Design of a Multi-Functional Mobile Robot

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Competition Overview [1]

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

Figure 1: Host of Competition

Competition Overview [1]

- 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 [1]

- 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
- Project Objective
  - Design a multi-functional robot capable of lifting, throwing, and hitting while maintaining a high degree of mobility
  - Win the ASME Student Design Competition

Competition Constraints [1]

- 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

Project Overview

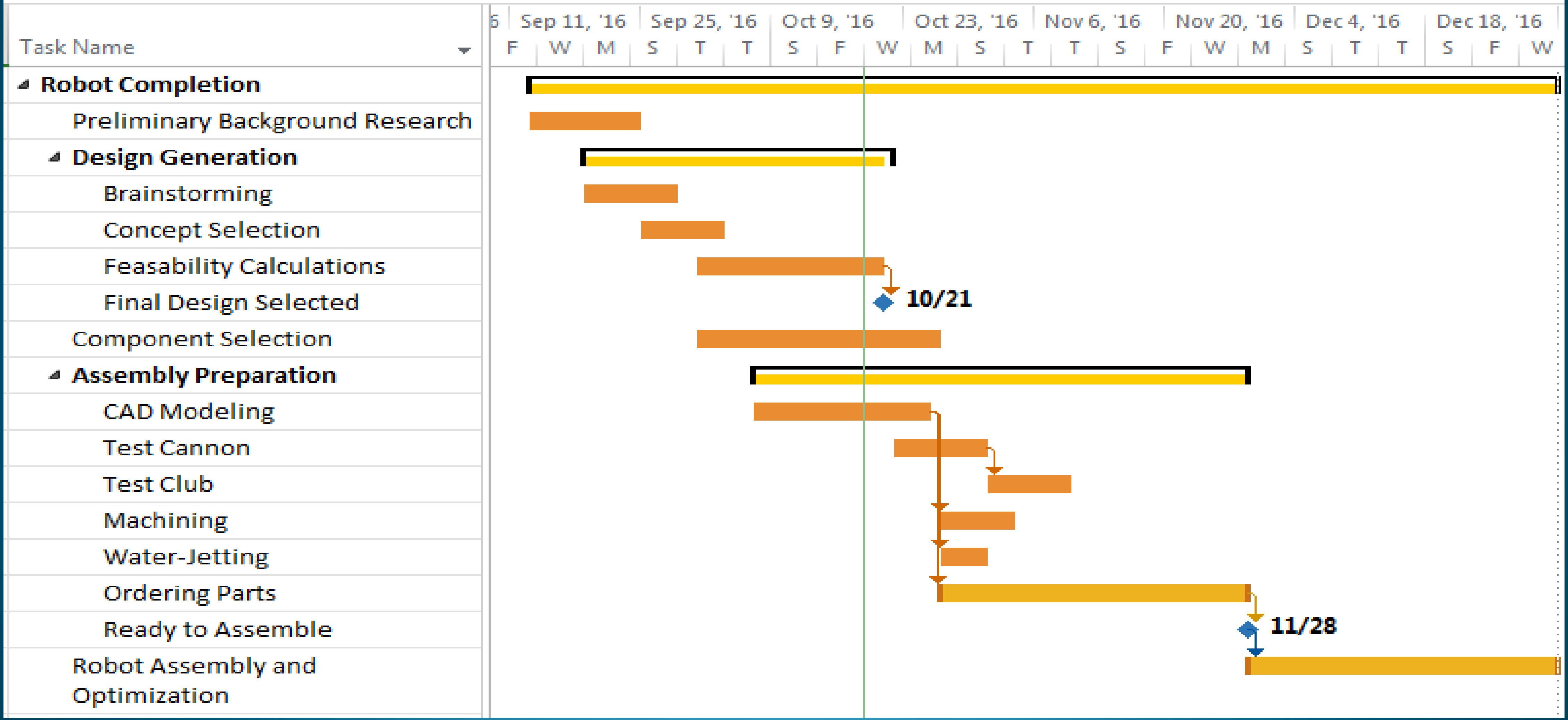
- Background Research
- Brainstorming
- Design Generation
- **Component Selection**
- Preliminary Testing
- Assembly
- Optimization
- Compete
- Win

Where we have been

Where we are

Where we are going

Project Overview: Gantt Chart



Background Research: Climbing Robots

- Whegged Approach
  - Biologically inspired
  - Great obstacle climbing ability
  - Stability issues [2]
    - Constantly shifting contact points with ground
  - Poor linear motion
  - Generally cannot support heavy loads

