Safety Enhancement Concept SE 209.4 (R&D) ASA – Research – Simulator Fidelity	
Safety Enhancement Action:	To improve pilot performance during recovery from a full stall, the aviation industry should perform research to determine the benefits of using various levels of prototype advanced aerodynamic modeling of full stall characteristics to perform full stall recovery training.
Implementers: (Select all that apply)	☒ Air Carrier ☐ Industry Association ☐ Commercial Aviation Safety Team (CAST) ☐ Joint Implementation Measurement and Data Analysis Team (JIMDAT) ☒ Research Organization ☒ Labor Organization ☒ Manufacturer ☒ Regulator ☐ Other (specify) ______________________
Statement of Work:	To reduce accidents and incidents due to loss of airplane state awareness and improve pilot performance during recovery from a full stall, the aviation community should perform research, in accordance with U.S. Public Law 111–216, to determine— 1) The upset and stall recognition and recovery learning objectives (i.e., metrics for satisfactorily completing the training); 2) The ability to satisfactorily model full stall characteristics across a variety of aircraft types; 3) Whether the various model characteristics make a difference in full stall recovery training; and 4) How to insert aircraft response characteristics into the simulator to ensure the skills learned in simulator training are directly usable in real flight.
Total Financial Resources:	**Total: $14.5M** Output 1: $0.5M Output 2: $2.0M Output 3: $6.0M Output 4: Action withdrawn
Relation to Current Aviation Community Initiatives:	• Federal Aviation Administration (FAA) Section 208 Aviation Rulemaking Committee & International Civil Aviation Organization (ICAO) Loss of Control Avoidance & Recovery Training • Title 14, Code of Federal Regulations (14 CFR) part 60 rulemaking on upset prevention and recovery training, which is specifying modeling of full-stall characteristics • International Committee for Aviation Training in Extended Envelopes • National Aeronautics and Space Administration (NASA) Aviation Safety Program
Performance Goal Indicators:	
Key Milestones:	

		Flow time (mo)	Start Date	End Date	
	Output 1:	12	12/31/2013	12/31/2014	
	Output 2:	12	12/31/2013	12/31/2014	
	Output 3:	57	12/31/2013	9/30/2018	
	Output 4:Action withdrawn				
	Completion:	**87**	**12/31/2013**	**3/31/2021**	

Potential Obstacles:	The paucity of available full-stall data for some aircraft types may make it difficult to assess the accuracy of the full-stall models. It is challenging to conduct an in-flight experiment with sufficient experimental power to confidently conclude effective transfer of training was accomplished.	
Detailed Implementation Plan Notes:	None	
CICTT Code:	Loss of Control–Inflight (LOC–I)	
Output 1:		
Description:	Aviation industry associations and regulators should define the learning objectives (i.e., metrics) for upset prevention and recovery training.	
Lead Organization:	Federal Aviation Administration (FAA) Flight Standards Service (AFS)	
Supporting Organizations:	Air carriers Air Line Pilots Association (ALPA) Airbus Allied Pilots Association (APA) Bombardier, Inc. Embraer FAA Aircraft Certification Service (AIR) FAA Civil Aerospace Medical Institute National Aeronautics and Space Administration Simulator manufacturers The Boeing Company	
Implementers: (Select all that apply)	☒ Air Carrier ☐ Industry Association ☐ Commercial Aviation Safety Team (CAST) ☐ Joint Implementation Measurement and Data Analysis Team (JIMDAT)	☒ Research Organization ☒ Labor Organization ☒ Manufacturer ☒ Regulator ☐ Other (specify) ________________________

