99157B
IronMechs2.0
November 20, 2022
Haymarket, VA

VEX Today, Lockheed Martin Tomorrow

Authors: Daniel, Gabe, Max, and Weston

Editors: Adi and Eddie

Why Lockheed Martin

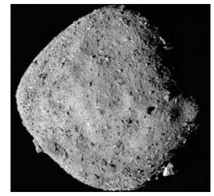


Figure 1 ORISIS Rex needed to reach an asteroid that is 4.6 million miles away! [1]

We chose Lockheed Martin (LM) because we are inspired by their great work in space exploration. They built the Orion spacecraft that will send humans to the moon for the first time in FIFTY YEARS! This work will turn the moon into a steppingstone for deep space exploration. They also built the ORISIS Rex probe that was sent to an asteroid to collect samples and bring them back to Earth!

We met with LM engineers to learn about their engineering process and how they accomplish these complex missions.

Figure 2 Visiting and learning about Lockheed Martin's engineering process and showing them our engineering notebook

We learned LM uses an iterative systems engineering "V" and we saw similarities to our process. Below further explains how their process is similar ours.

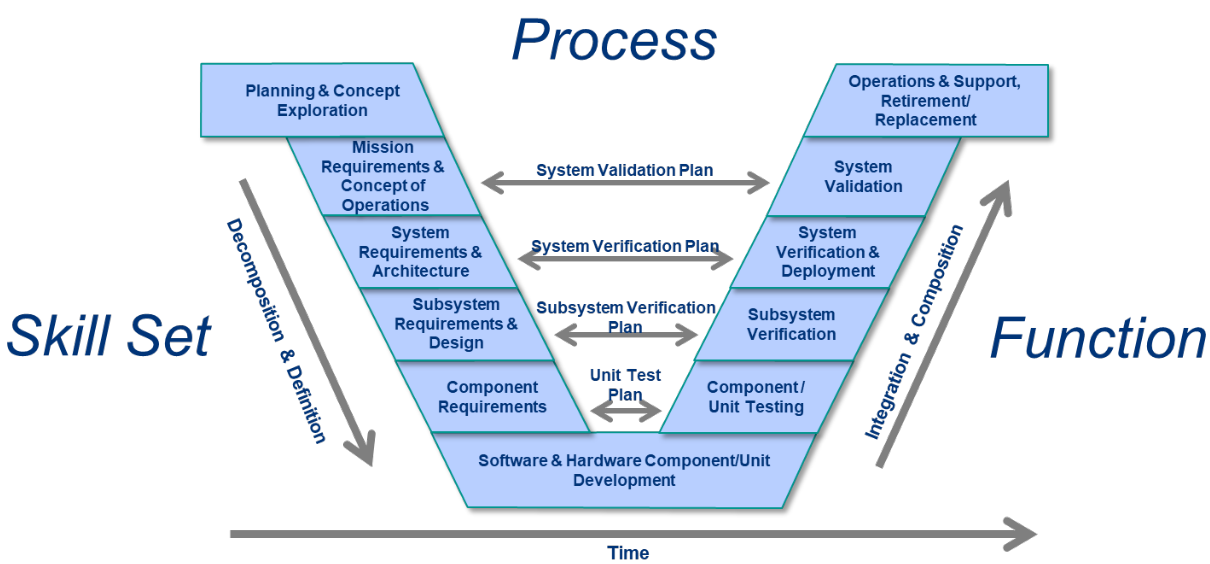


Figure 3 Lockheed Martin's systems engineering "V" [1]

Step 1: Identify the Problem

LM begins with "Planning & Concept Exploration" to understand the goal of the mission and identify challenges they'll face. This step also helps keep people on the same page, so they can work effectively together.

