Gail Smith
Kennedy Space Center
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J-2X, The Engine of the Future

Reviewed by:

Alan Zide
Constellation Project Office
Launch Vehicle Division, LX-V
Airborne Electrical Project Manager

Robert Moore
Constellation Project Office
Launch Vehicle Division, LX-V
MEI/Airborne Electrical

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Gail Smith
INSPIRE Tier 2B
Kennedy Space Center
Constellation Project Office- Launch Vehicle Division
Mentors: Alan Zide & Robert Moore
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J-2X: The Engine of the Future

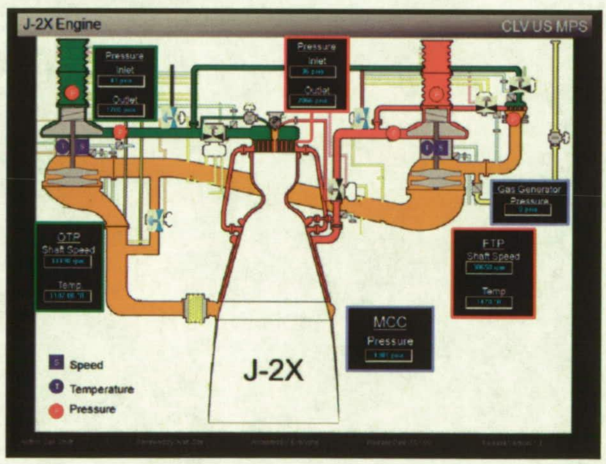
My title "J-2X: The Engine of the Future" may seem rather cliché, but there is a factual basis behind this claim. This summer I was granted the opportunity to work with the J-2X engine. This engine will be used on both the upper stages of the Ares I crew launch vehicle and the Ares V cargo launch vehicle. These two launch vehicles truly are the future of NASA's lunar space exploration. The J-2X is an essential part of the further exploration of the moon and Mars. On the Ares I, the J-2X will propel the Orion crew capsule into orbit, and on the Ares V, it will allow the EDS (Earth Departure Stage) to unite with the Orion.

Essentially, this engine needs to be highly efficient, expendable, and reliable. The Constellation Project is dedicated to reusing, with modifications, as many pre-existing technologies as possible. This is accomplished by reusing the technology of the J-2, which was used in the Apollo days as the Saturn V upper stage engine. The J-2X is not quite as efficient as the Space Shuttle Main Engine (SSME), which I had an opportunity to see, but the J-2X requires less than half the number of parts and will be expendable. The J-2X reuses heritage technology, has a low development cost, and is very reliable.

My project was two-fold, with both parts involving the J-2X Upper Stage engine (which will be used on both the Ares I and V). Mainly, I am responsible for using a program called Iris to create visual representations of the rocket engine's telemetry data. Also, my project includes the application of my newly acquired Pro Engineer skills in developing a 3D model of the engine's nozzle.

Iris

Iris is a tool that uses PowerPoint to display telemetry measurements streaming from a rocket. Telemetry is the science of gathering data on a Launch Vehicle or Spacecraft and transmitting this information to a ground user for monitoring the health and status of the vehicle—this is where Iris comes in. Iris decodes and displays the data coming in from the instrumentation, which are the physical sensors that measure and



record the data. NASA needed a program that produced integrated visual representations of the data in a way that was easily understandable—so they created Iris. Iris is utilized by the Launch Services Program (LSP) to monitor all of the launches which occur at KSC.

Creating an Iris page is rather simple once one is familiarized with the tools. Iris is compatible with either PowerPoint 2007 or 2003. The key to creating a successful Iris page is creativity, because making the measurements understandable is the end goal. Below are the procedures that I used to create my Iris page.

