The University of Texas at Austin, Mechanical Engineering

Flight Planning and Procedures

Spring 2016 Work Term Assignment

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5-4-2016

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Glossary of Acronyms

CO - Operations Division

E - day of Execution

FOD - Flight Operations Directorate

JSC - Johnson Space Center

LRP - Long Range Plan

NASA - National Aeronautics and Space Administration

OCA - Orbital Communications Adapter

ODF - Operations Data File

OOS - On Orbit Summary

OPTCP - Operations Planning Technical Control Panel

PPCR - Planning Product Change Request

RPE - Real-time Planning Engineer

WLP - Weekly Look Ahead Plan

Section I: Introduction

History

The National Aeronautics and Space Administration (NASA) was founded in 1958 by President Eisenhower as a civilian lead United States federal agency designed to advance the science of space. Over the years, NASA has grown with a vision to "reach for new heights and reveal the unknown for the benefit of humankind" (About NASA). Mercury, Gemini, Apollo, Skylab, and Space Shuttle are just a few of the programs that NASA has led to advance our understanding of the universe. Each of the eleven main NASA space centers located across the United States plays a unique role in accomplishing that vision. Since 1961, Johnson Space Center (JSC) has led the effort for manned spaceflight missions.

NASA Programs

JSC has a mission to "provide and apply the preeminent capabilities to develop, operate, and integrate human exploration missions spanning commercial, academic, international, and US government partners" (Co-op Orientation). To do that, JSC is currently focused on two main programs, Orion and the International Space Station (ISS). Orion is the exploration vehicle that will take astronauts to Mars; a vessel comparable to the Apollo capsule. The International Space Station (ISS) is a space research facility designed to expand our knowledge of science in microgravity. The first piece of the ISS was launched in November of 1998 and has been in a continuous low earth orbit ever since. Recently, two sub-programs have been developed to resupply the ISS. The Commercial Cargo program is currently flying cargo and payloads to the ISS; the Commercial Crew program will begin flying astronauts to the ISS in a few years.

Organization Structure

NASA currently employs approximately 16,000 civil servants, 3,000 of which are at JSC (Workforce Information Cubes for NASA). However, most NASA employees are contractors and are not included in this number. Employees at JSC are divided into sixteen directorates ranging from Engineering to Information Resources to Flight Operations to Safety & Mission Assurance. Each directorate is then split into divisions, branches, and finally groups. Each group plays a unique role in the success of human spaceflight.

Flight Planning and Procedures Branch (CO7)

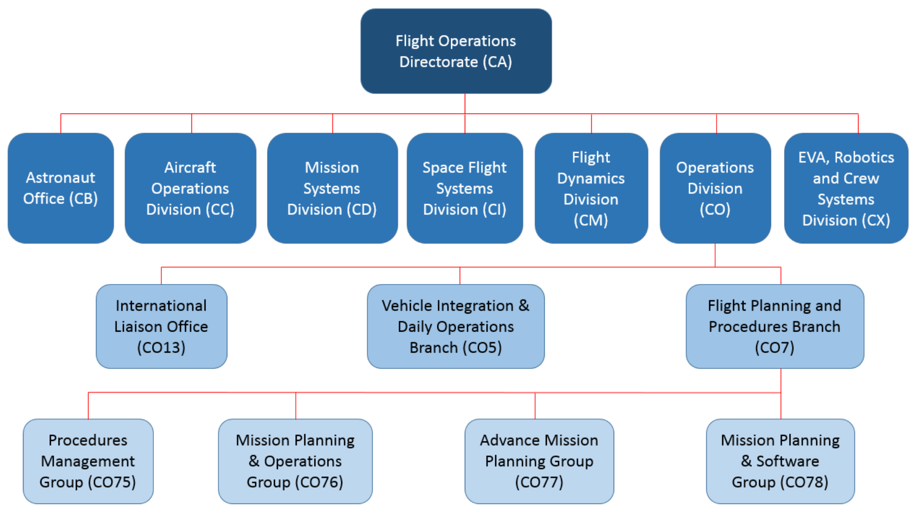

Figure 1 - Organization Chart for the Flight Operations Directorate, with an emphasis on the Operations Division

I have been working in the Flight Planning and Procedures Branch (CO7), which is part of the Operations Division of the Flight Operations Directorate (FOD). CO7 is split up into four groups. The Procedures Management Group (CO75) is responsible for ensuring all activities and events that could occur in space have accurate and updated procedures. The Mission Planning and Operations Group (CO76) is responsible for ensuring that all current missions have an accurate plan. The Advance Mission Planning Group (CO77) is responsible for establishing protocols for missions that have not flown yet (Orion for example). Lastly, the Mission Planning and Software Group (CO78) ensures that FOD has the necessary software tools to make a successful plan. The figure 1 is an organizational chart that shows where CO7 falls in the larger structure of FOD.

