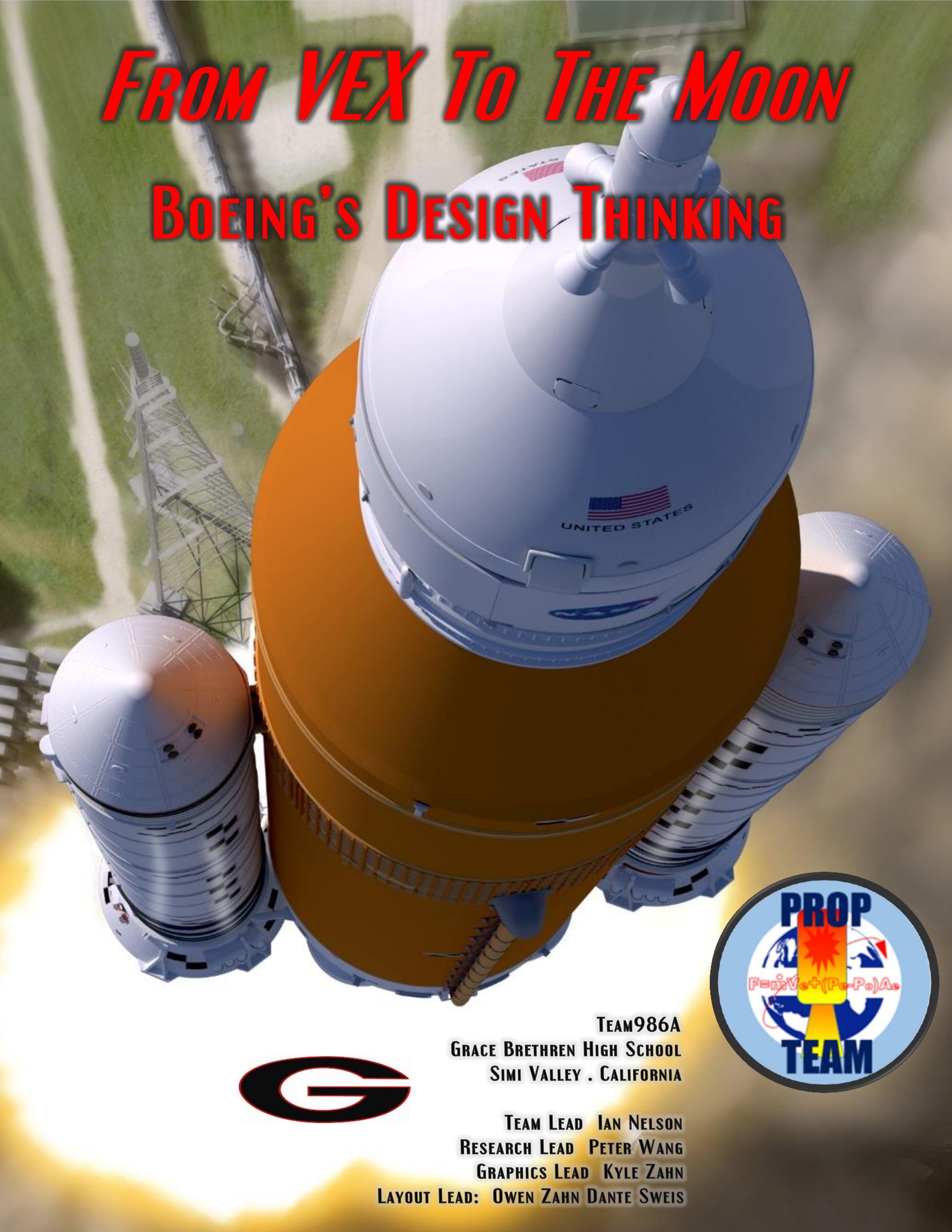
From VEX To The Moon

Boeing's Design Thinking



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Why Boeing?

Boeing is known for being the leader in the commercial aircraft manufacturing industry, as well as an innovator in military satellites, defense systems, key engineering support for the International Space Station, and robotics exploration of our solar system. It was originally founded by William E. Boeing, a timber executive, in 1916, and the company was first known as the Aero Products Company. Currently, one of Boeing's significant space contributions is building the core stage of Artemis and working on landing the first woman on the moon.