Procedures

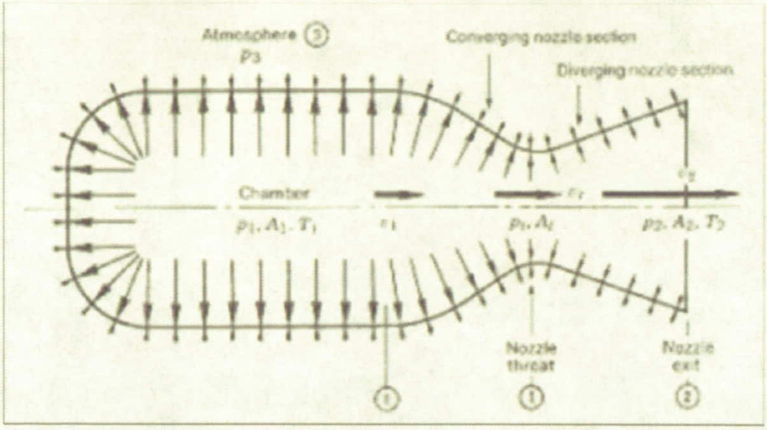
1. Open PowerPoint, having Iris already installed on the computer.
2. Activate Iris in Development Mode, because if you don't the program will auto-start and seek streaming data.
3. Locate the "More Controls" button on the main toolbar (2007) and select any of the controls that begin with a lowercased I (ex. iAnalogDisplayX Control.)
4. Insert the control and add the MSID (measurement) that will control the widget.
5. Incorporate the official Iris template and into the slide.
6. Once all of the tools are on the slide, add the "Web Page Preview" button on the Main Toolbar and activate it.
7. A web page will appear with your functional Iris screen.
8. Make changes as necessary in PowerPoint.

All of the sensors are assigned a criticality level, and certain requirements must be met at the different levels. This is a potential way of organizing the Iris screens. There are three main criticality levels, along with many sub-levels. In general, they descend in importance. With a Crit 1 sensor, cable, or box, a loss will result in loss of life and the mission entirely (crew and vehicle included); a Crit 2 failure will result in a loss of vehicle or mision; a Crit 3 malfunction could result in a minor loss, which could include data measurements, non-essential systems, etc.

Level	Means
Crit 1	Loss of life
Crit 2	Loss of vehicle
Crit 3	Minor loss

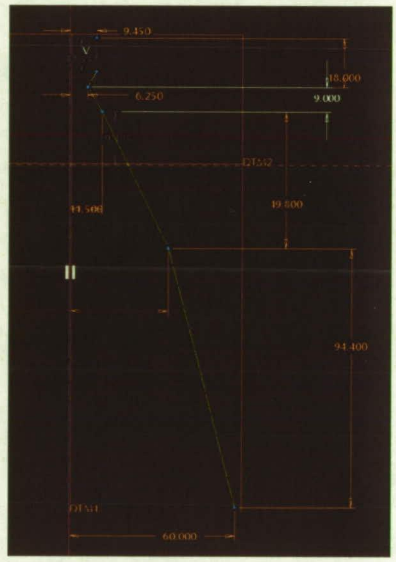
<u>J-2X Nozzle</u>

The next portion of my project involves the J-2X nozzle. First of all, the nozzle has three parts: the MCC (main combustion chamber), the Regen Nozzle, and the nozzle extension. The type of nozzle used is known as a De Laval nozzle. A De Laval nozzle consists of a converging section, a throat, and a diverging section. The De Laval nozzle is so efficient because of Bernoulli's Principle, which states that in a stream of fluid, speed increases when pressure decreases, and vice versa. The pressure in the MCC is very high, and exerts this pressure on the chamber walls. However, when an outlet is provided, the pressurized gas escapes through the



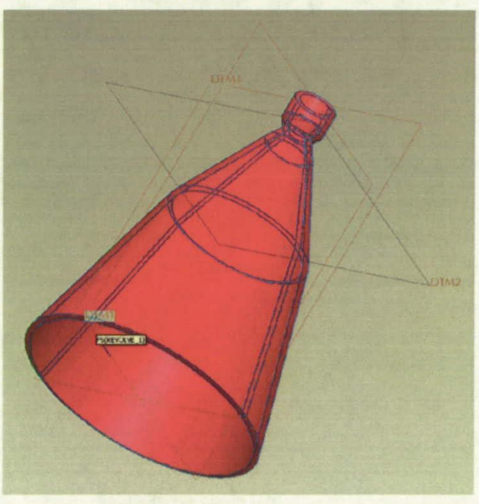
throat of the nozzle and into the diverging nozzle section. This change from high to low pressure allows the fuel to accelerate immensely on its way out of the nozzle; this, in short, propels the vehicle. The diagram above illustrates both the air pressure and air flow.

