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NASA KSC INTERNSHIP EXPERIENCE & PROJECT REPORT

NASA KENNEDY SPACE CENTER

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MECE 3300 ME Internship/Co-Op Project Report

I. Introduction

As part of the Spring 2021 Engineering Student Trainee rotation with the National Aeronautics and Space Administration (NASA) through the Pathways program at Kennedy Space Center (KSC). I served under KSC's Engineering directorate as a Pneumatics Engineering Intern for the Environmental and Life support Systems branch (NE-XF).

During my Internship, I primarily supported the Exploration Ground Systems (EGS) program under the direct supervision of NE-XF Pneumatics Senior Engineer, Ruben Jaca, and NE-XF matrix supervisor, Stephen M. Anthony. I worked on the completion of a Pressure Vessel and Pressurized System (PVS) certification for a Payload Accommodation Subsystem (PAS) prototype. As part of the Pathways program, I was additionally exposed to various career and skill enhancement activities.

It's important to mention that many technical aspects of my project may be protected by International Traffic and Arms Regulations (ITAR) and the content of this report is restricted to the **level of detailed allowed for public disclosure**.

Figure 1. Space Launch System (SLS) core stage arriving to KSC [10]

II. Agency and Center Overview: NASA Kennedy Space Center

NASA is an independent U.S. government agency proposed by Congress through the 12575 National Aeronautics and Space Act and approved by President Dwight D. Eisenhower on July 29, 1958. [2] Ever since it's foundation, NASA has remained as a leader in space exploration, scientific discover and aeronautics technology. Today, NASA employs over 18,000 professionals across the nation on its many different facilities and centers. [3]

Among its ten field centers, KSC is known as "the gateway to the universe".[4] It has been the launch site of every United States human space flight since 1968, and today it supports the following programs and initiatives [5]:

- Commercial Crew Program
- Deep Space Logistics
- Educational Launch of Nanosatellites
- **Exploration Ground Systems**
- Launch Services Program
- Research & Technology
- Station Payloads

To effectively address the goals of each of these programs and initiatives listed above, KSC is organized into different organizational business profiles, which are shown in Figure 2.

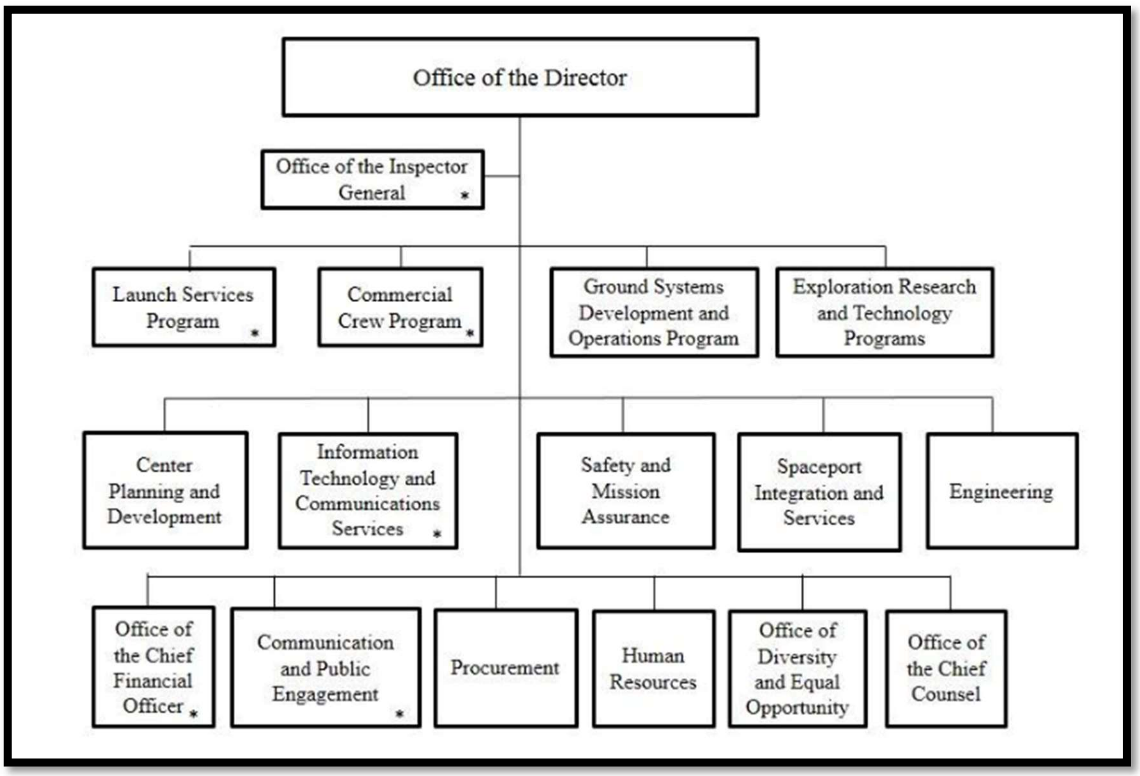

Figure 2. Kennedy Space Center Organizational Chart [6]

