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| **NASA Expendable Launch Vehicle (ELV)**  **Payload Safety Hazard Report**  (NPR 8715.7 and NASA-STD 8719.24) | | | 1. HAZARD REPORT #:  **MERV-PROP-01**  2. INITIATION DATE:  07/08/2015 |

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| 3. PROJECT NAME:  Project named AAAAA  PAYLOAD SYSTEM SAFETY ENGINEER:  Lucas Layman | | | 4. REVIEW PHASE:  ☒ Phase I  ☐ Phase II  ☐ Phase III |

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| 5. SYSTEM/SUBSYSTEM:  Propulsion  Structure  Propellants | | 6. HAZARD GROUP(S):  Fire/Explosion  Pressure | 7. DATE:  07/08/2015 |

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| 8. APPLICABLE SAFETY REQUIREMENTS:  N/A | | | |

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| **HAZARD** | | | |

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| 9. HAZARD TITLE: | | 10. HAZARD CATEGORY AND RISK LIKELIHOOD: | |

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| Failures of Upper Stage during USE operations that lead to USE Cavitation/Fire/Explosion | |  |  |

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| 11. DESCRIPTION OF HAZARD:  The Upper Stage is responsible for supply of propellants (LH2 and LO2) to the USE during operation. Failures after USE start that result in a decrease or termination of flow to the USE will cause USE turbopump over speed/cavitation/damage leading to an explosion. If Upper Stage fails to command USE shutdown, propellant depletion could occur also leading to cavitation. A decrease in Net Positive Suction Pressure (NPSP) or blockage in the feedlines could decrease flow and inadvertent closure of the prevalve would terminate flow. Ingestion of ullage gas in the feed line will also cause turbopump cavitation. Ullage gas could be ingested if a vortex forms or propellant is depleted. Contaminates that enter the USE inlet could cause significant damage. | | | |

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| 12. HAZARD CAUSES:  Cause 1 – Improper feed system design leads to incorrect pressures or temperatures during USE run  Cause 2 – Depleted propellants  Cause 3 – Loss of fuel and/or oxidizer supply  Cause 4 (TRANSFER): MERV-PRESS-02 – Failure to Maintain Liquid Hydrogen Propellant Tank Pressure leads to USE operational failure  Cause 5 (TRANSFER): MERV-PROP-04, Cause 1 – POGO causes dynamic oscillations attaining a resonant frequency with other US components or USE  Cause 6 – Excessive POGO creates surges | | | |

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| **CAUSES** | | | |

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| **Cause 1 - Improper feed system design leads to incorrect pressures or temperatures during USE run** | | | |

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| Risk Severity: I - Catastrophic | Risk Likelihood: C - Occassional | | |

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| **CAUSE DESCRIPTION:**  The Upper Stage feed system must be designed in order to provide correct propellant interface parameters to the USE for operation. Any errors in the design that cause these parameters to be violated could result in USE failures including cavitation/fire/ explosion. | | | |

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| **EFFECTS:**  Really terrible, horrible things happen. | | | |

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| **ADDITIONAL SAFETY FEATURES:**  We will do extreme inspections on the feed. | | | |

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| **CONTROLS:**  Control 1 (Design) - Numerous safety valves conforming to NASA-5713 will be in place around the tank.  Control 3 (TRANSFER): MERV-PROP-04, Cause 1 – POGO causes dynamic oscillations attaining a resonant frequency with other US components or USE | | | |

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| **VERIFICATIONS:**  **Verification 1 (Simulation) - Open to Safety Tracking List**  Responsible party: George Washington (george.washington@nasa.gov), Estimated Completion Date: July 2 2015  Description: Expansive Monte Carlo simulation of pressure distributions around rings 1, 2, and 5.  **Verification 2 - <STATUS TBD>**  Responsible party: <TBD> , Estimated Completion Date: <TBD>  Description: This second verification contains no verification data other than the description. It is associated with all the controls in the hazard though. | | | |

