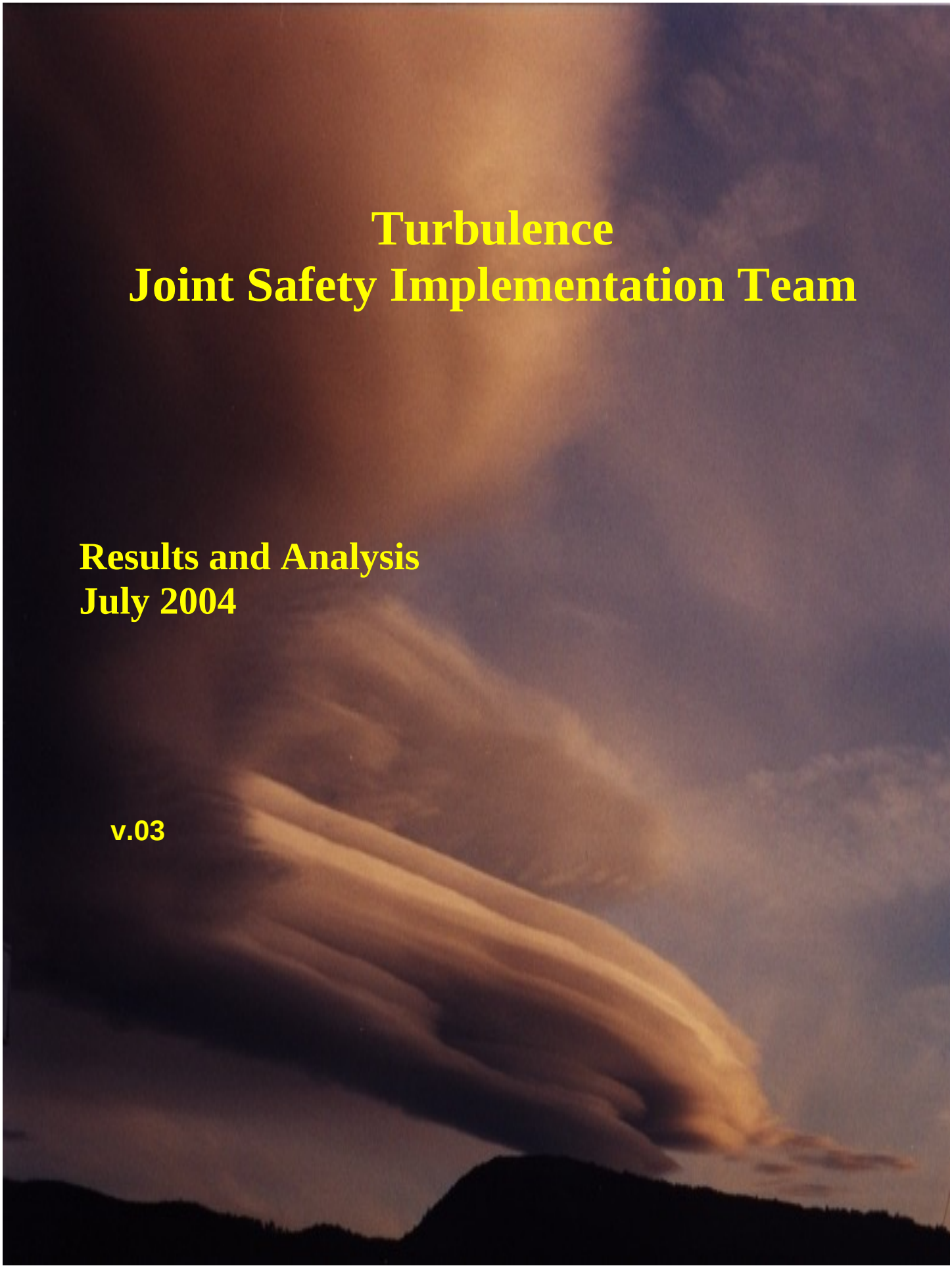

Turbulence
Joint Safety Implementation Team

Results and Analysis
July 2004

v.03

TURBULENCE

JOINT SAFETY IMPLEMENTATION TEAM

RESULTS AND ANALYSIS

JULY 2004

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I. EXECUTIVE SUMMARY

The Commercial Aviation Safety Team (CAST) is a collaboration of major organizations sharing a common aviation safety mission: to reduce the commercial aviation accident rate 80% over a ten-year period ending 2007. CAST membership includes the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration (NASA), and the Department of Defense (DOD), representing government, and many organizations representing the aviation industry. Among those organizations are airplane, engine, and avionics manufacturers; FAR Part 121 certificate holders (airlines); their trade organizations, such as Air Transport Association (ATA), Regional Airline Association (RAA), and National Air Carrier Association (NACA); and pilots' associations such as the Air Line Pilots Association (ALPA) and the Allied Pilots Association (APA). The general aviation community, in association with government, collaborates through a similar organization, the General Aviation Joint Steering Committee (GA JSC).

In August 1999, CAST chartered the Turbulence Joint Safety Analysis Team (JSAT) to review and analyze data on turbulence accidents and incidents, and then recommend interventions that could reduce the rate of turbulence accidents and the resultant injuries. CAST determined that, while turbulence accidents did not account for a significant number of fatalities, the emphasis of CAST, they did account for a high number of injuries. In particular, flight attendant injuries were deemed significant enough that CAST members agreed analysis of turbulence accidents should be done.

In January 2001, CAST accepted the "Results and Analysis" report submitted by the Turbulence JSAT. That report identified 30 interventions and rated the overall effectiveness of the interventions for potentially preventing each of the reviewed accidents. Four other interventions were either listed as potential research and development activities or simply not rated. CAST then chartered the Turbulence Joint Safety Implementation Team (JSIT) to identify the interventions recommended by the JSAT that were likely to be feasible and which offered high safety benefits. The JSIT then developed initial planning documents for the implementation of the selected interventions from the JSAT.

Using a CAST approved process, the JSIT team evaluated each intervention proposed by the Turbulence JSAT and developed intervention strategies and a recommended priority for implementation. Priority was based on the overall effectiveness as determined by the JSAT and the feasibility of implementing each intervention in the United States as determined by the JSIT.

During the initial JSIT evaluation process, those interventions (safety enhancements) that were determined to have high priority were divided into four broad project areas. The four project areas contained some interventions pertaining to research activities. As research solutions tend to be longer-term actions, care was taken not to discount these potential interventions due to potential low short-term overall effectiveness and feasibility ratings. Subsequently, the research related safety enhancements (those that might have potentially high future safety leverage) were removed from the four project areas and regrouped into three additional (research) projects. CAST reviewed the proposed seven projects and associated safety enhancements, amended them in some cases, and requested that detailed plans be developed. The JSIT then developed a

detailed implementation plan for each of the safety enhancements contained within the project areas, and submitted the proposed implementation plans to CAST.

The seven project areas pending implementation approval by CAST are as follows:

A. Implement Best Practices for Turbulence Avoidance

1) Adopt corporate culture of turbulence avoidance
2) Upgrade airline/government collection and distribution of turbulence information
3) Develop and implement minimum turbulence training standards

B. Improve the Quality of Turbulence Information

1) Secure and Distribute Additional Observations – Manual PIREPs and Automated EDRs
2) Secure and Distribute Additional Observations – Semi-automate manual PIREP entry
3) Improve turbulence forecast accuracy
4) Standardize terminology and make turbulence forecasts/warnings aircraft-category specific
5) Standardize vertical and horizontal clearance distance from the thunderstorms.

C. Implement Enhanced Airborne Turbulence Warnings

1) Employ Graphical Displays-Carry On
2) Employ Graphical Displays-Panel Mounted-New Production
3) Develop and Employ Airborne-Detection-Enhanced Radar-New Production
4) Develop and Employ Airborne Detection – Enhanced Radar – Retrofit Windshear Equipped Aircraft
5) Develop and Employ Airborne Detection – Enhanced Radar – Retrofit Non-Windshear-Equipped aircraft (JSIT Withdrew)

D. Implement Active In-flight Turbulence Mitigation – Research and Development for Next Generation Control Systems, New Production

1) Evaluate Alternative Sensor Architecture for Gust Measurement
2) Develop Aircraft Response/Flight Control Algorithms to Control Negative Aircraft Cabin Accelerations

E. Enhanced Airborne Turbulence Warnings – Research And Development for Next Generation Sensors, New Production

1) Develop Algorithms to Predict Turbulence Hazards Based on Inputs from Turbulence Detectors
2) Develop New Turbulence Detector Technology

F. Implement Cabin Injury Reduction During Turbulence

1) Improve Procedures for Reducing Cabin Injuries
2) Perform Cabin Design – Galley Handholds – New Production
3) Perform Cabin Design – Galley Handholds – Retrofit

G. Reduce Cabin Injuries During Turbulence – Research And Development

1) Complete Human Factors Research on Passenger Use of Seatbelts and Develop an Operational Implementation Plan
2) Develop a Concept of Operations for Instant Aircraft-Wide Communications
3) Develop Aircraft Equipment Other than Handholds to Foster Cabin Injury Reduction During Turbulence

This report includes results, conclusions and implementation plans that have been carefully formulated by government and industry experts. The Turbulence JSIT believes that the recommendations in this report, once implemented, will lead to a significant reduction in fatalities and injuries caused by turbulence.

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II. INTRODUCTION

In January 2001, the Commercial Aviation Safety Team (CAST) chartered the Turbulence Joint Safety Implementation Team (JSIT) to develop implementation plans for the interventions proposed by the Turbulence Joint Safety Analysis Team (JSAT) (see Appendix A for complete charter). The Turbulence JSIT's mission was to prioritize, select, and implement the interventions recommended by the Turbulence JSAT that would have the highest possible safety benefit return on investment. In doing so, the Turbulence JSIT would base its decision on all practical and major constraints, such as technical feasibility, time, and cost. As part of the process, the Turbulence JSIT worked closely with the Joint Implementation Measurement Data Analysis Team (JIMDAT) to coordinate the implementation of strategies and plans.

This report is produced using guidance found in the JSIT Process document, "Process Handbook - Joint Safety Implementation Team," dated February 28, 2000, and several CAST approved amendments. This report includes results, conclusions and implementation plans that have been carefully formulated by a representative cross-section of government and industry experts chosen for their turbulence expertise in aviation and meteorology. A complete list of Turbulence JSIT members appears in Appendix B.

The Turbulence JSIT believes that this report provides the aviation industry with a comprehensive plan that if adopted, will result in a significant reduction in turbulence injuries.

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III. APPLYING THE JSIT PROCESS TO TURBULENCE

The Turbulence JSIT followed the JSIT Process document and several CAST approved amendments. The CAST JSAT/JSIT process, depicted in Figure 1, has evolved over several years from "lessons learned" in previous JSAT/JSIT work. As the team worked through the various stages/process blocks recommended by CAST, it became obvious that the normal CAST scoring method, using only fatality statistics to determine cost/benefit, could not be applied to turbulence accidents. The turbulence database contained a large number of accidents with many related injuries, but very few fatalities. Other JSITs had fewer accidents, but large numbers of fatalities. As a result, CAST requested that additional scoring processes be developed and used to evaluate/prioritize Turbulence JSIT recommendations.

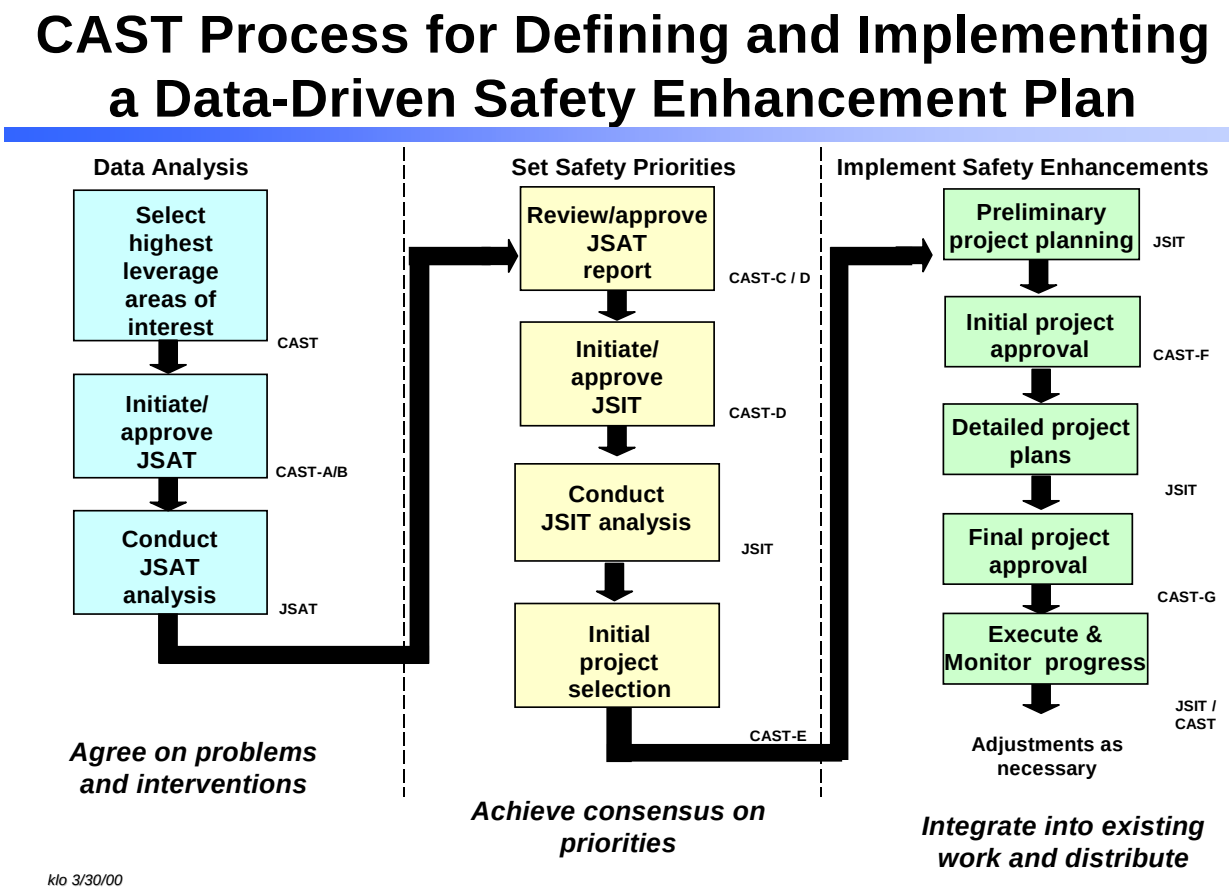

Figure 1

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IV. TURBULENCE ANALYSIS

Review of JSAT documents and Identified Interventions

The first meeting of the Turbulence JSIT took place February 7-8, 2001. At that meeting, the JSIT reviewed the work and output of the Turbulence JSAT. The JSAT "Analysis and Results" report contained 30 potential turbulence interventions (see Appendix C). The JSAT had developed and rated the overall effectiveness (OE) of each intervention for preventing future turbulence accidents based upon the analysis of the data provided to them. The charter for the Turbulence JSIT assigned the JSIT responsibility for determining implementation feasibility and overall effectiveness of each JSAT intervention, and identifying prospective intervention strategies for implementation.

Grouping of Interventions into Projects

The JSIT reviewed the interventions and grouped related interventions into four "projects areas":

- Airborne (Flight Deck) Detection and Display
- Detection and Forecasting/Communications/Meteorology/Other (ATC)
- Mitigation/Cabin Safety
- Aircraft Controls

The four project areas were then assigned to working groups within the JSIT. Each working group (team) consisted of 2-9 JSIT members with expertise in the respective project area. Each team selected a team lead or co-leads.

Determination of Intervention Feasibility

The working groups developed a feasibility rating (F) for each intervention in their project area using the feasibility elements (technical, financial, operational, schedule, regulatory, sociological) as outlined in the JSIT Process Handbook. Each group's assessments were collated and an average feasibility value for each intervention was calculated. The entire JSIT then reviewed the numerical assessment for feasibility elements, and changes were made in order to reach consensus.

Generation of Color-coded Spreadsheets

The Turbulence JSIT used the color-coding technique described in the JSIT Process Handbook to identify the high-priority projects that would be recommended for implementation. The initial step in generating color-coded spreadsheets was to numerically sort the interventions by their overall effectiveness (OE) and feasibility (F) ratings. This sorting identified clusters in the data where colors could be assigned. Break points for effectiveness and feasibility were set wherever naturally occurring breaks appeared between clusters of ratings. The JSIT used the following color code/numeric-rating matrix in developing intervention spreadsheets:

	OVERALL EFFECTIVENESS (OE)	FEASIBILITY (F)
RED	0-1.6	1-2.4
YELLOW	1.7-2.4	2.5-2.7
GREEN	2.5-4.0	2.8-3.0

Prioritization of Interventions

The JSIT's next step was to determine the product of the overall effectiveness rating (OE) and the feasibility rating (F). The simple math of multiplying the effectiveness value, already determined by the JSAT, by the feasibility value, determined by the JSIT, yielded a rating that was used to establish priorities of interventions. The resultant product, OE times F (OExF), is shown in a separate column on the interventions spreadsheet. The interventions were then sorted by this product value to aid in the prioritization. The sorted interventions are shown in Appendix D. Based upon the resulting sort of OExF, a cutoff value for OExF was established to identify the highest leveraged interventions. The cut-off score was determined to be 4.5. Note that after the meeting ended, the tri-chairs reviewed the cut-off and recommended it be changed to 5.1. All project areas containing one or more interventions with an OExF value of 5.1 or greater were considered as high-priority. The prioritization process resulted in the identification of five projects:

- New/Improved Airborne Turbulence Sensors
- Graphical Turbulence Displays and Data Dissemination
- Implement Best Practices For Turbulence Avoidance
- Improve The Quality Of Turbulence Information
- Reduce Cabin Injuries During Turbulence

Development of Statements of Work

Once the high-priority project areas were identified, the JSIT teams developed Statements of Work (SOW) for each project. The SOWs were completed and reviewed by the entire JSIT at the second JSIT meeting in late February 2001. See Appendix E.

Development of Project Plans

The SOWs for the high-priority project were then presented to CAST as part of a "plan-for-a-plan" for CAST initial ("E" level) approval and subsequent direction to proceed with a detailed implementation plan. See Appendix Appendix F for "plans-for-a-plan".

CAST "E" approval for all five projects was received in March 2001, and CAST gave the JSIT approval to pursue initial implementation plans, including development of Executive Summaries and corresponding resource requirements for the five projects. The Executive Summaries include estimated schedules and resources for each project and are shown in Appendix G.

Note that during the ensuing CAST approval process, the five projects were modified and the interventions realigned, resulting in four final projects and three research projects. In November

2002, the JSIT received CAST “F” level approval to develop final Detailed Implementation Plans (DIPs) for the four final projects plus 3 research projects. Brief descriptions of the seven projects are provided in the next section (V). See Appendix H for complete Detailed Implementation Plans.

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V. DETAILED PLAN SYNOPSES

A. IMPLEMENT BEST PRACTICES FOR TURBULENCE AVOIDANCE

PURPOSE:
The purpose of this project is reduce turbulence encounters by developing government and air carrier policies and procedures that will minimize inadvertent turbulence encounters through the implementation of the "best practices" outlined in Advisory Circular (AC) 00-30. The model program defined in the AC for carriers calls for turbulence avoidance as the first line of defense. It also outlines a comprehensive program of acquisition and use of turbulence information plus comprehensive initial and recurrent meteorological training standards for aircrews, dispatchers, and meteorologists. This project, building upon the structure of the AC, identifies actions to be performed by both Government and the carriers to fulfill the intent of AC00-30.

ACTION	COMPLETION	PRIMARY ORGANIZATION
Adopt and implement dispatch and flight operations policies that prescribe re-routing around forecast/observed significant clear air turbulence. Prerequisite: Implementation of SE68, Improved Turbulence Forecast Accuracy.	60 months from CAST approval	Airlines
Revise flight operations manuals and flight crew training to reflect "industry standard" clearance between thunderstorms and aircraft. Prerequisite: Implementation of SE70, Standardize Vertical and Horizontal Clearance distance from Thunderstorms.	36 months from CAST approval	Airlines
Revise/amend airline Op Specs accordingly as new turbulence re-route and thunderstorm clearance policies are adopted.	60 months from CAST approval	Airlines/FAA
Accelerate development and deployment of automated, graphical forecast products (such as those produced by the Integrated Turbulence Forecast Algorithm (ITFA)). Disseminate these graphical products that synthesize observations, forecasts, nowcasts, and model output to all airlines.	24 months after CAST approval	FAA Turbulence Product Development Team (PDT)
Define and develop next generation ground display concept that integrates in situ	60 months after CAST approval	FAA/Airlines/ NCAR/FSL/NWS

turbulence reports, PIREPs, and synthesized turbulence forecast graphics such as ITFA.		
Develop a plan for the operational implementation of a four-dimensional turbulence forecast product that assimilates objective EDR data.	36 months after CAST approval	FAA Turbulence PDT/NWS/FSL
Survey industry training programs with respect to “best practice” standards.	12 months after CAST approval	ATA
Develop minimum turbulence training standards.	36 months after CAST approval	ATA/FAA
Update the guidance in current FAA Order 8400.10, Chapter 2 (Airman Training Programs, paragraphs 1093/1121) and Chapter 5 (Dispatcher Training Requirements, paragraphs 1093/1121) to help ensure airline training programs meet new industry standard.	36 months after CAST approval	FAA
Develop and implement training programs in accordance with the provisions of FAA Order 8400.10.	36 months after CAST approval	Airlines

IMPLEMENTING ORGANIZATIONS:
Airlines, ATA, FAA, NCAR, FSL, NWS

B. IMPROVE THE QUALITY OF TURBULENCE INFORMATION

PURPOSE:
The purpose of this project is to reduce turbulence encounters by improving the quality and quantity of turbulence information used to support strategic flight planning and in-flight routing in order to efficiently avoid turbulence. Included are programs to increase the number and quality of turbulence observations to pinpoint the current location and severity of turbulence, initiatives to improve the accuracy of turbulence forecasts, and plans to develop consistent turbulence standards and metrics.

ACTION	COMPLETION	PRIMARY ORGANIZATION
Develop and implement a program to distribute in-house manual pilot reports to NWS/FAA.	36 months after CAST approval	Airlines/NWS
Train crews to follow established "PIREP" reporting procedures and encourage use of Flight Watch for PIREP input.	36 months after CAST approval	Airlines
Institute a PIREP awareness campaign.	18 months after CAST approval	FAA/Airlines/ Pilot Unions
Install Eddy Dissipation Rate (EDR) and supporting weather downlink software at all ACARS equipped airlines.	36 months after CAST approval	FAA/NCAR/ Airlines
Assess the utility to pilots, in terms of human factors and cost-effectiveness, of real-time cross-linking (from one aircraft to another) of EDR reports.	36 months after CAST approval	FAA/ATA/RAA
Ensure that future data link systems (post-ACARS) accommodate EDR reporting.	Ongoing CAST oversight	FAA/ATA/RAA/ ARINC
Semi-Automate ARTCC/Terminal entry of manual PIREPs	48 months after CAST approval	FAA/NATCA/

Develop automated turbulence forecast algorithms (e.g., the Integrated Turbulence Forecast Algorithm, ITFA), utilizing all turbulence information including EDR reports, to be used to improve manual forecasts and eventually replace manually produced AIRMETS and SIGMETS.	60 months after CAST approval	NCAR
Utilizing automated forecasting techniques from the above action, implement improved manual/automated turbulence forecast.	60 months after CAST approval	NWS (AWC)/ Airlines
Develop/implement turbulence forecast verification system.	60 months after CAST approval	NOAA/FSL/ NWS
Adopt EDR as the industry-wide, aircraft independent metric for measuring and reporting atmospheric turbulence.	60 months after CAST approval	FAA/NWS/ NCAR/NASA/ Airlines
Develop an industry "ride report" standard that is aircraft category specific, and that is calibrated to an objective in situ measure of turbulence (EDR).	60 months after CAST approval	FAA/NCAR/ NASA/NWS/ Airlines
Develop an industry ConOps that defines how both the objective measure of turbulence (EDR) and ride report information is communicated and used by flight crews, dispatch functions, weather information services, and air traffic control. Include a definition of where in the infrastructure the conversion to/from EDR and ride report is accomplished.	24 months after CAST approval	FAA/NCAR/ NASA/Airlines/NWS
Develop an industry standard that defines how turbulence warning and forecast products are generated to be both aircraft category specific and still meet the needs of pilots, dispatchers, weather information services providers, and controllers.	24 months after CAST approval	FAA Turbulence PDT
Develop training materials	24 months after CAST approval	FAA/NWS
Implement training for pilots, dispatchers, controllers and weather service providers.	24 months after CAST approval	Airlines/FAA/ NWS

Review current industry clearance standards between aircraft and thunderstorms.	24 months after CAST approval	FAA/NASA/ Airlines/NCAR
Complete research to determine scientifically valid standards.	36 months after CAST approval	NCAR/NASA
Train flight crews to new standards	36 months after CAST approval	Airlines/FAA

IMPLEMENTING ORGANIZATIONS:
Airlines, ATA, FAA, NCAR, FSL, NWS, ARINC

C. IMPLEMENT ENHANCED AIRBORNE TURBULENCE WARNINGS

PURPOSE:
The purpose of this project is to reduce turbulence encounters by providing improved, real-time turbulence information to aircrew of ownship, aircrew of nearby aircraft, ground operations personnel, and forecasters for turbulence avoidance decisions and for input to turbulence forecasts. To avoid turbulence, recommend the use automated, airborne, aircraft turbulence measurements, new flight deck displays of turbulence information, improved or new on-board look-ahead turbulence detection capabilities, and upgraded flight crew procedures for use of improved information. Use best industry practices and computer-human interface (CHI) standards to develop flight deck displays and aircrew procedures in order to make best use of enhanced turbulence information.

ACTION	COMPLETION	PRIMARY ORGANIZATION
Evaluate alternative architectures for integrating uplinked data, in industry standard format, using existing communication data links.	54 months after CAST approval *	FAA/NASA/ ATA/RAA/AIA/ Manufacturers
Set standards for alternate display systems (such as PC based options) incorporating CHI best practices and standards for real-time graphical flight deck display systems.	54 months after CAST approval *	NASA/FAA/ Manufacturers
Develop and implement algorithms to display turbulence on a carry on display.	54 months after CAST approval *	NASA/FAA/ Manufacturers
Develop improved weather avoidance operating procedures enabled by improved turbulence information on the flight deck using industry best practices and standards as well as CHI design.	54 months after CAST approval *	ATA/Airlines/ Manufacturers/ Employee Organizations
Implement new procedures.	54 months after CAST approval *	Airlines
Review and revise FAA Order 8400.10 as necessary to ensure uniform industry implementation of new procedures.	54 months after CAST approval *	FAA
Evaluate alternative architectures for integrating uplinked and onboard data, in industry standard format, making maximum utilization of existing communication data links.	60 months after CAST approval *	NASA/FAA/ ATA/RAA/AIA/ Manufacturers

Set standards for alternate display systems (such as PC based options) incorporating CHI best practices and standards for real-time graphical flight deck display systems design to enhance and support integration of weather and turbulence data sources.	60 months after CAST approval *	NASA/FAA/ Manufacturers
Develop algorithms for display of turbulence on existing panel-mounted displays.	60 months after CAST approval *	NASA-AvSP/ Manufacturers/ Airlines/FAA-AFS/HF, ATC
Implement algorithms in existing panel mounted displays in 7 aircraft type designs to display turbulence on integrated displays in new production aircraft produced in CY04 and beyond.	60 months after CAST approval *	Manufacturers
Develop improved weather avoidance operating procedures enabled by improved turbulence information on the flight deck using industry best practices and standards as well as CHI design.	60 months after CAST approval *	Manufacturers/ Airlines
Assist in development of improved avoidance procedures with experienced-based inputs to best practices.	60 months after CAST approval *	Employee Organizations
Review and revise FAA Order 8400.10 as necessary to ensure uniform industry implementation of new procedures. Implement new procedures.	60 months after CAST approval *	FAA/Airlines
Develop aircraft response algorithms to be applied to the aircraft hazard metric (RMS normal acceleration) to serve as a basis of new radar turbulence development and certification.	30 months after CAST approval	NASA/NCAR
Validate models and hazard metric.	30 months after CAST approval	NASA
Develop new radar with output suitable for providing warning to ownship flight deck and for data linking to other users.	36 months after CAST approval	Manufacturers/ AIA

Conduct in-service flight trials to determine the effectiveness of the turbulence detection algorithms and deployment feasibility.	36 months after CAST approval	ATA/RAA/
Assist with flight trials, post-flight analysis and confirm turbulence warning performance.	36 months after CAST approval	NASA
Assist in development of improved avoidance procedures with experienced-based inputs to best practices.	30 months after CAST approval	Employee Organizations
Develop performance criteria and flight deck interfaces (CHI design) for the new radar.	30 months after CAST approval	NASA-AvSP Turbulence Team
Develop Service Bulletin to upgrade PWS capable equipment to include enhanced turbulence.	10 years after CAST approval	Manufacturers
Develop Service Bulletins for installation of weather radar equipment with enhanced turbulence capability.	10 years after CAST approval	Manufacturers
Apply for regulatory certification of Service Bulletins and equipment modifications.	54 months after CAST approval	Manufacturers
Facilitate and provide certification.	54 months after CAST approval	FAA
Upgrade equipment and install Service Bulletins.	17 years after CAST approval	Airlines
Provide support as required.	17 years after CAST approval	Manufacturers
Provide regulatory approval of aircraft modifications.	17 years after CAST approval	FAA

Note (*) – denotes currently scheduled government / industry milestones

IMPLEMENTING ORGANIZATIONS:
Manufacturers, Airlines, FAA, NASA

D. ACTIVE IN-FLIGHT TURBULENCE MITIGATION – RESEARCH AND DEVELOPMENT

PURPOSE:
The purpose of this project is to reduce turbulence injuries in aircraft cabins that are caused by at6mospheric disturbances. The project reduces injuries by moving the aircraft control surfaces to counteract the acceleration forces that the turbulence produces. Couple a short-range forward-looking gust sensor in to the control system of the aircraft. Use feed-forward concepts to minimize the occurrence of negative acceleration forces that are highly correlated with in-flight turbulence injuries.

ACTION	COMPLETION	PRIMARY ORGANIZATION
Evaluate alternative sensor architecture concepts for accomplishing gust measurement. Construct demonstration and prototype models for evaluating and demonstrating sensor performance.	7 years after CAST approval	Sensor Manufacturers
Facilitate sensor concept demonstrations and flight evaluation of sensor performance.	7 years after CAST approval	NASA
Develop aircraft response algorithms to control negative aircraft cabin accelerations based on inputs from the forward-looking sensor.	12 months after CAST approval	NASA/ Manufacturers
Verify and validate flight control algorithms performance through simulator and flight testing.	60 months after CAST approval	NASA Aviation Safety Program WxAP
Develop performance criteria for the mitigation flight control system.	36 months after CAST approval	NASA AvSP Turbulence Team
Present report to CAST on feasibility and implementation costs for deployment decision.	9 years after CAST approval	NASA

IMPLEMENTING ORGANIZATIONS:
Manufacturers, NASA

E. ENHANCED AIRBORNE TURBULENCE WARNINGS – RESEARCH AND DEVELOPMENT

PURPOSE:
The purpose of this project is to reduce turbulence injuries by providing improved, real-time turbulence information to aircrew of ownship, aircrew of nearby aircraft, ground operations personnel, and forecasters for turbulence avoidance decisions and for input to turbulence forecasts. Use automated, airborne, aircraft turbulence measurements, new cockpit displays of turbulence information, improved or new on-board look-ahead turbulence detection capabilities, and upgraded flight crew procedures for use of improved information to avoid turbulence. Employ best industry practices and computer-human interface (CHI) standards to develop cockpit displays and aircrew procedures in order to make best use of enhanced turbulence information.

ACTION	COMPLETION	PRIMARY ORGANIZATION
Support research and development to enhance turbulence detection technology.	60 months after CAST approval *	NASA
Develop algorithms to predict turbulence hazards based on inputs from turbulence detectors.	60 months after CAST approval *	NCAR
Develop new turbulence detector technology with output suitable for providing warning to ownship flight deck and for data linking to other users. Conduct in-service flight trials to determine the effectiveness of the turbulence detection systems and deployment feasibility.	84 months after CAST approval *	Manufacturers/ATA/ NASA
Assist with flight trials, post-flight data analysis and confirm turbulence warning performance.	84 months after CAST approval *	NASA
Make implementation recommendation, if warranted, to CAST.	84 months after CAST approval *	NASA
	Note (*) - denotes currently scheduled government / industry milestones	

IMPLEMENTING ORGANIZATIONS:
Manufacturers, NASA, ATA, NCAR

F. IMPLEMENT CABIN INJURY REDUCTION DURING TURBULENCE

PURPOSE:
The purpose of this project is to reduce turbulence injuries to flight attendants and passengers through improved situational awareness, turbulence encounter management procedures (before, during and after encounter), enhanced communication and identification of effective cabin design safety features.