Our 7th grade science teacher, Jana Lovell, shared many stories about her brother's career as a Senior Engineering Manager for Boeing in Huntsville, Alabama. A lead engineer in Boeing's Rocket Propulsion Team, Mr. Joel Bridges worked on one of the most powerful rockets in history: Artemis. Because robotics has inspired our interest in STEM careers, we were elated when offered by Ms. Lovell for the once-of-a-lifetime interview with Mr. Bridges. Hoping on this amazing offer, we learned Boeing's Engineering Design Process called "Design Thinking" and its implementation within facets of engineering from Mr. Bridges.

Boeing has supported our school's Robotics program by providing grants to employees who volunteer at least 25 hours as STEM mentors. Our mentor Mr. Bill earned us this precious grant.

Resources

An interview with Mr. Joel Bridges was our primary source. He is a Senior Engineering Manager for the Rocket Propulsion Engineering Team at Boeing Huntsville, Alabama. Another source was Boeing's Technical Journal on Lean by Design: The Synthesis of Lean and Design Thinking

Figure 1. Team986A with Rocket Engineer Mr. Joel Bridges

THE ENGINEERING DESIGN PROCESSES (EDP)

The Engineering Design Process (EDP) is a systematic problem solving strategy to determine the best possible solution to a problem, acting as a guide for efficient project development. Boeing's engineering design process "Design Thinking" is similar to our team's Design Process. While they focus on users challenges, we focus on our driver's challenges. As seen in Figure 2, Boeing's Design Thinking has six phases and our EDP has seven but both have a very similar function and process, each being an iterative process with the ability to return to the previous phases.

BOEING DESIGN THINKING VS. TEAM 986A DESIGN PROCESS

Figure 2. Boeing's Design Thinking (left) vs Team 986A Engineering Design Process (right)

Phase 1: Empathize

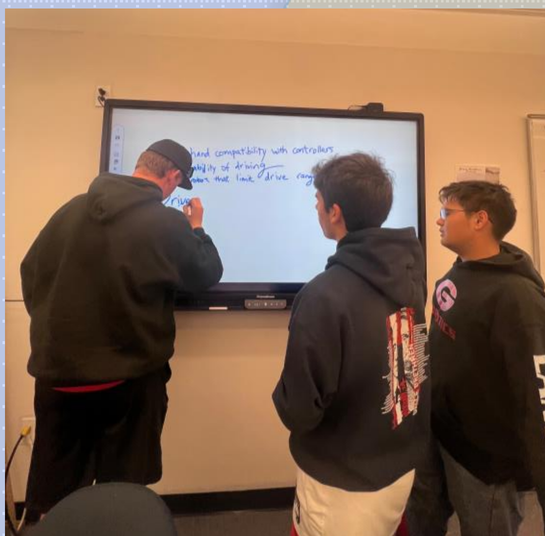

Figure 3. Team 986A discussing user compatibility of robots

Figure 4. Interaction with user feelings

Boeing's teams start with the Emphatize Phase, which focuses on interacting with their "users" to have an understanding of the subject and their challenges.

Team 986A's "user" is the robot driver. We take inputs from drivers in order to take operation challenges into consideration in later stages of the Design Process, such as during designing, building, and testing. We place ourselves into the shoes of the users before beginning a project.

Phase 2: Define

Having obtained the users challenges, the Define Phase allows Boeing engineers to examine and define the needs of the users, project requirements, implementation limits, with a focus on efficiency, resources, and time.

For our team, we create a Design Brief to understand design requirements, criteria, and constraints.

In both scenarios, specifications with detailed data are given to be followed.

Figure 5. Team 986A measuring the game field element dimensions

Figure 6. Boeing need to define spacecraft requirements based on space environments

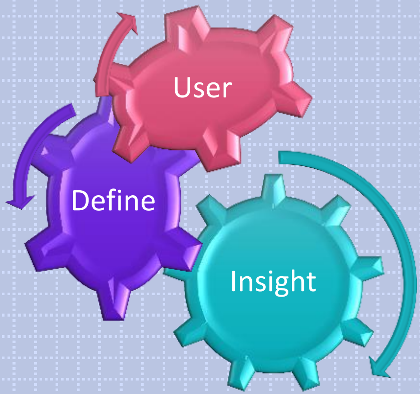

Figure 7. Relationships between User, Define, and Insight

Phase 3: Ideate

Multifaceted engineers convene for specific projects; they share lessons learned and find unique solutions. Boeing develops multiple detailed projects simultaneously to allow differing ideas to be generated. Multiple potential projects and solutions are discussed.