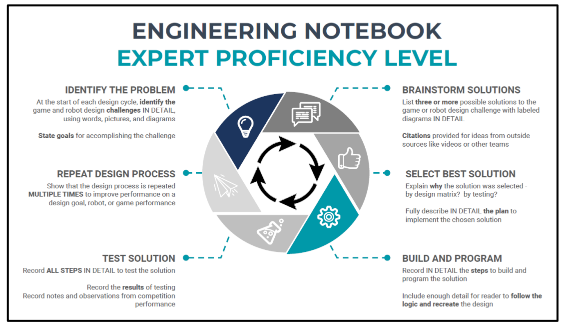


Figure 4 Our design process [2]

This is similar to our Identify the Problem step when we learned the game rules to find what we can and can't do. We also identified the challenges the robot would need to handle during gameplay. Finally, we set goals for the design cycle to help us work effectively together.

Step 2: Brainstorm the Solution

The "Mission Requirements and Concept of Operations" and "System Requirements and Architecture" steps is where LM brainstorm's possible solutions to their programs. For example, Orion must make sure 99% of the population can fit in the spacecraft. So, LM must design Orion's crew module to accommodate heights varying from a 6'5" male to a 4'10" female. They can evaluate their ideas using models and CAD to explore the design before they build it. We even got to try out their virtual reality system for exploring ideas and concepts on spacecrafts.

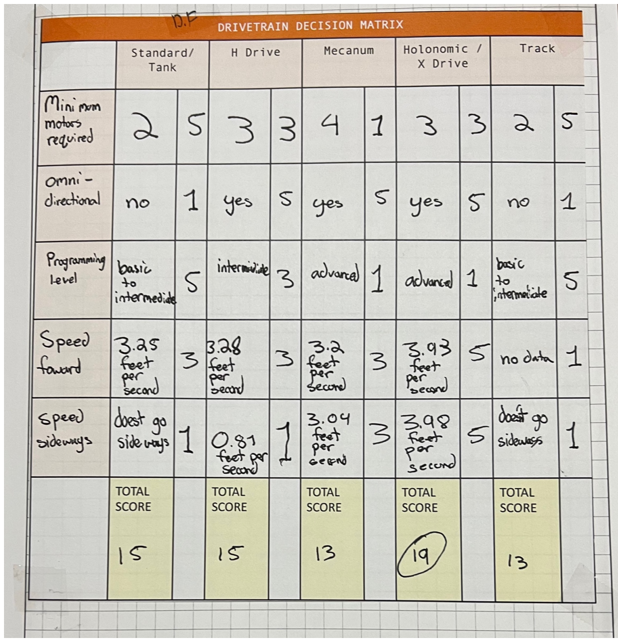
Figure 5 Iron Mechs 2.0 Trying Spacecraft VR

This is like our Brainstorm the Solution step where we brainstorm multiple options for a robotic mechanism and identify pros and cons of each. LM also brainstorms ideas by building them in CAD, like some VEX teams, to see if the solution will work.

Step 3: Select a Solution

During "Subsystems Requirements and Designs" LM regularly does "Make vs Buy" decisions to determine the best solution for a component. This is when they compare the material cost, time usage, difficulty, and other criteria to determine if they should either make, reuse, or buy parts. Once they have determined all the criteria for each option, they compare the options and review all the information gathered to make a decision on which option is the most efficient.

This is incredibly like our own decision matrix process where we come up with options for a robotic mechanism, determine criteria based on the situation for the mechanism, and then make a decision with all the information we have gathered from the process. Once we review and make the decision, we will start the building process and create the mechanism.



DRIVETRAIN DECISION MATRIX

	Standard/ Tank		H Drive		Mecanum		Holonomic / X Drive		Track	
Minimum motors required	2	5	3	3	4	1	3	3	2	5
Omni-directional	no	1	yes	5	yes	5	yes	5	no	1
Programming Level	basic to intermediate	5	intermediate	3	advanced	1	advanced	1	basic to intermediate	5
Speed forward	3.25 feet per second	3	3.28 feet per second	3	3.2 feet per second	3	3.93 feet per second	5	no data	1
Speed sideways	doesn't go sideways	1	0.81 feet per second	1	3.04 feet per second	3	3.98 feet per second	5	doesn't go sideways	1
	TOTAL SCORE 15		TOTAL SCORE 15		TOTAL SCORE 13		TOTAL SCORE 19		TOTAL SCORE 13	

Figure 6 sample decision matrix from our process

Step 4 Build the Solution

As part of LM's System Engineering "V", they build their systems by decomposing it into small subsystems for specialized teams build. For example, on Orion one team built the crew module while another team built the service module.