The Engineering Directorate (NE) and its comprising organizations are responsible for providing mission focus engineering products for a broad set of programs at KSC, including the Exploration Ground Systems (EGS) program. The organization develops and maintains experienced engineering and science personnel, and a set of specialized laboratories and test facilities, that perform design, development, applied research, technology development, fabrication, construction, test, verification and validation (V&V), operations, maintenance and sustaining engineering. [6] Technical reviews are conducted to inform all affected organization of the progress of a system or project, and they go over the engineering products that the NE peroneal develops.

III. Internship Overview: NASA Pathways Program

The NASA Pathways Intern employment program is an early career development program at NASA. This program provides the opportunity to explore careers while in school. Intern appointments may be for indefinite periods without pre-stablish ending dates, and student trainees are eligible for conversion after graduation.

At KSC, this program is administered and coordinated by the office of human resources, and engineering students are assigned to a technical organization to match their discipline with the current needs of the center. I am currently a Pathways Engineering Student Trainee at the Environmental and Life Support Systems branch (NE-XF) of the Engineering Directorate (NE) at KSC.

As part of the Pathways program, interns and supervisors coordinate to assign and complete Pathways program milestones for the duration of their intern's appointment, which includes completion of requirements for conversion, technical trainings, and project experience. [9] For my spring 2021 rotation, I was assigned to familiarize with multiple engineering tools, such as CREO Parametric, MATHCAD, NIST REFPROP, AFT Arrow and a proprietary NASA tool for document management. For discipline training, I was enrolled in three courses: Foundations of Aerospace at NASA, ASME Pressure Relief Device training and Space System Verification and Validation. For project experience, I was assigned to the NE-XF Pneumatics team working on the EGS Payload Accommodation Subsystem (PAS) prototype project.

Figure 3. Mobile Launcher (ML) arriving at KSC's Vehicle Assembly Building [11]

IV. Project Overview

Mobile Launcher-2, Payload Accommodation Subsystem (PAS)

With the mission to transform KSC from a government-run launch complex to a commercial spaceport with the capability to support a variety of launch vehicles and spacecrafts, the Exploration Ground

Systems (EGS) program develops and operates the systems and facilities required to process, transport and launch spacecrafts and rockets. [7]

Currently, EGS is developing the Mobile Launcher 2 (ML-2) ground support structure that will be used to assemble, process and launch the Block 1B and Block 2 configurations of the Space Launch System (SLS) rocket for Artemis missions IV to IX. ML-2 builds upon its predecessor, the Mobile Launcher (ML), that is commissioned for the SLS Block 1 configuration to be used in the Artemis I, II and III missions. However, ML-2 is redesigned to accommodate the major difference between the SLS Block 1 and Block 1B configurations, the replacement of the interim Cryogenic Propulsion Stage with the larger Exploration Upper Stage (EUS) developed by European Space Agency (ESA). [8]

To full-fill the new requirements of the SLS 1B configuration, ML-2 has undergone significant changes to most of its subsystems. Among those changes, a new Payload Accommodation Subsystem (PAS) configuration is under development to provide a control interphase for the delivery of the new Gaseous Nitrogen (GN2) pressure, temperature and flow requirements necessary for the Artemis IV payload.

PAS is a pneumatic/electric system remotely operated through ML-2 communications bus from the Launch Control Center (LCC). It supplies the GN2 commodity through the ML-2 umbilical that interphases ML-2 with SLS Block 1 B.

It was determined by the PAS fluids engineering lead that a stricter cleanliness level is required in the ML-2 configuration of PAS to satisfy the gas purity requirements. In order to cost-effectively determine the impact of installing a new purifier in the system, a prototype was developed to evaluate the performance of the PAS purification process with the new configuration. The Prototype was design with four main testing objectives:

1) Ensure the PAS flow controller can successfully interface to and be controlled by a Programable Logic Computer (PLC)
2) Ensure PAS heater can be successfully interfaced to and controlled by a Programmable Logic Computer (PLC)
3) Verify that the PAS purifier meet manufacturer advertised purification capacity for the Gaseous Nitrogen (GN2) commodity.

