NASA SBIR 2016 Phase I Solicitation

H6.04   Integrating ISHM with Flight Avionics Architectures for Cyber-Physical Space Systems

Lead Center: ARC

This call for SBIR proposals is for technology development of integrated flight control systems for seamless integration of flight avionics with Integrated Systems Health Management (ISHM) systems. Flight avionics, with Integrated Modular Avionics (IMA) have well-defined Caution and Warning (CW) Fault Detection Isolation and Response (FDIR) alerting systems which in can in real-time detect, isolate and respond to single failures at a time. Â For each CW failure, a predefined mapping to a CW response procedure is defined. In this way when real time conditions occur, response can be almost immediate. However this approach suffers when more than one failure is present. Under multiple CW failures more than one CW response procedure is active. Which of the predefined procedures should you execute? A procedure execution deadlock can occur. Currently when procedure deadlock occurs a number of questions need to be addressed by flight/ground:

- At what step in each procedure should you execute first?
- Should procedure steps be removed /added?
- Should procedure steps be interleaved between procedures?
- Should an entirely new procedure by synthesized?

The determination of how to proceed from procedure deadlock under multiple failure scenarios is critically dependent upon the correct multiple failure diagnosis of the situation. ISHM supports this determination due to the fact that ISHM can extend traditional CW FDIR systems to utilize a systems view of the spacecraft which leverages all (or most) of the available sensors and command talk-back information. Whereas traditional CW FDIR logic are often small fragments of logic and code which utilize subsets of the sensors, and in general Â have no knowledge and/or context of the other FDIR algorithms, a global view allows for a global response Â but also brings additional challenges of determining that the data from all the sensors is consistent. It is also important to recognize that failure signatures/ propagation/fault masking can be the result of not only hardware but also the interaction of the myriad control loops and procedural behavior that is induced by the flight avionics. Another key aspect is to perform interpretation of fault data in the context of mission operations, and subsequent fault recovery consistent with current mission goals. Additional challenges are also to devise methods to automatically develop the ISHM fault models from system descriptions such as the schematics, procedures, etc.

To date however seamless integration of ISHM systems with flight avionics CW FDIR systems has not matured to the level such that ISHM systems are trusted to support flight avionics systems in multiple failure high stress situations such as CW storms. Prior human-rated approaches have been proposed but not baselined for similar functional situations in both the Space Shuttle domain (Enhanced Caution and Warning (ECW) as part of the Cockpit Avionics Upgrade (CAU) program) as well as the International Space Station domain (ISS 24-hour autonomy mode).Â The challenge is to extend the lessons learned from these efforts to achieve program insertion. Such efforts will support both crewed as well as robotic missions, both near Earth as well as deep space missions. Support will be enabled under a variety of conditions including where:

- Communication time with Earth is insufficient and/or delayed.
- Communication bandwidth is insufficient.
- The complexity of analysis is beyond human comprehension.
- The reliance on a skeleton crew requires additional computational support.

Seamless integration can be defined through many dimensions. Several dimensions of interest are:

- Allow the operator the ability to select between a palette of ISHM modules.
- Allow the operator the ability to turn on/off the ISHM module.
- Real time support for flight avionics. At least one scenario should be defined which shows the operation of the flight avionics with and without ISHM.

In order to demonstrate a technology solution, proposed work should include as baseline, a representative set of hypothetical CW events, a FDIR procedure response for each CW event, and one or more scenarios where, with multiple CW events across subsystems, the set of applicable FDIR procedures deadlocks. The proposed work should then demonstrate how the procedure deadlock is resolved through the proposed technology solution which integrates ISHM with the flight avionics.