And the Humans Saves the Day or Maybe They Ruin It, The Importance of Humans in the Loop

Diana DeMott, Roger Boyer, and Mark Bigler

Flying a mission in space requires a massive commitment of resources, and without the talent and commitment of the people involved in this effort we would never leave the atmosphere of Earth. When we use the phrase “humans in the loop”, it could apply to almost any endeavor since everything starts with humans developing a concept, completing the design process, building or implementing a product and using the product to achieve a goal or purpose. Narrowing the focus to spaceflights, there are a variety of individuals involved throughout the preparations for flight and the flight itself. All of the humans involved add value and support for program success.

The purpose of this paper focuses on how a Probabilistic Risk Assessment (PRA) accounts for the human in the loop for potential missions using a technique called Human Reliability Analysis (HRA). Human actions can increase or decrease the overall risk via initiating events or mitigating them, thus Removing the human from the loop doesn’t always lowers the risk.

PRA and HRA were introduced into the NASA culture after the Shuttle had been flying for a number of years and experienced a major accident.

HRA captures the risk associated with interactions between humans and equipment, and predicts the impact of these interactions on the probability of overall mission failure. NASA personnel are highly trained and qualified, however, even the most highly qualified and trained individuals are susceptible to making errors that could impact the mission or crew. Therefore, human reliability is included in PRA models. Human Error Events represent the potential for humans to make a mistake given the variables inherent in a situation. The Human Error Assessment is an evaluation of how an individual could act given the parameters of a defined failure scenario. It is not intended to place blame.

Discussions will include how PRA addresses human risk contributions in the following areas:

- Scope of human actions assessed
- Identifying human actions important to mission success and failure
- Human causing failure versus human as backup to mitigate failures
- Inherent risks involved with using humans in the loop
- Inherent risk of not using humans in the loop
- So-called automated systems and early flight testing

When viewing all human errors as a single risk driver, questions arises concerning the value of humans operating as part of the system. Removing the human from the equation and changing these potential human error failure scenarios into automated actions could have the following consequences: 1) when using software settings to determine when to abort there are questions regarding what to use as trigger points and how to avoid an unnecessary Loss of Mission (LOM), 2) automating activation of abort functions based on specific parameters defined with limited information may be based on conservative assumptions and create an unnecessary LOM, 3) some potential vehicle separation issues may need crew intervention , 4) even with software controlled unmanned missions humans are involved with developing software codes, and uploading code to the spacecraft and 5) automated systems cannot

address potential situations that have not been identified but could escalate into failure events. Relying on software for expected or routine events may improve the reliability as long as all functions are identified and operate as expected. However, space flights are rarely routine and unexpected situations and unanticipated failures that affect software performance may occur and cause a LOM or Loss of Crew (LOC). This option would eliminate the opportunity for crew members to positively affect the event outcome.

Efforts that have been used to reduce risk associated with crew and ground support personnel actions include:

- Using a PRA to understand how and what contributes or encourages humans to make a mistake under expected conditions
- NASA trains crew, console controllers and support personnel to solve problems and react to failure scenarios
- NASA uses pre-planning and risk assessment to reduce risks
- NASA organizational support and monitoring is available continuously, with experts on call
- Factors that affect crew performance are identified, including how these conditions may change during different mission phases
- Human Factors and Operations are involved in all matters that affect the crew (such as cabin design, operational processes, procedures and flight rules) and provide support during the mission
- Crew and ground support personnel train for years prior to a mission
- Previous NASA experience and lessons learned are implemented in current programs to improve performance

The results of these actions are intended to reduce overall risk. Current program efforts in the design phase provides insights regarding risks contributors for given parameters, allowing a better understanding of overall risk concerns and allow for trade studies as needed. One of the benefits also allows the use of sensitivity analyses. Sensitivity analysis is a useful tool used to determine the impact of how changes to the assumptions or variables will differ from the previous or baseline study. By modifying or changing specific variables in the initial scenario, the analyst, operators, and engineers can gain insight into how changes impact the results. Studies can be run on such diverse subjects as determining the importance of a specific component to identifying the impact of changing a basic assumption used a part of the PRA's failure logic model.

A recent HRA sensitivity study for the new ORION vehicle provided insight into how crew actions associated with mitigation of LOC scenarios would affect the overall risk by comparing the risk associated with the crew's capability to initiate a manual abort and how risk changed with the removal of that capability. The result showed that ~33 % of overall risk was reduced when the crew could perform manual aborts versus having the crew as passengers only. During the Shuttle program, a similar sensitivity assessment was performed which assumed that neither the crew nor the mission control center could take action in response to failures causing a Loss of Crew and/or Vehicle (LOC/V). The difference in the risk when the crew and mission control actively responded to failures showed a risk reduction of ~91%.

The result of the sensitivity study demonstrates the value of having a highly trained, competent and flexible human backup system for expected and unexpected failures. While HRA assumes that humans will fail a percentage of the time, these studies show what would occur if a crew was not available to make the attempt as well.