Section II: Work Environment

Team Members

CO7 is a very large team of people. The branch chief, my supervisor, is Timothy Baum. The Procedures Management Group lead is Margaret Gibb, the Mission Planning Operations Group lead is Michael Boggs, the Advance Mission Planning Group lead is Lauren Rush, and the Mission Planning Software Group lead is Neil Woodbury. Lauren Rush was my mentor and she organized my project goals as well as all of my training opportunities. I also worked with Neil Woodbury, since most of my projects fell under Mission Planning Software. For specific project details I worked with the leads for each software planning tool. Katie Lodridge is the Planning Project Change Request (PPCR) lead. Shelby Bates and Mikayla Kockler are the WebAD leads. Richie Chantlos, Chris Wagner, and Ashley Henninger are the Viewer leads. Additionally, I worked with the Ops Plan position lead, Karen Wells, as well as the Operations Nomenclature database leads, Jodie Rhodes and Steve Gibson.

Meetings

I regularly attended two meetings - tools scrum and OPTCP. Tools scrum was a 30 minute status meeting that occurred every Monday, Wednesday, and Thursday morning. Any questions, comments, or concerns related to planning software were discussed. OPTCP (Operations Planning Technical Control Panel) was a 1-2 hour weekly meeting. The meeting discussed any updates that the planning community would need to know, such as visiting vehicle overviews, increment lessons learned, and planning process updates. I also attended regular tag-ups with my mentor. Additionally, I attended co-op committee meetings, lectures from astronauts and flight directors, and lab tours organized by the Co-op Tours and Lectures committee.

Section III: Technical Summary

Note: The Flight Operations Directorate (FOD) applies engineering solutions to the operations of all NASA missions. Traditional testing is not in the scope of the work that FOD is responsible for.

Background

Crew - The astronauts and cosmonauts on board the ISS.

Increment - A three month long period of time set by the arrival or departure of a crew vehicle.

Timeline - A physical representation of the daily plan, comparable to a daily agenda view in any calendar program.

Mission Control - The physical room where flight controllers command and support ISS operations.

Discipline - A team of flight controllers that focus on one aspect of the ISS. For example, ETHOS is the discipline that manages and maintains the internal environment and thermal control of the ISS.

Console - The physical desk that flight controllers sit behind in Mission Control. When someone is working real-time operations in Mission Control they will say "I am on console."

Planning Process

CO7 is responsible for creating the daily schedule for the astronauts on the ISS. The schedule includes all activities to be performed by the crew, such as maintenance, experiments, public affairs events, exercise, meals, etc. Planning starts 16 weeks before each increment begins. This first plan is called an on-orbit summary, or OOS, and analyzes the feasibility of the tasks that will be assigned to the crew. Two weeks before the day of execution a weekly look ahead plan

(WLP) is created to assign activities to specific days. As the day of execution, or “E”, approaches several different groups of people begin analyzing the plan. At E-7 (7 days before execution), a team called LRP Support finalizes the plan. This team ensures that no activity constraints are broken and checks with all of the other disciplines to make sure that their activities are represented appropriately on the plan. The RPE, or Real-time Planning Engineer, is responsible for managing the plan between E-6 and E-3. The RPE processes all approved plan changes and ensures that the plan is accurately uplinked to the server onboard the ISS. The Operations Planner (Ops Plan) is responsible for E-3 to E-0. Ops Plan sits in the front room of Mission Control and processes any last minute changes to the plan. Ops Plan represents the entire planning team if any plan-related issues arise during execution.

Planning Tools

The planning community uses several different tools throughout the planning process. Each tool has a specific function associated with the time range of the plan.

