Design of a Multi-Functional Mobile Robot

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Competition Overview

- ▶ Five Events
  - ▶ The Sprint
    - ▶ Timed event
    - ▶ Must touch a wall 10 meters away
    - ▶ Must cross starting and finish line
  - ▶ The Climb
    - ▶ Timed event
    - ▶ Three stairs
      - ▶ Between 8cm and 15cm in height per step
      - ▶ 50 cm x 50 cm landing per step

Competition Overview

▶ Five Events - Continued

  ▶ The Tennis Ball Throw

    ▶ Scored by distance thrown along an axis

    ▶ Ball can be placed on the device

    ▶ Scored from where the ball stops

  ▶ The Golf Hit

    ▶ Scored by distance, and proximity to target axis

      ▶ *Score = Distance Along Target Axis − Distance From Axis*

    ▶ Ball may be elevated 0.2 cm from the ground

    ▶ Scored from the first bounce

Competition Overview

- ▶ Five Events - Continued
  - ▶ The Lift
    - ▶ Lift a weight as high as possible and hold it for three seconds
    - ▶ Scoring formula:
      - ▶ $Score = Mass\ of\ Weight(kg) * Distance\ Lifted\ (cm)$
    - ▶ Heavy weight lifted a small height
    - ▶ Light weight lifted very high
- ▶ Overall Score
  - ▶ Sum of ranks from all events
  - ▶ Lowest score wins

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Competition Constraints

▶ 50 cm x 50 cm x 50 cm box
- ▶ Must contain:
  - ▶ Robot
  - ▶ Weight to be lifted
  - ▶ Batteries
  - ▶ Controller

▶ Batteries must be rechargeable

▶ All other energy must be returned to its original form
- ▶ This includes:
  - ▶ Compressed Air
  - ▶ Springs