To operate the PAS prototype, the system needs to be ensured and certified to operate without producing any hazards to the operator, facilities and personnel at KSC.

Pressure Vessels and Pressurized Systems (PVS) Certification

An important engineering product during design and development is the Pressure Vessels and Pressurized System Certification (PVS) report. This document is used to ensure all KSC NE owned, and operated pressure vessels and pressurized systems are safe to operate and certified according to NASA and KSC requirements.

Recalling that the PAS Prototype is a temporary pneumatic system design for integration testing of a new purifier in the Payload Accommodation Sub-system (PAS). The PAS Prototype certification consists of the delivery of an Exclusion Report. In accordance with NASA Requirements for Ground-Based Pressure Vessel and Pressurized Systems (PVS), an exclusion report is a less extensive Pressure System

Certification report for systems that satisfy the exclusion criteria, which includes the category of temporary prototypes for testing.

V. Technical Contributions

PVS Exclusion Report

As a member of the NE-XF Pneumatics team, I was assigned with the completion of the Exclusion Report and redesign of the PAS prototype. The exclusion report was successfully completed with the following items:

1) A detailed description of the prototype configuration, purpose and objectives and explanation of PVS certification exclusion criteria.
2) A schematic of the fluid system design including,
    a. Operating Pressure and temperature boundaries,
    b. All Components with their corresponding KSC reference designator number, and Maximum allowable working pressure (MAWP), as described in the manufacturer specifications.
    c. Indication of the pressure relief devices with set pressures and relative location to pressure boundaries.
3) A Material Compatibility assessment of the components with the GN2 commodity following KSC standards.
4) Flow Calculations:
    a. Relief Valve Sizing based on Regulator Failed Open scenario as specify by ASME B31.3.
    b. Required Bottle Volume for test duration, using conservation equation of mass energy and momentum - approved by NE-XF engineers
5) AFT arrow model results of Regulator to Relief valve configuration during normal operations
6) A component list with important specifications for each component, such as part number description, manufacturer, component temperature range, component pressure range, and component design code. Evidence for each component or specification sheet was annexed.

This engineering product is currently under review by the fluids lead engineer of the Payload Accommodating Subsystem (PAS) project. After his approval the PAS Prototype Exclusion Report is going be submitted to the NE PVS Project Manager for certification. Once certify, the PAS prototype components will be acquired, assemble and the prototype will be used to test the GN2 purifier and other testing objectives as intended.

PAS Prototype Design Upgrades

The PAS Prototype must satisfy both the PVS certification requirements and the test campaign requirements withing budget. To satisfy the PVS certification requirements, a GN2 k-bottle rack and a high-pressure single stage regulator were added. In order to reduce the cost of the system and eliminated unnecessary complexity, a check valve and second stage filter were eliminated from the design. Finally, the pressure lines of the system were modified to fit on a tabletop at one of KSC testing facilities.

All changes were updated and verified through technical review meetings with my technical mentor, where calculations were presented and verified for correctness.

Heater Setting Estimation

Since the PAS prototype was redesigned to satisfy all PVS and design requirements simultaneously, the system configuration and commodity operating states were altered from previous configurations. As a result, the PAS Prototype AFT arrow model had to be updated with the new PVS Exclusion configuration to determine and provide the PAS protype electrical team and operators with the required heater power settings.

AFT arrow is a commercially available fluid modeling tool widely used in the Aerospace and Chemical Processing Industry. It provides the capability to analyze compressible flow under steady-state operations. Using this tool, the PAS Prototype configuration was remodeled and tested through the required flow range. The results were used to determine the corresponding heater settings to achieve minimum and maximum output commodity temperatures.

Once the analysis was completed for all flow scenarios, the analysis was reviewed by other NE-XF pneumatic engineers, and a Prototype Heat Capacity Excel-file table was created to document the results.

VI. Conclusion

The Spring 2021 Engineering Student Trainee rotation at NASA's Kennedy Space Center (KSC), within the Engineering Directorate (NE) under the Environmental and Life Support Systems branch (NE-XF), was a valuable experience to learn about the rolls of a KSC pneumatics engineer in the design and development stages of the subsystems of a project, such as the Mobile Launcher 2 (ML2). I learned about NASA Systems Engineering and Technical Review process, and how to deliver peer-reviewed engineering products.

After a performance review of my work at KSC during the spring semester, I am also very fortunate to inform that the Pathways office has approved another Engineering Student Trainee rotation at NE-XF, where I'll be continuing to learn and improve my technical and professional skills to become a competitive candidate for a full-time position at NASA.

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