Actions:	1. FAA AFS will coordinate with research organizations, air carrier training organizations, pilot labor organizations, manufacturers of 14 CFR part 25 airplanes, simulator manufacturers, and FAA AIR to develop learning objectives relating to recovery from full aerodynamic stall. These objectives include, but are not limited to— a) Pilot knowledge of aerodynamics and flight dynamics associated with aircraft handling and recovery at the limits of the operational flight envelope, b) Development of situation awareness by using relevant information and cues to identify precursors to upset or stall situations, c) Teaching how to recognize upset and stall conditions in case situation awareness failed, and d) Development of upset and stall recovery procedures by adequate use of primary or alternate control strategies in a timely and proportional manner. 2. FAA AFS will disseminate the learning objectives to all parties through published guidance or a best practices document to all applicable organizations and JIMDAT. 3. JIMDAT will track implementation and report progress and completion to CAST.
Financial Resources:	Total: $0.5M
Itemized Resources:	R&D Orgs: $0.3M Manufacturers: $0.2M
Output Notes:	• This is a research detailed implementation plan (DIP). • FAA to determine the format of the guidance material.
Time Line:	12 months from CAST approval
Target Completion Date:	12/31/2014. Completed and closed 2/12/2015.
Output 2:	
Description:	Training and research organizations should identify the benefits of using various levels of prototype advanced aerodynamic modeling of full-stall characteristics to perform full-stall recognition and recovery training.
Lead Organization:	Federal Aviation Administration (FAA) Flight Standards Service (AFS)
Supporting Organizations:	Airbus Bombardier, Inc. Embraer FAA Aircraft Certification Service (AIR) National Aeronautics and Space Administration (NASA) Other research organizations The Boeing Company
Implementers:	☐ Air Carrier ☒ Research Organization

(Select all that apply)	☐ Industry Association ☐ Commercial Aviation Safety Team (CAST) ☐ Joint Implementation Measurement and Data Analysis Team (JIMDAT)	☐ Labor Organization ☒ Manufacturer ☒ Regulator ☐ Other (specify) ________________________
Actions:	1. FAA AFS will coordinate with National Aeronautics and Space Administration (NASA), FAA AIR, manufacturers and other research organizations to sponsor and perform research to identify the benefits of using various levels of aerodynamic modeling to meet the learning objectives in Output 1, as follows: a) Identify up to which angle-of-attack a simulator must be representative of the aircraft to meet the learning objectives in Output 1. b) Identify which aerodynamic characteristics must be modeled to meet the learning objectives in Output 1. c) Evaluate at key operating conditions (e.g., high-altitude). 2. Research organizations will publish results in publicly available reports and provide copies to JIMDAT and CAST for review. 3. FAA AFS will track the research and report progress to JIMDAT and CAST.	
Financial Resources:	Total: $2.0M	
Itemized Resources:	R&D Orgs: $1.0M FAA $1.0M	
Output Notes:	This is a research detailed implementation plan (DIP).	
Time Line:	• 12 months from CAST approval. • Research is already underway.	
Target Completion Date:	12/31/2014. Completed and closed 2/12/2015.	
Output 3:		
Description:	Defined aerodynamic model parameters, along with their availability and associated uncertainties, that are necessary for replicating full stall flight characteristics of various aircraft models, including wing-mounted twins, high-wing turboprops, and T-tail/aft engine configurations.	
Lead Organization:	National Aeronautics and Space Administration (NASA)	
Supporting Organizations:	Airbus Bombardier, Inc. Embraer Federal Aviation Administration (FAA) Aircraft Certification Service (AIR) Other research organizations The Boeing Company	

Implementers: (Select all that apply)	☐ Air Carrier ☐ Industry Association ☐ Commercial Aviation Safety Team (CAST) ☐ Joint Implementation Measurement and Data Analysis Team (JIMDAT) ☒ Research Organization ☐ Labor Organization ☒ Manufacturer ☒ Regulator ☐ Other (specify) ________________________
Actions:	1. NASA should coordinate with manufacturer and FAA research organizations to sponsor and undertake research to define aerodynamic model parameters, along with their availability and associated uncertainties, necessary for replicating full-stall flight characteristics of various aircraft models as necessary to satisfy the learning objectives in Output 1, as follows: a) Develop appropriate and complete model structures required to capture the dynamic characteristics of full-stall behavior for the following configurations: i. Wing-mounted twins, single aisle; ii. Wing-mounted twins, twin aisle, envelope protected; iii. Wing-mounted quads, twin aisle; iv. High-wing turboprop; v. T-tail with aft twin engines; and vi. T-tail tri-jets. b) Use the developed models to define the specific aerodynamic parameter requirements necessary to appropriately model full-stall characteristics at a level needed to support the learning objectives of Output 1. c) Identify the analytical (equation-based and numerical modeling) and empirical methods (wind tunnel, subscale flight, full-scale flight) , and other testing and numerical modeling of commercial aircraft required to define or evaluate aerodynamic coefficients in the non-linear area of flight envelope to the accuracy required for replicating the required characteristics. d) Evaluate the cost of the above mentioned testing and processing. e) Perform a sensitivity study against flight data (including subscale, as appropriate) to determine the principal variables and reduce the order of the model if appropriate. f) Investigate best practices and potentially evaluate new technique to determine the variables in the reduced-order model and estimate their uncertainties. g) Objectively demonstrate the models’ ability to match flight-test and other high fidelity data (this may necessitate collection of additional full-scale data on older aircraft types). 2. NASA and other research organizations should publish results in publicly available reports and provide copies to JIMDAT and CAST for evaluation.