Event 1: The Sprint

- ▶ Two-Pronged Approach

  - ▶ Differential Drive

    - ▶ Two powerful motors

    - ▶ Left- and right-side tracks are driven by the same motor

  - ▶ "Tape Measure" Loophole

    - ▶ Smaller DC Motor extends outwards towards the barrier

Event 2: The Lift

- Air Jacks & Pneumatic System
  - Lift series of rectangular weights on a flat, level surface
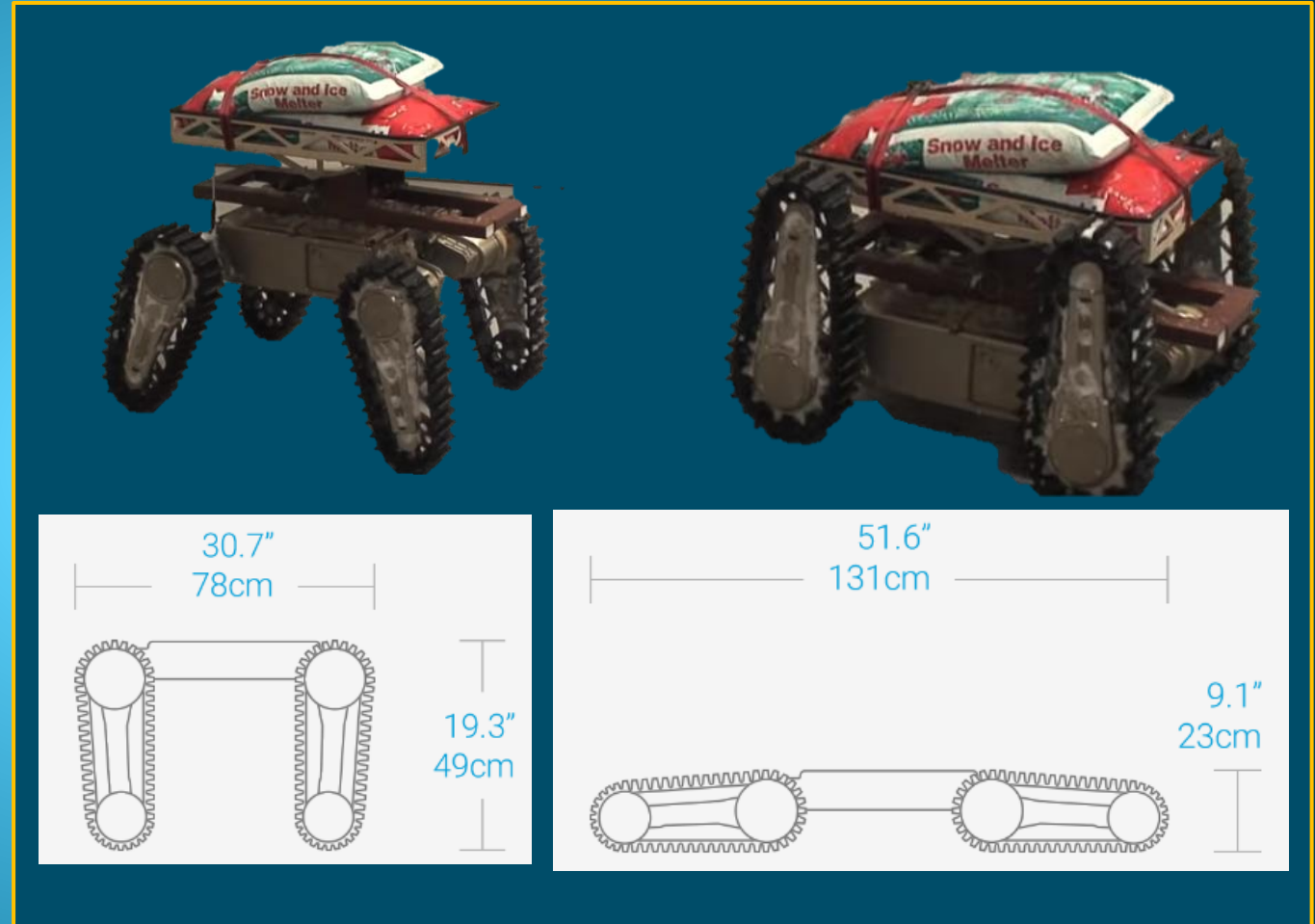 - Spring-loaded tensioners add stability

