



# ***BOEING***

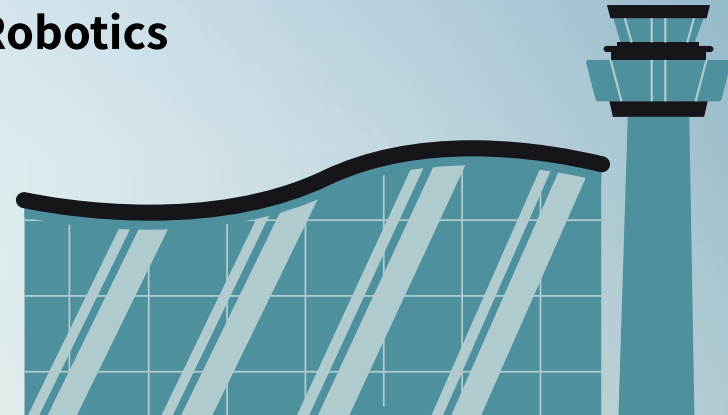
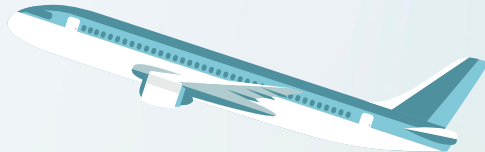
## **A Glimpse into Aerospace Design**

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# **LIMITLESS**

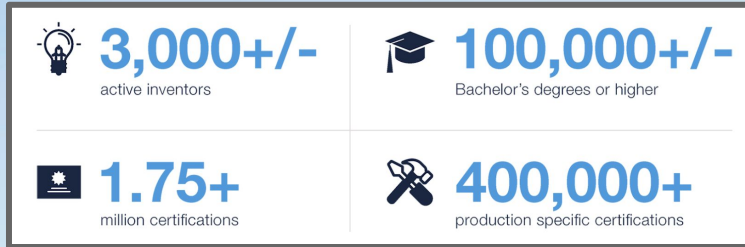
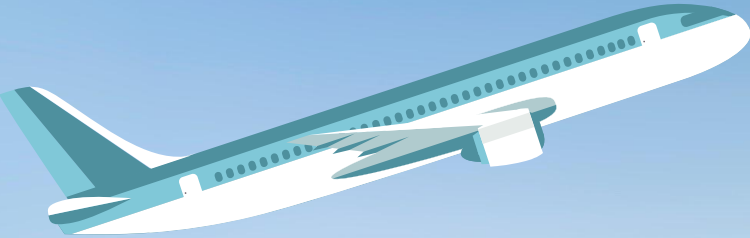


# Why Boeing?



For decades, Boeing has been one of the world's largest aerospace companies. They focus on creating more **efficient and commercially functional** airplanes and designing and improving military defense systems. As a major manufacturing company, Boeing relies heavily on the engineering design process to **produce its products**.

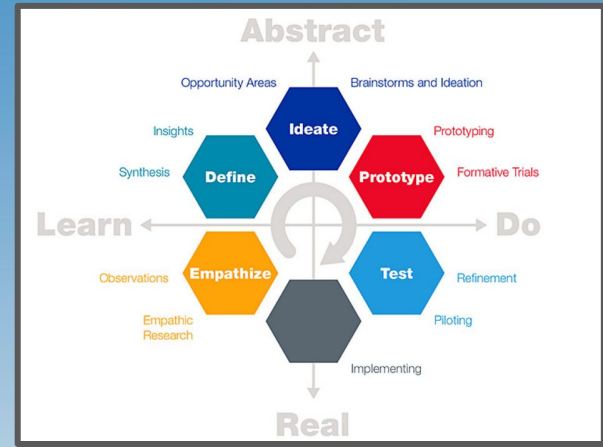
When speaking about the need for STEM focused employees, Boeing CEO Calhoun Bullish said "This industry is fighting every other industry to get STEM talent --- that fight's forever," Calhoun said. "Raytheon, Northrop (Grumman), Boeing, Airbus -- we're all hunting for it." (*Design*, n.d.) The **engineering design process is rooted deep** within the VEX Robotics Competition (VRC) and as a result, VRC produces the **exact STEM talent** that Boeing is looking for. Given how prominent the engineering design process is in VEX, we wanted to learn more about Boeing so we could streamline our own team.



