ND FTC Engineering Day

Dakota
First Tech Challenge

DECODE™
PRESENTED BY RTX

About Me

- **B.S. in Mechanical Engineering from NDSU**
- **Design Engineer at Bobcat Co.**
  - **Mini Track Loader and Small Articulating Loader Sustaining**
    - Take problems and develop solutions to ongoing field issues
    - Validate new sourced components
    - Revise design for efficiency, customer improvement, and cost-savings activities
    - Some attachment sustainment (snowblowers and landscape rakes)
- **Involved in FIRST Tech Challenge for 10 years**
  - **Member of 9707 (2015-2019)**
  - **Mentor of 17758 (2020-2022)**
  - **Mentor of 20680 (2021-2022)**
  - **Mentor of 9707 (2023-Present)**

Why does what I say mean something?

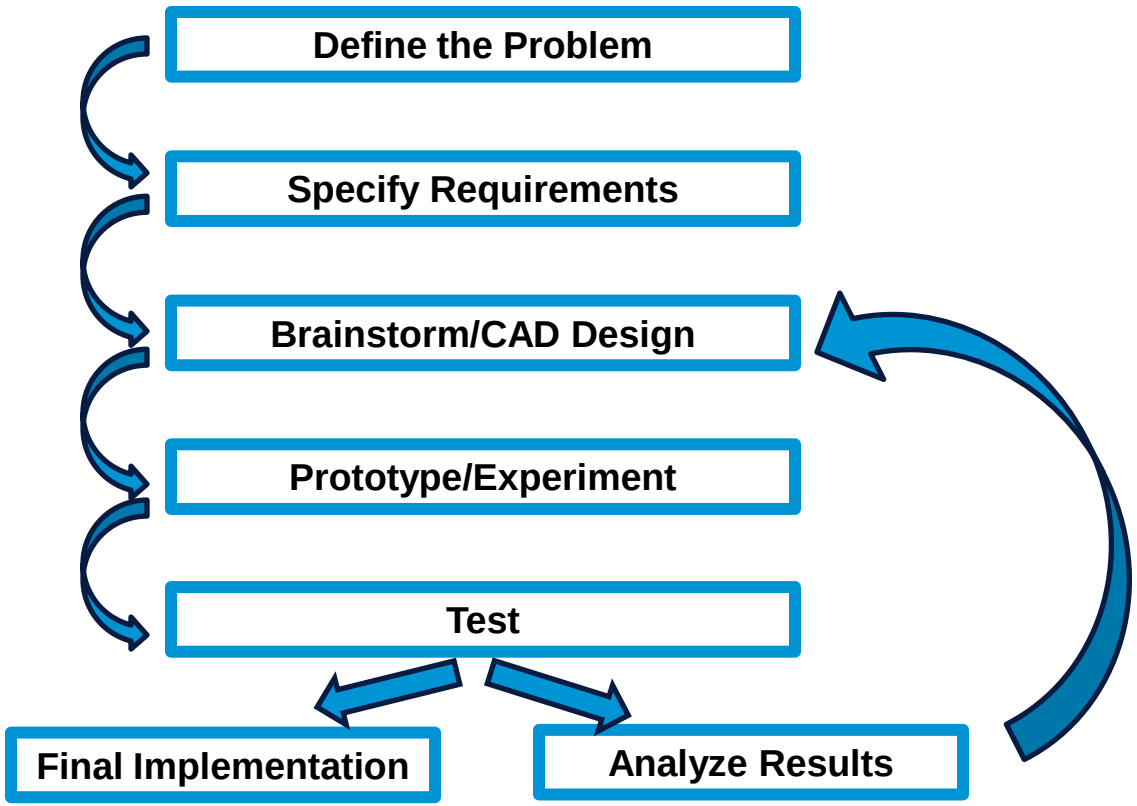
As a Mentor:

- **Judges' Award (x2)**
- **Finalist Alliance (x1)**
- **Innovate Award**
- **Winning Alliance (x4)**
- **Motivate Award**
- **Think Award**
- **Control Award (x3)**
- **Multitude of 2nds and 3rds in various awards**

As a Student:

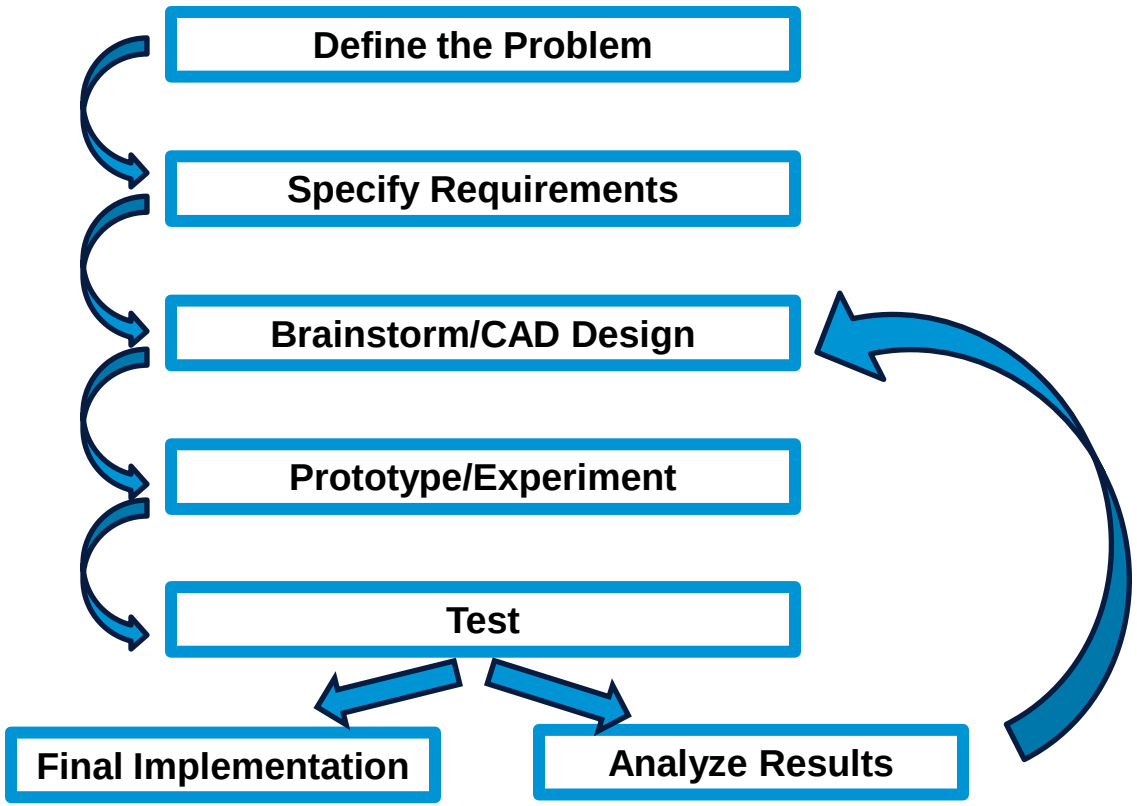
- **Winning Alliance Captain**
  - Advanced to Midwest Super Regionals with 5250
- **Design Award (x2)**
- **Innovate Award**

Engineering Design Process



- Define the problem: What are you trying to solve? What is the timeline?
- Specify requirements: What are the necessities for your proposed solution?
- Brainstorm/CAD Design: Draw or sketch a prototype on paper or in CAD.
- Prototype/Experiment: Put a first design together using physical materials.
- Test: Ensure you thoroughly test every part of your prototype to detect flaws.
- Analyze results: Examine what you learned from your tests to iterate successively.
- Final implementation: Polish and solidify a final design that won't change.