Event 3: The Throw

▶ Air Cannon & Pneumatic System

  ▶ Simple "Spud Gun" design

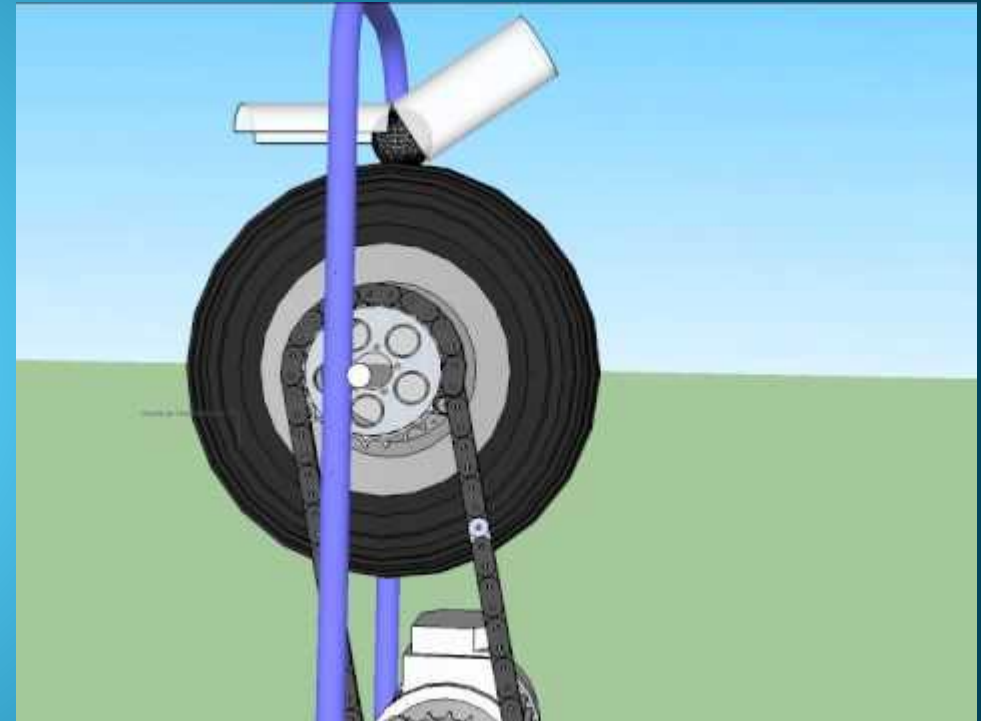 ▶ Quick release valve

  ▶ Control Launch angle using legs