ACTION	COMPLETION	PRIMARY ORGANIZATION
Identify and evaluate airline best practices.	9 months from CAST Approval.	ATA/Airlines/ FA Unions
Develop industry consensus on best practices.	11 months from CAST approval.	ATA/Airlines/ FA Unions
Review and evaluate results of above action item. Format information into Advisory Circular.	14 months from CAST approval.	FAA/AFS-200
Review FAA Order 8400.10 and propose revisions necessary to incorporate information and best practices contained in above AC and guide the Order revision through FAA coordination and publication.	18 months from CAST approval.	FAA/AFS-200
Create national training materials on turbulence (video or other products) based on best practices.	30 months from CAST approval.	FAA/Airlines/ FA Unions
Revise FA and pilot standard operating procedures and training programs to incorporate the recommendations and best practices contained in the AC.	32 months from CAST approval.	ATA/Airlines/Pilot Unions/FAA
Conduct the upgraded training during annual recurrent training for FAs and pilots to implement the recommendations and best practices contained in the AC.	44 months from CAST approval.	Airlines
Examine and evaluate current aircraft cabin interior products to identify those that provide optimum stability of occupants during all levels of turbulence for use in new aircraft.	6 months from CAST Approval.	ATA/Airlines/ FA Unions/ Manufacturers/FAA-CAMI

Identify industry best practices for procedures and training of FAs in use of handholds in galleys.	8 months from CAST approval.	FAA/AFS-200
Consolidate industry best practices and publish in new cabin safety AC to provide guidance for air carriers to use to develop procedures and training programs.	18 months from CAST approval.	FAA/AFS-200
Create national training materials on turbulence (video or other products) based on best practices.	18 months from CAST approval.	FAA/AFS-200
Include recommended handholds in galley packages for all new production aircraft.	Ongoing from 24 months after CAST approval.	Airlines/ Manufacturers
Implement new turbulence procedures and turbulence training for use of handholds as part of annual recurrent training.	30 months from CAST approval.	Airlines
Evaluate currently available handholds and select those most cost-effective for retrofit installation.	6 months from CAST Approval.	Airlines
Install handholds in existing galleys of legacy aircraft.	66 months from CAST approval.	Airlines

IMPLEMENTING ORGANIZATIONS:
Airlines, ATA, FAA

G. CABIN INJURY REDUCTION DURING TURBULENCE – RESEARCH AND DEVELOPMENT

PURPOSE:
The purpose of this project is to reduce turbulence injuries to flight attendants and passengers through improved situational awareness, turbulence encounter management procedures (before, during and after encounter), enhanced communication and identification of effective cabin design safety features.

ACTION	COMPLETION	PRIMARY ORGANIZATION
Develop Human Factors survey.	12 months from CAST approval.	NASA/Airlines
Complete research for human factors best practices for increasing passenger use of seat belts.	24 months from CAST approval.	NASA
Collaborate on a demonstration of results and develop recommendations to improve passenger seat belt usage.	26 months from CAST approval.	NASA/Airlines
Evaluate research findings and develop implementation plan.	28 months from CAST approval.	FAA/AFS-200
Present recommendations, as appropriate to CAST for implementation.	30 months from CAST approval.	FAA/AFS-200
Develop a concept of operations (ConOps) for “instant aircraft-wide communications”.	2 months from CAST Approval.	ATA/Airlines/ FA Unions/Pilot Unions
Working with TSA, identify low cost alternatives from existing technology for instant aircraft-wide communications.	8 months from CAST approval.	NASA/FAA-CAMI
Present findings and implementation recommendations to CAST	12 months from CAST approval.	ATA/Airlines
Identify and evaluate current aircraft cabin interior products that will provide optimized protection of occupants during all levels of turbulence for use in new production and retrofit aircraft.	12 months from CAST Approval.	ATA/Airlines/ FA Unions/ Manufacturers/FAA-CAMI

Determine implementation feasibility and cost effectiveness of candidate systems.	22 months from CAST approval	ATA/Airlines/ FAA
Make implementation recommendations to CAST.	22 months from CAST approval.	ATA/Airlines/ FAA

IMPLEMENTING ORGANIZATIONS:
Airlines, ATA, FAA

Executing Projects and Monitoring Progress

Once CAST "G" level approval is obtained for the Project's Detailed Implementation Plan (DIP), the responsible organizations as identified in the plan are expected to begin implementation strategies. CAST has created the JIMDAT to monitor the project implementation and effectiveness and provide feedback to CAST. In order to accomplish this task, the Joint Implementation Monitoring and Data Analysis Team (JIMDAT) requires that the JSIT provide the predicted effectiveness of each project, the primary problem statements the project is intended to address, and the project implementation milestones. Milestones are included in the DIPs (Appendix H).

The final Turbulence JSIT DIPs outline four projects, three research projects, and the corresponding 18 Safety Enhancements (SEs). The JSIT believes that the 18 SEs offer substantial safety benefit and are intended to be incorporated as part of the overall CAST prioritization schedule. Using the methodology contained in the JIMDAT, the JSIT determined the number of accidents that the project would be expected to prevent during the measurement period. The following chart depicts the potential to prevent turbulence related injuries assuming the non-R&D interventions are implemented.

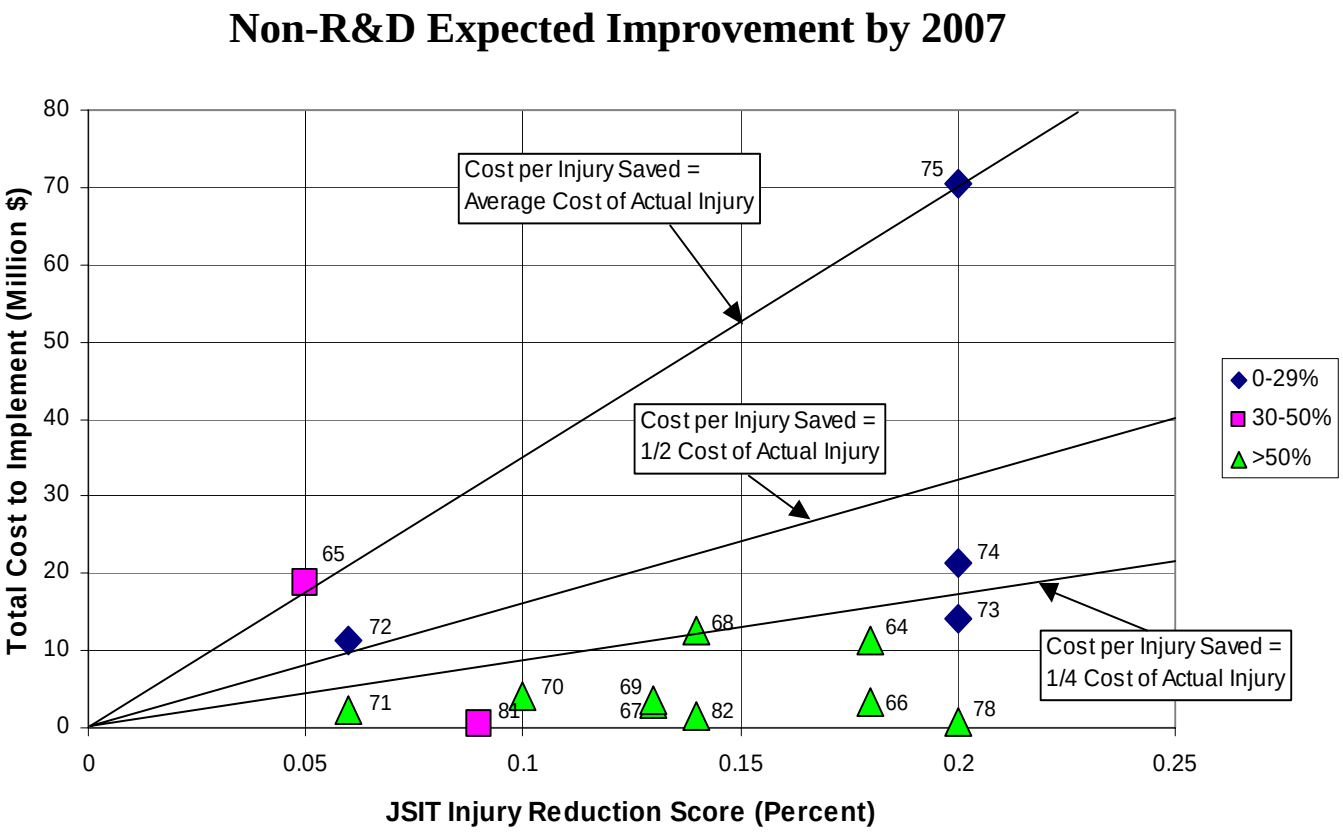

Figure 2

Figure 2 is a plot of the effectiveness of safety enhancements (Injury Reduction Score) versus their total cost. The numbers for injury reduction score, cost, and percent completion by 2007 were taken from the summary sheets prepared for each enhancement. Diagonal lines divide the enhancements into bins that relate the cost of each enhancement per injury avoided to the actual cost of an injury ($193,000), as calculated from Office of the Secretary of Transportation (OST) Memorandum, "Revised Departmental Guidance: Treatment of Value of Life and Injuries in Preparing Economic Evaluations," January 2002.

Safety Enhancement 66, calls for additional turbulence observations in the form of manual PIREPs and automated eddy dissipation rate measurements. By 2007, about 75 percent of the work needed to implement this enhancement will be completed, so the enhancement is shown by a triangle. The injury reduction score of 0.18 indicates the effectiveness of reducing turbulence injuries and is weighted by the proposed ranking of the enhancement against others to avoid double counting of eliminated injuries. The total cost to implement the enhancement is $3.45 million. The plotted position of the injury reduction score versus the cost to implement Safety Enhancement 66 falls well below the lowest diagonal line. This means that the cost of implementing this enhancement is very low compared to the cost of a serious injury, so that operators could realize cost savings fairly easily through injuries averted.

The JSIT has also identified the primary problems each of the projects is intended to correct. The following table lists the four projects and the corresponding Turbulence JSAT recommended interventions. See Appendix D for a complete list of interventions.

JSIT PROJECT NAME	***JSAT INTERVENTIONS ADDRESSED***
Implement Best Practices for Turbulence Avoidance	607, 609, 614, 616, 617
Improve the Quality of Turbulence Information	607, 608, 615, 617, 618, 619, 621, 628
Enhanced Airborne Turbulence Warnings	601, 612, 613, 621, 628
Cabin Injury Reduction During Turbulence	601, 602, 622, 623, 624, 625

VI. CONCLUSIONS

In accordance with the charter creating the Turbulence JSIT, CAST provided input at every step of the JSIT process. At various points in the process, CAST also gave approval to the JSIT on interim steps and products.

In developing the process to address the interventions recommended by the Turbulence JSAT, the JSIT considered many factors. Among those factors was the relatively small number of turbulence injuries and deaths versus the high cost of some JSAT interventions. This issue (cost/benefit ratio), plus the increasing number of CAST projects vying for limited resources, plagued the JSIT throughout the CAST "E" and "F" level approval process. As a result, numerous revisions to the JSIT plans were required, and nearly two years passed between CAST "E" and CAST "F" level approval:

March 2001 - CAST gave "E" level approval to all five projects. Subsequently, the JSIT teams began to develop Executive Summaries and Resource Analysis Templates (see Appendix G) to support a September 2001 CAST "F" level approval. The "F" level approval process (required in order to develop Detailed Implementation Plans – DIPs) was long and involved, spanning nearly 18 months due to changing industry conditions and revisions to the CAST process.

September 2001 CAST meeting - The CAST process was modified based on the JIMDAT report on "development of the strategic plan for future CAST work". This report presented a methodology for scoring the utility of each Safety Enhancement in terms of lives saved by 2007, by 2020, and a third stage, without a timeline, called "full implementation". The Turbulence JSIT subsequently revised documents accordingly in anticipation of the January 2002 CAST meeting.

January 2002 CAST meeting - "F" level approval for Turbulence JSIT projects was postponed due to modifications to the CAST process. The Turbulence JSIT was asked to revise documents and refine scores accordingly.

March 2002 CAST meeting results – "F" level approval was deferred, and more changes requested with regard to scores and costs. The JSIT was asked to prepare a briefing covering all project plans to be presented to the JIMDAT in May 2002. Pending JIMDAT approval, the JSIT briefing would be presented to CAST.

May 2002 – The JSIT briefing to JIMDAT resulted in a request to revise and prioritize Safety Enhancements for presentation to JIMDAT/CAST in October 2002.

October 2002 - JSIT delivered the revised briefing to the JIMDAT. It was agreed that the JSIT would make some amendments to the plan and then request F Level approval from CAST. The modified plan would include all the SEs except #75, which was an outlier compared to all other SE's, and very difficult to defend under existing economic circumstances.

November 2002 - CAST gave "F" level approval to develop DIPS for seven plans including 14 safety enhancements and 5 R&D initiatives.

In the final analysis, the Turbulence JSIT developed several justification strategies:

First, SE75 (Airborne Detection—Enhanced Radar—Retrofit non-WS Equipped A/C) was eliminated as too costly.

Second, the remaining project safety enhancements were split into R&D and non-R&D categories as follows:

Research and Development Safety Enhancements:

•SE76/76a : Improve Airborne Detection—NexGen Sensors—New Production and Retrofit
•SE77: Implement Active Turbulence Mitigation—NexGen Control Systems—New Production
•SE79: Implement Improved Seat Belt Usage
•SE80: Implement Aircraft-wide Communications
•SE83: Improve Cabin Design—A/C Equipment Other Than Galley Handholds – New Production & Retrofit

Non-Research and Development Safety Enhancements:

•SE78: Implement Procedures for Reducing Cabin Injuries
•SE81: Improve Cabin Design—Galley Handholds—New Production
•SE82: Improve Cabin Design—Galley Handholds—Retrofit
•SE66: Secure Additional Observations—Manual PIREPs and Automated EDRs
•SE67: Secure Additional Observations—Semi-automate Manual PIREP Entry
•SE69: Standardize Terminology
•SE71: Utilize Graphical Displays—Carry-on
•SE70: Develop Thunderstorm Clearance Standards
•SE64: Adopt Corporate Culture of Turbulence Avoidance
•SE73: Implement Airborne Detection—Enhanced Radar—New Production
•SE68: Improve Forecast Accuracy
•SE74: Implement Airborne Detection—Enhanced Radar—Retrofit WS Equipped A/C
•SE72: Utilize Graphical Displays—Panel Mounted—New Production
•SE65: Upgrade Corporate Communication Capabilities

Third, the non-R&D SEs were divided into three tiers, based on cost/benefit:

<u>Tier One</u> – Injury cost savings equal to five times the cost of the SE

•SE78: Implement Cabin Comm Procedures—Reduce Flight Attendant Exposure
•SE66: Secure Additional Observations—Manual PIREPs and EDRs
•SE82: Improve Cabin Design—Hand Holds—Retrofit

•SE67: Secure Additional Observations—Semi-automate Manual PIREP Entry
•SE69: Standardize Terminology
•SE70: Develop Thunderstorm Clearance Standards
•SE81: Improve Cabin Design—Hand Holds—New Production
•SE71: Implement Graphical Displays—Carry-on

Tier Two – Injury cost savings equal to two times the cost of the SE

•SE64: Adopt Corporate Culture of Turbulence Avoidance
•SE73: Implement Airborne Detection—Enhanced Radar—New Production
•SE74: Implement Airborne Detection—Enhanced Radar—Retrofit WS Equipped A/C
•SE68: Improve Forecast Accuracy

Tier Three – Injury cost savings equal to the cost of the SE

•SE72: Implement Graphical Displays—Panel Mounted—New Production
•SE65: Upgrade Corporate Communication Capabilities

The three tiers and the relative rankings of the SE's are depicted in the following diagram:

Non-R&D Expected Improvement by 2007

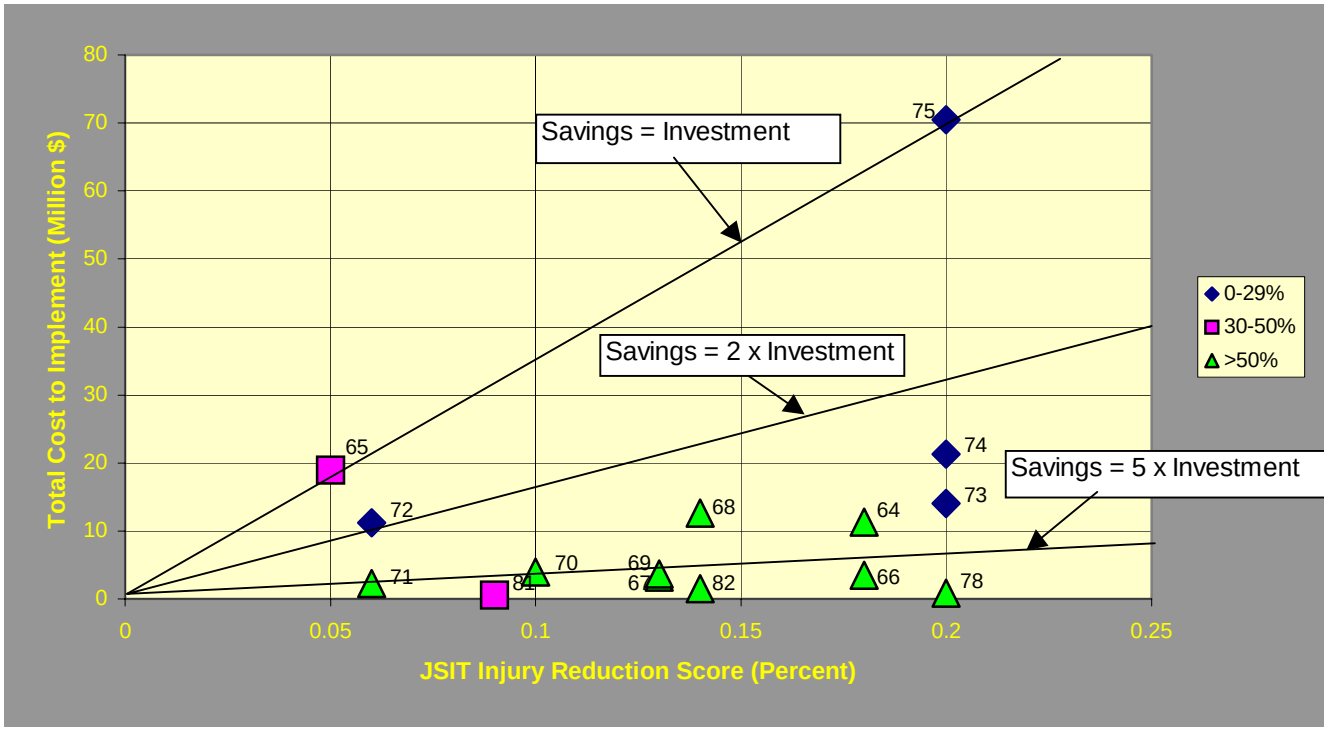

Figure 3

In March 2003, the JSIT delivered 4 DIPs, 3 Research DIPs, one set of summary sheets and three resource documents to the JIMDAT for CAST approval. (See Appendix H for DIPs.) At that time, the JSIT requested CAST to:

- Approve all Tier 1 and Tier 2 Safety Enhancements for inclusion in 2003 strategic plan.
- Add Tier 3 Safety Enhancements to a list of CAST Safety Enhancements for future implementation consideration.
- Approve all R&D initiatives.

One year later, in the March 2004 CAST meeting, the JIMDAT presented the DIP for the Turbulence SE 78 to CAST and received "G" level (implementation) approval. All other Turbulence JSIT recommendations are pending.

VII. RECOMMENDATIONS

The unifying goal of the Turbulence JSIT was to produce a practical plan yielding significant safety benefits, not for a selected group of organizations, but for the entire commercial aviation community. Because not all organizations comprising the general and commercial aviation communities are represented on CAST, the Turbulence JSIT recommends:

- That this report be treated as a public document and
- That CAST ensure prompt distribution of this report to all major organizations comprising the U.S. commercial and general aviation community, the presidents of IATA, IFALPA, the Chairman of the JAA Board, and the President of the Council of ICAO and
- That CAST continue the review process for all Turbulence Safety Enhancements culminating in the approval of all proposed Safety Enhancements as recommended by the Turbulence JSIT at the March 2003 CAST meeting.

The underlying concepts for the recommendations of the Turbulence JSIT are not new. Many of these concepts have been advocated by safety experts and operational personnel for decades. As a result of the JSIT, the best of those concepts, plus some new technology ideas, have been brought together in a single comprehensive plan as documented in this report.

Over the past 40 years, due in large part to cost/benefit considerations, little if any progress has been made in reducing turbulence related injuries. With few exceptions, these injuries have been accepted by commercial aviation as the "cost of doing business". In human terms, the "cost of doing business" between 1987 and 2000 has been 3 fatalities and 166 serious injuries (NTSB data). In addition, incident data from airlines indicate 15,000 minor injuries during that period, with an estimated annual cost to the airlines of $25.8 million.

The Turbulence JSIT recommendations contained within this report can and will significantly reduce these statistics. The JSIT strongly urges that CAST and its member organizations implement the eighteen safety enhancements identified as soon as possible. A serious program for reducing turbulence-related injuries demands no less of the airline safety community.

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APPENDICES

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INDEX OF APPENDICIES

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TURBULENCE

Charter for Joint Safety Implementation Team (JSIT)

I. Purpose. To develop implementation strategies and action plans and after approval by the CAST, coordinate the implementation of the strategies and plans.

II. Background. Industry and government, through CAST, have jointly agreed to pursue a data driven approach to identify high priority safety initiatives. Industry and government have further agreed that cooperatively and selectively pursuing implementation of the high leveraged safety intervention strategies will maximize safety benefit. Implementation of some of the intervention strategies may be international in scope.

III. Tasks.

A. Intervention strategies from the Turbulence JSAT will be analyzed by the Turbulence JSIT for the purpose of determining implementation feasibility and identification of prospective intervention strategies for implementation.

B. The Turbulence JSIT will present the prospective interventions identified for implementation to CAST for review and approval. Rationale for how all Turbulence JSAT intervention strategies were dispensed with will be included in the plan report.

C. For those CAST-approved Turbulence interventions identified for implementation, develop an implementation plan.

D. The Turbulence implementation plan will contain:

- prioritized implementation strategies
- identification of responsible parties
- a list of major implementation milestones
- metrics to monitor progress in meeting the milestones
- metrics for tracking success of the interventions
- communications strategy aimed at gaining “stakeholder” buy-in

E. For Turbulence strategies which are international in scope, the Turbulence JSIT implementation plan will consider how best to utilize the assistance of ICAO, IATA, FS, IFALPA, or other international organizations and appropriate international certificating authorities.

F. The Turbulence JSIT will present the detailed implementation CAST for review and approval.

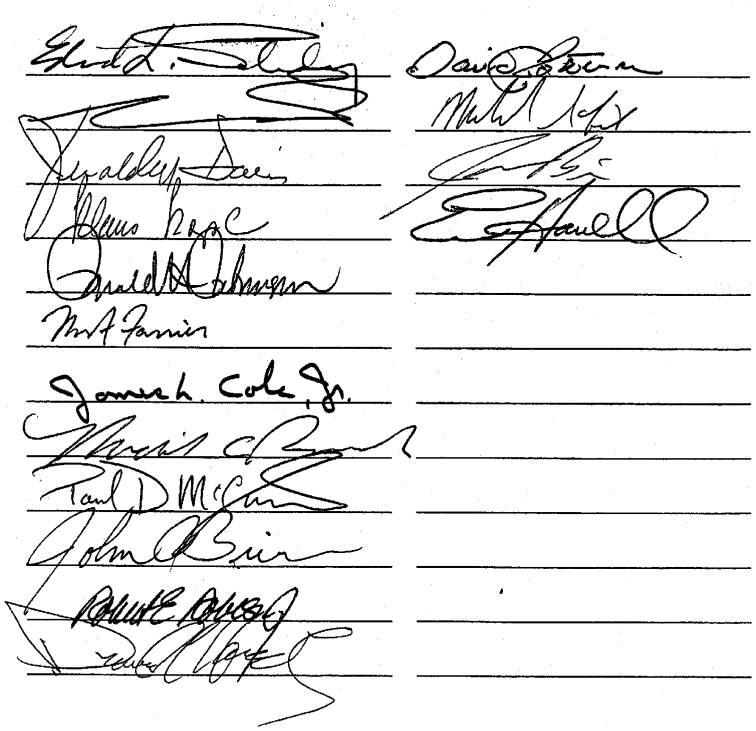
G. As directed by CAST, the JSIT will make periodic progress reports on implementation status to CAST.

IV. Products. The Turbulence JSIT deliverables include:

- Initial implementation plan
- Detailed implementation plan
- Progress reports to CAST documenting progress on implementation and established metrics

V. Membership. The Turbulence JSIT team membership will include "senior" representatives from those stakeholders who will be affected by the intervention strategies and those who may be responsible for implementation of those strategies.

VI. Resources. CAST participating organizations agree to provide appropriate financial, logistical and personnel resources necessary to carry out this charter and approved implementation strategies.



TURBULENCE JOINT SAFETY IMPLEMENTATION TEAM (JSIT) Membership Roster

ORGANIZATION	NAME	ADDRESS
Air Line Pilots Association (ALPA)	**Bob Frantz**	535 Herndon Parkway Herndon, VA 20172
	Bob Massey	P.O. Box 1710 Lake Arrowhead, CA 92352-1710
	Bill Phaneuf	535 Herndon Parkway Herndon, VA 20172
	Dan Stack	P.O. Box 1319 Ashland, NH 03217
Air Transport Association (ATA)	**Carl Knable**	1301 Pennsylvania Ave., NW Suite 1100 Washington, D.C. 20004-1707
	Russ Gold	1301 Pennsylvania Ave., NW Suite 1100 Washington, D.C. 20004-1707
Association of Professional Flight Attendants (APFA)	**Debbie Roland**	4095 Ringwood Rd. Nokesville, VA 20181
Boeing	**Jon Hildrum**	Boeing Commercial Airplane Group, MS 02-MP P.O. Box 3707 Seattle, WA 98124
FAA Flight Standards (AFS)		
FAA Aviation Weather Directorate (ARW)	**Richard J. Heuwinkel**	400 7th Street, SW Washington, D.C. 20590
	Debi Bacon	400 7th Street, SW Washington, D.C. 20590
FAA Aviation Research (AAR)	**George Greene**	
FAA System Safety (ASY)	**Felice Brunner**	800 Independence Ave, SW ASY-300 Washington, D.C. 20591
FA Accident Investigations (AAI)	**Bob Matthews**	800 Independence Ave. Washington, D.C. 20591

Appendix B – Turbulence JSIT Members

TURBULENCE JOINT SAFETY IMPLEMENTATION TEAM (JSIT) Membership Roster

ORGANIZATION	NAME	ADDRESS
Honeywell	**Tim McRoberts**	15001 NE 36th St. PO Box 97001, MS L3G Redmond, WA 98052
International Association of Machinists (IAM)	**Brian Wozniak**	15710 JFK Blvd. Suite 265 Houston, TX 77032
National Association of Air Traffic Specialists (NAATS)	**Kevin Kelley**	
National Aeronautics and Space Administration (NASA)	**Rod Bogue**	NASA Dryden Mail Stop 2033 Edwards, CA 93523-0273
National Air Traffic Controllers Association (NATCA)	**Matt Tucker**	400 7th Street, SW Washington, D.C. 20590
Rockwell Collins	**Roy Robertson**	Rockwell Collins, MS 106-207 400 Collins Rd NE Cedar Rapids, IA 52498
University Corporation of Atmospheric Research (UCAR)	**Tenny Lindholm**	P.O. Box 3000 3450 Mitchell Lane Boulder, CO 80301
AvMet Applications International, LLC	**Mark Phaneuf**	2300 Clarendon Blvd, Suite 1107 Arlington, VA 22201
	Robb Rottman	2300 Clarendon Blvd, Suite 1107 Arlington, VA 22201

JSAT INTERVENTION STRATEGIES

601 To ensure effective cockpit-cabin communication, FAA should require that air carriers' operating specifications and training programs include standardized procedures and phraseology for pre-flight and in-flight communication of turbulence hazards, degree of hazard and all clear declarations

602 To improve the timeliness and effectiveness of turbulence warning dissemination and damage reports, airlines should develop and implement instant two-way communications capability between cabin crew and flight crew anywhere in the aircraft at all times.

603 To ensure that passengers are aware of potential hazards, air carriers should develop and implement standardized pre-flight briefings to passengers (including multi-lingual briefings, as appropriate) that provide practical information about anticipated turbulence hazards and emphasize passenger responsibility for seat belt compliance.

604 To gain compliance by passengers who otherwise ignore seating or seat belt instructions, air carriers and Government should develop and implement enforcement policies and procedures on how to deal with passengers' who do not heed warnings.

605 To provide immediate warning to the cabin crew and passengers, air carriers should develop and implement automated aural or visual cabin alerting systems.

606 To alleviate the effect of encountering turbulence, researchers, manufacturers and air carriers should develop and implement a capability to quickly and automatically reconfigure the flight control system and adjust airspeed to mitigate forces acting upon occupants

607 To assure availability of the most current and highest quality turbulence information, air carriers should audit their current systems for receiving, analyzing and disseminating weather products and ensure that dispatchers and flight crews effectively obtain and use all available turbulence information contained currently in SIGMETS, PIREPS and AIRMETS, and in Flight Watch and HIWAS services.

608 To reduce inadvertent flight into turbulence associated with convection, industry and government should develop and implement separation standards that use visual cues and indications from on-board systems (such as radar, outside air temperature, etc).

609 To better manage turbulence risks, air carriers should improve fundamental knowledge about meteorology and types of turbulence by providing adequate initial and recurrent training to flight crews, meteorologists and dispatchers in turbulence assessment, recognition and avoidance.

610 To improve the effectiveness of flight planning and decision-making processes, government and industry should continue to develop collaborative decision making (CDM) and joint training programs in order to enhance effective CDM among dispatchers, meteorologists, ATC and flight crews, with emphasis on joint participation in flight planning, timely communication (including CPDLC, voice, etc.), in-flight decision making and ensuring that all functions share the same sources of weather information.

611 To provide more flexibility in route selection to avoid turbulence in International Airspace, the FAA and other governmental agencies should establish additional transoceanic tracks.

612 To more accurately depict low reflectivity thunderstorms, manufacturers and air carriers should develop and implement improved detection equipment and associated operating procedures.

613 To depict the best route of flight around turbulence, air carriers and manufacturers should develop and implement real-time graphical weather displays and turbulence alerts to the flight deck.

614 To provide clear detection and depiction of turbulence location and intensity, Government and industry should develop and implement methods to synthesize available airborne, ground-based and satellite data, forecasts, "nowcasts" and meteorological models.

615 To improve communication among providers and users of turbulence information, Government and industry should standardize ground and in-flight indications of turbulence hazard intensity and the phraseology used in dissemination, and should ensure that operators, flight crews, and ATC receive the same information.

616 To support a primary strategy of turbulence avoidance, air carriers should implement "best practices," as outlined in FAA Advisory Circular AC00-30b. These practices should include, but not be limited to, establishing full meteorological capabilities in-house or through a vendor, the establishment of a turbulence charting and alerting program that identifies current risks and areas where turbulence and mountain waves are most common, etc.

617 To ensure that all users and service providers have real-time access to PIREPs and other time-critical weather information, government and industry should develop a capability to share such information.

618 To obtain more PIREPs in conformance with the AIM, pilots should report turbulence in the form of PIREPs to ATC (may be broken out to specific ATC elements.

619 To make forecasts and warnings of turbulence and other hazardous weather more spatially and temporally precise, accurate and more applicable to specific routes and specific aircraft types and categories, government, weather providers and the air carriers should improve the accuracy of those products.

620 To improve the accuracy of turbulence forecasts, air carriers and FAA should expand the forecasting techniques and CDM practices currently employed in the Strategic Planning Implementation Team and CCFP to turbulence forecasting

621 To improve the collection and dissemination of objective real-time turbulence reports, air carriers and manufacturers should continue to develop and implement automatic methods for detecting turbulence encounters and reporting them electronically (along with other relevant weather information) to all users

622 To reduce flight attendants' exposure to turbulence, during climb and descent, air carriers should establish and implement a policy and related SOPs that require all flight attendants and passengers to be seated and restrained from takeoff to cruise altitude and from FL200 through landing.

623 To reduce flight attendants' exposure to turbulence while performing seat belt monitoring, FAA should require and air carriers should develop and implement clearly stated policies and standard operating procedures, to be included in flight attendant manuals, that allow cabin crew to prioritize, without repercussion, immediate duties and cabin service schedules, including the option to be seated while making seatbelt announcements in response to anticipated turbulence hazards or warnings.

624 To equip flight attendants with the insights and knowledge required to prioritize cabin duties versus the risk of turbulence injuries, FAA should require air carriers to develop and implement training for flight attendants in turbulence hazards, aircraft behavior in turbulence, and the need to ensure their own safety.

625 To reduce injuries to passengers and flight attendants during unexpected turbulence, FAA, air carriers and manufacturers should equip cabin interiors with handholds and other restraint systems or padding in appropriate locations (e.g., aisles, galleys, arm rests, lavatories, and jumpseat areas) and should consider locating jumpseats near work areas or installing auxiliary jumpseats adequate for turbulence encounters (but not for use during takeoff or landings).

626 To reduce injuries from ineffective or failed restraint systems, air carriers and manufacturers should consider the redesign of such systems to ensure that flight attendants and passengers, including small children, are secure during turbulence.

