 STRUCTURED INTERVIEW RESPONSES

UNITED AIRLINES

1. What is your overall impression of the ITFA product?

User	Response
1	See below.
2	Good starting point. Good guidance. It directs me to areas I need to look at.
3	Useful site, but too broad and generalized.
4	There haven't been many CAT events. It missed the boat in the categories of over-forecasting, order of magnitude (CAT intensities), and horizontal direction (missing areas).
5	
6	
7	

2. Did you use ITFA information when forecasting domestic CAT?

User	Response
1	I use upper air charts, model data and temperatures. Most severe turbulence was last week, but ITFA was not updating. I used it as a comparison basis and looked at it for evaluation purposes. After I made my forecast, I would correlate ITFA output with it. I mostly used the composite display and certain altitude layers (33-37k feet)
2	It's part of my forecasting process. I verify it with PIREPs.
3	I used it mainly as a filter to confirm other information sources. Sometimes PIREPs are unreliable. When that appears to be the case, I'll look at IFTA.
4	I'm still using it. There are very few tools at our disposal and we have nothing better. I need to see some verification.
5	
6	
7	

3. How did the ITFA output compare to traditional sources of CAT information such as the UAL Turbulence Index and upper air charts?

User	Response
1	I often use the Canadian Internet site (CMC) which gives good turbulence guidance. ITFA is not valuable, but I want to help evaluate it.
2	I use it in conjunction with upper air charts. A valuable addition.
3	Another tool in the suite of information available.
4	See above.
5	
6	
7	

4. ITFA Performance/Accuracy. Please describe ITFA performance, conditions under which it performed well and/or poorly, how it handled CAT coverage and intensities, and confidence level in output.

User	Response
1	I never evaluated it that way. I never noticed. I don't take on that role.
2	Seems to be somewhat accurate. It doesn't seem to have any problems in capturing turbulence. Intensity values seem to be a little low, e.g. it will sometimes indicate light turbulence when there is moderate.
3	It seems to pick up low level turbulence over So. CA and works well there. It may be over forecasting. It also shows a lot of moderate turbulence when PIREPs are not confirming this.
4	I can't answer that honestly. I can't tell when ITFA hit or missed. My confidence has decreased over time. Intensity and coverage are typically over-forecast. Although it reported a lot of moderate CAT, no alert was necessary.
5	
6	
7	

5. Overall, what was your confidence level in the ITFA CAT Potential forecasts?

User	Response
1	Questionnable. I can't answer that.
2	I'm confidant enough that it will focus on significant areas of CAT. It also gives me a general view of overall turbulence.
3	As high as other CAT sources I use. I like the automation.
4	See above.
5	
6	
7	

6. Which of the hour forecasts were most beneficial?

User	Response
1	NA
2	3-6 hours out. I will sometimes look farther out to see trends. I use a lot of weather models for trending information. It's also helps to put an end-time on a CAT alert.
3	I look out as far as possible. 8 to12 hours is good.
4	I usually look out to 9 hours. I like to see trending.
5	
6	
7	

7. Are flight level ranges of 15,000 to 45,000 feet adequate?

User	Response
1	Adequate levels.
2	Adequate.
3	Need 1K gradations between flight levels. Also need more composites, e.g. 33-45K feet.
4	Flight levels are fine.
5	
6	
7	

8. Did ITFA have any effect on your perceived mental workload associated with forecasting and issuing advisories on domestic CAT?

User	Response
1	No effect.
2	It helped to get a first look at the potential for CAT.
3	Aids in forecasting.
4	Nothing noticeable.
5	
6	
7	

9. Did you ever experience any problems in accessing ITFA products?

User	Response
1	Just RUC problems.
2	No
3	On weekends there is some reliability issue. Lately ITFA has not been updating.
4	No.
5	
6	
7	

10. Is there anything that could be changed or added to the ITFA product to make it more useful to you?

User	Response
1	Use different colors for black and white print-outs. Maybe vertical lines or cross hatching to differentiate the different intensities.
2	No.
3	Overlay PIREPs on the ITFA display.

4	Improve turbulence detection and placement. Too much areal coverage and intensity.
5	
6	
7	

APPENDIX D

COMAIR AND UAL TELEPHONE INTERVIEW QUESTIONS

Comair Telephone Interview Questions
2002 ITFA Demonstration

Date:_____ Time:_____ Dispatcher Title:_____

1) In your flight planning today, was CAT a factor?

2) To identify or plan for CAT, was ITFA information used? If not, why? (end interview)

3) If yes, please identify one route of flight significantly affected by CAT and describe:

   i) Location of flight route (point to point):_____

   ii) How did you use ITFA?

      (1) Pre-flight self-brief?
         (a) Preliminary picture of where CAT may be or is expected to be?

      (2) During flight plan generation?

      (3) For CAT monitoring while flight(s) were enroute?

      (4) As an additional CAT information source?

      (5) To confirm your idea of where CAT was likely to occur?

      (6) Other?

   iii) How do you feel ITFA performed for this specific flight route?

      (1) Was it able to localize an area of CAT?
         (a) Did it over forecast?
         (b) Did it under forecast?

      (2) How accurate was it in indicating CAT altitude?

      (3) How accurate was it in predicting CAT duration?
         (a) Onset of CAT?
         (b) Offset of CAT?

      (4) How accurate was it in identifying CAT intensity?

   iv) Was ITFA information useful in planning flights along this route?

      (1) Why or why not was it useful?

      (2) Did it have any effect (positive, negative, or none) on flight planning in relation to CAT?

United Airlines Phone Interview Questions
2002 ITFA Demonstration

Date:_____ Time:_____ Meteorologist ID:_____ Desk:_____

1 For the contiguous United States, did you issue any turbulence alerts for CAT?

2 In determining and/or predicting CAT for these alerts, was ITFA information used? If no, why? (end interview)

3 If yes, for one alert box area, please describe your CAT forecast in terms of:

i) Location/ area covered by CAT alert (boundaries) _____

ii) Altitude of CAT _____

iii) Intensity of CAT _____

iv) Duration of CAT (onset and offset) _____

4 What were the probable or known conditions contributing to this turbulence alert, e.g. strong shear conditions, jet stream influence, etc.?

5 How was ITFA information used in your process of determining/predicting this CAT alert area?

6 How did ITFA perform?

a) Did it localize the area of CAT?
b) Were intensity predictions accurate?
c) Were altitude depictions accurate?
d) Was the window of duration (onset and offset of CAT) accurate?

7 For this alert, how did ITFA information compare to other information sources available, e.g., upper air charts, UAL Turbulence Index?