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iPAS Propulsion Subsystem

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Introduction

The Integrated, Power, Avionics, and Software (iPAS) facility is an integrated hardware/software test and evaluation environment. The main goal of the iPAS project is to support the development of common avionics, hardware, and software architecture that can be applied over various missions. The iPAS facility will be constructed using existing hardware and software. This facility will provide a common test bed framework that supports integrated hardware/software testing for a variety of applications. The iPAS will simulate many integrated subsystems and the propulsion system is one of them. The focus of this paper will be on the design and development of the pressure system for the iPAS propulsion subsystem. The goal of the propulsion system is not to generate thrust but to produce some noise as well as feedback.

Abstract

The ultimate goal of the Integrated Power, Avionics and Software (iPAS) project is to develop a simulation facility that can be apply to various missions that use common avionics, hardware, and software architecture. The iPAS facility will model several subsystems, the EP4 contribution to the project is to design and build a low fidelity representation of the in-space propulsion system for the iPAS simulation. The system would use a pressurized bottle to provide the gas for the thrusters. Air will be used to perform the simulation to prevent a hazardous environment in the facility. Three cold gas thrusters previously used for the X-38 program will be used for the simulation because they are on hand and available for use. An incremental design-build-test approach will be taken where the X-38 thrusters may be replaced with actual flight thrusters as the flight design is matured. A pressurized system must be designed, built, and tested to reduce the 2,400psi bottle pressure to a reasonable pressure (0-800psig) to minimize the

amount of noise created upon thruster activation. Once all the subsystems are completed they will be integrated together for testing.

Goal and Purpose

Now that the Space Shuttle Program has ended, the next step for human space exploration in NASA is to explore the deep space beyond the moon. The iPAS facility will provide the possibility to simulation and test a variety of missions. The first iPAS simulation will be for the Multi-Mission Space Exploration Vehicle (MMSEV) and it will be conducted in September 2011. iPAS will simulate the MMSEV maneuvering around an asteroid explore and take data samples while communicating and sending data to ground. The main purpose of iPAS is to demonstrate the capability that this kind of testing can be performed in a ground facility.

The propulsion system is one of the iPAS' subsystems and I worked on the design, build and test of the pressure system required to provide compressed gas to the thrusters. Although the main purpose of a thruster is to provide thrust, the thrusters used for the simulation will only provide noise and feedback with very low thrust. This will be achieved by controlling the flow and pressure of the compressed gas flowing into the thrusters' valve. Three X-38 cold gas thrusters were chosen; they could possible model X-Y-Z directions or pitch, roll and yaw. There is a possibility to add an Apollo thruster in the future and the pressure system was designed to accommodate for this possibility. Figure 1 depicts the pressure system schematic; the dotted lines represent the Apollo thruster.

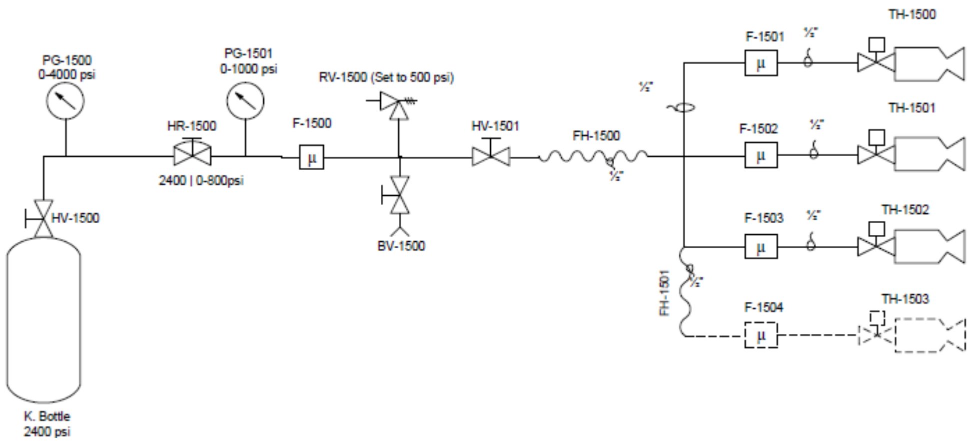

Figure 1. iPAS pressure system diagram.