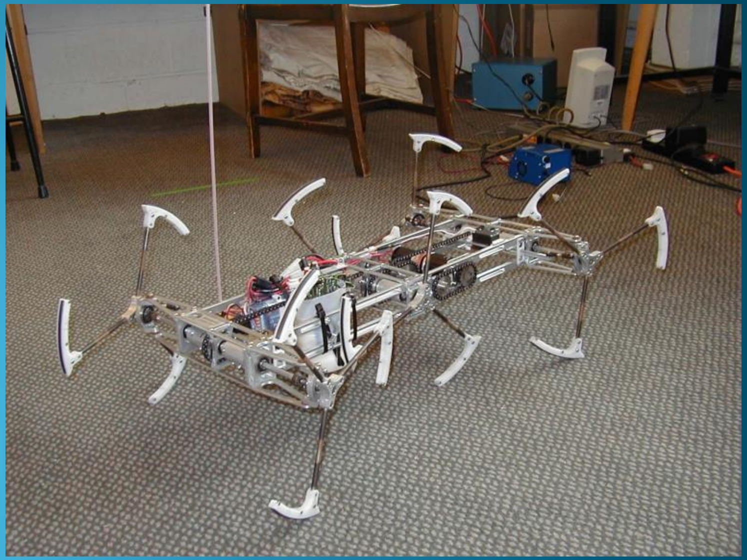


Figure 2: Whegged robot [2]

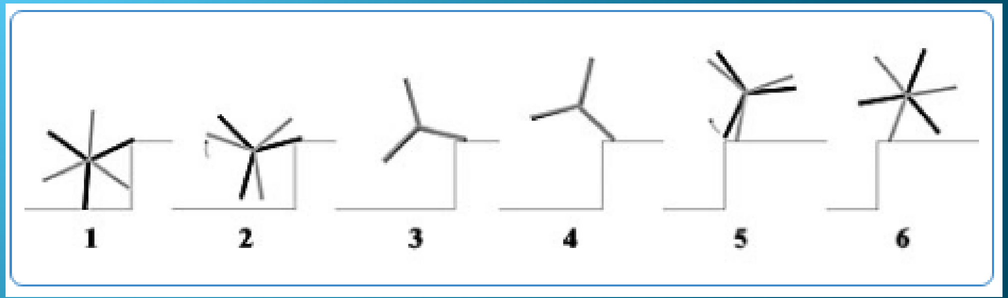


Figure 3: Time-lapse kinematics of a whegged climber [3]

Background Research: Climbing Robots

- Tracked Motion
  - Effective over many terrains
  - Great obstacle climbing ability
  - Few stability issues
    - Low center of gravity
    - Stable platform
  - Supports heavy loads
  - High Power Consumption

Figure 4: Tracked robot with rotating arms [4]

Background Research: Climbing Robots

- Chaos Platform [5]
  - Best Aspects of:
    - Legged Robot
    - Tracked Robot
  - Highly versatile
  - Many possible configurations
  - High power consumption