627 To reduce injuries that result from overhead storage bins that open during turbulence encounters, manufacturers should evaluate and redesign, as applicable, storage bins and all other items suspended overhead from the ceiling.

628 To detect and warn of imminent turbulence encounters, manufacturers, air carriers and Government should develop and implement an airborne, ground-based or satellite system that warns of impending turbulence immediately ahead of the aircraft.

629 To reduce injuries from inadvertent contact with service equipment (such as serving carts and hot beverage equipment), manufacturers, air carriers and FAA should test, redesign, and implement additional systems to secure service and equipment items, such as cart-restraint floor tracks or "mushrooms", retractable arms, and sealed hot beverage containers.

630 To ensure passenger adherence, DOT and FAA and air carriers should continually promote seat belt usage and compliance with advisories and warnings by extending the "Vince and Larry" Seat Belt Campaign to aviation and by other public service initiatives (e.g. videos, airport signage and posters, ticket covers, napkins, brochures, web sites

DETECTION AND FORECASTING - GROUND/METEOROLOGY/COMMUNICATION/OTHER (ATC)

Group Lead – Tenny Lindholm Co Lead – Carl Knable
Tri Chair Mole – Rick Heuwinkel
Tim McRoberts
Matt Tucker
Dorothy Haldeman
Tim Miner
Russ Gold
Carol Gaunt
Don McLennan

Intervention color-coding completed per JSIT Process Document. The following colors were assigned to the Overall Effectiveness (OE) score:

Green 2-4 – 4.0 Yellow 1.6 – 2.4 Red 0 – 1.6

The following colors were assigned to the Feasibility scores:

Green 2.8 – 3.0 Yellow 2.5 – 2.7 Red 1.0 – 2.4

The cut-off score was determined to be 4.25 (blue horizontal line). Note – Intervention 615 moved up to pair with 610

Overall Effectiveness	Technical	Financial	Operational	Schedule	Regulatory	Sociological	Feasibility	E x F	Intervention #	INTERVENTIONS
3.9	3	3	3	2	3	1	2.50	9.75	616	To support a primary strategy of turbulence avoidance, air carriers should implement "best practices," as outlined in FAA Advisory Circular AC00-30b. These practices should include, but not be limited to, establishing full meteorological capabilities in-house or through a vendor, the establishment of a turbulence charting and alerting program that identifies current risks and areas where turbulence and mountain waves are most common, etc.
3.2	2	2	3	2	3	3	2.50	8.00	628	To detect and warn of imminent turbulence encounters, manufacturers, air carriers and government should develop and implement an airborne, ground-based or satellite system that warns of impending turbulence immediately ahead of the aircraft.

Appendix D – Interventions and Dispositions by Project Group

Overall Effectiveness	Technical	Financial	Operational	Schedule	Regulatory	Sociological	Feasibility	E x F	Intervention #	INTERVENTIONS
2.9	2	2	3	2	3	3	2.50	7.25	619	To make forecasts and warnings of turbulence and other hazardous weather more spatially and temporally precise, accurate and more applicable to specific routes and specific aircraft types and categories, government, weather providers and the air carriers should improve the accuracy of those products.
2.6	2	3	3	2	3	3	2.67	6.93	614	To provide clear detection and depiction of turbulence location and intensity, government and industry should develop and implement methods to synthesize available airborne, ground-based and satellite data, forecasts, "nowcasts" and meteorological models.
2.1	3	3	3	3	3	3	3.00	6.30	609	To better manage turbulence risks, air carriers should improve fundamental knowledge about meteorology and types of turbulence by providing adequate initial and recurrent training to flight crews, meteorologists and dispatchers in turbulence assessment, recognition and avoidance.
2	3	3	3	3	3	3	3.00	6.00	618	To obtain more PIREPs in conformance with the AIM, pilots should report turbulence in the form of PIREPs to ATC (may be broken out to specific ATC elements).
2.3	3	3	2	2	3	2	2.50	5.75	617	To ensure that all users and service providers have real-time access to PIREPs and other time-critical weather information, government and industry should develop a capability to share such information.
2.2	3	3	2	3	2	2	2.50	5.50	608	To reduce inadvertent flight into turbulence associated with convection, industry and government should develop and implement separation standards that use visual cues and indications from on-board systems (such as radar, outside air temperature, etc).
1.7	3	3	3	3	3	3	3.00	5.10	607	To assure availability of the most current and highest quality turbulence information, air carriers should audit their current systems for receiving, analyzing and disseminating weather products and ensure that dispatchers and flight crews effectively

Appendix D – Interventions and Dispositions by Project Group

Overall Effectiveness	Technical	Financial	Operational	Schedule	Regulatory	Sociological	Feasibility	E x F	Intervention #	INTERVENTIONS
										obtain and use all available turbulence information contained currently in SIGMETS, PIREPS and AIRMETS, and in Flight Watch and HIWAS services.
2	3	3	2	2	2	2	2.33	4.67	610	To improve the effectiveness of flight planning and decision-making processes, government and industry should continue to develop collaborative decision making (CDM) and joint training programs in order to enhance effective CDM among dispatchers, meteorologists, ATC and flight crews, with emphasis on joint participation in flight planning, timely communication (including CPDLC, voice, etc.), in-flight decision making and ensuring that all functions share the same sources of weather information.
1.6	3	3	2	3	3	2	2.67	4.27	620	To improve the accuracy of turbulence forecasts, air carriers and FAA should expand the forecasting techniques and CDM practices currently employed in the Strategic Planning Implementation Team and CCFP to turbulence forecasting.
1	3	3	3	3	2	3	2.83	2.83	615	To improve communication among providers and users of turbulence information, government and industry should standardize ground and in-flight indications of turbulence hazard intensity and the phraseology used in dissemination, and should ensure that operators, flight crews, and ATC receive the same information.
1.1	3	3	2	2	2	2	2.33	2.57	611	To provide more flexibility in route selection to avoid turbulence in International Airspace, the FAA and other governmental agencies should establish additional transoceanic tracks.

AIRBORNE (FLIGHT DECK) DETECTION & DISPLAY

Group Lead – Carol Nickels Co Lead – Roy Robertson
Tri Chair Mole – Rod Bogue
Jon Hildrum
Tenny Lindholm
Tim McRoberts
Dan Stack
Hank Krakowski

Intervention color-coding completed per JSIT Process Document. The following colors were assigned to the Overall Effectiveness (OE) score:

Green 2-4 – 4.0 Yellow 1.6 – 2.4 Red 0 – 1.6

The following colors were assigned to the Feasibility scores:

Green 2.8 – 3.0 Yellow 2.5 – 2.7 Red 1.0 – 2.4

The cut-off score was determined to be 4.25 (blue horizontal line).

Overall Effectiveness	Technical	Financial	Operational	Schedule	Regulatory	Sociological	Feasibility	E x F	Intervention #	INTERVENTIONS
3.3	2	3	3	3	3	3	2.83	9.35	621	To improve the collection and dissemination of objective real-time turbulence reports, air carriers and manufacturers should continue to develop and implement automatic methods for detecting turbulence encounters and reporting them electronically (along with other relevant weather information) to all users.
2.9	3	2	2	1	2	3	2.17	6.28	613	To depict the best route of flight around turbulence, air carriers and manufacturers should develop and implement real-time graphical weather displays and turbulence alerts to the flight deck.
1.8	2	3	3	2	2	3	2.50	4.50	612	To more accurately depict low reflectivity thunderstorms, manufacturers and air carriers should develop and implement improved detection equipment and associated operating procedures.

MITIGATION/CABIN INJURIES

Group Lead – Bob Frantz Co Lead – Felice Brunner
Tri Chair Mole – Bob Massey
Debbie Roland
Chuck Overby
Vahid Motevalli
Bob Mathews
Brian Wozniak
Vince Rossi

Intervention color-coding completed per JSIT Process Document. The following colors were assigned to the Overall Effectiveness (OE) score:

Green 2-4 – 4.0 Yellow 1.6 – 2.4 Red 0 – 1.6

The following colors were assigned to the Feasibility scores:

Green 2.8 – 3.0 Yellow 2.5 – 2.7 Red 1.0 – 2.4

The cut-off score was determined to be 4.25 (blue horizontal line). Note – Intervention 603 moved up to pair with 630; 627 moved up to 625

Overall Effectiveness	Technical	Financial	Operational	Schedule	Regulatory	Sociological	Feasibility	E x F	Intervention #	INTERVENTIONS
3.6	3	3	2	3	3	1	2.50	9.00	622	To reduce flight attendants' exposure to turbulence, during climb and descent, air carriers should establish and implement a policy and related SOPs that require all flight attendants and passengers to be seated and restrained from takeoff to cruise altitude and from FL200 through landing.
2.9	3	3	3	3	2	3	2.83	8.22	601	To ensure effective cockpit-cabin communication, FAA should require that air carriers' operating specifications and training programs include standardized procedures and phraseology for pre-flight and in-flight communication of turbulence hazards, degree of hazard and all clear declarations.
2.7	3	3	3	3	2	3	2.83	7.65	623	To reduce flight attendants' exposure to turbulence while performing seat belt monitoring, FAA should require and air carriers should develop and implement clearly stated policies and standard operating procedures, to be included in flight attendant manuals, that allow cabin crew to prioritize, without repercussion, immediate duties

Overall Effectiveness	Technical	Financial	Operational	Schedule	Regulatory	Sociological	Feasibility	E x F	Intervention #	INTERVENTIONS
										and cabin service schedules, including the option to be seated while making seatbelt announcements in response to anticipated turbulence hazards or warnings.
2	3	3	3	3	2	3	2.83	5.67	624	To equip flight attendants with the insights and knowledge required to prioritize cabin duties versus the risk of turbulence injuries, FAA should require air carriers to develop and implement training for flight attendants in turbulence hazards, aircraft behavior in turbulence, and the need to ensure their own safety.
1.8	3	3	3	2	3	3	2.83	5.10	602	To improve the timeliness and effectiveness of turbulence warning dissemination and damage reports, air carriers should develop and implement instant two-way communications capability between cabin crew and flight crew anywhere in the aircraft at all times.
1.8	3	2	3	2	3	2	2.50	4.50	625	To reduce injuries to passengers and flight attendants during unexpected turbulence, FAA, air carriers and manufacturers should equip cabin interiors with handholds and other restraint systems or padding in appropriate locations (e.g., aisles, galleys, arm rests, lavatories, and jump seat areas) and should consider locating jump seats near work areas or installing auxiliary jump seats adequate for turbulence encounters (but not for use during takeoff or landings).
1.5	3	3	3	2	3	3	2.83	4.25	629	To reduce injuries from inadvertent contact with service equipment (such as serving carts and hot beverage equipment), manufacturers, air carriers and FAA should test, redesign, and implement additional systems to secure service and equipment items, such as cart-restraint floor tracks or “mushrooms”, retractable arms, and sealed hot beverage containers.
1.5	3	3	3	3	3	2	2.83	4.25	630	To ensure passenger adherence, DOT and FAA and air carriers should continually promote seat belt usage and compliance with advisories and warnings by extending the “Vince and Larry” Seat Belt

Appendix D – Interventions and Dispositions by Project Group

Overall Effectiveness	Technical	Financial	Operational	Schedule	Regulatory	Sociological	Feasibility	E x F	Intervention #	INTERVENTIONS
										Campaign to aviation and by other public service initiatives (e.g. videos, airport signage and posters, ticket covers, napkins, brochures, web sites, etc.).
1.7	3	3	3	2	2	2	2.50	4.25	605	To provide immediate warning to the cabin crew and passengers, air carriers should develop and implement automated aural or visual cabin alerting systems.
1.3	3	3	3	3	3	3	3.00	3.90	603	To ensure that passengers are aware of potential hazards, air carriers should develop and implement standardized pre-flight briefings to passengers (including multi-lingual briefings, as appropriate) that provide practical information about anticipated turbulence hazards and emphasize passenger responsibility for seat belt compliance.
1.8	3	3	2	2	2	1	2.17	3.90	604	To gain compliance by passengers who otherwise ignore seating or seat belt instructions, air carriers and government should develop and implement enforcement policies and procedures on how to deal with passengers' who do not heed warnings.
1.1	3	3	3	3	3	3	3.00	3.30	626	To reduce injuries from ineffective or failed restraint systems, air carriers and manufacturers should consider the redesign of such systems to ensure that flight attendants and passengers, including small children, are secure during turbulence.
0.8	3	3	3	3	3	3	3.00	2.40	627	To reduce injuries that result from overhead storage bins that open during turbulence encounters, manufacturers should evaluate and redesign, as applicable, storage bins and all other items suspended overhead from the ceiling.

AC CONTROLS
Group Lead – Bob Frantz
Jon Hildrum

Intervention color-coding completed per JSIT Process Document. The following colors were assigned to the Overall Effectiveness (OE) score:

Green 2-4 – 4.0 Yellow 1.6 – 2.4 Red 0 – 1.6

The following colors were assigned to the Feasibility scores:

Green 2.8 – 3.0 Yellow 2.5 – 2.7 Red 1.0 – 2.4

The cut-off score was determined to be 4.25 (blue horizontal line).

Overall Effectiveness	Technical	Financial	Operation	Schedule	Regulator	Sociologic	Feasibility	E x F	Intervention #	INTERVENTIONS
1.7	1	1	3	1	2	3	1.83	3.12	606	To alleviate the effect of encountering turbulence, researchers, manufacturers and air carriers should develop and implement a capability to quickly and automatically reconfigure the flight control system and adjust airspeed to mitigate forces acting upon occupants.

IMPLEMENT BEST PRACTICES FOR TURBULENCE AVOIDANCE

SOW: The purpose of this project is to develop government and air carrier policies and procedures that will minimize inadvertent turbulence encounters through the implementation of the "best practices" of AC00-30b. This includes a comprehensive program of acquisition and use of turbulence information, as well as turbulence avoidance as the first line of defense. To enhance the best practices of AC00-30b, the project also supports development of comprehensive initial and recurrent meteorological training standards for aircrews, dispatchers, and meteorologists.

Overall Effectiveness	Technical	Financial	Operation	Schedule	Regulator	Sociologic	Feasibility	E x F	Intervention #	INTERVENTIONS
3.9	3	3	3	2	3	1	2.50	9.75	616	To support a primary strategy of turbulence avoidance, air carriers should implement "best practices," as outlined in FAA Advisory Circular AC00-30b. These practices should include, but not be limited to, establishing full meteorological capabilities in-house or through a vendor, the establishment of a turbulence charting and alerting program that identifies current risks and areas where turbulence and mountain waves are most common, etc.
2.1	3	3	3	3	3	3	3.00	6.30	609	To better manage turbulence risks, air carriers should improve fundamental knowledge about meteorology and types of turbulence by providing adequate initial and recurrent training to flight crews, meteorologists and dispatchers in turbulence assessment, recognition and avoidance.
1.7	3	3	3	3	3	3	3.00	5.10	607	To assure availability of the most current and highest quality turbulence information, air carriers should audit their current systems for receiving, analyzing and disseminating weather products and ensure that dispatchers and flight crews effectively obtain and use all available turbulence information contained currently in SIGMETS, PIREPS and AIRMETS, and in Flight Watch and HIWAS services.
2	3	3	2	2	2	2	2.33	4.67	610	To improve the effectiveness of flight planning and decision-making processes, government and industry should continue to develop collaborative

Overall Effectiveness	Technical	Financial	Operation	Schedule	Regulator	Sociologic	Feasibility	E x F	Intervention #	INTERVENTIONS
										decision making (CDM) and joint training programs in order to enhance effective CDM among dispatchers, meteorologists, ATC and flight crews, with emphasis on joint participation in flight planning, timely communication (including CPDLC, voice, etc.), in-flight decision making and ensuring that all functions share the same sources of weather information.
1.6	3	3	2	3	3	2	2.67	4.27	620	To improve the accuracy of turbulence forecasts, air carriers and FAA should expand the forecasting techniques and CDM practices currently employed in the Strategic Planning Implementation Team and CCFP to turbulence forecasting.
1.1	3	3	2	2	2	2	2.33	2.57	611	To provide more flexibility in route selection to avoid turbulence in International Airspace, the FAA and other governmental agencies should establish additional transoceanic tracks.

IMPROVE THE QUALITY OF TURBULENCE INFORMATION

SOW: Improve the quality and quantity of turbulence information to support strategic flight planning and in-flight routing to efficiently avoid turbulence. These improvements include more and better turbulence observations to pinpoint the current location and severity of turbulence, improved accuracy of turbulence forecasts, improved turbulence standards and metrics, and improved depiction and dissemination of turbulence information.

Overall Effectiveness	Technical	Financial	Operation	Schedule	Regulator	Sociologic	Feasibility	E x F	Intervention #	INTERVENTIONS
2.9	2	2	3	2	3	3	2.50	7.25	619	To make forecasts and warnings of turbulence and other hazardous weather more spatially and temporally precise, accurate and more applicable to specific routes and specific aircraft types and categories, government, weather providers and the air carriers should improve the accuracy of those products.
2.6	2	3	3	2	3	3	2.67	6.93	614	To provide clear detection and depiction of turbulence location and intensity, government and industry should develop and implement methods to synthesize available airborne, ground-based and satellite data, forecasts, “nowcasts” and meteorological models.
2	3	3	3	3	3	3	3.00	6.00	618	To obtain more PIREPs in conformance with the AIM, pilots should report turbulence in the form of PIREPs to ATC (may be broken out to specific ATC elements).
2.3	3	3	2	2	3	2	2.50	5.75	617	To ensure that all users and service providers have real-time access to PIREPs and other time-critical weather information, government and industry should develop a capability to share such information.
2.2	3	3	2	3	2	2	2.50	5.50	608	To reduce inadvertent flight into turbulence associated with convection, industry and government should develop and implement separation standards that use visual cues and indications from on-board systems (such as radar, outside air temperature, etc).

Overall Effectiveness	Technical	Financial	Operation	Schedule	Regulator	Sociologic	Feasibility	E x F	Intervention #	INTERVENTIONS
1	3	3	3	3	2	3	2.83	2.83	615	To improve communication among providers and users of turbulence information, government and industry should standardize ground and in-flight indications of turbulence hazard intensity and the phraseology used in dissemination, and should ensure that operators, flight crews, and ATC receive the same information.

NEW/IMPROVED AIRBORNE TURBULENCE SENSORS

SOW: The purpose of this project is to develop new/improved airborne turbulence sensors to detect and inform flight crews of imminent low reflectivity and/or clear air turbulence encounters in the flight path of the aircraft. This project will also include outputs from the sensor that may be downlinked to the ground or other aircraft. Operating procedures will be developed to utilize information from this new sensor technology.

Overall Effectiveness	Technical	Financial	Operational	Schedule	Regulatory	Sociological	Feasibility	E x F	Intervention #	INTERVENTIONS
3.3	2	3	3	3	3	3	2.83	9.35	621	To improve the collection and dissemination of objective real-time turbulence reports, air carriers and manufacturers should continue to develop and implement automatic methods for detecting turbulence encounters and reporting them electronically (along with other relevant weather information) to all users.
3.2	2	2	3	2	3	3	2.50	8.00	628	To detect and warn of imminent turbulence encounters, manufacturers, air carriers and government should develop and implement an airborne, ground-based or satellite system that warns of impending turbulence immediately ahead of the aircraft.
2.9	3	2	2	1	2	3	2.17	6.28	613	To depict the best route of flight around turbulence, air carriers and manufacturers should develop and implement real-time graphical weather displays and turbulence alerts to the flight deck.
1.8	2	3	3	2	2	3	2.50	4.50	612	To more accurately depict low reflectivity thunderstorms, manufacturers and air carriers should develop and implement improved detection equipment and associated operating procedures.

Note: Intervention 612 was below the cutoff line but was considered covered by plans made for intervention 628.

GRAPHICAL TURBULENCE DISPLAYS AND DATA DISSEMINATION

SOW: The purpose of this project is to update the flight displays to provide real-time graphical weather and turbulence alerts for both strategic and tactical display. This may be derived from on-board and/or uplinked data sources. This project also includes automatic reporting of turbulence encounters for subsequent distribution to others users.

Overall Effectiveness	Technical	Financial	Operational	Schedule	Regulatory	Sociological	Feasibility	E x F	Intervention #	INTERVENTIONS
3.3	2	3	3	3	3	3	2.83	9.35	621	To improve the collection and dissemination of objective real-time turbulence reports, air carriers and manufacturers should continue to develop and implement automatic methods for detecting turbulence encounters and reporting them electronically (along with other relevant weather information) to all users.
3.2	2	2	3	2	3	3	2.50	8.00	628	To detect and warn of imminent turbulence encounters, manufacturers, air carriers and government should develop and implement an airborne, ground-based or satellite system that warns of impending turbulence immediately ahead of the aircraft.
2.9	3	2	2	1	2	3	2.17	6.28	613	To depict the best route of flight around turbulence, air carriers and manufacturers should develop and implement real-time graphical weather displays and turbulence alerts to the flight deck.
1.8	2	3	3	2	2	3	2.50	4.50	612	To more accurately depict low reflectivity thunderstorms, manufacturers and air carriers should develop and implement improved detection equipment and associated operating procedures.

Note: Intervention 612 was below the cutoff line but was considered covered by plans made for intervention 628.

CABIN INJURY REDUCTION DURING TURBULENCE

SOW: The purpose of this project is to minimize the potential for injury to flight attendants and passengers through pre- encounter preparation and procedures, reduction in cabin design hazards, and turbulence injury potential awareness training.

Overall Effectiveness	Technical	Financial	Operations	Schedule	Regulatory	Sociological	Feasibility	E x F	Intervention #	INTERVENTIONS
3.6	3	3	2	3	3	1	2.50	9.00	622	To reduce flight attendants' exposure to turbulence, during climb and descent, air carriers should establish and implement a policy and related SOPs that require all flight attendants and passengers to be seated and restrained from takeoff to cruise altitude and from FL200 through landing.
2.9	3	3	3	3	2	3	2.83	8.22	601	To ensure effective cockpit-cabin communication, FAA should require that air carriers' operating specifications and training programs include standardized procedures and phraseology for pre-flight and in-flight communication of turbulence hazards, degree of hazard and all clear declarations.
2.7	3	3	3	3	2	3	2.83	7.65	623	To reduce flight attendants' exposure to turbulence while performing seat belt monitoring, FAA should require and air carriers should develop and implement clearly stated policies and standard operating procedures, to be included in flight attendant manuals, that allow cabin crew to prioritize, without repercussion, immediate duties and cabin service schedules, including the option to be seated while making seatbelt announcements in response to anticipated turbulence hazards or warnings.
2	3	3	3	3	2	3	2.83	5.67	624	To equip flight attendants with the insights and knowledge required to prioritize cabin duties versus the risk of turbulence injuries, FAA should require air carriers to develop and implement training for flight attendants in turbulence hazards, aircraft behavior in turbulence, and the need to ensure their own safety.

Overall Effectiveness	Technical	Financial	Operations	Schedule	Regulatory	Sociological	Feasibility	E x F	Intervention #	INTERVENTIONS
1.8	3	2	3	2	3	2	2.50	4.50	625	To reduce injuries to passengers and flight attendants during unexpected turbulence, FAA, air carriers and manufacturers should equip cabin interiors with handholds and other restraint systems or padding in appropriate locations (e.g., aisles, galleys, arm rests, lavatories, and jumpseat areas) and should consider locating jumpseats near work areas or installing auxiliary jumpseats adequate for turbulence encounters (but not for use during takeoff or landings).
1.5	3	3	3	2	3	3	2.83	4.25	629	To reduce injuries from inadvertent contact with service equipment (such as serving carts and hot beverage equipment), manufacturers, air carriers and FAA should test, redesign, and implement additional systems to secure service and equipment items, such as cart-restraint floor tracks or "mushrooms", retractable arms, and sealed hot beverage containers.
1.5	3	3	3	3	3	2	2.83	4.25	630	To ensure passenger adherence, DOT and FAA and air carriers should continually promote seat belt usage and compliance with advisories and warnings by extending the "Vince and Larry" Seat Belt Campaign to aviation and by other public service initiatives (e.g. videos, airport signage and posters, ticket covers, napkins, brochures, web sites, etc.).
1.1	3	3	3	3	3	3	3.00	3.30	626	To reduce injuries from ineffective or failed restraint systems, air carriers and manufacturers should consider the redesign of such systems to ensure that flight attendants and passengers, including small children, are secure during turbulence.
0.8	3	3	3	3	3	3	3.00	2.40	627	To reduce injuries that result from overhead storage bins that open during turbulence encounters, manufacturers should evaluate and redesign, as applicable, storage bins and all other items suspended overhead from the ceiling.

CABIN INJURY REDUCTION DURING TURBULENCE

SOW: The purpose of this project is to optimize the securing of passengers, cabin equipment and luggage, and flight attendants after a warning of imminent turbulence has been received.

Overall Effectiveness	Technical	Financial	Operational	Schedule	Regulatory	Sociological	Feasibility	E x F	Intervention #	INTERVENTIONS
2.9	3	3	3	3	2	3	2.83	8.22	601	To ensure effective cockpit-cabin communication, FAA should require that air carriers' operating specifications and training programs include standardized procedures and phraseology for pre-flight and in-flight communication of turbulence hazards, degree of hazard and all clear declarations.
1.8	3	3	3	2	3	3	2.83	5.10	602	To improve the timeliness and effectiveness of turbulence warning dissemination and damage reports, air carriers should develop and implement instant two-way communications capability between cabin crew and flight crew anywhere in the aircraft at all times.
1.7	3	3	3	2	2	2	2.50	4.25	605	To provide immediate warning to the cabin crew and passengers, air carriers should develop and implement automated aural or visual cabin alerting systems.
1.3	3	3	3	3	3	3	3.00	3.90	603	To ensure that passengers are aware of potential hazards, air carriers should develop and implement standardized pre-flight briefings to passengers (including multi-lingual briefings, as appropriate) that provide practical information about anticipated turbulence hazards and emphasize passenger responsibility for seat belt compliance.
1.8	3	3	2	2	2	1	2.17	3.90	604	To gain compliance by passengers who otherwise ignore seating or seat belt instructions, air carriers and government should develop and implement enforcement policies and procedures on how to deal with passengers' who do not heed warnings.

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Plan for a Plan

IMPLEMENT BEST PRACTICES FOR TURBULENCE AVOIDANCE

SOW: The purpose of this project is to develop government and air carrier policies and procedures that will minimize inadvertent turbulence encounters through the implementation of the "best practices" of AC00-30b. This includes a comprehensive program of acquisition and use of turbulence information, as well as turbulence avoidance as the first line of defense. To enhance the best practices of AC00-30b, the project supports the development of comprehensive initial and recurrent meteorological training standards for aircrews, dispatchers, and meteorologists.

OPTIONS:

- Develop and implement corporate culture in all airlines that views turbulence avoidance as the first line of defense. (616)
- Establish a full meteorological support system for dispatch and crews. (616)
- Develop air carrier communications system (not ATC based) that ensures collection and distribution of manual and automated pilot reports. (616, 607)
- Establish corporate systems that ensure collection of all available turbulence information (forecasts and observations), and the subsequent timely distribution of that information to dispatchers and aircrews. (607)
- Acquire and utilize all available turbulence information contained currently in SIGMETS, PIREPS AND AIRMETS and obtainable through HIWAS and Flight Watch services. (607)
- Institute comprehensive turbulence training for aircrews, dispatchers, and meteorologists. (609)

STAKEHOLDERS: Airlines, Unions, FAA, NCAR, and NWS.

POTENTIAL IMPACT:

Benefits:

- Based on the JSAT data for the one airline that has fully implemented best practices of AC00-30b, full implementation of these practices by all air carriers could reduce the turbulence accident rate by 80-90% with a commensurate reduction in liability from consumers and lost work time for flight attendants.

Potential Costs:

- Possible significant resistance to the paradigm shift necessary within the airline industry from adopting a single turbulence policy. (3)
- Increased cost to airlines for training and staffing. (3)
- Potential need for FAA oversight.(3)
- Potential increased operating costs for avoidance of forecasted turbulence areas. (3)

CURRENT STATUS:

- Advisory Circular AC00-30b is in effect, and addresses:
  - An appropriate initial and recurrent training program,
  - A dedicated planning/dispatch function, and
  - A fully supported operational implementation of a pilot reporting (PIREP)/communications system (not ATC-based).
- The one airline using AC00-30b has historically shown a lower turbulence accident rate than the industry as a whole. That airline had less than 1% of the turbulence accidents studied by the JSAT.
- Training programs vary widely among the airlines.

PROJECT PLANNING LEADER: Tenny Lindholm/Carl Knable

DETAILED PLAN BY: May 1, 2001

Plan for a Plan

IMPROVE THE QUALITY OF TURBULENCE INFORMATION

Improve the quality and quantity of turbulence information to support strategic flight planning and in-flight routing to efficiently avoid turbulence. These improvements include more and better turbulence observations to pinpoint the current location and severity of turbulence, improved accuracy of turbulence forecasts, improved turbulence standards and metrics, and improved depiction and dissemination of turbulence information.

Options:

- Increase quantity of turbulence observations through additional manual PIREPs [618] and new automated, aircraft-based observations [617].
- Improve forecast accuracy of moderate or severe turbulence events to performance metrics of 80% Probability of Detection "yes" (PODy) and 85% Probability of Detection "no" (PODn) so that dispatchers have the confidence to routinely route aircraft around turbulence forecast areas, and operate a verification system to track operational performance against these metrics [619].
- Ensure distribution of all time-critical turbulence information to all users [617].
- Increase operational utility of observations and forecasts by standardizing turbulence terminology [615], by synthesizing observations, forecasts, "nowcasts", and output from meteorological models [614], by making forecasts and warnings aircraft category specific [619], and by developing scientifically valid horizontal and vertical clearance requirements between aircraft and convective activity [608].

STAKEHOLDERS: Airlines, FAA, NWS, ARINC, NCAR, FSL, NASA, AWC, CWSUs, DOD, Unions, and Vendors

POTENTIAL IMPACT:

Benefits:

- About 50% reduction in injuries through implementation of improved forecasts and separation standards.
- Reduced liability risks from consumers and loss of work time for flight attendants.
- Potentially fewer reroutes due to less airspace being impacted because of more accurate forecasts.

Potential Costs:

- Low additional costs for research, hardware, communications, avionics, display, training and personnel. (3)
- Potential reduction in available airspace due to increased separation from convective activity. (3)

CURRENT STATUS:

- FAA funded NWS/FSL/NCAR turbulence Product Development Team (PDT) is currently testing automated turbulence forecast models and has initiated software implementation for Eddy Dissipation Rate (EDR), an automated measure of turbulence, on commercial aircraft.
- Six airlines are currently providing automated ACARS weather reports, and one airline is downlinking EDR data.
- One airline has adopted an in-house collection and distribution system, however, it does not have access to PIREPs from other airlines.
- ATC architecture cannot currently process and distribute automated aircraft reports including EDR.
- Many PIREPs are lost to system constraints and format issues.
- The Aviation Digital Data Service (ADDS), part of the Aviation Gridded Forecast System PDT, has initiated efforts to integrate turbulence forecasts and PIREPs into a single user display.

PROJECT PLANNING LEADER: Tenny Lindholm/Carl Knable

DETAILED PLAN BY: May 1, 2001

Plan for a Plan

NEW/IMPROVED AIRBORNE TURBULENCE SENSORS

SOW: The purpose of this project is to develop new/improved airborne turbulence sensors to detect and inform flight crews of imminent low reflectivity and/or clear air turbulence encounters in the flight path of the aircraft. This project will also include outputs from the sensor that may be downlinked to the ground or other aircraft. Operating procedures will be developed to utilize information from this new sensor technology. (628, 612, 621)

OPTIONS:

- Upgrade existing on-board weather radar systems to enhance turbulence detection.
- NASA/Industry cooperation in developing new/enhanced sensor technologies needed for commercial products to detect low reflectivity and/or clear air turbulence.
- Approval standards developed for performance and flight deck effect of next generation turbulence sensors.
- Develop improved procedures based on the information provided by the new/enhanced technology from the on-board weather detection systems.

STAKEHOLDERS: Aircraft/Avionics Manufacturers, Airlines, Passengers, Atmospheric Research Organizations, and Government Agencies

POTENTIAL IMPACT:

Benefits:

- Reduction of turbulence related injuries by:
- Providing advanced warning of turbulence encounters through improved detection of clear air and low reflectivity turbulence
- New operating procedures
- Improve NAS due to implied benefits from free flight.
- Marketing of “Safer Skies” means more passengers.

Potential Costs:

- Cost to develop, certify, and implement is minor for enhancement to existing systems, major for new sensor technology (2).
- Update to display systems to depict turbulence icons is minor (3).
- Impact on airlines to upgrade to this enhanced system is minor for enhanced existing systems, and major for new sensor technology (2).
- Structural modifications required for aircraft to accommodate new sensor technology

CURRENT STATUS:

- Avionics suppliers are presently finalizing development of enhanced turbulence radar.
- Industry teams consisting of NASA, FAA, NCAR, Academia, Airlines, OEM's and manufacturers are currently involved in developing and testing turbulence detection algorithms.
- FAA/Industry workshop to define acceptable certification requirements for enhancements to the turbulence systems is currently in progress.
- FAA and NASA are currently supporting this activity by flight-testing a data collection turbulence radar and LIDAR on the NASA B757.
- Manufacturers are currently researching and flight-testing enhanced weather radar, LIDAR, IR and radiometric sensors.

