CAREER READINESS

AMAZON ROBOTICS

CONTINUUM ROBOTICS

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AMAZON ROBOTICS

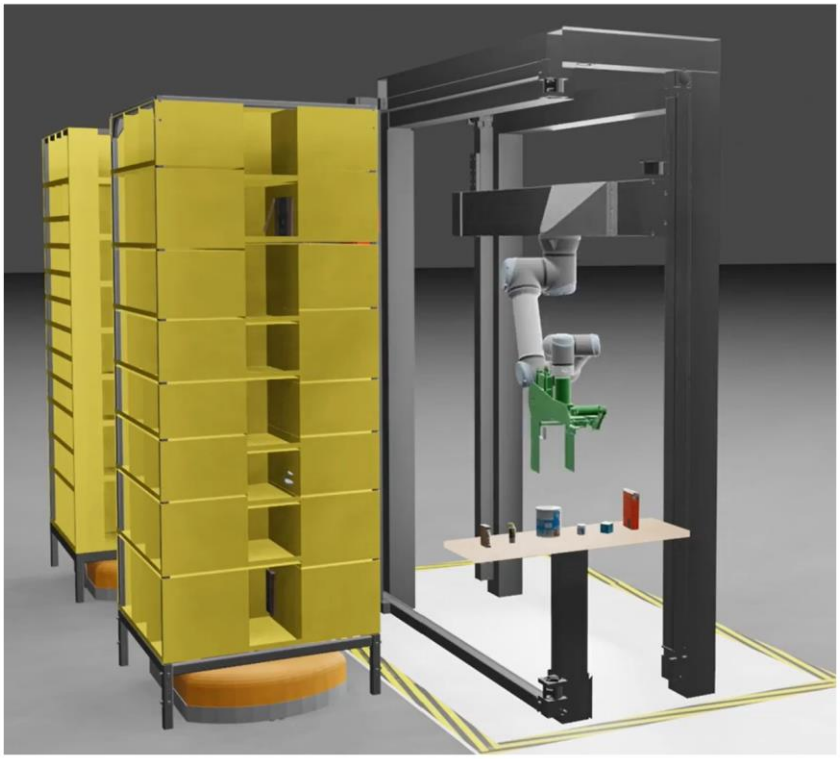
WHY CHOOSE AMAZON ROBOTICS?

Amazon Robotics designs, develops and manufactures robotic systems that automate Amazon fulfillment centers. Since 2003, they've revolutionized the use of technology and robotics in the e-commerce industry to increase efficiency and accuracy, whilst lowering cost in fulfillment centers.

We were fascinated and curious about how Amazon leverages robots and how they use the engineering design process in creating their systems. With the help of Cassie Meeker, a Senior Applied Scientist, and Sydney Kaplan, a Robotics Hardware Engineer, from the Amazon Robotics Lab in Seattle, we toured the facility, learned about their design process, and how they applied the process in developing the Stow robot.

WHAT IS THE STOW ROBOTIC SYSTEM?

At Amazon fulfillment centers, miscellaneous items are stored into large pods with up to 40 bins. The stow robotic system is working to store items into the pods in a time and space-efficient manner. It's comprised of two subsystems: a robotic arm and an EOAT (end-of-arm tool).



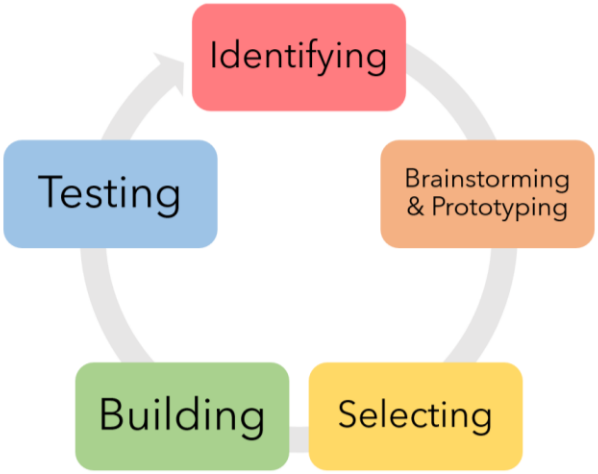
A simulated image of the Stow Robot with the storage pods.