	3. NASA will track research and report progress to CAST.
Financial Resources:	Total: $6.0M
Itemized Resources:	R&D Orgs: $6.0M to perform study (does not include costs of potential additional full-scale flight testing, if necessary)
Output Notes:	This is a research detailed implementation plan (DIP).
Time Line:	51 months from CAST approval
Target Completion Date:	9/30/2018 (extended from 3/31/2018). Completed and closed 10/04/2018 based on completed NASA research. JIMDAT will review reports and recommend appropriate follow-on actions.
Output 4:	
Description:	Research organizations, in collaboration with training organizations, should determine whether the characteristics presented in the simulator enable pilots to recognize stalls and to perform realistic post-stall recoveries in an actual airplane. The data collected should be used to optimize stall training. Characteristics of particular note are— • Handling characteristics near stall angle of attack, • Motion cue for realism of buffet near stall angle of attack, and • Motion cue for realism of stall g-break and nose drop if any.
Lead Organization:	Federal Aviation Administration (FAA) Flight Standards Service (AFS)
Supporting Organizations:	Air carriers (pilots) Airbus Bombardier, Inc. Embraer National Aeronautics and Space Administration (NASA) Other research organizations
Implementers: (Select all that apply)	☒ Air Carrier ☐ Industry Association ☐ Commercial Aviation Safety Team (CAST) ☐ Joint Implementation Measurement and Data Analysis Team (JIMDAT) ☒ Research Organization ☐ Labor Organization ☒ Manufacturer ☒ Regulator ☐ Other (specify) ______
Actions:	1. Based on the results of the first three outputs, FAA AFS should coordinate with NASA and other research organizations to conduct a study using an in-flight simulator to validate that the model characteristics used to train upset prevention and recovery techniques will transfer to flight, as follows: a) Perform an in-flight experiment to compare the skills of a group that has had the simulator training with the determined model characteristics versus the skills of a group that has not had the simulator training.

	b) Assess the skills relative to the learning objectives identified in Output 1. c) Recommend improvements to stall training should be made based upon the research results. 2. Research organizations should publish results in publicly available reports and provide copies to JIMDAT and CAST for review. 3. FAA AFS will track the research and report progress to JIMDAT and CAST.
Financial Resources:	Total: $6.0M
Itemized Resources:	R&D Orgs: $5.9M to perform study Air carriers: $0.1M (to provide pilots for the study)
Output Notes:	This is a research detailed implementation plan (DIP).
Time Line:	36 months from completion of Output 3
Target Completion Date:	Action withdrawn 04/07/2021, based on the proposed study no longer being necessary as the intent of the study was to support implementation of training requirements; the training requirements have already been implemented.
Reference Material	
Supporting CAST Intervention Strategies	NOTE: *This section lists applicable CAST Intervention Strategies (IS) used to develop the actions in this detailed implementation plan (DIP). These ISs are listed to provide traceability and supporting rationale for the recommended actions. IS recommendations may be wholly or only partly represented in the DIP, based on a final determination of feasible actions during DIP development.* IS 1239—To improve pilot performance during recovery from a full stall, the aviation industry should perform research to determine the benefit, if any, of post-stall recovery training using prototype advanced aerodynamic modeling of full-stall characteristics (e.g., the NASA Enhanced Upset Recovery Simulation). IS 1240—To improve flight crew proficiency in responding to stall warning, airlines/operators should develop and implement changes in approach-to-stall training that include realistic scenarios, such as approach-to-stall with the autopilot on, recognition and recovery from initial improper response, recognition of transition from pre-stall to post-stall conditions.