To Predict ▶ To Design ▶ To Perform

College of Engineering
Department of Mechanical & Industrial Engineering

ME, ECE, BE Capstone Design Programs

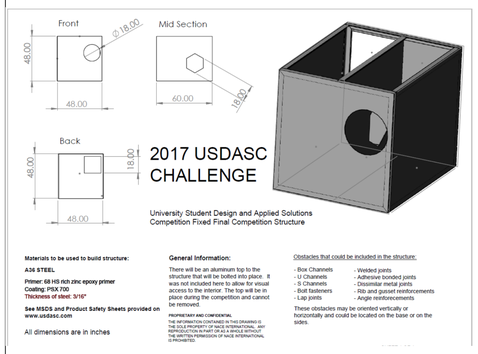
Team #30: University Student Design & Applied Solutions Competition

Andrew LeBlanc (ME), Rachael Doyle (ME), Marlou de Guzman (EE)

NACE INTERNATIONAL

Competition Background

- Develop a system for corrosion inspection in difficult-to-access areas
- Involves written, oral, and application testing of design concept
- Application test structure is a 5’ x 4’ x 4’ structural steel container
  - 3/16” steel panels composing container
  - Circular and square entry openings
  - Pentagonal opening between compartments

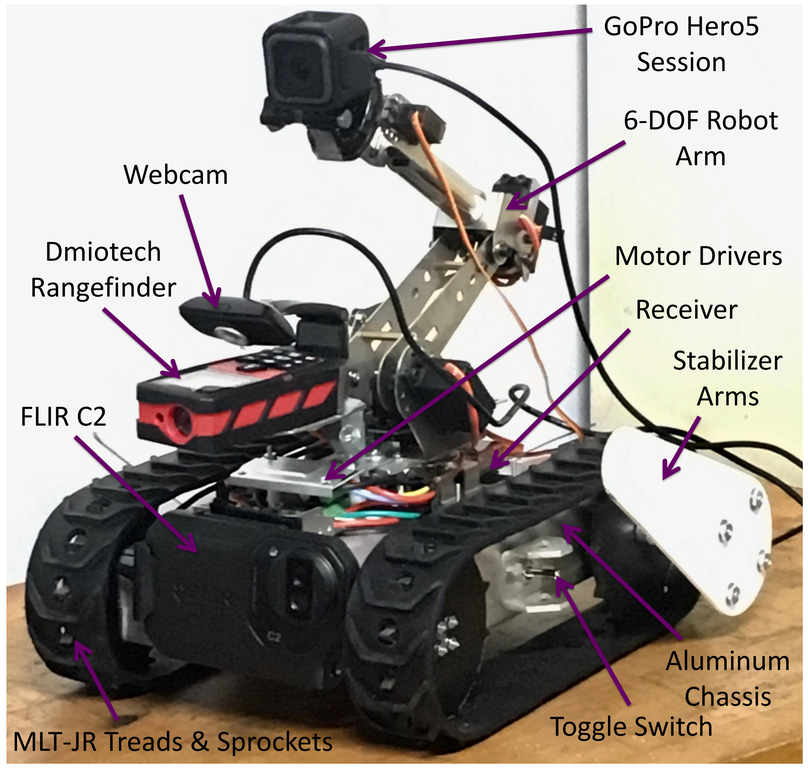


Project Objectives

- Inspect, identify, and quantify corrosion related defects within fixed structure
- Move through structure without human touch
  - May be placed inside and retrieved after inspection
- Equipped with versatile mode of communicating information to operator
- Succinctly report the size, location, and type of corrosion
  - Presence of water or other liquid
  - Presence of surface corrosion
  - Extent of coating degradation
- Report should be in an easily usable format for judges and operators