Our Team with Cassie and Sydney at the Amazon Robotics Facility

DESIGN PROCESS

The engineering design process is a systematic, iterative approach to develop solutions to problems.

Amazon Robotics' design process contains five steps: Identifying, Brainstorming/Prototyping, Selecting, Building and Testing. This is similar to the design process our team uses to develop VRC robots. We use the design process separately for each subsystem. This creates the most proficient robot.



STEP 1: IDENTIFYING

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The first step in Amazon's design process is to identify the given problem and come up with requirements. With the Stow project, the problem was to properly stow items of various shapes. Some of the requirements were (Kaplan):

1. Ability to handle different types of packaging/material.
2. Ability to efficiently leverage storage space by repositioning other items.

OUR TEAM:

Similarly, our first step is to identify the goal of the challenge and generate a list of requirements for each mechanism to achieve the goal.

For Over Under, the drivetrain requirements we identified included:

1. Ability to cross the long barrier.
2. Ability to push other robots during Teamwork matches.

STEP 2: BRAINSTORMING & PROTOTYPING

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Next, Amazon engineers brainstorm solutions to achieve the identified requirements. They then prototype simplified versions of the solutions. In the opinions of Sydney and Cassie, prototyping, "failing fast, trying new things", is crucial to the design process because it allows for trial and error (Kaplan). According to an Amazon Science article, some examples of past prototypes for the EOAT are (O'Neill):

- Metal pinchers
- Suction cups
- Two paddles

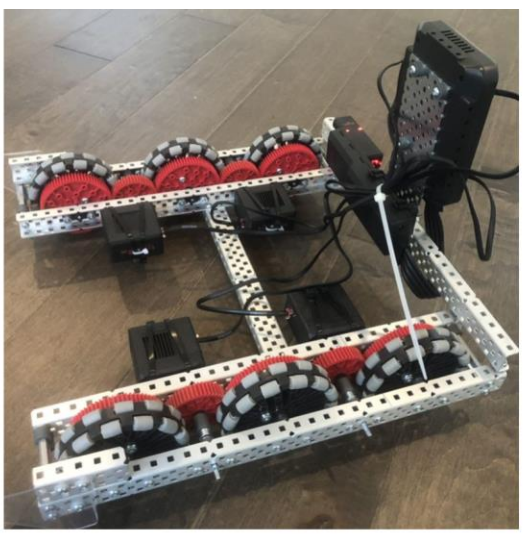
OUR TEAM:

"Brainstorming/Prototyping" is also critical in our process. We brainstorm solutions to the problem/requirements, draw sketches, and list pros & cons for each potential design. Then, we build simple prototypes for testing.

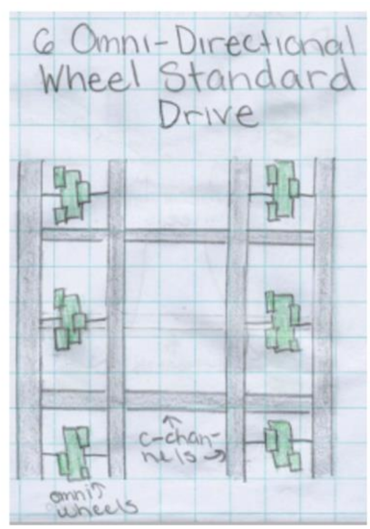
Pros
• Fast • Excellent traction • Cannot get pushed from the side

Cons
• Can only move forwards and backwards • Not compact

Pros and Cons Table



Drivetrain Prototype



Drivetrain Sketch

STEP 3: SELECTING

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The third step in Amazon Robotics' process is to select a prototype to proceed with. The current EOAT selected through multiple iterations of the design process "consists of two long paddles that ... squeeze an item to pick it up, with conveyor belts on their inner surfaces to shoot the item into the bin" (Ackerman). This step minimizes the number of prototypes whilst identifying the most viable one.

