# MASTER OF SCIENCE
# IN
# ASTRONAUTICAL ENGINEERING

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**DESIGN AND BUILD OF EVA COMPATIBLE, BOLT/MOTOR BRACKET ASSEMBLIES FOR THE R-SLC SYSTEM AND ANALYSIS FOR FOLLOW-ON REDUCED GRAVITY TESTING**

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The Robotic-Sidewall Logistics Carrier (R-SLC) is a design solution for putting small payloads (military and non-military) on orbit while meeting the requirement to transfer experiment and logistics equipment between the Space Shuttle and the International Space Station (ISS) by robotics rather than through the conduct of extra vehicular activities (EVA). The concept, design, and fabrication were all conducted by students and faculty at the Naval Postgraduate School (NPS) and the Boeing Defense and Space Group (Boeing).

Using as much off-the-shelf technology as practical for the design, the R-SLC will provide a light weight, stand alone means to more cost effectively carry small payloads aloft in the Shuttle cargo bay. This hardware will be fully Remote Manipulator System (RMS) compatible for on orbit removal and retrieval operations. Transferring or deploying payloads via the RMS reduces the requirement for astronauts to conduct EVA operations. EVA operations will only be required where system failure of power or robotics occurs.

This thesis project, specifically the bolt/motor bracket assemblies of the R-SLC, will integrate some off-the-shelf parts with three primary hardware elements specifically designed for this assembly. This innovation will provide the means to attach an EXPRESS pallet adapter to a side wall carrier so that it is removable and replaceable during EVA contingency operations. Special considerations were given to human factors engineering during the design process in order to accommodate the suited astronaut in a zero-gravity environment. Part two of this thesis encompasses the hazard and structural analyses of specifically designed flight support equipment and planning for a reduced gravity flight test aboard the NASA KC-135A aircraft in order to validate EVA compatibility.

**DoD KEY TECHNOLOGY AREA:** Other (Manned Space Flight)

**KEYWORDS**: Orbiter, Robotics, Logistics, Space Shuttle, ISS

**INVESTIGATION OF THE EFFECTS OF VARIOUS NOZZLE CONFIGURATIONS ON SOLID-ROCKET-PLUME INTENSITIES AND SPECTRA**

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Subscale rocket motors were fired and the plume signatures were measured in the infrared (IR) and ultraviolet (UV) wavelength regimes. Band-averaged and spectral data were recorded using an SR5000 IR spectrometer (2.5 to 5.5 μm range), an

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Agema 870 IR thermal imaging camera (3.5 to 5 μm range), and the Naval Postgraduate School UltraViolet Imaging Spectrometer (NUVIS) (325 to 405 nm range). Rocket motor nozzle geometries were varied to determine the effects of over- and under-expansion on the plume band-averaged intensity and spectra. Four different solid rocket propellants were used: X-61, NWC-278, AC-13, and AC-14. The enhanced mixing nozzle, used in conjunction with the X-61 propellant, reduced the plume signature in both the UV and IR regions. The total UV intensity of the plume decreased by about 30%, and varied as function of distance from the rocket nozzle. The intensity difference was more pronounced at shorter wavelengths (325-385 nm) than at longer wavelengths (385-405 nm). The difference in power was not as large in the IR region (about 7%). Intensity results from the analysis of the NWC-278, AC-13, and AC-14 runs were inconclusive. Data from the NUVIS and Agema instruments were used to create spectra for each of the propellants. While distinct features were discernible in the UV spectra, they could not be identified with a specific atom or molecule. The IR spectra were characterized by several molecular bands attributed to a combination of $CO_2$, $H_2O$, and HCl.

**DoD KEY TECHNOLOGY AREAS:** Aerospace Propulsion and Power, Sensors

**KEYWORDS:** Solid Propellant Rocket, Rocket Plume Spectra, Rocket Plume Intensity, Plume Signature