Dynamic Modeling of Ascent Abort Scenarios for Crewed Launches

Mark Bigler, NASA Johnson Space Center
Roger L. Boyer, NASA Johnson Space Center

For the last 30 years, the United States's human space program has been focused on low Earth orbit exploration and operations with the Space Shuttle and International Space Station programs. After nearly 50 years, the U.S. is again working to return humans beyond Earth orbit. To do so, NASA is developing a new launch vehicle and spacecraft to provide this capability. The launch vehicle is referred to as the Space Launch System (SLS) and the spacecraft is called Orion. The new launch system is being developed with an abort system that will enable the crew to escape launch failures that would otherwise be catastrophic as well as probabilistic design requirements set for probability of loss of crew (LOC) and loss of mission (LOM). In order to optimize the risk associated with designing this new launch system, as well as verifying the associated requirements, NASA has developed a comprehensive Probabilistic Risk Assessment (PRA) of the integrated ascent phase of the mission that includes the launch vehicle, spacecraft and ground launch facilities.

Given the dynamic nature of rocket launches and the potential for things to go wrong, developing a PRA to assess the risk can be a very challenging effort. Prior to launch and after the crew has boarded the spacecraft, the risk exposure time can be on the order of three hours. During this time, events may initiate from either of the spacecraft, the launch vehicle, or the ground systems, thus requiring an emergency egress from the spacecraft to a safe ground location or a pad abort via the spacecraft's launch abort system. Following launch, again either the spacecraft or the launch vehicle can initiate the need for the crew to abort the mission and return to the home. Obviously, there are thousands of scenarios whose outcome depends on when the abort is initiated during ascent as to how the abort is performed. This includes modeling the risk associated with explosions and benign system failures that require aborting a spacecraft under very dynamic conditions, particularly in the lower atmosphere, and returning the crew home safely. This paper will provide an overview of the PRA model that has been developed of this new launch system, including some of the challenges that are associated with this effort.

Key Words: PRA, space launches, human space program, ascent abort, spacecraft, launch vehicles