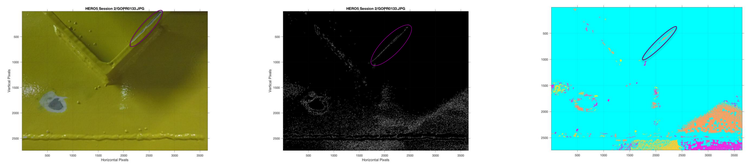
Engineering Specifications

Specification	Target	Actual
Weight (lb.)	≤ 10	9.50
Size (ft.^{3})	≤ 1	0.60
Clearance (in.)	≥ 1	1
Detection Radius (in.)	≥ 24” & below	18
Carrying Capacity (lb.)	≥ 10	10
Operating Voltage	≤ 24	24
Detection Time (min.)	≤ 45	45
Compilation Time (min.)	≤ 15	15
Water Detection Efficiency	≥ 70%	Based on Competition Results
Surface Detection Efficiency	≥ 60%	Based on Competition Results
Coating Detection Efficiency	≥ 70%	Based on Competition Results
Cost	≤ $5,000	$3,228.61
Location Accuracy	≤ 1 in.^{2}	Based on Competition Results
Size Accuracy	≤ 3 mm	Based on Competition Results



Testing Results

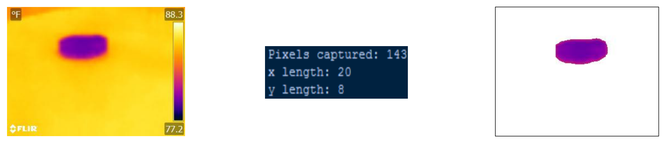
GoPro Data Acquisition



Initial Image | Edge Detection from Binary Image | Label Matrix

Object: Pixel Sizing: 63.754 mm x 6.35 mm Actual Sizing: 63.50 mm x 4.763 mm Error: 0.254 mm x 1.588 mm
Defect Location: 46.203 mm x 180.47 mm Actual Location: 47.625 mm x 177.80 mm Error: 1.422 mm x 2.67 mm

FLIR Data Acquisition



Initial Image | Pixel Data | Removal of Defect from Image

Object: Pixel Sizing: 26.289 mm x 24.737 mm Actual Sizing: 25.4 mm x 25.4 mm Error: 0.889 mm x 0.663 mm
Actual Location from Laser Device: 533.4 mm x 304.8 mm on ground surface

Inspection Process

Operators trigger cameras → Cameras take images → Images transported to computer → Processing code identifies corrosion → Similar code quantifies pixel data of defects → Usable data transported to Excel spreadsheet → Necessary data moved to submission document → Submit document to judges

Safety

- Control current and power flowing from battery sources
  - Implemented fuses and toggle switch to prevent hazards
- Implementation of Li-Po battery sources within system
  - Kept batteries in heat resistant bags while charging
- Constructed for nondestructive inspection to eliminate operational dangers
  - Reduced operating speed of robot arm and stabilizer arms
  - Implemented image inspection devices
  - Enhanced acceleration control for navigation

Timeline

Project Scope

- Project Identification 9/1 – 9/13
- Project Development 9/13 – 9/20
- Function Definition 9/20 – 10/1
- Objective Definition 10/1 – 10/8

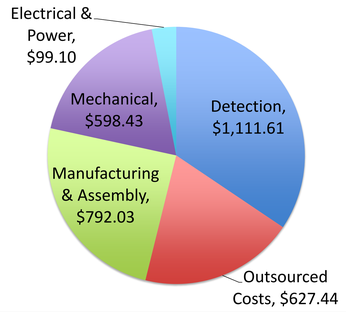
Embodiment

- Concept Generation 10/8 – 11/8
- Engineering Analysis 10/15 – 11/15
- Modeling & Simulation 10/22 – 11/22

Prototype Assembly

- Assembly Planning 11/15 – 11/29
- Procurement 12/1 – 1/31
- Manufacturing 2/1 – 3/15
- Assembly 3/15 – 3/29
- Testing 3/29 – 4/17
- Competition Simulation 4/17 – 4/23

Budget



Sponsors: Kim Ray, NACE International, Jack Rettig

Advisors: Dr. Gerald Knapp, Dr. Marcio de Queiroz