OUR TEAM:

We also conduct extensive prototypical testing with consistent benchmarks/procedures. The results are recorded in a table and used to compile decision matrices. These matrices organize ratings from 1-5 for each of the testing categories which allows us to select the best prototype to proceed with.

	Ability to Move Over Obstacles	Driving Speed	Resistance	Total
4 Omni Wheels	1	4	1	6
2 Omni Wheels and 2 Traction Wheels	1	3	2	6
4 Traction Wheels	1	3	3	7

Testing result chart for drivetrain prototypes

Wheel Types	Able to Driver Over	Time it Took to Drive Over
6 Omni Wheels	Not Able	N/A
4 Omni Wheels and 2 Traction Wheels	Able	3.19 seconds
4 Omni Wheels and 2 Flex Wheels	Able	2.01 seconds
6 Traction Wheels	Able	2.34 seconds

Decision matrix for drivetrain prototypes

STEP 4: BUILDING

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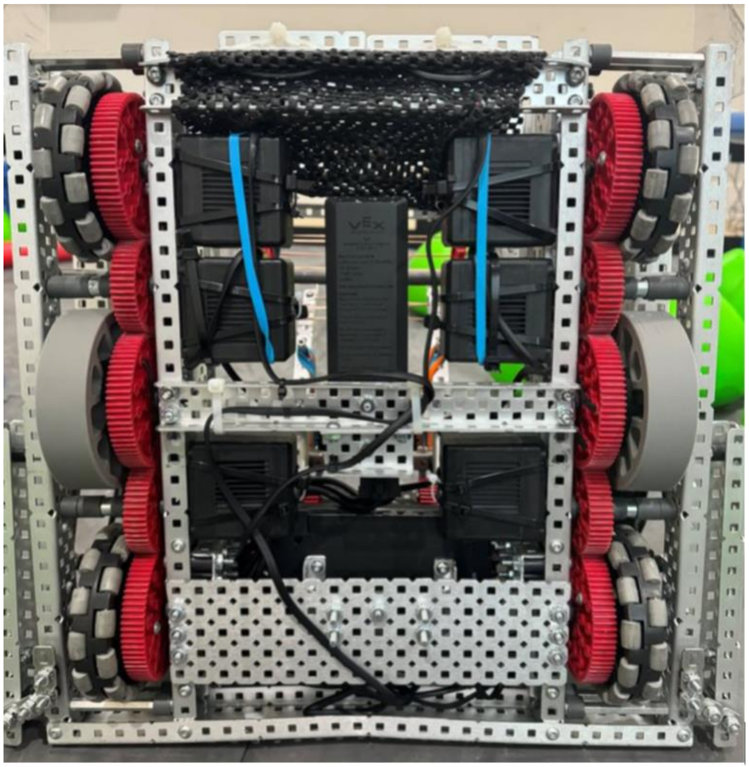
Once a prototype is selected, Amazon engineers build the large-scale, working-version of the subsystem and integrate it into the rest of the existing robotic system. For example, incorporating the robotic arm and EOAT together.

The Stow robot's EOAT after being built

OUR TEAM:

Our fourth step is to plan, design, and build the selected solution. We start by creating a CAD model, then planning out the necessary materials, lastly, we build the subsystem and integrate it into our robot.



Our first iteration drivetrain after being built

STEP 5: TESTING

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Amazon's fifth step is to test the constructed mechanism. This identifies problems that need to be resolved in the next iteration or validates the product is finalized.

For instance, regarding the EOAT, a previous design had "paddles and ... a plunger to push [items] in", but testing revealed the mechanism "was prone to error because not all items reacted to it in the same way" (O'Neill).