PROJECT PLANNING LEADER (S): Carol Nickels – Rockwell Collins
Roy Robertson – Rockwell Collins
Tim McRoberts – Honeywell

DETAILED PLAN BY: May 1, 2001

Plan for a Plan

GRAPHICAL TURBULENCE DISPLAYS AND DATA DISSEMINATION

SOW: The purpose of this project is to update the flight displays to provide real-time graphical weather and turbulence alerts for both strategic and tactical display. This may be derived from on-board and/or uplinked data sources. This project also includes automatic reporting of turbulence encounters for subsequent distribution to other users.

- Develop automatic reporting of on-board detected turbulence encounters in a standardized aircraft independent format. (621, 615b)
- Utilize upgraded downlink communications infrastructure for collection and dissemination of real-time turbulence reports. (621)
- Develop new or improve existing real-time graphical cockpit displays systems for integration of turbulence and weather data sources to assist selection of the best route of flight around turbulence. (613, 628)
- Utilize and expand existing means for uplinking weather information and integrating it with on-board information to support an integrated strategic and tactical display of real-time weather and turbulence information. (621, 628, 613)
- Develop or explore additional ground based or satellite systems that could warn of impending turbulence encounters. (628)

OPTIONS:

- Encourage existing industry efforts for automatically detecting and reporting turbulence encounters to a ground network for dissemination to other users.
- Improve the infrastructure for better exchange of weather data/turbulence between proximate aircraft and between the aircraft and ground (e.g. ADS-B).
- OEM's work with display manufacturers to improve technology for enhanced display of strategic and tactical weather.
- Encourage airlines to develop better procedures based on the information provided by the enhanced technology from the on-board weather detection systems.
- Integrate turbulence encounter data with aircraft response characteristics to develop standardized aircraft independent turbulence reports.
- Encourage use of FOQA data without penalty.

STAKEHOLDERS: Aircraft/Avionics Manufacturers, Airlines, Passengers, ATC, Atmospheric Research Organizations, and Government Agencies

POTENTIAL IMPACT:

Benefits:

Reduction of turbulence related injuries by:

- Significantly improved awareness of weather and turbulence situation affecting the aircraft through new cockpit information and display technologies.
- Improved reporting and dissemination of turbulence encounters
- Improve NAS due to implied benefits from free flight.
- Marketing of "Safer Skies" means more passengers.

Potential Costs:

- Cost to upgrade display system is major (2).
- Cost to develop infrastructure for ground-based weather to aircraft, aircraft to ground, and aircraft-to-proximate aircraft is minor (3).

CURRENT STATUS:

A major NASA AWIN program currently in progress which includes the following major program elements:

- Enhanced Weather Products
- Cooperative Research Agreements
- Operational Systems
- System Engineering

<u>The AWIN program encompasses many of the industry efforts listed below.</u>

- Airline/NCAR/Manufacturer developing and evaluating automatic turbulence reporting downlink.

- Avionics manufacturers currently researching and testing display of weather & turbulence information to include storm height, predicted storm motion, wind velocity, predicted turbulence regions.

- Avionics manufacturer and NASA researching and testing combined display merging uplinked strategic ground based weather products with on-board real time weather radar data.

- Avionics manufacturers currently working with airlines to uplink strategic weather to a PC display via Satcom. (I2S, SWIS, AWIN)

- NCAR/NASA/Airlines working to develop aircraft independent turbulence metric Aviation Digital Data Service (ADDS) for standardized dissemination to other aircraft and air traffic controllers. (e.g. Eddy Dissipation Rate (EDR).

PROJECT PLANNING LEADER(S): Carol Nickels – Rockwell Collins
Roy Robertson – Rockwell Collins
Tim McRoberts – Honeywell

DETAILED PLAN BY: May 1, 2001

Plan for a Plan

CABIN INJURY REDUCTION DURING TURBULENCE

A. SOW: The purpose of this project is to optimize the securing of passengers, cabin equipment and luggage, and flight attendants after a warning of imminent turbulence has been received.

Options:

- Standardize procedures for communicating onset time, intensity, and duration of impending turbulence encounter between cockpit and cabin crew. [601]

- Provide means to establish instant communications with all flight attendants for purpose of conveying time critical warning information as well as ability to convey injury and damage information. Particularly critical in large, multi cabin aircraft. [602]

Stakeholders: Airlines, FAA, flight attendant unions, pilot unions

Potential Impact: Very low overall financial costs. Ability to leverage best practices. Directly addresses major injury category of flight attendant.

Current Status: Various programs in existence.

B. SOW: The purpose of this project is to develop government and air carrier policies and procedures in the areas of **communications**, education, training and SOP in order to reduce injuries due to anticipated and unanticipated turbulence. Specifically training of Flight attendants to understand turbulence and means to better safeguard themselves. Improved communications between pilots and flight attendants to accurately apprise each other as to actual or predicted turbulence conditions. To educate the flying public of the dangers of turbulence and to develop proper procedures to ensure their safety. To develop policy and procedures to carry out the above goals.

- To improve effective cockpit-cabin communications. (601)

- To develop procedures to inform passengers regarding expected weather and turbulence.(601-603 brought in)

- Develop a two-way instant communications between the cockpit and working flight attendants located in key positions throughout the cabin.(602)

Options: Investigate best procedures/practices currently being done.

Stakeholders: Airlines, FAA, flight attendant and pilot unions.

Potential Impact: Very low financial costs, currently being done, and reduce injuries, and reduced liability.

Current Status: Various programs are underway within the industry.

C. SOW: The purpose of this project is to improve passenger safety by educating the flying public about the actions they can take to reduce their risk during turbulence

- Develop programs for the flying public to teach them of the hazards of turbulence and the importance of seatbelt compliance for themselves and their families.(630)

- Develop programs to teach the flying public the importance of protecting themselves if caught out of their seats during turbulence.(630)

Options:

- To expand the Department of Transportation surface safety programs to include air travelers.(630)

- To request approval from the Department of Transportation for the use of "Vince and Larry" dummies for use in educating the flying public.(630)

- Continue efforts started by "Partners in Cabin Safety" with the completion of public education programs.(630)

- National Air Safety Awareness program and program that can be used for "Outreach".(630)

Stakeholders: Airlines, FAA, flight attendant and pilot unions, travel agents, TV networks, airlines, DOT, National Safety Council, industry organizations, and passengers

Potential Impact:

Very low financial costs

Uses established and effective fictional characters to influence public behavior, however, the National Safety Council (NSC) or the National Highway Traffic Safety Administration (NHTSA) resisted the use of Vince and Larry in the past for airline messages because they believed any non-highway use of those characters reduced the effectiveness of their message.

Reduce injuries, heighten public awareness, lower liability costs.

Current Status: Educational materials have been developed by the FAA and Partnership in Cabin Safety (PICS). NSC has retired Vince and Larry, but continues to hold copyright.

D. SOW: Standard Operating Procedures and Policy provide perimeters for safe and consistent operation. This project will explore cabin SOPs which minimize passenger and flight attendant exposure to turbulence hazards during various flight phases.

OPTIONS

- Develop SOP's to require all flight attendants and passengers to be seated and restrained from takeoff to cruise altitude and from FL 200 through landing as practicable for each fleet. (622)

- Develop SOP's for clearly stated policies and standard procedures that allow cabin crew to prioritize immediate duties and cabin activities in response to anticipated and unanticipated turbulence. (623)

Stakeholders: Airlines, flight attendant and pilot unions, FAA, passenger associations

Potential Impact: Very low implementation costs, fewer injuries resulting in reduced loss of time at work and reduced litigation, changes in company manual and inflight communication procedures, changes in sequence of flight cabin crew responsibilities, increased FAA oversight, marketing and management concerns on the part of air carriers regarding limitations of cabin crew availability in cabin for service. An under FL 200 rule would affect certain operators and certain flights adversely requiring seating during entire flight. However, it will have no affect on those flights that do not have cabin service

Current Status: Currently practiced by some airlines

E. SOW: The purpose of this project is to develop government and air carrier policies and procedures in the areas of communications, education, **training** and SOP's in order to reduce injuries due to anticipated and unanticipated turbulence. A specific goal is training of flight attendants to understand turbulence and how to better safeguard themselves. Communications between pilots and flight attendants to accurately apprise each other of actual or predicted turbulence conditions must be improved. The flying public must be educated about the dangers of turbulence and the proper procedures to ensure their safety. And, policy and procedures to carry out the above goals must be developed. Airlines must:

- Develop training programs to provide flight attendants with more information about the nature turbulence, the effects on aircraft and the hazards that may occur.(624)

- Develop training programs to educate flight attendants on the importance of putting their own safety first during turbulence.(624)

- Develop standardized cockpit-cabin turbulence procedures and phraseology to be incorporated into existing training programs.(601)
- Develop programs for flight attendants to teach them the importance of preflight briefings and in-flight updates in regard to weather and turbulence and planning of cabin service.(623)

Stakeholders: Airlines, flight attendant and pilot unions, FAA

Potential Impact: Quickly implemented, low cost, heighten flight attendant safety awareness, and reduce flight attendant injuries.

Current status: Various programs are underway within the industry

F. SOW: The purpose of this project is to minimize the potential for injury to flight attendants and passengers through pre-encounter preparation and procedures, reduction in cabin design hazards, and turbulence injury potential awareness training.

Options:

- Establish policy and procedures for flight attendants to remain seated during critical exposure periods of initial climb out and final descent. [622]

- Establish policy and procedures for prioritization of flight attendant duties during period prior to imminent turbulence encounter. [623]

- Develop and implement standardized procedures and phraseology for preflight and inflight communications of anticipated turbulence encounters. [601]

- Provide for improved handhold, padding and restraint in cabin interiors and of equipment through upgrade on attrition or new aircraft acquisition basis. Maximum use of off the shelf products and technology. [625]

- Establish flight attendant education and training program to educate on the hazards of turbulence and need to prioritize duties with respect to potential of self-injury. [624]

Stakeholders: Airlines, FAA, Flight Attendant unions.

Potential Impact: Very low overall financial costs. Ability to leverage best practices. Directly addresses major injury category of flight attendant.

Current Status: Various programs in existence. Suitable cabin equipment currently available.

Project Planning Leader: Bob Frantz, ALPA
Felice Brunner, FAA

Detailed Plan By: 1 May 2001

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Turbulence
Joint Safety Implementation Team

Implement Best Practices for Turbulence Avoidance

Executive Summary

Statement of Work: Develop government and air carrier policies and procedures that will minimize inadvertent turbulence encounters through the implementation of the "best practices" outlined in AC00-30b. The model program defined in the AC for carriers calls for turbulence avoidance as the first line of defense. It also outlines a comprehensive program of acquisition and use of turbulence information plus comprehensive initial and recurrent meteorological training standards for aircrews, dispatchers, and meteorologists. This project, building upon the structure of the AC, identifies actions to be performed by both government and the carriers to fulfill the intent of AC00-30b.

The principal provisions of AC00-30b "Best Practices" are:

- Adopt the corporate philosophy of avoidance of turbulence as first line of defense.
- Use all applicable weather data and products including alphanumeric wx information such as METARS, area forecasts and TAFs, wind & temp forecasts, NWS in-flight advisories (SIGMETS, Convective SIGMETS and AIRMETS), upper air charts, graphical radar summaries or composites, and satellite imagery.
- Use sophisticated product generation to merge diverse sources into graphical products to track turbulence.
- Compile turbulence information, including PIREPs, and make it easily accessible to controllers and dispatchers.
- Ensure timely and accurate pilot reporting (PIREPs). [see Quality Project]
- Ensure efficient air-ground and ground-ground communication system for exchange of turbulence information to and between aircrew, dispatcher and meteorological support function.
- Maintain dedicated and continuous training program for aircrews, dispatchers, meteorologists, and other operational control personnel.

Lead Organization for Overall Project Coordination: Air Transport Association (ATA)

Safety Enhancement 1/71: Reduce the turbulence accident rate by developing and implementing a corporate culture in all airlines that views turbulence avoidance as the first line of defense [616].

JIMDAT #:	0.4 Full	2020: 0.3	2007: 0.3
InjryRdxIndx:	0.06 Full	2020: 0.05	2007: 0.05

Resources: $2.1M (See Resource Template for Details)

Completion Date: 24-60 months

Output: Develop and implement corporate culture in all airlines that views turbulence avoidance as the first line of defense [616].

Lead Organization for Output Coordination: ATA/Operations Committee

Resources: ATA, RAA, FAA

Timeline: 24-60 months

Actions:

- **Airlines** - Implement dispatch and flight operations policies that require mandatory re-routing around forecast/observed significant clear air turbulence, as well as maintaining standard clearance between thunderstorms and aircraft. Prerequisite: Implementation of JSIT Turbulence Project to "Improve the Quality of Turbulence Information."

- **Airlines/FAA** - As new turbulence re-route and thunderstorm clearance policies are adopted, revise/amend airline OpSpecs accordingly.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** All participating airlines to adopt new clear air turbulence and thunderstorm avoidance operating policies.

- **Indicator:** ATA will survey airlines at 12-month intervals to determine level of implementation.

Safety Enhancement 2/72: Improve situational awareness by establishing corporate communication systems that ensure collection of all available turbulence information (forecasts and observations), and the subsequent timely distribution of that information to dispatchers and aircrews [607, 616], and controllers, airline meteorological support functions, and NWS [617].

JIMDAT#:	0.0 Full	2020: 0.0	2007: 0.0
InjryRdxIndx:	0.04 Full	2020: 0.03	2007: 0.03

Resources: $22.6M (See Resource Template for Details)

Completion Date: 12-36 months

Output 1: Establish corporate communication systems that ensure collection of all available turbulence information (forecasts and observations), and the subsequent timely distribution of that information to dispatchers and aircrews [607, 616].

Lead Organization for Output Coordination: ATA/Operations Committee

Resources: ATA, RAA, FAA

Timeline: 12-36 months

Actions:

- **Airlines/FAA -** Develop and implement standard and procedures on communications for collection and distribution of observed and forecast turbulence information.

- **Airlines -** Develop and implement training programs in accordance with these standards.

- **FAA -** Review current FAA Order 8400.10, Volume 3, Chapter 7 (Aviation Weather Systems), Paragraphs 1423, 1425, 1427, and 1457 "C" on airline communications systems in light of the industry standards and modify the Order to eliminate provisions that are unneeded and inconsistent with the industry standards.

Output 2: Ensure timely distribution of all critical turbulence information to and between aircrew, dispatcher, controller, airline meteorological support function, and NWS [617].

Lead Organization for Output Coordination: ATA/Air Traffic Operations and Meteorology

Resources: ATA, FAA, NWS, RAA, ARINC, Commercial Weather Vendors

Timeline: 12-36 months.

Actions:

- **Airlines/FAA/NWS/ARINC** – Conduct system-wide assessment of communications/distribution system for gridded, alpha-numeric, and graphical image turbulence information in the NAS and develop a plan for needed upgrades in ground-to-ground and ground-to-air systems.

- **Airlines/FAA/NWS** – Implement the upgrade plan through a cost-effective mix of Internet, Intranet and other communications systems.

- **Airlines/Vendors/FAA** – Develop a tailored "forced" cockpit uplink for critical alpha/numeric reports and forecasts, followed up with a comparable graphic product to take advantage of evolving cockpit display technology.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal, Output 1:** All participating airlines to adopt communications systems that improve in-house collection and distribution of turbulence data.
- **Indicator, Output 1:** Increased volume of turbulence reports and information being relayed to dispatchers and crews.

- **Goal, Output 2:** Government and industry to develop systems to improve volume, timeliness, and distribution of turbulence information.
- **Indicator, Output 2:** Timely and complete distribution of turbulence information to dispatchers, pilots, controllers, and meteorologists.

Safety Enhancement 3/73: Improve situational awareness by developing effective graphical turbulence products that synthesize observations, forecasts, "nowcasts", output from meteorological algorithms, and models [614].

JIMDAT#:	1.0 Full	2020: 0.0	2007: 0.0
InjryRdxIndx:	0.04 Full	2020: 0.03	2007: 0.03

Resources: **$4.9M (See Resource Template for Details)**

Completion Date: 12-60 months

Output: Develop effective graphical turbulence products that synthesize observations, forecasts, "nowcasts", output from meteorological algorithms, and models [614].

Lead Organization for Output Coordination: FAA/AUA-400

Resources: FAA, ATA, RAA, NCAR, NWS, FSL

Timeline: 12-60 months

Actions:

- **FAA/NCAR/FSL/NWS/Airlines -** Continue to test products that synthesize observations, forecasts, nowcasts, and model output.

- **FAA/NCAR/FSL/NWS/Airlines -** Define next generation ground display requirements, and develop follow-on data assimilation and depiction systems.

- **NWS/FSL -** Develop a plan for the operational implementation of a four-dimensional turbulence forecast product that assimilates objective EDR data.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Improved situational awareness for pilots, controllers, and dispatchers.
- **Indicator:** Availability of an integrated, graphical, operational government/industry turbulence product.

Safety Enhancement 4/74: Improve overall knowledge of turbulence and effective operational techniques by instituting comprehensive turbulence training for aircrews, dispatchers, and meteorologists [609].

JIMDAT#:	1.0 Full	2020: 0.0	2007: 0.0
InjryRdxIndx:	0.11 Full	2020: 0.09	2007: 0.09

Resources: ***$8.2M (See Resource Template for Details)***

Completion Date: 12-24 months

Output: Institute comprehensive turbulence training for aircrews, dispatchers, and meteorologists [609].

Lead Organization for Output Coordination: ATA/Operations Committee

Resources: ATA, FAA, RAA, Commercial Weather Vendors

Timeline: 12-24 months

Actions:

- **ATA/RAA/FAA** – Survey current industry training programs, and develop minimum turbulence training standards.

- Airline/Vendors - Develop and implement training programs in accordance with the standards.

- FAA – Review current FAA Order 8400.10, Chapter 2 (Airman Training Programs, Paragraphs 379/439, and Chapter 5 (Dispatcher Training Requirements), Paragraphs 1093/1121 and modify the Order as necessary to eliminate provisions that are unneeded and inconsistent with the industry standards.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Comprehensive turbulence training programs instituted at all participating airlines.
- **Indicator:** Improved operational decision-making by pilots, dispatchers, and meteorologists, and a corresponding reduction in the number of turbulence injuries.

Turbulence
Joint Safety Implementation Team

Improve the Quality of Turbulence Information

Executive Summary

Statement of Work: Improve the quality and quantity of turbulence information used to support strategic flight planning and in-flight routing in order to efficiently avoid turbulence. Included are programs to increase the number and quality of turbulence observations to pinpoint the current location and severity of turbulence, initiatives to improve the accuracy of turbulence forecasts, and plans to develop consistent turbulence standards and metrics.

Lead Organization for Overall Project Coordination: FAA/ARS-1

Safety Enhancement 5/75: Enhance situational awareness by increasing the quantity of turbulence observations through additional manual PIREPs [618], new automated aircraft-based observations [621], other potential non-airborne sources [628], and ensure full distribution of reports to all users [617].

JIMDAT#:	1.0 Full	2020: 0.4	2007: 0.3
InjryRdxIndx:	0.14 Full	2020: 0.11	2007: 0.11

Resources: $11.15M (See Resource Template for Details)

Completion Date: 6-36 months

Output: Increase the quantity of turbulence observations through additional manual PIREPs [618], new automated aircraft-based observations [621], and other potential non-airborne sources [628], and ensure full distribution of reports to all users [617].

Lead Organization for Output Coordination: FAA/ARS-100

Resources: FAA, ATA, RAA, NAATS, NATCA, NWS, NCAR, ARINC, Pilot Unions

Timeline: 6-36 months

Actions:

- **Airlines/NWS** – Develop and implement a program to distribute in-house manual pilot reports to NWS/FAA.
- **Airlines** -- Train crews to follow established "PIREP" reporting procedures and encourage use of Flight Watch for PIREP input.
- **FAA** – Automate ARTCC/Terminal entry of manual PIREP.
- **FAA/NCAR/Airlines** – Install Eddy Dissipation Rate (EDR) and supporting weather downlink software at all ACARS airlines.
- **FAA/ATA/RAA/NAATS/NATCA** – Assess the utility to pilots, in terms of human factors and cost-effectiveness, of real-time cross linking (from one aircraft to another) of EDR reports.
- **FAA/ATA/RAA/ARINC** – Ensure that future data link systems (post-ACARS) accommodate EDR reporting.
- **All organizations** – Institute a PIREP awareness campaign.
- **FAA/NASA** – Assess feasibility of satellite or ground based real-time turbulence warnings for aircraft in flight.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Improved knowledge about the current state and distribution of atmospheric turbulence.
- **Indicator:** Increased volume and distribution of turbulence reports.

Safety Enhancement 6/76: Fifty to sixty percent reduction in turbulence encounters through improved forecast accuracy - develop systems to forecast verifiable moderate and severe turbulence events to performance metrics of 80% Probability of Detection "yes" (PODy) and 85% Probability of Detection "no" (PODn), so that dispatchers have the confidence to routinely route aircraft around turbulence forecast areas, and operate a verification system to track operational performance against these metrics [619].

JIMDAT#:	1.0 Full	2020: 0.1	2007: 0.0
InjryRdxIndx:	0.11 Full	2020: .09	2007: 0.09

Resources: ***$12.6M (See Resource Template for Details)***

Completion Date: 24-60 months

Output: Improve forecast accuracy of verifiable moderate and severe turbulence events to performance metrics of 80% Probability of Detection "yes" (PODy) and 85% Probability of Detection "no" (PODn), so that dispatchers have the confidence to routinely route aircraft around turbulence forecast areas, and operate a verification system to track operational performance against these metrics [619].

Lead Organization for Output Coordination: FAA, AUA-400

Resources: FAA, NCAR, NWS, FSL, ATA, NASA

Timeline: 24-60 months.

Actions:

- **NCAR** – Develop automated turbulence forecast algorithm utilizing all turbulence information including EDR reports.
- **NWS (AWC)/Airlines** – Improve manual/automated turbulence forecast.
- **NOAA /FSL/NWS** – Develop/Implement turbulence forecast verification system.
- **Airlines/FAA/NCAR/NWS** – Consider the "Collaborative Convective Forecasting Product – CCFP" approach to turbulence forecasting.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Government and industry to develop improved turbulence forecasts.
- **Indicator:** Operational forecasts of moderate and severe turbulence that verify to performance metrics of 80% Probability of Detection "yes" (PODy) and 85% Probability of Detection "no" (PODn).

Safety Enhancement 7/77: Improve situational awareness and the operational utility of observations and forecasts by standardizing turbulence terminology (ride reports) [615] and by making forecasts and warnings aircraft category specific [619].

JIMDAT#:	1.0 Full	2020: 0.7	2007: 0.0
InjryRdxIndx:	0.11 Full	2020: 0.09	2007: 0.09

Resources: ***$3.7M (See Resource Template for Details)***

Completion Date: 24-60 months

Output:
Increase operational utility of observations and forecasts by standardizing turbulence terminology (ride reports) [615] and by making forecasts and warnings aircraft category specific [619].

Lead Organization for Output Coordination: FAA/AUA-400

Resources: FAA, ATA, RAA, NCAR, NWS, FSL, NASA

Timeline: 24-60 months

Actions:

- **FAA/NWS/NASA/Airlines** – Adopt EDR as the industry-wide, aircraft independent metric for measuring atmospheric turbulence.

- **FAA/NCAR/NASA/Airlines** – Develop an industry "ride report" standard that is aircraft category specific, and that is calibrated to an objective in-situ measure of turbulence (EDR).

- **FAA/NCAR/Airlines/NWS** – Develop an industry "concept of operations" that defines how both the objective measure of turbulence (EDR) and ride report information is communicated and used by flight crews, dispatch functions, weather information services, and air traffic control. Include a definition of where in the infrastructure the conversion to/from EDR and ride report is accomplished. Requires coordination with Red Team.

- **FAA/NCAR/FSL/NWS/Airlines** – Develop an industry standard that defines how turbulence warning and forecast products are generated to be both aircraft category specific, and still meet the needs of dispatchers, weather information services, and air traffic control.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Standardizing turbulence terminology and developing aircraft category specific products.
- **Indicator:** Participating airlines adopt the EDR reporting standard, and a government/industry standard is developed for distribution of turbulence information that is adaptable for delivery to both aircraft (category specific) and ground support personnel.

Safety Enhancement 8/78: Reduce convective turbulence injury rate by 50% through the development and implementation of scientifically valid horizontal and vertical clearance standards between aircraft and convective activity [608].

JIMDAT#:	0.4 Full	2020: 0.3	2007: 0.3
InjryRdxIndx:	0.06 Full	2020: 0.05	2007: 0.05

Resources: $4.0M (See Resource Template for Details)

Completion Date: 12-60 months

Output: Develop scientifically valid horizontal and vertical clearance standards between aircraft and convective activity to reduce inadvertent turbulence encounters [608].

Lead Organization for Output Coordination: FAA/AUA-400

Resources: FAA, ATA, RAA, NCAR, NWS, NASA

Timeline: 12-60 months

Actions:

- Airlines/FAA/NCAR/NASA – Review current industry clearance standards between aircraft and thunderstorms.
- NCAR/NASA – Complete research to determine scientifically valid standards.
- Airlines/FAA – Train flight crews to new standards.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Government and industry to develop scientifically valid thunderstorm clearance standards.
- **Indicator:** Adoption of new clearance standards by the airlines and a corresponding reduction in convective turbulence injuries.

Turbulence
Joint Safety Implementation Team

Enhanced Airborne Turbulence Warnings

Executive Summary

Statement of Work: Provide improved, real-time detection, warning, and situational awareness for pilot avoidance actions regarding impending turbulence; and provide enhanced in situ turbulence information to nearby aircraft and ground forecasters. Achieve these improvements through application of an airborne, aircraft-independent turbulence metric and development and implementation of cockpit displays of turbulence information, improved or new on-board look-ahead turbulence detection capabilities, and upgraded flight crew procedures designed to avoid turbulence. Use best industry practices and computer-human interface (CHI) standards in development of cockpit displays and aircrew procedures for use of enhanced turbulence information.

Lead Organization for Overall Project Coordination (LOOPC): NASA-Aviation Safety Program

Safety Enhancement 9/64: To assist in the selection of optimal flight routes around turbulence, develop and implement a carry-on capability for real-time graphical flight deck display for integration of multiple airborne and ground-based turbulence and weather data sources. Also develop and implement industry best practices and procedures to make effective use of the improved information.

JIMDAT#:	0.9 Full	2020: 0.4	2007: 0.2
InjryRdxIndx:	0.0 Full	2020: 0.0	2007: 0.02

Resources: $42.75M (See Resource Template for Details)

Completion Date: CY2004

Output: Develop and implement a carry-on capability for real-time graphical flight deck display for integration of multiple airborne and ground-based turbulence and weather data sources to assist with the selection of optimal flight routes around turbulence [613] [621].

LOOC: NASA–Aviation Safety Program–Weather Accident Prevention Element

Resources: NASA, Manufacturers, Airlines, FAA (AFS/Human Factors), ATC

Timeline: **Present -** CY2004

Actions:

- **FAA/NASA/ATA, RAA/AIA, Boeing, Airbus** -- Evaluate alternative architectures for integrating uplinked and onboard data, in industry standard format, making maximum utilization of existing communication data links.

- **NASA** -- Facilitate demonstrations of real time graphical flight deck displays.

- **NASA/FAA/Boeing/Airbus** – Set standards for alternate display systems (such as PC based options) incorporating (CHI) Best practices and standards for real-time graphical flight deck display systems design to enhance and support integration of weather and turbulence data sources.

- **NASA/FAA/ Boeing/Airbus** -- Develop and implement algorithms to display turbulence derived from Eddy Dissipation Rate (EDR), radar, lidar or other airborne sensors in ownship flight deck.

- **Boeing/Airbus/airlines/employee organizations** – Develop improved weather avoidance operating procedures enabled by improved turbulence information in the cockpit using industry best practices and standards as well as CHI design.

- **Airlines** – Implement new procedures.

- **FAA –**Review current FAA Order 8400.10 in light of the industry standards and modify the Order to eliminate provisions that are unneeded and inconsistent with the industry best practices and standards.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Carry-on capability for Real Time Integrated Multiple Source Weather/Turbulence Display with published guidelines for avoiding turbulence hazards.
- **Indicator:** 30% of fleet contains some form of integrated graphical weather/turbulence display.

Safety Enhancement 10/65: To assist in selection of the best flight route around turbulence, develop and implement fully integrated turbulence information capabilities for real-time graphical flight deck display for integration of multiple airborne and ground-based turbulence and weather data sources and develop and implement industry best practices and procedures to make effective use of the improved information. Implement this capability for new aircraft and scheduled upgrades of recent technology displays.

JIMDAT#:	0.9 Full	2020: 0.4	2007: 0.0
InjryRdxIndx:	0.05 Full	2020: 0.04	2007: 0.02

Resources: $61.25M (See Resource Template for Details)

Completion Date: CY2007

Output: Develop and implement fully integrated turbulence information capabilities for real-time graphical flight deck display for integration of multiple airborne and ground-based turbulence and weather data sources to assist selection of best route of flight around turbulence [613] [621].

LOOC: NASA–Aviation Safety Program–Weather Accident Prevention Element

Resources: NASA, Manufacturers, Airlines, FAA (AFS/Human Factors), ATC

Timeline: **Present -** CY2007

Actions:

- **FAA/NASA/ATA, RAA/AIA, Boeing, Airbus** -- Evaluate alternative architectures for integrating uplinked and onboard data, in industry standard format, making maximum utilization of existing communication data links.

- **NASA** -- Facilitate demonstrations of real time graphical flight deck displays.

- **NASA/FAA/Boeing/Airbus** – Set standards for alternate display systems (such as PC based options) incorporating (CHI) Best practices and standards for real-time graphical flight deck display systems design to enhance and support integration of weather and turbulence data sources.

- **NASA/FAA/ Boeing/Airbus** -- Develop and implement algorithms to display turbulence derived from Eddy Dissipation Rate (EDR), radar, lidar or other airborne sensors in ownship flight deck.

- **Boeing/Airbus/airlines/employee organizations** – Develop improved weather avoidance operating procedures enabled by improved turbulence information in the cockpit using industry best practices and standards as well as CHI design.
- **Airlines** – Implement new procedures.

- **FAA –** Review current FAA Order 8400.10 in light of the industry standards and modify the Order to eliminate provisions that are unneeded and inconsistent with the industry Best practices and standards.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Real Time Integrated Multiple Source Weather/Turbulence Display with published guidelines for avoiding turbulence hazards.
- **Indicator:** 15% of fleet contains some form of integrated graphical weather/turbulence display.

Safety Enhancement 11/66: Provide in-flight warning of impending convective turbulence encounters for ownship through development, validation, implementation, certification, and deployment of forward-looking, radar-based remote sensor capability to estimate a RMS normal acceleration-based hazard metric. Implement these capabilities for new commercial aircraft.

JIMDAT#:	1.0 Full	2020: 0.4	2007: 0.1
InjryRdxIndx:	0.14 Full	2020: 0.11	2007: 0.04

Resources: $57.75M (See Resource Template for Details)

Completion Date: 4th Qtr CY2003

Output: Develop, validate, implement, certify and deploy forward-looking, radar-based remote sensor capability to estimate an RMS normal acceleration-based hazard metric to provide in-flight warning of impending convective turbulence encounters.[628] [621]

LOOC: NASA–Aviation Safety Program–Weather Accident Prevention Element

Resources: NASA, FAA, NCAR, Manufacturers, and Airlines

Timeline: Present to 4th Qtr CY2003

Actions:

- **NASA/NCAR** -- Develop aircraft response algorithms to be applied to the aircraft hazard metric (RMS normal acceleration) to serve as basis of radar based turbulence sensor development and certification.

- **NASA** -- Validate models and hazard metric.

- **AIA, Boeing, Airbus** -- Upgrade existing weather radar with output suitable for providing warning to ownship flight deck.

- **NASA AvSP Turbulence Team** --Develop technical specifications and flight deck interfaces (CHI design) for the upgraded turbulence radar.

- **ATA, RAA** -- Conduct in-service flight trials to determine the effectiveness of the turbulence detection algorithms.

- **NASA** -- Assist with the flight trials, post-flight data analysis and confirm turbulence-warning performance.

- **Airlines/FAA** – Develop industry standard operating procedures and training programs for flight crews to utilize the warnings.

- **FAA** --. Review current FAA Order 8400.10 in light of the industry standards and modify the Order to eliminate provisions that are unneeded and inconsistent with the industry Best practices and standards. Monitor the trials and approve certification of the upgraded weather radar system.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Real Time Alerting Sensor for Convective Related Turbulence with published turbulence hazard avoidance guidelines in place.
- **Indicator:** 30% of the fleet contains enhanced turbulence radar

Safety Enhancement 12/67: Provide in-flight warning of impending convective turbulence encounters for ownship through development, validation, implementation, certification, and deployment of forward-looking, radar-based remote sensor capability to estimate a RMS normal acceleration-based hazard metric. Implement these capabilities for *legacy windshear equipped* commercial aircraft. [Note, this SE is the same as SE10 except that it applies only to *legacy windshear equipped* commercial aircraft.]