Engineering Design Process

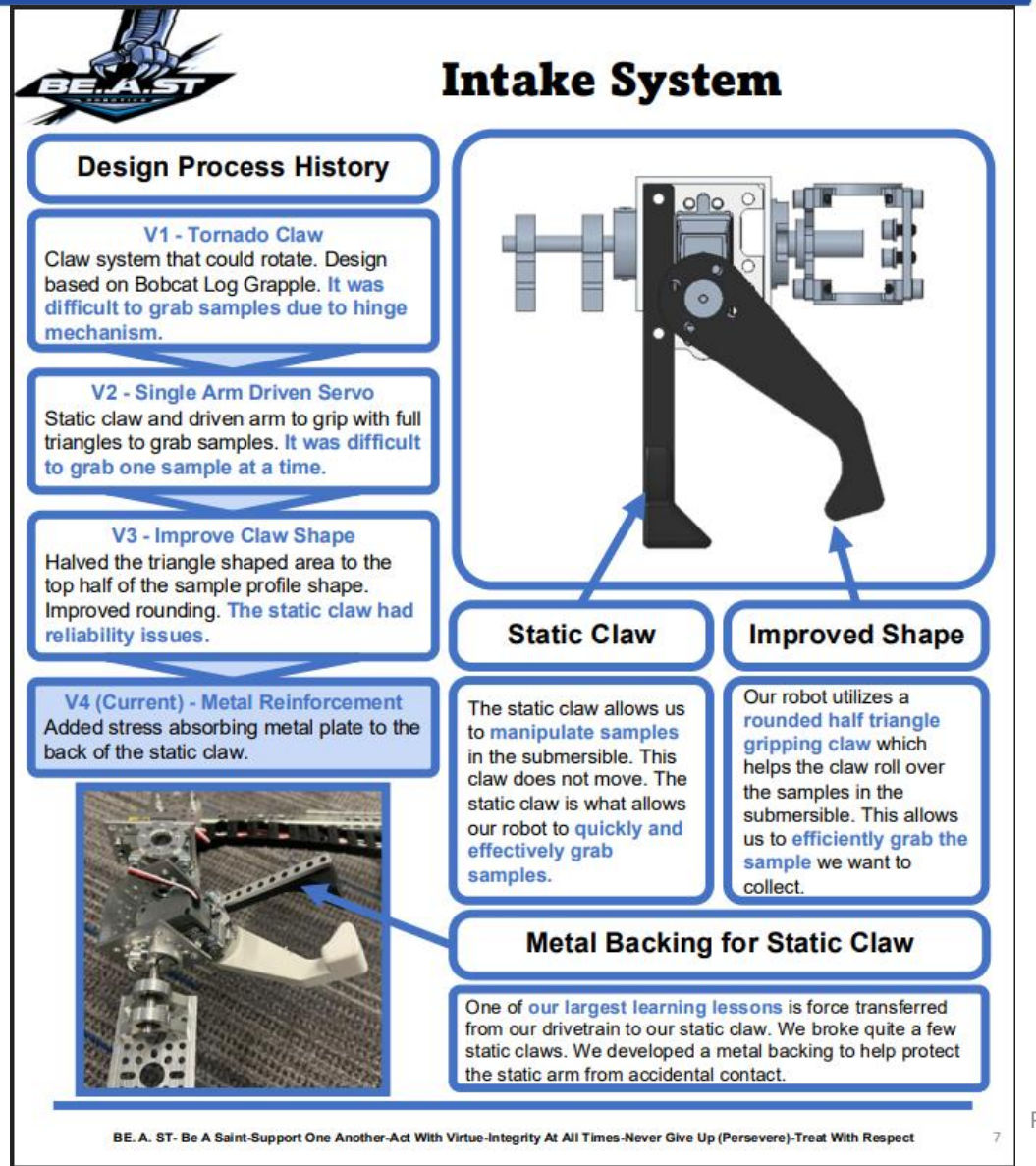


Think Award Criteria		
Required	1	Team must submit a PORTFOLIO. The PORTFOLIO must include engineering content which includes at least one of the following: A. evidence of use of the engineering process B. lessons learned and implemented related to the design of their ROBOT, C. trade off analysis /cost benefit analysis, and/or D. mathematical analysis used to make design decisions.
Encouraged	2	Team PORTFOLIO may include information about resources which includes any number of the following examples: A. how the team learns from team mentors, and/or a development plan for team members to learn new skills, B. how the team recruited new people into *FIRST,* and/or C. how the team identified goals and tracked progress towards their goals throughout the season.
Encouraged	3	PORTFOLIO information is organized in a clear and intuitive manner

Control Award Criteria		
Required	1	Team must submit a PORTFOLIO. The PORTFOLIO must include all of the following: A. hardware and/or software control COMPONENTS on the ROBOT, B. which challenges each COMPONENT or system is intended to solve, and C. how does each COMPONENT or system work.
Required	2	Team must use one or more hardware or software solutions to improve ROBOT functionality by using external feedback and control.
Encouraged	3	The control solution(s) should work consistently during most MATCHES.
Encouraged	4	Team could discuss, describe, display, or document how the solution may consider reliability either through demonstrated effectiveness or identification of how the solution could be improved
Encouraged	5	Use of the engineering process to develop the control solutions (sensors, hardware and/or algorithms) used on the ROBOT includes lessons learned.