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| **Cause 2 - Depleted propellants** | | | |

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| Risk Severity: I - Catastrophic | Risk Likelihood: C - Occassional | | |

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| **CAUSE DESCRIPTION:**  If propellants are depleted before MECO, cavitation of turbo pumps could occur if USE is not shutdown. | | | |

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| **EFFECTS:**  It's not so bad. | | | |

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| **ADDITIONAL SAFETY FEATURES:**  None. | | | |

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| **CONTROLS:**  Control 4 (TRANSFER): MERV-PROP-04 – <TBD> , Control 42 | | | |

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| **VERIFICATIONS:**  **Verification 1 (Simulation) - Open to Safety Tracking List**  Responsible party: George Washington (george.washington@nasa.gov), Estimated Completion Date: July 2 2015  Description: Expansive Monte Carlo simulation of pressure distributions around rings 1, 2, and 5.  **Verification 2 - <STATUS TBD>**  Responsible party: <TBD> , Estimated Completion Date: <TBD>  Description: This second verification contains no verification data other than the description. It is associated with all the controls in the hazard though. | | | |

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| **Cause 3 - Loss of fuel and/or oxidizer supply** | | | |

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| Risk Severity: I - Catastrophic | Risk Likelihood: C - Occassional | | |

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| **CAUSE DESCRIPTION:**  Total loss of fuel and/or oxidizer supply would be caused by a failed close prevalve during USE operation. This could be from failure of the prevalve or of the pneumatic system/command to the prevalve. A single dual coil pneumatic valve controls the pressure to both prevalves. If this pneumatic valve (HF/OF -1000) is inadvertently activated the prevalves will close. Should there be a total loss of the fuel or oxidizer supply from the Upper Stage to the J-2X during operation, this would unload the Fuel or Oxidizer Turbopump and the pump could experience rotor overspeed which may induce pump or turbine component failure (including component rotational burst), and possibly FTP/OTP structural disintegration. This structural disintegration will cause turbopump loss of function, generation of shrapnel, uncontained USE damage and possibly fire/explosion, leading to loss of mission, and/or a loss of crew/vehicle. In addition loss of fuel supply only would cause the USE gas generator to run LO2 rich. | | | |

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| **EFFECTS:**  end of the world. | | | |

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| **ADDITIONAL SAFETY FEATURES:**  Analysis, simulation, and demonstration to 5 9's reliability, which doesn't make sense but whatever. | | | |

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| **CONTROLS:**  None | | | |

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| **VERIFICATIONS:**  None | | | |

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| **Cause 4 (TRANSFER): MERV-PRESS-02 – Failure to Maintain Liquid Hydrogen Propellant Tank Pressure leads to USE operational failure** | | | |

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| Risk Severity: N/A | Risk Likelihood: N/A | | |

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| **TRANSFER REASON:**  TRansferred to a relevant Hazard here | | | |

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| **CONTROLS:**  None | | | |

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| **VERIFICATIONS:**  None | | | |

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| **Cause 5 (TRANSFER): MERV-PROP-04, Cause 1 – POGO causes dynamic oscillations attaining a resonant frequency with other US components or USE** | | | |

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| Risk Severity: N/A | Risk Likelihood: N/A | | |

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| **TRANSFER REASON:**  This cause is described in another hazard cause. Look it up. | | | |

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| **CONTROLS:**  Control 4 (TRANSFER): MERV-PROP-04 – <TBD> , Control 42 | | | |

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| **VERIFICATIONS:**  **Verification 1 (Simulation) - Open to Safety Tracking List**  Responsible party: George Washington (george.washington@nasa.gov), Estimated Completion Date: July 2 2015  Description: Expansive Monte Carlo simulation of pressure distributions around rings 1, 2, and 5.  **Verification 2 - <STATUS TBD>**  Responsible party: <TBD> , Estimated Completion Date: <TBD>  Description: This second verification contains no verification data other than the description. It is associated with all the controls in the hazard though. | | | |