The major components of this pressure system are: pressure regulator, relief valve, ventilation valve, meter valve, pressure gauges, conical filters, flexible hose and the thrusters. The pressure regulator and the relief valve had to be carefully chosen. The pressure regulator must be able to withstand the 2,400 psig from a K bottle; in addition, it has to be able to drop that pressure to 800 psig. Although the simulation will be run at relative low-pressure due to a hearing hazard, this regulator was chosen because there is the possibility that this design might be used in a future at another project that my mentor is working on. The relief valve is used to protect the upstream lower-pressure components and it was sized to handle the maximum flow rate coming out of the regulator; that is if the regulator fails. The relief valve is set to a specific cracking pressure to protect the lowest pressure rated components, in this case it was set to 500 psig. If the pressure coming out of the regulator is 500 psig or higher the relief valve will pop open and the system will be depressurized protecting the lower-pressure components downstream. Two pressure gauges were used, one before and one after the regulator, to monitor the system pressure at all times. The vent valve is used to depressurize the whole system and the meter valve allows control of the flow. The flexible hose enables to isolate the regulation panel from the thrusters' assembly. The X-38 thrusters are expensive equipment so 20 micrometers conical filters were used to protect the thruster's valve from any particle contamination that might built up in the system. Figure 2 shows the layout of the pressure regulation panel.

Figure 2. iPAS pressure regulation panel.

Pressurized air will be utilized as the gas for this demonstration because there will be people inside the facility while testing and using air will prevent any asphyxiation hazards. The air will be supplied by a K bottle. The thrusters are of relatively small size so it makes them portable and can be mounted almost anywhere. Figure 3 shows an X-38 cold gas thruster. The nozzle is enclosed in a box as it can be seen in the thruster cross-section view in figure 3. In this view one can see the converging-diverging nozzle. Also, there is a pressure transducer (in green) before the nozzle's throat and it is used to give pressure feedback. The transducer outputs a full-scale 0-300 mV for thruster range of 0-1000 psig.

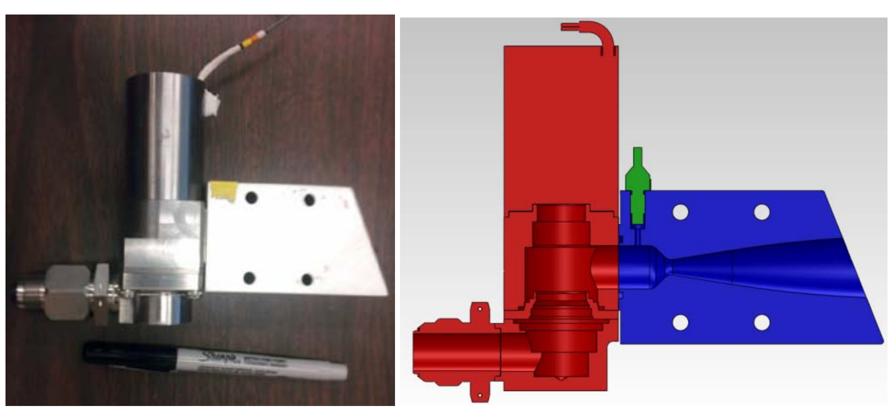

Figure 3. X-38 thruster and cross-section view.

Usually the thruster's valve armature is used to mount or hold the thruster in place. However, the X-38 thruster is design so that it can be mounted by the nozzle box. In this case, L-brackets were used to mount the thruster to a platform. This arrangement can be seen in figure 4. In this figure, one can see the tee connection where the Apollo thruster could be integrated later.

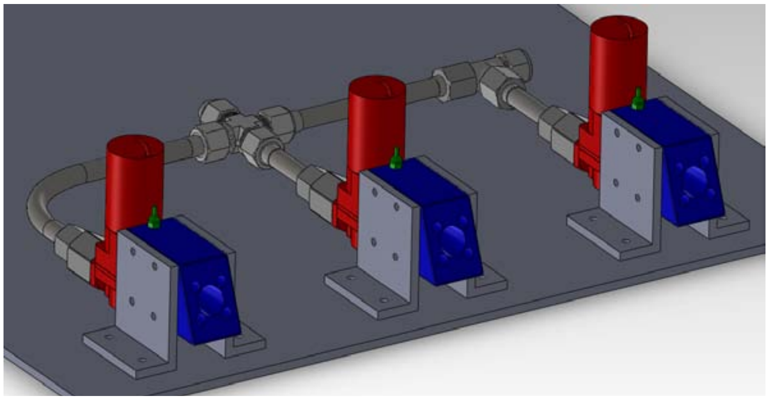

Figure 4. X-38 thrusters' assembly.

As shown in figure 5 the system is on wheels so it is really easy to move it around and the flexible hose enables having the thrusters and the pressure bottle at different near by locations. If the thrusters and bottle are separated, the flexible hose will be run under the floor for safety.