Event 4: The Climb

▶ Chaos Frame

  ▶ Four, individually tracked and rotating legs

  ▶ Each leg capable of 360 degrees of rotation

  ▶ Four points of constant ground contact
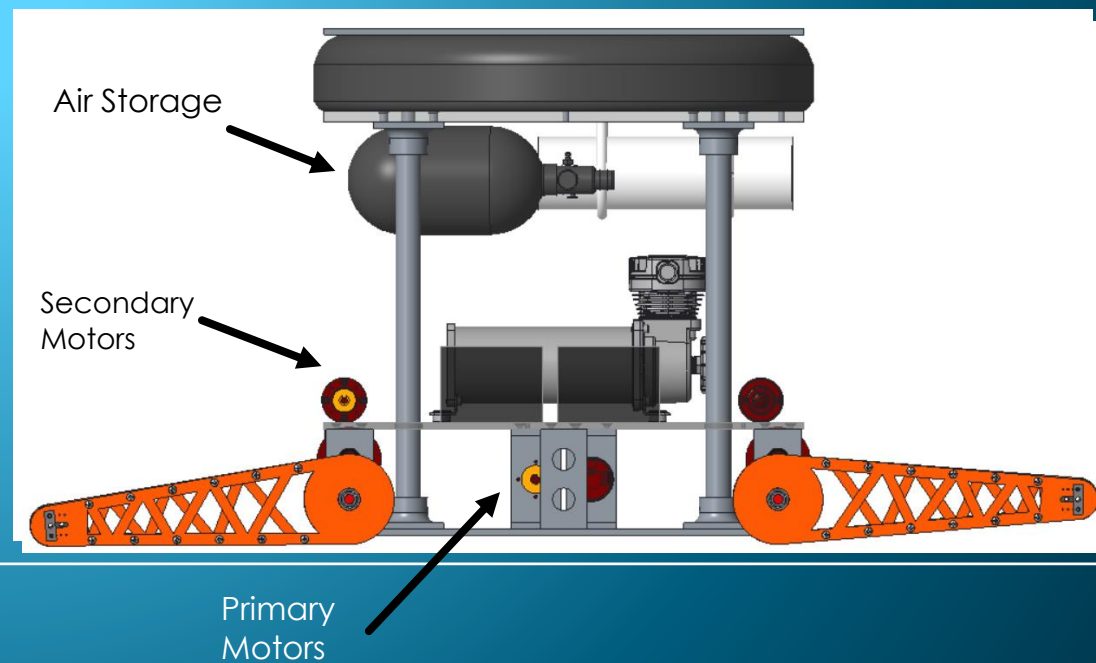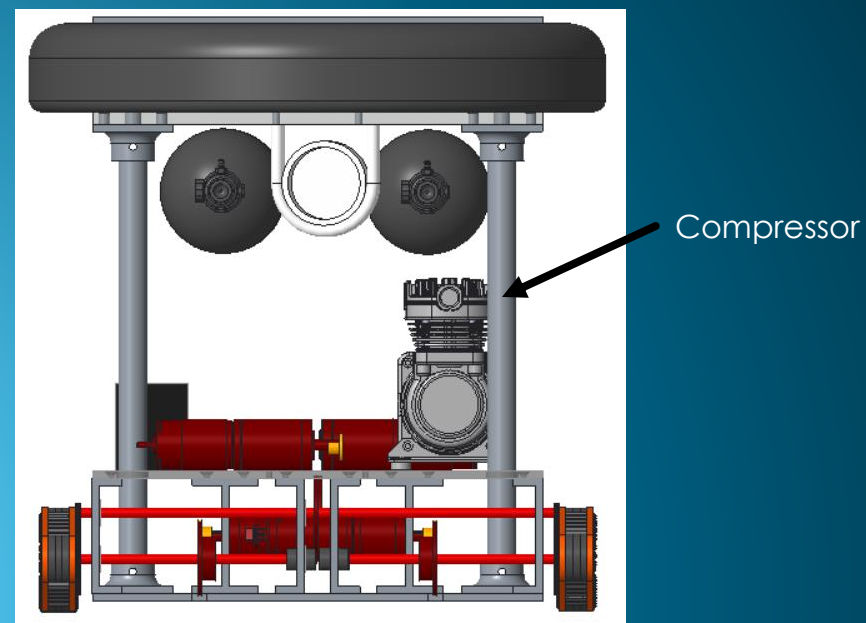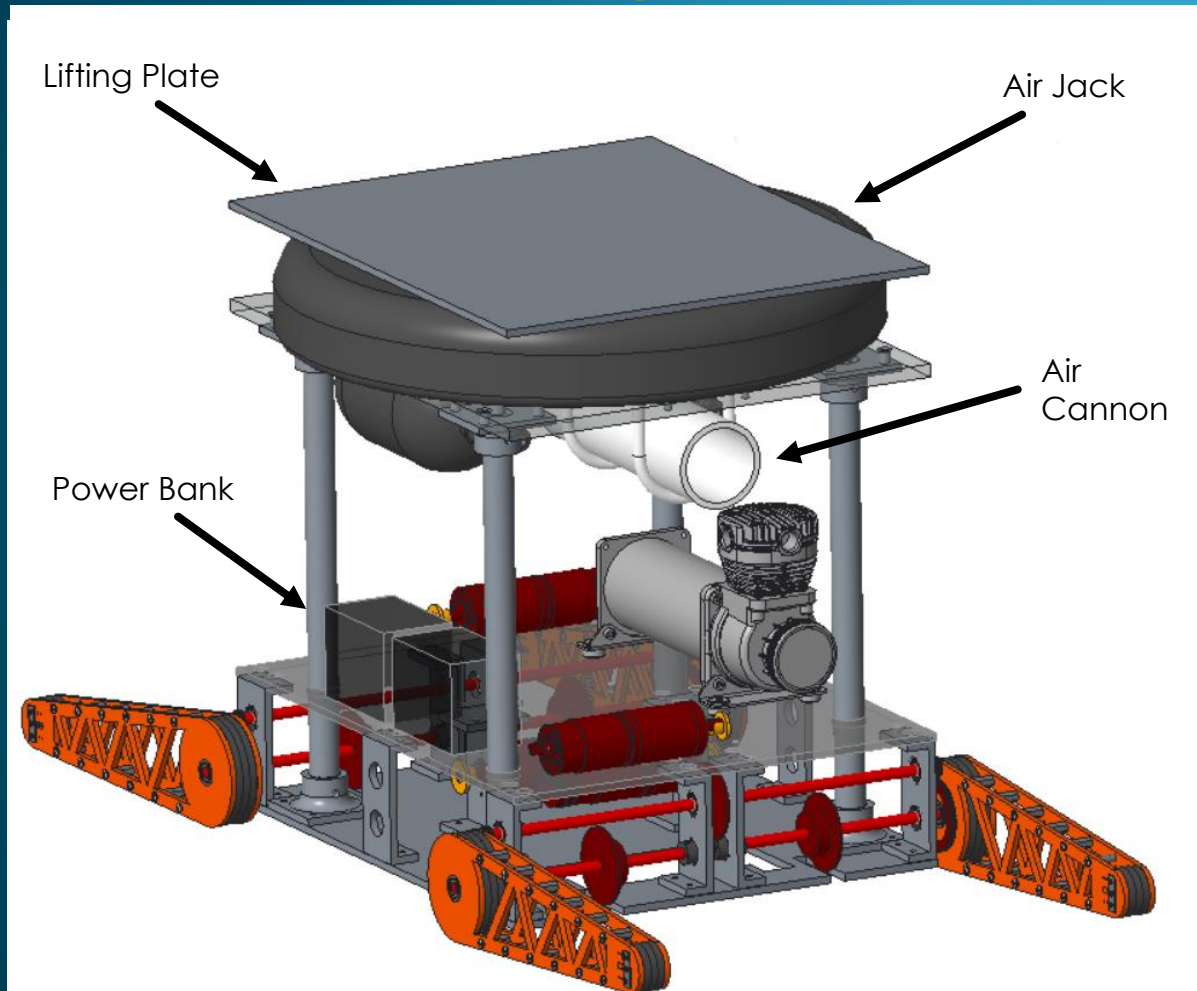
Event 5: The Hit