JIMDAT#:	1.0 Full	2020: 0.0	2007: 0.0
InjryRdxIndx:	0.0 Full	2020: 0.0	2007: 0.04

Resources: $70.3M (See Resource Template for Details)

Completion Date: 4th Qtr CY2003

Output:

LOOC: NASA–Aviation Safety Program–Weather Accident Prevention Element

Resources: NASA, FAA, NCAR, Manufacturers, and Airlines

Timeline: Present to 4th Qtr CY2003

Actions: [These actions are identical to those for SE10.]

- **NASA/NCAR** -- Develop aircraft response algorithms to be applied to the aircraft hazard metric (RMS normal acceleration) to serve as basis of radar based turbulence sensor development and certification.
- **NASA** -- Validate models and hazard metric.
- **AIA, Boeing, Airbus** -- Upgrade existing weather radar with output suitable for providing warning to ownship flight deck.
- **NASA AvSP Turbulence Team** --Develop technical specifications and flight deck interfaces (CHI design) for the upgraded turbulence radar.
- **ATA, RAA** -- Conduct in-service flight trials to determine the effectiveness of the turbulence detection algorithms.
- **NASA** -- Assist with the flight trials, post-flight data analysis and confirm turbulence-warning performance.
- **Airlines/FAA** – Develop industry standard operating procedures and training programs for flight crews to utilize the warnings.
- **FAA** -- Assure current FAA Order 8400.10 supports the industry Best practices and standards. Monitor the trials and approve certification of the upgraded weather radar system.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Real time alerting sensor for convective related turbulence with published turbulence hazard avoidance guidelines in place.
- **Indicator:** 30% of the fleet contains enhanced turbulence radar

Safety Enhancement 13/68: Provide in-flight warning of impending convective turbulence encounters for ownship through development, validation, implementation, certification, and deployment of forward-looking, radar-based remote sensor capability to estimate a RMS normal acceleration-based hazard metric. Implement these capabilities for *legacy non-windshear*

equipped commercial aircraft. [Note, this SE is the same as SE10 and SE11 except that it applies only to *legacy* ***non****-windshear equipped* commercial aircraft.]

JIMDAT#:	0.0 Full	2020: 0.0	2007: 0.0
InjryRdxIndx:	0.0 Full	2020: 0.0	2007: 0.01

Resources: $70.5M (See Resource Template for Details)

Completion Date: 4th Qtr CY2005 (two years longer to allow for retrofit market)

Output:

LOOC: NASA–Aviation Safety Program–Weather Accident Prevention Element

Resources: NASA, FAA, NCAR, Manufacturers, and Airlines

Timeline: Present to 4th Qtr CY2003

Actions: [These actions are identical to those in SE10 and SE11.]

- **NASA/NCAR** -- Develop aircraft response algorithms to be applied to the aircraft hazard metric (RMS normal acceleration) to serve as basis of radar based turbulence sensor development and certification.
- **NASA** -- Validate models and hazard metric.
- **AIA, Boeing, Airbus** -- Upgrade existing weather radar with output suitable for providing warning to ownship flight deck.
- **NASA AvSP Turbulence Team** --Develop technical specifications and flight deck interfaces (CHI design) for the upgraded turbulence radar.
- **ATA, RAA** -- Conduct in-service flight trials to determine the effectiveness of the turbulence detection algorithms.
- **NASA** -- Assist with the flight trials, post-flight data analysis and confirm turbulence-warning performance.
- **Airlines/FAA** – Develop industry standard operating procedures and training programs for flight crews to utilize the warnings.
- **FAA** -- Review current FAA Order 8400.10 in light of the industry standards and modify the Order to eliminate provisions that are unneeded and inconsistent with the industry Best practices and standards.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Real Time Alerting Sensor for Convective Related Turbulence with published guidelines for use of warnings for turbulence avoidance.

- **Indicator:** An additional 10% of the fleet contains enhanced turbulence radar

Safety Enhancement 14/69: Provide in-flight warning of impending turbulence encounters through research, development, validation, implementation, certification, and deployment of new (next generation) forward-looking, remote sensor capability (i.e. Lidar, Radiometery). Implement these capabilities for new commercial aircraft.

JIMDAT#:	0.0 Full	2020: 0.0	2007: 0.0
InjryRdxIndx:	0.09 Full	2020: 0.07	2007: 0.01

Resources: Initial: $535.25M (See Resource Template for Details)

Completion Date: 4th Qtr CY2005

Output: Develop, validate, implement, certify, and deploy **new** (next generation) forward-looking, remote sensor capability (i.e. Lidar, Radiometry). Estimate an RMS normal acceleration-based hazard metric to provide in-flight warning of impending turbulence encounters for ownship. [628] [621]

LOOC: NASA–Aviation Safety Program–Weather Accident Prevention Element

Resources: FAA, NASA, NCAR, AIA, Boeing, Airbus

Timeline: Present to 4th Qtr CY2005

Actions: [These actions are identical to actions for SE10-12 except for additions shown in *italics* and strikeouts.]

- **NASA/NCAR** -- Develop aircraft response algorithms to be applied to the aircraft hazard metric (RMS normal acceleration) to serve as basis of radar based turbulence sensor development and certification.

- **NASA** -- Validate models and hazard metric.

- **AIA, Boeing, Airbus** -- Upgrade turbulence *warning systems* with output suitable for *data linking to other users.*

- **NASA AvSP Turbulence Team** --Develop technical specifications and flight deck interfaces (CHI design) for *turbulence warning information.*

- ***Airlines –*** *Develop a minimum acceptable level of performance (in terms of warning lead time and reliability) on which to base a deployment go/no go decision.*

- **ATA, RAA** -- Conduct in-service flight trials to determine the effectiveness of the turbulence *warning strategy and to assess whether the minimum acceptable level of performance has been met to support industry-wide deployment.*

- **NASA** -- Assist with the flight trials, post-flight data analysis and confirm turbulence-warning performance.

- **Airlines/FAA** – Develop industry standard operating procedures and training programs for flight crews to utilize the warnings.

- **FAA** --. Review current FAA Order 8400.10 in light of the industry standards and modify the Order to eliminate provisions that are unneeded and inconsistent with the industry best practices and standards. Monitor the trials and approve certification of the upgraded weather radar system.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Real Time Alerting Sensor for Clear Air Turbulence with published turbulence hazard avoidance guidelines in place.
- **Indicator:** 10% of the fleet contains next generation CAT sensor

Safety Enhancement 15/70: Provide in-flight warning of impending turbulence encounters through research, development, validation, implementation, certification, and deployment of **new** (next generation) forward-looking, remote sensor capability (i.e. Lidar, Radiometery). Implement these capabilities for legacy commercial aircraft.

JIMDAT#:	0.6 Full	2020: 0.5	2007: 0.5
InjryRdxIndx:	0.00 Full	2020: 0.00	2007: 0.00

Resources: $33.75M (See Resource Template for Details)

Completion Date: 4th Qtr CY2007

Output: Develop, validate, implement, certify and deploy forward-looking, radar-based and lidar-based remote sensor capability to estimate a normal acceleration-based hazard metric to provide in-flight warning of potential convective turbulence encounters for aircraft in the ownship vicinity. Provide EDR downlinked input to turbulence nowcast and forecast systems.[628] [621]

LOOC: NASA–Aviation Safety Program–Weather Accident Prevention Element

Resources: NASA, FAA, NCAR, Manufacturers, and Airlines

Timeline: Present to 4th Qtr CY2007

Actions:

- **NASA/NCAR** -- Develop aircraft response algorithms to be applied to the aircraft hazard metric (normal acceleration) to serve as basis of radar based turbulence sensor development and certification.

- **NASA** -- Validate models and hazard metric.

- **AIA, Boeing, Airbus** -- Upgrade turbulence warning systems with output suitable for data linking to other users.

- **Airlines** – Develop a minimum acceptable level of performance (in terms of warning lead time and reliability) on which to base a deployment go/no go decision.

- **NASA AvSP Turbulence Team** --Develop technical specifications and flight deck interfaces (CHI design) for the turbulence warning information.

- **ATA, RAA** -- Conduct in-service flight trials to determine the effectiveness of the turbulence warning strategy and to assess whether the minimum acceptable level of performance has been met to support wide-spread deployment.

- **NASA** -- Assist with the flight trials, post-flight data analysis and confirm turbulence-warning performance.
- **Airlines/FAA** – Develop industry standard operating procedures and training programs for flight crews to utilize the warnings.

- **FAA** -- Review current FAA Order 8400.10 in light of the industry standards and modify the Order to eliminate provisions that are unneeded and inconsistent with industry Best practices and standards. Monitor the trials and approve certification of the turbulence warning system.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Real Time Alerting Sensor for Convective Related Turbulence to aircraft in ownship vicinity and downlinked EDR-based turbulence reports with turbulence hazard avoidance guidelines in place.
- **Indicator:** An additional 10% of the fleet contains proximate aircraft warning and EDR downlink capability.

Turbulence
Joint Safety Implementation Team

Cabin Injury Reduction During Turbulence

Executive Summary

Statement of Work: Reduce turbulence injuries to flight attendants and passengers through improved situational awareness, turbulence encounter management procedures (before, during and after encounter), enhanced communication and identification of effective cabin design safety features.

Lead Organization for Overall Project Coordination (LOOPC): ATA

Safety Enhancement 16/79: Develop guidance and implement procedures for reducing flight attendant exposure to turbulence.

JIMDAT#:	0.0	Full	2020: 0.0	2007: 0.0
InjryRdxIndx(Phase1):	0.20	Full	2020: 0.15	2007: 0.15

Resources: $0.75M (Phase 1, Outputs 1-3) '07 Imp: 100% (Phase 1)
$0.42M (Phase 2, Outputs 4-7) '07 Imp: 100% (Phase 2)
(See Resource Template for Details)

Phase I

- Steering committee with 12 months to collect and consolidate turbulence procedures best practices and to produce one comprehensive document that addresses Safety Enhancements 16, 17, 18, 19, and 20.

- One FAA Flight Standards staff (Cabin Safety) with 1 month to take final work product from steering committee to evaluate, review and format the information into an Advisory Circular, then guide the Advisory Circular through FAA coordination and publication.

- One FAA Flight Standards staff (Cabin Safety) with 1 week to review current Order 8400.10 and propose revisions needed to incorporate information and best practices contained in the published Advisory Circular.

- One FAA staff with one year to update existing turbulence training video or create other training aids for flight attendants, pilots, and dispatchers.

- Two employees from each air carrier, one from airline flight attendant training/safety department and one from airline flight department with approximately one week to develop the procedural and training requirement supporting the best practices contained in the Advisory Circular (these would be included in initial and recurrent crewmember training.

- **Note: Whenever an Advisory Circular is mentioned in this project, we are referring to one Advisory Circular that addresses Safety Enhancements 16, 17, 18, 19 and 20.**

Phase II

- One NASA-AMES researcher with two years to develop and administer the human factors survey.

- Two air carrier representatives, one from airline flight attendant training/safety department and one from airline flight department for approximately two weeks to assist with initial concept of the human factors survey.

- One FAA Flight Standards staff (Cabin Safety) with one month to revise current Advisory Circular to incorporate research results.

Completion Date: Phase I: 15 months; Phase II: 2 years

Output: Develop guidance and implement procedures for reducing flight attendant exposure to turbulence. (622,623,624)

LOOC: ATA

Resources: Steering committee comprised of ATA, Cabin Operations Committee/Flight Operations Committee, Airlines (Directors of Operations and Safety), Flight Attendant Unions, Pilot Unions

Additional Resources: NASA-AMES, FAA (CAMI), George Washington University, FAA/AFS-200 (Cabin Safety), ATA (Flight Safety Committee, Training Committee, Safety Council, Operations Council)

Timeline: 11 months

Actions:

- **STEERING COMMITTEE**
  --Collects airlines' best practices relating to turbulence procedures, including communication, in the cabin.
  --Consolidates these into an industry consensus of best practices that establish policy guidance for air carriers' procedures to include:
- Flight attendants to remain seated during critical exposure periods including climb and descent. (622)
- Flight attendants to be seated during periods of significant turbulence risk (622)
- Prioritizing flight attendant duties prior to and during turbulence encounters to minimize unnecessary flight attendant exposure. (623)
- Training of flight attendants in turbulence hazards, critical exposure periods, aircraft behavior in turbulence, the use of available aircraft handholds, and the need to ensure their own safety, so that they are equipped with the insights and knowledge required to prioritize cabin duties versus the risk of turbulence injuries. (624)

Airlines -- Revise flight attendant and pilot standard operating procedures and training programs to incorporate the recommendations and best practices contained in the Advisory Circular. (601)

- **FAA and Industry --** create training materials on turbulence (video or other products) based on best practices.
- **Airlines** -- Conduct the necessary training for flight attendants and pilots to implement the recommendations and best practices contained in the Advisory Circular. (601)
- **FAA/AFS-200 (Cabin Safety**)-- Take final work product from steering committee to evaluate, review and format the information into an Advisory Circular, then guide the Advisory Circular through FAA coordination and publication.
- **FAA/AFS-200 (Cabin Safety)**-- Review current Order 8400.10 and propose revisions needed to incorporate information and best practices contained in the published Advisory Circular.
- **NASA AMES** -- with the assistance of other resources, will complete research for human factors best practices for (1) increasing passenger use of seatbelts: and (2) ensuring the crewmembers understand turbulence policies, standardized procedures and phraseology.
- **ATA, Cabin Operations Committee** -- Evaluate the findings and create plan(s) to be implemented.
- **ATA, Cabin Operations Committee** -- Based on the findings of the research study and implementation plan, update/modify the above AC to include best practices.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Reduce Flight Attendant and Passenger exposure to turbulence by:
    - Writing and issuing an initial Advisory Circular to reflect known 'best practices' for Flight Attendant procedures and training in regard to minimizing injuries due to turbulence.
    - After evaluation of Human Factors research, update/modify current Advisory Circular to include best practices.

- **Indicator:** Part 121 Carriers implement 'best practices' including establishing policies and increasing turbulence awareness resulting in reduced injuries to flight attendants and passengers.

Safety Enhancement 17/80: Implement improved communications' procedures and standardized phraseology to enhance securing of the cabin in the face of turbulence. (601) (602)

JIMDAT#:	0.0 Full	2020: 0.0	2007: 0.0
InjryRdxIndx:	0.16 Full	2020: 0.13	2007: 0.13

Resources: $0.27M (See Resource Template for Details)

Resource Characteristics

- Steering committee with 6 months to collect, evaluate, and consolidate turbulence communication procedures and standardized phraseology best practices.

- One FAA Flight Standards staff (Cabin Safety) with one month to take final work product from steering committee to evaluate, review, and format the information into an Advisory Circular, then guide the Advisory Circular through FAA coordination and publication.

- One FAA Flight Standards staff (Cabin Safety) with 1 week to review current Order 8400.10 and propose revisions needed to incorporate information and best practices contained in the published Advisory Circular.

- Two employees from each air carrier, one from airline flight attendant training/safety department and one from airline flight department with approximately 1 week to develop the procedural and training requirement supporting the best practices contained in the advisory circular (these would be included in initial and recurrent crewmember training).

- **Note: Whenever an Advisory Circular is mentioned in this project, we are referring to one Advisory Circular that addresses Safety Enhancements 16, 17, 18, 19 and 20.**

Completion Date: 15 months

Output: Implement improved communications procedures and standardized phraseology to enhance securing of the cabin prior to the onset of turbulence. (601) (602)

LOOC: ATA, Cabin Operations Committee/Flight Operations Committee

Resources: Steering committee comprised of ATA, Cabin Operations Committee/Flight Operations Committee, Airlines (Directors of Operations and Safety), Flight Attendant Unions, and Pilot Unions

Additional Resources: NASA AMES, FAA (CAMI), George Washington University, FAA/AFS-200 (Cabin Safety), ATA (Flight Safety Committee, Training Committee, Safety Council, Operations Council)

Timeline: 14 months

Actions:

- **Steering Committee**
  --Collects and examines current airline operations identifying best practices for standardized procedures, phraseology, and related training to optimize critical two-way pre-flight and in-flight communications between the flight crew and the cabin crew regarding anticipated time, intensity and duration of impending turbulence encounters, and all clear declarations. (601)

  --Consolidate the good practice results into an industry consensus best practices advisory circular which identifies best practices in standardized procedures and phraseology and related training for critical two-way communications between the flight crew and the cabin crew regarding anticipated time, intensity and duration of impending turbulence encounters, and all clear declarations. (601)

- **Airlines** Revise flight attendant and pilot standard operating procedures and training programs to incorporate the recommendations and best practices contained in the Advisory Circular. (601)

- **Airlines** -- Conduct the necessary training for flight attendants and pilots to implement the recommendations and best practices contained in the Advisory Circular. (601)

- **FAA/AFS-200 (Cabin Safety**)-- Take final work product from steering committee to evaluate, review, and format the information into an Advisory Circular, then guide the Advisory Circular through FAA coordination and publication.

- **FAA/AFS-200 (Cabin Safety)--** Review current Order 8400.10 and propose revisions needed to incorporate information and best practices contained in the published Advisory Circular.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Improve Communications procedures by implementing:
  -- Best practices for 'two-way' communications between the flight crew and cabin crew regarding turbulence procedures.

- **Indicator:** --All Part 121 Air Carriers have implemented best practices regarding communications resulting in reduction in injuries to flight attendants and passengers.

Safety Enhancement 18/81: Identify low cost alternatives from existing technology for accomplishing instant (aircraft-wide, wireless) communications capability.

JIMDAT#:	0.0 Full	2020: 0.0	2007: 0.0
InjryRdxIndx:	0.00 Full	2020: 0.00	2007: 0.00

Resources: $0.35M (See Resource Template for Details)

Resource Characteristics:

- One NASA employee for six months.

- One FAA human factors employee for 6 months.

- Steering committee for 6 months to collect and consolidate turbulence procedures best practices and produce one comprehensive document that addresses Safety Enhancements 16, 17, 18, 19, and 20.

- One FAA Flight Standards employee (Cabin Safety) for one month to take final work product from steering committee to evaluate, review, and format the information into an Advisory Circular, then guide the Advisory Circular through FAA coordination and publication.

- One FAA Flight Standards employee (Cabin Safety) for 1 week to review current Order 8400.10 and propose revisions needed to incorporate information and best practices contained in the published Advisory Circular.
- **Note: Whenever an Advisory Circular is mentioned in this project, we are referring to one Advisory Circular that addresses Safety Enhancements 16, 17, 18, 19 and 20.**

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Completion Date: 1 year

Output: Conduct an evaluation of aircraft-wide wireless communications/human factors and incorporate recommendations into the Advisory Circular. (602)

LOOC: NASA

Resources: Steering committee comprised of NASA, ATA, Cabin Operations Committee/Flight Operations Committee, Airlines (Directors of Operations and Safety), Flight Attendant Unions, Pilot Unions, and FAA Human Factors

Additional Resources: FAA (CAMI), George Washington University, FAA/AFS-200 (Cabin Safety), ANM-100 ATA (Flight Safety Committee, Training Committee, Safety Council, Human Factors Committee, Operations Council)

Timeline: 1 year

Actions:

- NASA --Identify low cost alternatives from existing technology for accomplishing the needed instant (aircraft-wide, wireless) communications capability. (602)

- NASA—Conduct an evaluation of an aircraft-wide (wireless) communications system.(602)

- FAA Human Factors—Conduct an evaluation of an aircraft wide- (wireless) communications system.(602)

- Airlines—Determine whether the proposed communication system is technically mature and sufficiently cost-effective to implement.

- Airlines – Implement the communications system.
- FAA/AFS-200—Incorporate the results in the Advisory Circular that provides guidance to airlines on best alternatives for instant communications.(602)

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal**: Improve communications by developing and installing two way (wireless) communications systems in commercial aircraft.
- **Indicator:** Part 121 aircraft install wireless communications systems ____% of the commercial fleet.

Safety Enhancement 19/82: Evaluate, recommend, and provide guidance on products that include cabin safety design improvements (such as cabin handholds i.e. "Partition Flow Thru's " in galleys) which provide increased stability for the aircraft occupants during all levels of turbulence on new type certificated aircraft and new production cabin interiors.

JIMDAT#:	0.0 Full	2020: 0.0	2007: 0.0
InjryRdxIndx:	0.14 Full	2020: 0.11	2007: 0.04

Resources: $0.55M (See Resource Template for Details)

Resource Characteristics:

- Steering committee with 6 months to evaluate current aircraft cabin interior products while determining the best products that provide increased stability of occupants during all levels of turbulence for use in new aircraft and produce one comprehensive document that addresses Safety Enhancements 16, 17, 18, 19, and 20.

- One FAA Flight Standards staff (Cabin Safety) with 1 month to take final work product from steering committee to evaluate, review and format the information into an Advisory Circular, then guide the Advisory Circular through FAA coordination and publication.

- One FAA Flight Standards staff (Cabin Safety) with1 week to review current Order 8400.10 and propose revisions needed to incorporate information and best practices contained in the published Advisory Circular.

- Two employees from each air carrier, one from airline flight attendant training/safety department and one from airline flight department with approximately one week to develop the procedural and training requirement supporting the best practices contained in the Advisory Circular (these would be included in initial and recurrent crewmember training).

- **Note: Whenever an Advisory Circular is mentioned in this project, we are referring to one Advisory Circular that addresses Safety Enhancements 16, 17, 18, 19 and 20.**

Completion Date: 1 year

Output: Evaluate, recommend, and provide guidance on products which include cabin safety design improvements (such as handholds i.e. "Partition Flow-Thru's in galleys) which provide increased stability for the aircraft occupants during all levels of turbulence on new type certificated aircraft and new production cabin interiors. (625)

LOOC: ATA Cabin Operations Committee

Resources: Steering Committee comprised of ATA, Cabin Safety Committee/Flight Operations Committee, airlines (designated engineering representative), aircraft cabin design vendors, aircraft manufacturers, and flight attendant unions

Additional Resources: FAA/AFS-200 (Cabin Safety), FAA/ANM-100, FAA/AIR, and FAA/CAMI.

Timeline: 1 year

Actions:

- **Steering Committee**
  --Examines and evaluates current aircraft cabin interior products to identify those that provide increased stability of occupants during all levels of turbulence for use in new aircraft.
  -- Consolidates these into an industry consensus of best practices that establish policy guidance for air carriers to:
  --Develops aircraft cabin interior products that provide increased stability for occupants during all levels of turbulence. (625)
  --Develops air carrier procedures for flight attendants on the use of all aircraft cabin interior products that provide stability during all levels of turbulence.(625)
  --Develops and implements training for flight attendants on the availability and use of aircraft cabin interior products that provide stability during all levels of turbulence.(625)

- **FAA/AFS-200 (Cabin Safety**)-- Take final work product from steering committee to evaluate, review and format the information into an Advisory Circular, then guide the Advisory Circular through FAA coordination and publication.

- **FAA/AFS-200 (Cabin Safety)**-- Review current Order 8400.10 and propose revisions needed to incorporate information and best practices contained in the published Advisory Circular.

- **Airlines** -- Revise flight attendant and pilot standard operating procedures and training programs to carry out the provisions of the cabin safety design guidance product.

- **Airlines** -- Conduct the necessary training for flight attendants and pilots to implement the provisions of the cabin safety design guidance product. (625)

- **ATA, Cabin Operations Committee** – Evaluate the findings and create plan(s) to be implemented.
- **Airlines --** Install recommended products on the new aircraft.(625)

Performance Goals and Indicators for Safety Enhancement/Outputs:

- **Goals:** Reduce Flight Attendant and Passenger Injury during periods of turbulence by implementing improved cabin equipment in new aircraft to provide increased stability for the aircraft occupants during all levels of turbulence:

- **Indicators** --Part 121 Carriers install recommended products in their new aircraft resulting in reduced injuries to flight attendants and passengers.

Safety Enhancement 20/83: Evaluate, recommend and provide guidance on products which include cabin safety design improvements (such as handholds i.e. "Partition Flow-Thru's in galleys) which provide increased stability for the aircraft occupants during all levels of turbulence on existing aircraft.

JIMDAT#:	0.0 Full	2020: 0.0	2007: 0.0
InjryRdxIndx:	0.14 Full	2020: 0.11	2007: 0.07

Resources: $1.2M (See Resource Template for Details)

Resource Characteristics:

- Steering committee with six months to evaluate current aircraft cabin interior products while determining the best products that provide increased stability of occupants during all levels of turbulence for use in existing aircraft and produce one comprehensive document that addresses Safety Enhancements 16, 17, 18, 19, and 20.

- One FAA Flight Standards employee (Cabin Safety) to take final work product from steering committee to evaluate, review and format the information into an Advisory Circular, then guide the Advisory Circular through FAA coordination and publication.

- One FAA Flight Standards employee (Cabin Safety) for 1 week to review current Order 8400.10 and propose revisions needed to incorporate information and best practices contained in the published Advisory Circular.
- Two employees from each air carrier, one from airline flight attendant training/safety department and one from airline flight department for approximately one week to develop the procedural and training requirement supporting the best practices contained in the advisory circular (these would be included in initial and recurrent crewmember training).

- **Note: Whenever an Advisory Circular is mentioned in this project, we are referring to one Advisory Circular that addresses Safety Enhancements 16, 17, 18, 19 and 20.**

Completion Date: 5 years

Output: Evaluate, recommend and provide guidance on products which include cabin safety design improvements (such as handholds i.e. "Partition Flow-Thru's in galleys) that provide increased stability for the aircraft occupants during all levels of turbulence on existing aircraft. (625)

LOOC: ATA, Cabin Operations Committee

Resources: Steering Committee comprised of ATA, Cabin Safety Committee/Flight Operations Committee, airlines (designated engineering representative), aircraft cabin design vendors, aircraft manufacturers, and flight attendant unions

Additional Resources: FAA/AFS-200 (Cabin Safety), FAA/ANM-100, FAA/AIR, FAA/CAMI, ATA (Flight Safety Committee, Training Committee, Safety Council, Operations Council)

Timeline: 5 years

Actions:

- **Steering Committee**
  --Examines and evaluates current aircraft cabin interior products while determining the best products that provide increased stability of occupants during all levels of turbulence for use in existing aircraft.
  -- Consolidates these into an industry consensus of best practices that establish policy guidance for air carriers to:
  --Develop aircraft cabin interior products that provide increased stability for occupants during all levels of turbulence. (625)
  --Develop air carrier procedures for flight attendants on the use of all aircraft cabin interior products that provide stability during all levels of turbulence.(625)
  --Develop and implement training for flight attendants on the availability and use of aircraft cabin interior products that provide stability during all levels of turbulence.(625)
- **FAA/AFS-200 (Cabin Safety**)-- Take final work product from steering committee to evaluate, review, and format the information into an Advisory Circular, then guide the Advisory Circular through FAA coordination and publication.

- **FAA/AFS-200 (Cabin Safety)**-- Review current Order 8400.10 and propose revisions needed to incorporate information and best practices contained in the published Advisory Circular.

- **Airlines** -- Revise flight attendant and pilot standard operating procedures and training programs to carry out the provisions of the cabin safety design guidance product.

- **Airlines** -- Conduct the necessary training for flight attendants and pilots to implement the provisions of the cabin safety design guidance product. (625)

- **ATA, Cabin Operations Committee** – Evaluate the findings and create plan(s) to be implemented.

- **Airlines --** Install recommended products on existing aircraft.(625)

Performance Goals and Indicators for Safety Enhancement/Outputs:

- **Goals:** Reduce flight attendant and passenger injury during periods of turbulence by implementing improved cabin equipment on existing aircraft to provide increased stability for the aircraft occupants during all levels of turbulence.

- **Indicators** --Part 121 Carriers install recommended products in their existing aircraft resulting in reduced injuries to flight attendants and passengers.

Turbulence
Joint Safety Implementation Team

Detailed Implementation Plan
For
Implement Best Practices for Turbulence Avoidance

Statement of Work: Develop government and air carrier policies and procedures that will minimize inadvertent turbulence encounters through the implementation of the "best practices" outlined in Advisory Circular (AC) 00-30. The model program defined in the AC for carriers calls for turbulence avoidance as the first line of defense. It outlines a comprehensive program of acquisition and use of turbulence information plus comprehensive initial and recurrent meteorological training standards for aircrews, dispatchers, and meteorologists. This project, building upon the structure of the AC, identifies actions to be performed by both government and the carriers to fulfill the intent of AC00-30.

The principal provisions of AC00-30b "Best Practices" are:

a. *Adopt the corporate philosophy of avoidance of turbulence as a first line of defense.*
b. *Use all applicable weather data and products including alphanumeric weather information such as METARS, area forecasts and terminal area forecasts (TAFs), wind & temperature forecasts, NWS in-flight advisories (SIGMETS, Convective SIGMETS and AIRMETS), upper air charts, graphical radar summaries or composites, and satellite imagery.*
c. *Use sophisticated product generation to merge diverse sources into graphical products to track turbulence.*
    (1) *Compile turbulence information, including PIREPs, and make it easily accessible to controllers and dispatchers.*
    (2) *Ensure timely and accurate pilot reporting (PIREPs). [see Improve the Quality of Turbulence Information Project]*
d. *Ensure efficient air-ground and ground-ground communication system for exchange of turbulence information to and between aircrew, dispatcher and meteorological support function.*
e. *Maintain dedicated and continuous training program for aircrews, dispatchers, meteorologists, and other operational control personnel.*

Lead Organization for Overall Project Coordination (LOOPC): Air Transport Association (ATA)

SAFETY ENHANCEMENT 64: Corporate culture of turbulence avoidance.

Score (InjuryRdx%): 2007: 0.13 2020: 0.18 Full: 0.18 '07 Imp: 75%

Total Resources Required:

	Government		Manufacturers		Operators		Total
	FTE	$M	FTE	$M	FTE	$M	FTE/$M
2007	8.0	2.9			9.5	3.7	17.5/6.6
2020	6.0	1.8			6.5	2.9	12.5/4.7
Totals	14.0	4.7			16	6.6	30/11.3

Completion Date: Completed 60 months after CAST approval of Safety Enhancement.

Output 1: Develop/implement corporate culture of turbulence avoidance.

a. **Airlines**: Implement dispatch/flight operations policies prescribing re-routing around observed/forecast significant turbulence, and standard clearance between thunderstorms and aircraft.

b. **Airlines/FAA**: Revise/amend airline safety programs and operations procedures accordingly.

Resources: ATA Operations Committee (LOOC), RAA, FAA.

Timeline: Completed 60 months after CAST approval of Safety Enhancement.

Actions:

- **Airlines** -- Adopt and implement dispatch and flight operations policies that prescribe re-routing around forecast/observed significant clear air turbulence. Prerequisite: Implementation of SE68, Improved Turbulence Forecast Accuracy.

- **Airlines** -- Revise flight operations manuals and flight crew training to reflect "industry standard" clearance between thunderstorms and aircraft. Prerequisite: Implementation of SE70, Standardize Vertical and Horizontal Clearance Distance from Thunderstorms.

- **FAA/Airlines** -- Revise/amend airline OpSpecs accordingly as new turbulence re-route and thunderstorm clearance policies are adopted.

Output 2: Develop/utilize graphical turbulence products.

Resources: FAA/AUA-400 (LOOC), FAA, ATA, RAA, NCAR, NWS, FSL

Timeline: Completed 60 months after CAST approval of Safety Enhancement.

Actions:

- **FAA Turbulence Product Development Team (PDT)** -- Accelerate development and deployment of automated, graphical forecast products (such as are produced by the Integrated Turbulence Forecast Algorithm (ITFA)). Disseminate these new graphical products that synthesize observations, forecasts, nowcasts, and model output to all airlines.

- **FAA/NCAR/FSL/NWS/Airlines** -- Define and develop next generation ground display concept that integrates in situ turbulence reports, PIREPs, and synthesized turbulence forecast graphics such as ITFA.

- **FAA Turbulence PDT/NWS/FSL** -- Develop a plan for the operational implementation of a four-dimensional turbulence forecast product that assimilates objective EDR data.

Output 3: Develop and implement standards for turbulence communications procedures and training in support of airline aircrews, dispatchers, and meteorologists.

Resources: ATA Operations Committee (LOOC), FAA, RAA, commercial weather vendors

Timeline: Completed 36 months after CAST approval of Safety Enhancement.

Actions:

- **ATA** -- Survey industry training programs with respect to "best practice" standards.

- **ATA/FAA** -- Develop minimum turbulence training standards.

- **FAA** -- Update the guidance in current FAA Order 8400.10, Chapter 2 (Airman Training Programs, paragraphs 379/439) and Chapter 5 (Dispatcher Training Requirements, paragraphs 1093/1121) to help ensure airline training programs meet new industry standard.

- **Airlines** -- Develop and implement training programs in accordance with the provisions of FAA Order 8400.10.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal, Output 1:** All participating airlines to adopt new clear air turbulence and thunderstorm avoidance operating policies.
    - **Indicator, Output 1:** ATA will survey airlines at 12-month intervals to determine level of implementation.

- **Goal, Output 2:** Improved situational awareness for pilots, controllers, and dispatchers.
- **Indicator, Output 2:** Availability of an integrated, graphical, operational government/industry turbulence product.
- **Goal, Output 3:** Comprehensive turbulence training programs instituted at all participating airlines.
- **Indicator, Output 3:** Improved operational decision-making by pilots, dispatchers, and meteorologists, and a corresponding reduction in the number of turbulence injuries.