IPV - International Procedures Viewer

IPV stores all procedures performed by the crew. The procedures are in the form of a static PDF or a dynamic XML document. Each procedure in IPV has a unique document number that can be linked to an activity. The IPV homepage can be seen in figure 2.

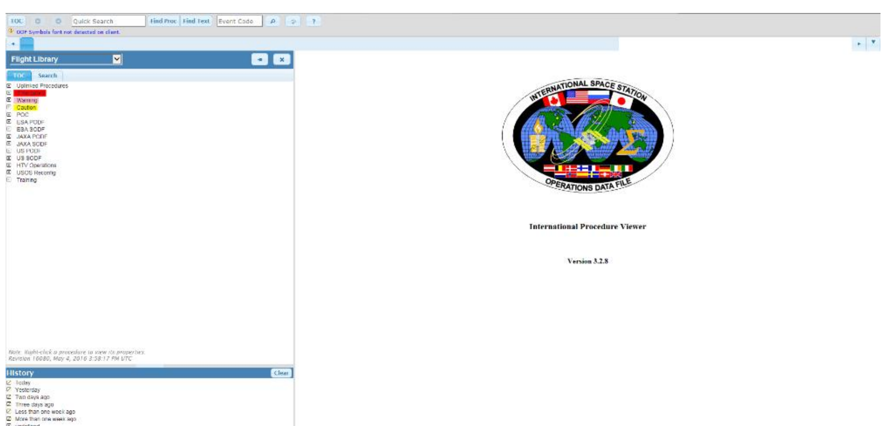

Figure 2 - Landing Page for IPV

WebAD - Web Based Activity Dictionary

WebAD is a database of all activities performed by the crew. Each activity in WebAD contains the duration, procedures, activity constraints, and resources used for that activity. Figure 3 shows an example activity in WebAD. WebAD is used in the pre-planning process. Each discipline can access WebAD and enter their own activities. The planning team manages the overall catalog of activities in WebAD and ensures that information is entered correctly. This tool also simplifies the pre-planning process because once an activity is created it can be scheduled as many times as necessary.

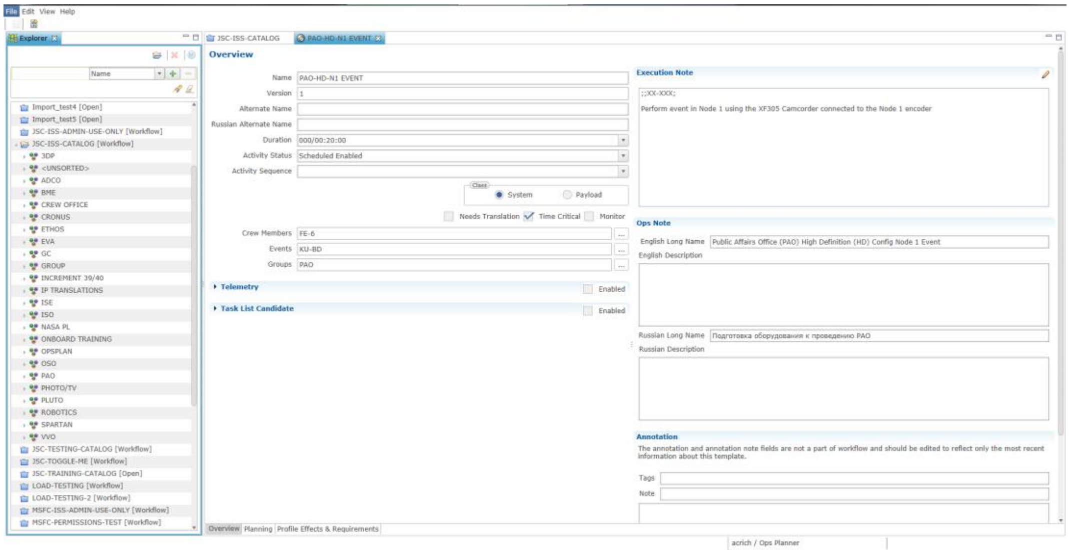

Figure 3 - WebAD Sample Activity

Score

Score is the tool that is used to physically create the timeline. WebAD activities are imported into Score and are dragged and