► Pitching Wheel System

  ► Powerful DC motor spins a single wheel upwards of 5000 rpm

  ► Ball is forced through a curved track such that it exits forwards

  ► Exit velocities calculated to be upwards of 15 m/s

Overall Design

Lifting Plate
Air Jack
Air Cannon
Power Bank
Compressor
Air Storage
Secondary Motors
Primary Motors

Modeling and Simulation

► FEA performed on all at-risk sections

   ► Iterations of the models were performed until satisfactory

► CAD is nearly complete

   ► One section (pitching wheel) remains to be designed
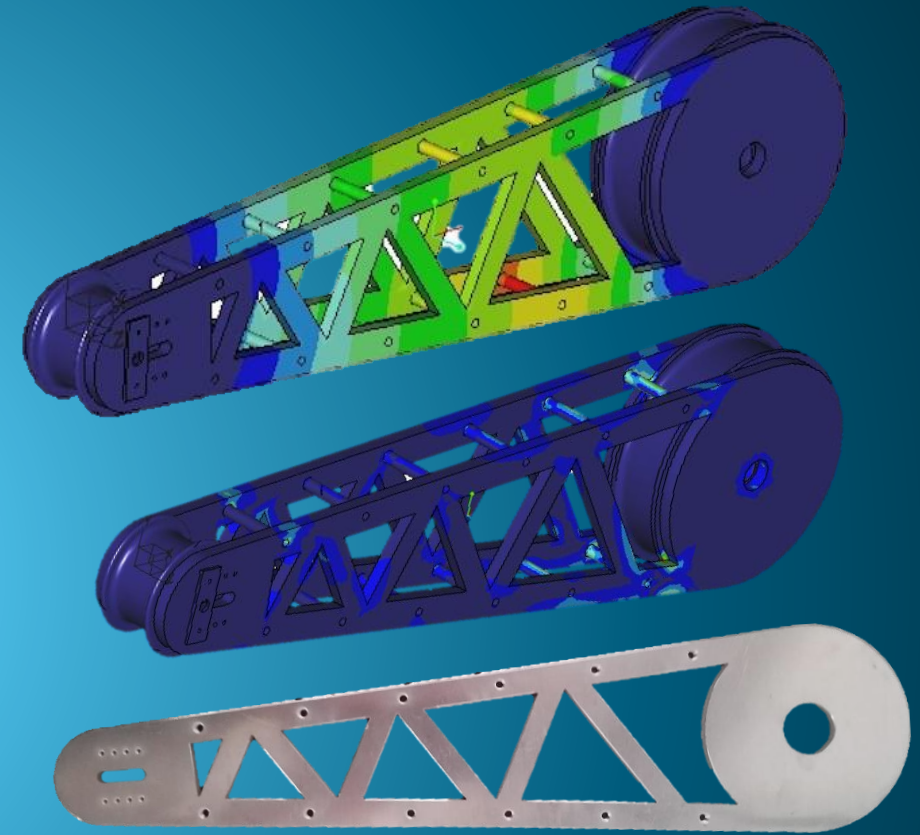
(Top) Displacement (mm)
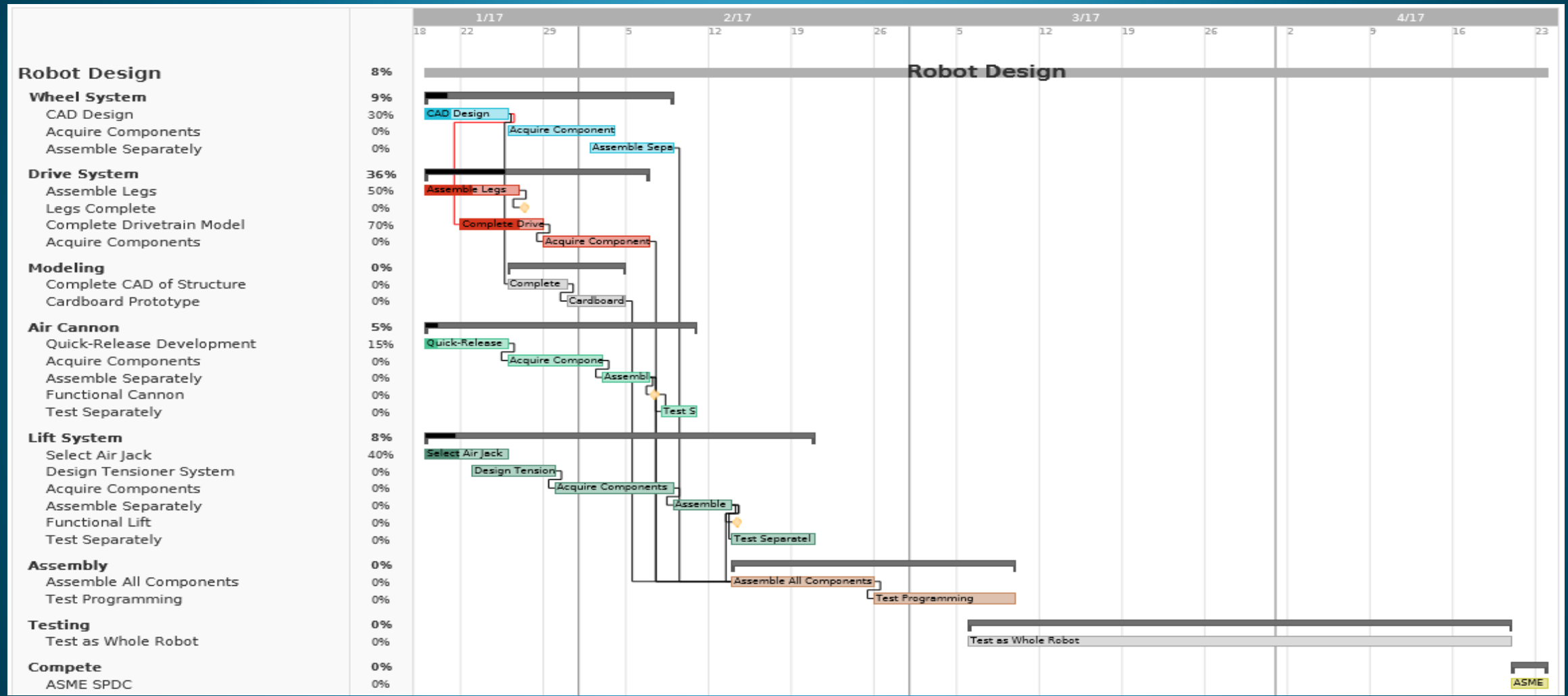(Center) Von Mises Stress (kPa)
(Bottom) Final product