SAFETY ENHANCEMENT 65: Upgrade airline/Government collection and distribution of turbulence information.

Score (InjuryRdx%): 2007: 0.02 2020: 0.05 Full: 0.05 '07 Imp: 40%

Total Resources Required:

	Government		Manufacturers		Operators		Total
	FTE	$M	FTE	$M	FTE	$M	FTE/$M
2007	4.000	1.300			4.500	1.800	8.5/3.1
2020	1.250	0.550			4.250	1.750	5.5/2.3
Totals	5.250	1.850			8.750	3.550	14.0/5.4

Completion Date: Completed 60 months after CAST approval of Safety Enhancement.

Output 1: Upgrade Government and airline ground-to-ground and ground-to-air communications systems for turbulence information.

Resources: ATA Operations Committee (LOOC), FAA, NWS, RAA, ARINC, Commercial Weather Vendors

Timeline: Completed 60 months after CAST approval of Safety Enhancement.

Actions:

- **Airlines/FAA/NWS/ARINC** -- Conduct system-wide assessment of communications/distribution system for gridded, alphanumeric, and graphical image turbulence information exchange in the National Airspace System (NAS) and develop a plan for needed upgrades in ground-to-ground and ground-to-air systems.

- **Airlines/FAA/NWS** -- Implement the upgrade plan through a cost-effective mix of Internet, Intranet and other evolving communications systems.

- **Airlines/Vendors/FAA** -- Develop a tailored "forced" uplink of critical alpha/numeric reports and forecasts to existing displays on the flight deck, and follow up with a comparable graphic product to take advantage of evolving flight deck display technology.

Output 2: Develop standards, based on airline "best practices", for utilization of turbulence information in airline flight planning systems.

Resources: ATA Meteorology Committee (LOOC), FAA, NWS, RAA, ARINC, commercial weather vendors

Timeline: Completed 36 months after CAST approval of Safety Enhancement.

Actions:

- **ATA/Airlines** -- Identify airline "best practices" for operational utilization of turbulence information in airline flight management systems.

- **ATA/Airlines** -- Develop design standards for operational utilization of turbulence information in airline flight management systems based on these "best practices".

- **Airlines** -- Implement design standards during routine upgrades and/or replacement of airline flight planning systems.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal, Output 1:** Government and industry to develop systems to improve volume, timeliness, and distribution of turbulence information.
- **Indicator, Output 1:** Timely and complete distribution of turbulence information to dispatchers, pilots, controllers, and meteorologists.
- **Goal, Output 2:** All participating airlines to adopt communications systems that improve in-house collection and distribution of turbulence data.
- **Indicator, Output 2:** Increased volume of turbulence reports and information being relayed to dispatchers and crews.

Relationship to Current Aviation Community Initiatives

- AC00-30 is in effect, and addresses:
  - An appropriate initial and recurrent training program,
  - A dedicated planning/dispatch function, and
  - A fully supported operational implementation of a pilot reporting (PIREP)/communications system (not ATC-based).
- The one airline using the "best practices" of AC00-30 has historically shown a lower turbulence accident rate than the industry as a whole. Less than 1% of the turbulence accidents studied by the JSAT were attributed to that airline.
- Training programs vary widely among the airlines.

Programmatic Approach

Organizational Strategy

The FAA Act of 1958 established the inherent obligation of any air carrier certificate holder to maintain the highest level of safety in the public interest. In addition to its regulatory and enforcement functions, the FAA has developed many voluntary programs for the promotion of safety culture from within an air carrier corporation. It is incumbent on the air carriers and their employee groups to embrace these voluntary programs and to implement them as effectively as possible. The CEO and the Director of Safety are the principal advocates of safety culture within the corporation, without whose efforts an effective safety program fails. Collaboration between managers and non-manager employees is absolutely essential.

The Lead Organization for Overall Project Coordination (LOOPC) is ATA, a member of the CAST. ATA will coordinate industry implementation of the best practices of AC00-30b, including a program to improve the dissemination and use of turbulence information. The Lead Organizations for Output Coordination (LOOC) are identified in each Output of this

Implementation Plan. Included are ATA and FAA organizations with responsibilities for oversight. The roles and responsibilities of the LOOPC and LOOC are described in the CAST approved JSIT Process Document.

Implementation Activities

The ATA Flight Operations Committee will assume oversight of this project with an ATA/FAA working group to coordinate and ensure implementation.

Key Products and Milestones

Safety Enhancement 64: Develop/implement corporate culture of turbulence avoidance.		
Output 1: Develop/implement corporate culture of turbulence avoidance: a. Implement dispatch/flight operations policies prescribing rerouting around observed/forecast significant turbulence, and standard clearance between thunderstorms and aircraft. b. Revise/amend airline safety programs and operations procedures accordingly.		
Action	**Responsible Party**	**Completion Date**
Adopt and implement dispatch and flight operations policies that prescribe re-routing around forecast/observed significant clear air turbulence. Prerequisite: Implementation of SE68, Improved Turbulence Forecast Accuracy.	**Airlines**	**60 months from CAST approval**
Revise flight operations manuals and flight crew training to reflect "industry standard" clearance between thunderstorms and aircraft. Prerequisite: Implementation of SE70, Standardize Vertical and Horizontal Clearance distance from Thunderstorms.	**Airlines**	**36 months from CAST approval**
Revise/amend airline OpSpecs accordingly as new turbulence re-route and thunderstorm clearance policies are adopted. .	**Airlines/FAA**	**60 months from CAST approval**

Output 2: Develop/utilize graphical turbulence products		
Action	**Responsible Party**	**Completion Date**
Accelerate development and deployment of automated, graphical forecast products (such as are produced by the Integrated Turbulence Forecast Algorithm (ITFA)). Disseminate these graphical products that synthesize observations, forecasts, nowcasts, and model output to all airlines.	**FAA Turbulence Product Development Team (PDT)**	**24 months after CAST approval**
Define and develop next generation ground display concept that integrates in situ turbulence reports, PIREPs, and synthesized turbulence forecast graphics such as ITFA	**FAA/Airlines/ NCAR/FSL/NWS**	**60 months after CAST approval**
Develop a plan for the operational implementation of a four-dimensional turbulence forecast product that assimilates objective EDR data.	**FAA Turbulence PDT/NWS/FSL**	**36 months after CAST approval**

Output 3: Develop and implement standards for turbulence communications procedures and training in support of airline aircrews, dispatchers, and meteorologists.		
Action	**Responsible Party**	**Completion Date**
Survey industry training programs with respect to "best practice" standards.	**ATA**	**12 months after CAST approval**
Develop minimum turbulence training standards.	**ATA/FAA**	**36 months after CAST approval**
Update the guidance in current FAA Order 8400.10, Chapter 2 (Airman Training Programs, paragraphs 1093/1121) and Chapter 5 (Dispatcher Training Requirements, paragraphs 1093/1121) to help ensure airline training programs meet new industry standard.	**FAA**	**36 months after CAST approval**
Develop and implement training programs in accordance with the provisions of FAA Order 8400.10.	**Airlines**	**36 months after CAST approval**

Safety Enhancement 65: Upgrade airline/Government collection and distribution of turbulence information.		
Output 1: Upgrade Government and airline ground-to-ground and ground-to-air communications systems for turbulence information.		
Action	**Responsible Party**	**Completion Date**
Conduct system-wide assessment of communications/distribution system for gridded, alphanumeric, and graphical image turbulence information exchange in the National Airspace System (NAS) and develop a plan for needed upgrades in ground-to-ground and ground-to-air systems.	**Airlines/FAA/ NWS/ARINC**	**12months after CAST approval**
Implement the upgrade plan through a cost-effective mix of Internet, Intranet and other evolving communications systems.	**FAA/Airlines/ NWS**	**36 months after CAST approval**
Develop a tailored "forced" cockpit uplink of critical alpha/numeric reports and forecasts to existing displays on the flight deck, and follow up with a comparable graphic product to take advantage of evolving flight deck display technology.	**Airlines/ Vendors, FAA**	**60 months after CAST approval**
Output 2: Develop standards, based on airline "best practices", for utilization of turbulence information in airline flight planning systems.		
Action	**Responsible Party**	**Completion Date**
Identify airline "best practices" for operational utilization of turbulence information in airline flight management systems.	**ATA/Airlines**	**12 months after CAST approval**
Develop design standards for operational utilization of turbulence information in airline flight management systems based on these "best practices".	**ATA/Airlines**	**24 months after CAST approval**
Implement design standards during routine upgrades and/or replacement of airline flight planning systems.	**Airlines**	**36 months after CAST approval**

Risk Description and Risk Mitigation Plan

RISK DESCRIPTION	RISK MITIGATION PLAN
R1 – changing corporate culture will be difficult and ATA may not be able to insure full compliance with the standards developed.	M1 - Insure corporate buy-in of plan

Impact on Non-FAR Part 121 or International Applications

Implementation of this project will be independent of ICAO Standards and Recommended Practices (SARPS) but will likely lead foreign carriers to follow suit. Training programs could be made available to international carriers and general aviation.

Turbulence
Joint Safety Implementation Team

Detailed Implementation Plan
For
Improve the Quality of Turbulence Information

Statement of Work: Improve the quality and quantity of turbulence information used to support strategic flight planning and in-flight routing in order to efficiently avoid turbulence. Included are programs to increase the number and quality of turbulence observations to pinpoint the current location and severity of turbulence, initiatives to improve the accuracy of turbulence forecasts, and plans to develop consistent turbulence standards and metrics.

Lead Organization for Overall Project Coordination (LOOPC): FAA/ARS-1

SAFETY ENHANCEMENT 66: Additional Observations – Manual PIREPs and Automated EDRs.

Score (InjuryRdx%): 2007: 0.14 2020: 0.18 Full: 0.18 '07 Imp: 75%

Total Resources Required:

	Government		Manufacturers		Operators		Total
	FTE	$M	FTE	$M	FTE	$M	FTE/$M
2007	3.4	1.647	0.1	0.04	1.55	1.05	5.05/2.737
2020	0.2	0.213			0.95	0.5	1.15/0.713
Totals	3.6	1.86	0.1	0.04	2.50	1.55	6.2/3.45

Completion Date: Completed 36 months after CAST approval of Safety Enhancement.

Output 1: Increase quantity and quality of manual PIREPs through aircrew training and improved distribution within airlines and to FAA/NWS.

Resources: ATA Meteorological Committee (LOOC), FAA, RAA, NAATS, NATCA, NWS, NCAR, ARINC, Pilot Unions.

Timeline: Completed 36 months after CAST approval of Safety Enhancement.

Actions:

- **Airlines/NWS** -- Develop and implement a program to distribute in-house manual pilot reports to NWS/FAA.

- **Airlines** -- Train crews to follow established "PIREP" reporting procedures and encourage use of Flight Watch for PIREP input.

- **FAA/Airlines/Pilot Unions** -- Institute a PIREP awareness campaign.

Output 2: Implement National Air Space (NAS)-wide automated turbulence reporting based on Eddy Dissipation Rate (EDR).

Resources: FAA/AUA-400 (LOOC), NCAR, NASA, ATA, RAA

Timeline: Completed 36 months after CAST approval of Safety Enhancement.

Actions:

- **FAA/NCAR/Airlines** -- Install EDR and supporting weather downlink software at all ACARS equipped airlines.

- **FAA/ATA/RAA** -- Assess the utility to pilots, in terms of human factors and cost-effectiveness, of real-time cross-linking (from one aircraft to another) of EDR reports.

- **FAA/ATA/RAA/ARINC** -- Ensure that future data link systems (post-ACARS) accommodate EDR reporting.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Improved knowledge about the current state and distribution of atmospheric turbulence.
- **Indicator:**
  - Starting 12 months after project initiation, and at 12-month intervals thereafter, FSL will issue a report summarizing the volume of manual, automated, and EDR aircraft reports. The report will include the number of reports for the 12 month period prior to project initiation, compared to the corresponding number of reports for each 12 month period subsequent to initiation, with the following goals:
    - Year 1 goal to increase reports by: 10% (manual), 5% (automated), 10% (EDR).
    - Year 2 goal to increase reports by: 5% (manual), 10% (automated), 50% (EDR).
    - Year 3 goal to increase reports by: 5% (manual), 10% (automated), 50% (EDR).
  - Within 12 months, ATA to develop baseline report on the status of data distribution at each airline, with subsequent reports at 24 and 36 months. The report will include details on each airline's efforts to complete automated PIREP/forecast distribution, in-house PIREP delivery to NWS/FAA, and “forced” uplink of critical turbulence data.
  - Within 12 months, and subsequent 12 month intervals, the FAA will issue a report on the status of:
    - PIREP data distribution between the FAA, the NWS, and the airlines.
    - PIREP data distribution within the FAA.

SAFETY ENHANCEMENT 67: Additional Observations – Semi-automate manual PIREP entry.

Score (InjuryRdx%): 2007: 0.13 2020: 0.13 Full: 0.13 '07 Imp: 100%

Total Resources Required:

	Government		Manufacturers		Operators		Total
	FTE	$M	FTE	$M	FTE	$M	FTE/$M
2007	4.9	5.1				0.3	4.9/5.4
2020							
Totals	4.9	5.1				0.3	4.9/5.4

Completion Date: Completed 48 months after CAST approval of Safety Enhancement.

Output 1: Semi-Automate ARTCC/terminal controllers' entry of manual PIREP's.

Resources: FAA/ARS-100 (LOOC), ATA, RAA, NAATS, NATCA, NWS, NCAR

Timeline: Completed 48 months after CAST approval of Safety Enhancement.

Actions:

- **FAA** -- Semi-Automate ARTCC/terminal controllers' entry of manual PIREP's.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Improved knowledge about the current state and distribution of atmospheric turbulence.
- **Indicator:** Automated input of manual PIREPS in FAA facilities.

SAFETY ENHANCEMENT 68: Improved turbulence forecast accuracy.

Score (InjuryRdx%): 2007: 0.11 2020: 0.14 Full: 0.14 '07 Imp: 80%

Total Resources Required:

	Government		Manufacturers		Operators		Total
	FTE	$M	FTE	$M	FTE	$M	FTE/$M
2007	25.4	7.8					25.4/7.8
2020	12	4.8					12/4.8
Totals	37.4	12.6					37.4/12.6

Completion Date: Completed 60 months after CAST approval of Safety Enhancement.

Output 1: Develop/implement improved forecasts based on multiple data sources.

Resources: FAA/AUA-400 (LOOC), NCAR, NWS, FSL, ATA, NASA

Timeline: Complete 60 months after CAST approval of Safety Enhancement.

Actions:

- **NCAR** -- Develop automated turbulence forecast algorithms (e.g., the Integrated Turbulence Forecast Algorithm, ITFA), utilizing all turbulence information including EDR reports, to be used to improve manual forecasts and eventually replace manually produced AIRMETS and SIGMETS.

- **NWS (AWC)/Airlines** -- Utilizing automated forecasting techniques from the action above, implement improved manual/automated turbulence forecasts.

Output 2: Develop/implement turbulence forecast verification system.

Resources: FAA/AUA-400 (LOOC), NOAA, FSL, NWS

Timeline: Completed 60 months after CAST approval of Safety Enhancement.

Actions:

- **NOAA /FSL/NWS** -- Develop/implement turbulence forecast verification system.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goals:** Government and industry to improve forecast accuracy of verifiable moderate and severe turbulence events to performance metrics of 80% Probability of Detection "yes" (PODy) and 85% Probability of Detection "no" (PODn), resulting in a non-convective injury rate reduction of 56%.

- **Indicators:**
  - NCAR/FSL will develop a baseline turbulence forecast verification system for ITFA and NWS High Level Significant Weather Prog (HLSW) (domestic coverage only) developed within 12 months.
  - At 24, 36, 48, and 60-month intervals, compare verification results of ITFA, HLSW, and any other new turbulence forecast products to the stated goals (80% PODy and 85% PODn).
  - Beginning 12 months after project initiation, and at 12-month intervals thereafter, the FAA will issue a report summarizing NTSB turbulence statistics. Each report will include both the non-convective and convective injury rate for the 12-month period prior to project initiation, compared to the corresponding injury rate for each 12-month period subsequent to initiation.
  - Beginning 12 months after project initiation, and at 12-month intervals thereafter, the ATA will issue a report summarizing airline flight attendant loss of time statistics. Each report will include loss of time data for the 12-month period prior to project initiation,

compared to the corresponding loss of time data for each 12-month period subsequent to initiation.

- Beginning 12 months after project initiation, and at 12-month intervals thereafter, the ATA will issue a report summarizing the frequency of turbulence related passenger claims. Each report will include the number of claims for the 12-month period prior to project initiation, compared to the corresponding number of claims for each 12-month period subsequent to initiation.

SAFETY ENHANCEMENT 69: Standardize terminology and make turbulence forecasts/warnings aircraft-category specific.

Score (InjuryRdx%): 2007: 0.10 2020: 0.13 Full: 0.13 '07 Imp: 80%

Total Resources Required:

	Government		Manufacturers		Operators		Total
	FTE	$M	FTE	$M	FTE	$M	FTE/$M
2007	4.2	2.85			1.1	0.85	5.3/3.7
2020							
Totals	4.2	2.85			1.1	0.85	5.3/3.7

Completion Date: Complete 60 months after CAST approval of Safety Enhancement.

Output 1: Deploy EDR ride report.

Resources: FAA/AUA-400 (LOOC), ATA, RAA, NCAR, NWS, FSL, NASA

Timeline: Complete 60 months after CAST approval of Safety Enhancement.

Actions:

- **FAA/NWS/NCAR/NASA/Airlines** -- Adopt EDR as the industry-wide, aircraft independent metric for measuring and reporting atmospheric turbulence.

- **FAA/NCAR/NASA/NWS/Airlines** -- Develop an industry "ride report" standard that is aircraft category specific, and that is calibrated to an objective in situ measure of turbulence (EDR).

Output 2: Develop/implement Concept of Operations (ConOps) for air-ground, air-air communication of EDR and derived products.

Resources: FAA/AUA-400 (LOOC), NCAR/Airlines/NWS.

Timeline: Completed 24 months after CAST approval of Safety Enhancement.

Actions:

- **FAA/NCAR/Airlines/NASA/NWS** -- Develop an industry ConUse that defines how both the objective measure of turbulence (EDR) and ride report information is communicated and used by flight crews, dispatch functions, weather information services, and air traffic control. Include a definition of where in the infrastructure the conversion to/from EDR and ride report is accomplished.

Output 3: Develop an industry standard that defines how turbulence warning and forecast products are generated to be both aircraft category specific and still meet the needs of pilots, dispatchers, weather information service providers, and air traffic controllers.

Resources: FAA/AUA-400 (LOOC), NCAR, FSL, NASA, NWS, Airlines

Timeline: Completed 24 months after CAST approval of Safety Enhancement.

Actions:

- **FAA's Turbulence Product Development Team (PDT)** – Develop an industry standard that defines how turbulence warning and forecast products are generated to be both aircraft category specific, and still meet the needs of pilots, dispatchers, weather information service providers, and controllers .

Output 4: Develop/implement training for pilots, dispatchers, air traffic controllers, and weather service providers.

Resources: NWS (LOOC), FAA/NCAR/NASA/Airlines

Timeline: Completed 24 months after CAST approval of Safety Enhancement.

Actions:

- **FAA/NWS** -- Develop training materials.
- **Airlines, FAA, NWS** -- Implement training for pilots, dispatchers, air traffic controllers, and weather service providers.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goals:** Standardize turbulence terminology and developing aircraft category specific products.
- **Indicators:**
    - NCAR, at 12 month intervals, will survey the FAA, NWS, NASA, and the airlines, and report on the level of EDR implementation, and progress in developing an industry “ride report” standard (aircraft category specific and calibrated to EDR).
    - Within 24 months, under the leadership of the FAA's Turbulence PDT, a NAS “concept of operations” plan will be completed that defines how both EDR and ride report information is communicated and used by flight crews, dispatch functions,

weather information services, and air traffic control. "Concept of operations" plan will include a definition of where in the infrastructure the conversion to/from EDR and ride report is accomplished. Industry-wide operational implementation of the "concept of operations" to be completed within 24-60 months under FAA leadership.

- Within 24 months, under the leadership of the FAA's Turbulence PDT, an industry standard will be developed that defines how turbulence warning and forecast products are generated to be both aircraft category specific, and still meet the needs of dispatchers, weather information services, and air traffic control. Industry standard for turbulence warning and forecast products to be implemented within 24-60 months, in conjunction with the "concept of operations".

SAFETY ENHANCEMENT 70: Standardize vertical and horizontal clearance distance from thunderstorms

Score (InjuryRdx%): 2007: 0.10 2020: 0.10 Full: 0.10 '07 Imp: 100%

Total Resources Required:

	Government		Manufacturers		Operators		Total
	FTE	$M	FTE	$M	FTE	$M	FTE/$M
2007	1.5	2.5			1.2	1.5	2.7/4.0
2020							
Totals	1.5	2.5			1.2	1.5	2.7/4.0

Completion Date: Completed 36 months after CAST approval of Safety Enhancement.

Output 1: Review current airline thunderstorm clearance procedures, develop scientifically valid standards for horizontal and vertical clearance between aircraft and convective activity, and train aircrews to new standards.

Resources: FAA/AUA-400 (LOOC), ATA, RAA, NCAR, NWS, NASA

Timeline: Completed 36 months after CAST approval of Safety Enhancement.

Actions:

- **Airlines/FAA/NCAR/NASA** -- Review current industry clearance standards between aircraft and thunderstorms.
- **NCAR/NASA** -- Complete research to determine scientifically valid standards.
- **Airlines/FAA** -- Train flight crews to new standards.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Government and industry to develop scientifically valid thunderstorm clearance standards, resulting in a convective injury rate reduction of 50% and a commensurate reduction in flight attendant injuries and liability claims.

- **Indicators:**
  - ATA to complete a review of current airline thunderstorm clearance standards and issue a report within 6 months.
  - NCAR/NASA will complete any required in situ research of aircraft and thunderstorm clearance standards and issue a report within 12-36 months.
  - ATA, starting at 36 months, and annually thereafter, will report on operational implementation of new standards at each airline.
  - Beginning 12 months after project initiation, and at 12-month intervals thereafter, the FAA will issue a report summarizing NTSB turbulence statistics. Each report will include both the non-convective and convective injury rate for the 12-month period prior to project initiation, compared to the corresponding injury rate for each 12-month period subsequent to initiation.
  - Beginning 12 months after project initiation, and at 12-month intervals thereafter, the ATA will issue a report summarizing airline flight attendant loss of time statistics. Each report will include loss of time data for the 12-month period prior to project initiation, compared to the corresponding loss of time data for each 12-month period subsequent to initiation.
  - Beginning 12 months after project initiation, and at 12-month intervals thereafter, the ATA will issue a report summarizing the frequency of turbulence-related passenger claims. Each report will include the number of claims for the 12-month period prior to project initiation, compared to the corresponding number of claims for each 12-month period subsequent to initiation.

Relationship to Current Aviation Community Initiatives

- Varying levels of dissemination and reporting of PIREP information:
  - Meteorological Data Collection and Reporting System (MDCRS)
  - FSL/ACARS Website
  - Airline direct input to NWS
  - Aviation Digital Data Service (ADDS)
- The following automation systems are being developed to assist input and dissemination of information in the Air Traffic arena:
  - Enroute Automation Modernization (ERAM)
  - ASOS Controller Equipment - Information Display System (ACE-IDS)
  - Enroute Information Display System (ERIDS)
- One airline has adopted its own in-house collection and distribution system; however, it does not capitalize upon PIREPs from other airlines and therefore limits the geographical scope and usefulness as a universal system.
- Six airlines are currently providing automated ACARS weather reports.
- One airline is currently downlinking EDR data. Expansion is planned to other domestic and international carriers within the next 18 months.
- FAA funded NWS/FSL/NCAR Turbulence Product Development Team (PDT) is currently testing and transferring to operations an automated turbulence forecast model.
- The ADDS integrates turbulence forecasts and PIREPs into a single user display.

Programmatic Approach

Organizational Strategy

The FAA Act of 1958 established the inherent obligation of any air carrier certificate holder to maintain the highest level of safety in the public interest. Besides its regulatory and enforcement functions, the FAA also leads an aviation weather research and development effort in collaboration with other government agencies and private industry. PDTs have been formed by the FAA's Aviation Weather Research Program (AWRP) to address all known aviation weather hazards. In particular, the Turbulence PDT is currently researching the physical processes associated with all forms of turbulence with the goal of introducing operational versions of advanced diagnoses, nowcasts, and forecasts in the near term. We propose to use this organizational strategy to oversee the integration of outputs described in this plan with the current research activities sponsored by the FAA. The PDT brings together the best the research community has to offer in terms of expertise in the fields that have direct application to the turbulence problem. These organizations include the National Weather Service (NWS), the National Center for Atmospheric Research (NCAR), the National Aeronautics and Space Administration (NASA), and the National Oceanic and Atmospheric Administration's Forecast Systems Laboratory (FSL). The PDT maintains a strong linkage to the user community through the airlines, Air Transport Association (ATA), air traffic management/control, the Regional Airline Association (RAA), the NWS and airline pilot unions.

The Lead Organization for Overall Project Coordination (LOOPC) is ARS-1, a member of the CAST and a designee of ATS-1, the Associate FAA Administrator responsible for Air Traffic Services. The Lead Organizations for Output Coordination (LOOC) are identified in each Output of this Implementation Plan. Included are FAA organizations with responsibilities associated with the outcomes. Also included is the ATA, with a role of coordinating industry participation in the dissemination of improved turbulence information. The roles and responsibilities of the LOOPC and LOOC are described in the CAST approved JSIT Process Document.

Implementation Activities

The research community, FAA, ATA/RAA, and other industry participants will collaborate to accomplish the following activities (outputs).

Key Products and Milestones

Safety Enhancement 66: Additional Observations – Manual PIREPs and Automated EDRs.		
Output 1: Increase quantity and quality of manual PIREPs through aircrew training and improved distribution within airlines and to FAA/NWS.		
Action	**Responsible Party**	**Completion Date**

Develop and implement a program to distribute in-house manual pilot reports to NWS/FAA.	**Airlines/NWS**	**36 months after CAST approval**
Train crews to follow established "PIREP" reporting procedures and encourage use of Flight Watch for PIREP input.	**Airlines**	**36 months after CAST approval**
Institute a PIREP awareness campaign.	**FAA/Airlines/ Pilot Unions**	**18 months after CAST approval**

Output 2**:** Implement National Air Space (NAS)-wide automated turbulence reporting based on Eddy Dissipation Rate (EDR).

Action	**Responsible Party**	**Completion Date**
Install Eddy Dissipation Rate (EDR) and supporting weather downlink software at all ACARS equipped airlines.	**FAA/NCAR/ Airlines**	**36 months after CAST approval**
Assess the utility to pilots, in terms of human factors and cost-effectiveness, of real-time cross-linking (from one aircraft to another) of EDR reports.	**FAA/ATA/RAA**	**36 months after CAST approval**
Ensure that future data link systems (post-ACARS) accommodate EDR reporting.	**FAA/ATA/RAA/ ARINC**	**ongoing CAST oversight**

Safety Enhancement 67: Additional Observations – Semi-Automate manual PIREP entry.

Output: Semi-automate ARTCC/terminal controller's entry of manual PIREPs

Action	**Responsible Party**	**Completion Date**
Semi-Automate ARTCC/Terminal entry of manual PIREPs	**FAA/NATCA/**	**48 months after CAST approval**

Safety Enhancement 68: Improved turbulence forecast accuracy.		
Output 1: Develop/implement improved forecasts based on multiple data sources		
Action	**Responsible Party**	**Completion Date**
Develop automated turbulence forecast algorithms (e.g., the Integrated Turbulence Forecast Algorithm, ITFA), utilizing all turbulence information including EDR reports, to be used to improve manual forecasts and eventually replace manually produced AIRMETS and SIGMETS.	**NCAR**	**60 months after CAST approval**
Utilizing automated forecasting techniques from the above action, implement improved manual/automated turbulence forecast.	**NWS (AWC)/ Airlines**	**60 months after CAST approval**
Output 2: Develop/implement turbulence forecast verification system.		
Action	**Responsible Party**	**Completion Date**
Develop/implement turbulence forecast verification system.	**NOAA/FSL/ NWS**	**60 months after CAST approval**

Safety Enhancement 69: Standardize terminology and make turbulence forecasts/warnings aircraft-category specific.		
Output 1**:** Deploy EDR ride report.		
Action	**Responsible Party**	**Completion Date**
Adopt EDR as the industry-wide, aircraft independent metric for measuring and reporting atmospheric turbulence.	**FAA/NWS/ NCAR/NASA/ Airlines**	**60 months after CAST approval**
Develop an industry "ride report" standard that is aircraft category specific, and that is calibrated to an objective in situ measure of turbulence (EDR).	**FAA/NCAR/ NASA/NWS/ Airlines**	**60 months after CAST approval**
Output 2: Develop/implement Concept of Operations (ConOps) for air-ground, air-air communication of EDR and derived products.		
Action	**Responsible**	**Completion Date**

	Party	
Develop an industry ConOps that defines how both the objective measure of turbulence (EDR) and ride report information is communicated and used by flight crews, dispatch functions, weather information services, and air traffic control. Include a definition of where in the infrastructure the conversion to/from EDR and ride report is accomplished.	**FAA/NCAR/ NASA/Airlines/ NWS**	**24 months after CAST approval**
Output 3: Develop an industry standard that defines how turbulence warning and forecast products are generated to be both aircraft category specific and still meet the needs of pilots, dispatchers, weather information service providers, and air traffic controllers.		
Action	**Responsible Party**	**Completion Date**
Develop an industry standard that defines how turbulence warning and forecast products are generated to be both aircraft category specific and still meet the needs of pilots, dispatchers, weather information services providers, and controllers.	FAA Turbulence PDT	**24 months after CAST approval**
Output 4: Develop/implement training for pilots, dispatchers, air traffic controllers, and weather service providers.		
Action	**Responsible Party**	**Completion Date**
Develop training materials Implement training for pilots, dispatchers, controllers and weather service providers.	**FAA/NWS** **Airlines/FAA/ NWS**	**24 months after CAST approval** **24 months after CAST approval**

Safety Enhancement 70: Standardize vertical and horizontal clearance distance from thunderstorms.		
Output: Review current airline thunderstorm clearance procedures, develop scientifically valid standards for horizontal and vertical clearance between aircraft and convective activity, and train aircrews to new standards.		
Action	**Responsible Party**	**Completion Date**
Review current industry clearance standards between aircraft and thunderstorms. Complete research to determine scientifically valid standards. Train flight crews to new standards	**FAA/NASA/ Airlines/NCAR** **NCAR/NASA** **Airlines/FAA**	**24 months after CAST approval** **36 months after CAST approval** **36 months after CAST approval**

Risk Description and Risk Mitigation Plan:

RISK DESCRIPTION	RISK MITIGATION PLAN
R2 – Turbulence is a small-scale dynamic phenomenon. The forecast problem may be more difficult than currently perceived and, as such, the stated goals of 80% PODy/85% PODn may be hard to achieve.	M2 – Monitor scientific discovery, product development, and verification results. Adjust expectations as necessary. NOTE: These activities are already part of the Turbulence PDT direction from AWRP.
R3 – FAA and airline software development/implementation and budget cycles may impact completion dates.	M3 – Implement as part of regularly scheduled P^3I for airlines and FAA. Monitor budget developments carefully to support future planning.
R4 - Manual PIREP systems will always be subject to higher priority concerns.	M4 – Maintain manual systems until automation gains user confidence. Automated systems will reduce workload.
R5 – Increased clearance standards from convective activity may contribute to perception of increased delays.	M5 - Perception of increased delays may be offset by more precise forecast of convective activity and turbulence.

Impact on Non-FAR Part 121 or International Applications

There will be a disconnect in terminology with general aviation aircraft and non-US carriers who have not adopted ICAO EDR standards.

Turbulence
Joint Safety Implementation Team

Detailed Implementation Plan
For
Enhanced Airborne Turbulence Warnings

Statement of Work: Provide improved, real-time turbulence information to aircrew of ownship, aircrew of nearby aircraft, ground operations personnel, and forecasters for turbulence avoidance decisions and for input to turbulence forecasts. Accomplish the improvement through automated, airborne, aircraft turbulence measurements, new flight deck displays of turbulence information, improved or new on-board look-ahead turbulence detection capabilities, and upgraded flight crew procedures for use of improved information to avoid turbulence. Use best industry practices and computer-human interface (CHI) standards to develop flight deck displays and aircrew procedures in order to make best use of enhanced turbulence information.

Lead Organization for Overall Project Coordination (LOOPC): NASA-Aviation Safety Program (AvSP)

SAFETY ENHANCEMENT 71: Graphical Displays-Carry On.

Score (InjryRdx %): 2007: 0.05 2020: 0.06 Full: 0.06 ’07 Imp: 75%

Total Resource Requirements:

	Government		Manufacturers		Operators		Total
	FTE	$	FTE	$	FTE	$	FTE/$M
2007		2.25					0/2.25
2020							
Totals		2.25					0/2.25

Completion Date: 54 months after CAST approval of Safety Enhancement.

Note: This enhancement assumes the US fleet will become equipped with electronic flight bag or other carry on displays. The enhancement provides first generation products for those displays.

