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Mars 2020 Risk Integration and Uncertainty Working Group Status Report, FY 2017

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ABSTRACT

This report provides a list of accomplishments of the Mars 2020 Risk Integration and Uncertainty Working Group for the fiscal year 2017 which includes participation in the Technical Information Meeting #2, review and comments on the methodologies and results provided in the Mars 2020 Safety Analysis Report (SAR) Draft Databook, development of a Probabilistic Risk Assessment model in the risk assessment program SAPHIRE using the data provided in the SAR Databook, and an independent launch risk analysis based on the Mars 2020 launch vehicle's lineage and design similarity to other launch vehicles.

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ACRONYMS

45th SW	US Air Force 45th Space Wing which operates Cape Canaveral Air Force Station and the eastern range for space launches
ASCA	A private risk analysis company specializing in aerospace and nuclear risk
INSRP	Interagency Nuclear Safety Review Panel
JPL	Jet Propulsion Laboratory
PRA	Probabilistic Risk Analysis
RIUWG	Risk Integration and Uncertainty Working Group
SAPHIRE	Systems Analysis Programs for Hands-on Integrated Reliability Evaluations
SAR	Safety Analysis Report
TIM	Technical Information Meeting
ULA	United Launch Alliance (launch vehicle manufacturer)

1. Risk Integration and Uncertainty Working Group

The Risk Integration and Uncertainty Working Group (RIUWG) consists of three Idaho National Laboratory members, Curtis L. Smith, James K. Knudsen, and Kurt G. Vedros, a member from Pacific Northwest National Laboratory (Robin S. Sullivan), a member from NASA (James H. Rogers), and a member from the US Nuclear Regulatory Commission (Don G. Marksberry). The RIUWG is tasked to support the Interagency Nuclear Review Panel (INSRP) for review and oversight of the Mars 2020 mission to place a scientific laboratory rover on Mars which will use a radioisotope thermal generator (RTG) as a power source. The area of expertise of the RIUWG is in risk analysis methodology and application.

2. Accomplishments in Fiscal Year 2017

The RIUWG was formed in early calendar year 2017 and participated in the second Technical Information Meeting (TIM) provided by the Mars 2020 program. Program consists of NASA contractors including the launch vehicle manufacturer United Launch Alliance (ULA), ASCA (a private risk analysis firm specializing in aerospace and nuclear risk), and Sandia National Laboratory (SNL).

2.1 Mars 2020 Technical Information Meeting #2

The RIUWG attended the second TIM April 11-13. The meeting concentrated on providing solid rocket motor fire test results and full stack intact impact on the launch facility consequences. Two accidents involving impact to a launch facility were analyzed, a Falcon 9 failure at Kennedy Space Center (KSC) and an Antares failure at Wallops Island. Both involved large explosions and the KSC failure raised concern over lifting large pieces of concrete and the possibility of that concrete impacting the RTG. A tour of the launch facility to be used for the Mars 2020 mission was provided as well. In addition to informing the RIUWG on these topics, the RIUWG also provided feedback and observations to the INSRP panel that provided questions and comments for the Program on the last day.

2.2 Mars 2020 SAR Draft Databook

The RIUWG reviewed the Mars 2020 SAR Draft Databook provided to the INSRP team in late April. This is a primary task for the RIUWG. A thorough review was performed of the completeness and methodologies used in the risk analysis sections of the databook.

The RIUWG met at INL July 10-11 to pare down an initial list of 200+ questions and comments categorized as follows:

- Expert elicitation
- More details of quantification
- Weird things/not reproducible
- Missing elements (e.g. rollback was not included in analysis)
- Using “more data” (from the time of Mars Science Laboratory launch)
- Human element in mission risk
- Methods applications (e.g. Human Reliability Analysis, convolutions, etc. …)
- Better ties to the technical basis

Many initial questions were resolved through dialogue during this meeting with Program personnel, the majority of which involved familiarity with operations. The official list was decreased to 56 official comments following the July 10-11 meetings and this list was formally transmitted to the Program by email. These comments are not listed here due to the proprietary information contained in some of the comments.

A formal meeting was held on August 31 via teleconference with ASCA, ULA, Jet Propulsion Laboratory (JPL), and 45th SW to cover specific questions concerning PRA data entries and structure.

There are still comments pending resolution and the review process will continue with the SAR delivery in FY18.

2.3 Mars 2020 Probabilistic Risk Assessment in SAPHIRE

The RIUWG created a model in SAPHIRE version 8 that matches the event sequence diagrams and fault trees shown in the Mars 2020 SAR Databook. This model was vital to verifying the quantification of risk presented in the Databook and provided discovery of many questions and comments on the PRA created by ASCA.

The SAPHIRE model will continue to be vital for the use of sensitivity and additional analysis studies going forward.

2.4 Mars 2020 Independent Launch Risk Assessment

The RIUWG analyzed the similarities of launch vehicles to the Atlas V configuration which will launch the Mars 2020 mission by use of design parameter comparison and cluster analysis. Histories of launch vehicles were then used for a Bayesian analysis of launch vehicle failure probability incorporating appropriate weights given to the various launch vehicle designs.

This independently calculated launch vehicle failure probability will be used to quantify the mission risk profile for a comparison to the Program's mission risk profile.