Helicopter Safety Enhancement (H-SE) 81: Improve Simulator Modeling for Outside-the-Envelope Flight Conditions	
Safety Enhancement Action:	Technology/Equipment: FAA and industry to provide recommendations for improving simulator mathematical physics models for level A-D Full Flight Simulators (FFSs), basic and advanced Aviation Training Devices (ATDs),[1] and Level 4-7 Flight Training Devices (FTD) for outside-the-envelope flight conditions.
Expected Implementers:	• FAA – AFS-200, AFS-800 • FAA – Tech Center, ANG-E2 • USHST – Special Emphasis Area (SEA) Training Team • Helicopter OEMs – General Aviation Manufacturers Association (GAMA) will coordinate • HAI – Training Committee • Simulation/Training Device Manufacturers
Statement of Work:	The USHST's working group analyzed 52 fatal accidents that occurred between 2009-2013 and found some cases where loss of control inflight (LOC-I) occurred during basic maneuvers (*e.g.*, hover, quick stop) and during unsuccessful attempted recovery from potentially unsafe conditions (*e.g.*, Loss of Tail Rotor Effectiveness, Settling with Insufficient Power). To address these issues, this H-SE seeks to improve the accuracy of full flight simulators (FFS)/flight training devices. The intent is to provide recommendations for developing better mathematical/physics-based models for helicopter flight dynamics in order to achieve more realistic, higher-fidelity simulations of outside-the-envelope flight conditions. Current models are not accurate at edge-of-the-envelope and outside-of-the-envelope flight regimes. This may lead to unrealistic training of maneuvers such as loss of tail rotor effectiveness, vortex ring state/settling with power, and autorotations and a negative transfer of training when similar situations are encountered during actual flight. There is the possibility of some overlap in the work between H-SE 81 and H-SE 127A. H-SE 127A addresses the possible use of

[1] *See, e.g.*, FAA National Simulator Program, available at https://www.faa.gov/about/initiatives/nsp/.

	simulation for purposes of preventing, recognizing, and recovering from spatial disorientation. Project: 1. USHST to coordinate formation of H-SE 81 team. 2. FAA, industry, and academia to review existing helicopter simulator/physics-based models and conduct research/testing to develop recommendations regarding improved helicopter mathematical/physics-based models. 3. FAA AFS-200/AFS-800 to update advisory circulars AC-120-45A and AC-61-136A (or create helicopter-specific variants) based on recommendations to facilitate use of improved fidelity helicopter flight dynamics models in helicopter simulators. 4. H-SE 81 team to conduct outreach to simulator and flight training device manufacturers regarding recommendations for higher-fidelity mathematical models. The following 2 fatal accidents prompted this H-SE: WPR12GA106 CEN13FA205
Relation to Current Aviation Community Initiatives:	• FAA Terminal Area Safety Stall Modelling Research • Rotorcraft ASIAS HFDM Research Helicopter Performance Based Models
Performance Goal Indicators:	• Publication of recommendations for helicopter simulator mathematics/physics. • Revised FAA guidance to facilitate use of recommendations. • Recommendations promoted to industry.
Key Milestones:	Total Months / Start Date / End Date Output 1: 2 / Sept. 15, 2017 / Nov. 15, 2017 Output 2: 24 / Nov. 15, 2017 / Nov. 15, 2019 Output 3: 24–36 / Nov. 15, 2019 / Nov. 15, 2022 Output 4: 9 / Nov. 15, 2022 / Aug. 15, 2023 **Completion: 59–71 months**