Output 1: Evaluate/demonstrate integration of uplinked information on existing carry-on displays.

Resources: NASA/AvSP (LOOC), Manufacturers, Airlines, FAA (AFS/Human Factors), ATC

Timeline: Completed 54 months after CAST approval of Safety Enhancement.

Actions:

- **FAA/NASA/ATA, RAA/AIA, Manufacturers** -- Evaluate alternative architectures for integrating uplinked data, in industry standard format, using existing communication data links.

Output 2: Set standards and CHI best practices for real time graphical flight deck display systems. Develop and implement algorithms.

Resources: NASA/AvSP (LOOC), Manufacturers, Airlines, FAA (AFS/Human Factors), ATC

Timeline: Completed 54 months after CAST approval of Safety Enhancement.

Actions:

- **NASA/FAA/Manufacturers** -- Set standards for alternate display systems (such as PC based options) incorporating CHI best practices and standards for real-time graphical flight deck display systems.
- **NASA/FAA/ Boeing/Airbus** -- Develop and implement algorithms to display turbulence on a carry on display.

Output 3: Develop/implement avoidance procedures.

Resources: NASA/AvSP (LOOC), Manufacturers, Airlines, FAA (AFS/Human Factors), ATC

Timeline: Completed 54 months after CAST approval of Safety Enhancement.

Actions:

- **Manufacturers/Airlines/Employee Organizations** -- Develop improved weather avoidance operating procedures enabled by improved turbulence information in the flight deck using industry best practices and standards as well as CHI design.
- **Airlines** -- Implement new procedures.

Output 4: Review FAA Order 8400.10 to modify/eliminate inconsistencies between the new procedures and the Order.

Resources: NASA/AvSP (LOOC), Manufacturers, Airlines, FAA (AFS/Human Factors), ATC

Timeline: Completed 54 months after CAST approval of Safety Enhancement.

Actions:

- **FAA** -- Review and revise FAA Order 8400.10 as necessary to ensure uniform industry implementation of new procedures.

Performance Goals & Indicators for Safety Enhancements/Outputs:

- **Goal:** Real Time Integrated Multiple Source Weather/Turbulence Display
- **Indicator: Short Term:** First generation turbulence products are ready for implementation into the fleet by 2007
- **Indicator: Long Term:** 80% of fleet contains some form of integrated graphical weather/turbulence display by 2010.

SAFETY ENHANCEMENT 72: Graphical Displays-Panel Mounted-New Production

Score (InjryRdx%): 2007: 0.008 2020: 0.06 Full: 0.06 '07 Imp: 14%

Total Resources Required:

	Government		Manufacturers		Operators		Total
	FTE	$	FTE	$	FTE	$	FTE/$M
2007		4.25					0/4.25
2020				7.0			0/7.0
Totals		4.25		7.0			0/11.25

Completion Date: Completed 60 months after CAST approval of Safety Enhancement.

Output 1: Evaluate/demonstrate integration of uplinked/onboard information on existing displays.

Resources: NASA-AvSP (LOOC), FAA, NCAR, Manufacturers, and Airlines

Timeline: Completed 60 months after CAST approval of Safety Enhancement.

Actions:

- **NASA/FAA/ATA, RAA/AIA, Manufacturers** -- Evaluate alternative architectures for integrating uplinked and onboard data, in industry standard format, making maximum utilization of existing communication data links.

Output 2: Set standards and CHI best practices for display systems. Develop and implement algorithms.

Resources: NASA/AvSP (LOOC), Manufacturers, Airlines, FAA (AFS/Human Factors), ATC

Timeline: Completed 60 months after CAST approval of Safety Enhancement.

Actions:

- **NASA/FAA/Manufacturers** -- Set standards for alternate display systems (such as PC based options) incorporating CHI best practices and standards for real-time graphical flight deck display systems design to enhance and support integration of weather and turbulence data sources.

- **NASA-AvSP/FAA-AFS (HF)/Manufacturers** -- Develop algorithms for display of turbulence on existing panel-mounted displays.

- **Manufacturers** -- Implement algorithms in existing panel mounted displays in 7 aircraft type designs to display turbulence on integrated displays in new production aircraft produced in CY04 and beyond.

Output 3: Develop/implement avoidance procedures.

Resources: NASA/AvSP (LOOC), Manufacturers, Airlines, FAA (AFS/Human Factors), ATC

Timeline: Completed 60 months after CAST approval of Safety Enhancement.

Actions:

- **Manufacturers/Airlines** -- Develop improved weather avoidance operating procedures enabled by improved turbulence information on the flight deck using industry best practices and standards as well as CHI design.

- **Employee Organizations** -- Assist in development of improved avoidance procedures with experienced-based inputs to best practices.

Output 4: Review FAA Order 8400.10 to modify/eliminate inconsistencies between the new procedures and the Order.

Resources: NASA/AvSP (LOOC), Manufacturers, Airlines, FAA (AFS/Human Factors), ATC

Timeline: Completed 60 months after CAST approval of Safety Enhancement.

Actions:

- **FAA** -- Review and revise FAA Order 8400.10 as necessary to ensure uniform industry implementation of new procedures.

- **Airlines** -- Implement new procedures.

SAFETY ENHANCEMENT 73: Airborne-Detection-Enhanced Radar-New Production

Score (InjryRdx%): 2007: 0.03 2020: 0.20 Full: 0.20 '07 Imp: 14%

Total Resources Required:

	Government		Manufacturers		Operators		Total
	FTE	**$**	**FTE**	**$**	**FTE**	**$**	**FTE/$M**
2007		**4.75**		**3.0**		**2.1**	**0/9.85**
2020						**4.2**	**0/4.20**
Totals		**4.75**		**3.0**		**6.3**	**0/14.05**

Note: This project is ongoing with government and manufacturers as partners and at a significant level of government funding.

Completion Date: R&D and type design completed 36 months after CAST approval of Safety Enhancement and installation in new aircraft production begins within the following year.

Output 1: Develop/validate algorithms to estimate RMSg.

Resources: NASA-AvSP (LOOC), FAA, NASA, NCAR, AIA, Boeing, Airbus

Timeline: Completed 30 months after CAST approval of Safety Enhancement.

Actions:

- **NASA/NCAR** -- Develop aircraft response algorithms to be applied to the aircraft hazard metric (RMS normal acceleration) to serve as a basis of **new radar** turbulence development and certification.

- **NASA** -- Validate models and hazard metric.

Output 2: Upgrade, flight test, certify radar.

Resources: NASA/AvSP (LOOC), Manufacturers, Airlines, FAA (AFS/Human Factors), ATC

Timeline: Completed 36 months after CAST approval of Safety Enhancement.

Actions:

- **Manufacturers/AIA** -- Develop **new** Radar with output suitable for providing warning to ownship flight deck and for data linking to other users.

- **ATA/RAA** -- Conduct in-service flight trials to determine the effectiveness of the turbulence detection algorithms and deployment feasibility.
- **NASA** -- Assist with the flight trials, post-flight data analysis and confirm turbulence warning performance.

Output 3: Develop/implement procedures and training.

Resources: NASA/AvSP (LOOC), Manufacturers, Airlines, FAA (AFS/Human Factors), ATC

Timeline: Completed 30 months after CAST approval of Safety Enhancement.

Actions:

- **Employee Organizations** -- Assist in development of improved avoidance procedures with experienced-based inputs to best practices.

- **NASA AvSP Turbulence Team** -- Develop performance criteria and flight deck interfaces (CHI design) for the **new** radar.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Real Time Alerting Sensor for Clear Air Turbulence
- **Indicator:** 20% of the fleet contains next generation CAT sensor

SAFETY ENHANCEMENT 74: Airborne Detection – Enhanced Radar – Retrofit Windshear Equipped Aircraft

Note: This is based on Safety Enhancement 73.

Score (InjryRdx%): 2007: 0.02 2020: 0.20 Full: 0.20 ’07 Imp: 9%

Total Resource Requirements:

	Government		Manufacturers		Operators		Total
	FTE	**$**	**FTE**	**$**	**FTE**	**$**	**FTE/$M**
2007				**0.1**		**7.0**	**0/7.1**
2020				**0.2**		**14.0**	**0/14.2**
Totals				**0.3**		**21.0**	**0/21.3**

Completion Date: Completed 10 years after CAST approval of Safety Enhancement.

Output 1: Design, develop fleet retrofit - Service Bulletins.

Resources: Manufacturers

Timeline: Coincident with turbulence product introductions

Actions:

- **Manufacturers** -- Develop Service Bulletin to upgrade PWS capable equipment to include enhanced turbulence.

- **Manufacturers** -- Develop Service Bulletins for installation of weather radar equipment with enhanced turbulence capability.

Output 2: Certify retrofit configuration through Service Bulletins and Supplemental Type Certificates (STC)s.

Resources: Manufacturers, Airlines, FAA ATC

Timeline: Completed 54 months after CAST approval of Safety Enhancement.

Actions:

- **Manufacturers** -- Apply for regulatory certification of Service Bulletins and equipment modifications.

- **FAA** -- Facilitate and provide certification.

- **Airlines** -- Support certification effort as required. May require providing aircraft for flight test demonstration if an STC.

Output 3: Upgrade weather radar equipment and install Service Bulletins in aircraft.

Resources: Manufacturers, Airlines, FAA

Timeline: Completed 17 years after CAST approval of Safety Enhancement.

Actions:

- **Airlines** -- Upgrade equipment and install Service Bulletins.
- **Manufacturers** -- Provide support as required.
- **FAA** -- Provide regulatory approval of aircraft modifications.

SAFETY ENHANCEMENT 75: Airborne Detection – Enhanced Radar – Retrofit Non-Windshear-Equipped aircraft

[ELIMINATED FROM CONSIDERATION BY JSIT ON GROUNDS OF COST]

Relationship to Current Aviation Community Initiatives

Safety Enhancements 71 and 72

The current aviation community initiatives for a graphical weather display include the following:

- **AWIN:** Aviation Weather INformation is a broad based government/industry initiative to provide advanced weather products into the flight deck.

- **WINNCOMM:** Weather INformation Network COMMunication - NASA program that is investigating communication alternatives of weather products to the flight deck. This program will support flight deck initiatives such as AWIN.

- **WINN:** Weather INformation Network - Public/Private partnership focused on bringing to market a means of providing ground-based weather information to the flight deck and AOC of an airliner (anywhere in the world) or dispatch. Motivated by a government/industry desire to improve current and projected aviation weather hazard performance. Either server based using integrated display or external display with GPS link. Has been demonstrated in 777 simulator and NASA 757.

- **EWXR:** Enhanced Weather Radar is a program funded and in flight test to develop advanced processes for utilization of on-board weather radar information. Features under development include storm motion tracking, weather hazard analysis, storm top determination, and combination of airborne and ground based weather products to create a composite strategic and tactical weather display.

- **ADDS:** Aviation Digital Data Service is a web-based tool that provides graphical weather products to aviation end users. It also is used to demonstrate experimental weather products on a common grid. Also provides National Weather Service products.

- **NOWCAST:** Weather diagnosis and forecast from 0 to 2 hours.

- **EDR:** Eddy Dissipation Rate is a derived atmospheric parameter for defining atmospheric turbulence. An ICAO standard is presently in the approval stage from member states.

- **RTCA Special Committee SC-195:** This committee is developing the standards for data link of graphical weather to the flight deck.

- **ASAP:** Comprehensive FAA guidance has recently been issued recommending each air carrier's voluntary participation in an Aviation Safety Action Program (ASAP) and specifying the terms of its operation. Under ASAP a participating air carrier would encourage its employees to come forth with observations bearing on safety. Under all but certain specific conditions those observations would not incur FAA penalties, but would encourage a collaboration of managers, employees, and the FAA to address and correct safety hazards before an accident might occur. (existing since April, 2000)

- **FOQA:** Public Law, FAA regulations, and comprehensive FAA guidance to enable implementation of Flight Operational Quality Assurance programs (FOQA). Under FOQA participation by an air carrier would be voluntary. Copious data from flight data recorders would be de-identified and used for analysis and identification of accident precursors. An air carrier would take corrective actions before an accident might occur, based on its analyses. At some later time, de-identified FOQA data and analysis might be shared among air carriers in order to share the safety benefits of FOQA among all air carriers. (was expected in 2000)

The current effort to improve weather avoidance operating procedures is being done on an ad-hoc basis by individual airlines. There is currently no cohesive industry wide initiative to develop improved procedures.

Safety Enhancements 73 and 74:

The following aviation community initiatives are on going for radar and next generation sensors:

- **Turbulence Prediction and Warning systems (TPAWS):** Currently NASA and FAA are leading a multi-disciplined Government/industry team for the development of enhanced turbulence systems. This includes both radar based and next generation systems. The team consists of NASA, FAA, avionics manufacturers and research organizations directed at developing the scientific basis, algorithms and performance requirements for the detection of convective and non-convective related turbulence.
- **NASA and NCAR** are developing turbulence and thunderstorm models and corresponding radar simulations for development of turbulence detection algorithms.
- **NASA** is conducting flight test of demonstration systems incorporating the hardware and algorithms developed by the team.
- **Radar Manufacturers** are developing enhanced turbulence radar systems.
- **NASA and FAA** are jointly conducting workshops for developing performance and certification criteria for development of turbulence sensors.

<u>Programmatic approach</u>

Organizational strategy

At the present time, several government/industry initiatives are in progress that directly address the turbulence issues contained in these safety enhancements. These initiatives consist of industry partners developing systems and concept demonstrations with NASA providing scientific support. While NASA currently provides critical support by funding the concept development, evaluation and scientific basis, the industry partners are funding the development of products for commercial service. Current aviation community initiatives are a blend of existing technologies and new and future research.NASA is the critical enabling body that allows industry partners to continue technology growth. CAST support of these projects also provides priority and emphasis within the FAA to support development of performance and certification criteria for these initiatives.

Our organizational strategy is to ensure that NASA continues to be funded at current or higher levels to provide for scientific research and development in support of industry initiatives that will advance turbulence safety issues. This research will include the scientific background for turbulence detection, aircraft response and crew procedures. Demonstrations will be required that include human factors evaluation, data standard evaluation, flight testing and full evaluation of completed composite image for graphical displays and numerous other possibilities. Principle stakeholders (regulators, airframes, airlines, and manufacturers) must be involved in developing the requirements, performance and certification criteria, and defining and evaluating

the human factors and display concepts against accepted best practices. The program priorities must be consistent with the dates laid out in this plan, and performed in a timely manner to support and meet aviation safety goals.

Implementation Activities

The flow of this program is to develop the science behind turbulence, demonstrate a prototype system, complete system requirements, develop a system, implement and install into the airline fleet. Actions to complete these activities are found in the **Key Products and Milestones** section.

The critical pieces are the funding of the science as well as demonstration and requirements phases of the above actions. Based on NASA progress, industry can proceed to development and implementation of the turbulence sensors and graphical displays.

Key Products and Milestones:

Safety Enhancement 71: Graphical Displays – Carry on.		
Output 1: Evaluate/demonstrate integration of uplinked information on existing carry-on displays.		
Action	**Responsible Party**	**Completion Date**
Evaluate alternative architectures for integrating uplinked data, in industry standard format, using existing communication data links.	**FAA/NASA/ ATA/RAA/AIA/ Manufacturers**	**54 months after CAST approval ***
Output 2**:** Set standards and CHI good practices and standards for real time graphical flight deck display systems. Develop and implement algorithms.		
Action	**Responsible Party**	**Completion Date**

Set standards for alternate display systems (such as PC based options) incorporating CHI best practices and standards for real-time graphical flight deck display systems. Develop and implement algorithms to display turbulence on a carry on display.	**NASA/FAA/ Manufacturers** **NASA/FAA/ Manufacturers**	**54 months after CAST approval *** **54 months after CAST approval ***
Output 3: Develop/implement avoidance procedures.		
Action	**Responsible Party**	**Completion Date**
Develop improved weather avoidance operating procedures enabled by improved turbulence information on the flight deck using industry best practices and standards as well as CHI design. Implement new procedures	**ATA/Airlines/ Manufacturers/ Employee Organizations** **Airlines**	**54 months after CAST approval *** **54 months after CAST approval ***
Output 4: Review FAA Order 8400.10 to modify/eliminate inconsistencies between the new procedures and the Order.		
Action	**Responsible Party**	**Completion Date**
Review and revise FAA Order 8400.10 as necessary to ensure uniform industry implementation of new procedures.	**FAA**	**54 months after CAST approval ***

Safety Enhancement 72: Graphical Displays – Panel Mounted-New Production		
Action	**Responsible Party**	**Completion Date**
Output 1: Evaluate/demonstrate integration of uplinked/onboard information on existing carry-on displays.		
Action	**Responsible Party**	**Completion Date**

Evaluate alternative architectures for integrating uplinked and onboard data, in industry standard format, making maximum utilization of existing communication data links.	**NASA/FAA/ ATA/RAA/AIA/ Manufacturers**	**60 months after CAST approval ***
Output 2: Set standards and CHI good practices for display systems. Develop and implement algorithms.		
Action	**Responsible Party**	**Completion Date**
Set standards for alternate display systems (such as PC based options) incorporating CHI best practices and standards for real-time graphical flight deck display systems design to enhance and support integration of weather and turbulence data sources.	**NASA/FAA/ Manufacturers**	**60 months after CAST approval ***
Develop algorithms for display of turbulence on existing panel mounted displays	**NASA-AvSP/ Manufacturers/ Airlines/FAA-AFS/HF, ATC**	**60 months after CAST approval ***
Implement algorithms in existing panel mounted displays in 7 aircraft type designs to display turbulence on integrated displays in new production aircraft produced in CY04 and beyond.	**Manufacturers**	**60 months after CAST approval ***
Output 3: Develop/implement avoidance procedures.		
Action	**Responsible Party**	**Completion Date**

Develop improved weather avoidance operating procedures enabled by improved turbulence information on the flight deck using industry best practices and standards as well as CHI design Assist in development of improved avoidance procedures with experienced-based inputs to best practices	**Manufacturers/ Airlines** **Employee Organizations**	**60 months after CAST approval *** **60 months after CAST approval ***
Output 4: Review FAA Order 8400.10 to modify/eliminate inconsistencies between the new procedures and the Order.		
Action	**Responsible Party**	**Completion Date**
Review and revise FAA Order 8400.10 as necessary to ensure uniform industry implementation of new procedures. Implement new procedures.	**FAA** **Airlines**	**60 months after CAST approval *** **60 months after CAST approval ***

Safety Enhancement 73: Airborne-Detection-Enhanced Radar-New Production.		
Output 1: Develop/validate algorithms to estimate RMSg.		
Action	**Responsible Party**	**Completion Date**
Develop aircraft response algorithms to be applied to the aircraft hazard metric (RMS normal acceleration) to serve as a basis of **new radar** turbulence development and certification. Validate models and hazard metric.	**NASA/NCAR** **NASA**	**30 months after CAST approval** **30 months after CAST approval**
Output 2**:** Upgrade, flight test, certify radar.		
Action	**Responsible Party**	**Completion Date**

Develop **new** radar with output suitable for providing warning to ownship flight deck and for data linking to other users. Conduct in-service flight trials to determine the effectiveness of the turbulence detection algorithms and deployment feasibility. Assist with flight trials, post-flight analysis and confirm turbulence warning performance	**Manufacturers/ AIA** **ATA/RAA/** **NASA**	**36 months after CAST approval** **36 months after CAST approval** **36 months after CAST approval**
Output 3: Develop/implement procedures and training.		
Action	**Responsible Party**	**Completion Date**
Assist in development of improved avoidance procedures with experienced-based inputs to best practices. Develop performance criteria and flight deck interfaces (CHI design) for the **new** radar.	**Employee Organizations** **NASA-AvSP Turbulence Team**	**30 months after CAST approval** **30 months after CAST approval**

Safety Enhancement 74: Airborne-Detection-Enhanced Radar-Retrofit Windshear Equipped Aircraft.		
Output 1: Design, develop, fleet retrofit – Service Bulletins		
Action	**Responsible Party**	**Completion Date**
Develop Service Bulletin to upgrade PWS capable equipment to include enhanced turbulence. Develop Service Bulletins for installation of weather radar equipment with enhanced turbulence capability.	**Manufacturers** **Manufacturers**	**10 years after CAST approval** **10 years after CAST approval**
Output 2**:** Certify retrofit configuration through Service Bulletins and Supplemental Type Certificates (STCs).		
Action	**Responsible Party**	**Completion Date**
Apply for regulatory certification of Service Bulletins and equipment modifications. Facilitate and provide certification.	**Manufacturers** **FAA**	**54 months after CAST approval** **54 months after CAST approval**
Output 3: Upgrade weather radar equipment and install Service Bulletins in aircraft.		
Action	**Responsible**	**Completion Date**

	Party	
Upgrade equipment and install Service Bulletins.	**Airlines**	**17 years after CAST approval**
Provide support as required	**Manufacturers**	**17 years after CAST approval**
Provide regulatory approval of aircraft modifications.	**FAA**	**17 years after CAST approval**

Note: '' - denotes currently scheduled government / industry milestones*

Risk Description and Risk Mitigation Plan:

RISK DESCRIPTION	RISK MITIGATION PLAN
R6 - Government does not maintain monetary support of turbulence effort within the responsible Government agency.	M6 – CAST and industry assist the responsible Government agency by advocating funding and prioritization for continued turbulence funding. Industry provides guidance for needs and priorities to support aviation safety.
R7 - Responsible Government organization priority shifts away from turbulence.	M7 - CAST and Industry assist the responsible Government organization by advocating funding and prioritization for continued turbulence funding. Industry provides guidance for needs and priorities to support aviation safety.
R8 - Responsible Government organization schedule not compatible with industry need.	M8 - Industry assists the responsible government organization in aligning goals with industry needs through AvSP Turbulence Team meetings.
R9 – Inability to complete significant fleet installations in time to impact 2007 safety goals	M9 – Align the responsible government organization/industry goals to optimize completion of required outputs, involve airlines in planning and development, ensure compatibility with airline needs.
R10 – Unfavorable airline economics and competition for funds with other needs.	M10.1 – Develop cost/benefit analysis to encourage airlines to implement in time to impact 2007 AvSP goals. M10.2 Manufacturers/OEMs provide low cost upgrades for incentive.
R11 – Lack of manufacturer/OEM incentives/commitment	M11.1 – Manufacturers/OEMs develop business case based on airline needs to show economic feasibility of system product development

	M11.2 – Competition between suppliers will drive development
R12 – Human Factors (CHI) display product relevance – flight deck real estate.	M12.1 – Conduct Human Factors evaluations early in system development, involving OEMs, airlines and regulators to ensure best practices and effective use of flight deck resources M12.2 – Evaluation of alternative methods of presentation.
R13 – Performance of sensors falls short of minimum performance expectations for safety improvement.	M13.1 – Continued research for improved sensor performance. M13.2 – Educate the aviation community to what expectations for individual sensors should be. M13.3 – Restructure turbulence response procedures to utilize available sensor performance.

Impact on Non-Part 121 or International Applications

Part 129 - International
Benefits achieved by implementing these safety enhancements will benefit the international fleet in a like fashion to the U.S. fleet.

Part 135
Part 135 aircraft would benefit from these safety enhancements if the aircraft were able to equip with the sensor, e.g., have a radome large enough to handle air transport size radar antenna.

General Aviation
Sensor equipment will most likely not fit on the majority of general aviation aircraft. However, these safety enhancements would benefit general aviation if the graphical display or carry on display were used.

Turbulence
Joint Safety Implementation Team

Research Detailed Implementation Plan
For
Active In-Flight Turbulence Mitigation

Statement of Work: Provide active turbulence mitigation through movement of the aircraft control surfaces for generating forces to counteract acceleration forces experienced in aircraft cabins subject to atmospheric turbulence. Accomplish this mitigation through coupling of a short-range forward-looking gust sensor into the aircraft control system. Use feed-forward concepts to minimize the occurrence of negative acceleration forces that are highly correlated with in-flight turbulence injuries.

Lead Organization for Overall Project Coordination (LOOPC): NASA-Aviation Safety Program

SAFETY ENHANCEMENT 77 (Research): Active Turbulence Mitigation – Next Generation Control Systems – New Production

Score (Injury Reduction): 2007: 0 2020: 0.10 Full: 0.20 '07 Imp: 0%

Total Resource Requirements:

	Government		Manufacturers		Operators		Total
	FTE	$M	FTE	$M	FTE	$M	FTE/$M
2007		1.5					0/$1.5
2020		14.5		2.0			0/$16.5
Totals		16.0		2.0			0/$18

Note: Current level of expenditure at NASA is about $200K annually.

Completion Date: 9 years after CAST approval of Safety Enhancement.

Output 1: Develop a short-range forward-looking gust sensor for measuring the vector gust magnitude of oncoming turbulence. Design the sensor with sufficient accuracy and high data rates and reliability appropriate for integration into a control system meeting the high standards of typical commercial aircraft flight control systems.

Resources: NASA–Aviation Safety Program–Weather Accident Prevention Element (LOOC), Sensor Manufacturers

Timeline: Complete 7 years after CAST approval of Safety Enhancement.

Actions:

- **Sensor Manufacturers** -- Evaluate alternative sensor architecture concepts for accomplishing the gust measurement. Construct demonstration and prototype models for evaluating and demonstrating sensor performance.
- **NASA** -- Facilitate sensor concept demonstrations and flight evaluation of sensor performance.

Output 2: Develop, validate, and implement prototype commercial aircraft flight control systems for mitigating turbulence-initiated cabin accelerations using the short-range gust sensor measurements.

Resources: NASA–Aviation Safety Program–Weather Accident Prevention Element (LOOC), Aircraft Manufacturers

Timeline: Completed 9 years after CAST approval of Safety Enhancement.

Actions:

- **NASA/Manufacturers** -- Develop aircraft response algorithms to control negative aircraft cabin accelerations based on inputs from the forward-looking sensor.
- **NASA Aviation Safety Program WxAP** -- Verify and validate flight control algorithms performance through simulator and flight-testing.
- **NASA AvSP Turbulence Team** -- Develop performance criteria for the mitigation flight control system.
- **NASA** -- Present report to CAST on feasibility and implementation cost for deployment decision.

Performance Goals & Indicators for Safety Enhancement/Outputs

- **Goal:** Turbulence Mitigation flight control system
- **Indicator: Short Term:** First Generation technology is ready for implementation into the fleet by 2010
- **Indicator: Long Term:** Deployment decision by CAST.

Relationship to Current Aviation Community Initiatives

Output 1:

The current aviation community initiatives for a short-range forward-looking gust flow sensor consist of the following:

- **MOADS:** Molecular Air Data Sensor is a joint Navy/Air force initiative to develop a flow direction sensor for high performance military aircraft.

- **AVOSS:** A NASA sponsored ground-based system for measuring hazardous near-ground wake vortices to determine decay rates and behavior under varying wind conditions.

- **TALANT:** An airborne system based on Carbon Dioxide lasers for acquiring airspeed and flow direction angles used by Airbus for calibration purposes.

Output 2:

The following aviation community initiatives are on going for turbulence mitigation flight control systems:

- **Turbulence Prediction and Warning System (TPAWS):** Currently NASA is leading a multi-disciplined government/industry team for the development of enhanced turbulence systems. This activity focuses on next generation systems and includes NASA, Aircraft Manufacturers, and Sensor Manufacturers.
- **NASA and Aircraft Manufacturers** are developing aircraft control algorithms for suppressing turbulence accelerations in the cabin.
- **NASA** is flight-testing a prototype LIDAR sensor for detection of clear air turbulence.

<u>Programmatic approach</u>

Organizational strategy

Currently, government/industry initiatives are underway that directly address the turbulence issues contained in these safety enhancements. These initiatives consist of industry partners developing systems and concept demonstrations with NASA providing scientific support. NASA currently provides critical support by funding the concept development, evaluation and scientific basis, when the technology reaches sufficient maturity, the industry partners will fund the development of products for commercial service.

NASA is the critical enabling body that allows industry partners to continue technology growth. CAST support of these projects also provides priority and emphasis within the FAA to support development of performance and certification criteria for these initiatives.

Our organizational strategy is to make sure NASA continues to be funded at present or greater levels to provide enabling scientific research and development in support of industry initiatives that will advance turbulence safety issues. This research will include the scientific background for turbulence detection and aircraft response characterization. Demonstrations will be required that include data standard evaluation, flight-testing and full evaluation of turbulence mitigation systems. Principle stakeholders (regulators, airframes, airlines, and manufacturers) must be involved in developing the requirements, performance and certification criteria. The program priorities must be consistent with the dates laid out in this plan, and performed in a timely manner to support and meet aviation safety goals.

Implementation Activities

The flow of this program is to develop the science behind turbulence, demonstrate prototype system(s), complete system requirements, and report feasibility and cost to CAST for a deployment decision. Actions to complete these activities are found in the **Key Products and Milestones** section.

Key Products and Milestones

Safety Enhancement 77: Active Turbulence Mitigation – Next Generation Control Systems – New Production.		
Output 1: Develop a short-range forward-looking gust sensor for measuring the vector gust magnitude of oncoming turbulence. Design the sensor with sufficient accuracy and high data rates and reliability appropriate for integration into a control system meeting the high standards of typical commercial aircraft flight control systems.		
Action	**Responsible Party**	**Completion Date**
Evaluate alternative sensor architecture concepts for accomplishing the gust measurement. Construct demonstration and prototype models for evaluating and demonstrating sensor performance.	**Sensor Manufacturers**	**7 years after CAST approval**
Facilitate sensor concept demonstrations and flight evaluation of sensor performance.	**NASA**	**7 years after CAST approval**
Output 2: Develop, validate, and implement, prototype commercial aircraft flight control systems for mitigating turbulence-initiated cabin accelerations using the short-range gust sensor measurements.		
Action	**Responsible Party**	**Completion Date**
Develop aircraft response algorithms to control negative aircraft cabin accelerations based on inputs from the forward-looking sensor.	**NASA/ Manufacturers**	**12 months after CAST approval**
Verify and validate flight control algorithms performance through simulator and flight testing	**NASA Aviation Safety Program WxAP**	**60 months after CAST approval**
Develop performance criteria for the mitigation flight control system.	**NASA AvSP Turbulence Team**	**36 months after CAST approval**
Present report to CAST on feasibility and costs for deployment decision.	**NASA**	**9 years after CAST approval**

Risk Description and Risk Mitigation Plan:

RISK DESCRIPTION	**RISK MITIGATION PLAN**
R6 - Government does not maintain	M6 – CAST and industry assist the

monetary support of turbulence effort within NASA AvSP.	responsible government agency by advocating funding and prioritization for continued turbulence funding. Industry provides guidance for needs and priorities to support aviation safety.
R7 - Responsible government organization priority shifts away from turbulence.	M7 - CAST and industry assist the responsible government organization by advocating funding and prioritization for continued turbulence funding. Industry provides guidance for needs and priorities to support aviation safety.
R8 - Responsible government organization schedule not compatible with industry need.	M8 - Industry assists the responsible government organization in aligning goals with industry needs through AvSP Turbulence Team meetings.
R9 – Inability to complete significant fleet installations in time to impact 2007 safety goals	M9 – Align the responsible government organization/industry goals to optimize completion of required outs, involve airlines in planning and development, ensure compatibility with airline needs.
R11 – Lack of manufacturer/OEM incentives/commitment	M11.1 Manufacturers/OEMs develop business cased based on airline needs to show economic feasibility of system product development M11.2 Competition between suppliers will drive development.
R12 – Human Factors (CHI) display product relevance – flight deck real estate.	M12.1 – Conduct Human Factors evaluations early in system development, involving OEMs, airlines and regulators to ensure best practices and effective use of flight deck resources. M12.2 – Evaluation of alternative methods of presentation.
R13 – Performance of sensors falls short of minimum performance expectations for safety improvement.	R13.1 – Continue research for improved sensor performance. M13.4 – Restructure turbulence mitigation algorithm to utilize available sensor performance.

Impact on Non-Part 121 or International Applications

Part 129 – International. Since this enhancement is for new production aircraft, once approved, international implementation will likely match domestic implementation.

Part 135. Would benefit Part 135 operations to the degree that those aircraft are capable.

General Aviation. Size and cost of sensor suite expected to diminish with increasing technology maturity so that sensors could fit in limited space available. High-end GA aircraft control systems may be amenable to incorporating turbulence mitigation algorithms.

Turbulence
Joint Safety Implementation Team

Research Detailed Implementation Plan
For
Enhanced Airborne Turbulence Warnings

Statement of Work: Provide improved, real-time turbulence information to aircrew of ownship, aircrew of nearby aircraft, ground operations personnel, and forecasters for turbulence avoidance decisions and for input to turbulence forecasts. Accomplish the improvement through automated, airborne, aircraft turbulence measurements, new cockpit displays of turbulence information, improved or new on-board look-ahead turbulence detection capabilities, and upgraded flight crew procedures for use of improved information to avoid turbulence. Use best industry practices and computer-human interface (CHI) standards to develop cockpit displays and aircrew procedures in order to make best use of enhanced turbulence information.