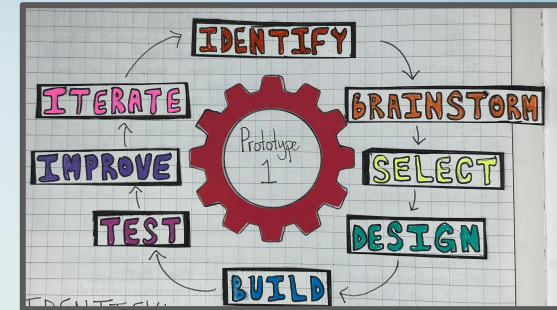
**Figure 1:** The statistics of Employee's education and certifications at Boeing.

# The Engineering Design Process

The Engineering Design Process (EDP) is a systematic approach to solving problems and **creating new and improved products or systems**. The EDP steps include problem solving processes like determining your objectives and constraints, prototyping, testing, and evaluation. (TWI, n.d) **Boeing has a 5 step Design Thinking Method** to create deliverables. The 5 steps are: Define, Ideate, Prototype, Test, Empathize. (Fig. 2) (*Design Process*, 2018) Our VRC design cycle (Fig. 3) is **very similar**. It contains the most important points of defining the issue, developing solutions, and optimizing prototypes.



**Figure 2:** The 5 Step Boeing *Design Thinking Process*



**Figure 3:** Our 8 Step Engineering Design Cycle

# Step 1: Define



At Boeing, the EDP begins with the **identification and definition** of a problem or opportunity for improvement. This could be in response to customer needs, **industry trends**, or internal goals. For example, an airline might request a more fuel efficient aircraft, or the company might decide to develop a new type of propulsion system. (*Business Strategy, 2021*)

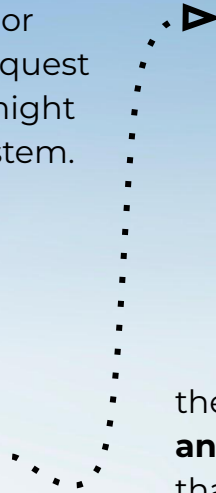


**Figure 4:** A 2022 Boeing Investor Conference.



**Figure 5:** Vedad Mahmulyin, a Boeing engineer who saved millions of dollars by identifying ways to save money.

In VRC, we begin the process by determining the game's challenge. With Spin Up, we did **game analysis** and determined that we needed a robot that could score high goal discs and could do rollers and endgame. **As the season goes on**, our robot eventually needs to be able to score the autonomous win point and have overfilling capabilities.



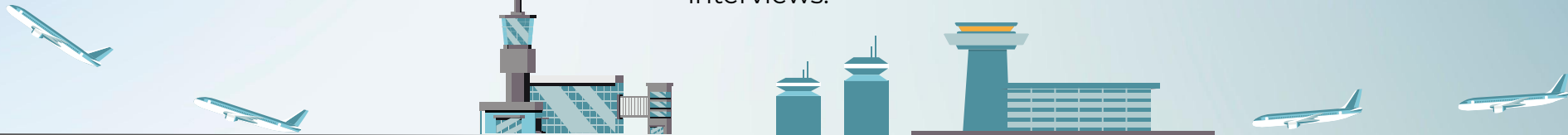
# Step 2: Ideate



**Figure 6:** A Boeing IT team working as a group.

After identification, the design team comes up with **ideas and solutions** on how to efficiently solve the problem. *Business Chronicle* describes how Boeing uses a business strategy of **Research and Development (R&D)**, which is where they scope out competitors to see what other technology and solutions are on the market. Facing fierce market competition, Boeing uses **product differentiation**, making them stand out from competitors so they seem more appealing to consumers. (Business Strategy, 2021)

In VRC, we regularly have to come up with solutions that are as **elegant and waste-free** as possible. Fast autonomous, sleek build, and reliable subsystems that function well without being overly designed are necessary. **Similar to Boeing**, we evaluate our designs against those of our competitors to make sure we stand out during judging interviews.



# Step 3: Prototype

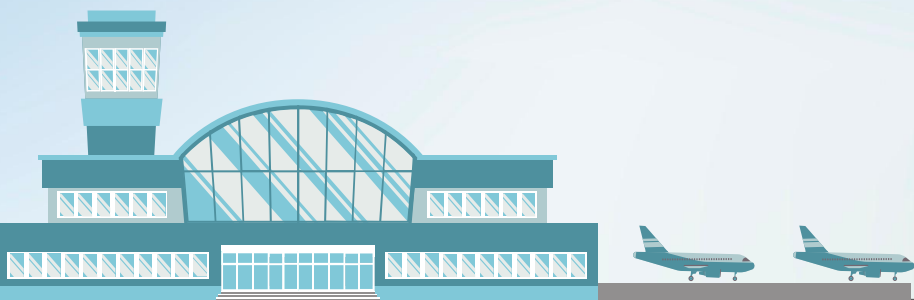
The selected solution is then prototyped to ensure it performs as expected. In addition to selecting and building a prototype, **Boeing needs to sell the prototype** to the customer. When talking about the importance of a model, chief engineer Perry Ziegenbein said “A picture is worth a thousand words, a flying model is worth a million words” (*Rapid Prototyping*, n.d). In VRC, prototypes are our main deliverables for tournaments. We make sure our **delivered robot is capable** of reaching the metrics that are needed to succeed and win the game.