Similar to our Generate and Develop Phase, we brainstorm solutions and use a Decision Matrix to compare solutions based on criteria to find an optimal design. We design using technical drawings, list detailed construction steps, and material lists.

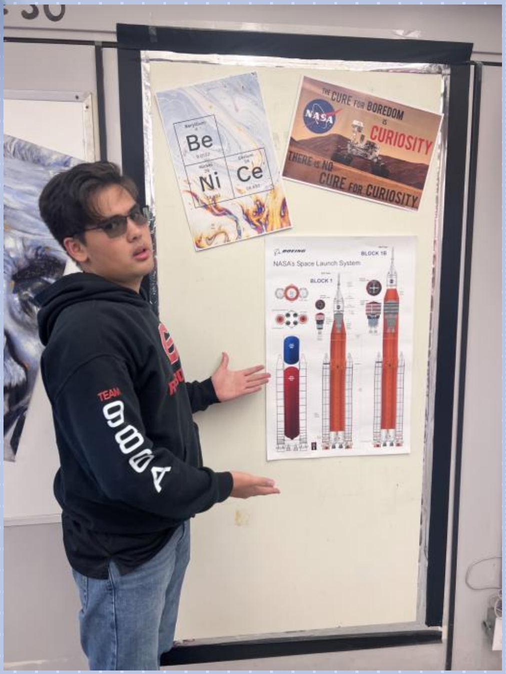

Figure 8. Artemis Rocket core stage sketch

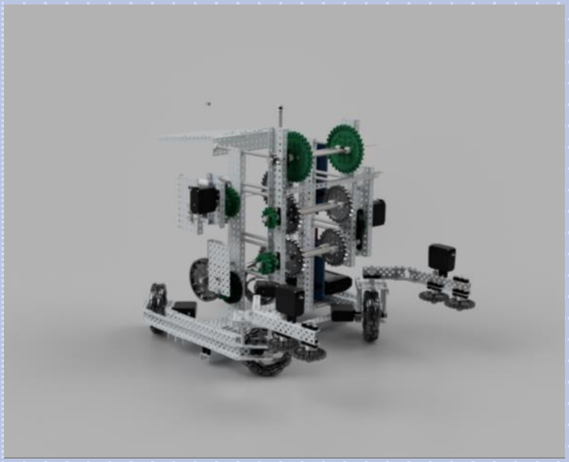

Figure 9. Team 986A rendered robot CAD model

PHASE 4: PROTOTYPE

Figure 10. Boeing prototype

Figure 11. Building Prototype

A prototype is an early sample of a product built to test a concept.

During the prototype phase, Boeing constructs a sample of all prospective ideas to evaluate the best solution to address the user's challenge.

We build a robot from CAD specifications to evaluate the proposed design. If deemed infeasible in later testing, we will track back to an earlier process of the iterative design process and design other prospective ideas.

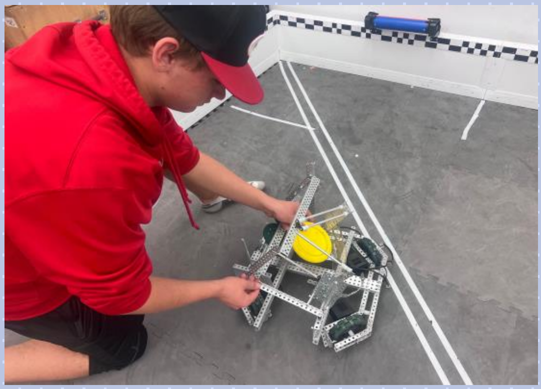

Figure 12. Owen with the prototype

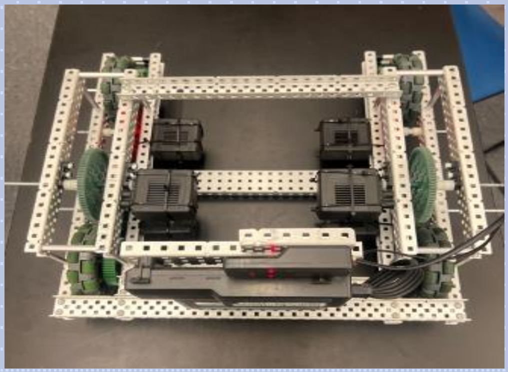

Figure 13. Base prototype

PHASE 5: TEST

Boeing team prepares the product for testing. Boeing conducts integration testing, a process that tests interfaces between modules and report defects that may come up. Modules are tested independently before integration testing is done. The team tests the realistic conditions under which it will perform.

