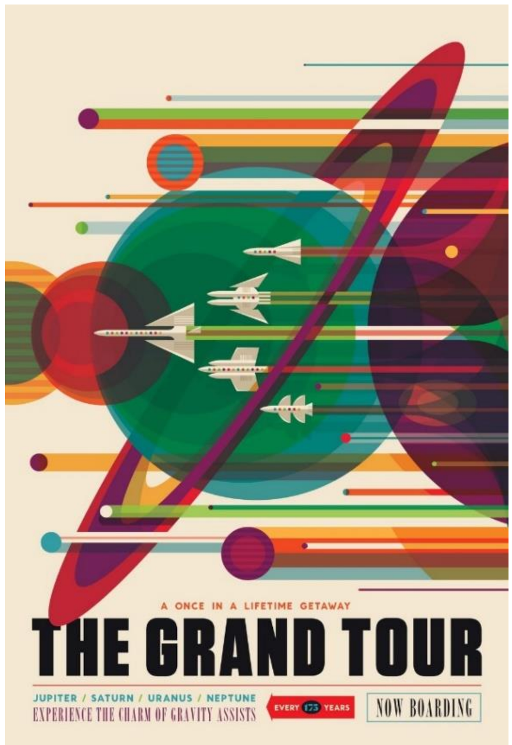
2022 Career Readiness Online Challenge

JPL: Innovation Through

The Engineering Design Process



Team Number: 986A
Team Name: Lancers
Location: Simi Valley, California

Project Lead: Ian Nelson, 10th Grade
Research Lead: Peter Wang, 11th Grade
Owen Zahn, 11th Grade
Ben Solomon, 10th Grade

Summary Report

We chose NASA's only federally funded research and development center managed by Caltech - Jet Propulsion Lab (JPL), as our STEM company. JPL continues to inspire us because they are doing "the impossible", by dominating the world in robotic space exploration. They've made many innovations in robotics that allow for complex tasks to be done on other planets. This includes driving, soft landings, small body orbiting, sampling, subsurface access, and many other firsts for robotics.

In doing this project, we learned much about JPL's processes for completing innovative projects by interviewing a seasoned JPL engineer and Supervisor of the Flight Instrument Detectors and Camera Systems Group, Mr. Mark Schwochert. He has visited our school's robotics program, talked with us, and provided some guidance. We also found online resources and YouTube videos. Normally, for all NASA projects, JPL undergoes the Engineering Design Process, or EDP. However, because JPL also does projects for other federal, state, or local government agencies, they sometimes use a modified EDP. They use the EDP to develop technologies to explore some of the biggest mysteries of the universe. The EDP is crucial in understanding the science of earth, our vast solar system, and the outer space. Without it, JPL could not build the instruments, rovers, spacecraft, and robots needed to explore and gather data.
Each project is broken down into systems and subsystems with several levels. JPL has managers and engineers working for each subsystem, and even more engineers working on each level. As part of their process, JPL has meetings at many levels, especially for large projects. The meetings are scheduled and run by the manager for each level and include team members and engineers responsible for a piece of hardware or subsystem element.

To help manage the EDP, JPL uses a variety of online tools. An example would be generating and managing the technical requirements for a specific project. JPL uses a browser-based application for development and management of requirements called DOORS Next Generation (DNG) that allows many users to collaborate on a single project. Excel spreadsheets are sometimes used in the beginning of a project, but projects usually end up in an online tool like DNG to automatically configure control.

There are usually meetings at least once a week at each level of the project, and there are different topics of discussion that require their own meetings. For example, a person working on a flight project would probably attend at least 5 or more meetings a week, each covering different aspects of the project.

We found that big projects, like the Ingenuity Mars Helicopter, took about 4 to 5 years to develop. However, such technology was built on other earlier projects that helped develop and prove the concept before it was decided to be used on an actual Mars mission.