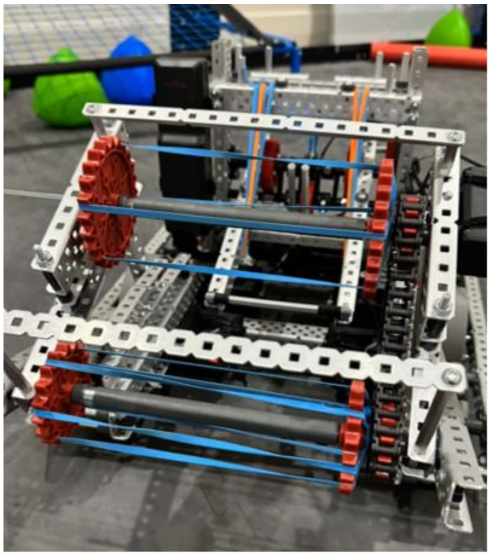
OUR TEAM:

Testing is crucial to the design process. We enlist the different conditions and strategies for our robot and enumerate through the scenarios to verify the robot works as hoped and decide what needs to be done in the next iteration.

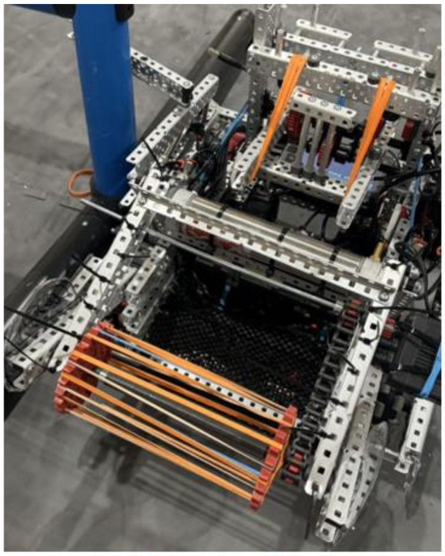
Testing Benchmark	Time (in seconds
Time Taken to Drive Over Long Barrier	2.01
Time Taken to Drive Across FIeld	5.13

An example of a testing result chart for one of our drivetrains

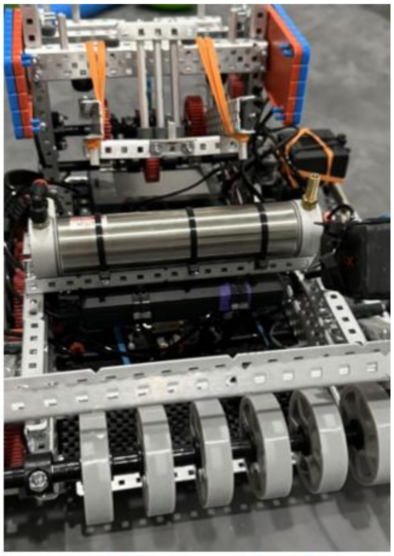
As mentioned, the design process is iterative, and the same process is applied in the next iteration for the new problem that's given. For instance, our current intake mechanism has gone through multiple iterations:



1st Iteration Intake
Two Rollers



2nd Iteration Intake
One Roller



3rd Iteration Intake
Flex Wheel Roller

CAREER PREPAREDNESS

Our design process is very similar to Amazon Robotics'. The training and practice in VRC familiarizes us with the processes utilized in the professional STEM field, preparing us for future experiences.

Furthermore, documentation is important in the STEM industries. Sydney mentioned that Amazon requires design proposals to be documented in a six-page narrative that's used for discussions and decisions. VEX also emphasizes documentation using an Engineering Notebook, a complete record of a team's design process.

Through working with teammates, participation in VRC improves collaboration/communication skills and teaches the appreciation of diversity. VRC also provides a platform to build a broader network with others who are passionate about robotics and STEM, which can be the basis for our professional network in the future. We are grateful that we have an opportunity to compete in the VEX Robotics Competition, which sufficiently prepares us for a future STEM career.

WORKS CITED

Ackerman, Evan. "Stowing Is a 'Beautiful Problem' That Amazon Is Solving With Robots." IEEESpectrum, 6 Jan. 2023, www.spectrum.ieee.org/amazon-warehouse-robots-2659064182.

Kaplan, Sydney, and Cassie Meeker. Amazon Robotics. Personal interview. 10 Jan. 2024.

O'Neill, Sean. "How Amazon Robotics researchers are solving a 'beautiful problem.'" AmazonScience, 15 Nov. 2022, www.amazon.science/latest-news/how-amazon-robotics-researchers-are-solving-a-beautiful-problem.