Figure 14. Ian and Owen testing robot catapult

In our test phase, the programmer tests each subsystem – the base, intake, flywheel. When subsystems are integrated, more complex test scenarios are created and executed to detect errors related to the interface.

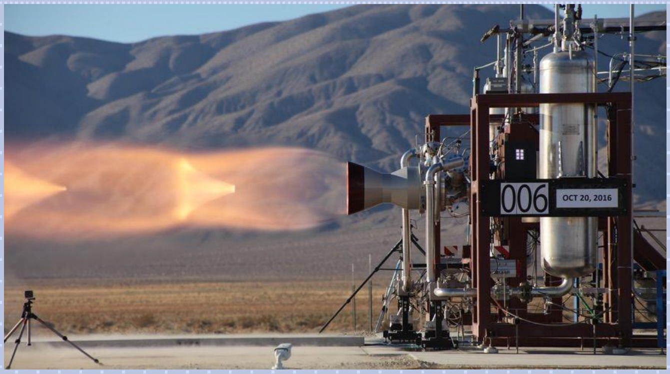

Figure 15. Aborted Boeing engine test

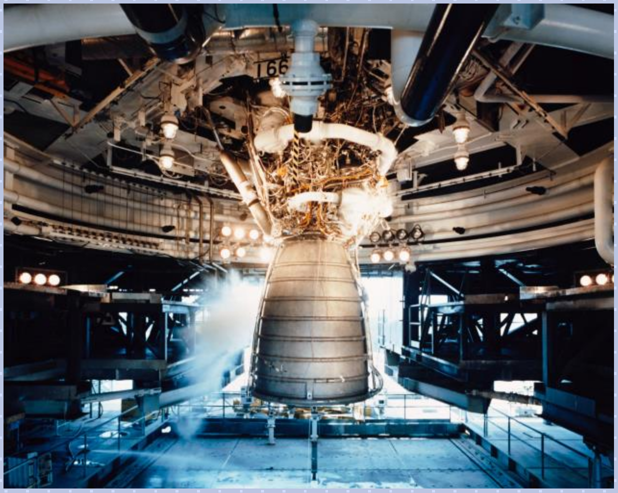

Figure 16. Boeing space shuttle main engine test

Phase 6: Implementation

Implementation is the proof and action of concept in reality.

Figure 17. Artemis Launch

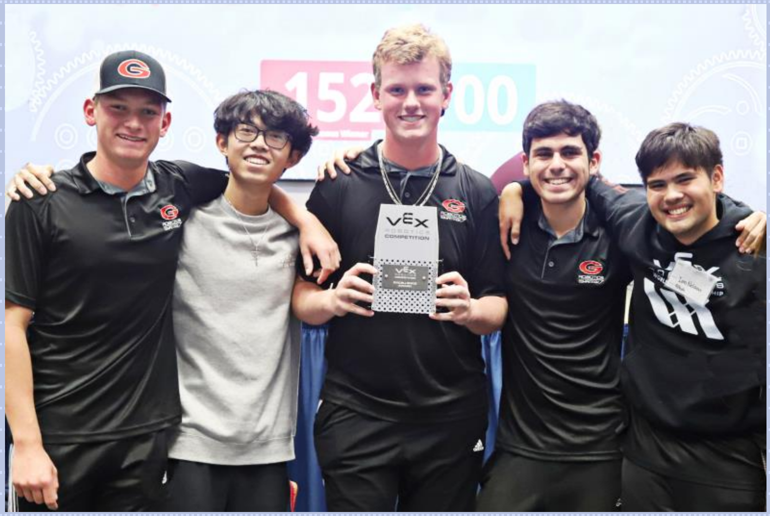

Figure 18. Team 986A successful implementation of robot: received Excellence Award

VEX Building Future Careers

Participation in VEX Robotics engages students in STEM. All of our team members have taken advanced courses in Computer Engineering, Principles of Engineering, Robotics, and Aerospace Engineering.

Within Robotics, we conceptualize, brainstorm, research and collaborate. This helps student prepare for project planning, information analysis, task management, and effective communication in many future careers. Through alliance collaboration and sharing information with judges, VEX Robotics Competitions offer students unique opportunities to develop socialization, communication, and presentation skills.

Perhaps one day, through a culmination of experiences and skills, VEX students will reach for the moon.

Work Cited

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