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Size Constraints

► The largest obstacle

  ► Gear ratios

  ► Air storage capacity

  ► Actuators

  ► Lifting mechanism

  ► Compressor

  ► ***Mechanisms for "The Hit"***

Project Schedule: Gantt Chart

Project Summary

- Competition
  - 5 events
  - Project Scope

- Design
  - Dual power sources
    - DC electric and Pneumatic

- Progress
  - Legs nearly constructed
  - Full design to be completed within a week

Where We Are Going

- ► Immediate Tasks
  - ► Complete redesign of approach to "The Hit"
    - ► "Tall Tentpole"

  - ► Make Cannon and Lift Operational

- ► Long-Term Goals
  - ► Have a functional robot by the end of February

  - ► Finish troubleshooting the coding and power system before mid-March

  - ► 1 month of testing before competition

References

[1] ASME, "Engineering competitions: Student design competition," in *American Society of Mechanical Engineers*, 2017. [Online]. Available: https://www.asme.org/events/competitions/student-design-competition. Accessed: Sep. 13, 2016.

[2] B. Webb, "Phonotaxis in Crickets and Robots," in *University of Edinburgh School of Informatics*, School of Informatics, The University of Edinburgh. [Online]. Available: http://homepages.inf.ed.ac.uk/bwebb/. Accessed: Sep. 20, 2016.

[3] B. UL, "Wheg," in *Robotics Portal*. [Online]. Available: http://www.roboticsportal.it/en/wheg. Accessed: Sep. 20, 2016.

[4] D. Mihai, "Wheeled mobile robot development platforms," in *Build Robots*, Smashing Robotics, 2012. [Online]. Available: https://www.smashingrobotics.com/wheeled-mobile-robot-development-platforms-from-budget-to-full-featured/. Accessed: Sep. 21, 2016.

[5] A. S. Inc, "Chaos high mobility robot | ASI," in *ASI Robots*, ASI, 2016. [Online]. Available: https://www.asirobots.com/platforms/chaos/. Accessed: Sep. 25, 2016.

[6] "Scissor lift – battery powered working height 8 meters extended platform 6 meters minimum height 2000 meters width 760mm weight 1000 Kg supplied on trailer total weight 1540 Kg. Price: Full day only $180.00," in *Picton Hire*. [Online]. Available: http://pictonhire.com/product/scissor-lift/. Accessed: Oct. 06, 2016.

[7] A. Hitchcox, "Checklist for matching air cylinders to load requirements," in *Hydraulics & Pneumatics*, 2013. [Online]. Available: http://hydraulicspneumatics.com/cylinders-amp-actuators/checklist-matching-air-cylinders-load-requirements. Accessed: Oct. 01, 2016.

[8] "About Winbag," in *Winbag USA*. [Online]. Available: http://winbagusa.com/. Accessed: Oct. 08, 2016.

[9] B. Carter, "Robo-Pitcher Throwing in Detroit has 100MPH Fastball," in *WIRED*, WIRED, 2012. [Online]. Available: https://www.wired.com/2012/08/cy-ber-young-baseball-robot/. Accessed: Sep. 29, 2016.

[10] D. Tutelman, "What Happens at Impact," in *The Tutelman Site*, 2015. [Online]. Available: http://www.tutelman.com/golf/design/swing2.php. Accessed: Sep. 31, 2016.

[11] D. Ghanshyam Pardhi, "STRESS ANALYSIS OF SPLINE SHAFT USING FINITE ELEMENT METHOD AND ITS EXPERIMENTAL VERIFICATION BY PHOTO ELASTICITY," in *IJmerr*, 2014. [Online]. Available: http://www.ijmerr.com/uploadfile/2015/0409/20150409042403160.pdf. Accessed: Oct. 15, 2016.

Questions?