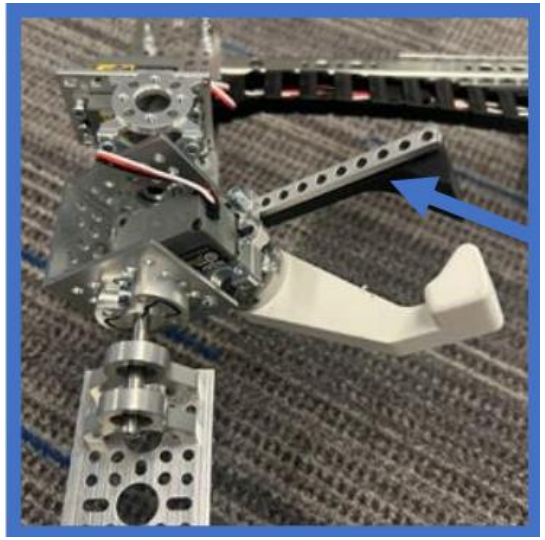
Example: FTC 9707 2024/25 Intake Claw

- Define the problem:
  - Pick up rectangular prisms with triangle cutouts out of the submersible and move to transfer mechanism
- Specify requirements:
  - Servo driven to reduce weight
  - Ability to rotate up and down to get to transfer
  - Efficient grab force – speed or torque servo
  - Mostly COTS for easier implementation (GoBilda)
  - 3d printable claw with minimal support structure to produce enough spares with minimal material usage
  - Easily serviceable to replace parts as needed
  - Rotates to pickup various angled samples
- Brainstorm/CAD Design: Draw or sketch a prototype on paper or in CAD.
  - Pick and place robot
  - Skid steer grapples
  - Claw machine
  - Scissors
  - Snowball maker
  - Excavator thumb
  - Vice / Clamp
  - Fractal clamp
  - Human hand
  - Rock Picker by TerraClear
  - Reach extender
  - Combine Harvester



Example: FTC 9707 2024/25 Intake Claw

- Prototype/Experiment:
  - First image is a rough prototype of a claw that rotates and picks up.
  - Bottom image – ND Championship Intake Claw
- Test: Ensure you thoroughly test every part of your prototype to detect flaws.
  - Developed test plan – record cycle times of robot
    - How long to grab from submersible?
    - How long to transfer? Is it consistent?
    - Durability? Clip on submersible to simulate fast grabbing
    - Can the sample shift in the claw causing issues with transfer?
- Analyze results:
  - First Claw – Slow, lacked grip strength, transfer was inconsistent
  - Second Claw – Removed degree of freedom – hard to grab just one sample
  - Third Claw – faster and easy to pick out samples. Reliability issues broke ~5 claws/hr
  - Final claw – Metal backing prevented claws breaking, issue with overall speed (too much manipulation allowed), took time to move into place
  - Proposed improvements not implemented – dual axis claw (more grip) increase servos to super speed servos, better radial load protection, make active intake like combine harvester
- Final implementation: Polish and solidify a final design that won't change.