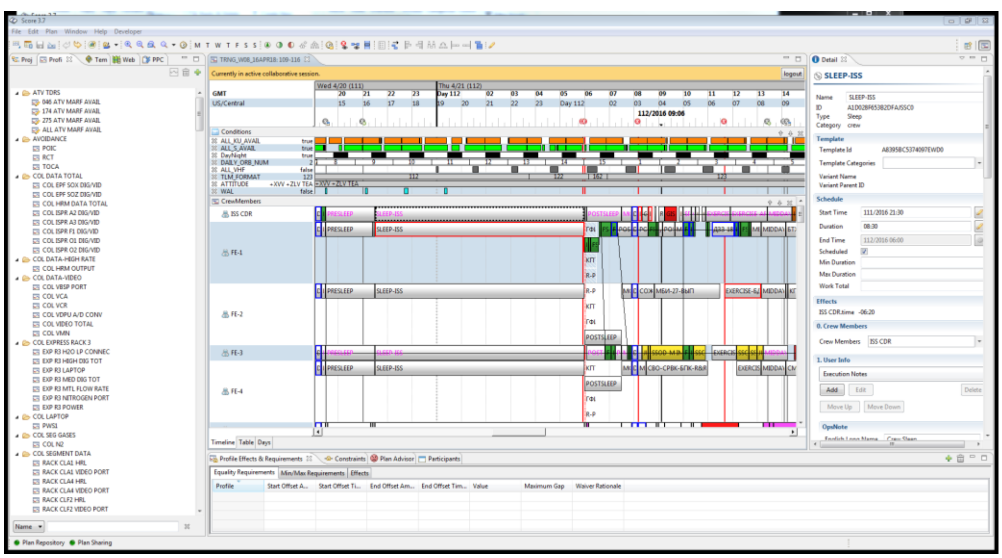

Figure 4 - Timeline Development in Score

dropped into the plan. Activities are assigned a time associated with their duration and appear as a block on the timeline. The Figure 4 shows an example timeline in Score. Score is used from E-14 through E-0 because it is the physical timeline creator.

PPCR - Planning Product Change Request

PPCR is the official tool used to change the plan between E-6 and E-0. Since the schedule is so close to the day of execution any changes must be approved by the flight director. This tool was developed to provide an easy way for disciplines to add, delete, or modify the activities in the timeline. It also provides a simple way for the RPE and Ops Plan to make changes. Figure 5 shows a sample PPCR.

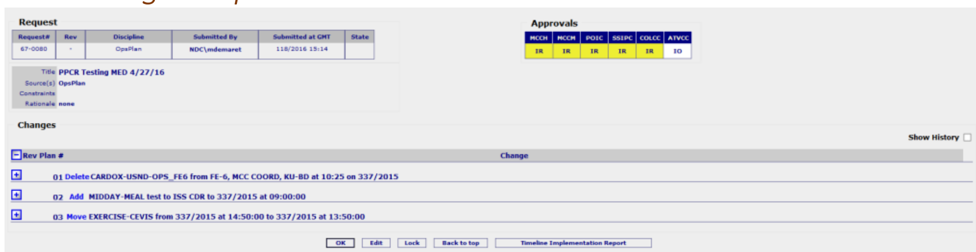

Figure 5 - Sample PPCR

OPTIMIS Viewer - Operations Planning Timeline Integration System Viewer

Viewer is the software tool that displays the final timeline. This is what the astronauts and ground control teams use to view the final plan for the day. Figure 6 shows a sample day in Viewer.