We learned about the biggest project Mr. Schwochert has worked on was an Earth Science mission called Orbiting Carbon Observatory (OCO). The project started in 2003 and continued through 2012. Like all complex and groundbreaking projects, sometimes things don't go as planned. Unfortunately, OCO-1 crashed into the ocean when the launch rocket failed. OCO-2, the replacement, took another 3 years to build and it eventually had a successful launch and successfully reached an Earth orbit.

Yellow - Milestones for Team 986A EDP & JPL High Level EDP

Green - Match Process

Red - Not a Match in Process

Team 986A Engineering Design Process	JPL Engineering Design Process
Phase I: Define the Problem	**Phase 0: Advanced Research**
Identify problem	Formal scholarly research
Check design requirements	Investigate research problem
Create a written plan called design brief	**Phase I: Definition of Project**
Phase II: Generate Concepts	Check requirement
Research past solutions	Analyze requirements
Brainstorm possible solutions	Develop conceptual design
Develop and compare all solutions (Decision Matrix)	Concept design review
Phase III: Develop Solution	Make model
Create a detailed design drawing or CAD	Test model
Record assembly steps	Buy/cost analysis
Material list	Lessons learned
Phase IV: Build	**Phase II: Preliminary Design**
Build robot by following technical drawings	Collect requirements
Phase V: Test	Develop preliminary design
Test robot performance, usability, and durability	Make and test simulations
Collect test data	Preliminary design review
Create test report	Buy/cost analysis
Phase VI: Evaluate	Lessons learned
Ponder solution effectiveness	**Phase III: Detailed Design**
Spot strength and weaknesses of robot	Collect requirements
Phase: VII: Communicate	Develop detailed design
Discuss solution and improvements	Make and test simulations
Phase VIII: Competition Review	Critical design review
Post mortem analysis	Buy/cost analysis
	Lessons learned
	Phase IV: Build and Test
	Manufacture and assemble products
	Design verification/qualification tests
	Collect data
	Documentation (controlled)
	Evaluate, Delivery Review

Image 1: Comparison of Team 986A's EDP versus JPL's high level EDP

On every mission, JPL follows an engineering design process, even if it is just a small project. It is necessary to make sure the project is complete, contains proper documentation, and succeeds through the life of the project. Documentation is also frequently needed for the funding process. JPL seeks to have the best-in-class engineers in fields including electrical, chemical, mechanical, and software systems engineering. They also have top scientists, technologists, researchers, and cybersecurity engineers.

The engineers use the acronym “DBAT”, which stands for Design, Build, Assemble and Test. When working on a large project, they will have several levels, reviews, or milestones to reach. Because all funding must be approved by the government, cost is always a major factor. Since they compete with other companies to get the projects, they not only have to have a great design, but they must keep careful control over costs.

In some ways, the EDP of our VEX robotics team has many similarities with JPL’s processes, only on a much smaller scale. We also follow an EDP process, have frequent team meetings to talk about ideas and evaluated progress, use online software such as Google Docs and Autodesk Fusion, and spend a great deal of time in the documentation process (known as our “engineering logbook”). Furthermore, we work on subsystems like the base, lift, hook, and intake and we put these systems together to make a complete robot. Each member of our team is, or works toward, being an expert. We have different roles like programmer, builder, driver, documenter, and computer-aided designer. While we are not seeking federal funding, our resources are limited, and we must be smart about keeping costs down and making smart use of our parts and equipment.

Being in VEX robotics has been a learning opportunity for us. Learning to work in teams, create building schedules, program 3D models, and staying organized and efficient are all skills we can use for the rest of our lives. Most importantly, applying the engineering design process will help us come up with the best possible solution by working systematically and strategically.

Beyond VEX, we may not need to build a competition robot to move multi-colored goals around a foam tile field, but the valuable skills we learned - like the importance of hard work and diligence, teamwork, and the importance of having fun in the process - will help us in school and someday at work. Many of us would like to work in field of engineering and our interests include optics, mechanical devices, data analysis, and computer programming. We discovered all these skills are also crucial in JPL’s quest for continuous innovation.

Citations and Resources

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