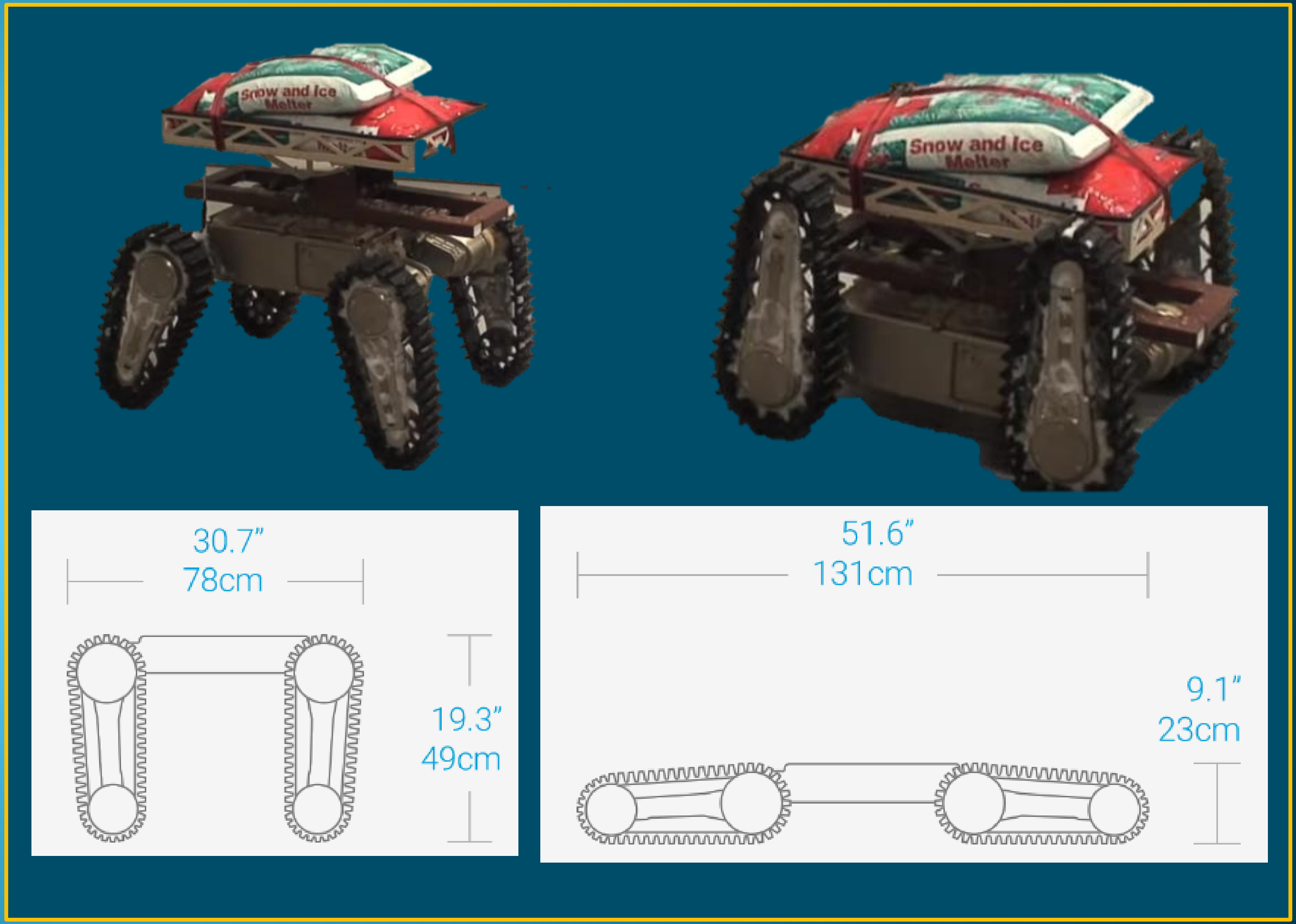


Figure 5: Chaos robot in different poses [5]

Background Research: Lifting Mechanisms

- Scissor Lift
  - Large potential height
  - Heavy frame
  - Large input force required
  - Many components
  - Very tight tolerances

Figure 6: Scissor Lift [6]

- Pneumatic Piston
  - Large forces generated
  - Few components
  - Limited height gain

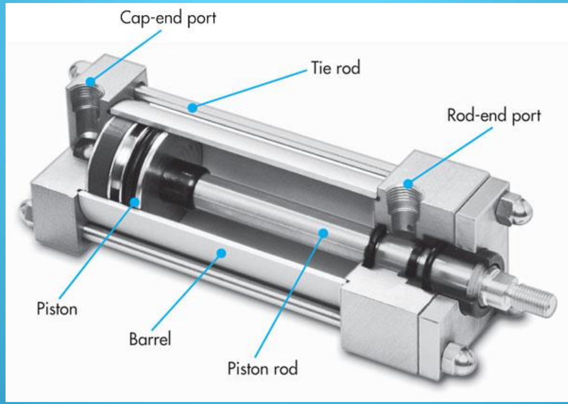


Figure 7: Piston cross section [7]

- Inflatable Jack
  - Lightweight
  - Flexible
  - Low lift height
  - Cost Effective

Figure 8: Inflatable jack in use [8]

Background Research: Launching Mechanisms

- Pneumatic Cannon
- Launches tennis ball using compressed air
- Chamber filled with air via
  - Air compressor
  - Air pump
- Capable of producing high ball velocities
- High accuracy, low recoil

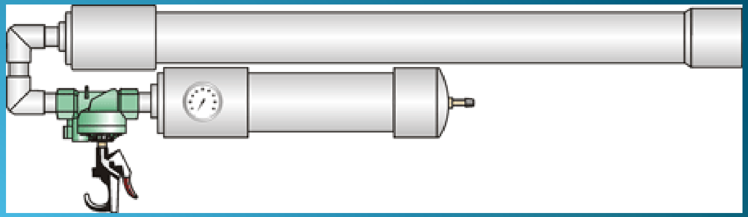


Figure 9: Example of a portable air-powered cannon

Figure 10: A larger air-powered cannon, the “Robo-Pitcher”, is capable of 100MPH launch velocities [9]

