Integrated Design and Analysis Environment for Safety Critical Human-Automation Systems

Barron Associates, Inc.

Technical Abstract

Numerous advances have been made in recent years in the areas of flight deck design, aircraft modeling, resilient control, and vehicle health management. The combination of these complementary technologies promises to revolutionize aircraft systems and operations safety in the decades ahead. However, the task of safely integrating these technologies is becoming increasingly difficult as their level of complexity, degree of automation, and demands from their operational environment grow. The Next Generation Air Transport System (NextGen), while providing significant benefits in terms of increased capacity and safety, will exacerbate this situation due to the large numbers of new and existing systems that will be required to interoperate. The multidisciplinary nature of these systems is a significant factor that makes analyzing their safety characteristics extremely difficult. While many development tools exist to conduct deep analyses within individual disciplines, there is a lack of tools available for deep analysis of complex multidisciplinary designs. The proposed research seeks to create a new class of development tool that will allow designers of complex systems-of-systems to explore the dynamic interactions between system components to uncover systemic vulnerabilities, precursory conditions, and likely outcomes. The Phase I project generated an initial implementation of the software package Idea, an Integrated Design and Analysis Environment that could be used to model complex interdependencies between flight deck operations, flight deck controls and display, and the underlying physical components of the aircraft. The proposed Phase II effort will mature this software and expand its capabilities, resulting in a flexible, standards-compliant tool that is ready for beta testing and subsequent commercialization. It will focus on enhancements that support cross-disciplinary modeling and analysis of safety-critical human-automation systems.

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Physical Modeling for Anomaly Diagnostics and Prognostics

Ridgetop Group, Inc.

Technical Abstract

Ridgetop developed an innovative, model-driven anomaly diagnostic and fault characterization system for electromechanical actuator (EMA) systems to mitigate catastrophic failures. Ridgetop developed a MIL-STD-1553 bus monitor and a MIL-STD-1553 bus controller that simulates the aircraft data bus, reads the environmental (i.e., altitude) and operational (i.e., response of system) data of a system and determines if a fault is manifesting; and if true determines the root cause and symptoms of the fault. Once an anomaly is detected, the Model-based Avionic Prognostic Reasoner (MAPR) solves a user-outlined state-space model, symbolically, using a Gauss-Newton optimization method and the information from the MIL-STD-1553 bus. This algorithm outputs a list of best fitting parameters to match the command to the actual performance. Rules are programmed in, based on results from principal component analysis . The rules determine both fault mode and the severity of that fault. The rules can distinguish between two failure modes: Mechanical jam and MOSFET failure, and healthy. The real-time processing will allow for critical evolutions in flight safety and provides a game-changing approach to condition-based maintenance. Once deployed, flight safety can be improved by allowing the on-board flight computers to read from the MAPR and update their control envelope based on its evaluations, reducing damage propagation and increasing operational safety. In Phase 2, we will develop a functioning ground-based prototype of the technology to show the efficacy of the method. A ground-based version of the tool is the best candidate for development to ease adoption by testing in a low-risk environment; this tool will be demonstrated at the end of Phase 2. The MAPR concept is also applicable to any system with a state-space representation but at this point it has been developed with EMAs in mind. The MAPR prototype is at TRL 5 and will reach a TRL 7 by the end of Phase 2.

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