

**Turbulence  
Joint Safety Implementation Team  
  
Research Detailed Implementation Plan  
For  
Enhanced Airborne Turbulence Warnings**

**DRAFT**

**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
<b>2007</b>		2.0		0.3			0/2.3
<b>2020</b>		13.0		2.5			0/15.5
<b>Totals</b>		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*

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 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, 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**

<b><u>Safety Enhancement 76: Airborne Detection – Next Generation Sensors – New Production.</u></b>		
<u>Output 1:</u> Develop/validate turbulence detection technology and algorithms to estimate RMSg from sensor inputs.		
<b>Action</b>	<b>Responsible Party</b>	<b>Completion Date</b>
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 *
<u>Output 2:</u> Develop, flight test, assess turbulence detector performance.		
<b>Action</b>	<b>Responsible Party</b>	<b>Completion Date</b>
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:**

<b>RISK DESCRIPTION</b>	<b>RISK MITIGATION PLAN</b>
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.	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.

<p>R12 - Human Factors (CHI) display product relevance – flight deck real estate.</p>	<p>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.</p> <p>M12.2: Evaluation of alternative methods of presentation.</p>
<p>R13 - Performance of sensors falls short of minimum performance expectations for safety improvement</p>	<p>M13.1 - Continue research for improved sensor performance.</p> <p>M13.2 - Educate the aviation community to what expectations for individual sensors should be.</p> <p>M13.3 - Restructure turbulence response procedures to utilize available sensor performance.</p>

**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..