Knowing all of this information, I proceeded to the second portion of my project, which involved modeling of the J-2X nozzle. To accomplish this, I had to learn the rudimentary workings of Pro Engineer; this is a program that engineers use to input dimensions to create 3D visual representations of parts and allows the user to integrate these parts to determine compatibility.



Procedures

1. Gather all dimensions needed to construct the nozzle.
2. In the Pro Engineer sketcher, use the tools to draw a 2D version of the nozzle.
3. Lock the aspect ratios of the nozzle (shown in orange on the right)
4. Edit the dimensions as necessary.
5. Approve the sketch (click the green checkmark).
6. Use the revolve tool. Your resulting figure should be a yellow translucent color.
7. Change the nozzle to a solid figure then activate the “shell” tool.

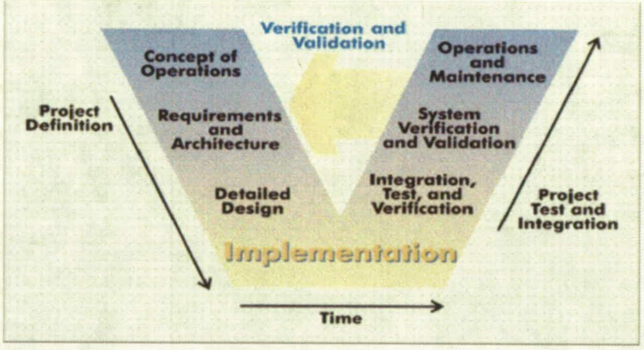


The solid visual representation of my J-2X nozzle is shown here in this picture. Highlighted in blue are the dimensions that I drew in the sketcher; the blue lines also represent the inside of the nozzle and the outside of the nozzle. This particular view showcases the 3D aspect of Pro Engineer very effectively.

The three light brown lines shown on the diagram are called datums. Datums are essentially glorified axes—representing the X, Y, and Z axes. To edit the visual display in Pro Engineer, there is a tool towards the bottom of the screen that allows the engineer to input particular numbers for the adjustment of the datums.

Lessons Learned

I learned a lot about the systems design process during this experience; it is a long and bumpy road, but is essential to creating a quality vehicle. First, a project definition is developed and refined throughout the design process. A System Requirements Review (SRR) occurs after the development of the System Requirements Document (SRD) and the Interface Requirements Document (IRD). After the SRR, the preliminary design phase occurs, culminating in a Preliminary Design Review (PDR). After an approved PDR, the detailed design phase occurs, ending with a Critical Design Review (CDR). After the CDR, the Design Certification Review (DCR) verifies that the design is followed and that the item can pass on to final verification testing. The Ares I vehicle that my mentors are most closely connected to is midway between PDR and CDR; it is expected to be at CDR in approximately 18 months.



The most rewarding part of the internship to me was the experience I gained in the NASA work force. Working near the flight hardware is probably the most inspiring and motivational type of work. Reading requirements documents is meticulous, necessary work that requires discipline to stay focused. I was able to sit in on several Technical Interface Meetings (TIMs) and design meetings which helped me to understand that there is always more than one way to solve a problem. As previously mentioned, I also developed an understanding of Pro Engineer, which most engineering majors don't see until their sophomore year of college. I've had an awesome opportunity to learn about the technology that NASA uses and, in the case of Iris, the the technology that NASA creates. Both of these technologies interested me, but Iris in particular was fascinating because I could apply my previous PowerPoint skills. Working closely with the LX-V Project Office engineering team opened my eyes to all of the different disciplines and types of engineering.

My INSPIRE summer experience here at KSC has exceeded all of my expectations. It was not a breeze, and I appreciated being challenged. I learned that in a professional setting, one of the most essential and difficult things to do is to admit one doesn't know something and work to find the answer to a particular quandry. My mentors, Alan Zide and Robert "Bob" Moore, have been excellent, but there were many other people without whose guidance my project would have been impossible. I learned more than I ever though possible, both in communication and applied skills.