Lead Organization for Overall Project Coordination (LOOPC): NASA-Aviation Safety Program

SAFETY ENHANCEMENT 76 (Research): Airborne Detection – Next Generation Sensors – New Production

Score (InjryRdx%): 2007: 0 2020: 0.12 Full: 0.12 ’07 Imp: 0%

Total Resource Requirements:

	Government		Manufacturers		Operators		Total
	FTE	$	FTE	$	FTE	$	FTE/$M
2007		2.0		0.3			0/2.3
2020		13.0		2.5			0/15.5
Totals		15.0		2.8			0/17.8

Completion Date: 7 years

Output 1: Develop/validate turbulence detection technology and algorithms to estimate RMSg from sensor inputs

Resources: NASA/NCAR

Timeline: 60 months after CAST approval of Safety Enhancement.

Actions:

- **NASA --** Support research and development to enhance turbulence detection technology
- **NCAR --** Develop algorithms to predict turbulence hazards based on inputs from turbulence detectors

Output 2: Develop, flight test, assess turbulence detector performance.

Resources: Manufacturers/ATA/RAA/NASA

Timeline: Completed 84 months after CAST approval of Safety Enhancement.

Actions:

- **Manufacturers/ATA/RAA** -- Develop new turbulence detector technology with output suitable for providing warning to ownship flight deck and for data linking to other users. Conduct in-service flight trials to determine the effectiveness of the turbulence detection systems and deployment feasibility.

- **NASA** -- Assist with flight trials, post-flight data analysis and confirm turbulence warning performance.

- **NASA** -- Make implementation recommendation, if warranted, to CAST.

Relationship to Current Aviation Community Initiatives

The following aviation community initiatives are on going for next generation sensors:

- **Turbulence Prediction and Warning Systems (TPAWS):** Currently NASA and the FAA are leading a multi-disciplined government/industry team for the development of enhanced turbulence systems. This includes both radar based and next generation systems. The team consists of NASA, FAA, avionics manufacturers and research organizations directed at developing the scientific basis, algorithms and performance requirements for the detection of convective and non-convective related turbulence.
- **NASA and NCAR** are developing turbulence and thunderstorm models and corresponding radar simulations for development of turbulence detection algorithms.
- **NASA** is conducting flight test of demonstration systems incorporating the hardware and algorithms developed by the team.
- **Radar manufacturers** are developing enhanced turbulence radar systems.
- **NASA** is flight-testing a prototype LIDAR sensor for detection of clear air turbulence.
- **NASA and the FAA** are jointly conducting workshops for developing performance and certification criteria for development of turbulence sensors.
- **Tropospheric Airborne Meteorological Data Reporting (TAMDAR):** As a part of the AWIN (Aviation Weather Information), this is an atmospheric measurements initiative to acquire meteorological information from aircraft in flight below 25k ft. altitude.

- **ASAP:** A part of the AWIN (Aviation Weather Information) ASAP is an initiative to use high resolution satellite-based weather observations to improve the accuracy and coverage of current meteorological data.

Programmatic approach:

Organizational strategy

Currently, several government/industry initiatives are ongoing that directly address the turbulence issues contained in these safety enhancements. These initiatives consist of industry partners developing systems and concept demonstrations with NASA providing scientific support. While NASA currently provides critical support by funding the concept development, evaluation and scientific basis, the industry partners are funding the development of products for commercial service. Current aviation community initiatives are a blend of existing technologies and new and future research.
NASA is the critical enabling body that allows industry partners to continue technology growth. CAST support of these projects also provides priority and emphasis within the FAA to support development of performance and certification criteria for these initiatives.

Our organizational strategy is to ensure NASA continues to be funded at current or higher levels to provide enabling scientific research and development in support of industry initiatives that will advance turbulence safety issues. This research will include the scientific background for turbulence detection, aircraft response and crew procedures. Demonstrations will be required that include human factors evaluation, data standard evaluation, flight testing and full evaluation of completed composite image for graphical displays and numerous other possibilities. Principle stakeholders (regulators, airframes, airlines, and manufacturers) must be involved in developing the requirements, performance and certification criteria, and defining and evaluating the human factors and display concepts against accepted best practices. The program priorities must be consistent with the dates laid out in this plan, and performed in a timely manner to support and meet aviation safety goals.

Implementation Activities

The flow of this program is to develop the science behind turbulence, demonstrate a prototype system, complete system requirements, develop a system, implement and install into the airline fleet. Actions to complete these activities are found in the **Key Products and Milestones** section.

The critical pieces are the funding of the science as well as demonstration and requirements phases of the above actions. Based on NASA progress, industry can proceed to development and implementation of the turbulence sensors and graphical displays.

Key Products and Milestones

Safety Enhancement 76: Airborne Detection – Next Generation Sensors – New Production.

Output 1: Develop/validate turbulence detection technology and algorithms to estimate RMSg from sensor inputs.		
Action	**Responsible Party**	**Completion Date**
Support research and development to enhance turbulence detection technology	**NASA**	**60 months after CAST approval ***
Develop algorithms to predict turbulence hazards based on inputs from turbulence detectors.	**NCAR**	**60 months after CAST approval ***
Output 2**:** Develop, flight test, assess turbulence detector performance.		
Action	**Responsible Party**	**Completion Date**
Develop new turbulence detector technology with output suitable for providing warning to ownship flight deck and for data linking to other users. Conduct in-service flight trials to determine the effectiveness of the turbulence detection systems and deployment feasibility.	**Manufacturers/ ATA/ NASA**	**84 months after CAST approval ***
Assist with flight trials, post-flight data analysis and confirm turbulence warning performance.	**NASA**	**84 months after CAST approval ***
Make implementation recommendation, if warranted, to CAST.	**NASA**	**84 months after CAST approval ***

Risk Description and Risk Mitigation Plan:

RISK DESCRIPTION	RISK MITIGATION PLAN
R6- Government does not maintain monetary support of turbulence effort within NASA AvSP	M6 – CAST and industry assist the responsible government agency by advocating funding and prioritization for continued turbulence funding. Industry provide guidance for needs and priorities to support aviation safety
R7 – Responsible government organization priority shifts away from turbulence.	M7 – CAST and industry assist the responsible government organization by advocating funding and prioritization for continued turbulence funding. Industry provides guidance for needs and priorities to support aviation safety.
R8 – Responsible government organization schedule not compatible with industry need.	M8 – Industry assists the responsible government organization in aligning goals with industry needs through AvSP Turbulence Team meetings..
R9 – Inability to complete significant fleet installations in time to impact 2007 safety goals.	M9 - Align the responsible government agency/industry goals to optimize completion of required outputs, involve airlines in planning and development ensure compatibility with airline needs.
R10 - Unfavorable Airline economics and competition for funds with other needs.	cost/benefit analysis to encourage airlines to implement in time to impact 2007 AvSP goals. M10.2: Manufacturers/OEMs provide low cost upgrades for incentive.
R11 - Lack of manufacturer / OEM incentives / commitment.	M11.1 - Manufacturers/OEMs develop business case based on Airline needs to show economic feasibility of system product development. M11.2 - Competition between suppliers will drive development.

R12 - Human Factors (CHI) display product relevance – flight deck real estate.	M12.1 - Conduct Human Factors evaluations early in system development, involving OEMs, Airlines and Regulators to ensure best practices and effective use of flight deck resources. M12.2: Evaluation of alternative methods of presentation.
R13 - Performance of sensors falls short of minimum performance expectations for safety improvement	e research for improved sensor performance. M13.2 - Educate the aviation community to what expectations for individual sensors should be. M13.3 - Restructure turbulence response procedures to utilize available sensor performance.

Impact on Non-Part 121 or International Applications

Part 129 - International
Benefits achieved by implementing these safety enhancements will benefit the international fleet in a like fashion to the U.S. fleet.

Part 135
Part 135 aircraft would benefit from these safety enhancements if the aircraft were able to equip with the sensor, e.g., have a radome large enough to handle air transport size radar antenna.

General Aviation
Sensor equipment will most likely not fit on the majority of general aviation aircraft. However, these safety enhancements would benefit general aviation if the graphical display or carry on display was used.

Turbulence
Joint Safety Implementation Team

Detailed Implementation Plan
For
Cabin Injury Reduction During Turbulence

Statement of Work: Reduce turbulence injuries to flight attendants (FAs) and passengers through improved situational awareness, turbulence encounter management procedures (before, during and after encounter), enhanced communication and identification and installation of effective cabin design safety features.

This project encompasses six safety enhancements, three of which are R&D (and are detailed in the Cabin Injury Reduction Research Detailed Implementation Plan) and three of which are immediately implementable. All six safety enhancements employ changes in procedures or equipage based upon industry best practices and documented in an Advisory Circular (AC).

Lead Organization for Overall Project Coordination (LOOPC): ATA Cabin Operations Committee/Flight Safety Committee

SAFETY ENHANCEMENT 78: Procedures for Reducing Cabin Injuries

Score (InjryRdx%): 2007: 0.20 2020: 0.20 Full: 0.20 '07 Imp: 100%

Total Resource Requirements:

	Government		Manufacturers		Operators		Total
	FTE	$M	FTE	$M	FTE	$M	FTE/$M
2007	1.84	.368			4.0	.934	5.84/$.1.302
2020							
Totals	1.84	.368			4.0	.934	5.84/$.1.302

Completion Date: Completed 26 months after CAST approval of Safety Enhancement.

Output 1: Develop industry consensus best practices for policies, procedures, training, and flight crew/cabin crew communications to minimize cabin occupant exposure to turbulence, especially for FA's.

Resources: FAA/AFS-200, Cabin Safety (LOOC), ATA Cabin Operations Committee/Flight Safety Committee, Airlines (Directors of Operations and Safety), Flight Attendant Unions, Pilot Unions, NASA-Ames, FAA (CAMI).

Timeline: Completed 11 months after CAST approval of Safety Enhancement.

Actions:

- **ATA/Airlines/FA Unions --** Identify and evaluate airlines best practices to address, wherever possible, the following JSAT identified interventions:
    - To reduce FAs' exposure to turbulence, air carriers should implement a policy and related SOPs for FAs to remain seated during periods of significant turbulence risk including climb and descent. (622 paraphrased)

    - To reduce FAs' exposure to turbulence, air carriers should implement a policy and related SOPs permitting FAs to prioritize their duties and cabin service schedules, including the option to be seated while making seatbelt announcements prior to and during turbulence encounters to minimize unnecessary FA exposure. (623 paraphrased)

    - "To equip FAs with the insights and knowledge required to prioritize cabin duties versus the risk of turbulence injuries, […air carriers should] develop and implement training for FAs in turbulence hazards, aircraft behavior in turbulence, [critical exposure periods, the use of available aircraft handholds], and the need to ensure their own safety." (624)

    - "To ensure effective cockpit-cabin communication, FAA should require that air carriers' operating specifications and training programs include standardized procedures and phraseology for pre-flight and in-flight communication of turbulence hazards, degree of hazard and all clear declarations." (601)

- **ATA/Airlines/FA Unions** -- From this collection, develop an industry consensus of best practices for incorporation into an AC (Output 2) that establishes policy guidance for air carrier's procedures.

Output 2: Document industry best practices in new AC, incorporate into FAA Order 8400.10 as necessary, and develop national training materials.

Resources: ATA Cabin Operations Committee/Flight Safety Committee (LOOC) and FAA/AFS-200, Cabin Safety

Timeline: Completed 30 months after CAST approval of Safety Enhancement.

Actions:

- **FAA/AFS-200, Cabin Safety** -- Take final work product from Output 1, review, evaluate and format the information into an AC, and guide the AC through FAA coordination and publication.

- **FAA/AFS-200, Cabin Safety** -- Review current FAA Order 8400.10 and propose revisions necessary to incorporate information and best practices contained in the published AC and guide the Order revision through FAA coordination and publication.

- **FAA and Industry** - Create national training materials on turbulence (video or other products) based on best practices.

Output 3: Revise procedures, develop airline training programs, and implement in annual recurrent training for flight and cabin crews.

Resources: ATA, Cabin Operations Committee/Flight Safety Committee (LOOC), airlines, Pilot Unions, FAA

Timeline: Completed 44 months after CAST approval of Safety Enhancement.

Actions:

- **Airlines** -- Revise FA and pilot standard operating procedures and training programs to incorporate the recommendations and best practices contained in the AC.

- **Airlines** -- Conduct the upgraded training during annual recurrent training for FAs and pilots to implement the recommendations and best practices contained in the AC.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Identify industry best practices procedures for protecting FAs and passengers and implement those in passenger-carrying airlines.
- **Indicator:** Part 121 carriers have implemented the "best practices".

SAFETY ENHANCEMENT 81: Cabin Design – Galley Handholds – New Production

Score (InjryRdx%): 2007: 0.04 2020: 0.09 Full: 0.09 '07 Impl: 40%

Total Resource Requirements:

	Government		Manufacturers		Operators		Total
	FTE	$M	FTE	$M	FTE	$M	FTE/$M
2007	0.10	0.02			0.80	0.26	0.9/$0.28
2020	0.15	0.03			1.20	0.24	1.35/$.27
Totals	0.25	0.05			2.00	0.50	2.25/$.55

Completion Date: 30 months after CAST approval of Safety Enhancement

Output 1: Determine best design for handholds in aircraft galleys.

Resources: ATA, Cabin Operations Committee (LOOC), airlines (designated engineering representative), aircraft cabin vendors, aircraft manufacturers, FA unions, FAA/AFS-200 (Cabin Safety), FAA/AIR, and FAA/CAMI.

Timeline: Completed 6 months after CAST approval of Safety Enhancement

Actions:

- **ATA/Airlines/Manufacturers/FA Unions --** Examine and evaluate current aircraft cabin interior products to identify those that provide optimum stability of occupants during all levels of turbulence for use in new aircraft.

Output 2: Establish best practices for procedures and national training materials for FAs' use of the handholds and publish in new AC (see SE 78) and FAA Order 8400.10.

Resources: FAA/AFS-200, Cabin Safety (LOOC**)**

Timeline: Completed 18 months after CAST approval of Safety Enhancement.

Actions:

- **FAA/AFS-200** -- Identify industry best practices for procedures and training of FAs in use of handholds in galleys.
- **FAA/AFS-200** -- Consolidate industry best practices and publish in new cabin safety AC to provide guidance for air carriers to use to develop procedures and training programs.
- **FAA/AFS-200** -- Create national training materials on turbulence (video or other products) based on best practices.

Output 3: Install recommended products in new production aircraft.

Resources: Airlines, manufacturers

Timeline: Ongoing

Actions:

- **Airlines/Manufacturers** -- Include handholds in galley packages for all new production aircraft.

Output 4: Revise FA and pilot procedures, upgrade training programs and implement new procedures and training.

Resources: Airlines

Timeline: Completed 30 months after CAST approval of Safety Enhancement.

Actions:

- **Airlines** -- Implement new turbulence procedures and turbulence training for the use of handholds as recurrent training**.**

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goals:** New production aircraft are equipped with galley handholds as they go into service and air crews are proficient in their use.

- **Indicators:** All new production aircraft are equipped with galley handholds as they go into service and air crews are proficient in their use.

SAFETY ENHANCEMENT 82: Cabin Design – Galley Handholds – Retrofit

Score (InjryRdx%): 2007: 0.11 2020: 0.14 Full: 0.14 '07 Imp: 80%

Total Resource Requirements:

	Government		Manufacturers		Operators		Total
	FTE	**$M**	**FTE**	**$M**	**FTE**	**$M**	**FTE/$M**
2007						**1.18**	**/$1.18**
2020						**0.29**	**--/$.29**
Totals						**1.47**	**/$1.47**

Completion Date: 60 months after CAST approval of Safety Enhancement

Output 1: Evaluate currently available handholds and select those most cost-effective for retrofit installation.

Resources: ATA, Cabin Safety Committee (LOOC), airlines (designated engineering representative), aircraft cabin vendors, aircraft manufacturers, and FA unions, FAA/AFS-200 (Cabin Safety), FAA/AIR, and FAA/CAMI.

Timeline: Completed 6 months after CAST approval of Safety Enhancement.

Actions:

- **Airlines** -- Evaluate currently available handholds and select those most cost-effective for retrofit installation.

Output 2: Install recommended products in legacy aircraft.

Resources: Airlines, manufacturers

Timeline: Completed 66 months after CAST approval of Safety Enhancement.

Actions:

- **Airlines** -- Install handholds in existing galleys of legacy aircraft.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goals:** Equip all legacy aircraft with galley handholds.

- **Indicators:** All legacy aircraft are equipped.

Programmatic approach

Organizational strategy

The Turbulence JSIT identified the ATA Cabin Operations Committee as the project lead for Cabin Injury Reduction During Turbulence. The project lead will coordinate and assist with the implementation of the activities outlined in this Detailed Implementation Plan and will, when requested, provide progress reports to the CAST. Implementation of this project is viewed as a shared responsibility and tasks will be divided among FAA and organizations/persons in industry. The Lead Organization for Overall Project Coordination (LOOPC) is the ATA Cabin Operations Committee. The Lead Organization for Output Coordination (LOOC) is FAA/AFS-200, Cabin Safety. The roles and responsibilities of the LOOPC and LOOC are described in the CAST approved JSIT Process Document.

Implementation Activities

Data has consistently shown that most turbulence related injuries occur to FAs and passengers who are not properly secured. Over the years Government and industry efforts have addressed this issue in an attempt to reduce turbulence injuries to FAs and passengers. These efforts lacked overall coordination and consequently have not been effective as indicated by the increasing trends in FA injuries. Central to the organizational strategy will be the integration of these various efforts combined with current data to develop comprehensive guidance. The Lead Organization in Output 1 and 2, working through the Principal Operation Inspectors, will initiate a process to determine existing best practices to be considered in the development of future guidance. Human factors research will further enhance the guidance for FA security and passenger seatbelt compliance.

Key Products and Milestones

Safety Enhancement 78: Procedures for reducing cabin injuries.		
Output 1: Develop industry consensus best practices for policies, procedures, training and flight crew/cabin crew communications to minimize cabin occupant exposure to turbulence, especially for FAs.		
Action	**Responsible Party**	**Completion Date**
Identify and evaluate airline best practices.	**ATA/Airlines/ FA Unions**	**9 months from CAST Approval.**

Develop industry consensus on best practices.	**ATA/Airlines/ FA Unions**	**11 months from CAST approval.**
Output 2**:** Document industry best practices in new AC, incorporate into FAA Order 8400.10 as necessary and develop national training materials.		
Action	**Responsible Party**	**Completion Date**
Review and evaluate results of above action item. Format information into Advisory Circular.	**FAA/AFS-200**	**14 months from CAST approval.**
Review FAA Order 8400.10 and propose revisions necessary to incorporate information and best practices contained in above AC and guide the Order revision through FAA coordination and publication.	**FAA/AFS-200**	**18 months from CAST approval.**
Create national training materials on turbulence (video or other products) based on best practices.	**FAA/Airlines/ FA Unions**	**30 months from CAST approval.**
Output 3: Revise procedures, develop individual airline training programs and implement in annual recurrent training for flight and cabin crews.		
Action	**Responsible Party**	**Completion Date**
Revise FA and pilot standard operating procedures and training programs to incorporate the recommendations and best practices contained in the AC.	**ATA/Airlines/Pilot Unions/FAA**	**32 months from CAST approval.**
Conduct the upgraded training during annual recurrent training for FAs and pilots to implement the recommendations and best practices contained in the AC.	**Airlines**	**44 months from CAST approval.**

Safety Enhancement 81: Cabin Design – Galley Handholds – New Production.		
Output 1: Determine best design for handholds in aircraft galleys.		
Action	**Responsible Party**	**Completion Date**
Examine and evaluate current aircraft cabin interior products to identify those that provide optimum stability of occupants during all levels of turbulence for use in new aircraft.	**ATA/Airlines/ FA Unions/ Manufacturers/ FAA-CAMI**	**6 months from CAST Approval.**

Output 2**:** Establish best practices for procedures and national training materials for FAs use of the handholds and publish in new AC (see SE78) and FAA Order 8400.10.		
Action	**Responsible Party**	**Completion Date**
Identify industry best practices for procedures and training of FAs in use of handholds in galleys.	**FAA/AFS-200**	**8 months from CAST approval.**
Consolidate industry best practices and publish in new cabin safety AC to provide guidance for air carriers to use to develop procedures and training programs.	**FAA/AFS-200**	**18 months from CAST approval.**
Create national training materials on turbulence (video or other products) based on best practices.	**FAA/AFS-200**	**18 months from CAST approval.**
Output 3: Install recommended products in new production aircraft.		
Action	**Responsible Party**	**Completion Date**
Include recommended handholds in galley packages for all new production aircraft.	**Airlines/ Manufacturers**	**Ongoing from 24 months after CAST approval.**
Output 4: Revise FA and pilot procedures, upgrade training programs and implement new procedures and training.		
Action	**Responsible Party**	**Completion Date**
Implement new turbulence procedures and turbulence training for use of handholds as part of annual recurrent training.	**Airlines**	**30 months from CAST approval.**

Safety Enhancement 82: Cabin Design – Galley Handholds – Retrofit.		
Output 1: Evaluate currently available handholds and select those most cost-effective for retrofit installation.		
Action	**Responsible Party**	**Completion Date**
Evaluate currently available handholds and select those most cost-effective for retrofit installation.	**Airlines**	**6 months from CAST Approval.**
Output 2**:** Install recommended products in legacy aircraft.		

Action	**Responsible Party**	**Completion Date**
Install handholds in existing galleys of legacy aircraft.	**Airlines**	**66 months from CAST approval.**

Risk Description and Risk Mitigation Plan:

RISK DESCRIPTION	RISK MITIGATION PLAN
R1 – Changing corporate culture will be difficult and ATA may not be able to insure full compliance with the standards developed.	M1 - Insure corporate buy-in of plan.
R6 – Government does not maintain monetary support of turbulence effort within responsible Government organization.	M6 – CAST and Industry assist responsible Government agency by advocating funding and prioritization for continued turbulence funding. Industry provides guidance for needs and priorities to support aviation safety.
R7 – Responsible Government organization priority shifts away from turbulence.	M7 – CAST and Industry assist the responsible Government organization by advocating funding and prioritization for continue turbulence funding. Industry provides guidance for needs and priorities to support aviation safety.
R10 – Unfavorable airline economics and competition for funds with other needs.	M10.1 – Develop cost/benefit analysis to encourage airlines to implement in time to impact 2007 AvSP goals. M10.2 – Manufacturers/OEMs provide low cost upgrades for incentive.

Impact on Non-Part 121 or International Applications

Cabin equipage will become standardized between domestic and international carriers over time. Procedures may remain distinct between international and domestic carriers except as they demonstrate lower injuries and lower operator costs which would induce international carriers to adopt.

Turbulence
Joint Safety Implementation Team

Research Detailed Implementation Plan
For
Cabin Injury Reduction During Turbulence

Statement of Work: Reduce turbulence injuries to flight attendants and passengers through improved situational awareness, turbulence encounter management procedures (before, during and after encounter), enhanced communication and identification of effective cabin design safety features.

This project encompasses six safety enhancements, three of which are R&D and three of which are immediately implementable (as detailed in the Cabin Injury Reduction Detailed Implementation Plan). All six safety enhancements employ changes in procedures or equipage based upon industry best practices and documented in an Advisory Circular (AC).

Lead Organization for Overall Project Coordination (LOOPC): ATA Cabin Safety Committee/Flight Operations Committee

SAFETY ENHANCEMENT 79 (Research): Improved Seat Belt Usage

Score (InjryRdx%): 2007: 0.10 2020: 0.10 Full: 0.10 ’07 Imp: 100%

Total Resources Required:

	Government		Manufacturers		Operators		Total
	FTE	**$M**	**FTE**	**$M**	**FTE**	**$M**	**FTE/$M**
2007	**2.1**	**0.42**					**2.1/$0.42**
2020							
Totals	**2.1**	**0.42**					**2.1/$0.42**

Completion Date: Completed 26 months after CAST approval of Safety Enhancement.

Output 1: Research Human Factors best practices for improving passenger seat belt use.

Resources: NASA (LOOC), airline representatives from airline flight attendant training and safety and flight operations.

Timeline: Completed 26 months years from CAST approval of Safety Enhancement.

Actions:

- **Airlines –** With NASA Ames, develop human factors survey

- **NASA Ames** -- Complete research for human factors best practices for increasing passenger use of seatbelts.

- **NASA/Airlines –** Collaborate on a demonstration of results and develop recommendations to improve passenger seat belt usage.

Output 2: Evaluate research findings and make appropriate recommendation for implementation to CAST.

Resources: FAA/AFS-200 (Cabin Safety) (LOOC), FAA (CAMI), NASA-Ames, ATA (Flight Safety Committee, Training Committee, Safety Council, Operations Council), and other experts as necessary.

Timeline: Completed 30 months after CAST approval of Safety Enhancement.

Actions:

- **FAA/AFS-200, Cabin Safety**: Evaluate research findings and develop implementation plan.

- **FAA/AFS-200, Cabin Safety**: Present recommendation, as appropriate, to CAST for implementation.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Complete research to show what measures will produce optimum seat-belt usage.

- **Indicator:** Acceptance of research report and implementation recommendation by CAST.

SAFETY ENHANCEMENT 80 (Research): Aircraft-wide Communications

Score (InjryRdx%): 2007: 0.0 2020: 0.16 Full: 0.16 '07 Imp: 0%

Total Resources Required:

	Government		Manufacturers		Operators		Total
	FTE	$M	FTE	$M	FTE	$M	FTE/$M
2007							/$0.0
2020	1.25	0.25				0.10	1.25/$0.35
Totals	1.25	0.25				0.10	1.25/$0.35

Completion Date: Completed 12 months after CAST approval of Safety Enhancement.

Output 1: Identify and evaluate current technology for instant aircraft-wide communications systems and make appropriate recommendations for implementation to CAST.

Resources: ATA Cabin Operations Committee/Flight Safety Committee (LOOC), NASA, FAA-HF (CAMI), FAA/AFS-200, Cabin Safety, Airlines (Directors of Operations and Safety), Flight Attendant Unions, Pilot Unions, TSA

Timeline: Completed 12 months after CAST approval of Safety Enhancement.

Actions:

- ATA/Airlines/FA Unions/Pilot Unions -- Develop a concept of operations (ConOps) for "instant aircraft-wide communications".
- NASA/FAA-CAMI -- Working with TSA, identify low cost alternatives from existing technology for instant aircraft-wide communications.
- ATA/Airlines -- Present findings and implementation recommendation, if any, to CAST.

Performance Goals & Indicators for Safety Enhancement/Outputs:

- **Goal:** Complete research to show what systems will yield cost/effective aircraft-wide communications.
- **Indicator:** Acceptance of research report and implementation recommendation by CAST.

SAFETY ENHANCEMENT 83 (Research): Cabin Design – Aircraft Equipment Other than Handholds – New Production & Retrofit

Score (InjryRdx%): 2007: 0.03 2020: 0.14 Full: 0.14 '07 Imp: 20%

Total Resources Required:

	Government		Manufacturers		Operators		Total
	FTE	$M	FTE	$M	FTE	$M	FTE/$M
2007	0.5	0.10				0.16	0.5/$0.26
2020							--/--
Totals	0.5	0.10				0.16	0.5/$0.26

Completion Date: 12 months after CAST approval of Safety Enhancement

Output 1: Identify and evaluate turbulence-friendly cabin interior products (current technology), other than handholds for possible installation in new production and retrofit in legacy aircraft.

Resources: ATA, Cabin Safety/Committee (LOOC), airlines (designated engineering representative), aircraft cabin vendors, aircraft manufacturers, and flight attendant unions, FAA/AFS-200 (Cabin Safety), FAA/AIR, and FAA/CAMI.

Timeline: Completed 12 months after CAST approval of Safety Enhancement.

Actions:

- **ATA/Airlines/FA Unions/Manufacturers/FAA-CAMI --** Identify and evaluate current aircraft cabin interior products that will provide optimized protection of occupants during all levels of turbulence for use in new production and retrofit aircraft.

Output 2: Determine implementation feasibility and cost/effectiveness of candidate systems and make implementation recommendation to CAST.

Resources: ATA, Cabin Safety Committee (LOOC), airlines (designated engineering representative), aircraft cabin vendors, aircraft manufacturers, and flight attendant unions, FAA/AFS-200 (Cabin Safety), FAA/AIR, and FAA/CAMI.

Timeline: Completed 24 months after CAST approval of this Safety Enhancement.

Actions:

- **ATA/Airlines/FAA:** Determine implementation feasibility and cost/effectiveness of candidate systems.
- **ATA/Airlines/FAA:** Make a recommendation for implementation to CAST

Programmatic approach:

Organizational strategy

The Turbulence JSIT identified the ATA Cabin Safety Committee as the project lead for Cabin Injury Reduction During Turbulence. The project lead will coordinate and assist with the implementation of the activities outlined in this Implementation Plan and will, when requested, provide progress reports to the CAST. Implementation of this project is viewed as a shared responsibility and tasks will be divided between FAA and organizations/persons in industry. The Lead Organization for Overall Project Coordination (LOOPC) is the ATA Cabin Safety Committee. The Lead Organization for Output Coordination (LOOC) is FAA/AFS-200, Cabin Safety. The roles and responsibilities of the LOOPC and LOOC are described in the CAST approved JSIT Process Document.

Implementation Activities

Data has consistently shown that most turbulence related injuries occur to FAs and passengers who are not properly secured. Over the years government and industry efforts have addressed this issue in an attempt to reduce turbulence injuries to FAs and passengers. These efforts have lacked overall coordination and consequently have not been effective as indicated by the increasing trends in FA injuries. Central to the organizational strategy will be the integration of

these various efforts combined with current data to develop comprehensive guidance. The Lead Organization in Output 1 and 2, working through the Principal Operation Inspectors, will initiate a process to determine existing best practices to be considered in the development of future guidance. Human factors research will further enhance the guidance for FA security and passenger seatbelt compliance.

Key Products and Milestones

Safety Enhancement 79: Improved Seat Belt Usage (Research)		
Output 1: Research Human Factors best practices for improving passenger seat belt use.		
Action	**Responsible Party**	**Completion Date**
Develop Human Factors survey.	**NASA/Airlines**	**12 months from CAST approval.**
Complete research for human factors best practices for increasing passenger use of seat belts.	**NASA**	**24 months from CAST approval.**
Collaborate on a demonstration of results and develop recommendations to improve passenger seat belt usage.	**NASA/Airlines**	**26 months from CAST approval.**
Output 2**:** Evaluate research findings and make appropriate recommendation for implementation.		
Action	**Responsible Party**	**Completion Date**
Evaluate research findings and develop implementation plan.	**FAA/AFS-200**	**28 months from CAST approval.**
Present recommendations, as appropriate to CAST for implementation.	**FAA/AFS-200**	**30 months from CAST approval.**

Safety Enhancement 80: Aircraft-wide Communications (Research).		
Output 1: Identify and evaluate current technology for instant aircraft-wide communications systems and make appropriate recommendations for implementation to CAST.		
Action	**Responsible Party**	**Completion Date**
Develop a concept of operations (ConOps) for "instant aircraft-wide communications".	**ATA/Airlines/ FA Unions/Pilot Unions**	**2 months from CAST Approval.**

Working with TSA, identify low cost alternatives from existing technology for instant aircraft-wide communications. Present findings and implementation recommendations to CAST	**NASA/FAA-CAMI** **ATA/Airlines**	**8 months from CAST approval.** **12 months from CAST approval.**

<u>Safety Enhancement 83</u>: Cabin Design – Aircraft Equipment other than Handholds – New production and Retrofit. (Research)		
<u>Output 1</u>: Identify and evaluate turbulence-friendly cabin interior products (current technology) other than handholds, for possible installation in new production and retrofit in legacy aircraft.		
Action	**Responsible Party**	**Completion Date**
Identify and evaluate current aircraft cabin interior products that will provide optimized protection of occupants during all levels of turbulence for use in new production and retrofit aircraft .	**ATA/Airlines/ FA Unions/ Manufacturers/ FAA-CAMI**	**12 months from CAST Approval.**
<u>Output 2</u>**:** Determine implementation feasibility and cost effectiveness of candidate systems and make implementation recommendations to CAST.		
Action	**Responsible Party**	**Completion Date**
Determine implementation feasibility and cost effectiveness of candidate systems.. Make implementation recommendations to CAST.	**ATA/Airlines/ FAA** **ATA/Airlines/ FAA**	**22 months from CAST approval.** **24 months from CAST approval.**

<u>Risk Description and Risk Mitigation Plan:</u>

RISK DESCRIPTION	RISK MITIGATION PLAN
R1 – Changing corporate culture will be difficult and ATA may not be able to insure full compliance with the standards developed.	M1 – Insure corporate buy-in of plan.
R6 – Government does not maintain	M6 – CAST and industry assist the

monetary support of turbulence effort within responsible Government organization.	responsible government agency by advocating funding and prioritization for continued turbulence funding. Industry provides guidance for needs and priorities to support aviation safety.
R7 - Responsible Government organization priority shifts away from turbulence.	M7 - CAST and industry assist the responsible government organization by advocating funding and prioritization for continued turbulence funding. Industry provides guidance for needs and priorities to support aviation safety.
R10 – Unfavorable airline economics and competition for funds with other needs.	M10.1 – Develop cost/benefit analysis to encourage airlines to implement in time to impact 2007 AvSP goals. M10.2 – Manufacturers/OEMs provide low cost upgrades for incentive.

Impact on Non-Part 121 or International Applications

Cabin equipage will become standardized between domestic and international carriers over time. Procedures may remain distinct between international and domestic carriers except as they demonstrate lower injuries and lower operator costs which would induce international carriers to adopt.