Launching Mechanism

- Pitching Machine Concept
- Can generate high projectile velocities
- Wheels can be vertical or horizontal
- High directional and spin control
- Fixed size to fit tennis ball
- Additional motor(s) required

Figure 11: Rendering of a tennis ball launcher utilizing spinning wheels [9]

Background Research: The Hit

- Golf Club: Engineered to hit golf balls for over a century
- Variety of clubs with different loft angles.
- Irons designed for hitting golf ball off the ground and launching the ball

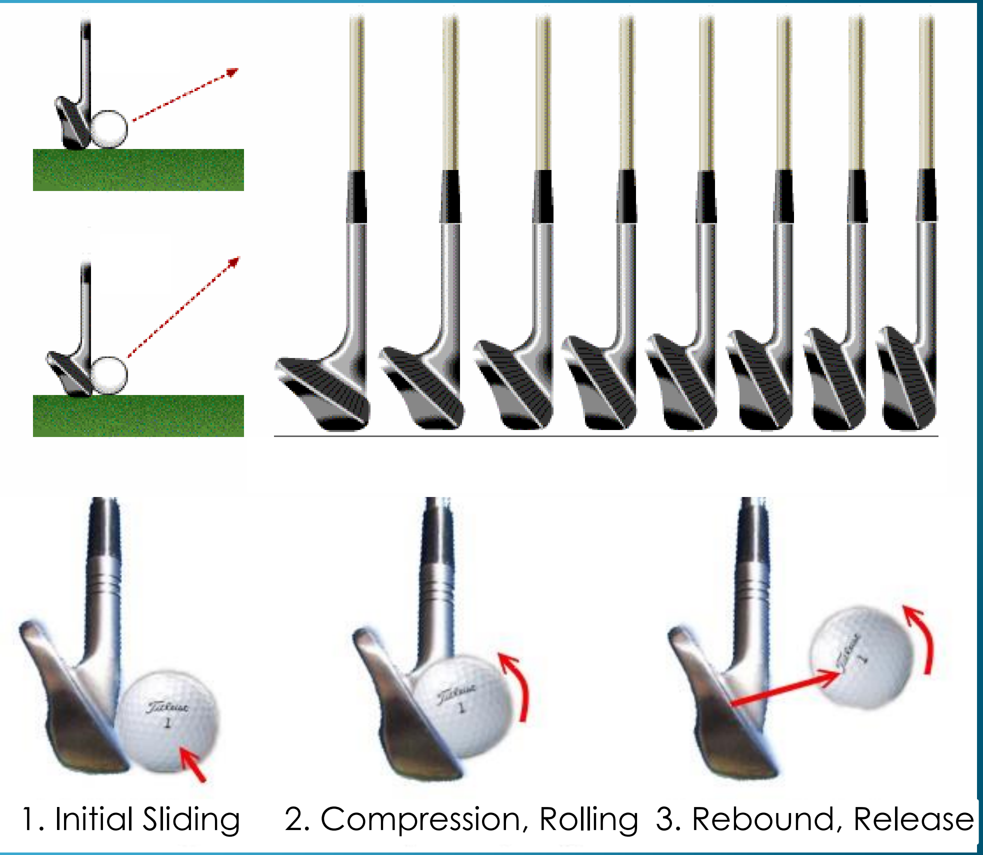


Figure 12: Examples of the many loft angles we could utilize in our design [10]

Design Selection: House of Quality

Competition Requirements (0-5)		Engineering Characteristics (0-10)					
		Power Consumption	Weight of Robot	Battery Capacity	Mass of lifted object	Modularity	Strength of Frame
Mobility	5	9	1	9			
Power	4	9	3		9		3
Stability	3			1			6
Size	5	1	4	5	9	3	
Durability	2		1				3
Safety	5	1		1	1		9
Score		91	39	78	86	15	81
Relative weight		23	10	20	22.1	3.8	20.8
Rank		1	5	4	2	6	3

Success of design is heavily dependent on:

1. Power Consumption
2. Mass of lifted object
3. Strength of Frame
4. Battery Capacity

Design Selection: Morphological Chart

Frame	Lift	Throw	Hit	Sprint	Primary Power Source
Whegs	Scissor-Lift	Air Cannon	Golf Club Head	Retractable Projectile	Electric Motors
Tracks	Pneumatic Piston	Catapult	Linear Actuator	Conventional	Pneumatic Air Compressor
Chaos	Air Bag	Pitching Wheels			Both