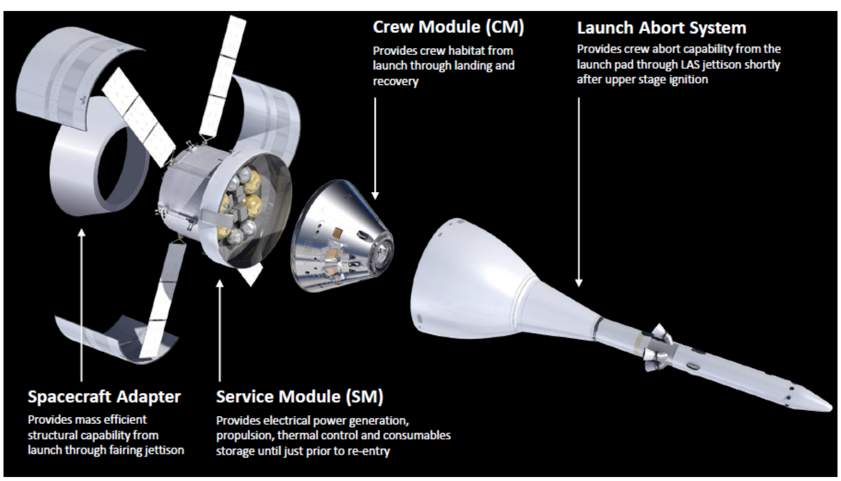


Figure 7 Orion spacecraft subsystems [1]

Our team followed a similar approach where we divided into pairs and built robotic mechanisms. For example, we had separate teams for the drivetrain, rolling the roller, and the expansion mechanism.

Figure 8 Drivetrain team, Expansion team, and Roller team building their robotic mechanisms

Step 5: Program the Solution

In the "Subsystems Requirement and Design" step LM determines how to use autonomous code to help independently operate spacecrafts. Take one of their recent missions where the goal is to get Orion to the moon and back to Earth. They used models to predict and determine the path they wanted to take to the moon.

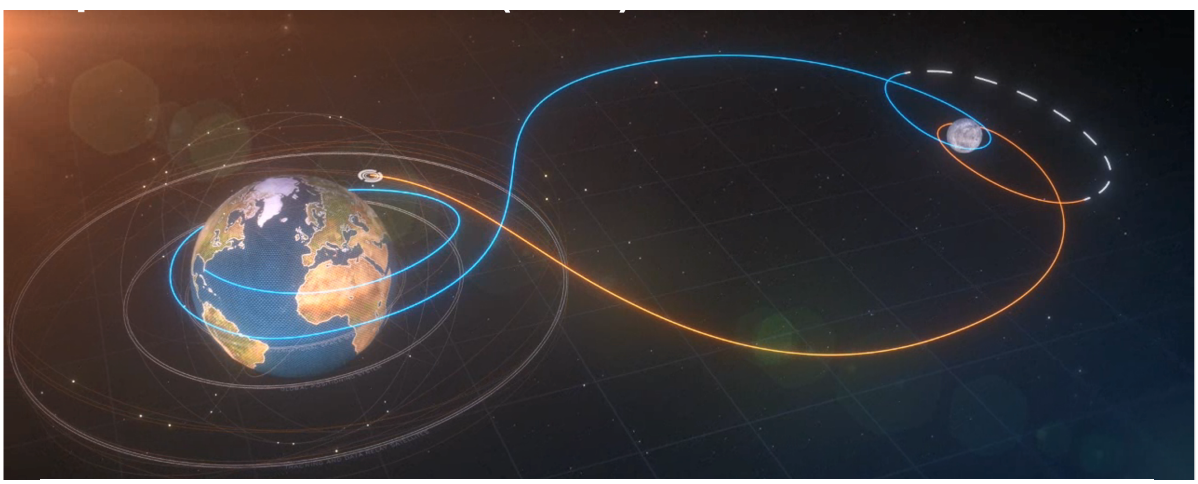


Figure 9 The orbital path to the moon and back to Earth [1]

However, in space LM cannot completely predict when solar flares and solar winds will impact the spacecraft. So, they use sensors and autonomous code to determine the spacecraft's actual position and make corrections to keep them on their path to the moon. LM codes using agile and iterative processes to help them code quickly, test quickly, and fail quickly so they can identify problems and fix their code.