**Figure 7:** Boeing 747 Prototype.  
(Museum of Flight)



**Figure 8:** Our final worlds-bound robot  
in the 2021 - 2022 VRC season.



# Step 4: Test

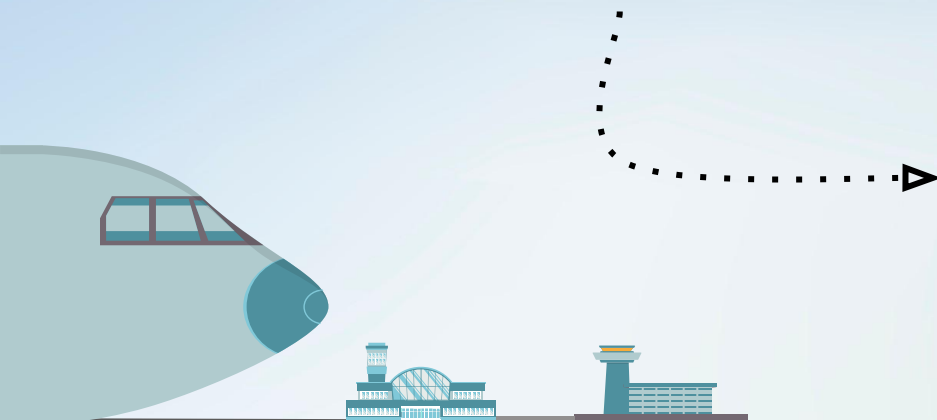


The testing process is **extremely important** to Boeing engineers as millions of people use their deliverables. Testing may involve building a **physical prototype** and conducting a series of tests, or creating a virtual model and running simulations. Boeing airplane models **undergo laboratory testing** throughout development to simulate and collect data(*Boeing Tests*, 2022).



**Figure 9:** Boeing's self flying car after a successful flight test.

In VRC, we test our robot under competition conditions so we can see how it will perform in an actual tournament. **We test scoring capabilities, durability, and speed** to see if the robot subsystems can perform as needed.



# Step 5: Empathize



Object Manipulator	Robustness	Reliability	Ease of Use	Scope	Build Difficulty	Total
Active Grip	3	4	5	4	3	19
Hook	3	2	2	3	3	13
Moby Forklift	3	3	5	3	4	18
Passive Lift	4	3	4	2	5	18

Winner: Active Grip

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**Figure 10:** Our claw Decision Matrix to decide what clamp to use last season.

Empathizing is a key factor in Boeing's success and allows it to continuously **innovate and improve** its products and systems. **Test results** determine if the prototype needs to be modified or not. Once the design is finalized, it is implemented in the production process and the **finished product** is delivered to the customer.

In VRC, this is when we work as a team to decide whether or not we want to keep our prototype or move on. We **analyze the testing data** and pick out the **flaws** and strengths of the deliverable, and we come up with new problems to solve.





# Career Preparation



Thanks to VRC, thousands of teams have been fully prepared for careers in STEM. As a manufacturing company, Boeing needs people who have **knowledge and experience** with designing and creating prototypes. VRC teaches **field related skills** like working with tools and machinery, using the EDP, and writing code. These students leave VRC with a foundation of technical knowledge required to **pursue a career in engineering**.



**Figure 11:** Our team next to our final prototypes after the entire EDP.

In addition to technical experience, VEX also **builds workplace and communication skills**. It is commonplace for students to practice project management, improve teamwork skills, and learn how to professionally interview. In addition to the standard EDP, Boeing famously uses the Lean process (*Lean*, 2022), which is a style of design that focuses on eliminating waste for the consumer by emphasizing simplicity and usability.

Our team uses Lean in the form of Agile Project Management which is an iterative approach to creating prototypes. This is shown whenever we do **scrumming or rapid iteration cycles**. Our team frequently uses teamwork skills to make sure all members are on the same page during the EDP. We prepare ourselves for future job interviews every time we do judged interviews at competitions. **Through VRC, we learn about incredible practices and skills that prepare us for future STEM careers.**



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