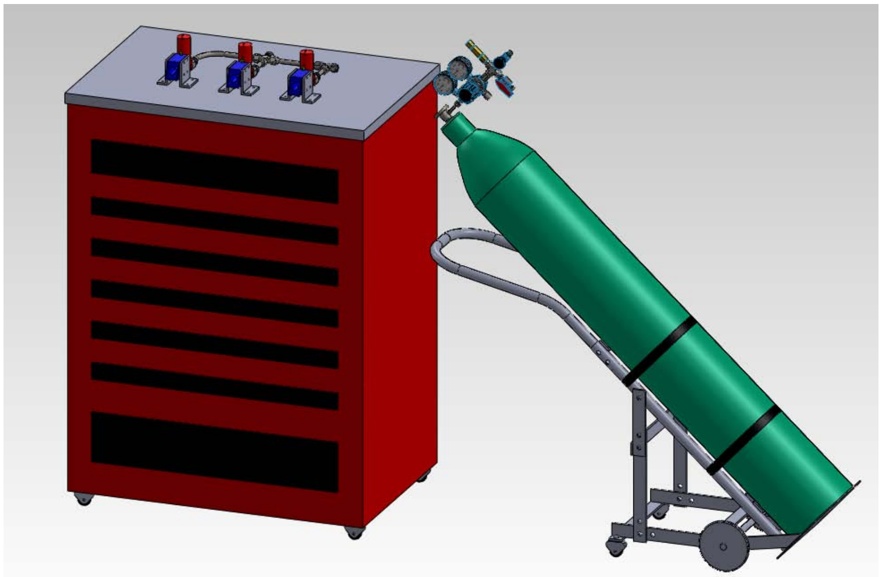

Figure 5. iPAS pressure system layout.

The first simulation by iPAS will be for the MMSEV as previously mentioned. Currently, there exists a computer simulation for the MMSEV and the set-up is shown in figure 6. One particular use of the iPAS facility is to simulate the Multi-Missions Space Exploration Vehicle (MMSEV). This simulation consists in going to an asteroid to explore it and take data samples. During the simulation, there will be communication and data transfer as it was a real space mission. The iPAS simulation will demonstrate how well all the integrated subsystems perform together.

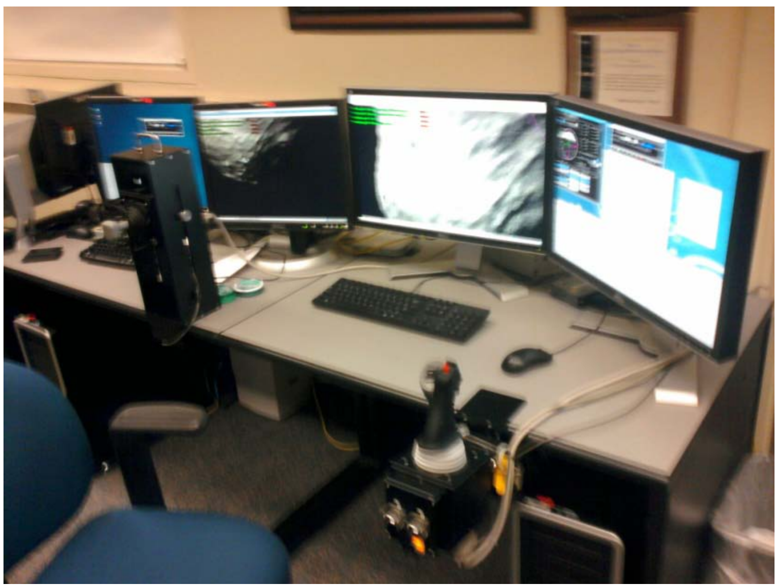

Figure 6. MMSEV computer simulation.

Impact of MUST Internship on My Career

The NASA JSC internship has given me a valuable knowledge in pressure systems design and build-up. I had the opportunity to work along NASA engineers/technicians and experience the work of an NASA engineer on a daily basis. My mentor, Joe Durning, and all the propulsion branch crew were very helpful in providing me guidance whenever I had any question regarding the iPAS project or anything else. With their mentorship I was able to work on the design, build, and test of my summer project. Unfortunately, I was not able to see the simulation of all the subsystems integrated but I was able to see the MMSEV computer simulation. I was very fortunate that I was placed in this particular section because I met new people that were willing to help me in every way they could. In addition, I had the opportunity to see and hear the historic STS-135 final launch from the Mission Evaluation Room at Johnson Space Center.

The NASA MUST Symposium at Baltimore, Maryland provided me very valuable and useful information. The graduate workshop was very informative and I am definitely applying for a fellowship to pursuit my masters' degree in mechanical engineering. In addition, most of the speakers were very inspiring and entertaining. I look forward to participating in the NASA MUST program next school year.