This is just like our Program the Solution step. Our VEX team codes our autonomous code bit by bit and not all at once. We test the robot at each step, and we correct problems before moving on. Just like LM, our team discovered through testing that we needed sensors to consistently reach the second roller across the field because we couldn't predict when the discs would push the robot off course.

Figure 10 Failing a test because discs are pushing our robot off course and over the autonomous line

Step 6: Test the Solution

LM uses several levels of testing across the systems engineering "V" process to find mistakes or issues and correct them. They use an agile iterative process to build, test, and fail quickly to learn from their failures. Failures are a part of engineering, and it is to be encouraged because only from failure, comes great learning.

This is like our testing process because we test early and often to find our mistakes and correct them. For example, our roller design failed testing multiple times, so we changed our design to address the failures.

Figure 11 Roller design changing and improving from failed tests

Step 7: Repeat the Design Process

LM does short and incremental design cycles so they can pinpoint a problem easily and fix it early. If you complete the entire project and then realize you did something wrong, it takes a lot more time and effort to fix. Our team also repeats this design cycle to improve the robot.

How VEX Robotics prepares us for a future career

After meeting with LM, we can clearly see how our VEX engineering process skills are applied in aerospace careers. Additionally, building a robot taught us teamwork skills, and teamwork is VERY important in real life. VEX has helped us deal with overcoming failures. Just like in a workplace environment, things you are not prepared for will happen, so you learn to adapt and solve the problem.

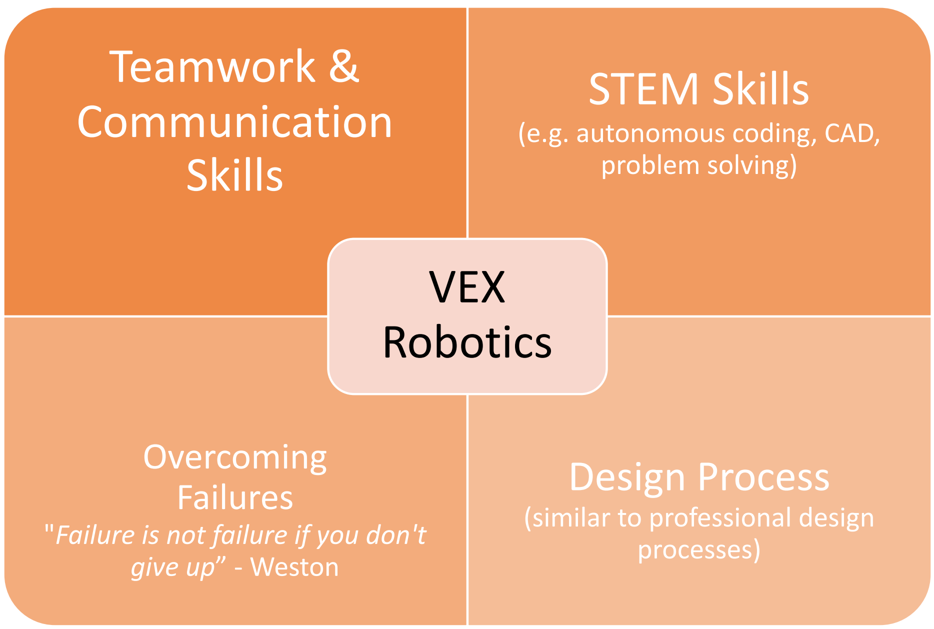


Figure 12 VEX Robotics teaches us the foundation for innovation and career readiness

References

1. "LM Space, Engineering in Space" Presentation 11/8/22
2. Advanced VRC Engineering Notebook Techniques, https://kb.roboticseducation.org/hc/en-us/articles/8498010646935-Advanced-VRC-Engineering-Notebook-Techniques