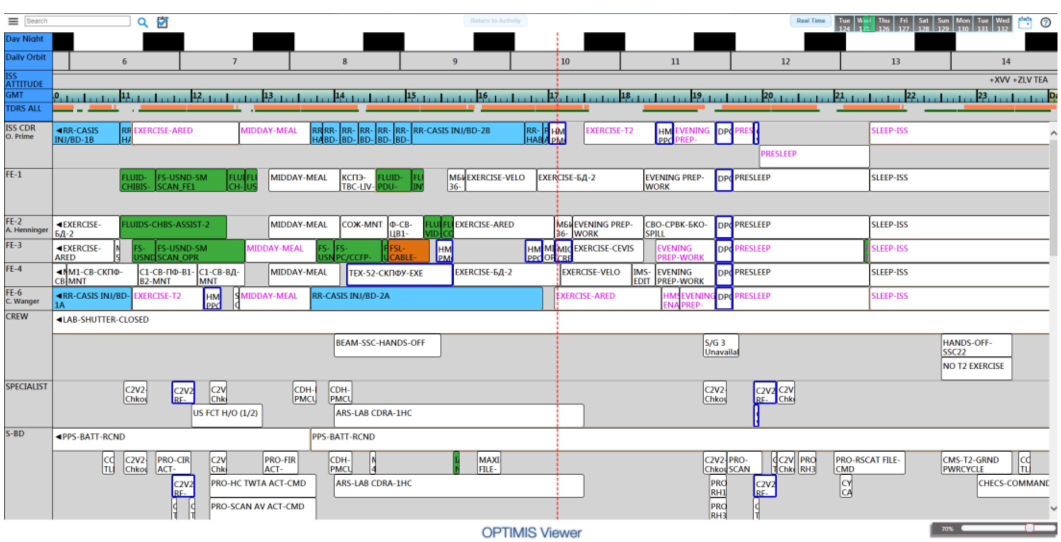

Figure 6 - Sample Day in Viewer

Project

Project Goals and Objectives

A key aspect of successful human spaceflight missions is training. Training documentation must be updated or recreated as new improvements are made to the tools that missions rely on. I completed several small projects during my 16 weeks in CO7, most of which involved updating training materials. Since multiple flight controller disciplines interact with planning products, my overall goal was to improve training on planning tool use. This would standardize the information that general flight controllers receive, reduce errors, and decrease the number of questions that the Ops Planner receives while on console.

My first task for the semester was to create reference sheets for WebAD, PPCR, and OPTIMIS Viewer with a target audience of the general flight controller community. My second task was to pull together a "goodie book" for Ops Plan. A goodie book is a reference guide that contains useful or commonly used documents. Lastly, I was tasked with creating a tutorial for the search feature tied to the cross-program operations nomenclature database.

Planning Tool Reference Sheets

These guides will be utilized by the general flight controller community that has been trained on each planning tool but does not interact with them on a daily basis. My quick reference guide would need to outline all of the critical steps and frequently forgotten information, while omitting the more intuitive and less important aspects of each tool.

To start, I watched all of the training videos for WebAD, PPCR, and OPTIMIS Viewer that were posted on the FOD Online Training Lessons website. Each software tool had a lesson flow of about 10 videos discussing general usage and features. I then read through the user guide for each software tool; an approximately 60 page document describing the functions of each tool in detail. Once I had a general understanding of how each tool worked, I revisited the user guides and pulled critical information in order to build a comprehensive guide of the important aspects of each tool.