Potential Obstacles:	• Cost • Lack of available data / proprietary limitations on data • Government procedures for updating guidelines/policy • Lack of government resources to undertake H-SE
Detailed Implementation Plan Notes:	To be successful, this H-SE requires expertise in simulation design. The authors and reviewers of this H-SE noted that the description of the what it is supposed to accomplish may not be at a sufficient level of detail for those who work in simulation design, so further refinement may be needed after consultation with simulation experts. Data exists from helicopter original equipment manufacturers or could be obtained through flight tests, aerodynamic models, wind tunnel tests, etc., to quantify and refine the models developed for use in the simulators. To implement the recommendations, changes to simulation software for AATDs and simulators may be required.
CICTT Code:	LOC-I
Output 1	
Description:	Form H-SE 81 team.
Lead Organization:	USHST
Supporting Organizations:	
Actions:	USHST to convene team of subject matter experts to support H-SE 81.
Output Notes:	
Time Line:	2 months
Target Completion Date:	Nov. 15, 2017
Output 2:	
Description:	Coordinate with the FAA, industry, and academia to review existing helicopter simulator/physics-based models and conduct research/testing to develop recommendations for improved helicopter mathematical/physics-based models.
Lead Organization:	H-SE 81 Team
Supporting Organizations:	• FAA – AFS-800 (General Aviation and Commercial Division) • FAA – AFS-200 (National Simulator Program Office) • FAA – Tech Center, ANG-E2 • Simulation/Flight Training Manufacturers • Helicopter OEMs (GAMA to coordinate)

	• Helicopter Operators (*e.g.*, Flight Training Schools) • Academia (*e.g.*, Embry Riddle)
Actions:	1. H-SE 81 to lead review of current simulator/flight training device models for fidelity and gaps in model data for outside-of-the-envelope flight regimes (*e.g.*, Hover, Quick Stop, LTE, VRS, Autorotations). 2. Collect simulation data from various simulator/training devices, helicopter types, and operators (*e.g.*, Flight Safety, CAE, ELITE, FRASCA, X-Plane, Microsoft Flight Simulator, etc.) and flight test data from operators performing candidate maneuvers across various mission segments. 3. Use data to develop recommendations for improved mathematical/physics-based flight dynamics simulator models. Test improved mathematical/physics-based flight dynamics simulator models as applicable and feasible.
Output Notes:	Models need to capture non-linear behavior of rotorcraft flight dynamics, particularly, mapping rotor rpm within an allowable range within the simulation. Incorporate blade dynamics within the models. Blade dynamics are critical in defining model specific aerodynamic behavior of a disk and with it phenomena specific to that type. For example, for Robinson products, their blade dynamics differ greatly from other "semi-rigid" systems (as the case could be made they are "semi-articulated" systems). and as such give us Low-G and Rotor stall concerns (which need to be addressed within LTE phenomena). These considerations should be made for both "semi-rigid" and "rigid" rotor systems.
Time Line:	24 months
Target Completion Date:	Nov. 15, 2019
Output 3:	
Description:	Update advisory circulars AC-120-45A and AC-61-136A (or create helicopter-specific variants) based on recommendations to facilitate use of improved fidelity helicopter flight dynamics models in helicopter simulators.
Lead Organization:	FAA – AFS-200 (AC-120-45A) and AFS-800 (AC-61-136A)
Supporting Organizations:	H-SE 81 Team
Actions:	Develop changes to FAA advisory circulars governing fidelity of simulators/flight training devices.
Output Notes:	The FAA believes that this can be done with updates to advisory circulars, as well as any policy/guidance documents and not

	through rulemaking, however, if those routes prove unsuccessful, an update to Part 61 is always possible as an alternate path.
Time Line:	24–36 months
Target Completion Date:	Nov. 15, 2022 *(for 36 mos)*
Output 4:	
Description:	USHST Outreach Team to initially communicate with simulator and flight training device manufacturers regarding recommendations for higher-fidelity mathematical models. Following the initial meetings, outreach can go out to the broader helicopter community.
Lead Organization:	USHST Outreach Team
Supporting Organizations:	• H-SE 81 Team • HAI – Training Committee
Actions:	1. H-SE 81 team to meet with simulator and training device OEMs and training providers to discuss recommendations for higher-fidelity models. 2. H-SE 81 team to present research and recommendations at helicopter community events.
Output Notes:	
Time Line:	9 months *(to organize and conduct initial outreach)*
Target Completion Date:	Aug. 15, 2023