Design Process History

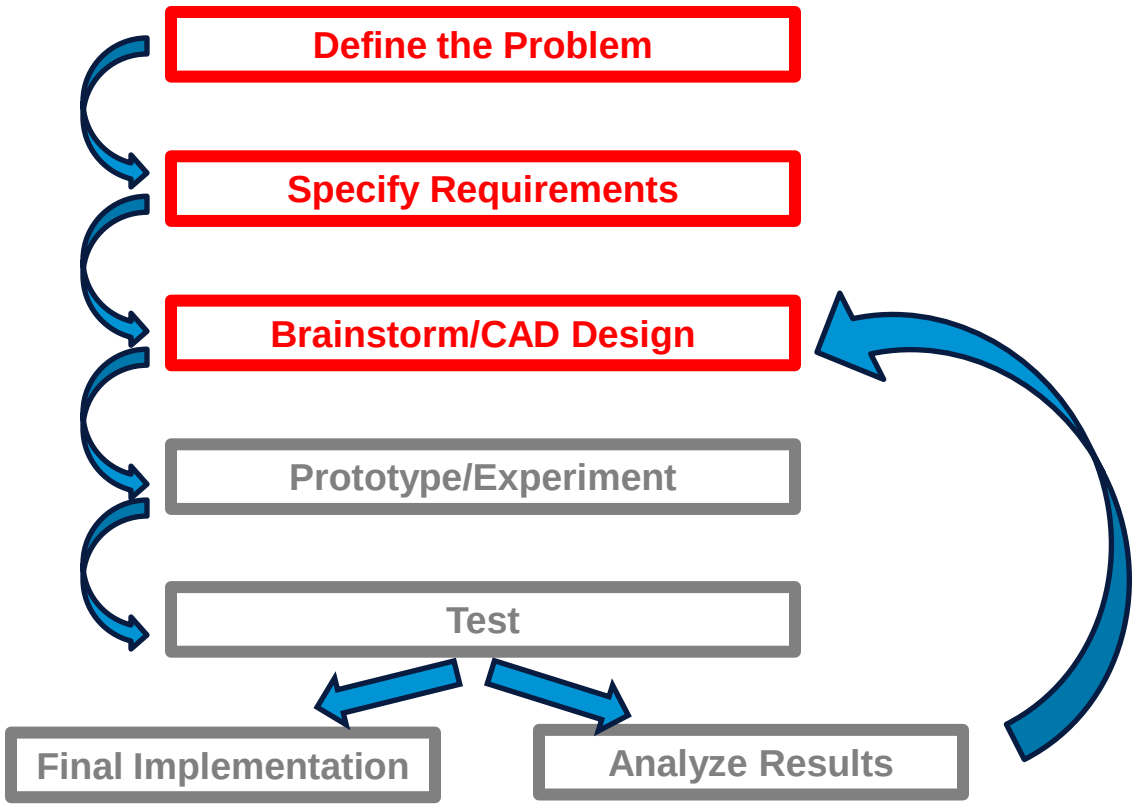
V1 - Tornado Claw
Claw system that could rotate. Design based on Bobcat Log Grapple. **It was difficult to grab samples due to hinge mechanism.**

V2 - Single Arm Driven Servo
Static claw and driven arm to grip with full triangles to grab samples. **It was difficult to grab one sample at a time.**

V3 - Improve Claw Shape
Halved the triangle shaped area to the top half of the sample profile shape. Improved rounding. **The static claw had reliability issues.**

V4 (Current) - Metal Reinforcement
Added stress absorbing metal plate to the back of the static claw.

Engineering Design Process - 2025/26 Game Challenge (Launching)



- Define the problem: What are we trying to accomplish?
  - Move spherical objects from floor/human player area to deposit area
  - Completed by January 2026
- Specify requirements:
  - Spherical objects: 5-inch diameter
  - Height: 38.5 inches
  - Distance: up to 15 feet away
  - Size constraint: 18 x 18 x 18 inches
  - Electronic constraints: no more than 2 motors and 2 servos
  - Etc
- Brainstorm: Think of real-world examples. Remember "we don't need to reinvent the wheel"
  - Snowblowers
  - Basketball Rebounders
  - Baseball Pitching Machines
  - Catapults / Slingshots / Trebuchets
  - Dog tennis ball thrower

Resource Library

Official FTC Resources

- First Tech Challenge Season Materials
- First Tech Challenge Documentation
- First Tech Challenge QnA
- FTC BC Workshops
- FTC Sim
- FIRST Tech Challenge YouTube

CAD / CAD Tutorials

- Onshape CAD for Robotics Competitions
- Onshape Education Account
- Pulley Generator (HTD3 and HTD5)
- Autodesk Education Account

Mechanism Libraries

- Unofficial FRC Mechanism Encyclopedia
- FRC Designs
- 8644 Brainstormers Tips&Tricks

Events and Scouting

- FTC Scout
- The Orange Alliance

Calculators

- JuliaDesignCalc
- ReCalc
- Thad's Every Calc

Programming

- Learn Java for FTC
- 9794 Wizards.exe Spell Books
- Block Programming Ref Manual

Biblical Level Resources

- Game Manual Zero
- Brogan M Pratt
- Engineering Portfolio Library

Vendors

- Vendor List
- GoBilda (25% FTC Team Discount)
- Metal (Bismarck)
- Metal (Fargo)