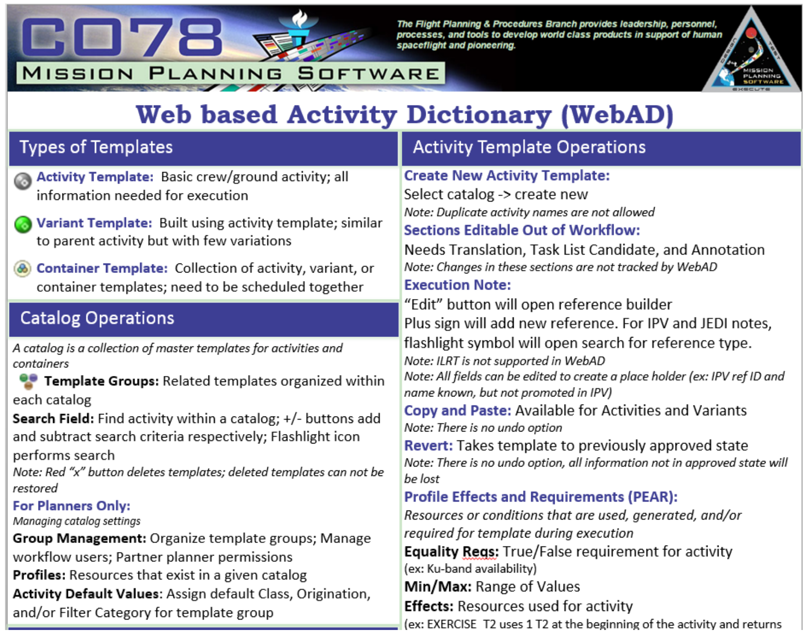

Figure 7 - Top Half of the WebAD Reference Sheet

I considered each major concept and decision that would be made while using the tool and recorded the information that I thought flight controllers would find most useful. This information included definitions of terms, keyboard shortcuts, helpful tips to improve efficiency, naming conventions that must be followed, search tips, rule exceptions, etc. Using PowerPoint, I formatted this information onto a one page reference sheet and sent it to the appropriate tools team leads for feedback. Their feedback included slight changes to examples, reordering of information, and the addition of other common mistakes made by flight controllers. The final version of each reference sheet will be included in the flight controller training academy documentation. A portion of the WebAD sheet is shown in figure 7.

Ops Plan Goodie Book

The Ops Plan Goodie Book is a compilation of documents that will be useful to Ops Planners on console. I met with the Ops Plan position lead, Karen, and she gave me a list of documents to find. The documents contained information such as task overviews, increment specific preferences, phone numbers, re-plan guidelines, etc. The documents came from several different sources, so I had to find each document, print it, and note its location. I assembled all of the documents into a binder organized into the following sections: task overview, increment specific, planning references, general references, re-planning, visiting vehicles, flight control team members, and phone numbers. Additionally, I created a table of contents listing the document name, description, location in the goodie book, and location in the intranet. As an extra measure to future-proof the goodie book, I created a folder in the network drive with shortcuts to all of the original documents.

Cross-Program Operations Nomenclature Tutorial

Nomenclature is crucial when communicating procedures through radio channels. The astronauts and flight controllers must have consistent and clear terminology for the object(s) being discussed. Operations nomenclature (OpNom) was established to simplify the engineering names of the software and hardware onboard all spacecraft to prevent space-to-ground miscommunication. NASA maintains an OpNom database to track every term.

Orion and the Space Launch System (SLS) are in the testing phase, which means that operations is now heavily involved in those programs. Since operations is involved, new OpNom must be established for these two new programs. This influx of OpNom in the database also means an influx of new users to the Cross-Program OpNom database search engine. The current end users of the search engine recently requested more training materials on how the search engine functions, so I was tasked with creating a tutorial.

I had two options for tutorial format; I could create a reference sheet or make a tutorial video. A video tutorial would be a dynamic demonstration of the search functions. Videos tend to be a more engaging way to learn information. However, I was assigned this project with only a month left in my co-op tour, so there was not enough time to schedule a recording session with the distance learning lab and have it produced by my last day. After coming to this conclusion, I began working on a reference sheet.

After reading through the issues the end user was having and running a few searches, I determined that the end user was expecting the search to function

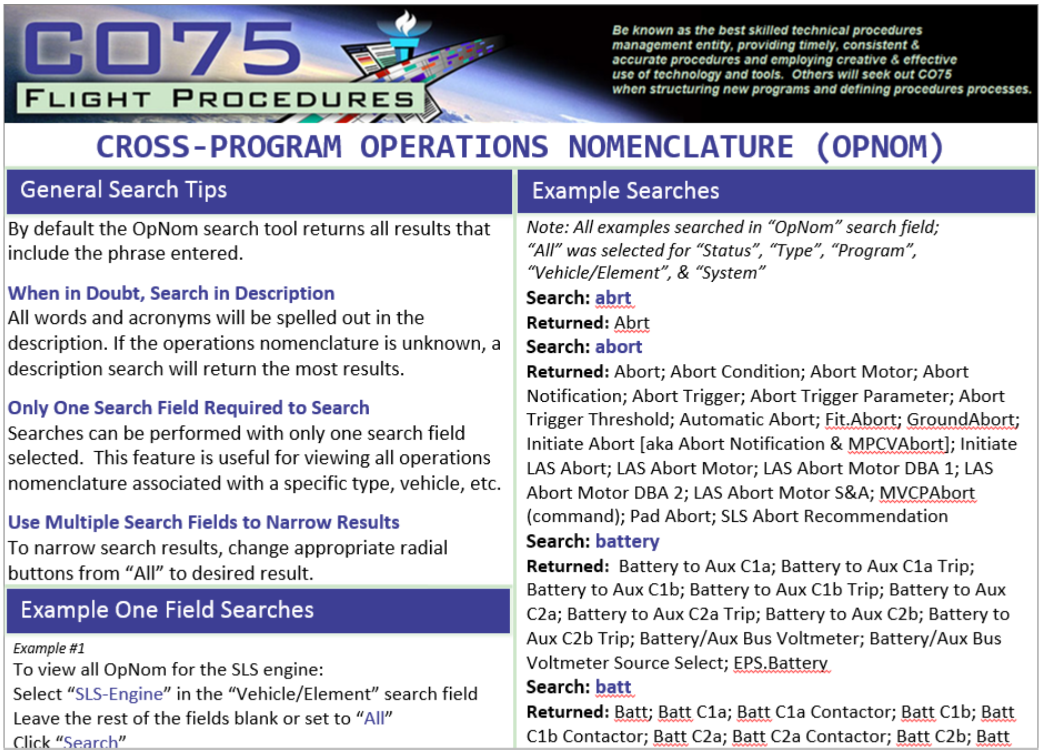

Figure 8 - Top Half of OpNom Reference Sheet

similar to Google. However, the OpNom search engine does not have as many features as the Google search engine does. This means that the end user does not get the search results that he/she is expecting. Currently, the search engine looks for the exact phrase entered and returns results that contain the exact phrase. The search also includes a default wildcard. For example, searching "battery" will return "Battery", "A Battery", and "Battery A", but will not return "Batt".

On the reference sheet I wrote a sentence or two about how the search engine functions. I then provided a couple examples to showcase the search. A sample of the reference sheet can be seen in Figure 8.

Other Opportunities

In addition to my own projects I assisted coworkers on a few smaller projects. The first involved being a voice actor for the WebAD training videos. WebAD had several updates since the training videos were last created and the WebAD team needed people to be the voice of a few of their videos. I went to the distance learning lab studio and was recorded reading the script that the WebAD team had written. Additionally, FOD was in the process of transitioning to a new version of SharePoint, so I helped pull all of the increment lessons learned from the old SharePoint website and put them on the new site.

The last major chunk of my time was spent shadowing CO7 console positions in mission control. CO7 is responsible for staffing one front room console position (Ops Plan) and three backroom console positions (RPE, OCA, and ODF). As mentioned previously, Ops Plan and RPE are responsible for changes to the plan between E-6 and E-0. OCA, orbital communications adapter, is responsible for uplinking and downlinking all data to the ISS. This includes the daily plan, all procedures, and all imagery that the crew interacts with. ODF, operations data file, is responsible for approving and processing all new procedures and maintaining IPV. I shadowed all of these console positions during normal workday hours and shadowed Ops Plan during the Soyuz TMA-20M launch and docking in mid-March (Figure 9). Additionally, CO7 runs the

Figure 9 - Soyuz Launch and Docking, L to R Wanessa Mattos, Allison Rich, Jason Mintz

International Execute Planning Center (IEPC) which contains several positions associated with pre-planning. I shadowed LRP support, which manages the E-7 plan.

Section IV: Conclusion

My most valuable experience this co-op tour was shadowing console positions. Real-time operations is a very unique career path and getting to watch the team of people that work to keep the ISS operational was fascinating. The most valuable lesson that I've learned at NASA is the importance of teamwork. Pure engineering can only get the rocket designed; humans have to work together to actually launch astronauts into space. Even just maintaining daily operations on the ISS takes an army of people, so being a team player is crucial to success at NASA.

My prior co-op experience had the largest impact on my performance at NASA because I had a general idea of what to expect in the workplace. My experience with engineering classes enabled me to create useful reference sheets. NASA is my dream job, so of course my co-op experience increased my motivation to finish my degree. Since NASA works with international partners, I now have more motivation to take a language class during my last semester at UT.

I have three more co-op tours at Johnson Space Center. Two tours will be the summers of 2016 and 2017 and one tour will be the spring of 2017. Each tour at JSC must be in a different branch. Summer of 2016 I will be working in the Engineering Directorate's Crew and Thermal Systems division in the Tools, Equipment, and Habitability Systems Branch. My main goal for the future is to become more familiar with all of the projects that are occurring at JSC. In regards to the impact of this term, I've gained a larger appreciation for how many people it takes to get astronauts into space. I really enjoyed working in FOD because every decision made has an impact on the crew or space station.

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