Design 1:

Design 2:

Design 3:

Design Selection: Pugh Matrix

Selection Criteria	Weight	Baseline	Design 1	Design 2	Design 3
Mobility	4	0	+1	0	+1
Power	5	0	0	-1	+1
Stability	3	0	+1	+1	0
Size	5	0	+1	-1	+1
Durability	2	0	0	+1	0
Safety	5	0	+1	-1	0
Total	-	0	17	-10	14

Scoring

+1: Better than baseline

0: No change from baseline

-1: Worse than baseline

Design 1:
- Chaos platform
- Dual power source
- Pneumatic Pistons

Design 2:
- Tracked Platform
- Purely electromechanical

Design 3:
- Chaos platform
- Dual Power
- Air jacks

Design Selection: Design 1

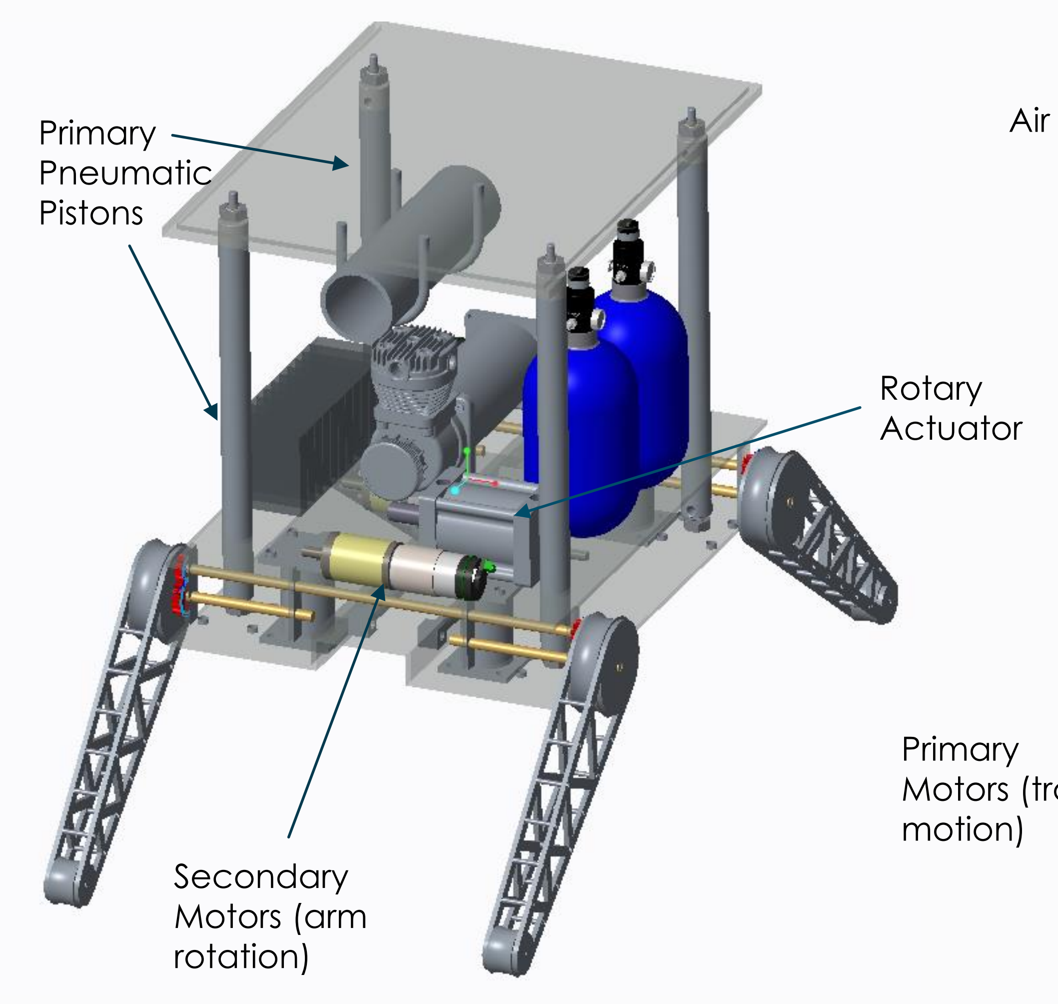


Figure 13: Isometric view of preferred design

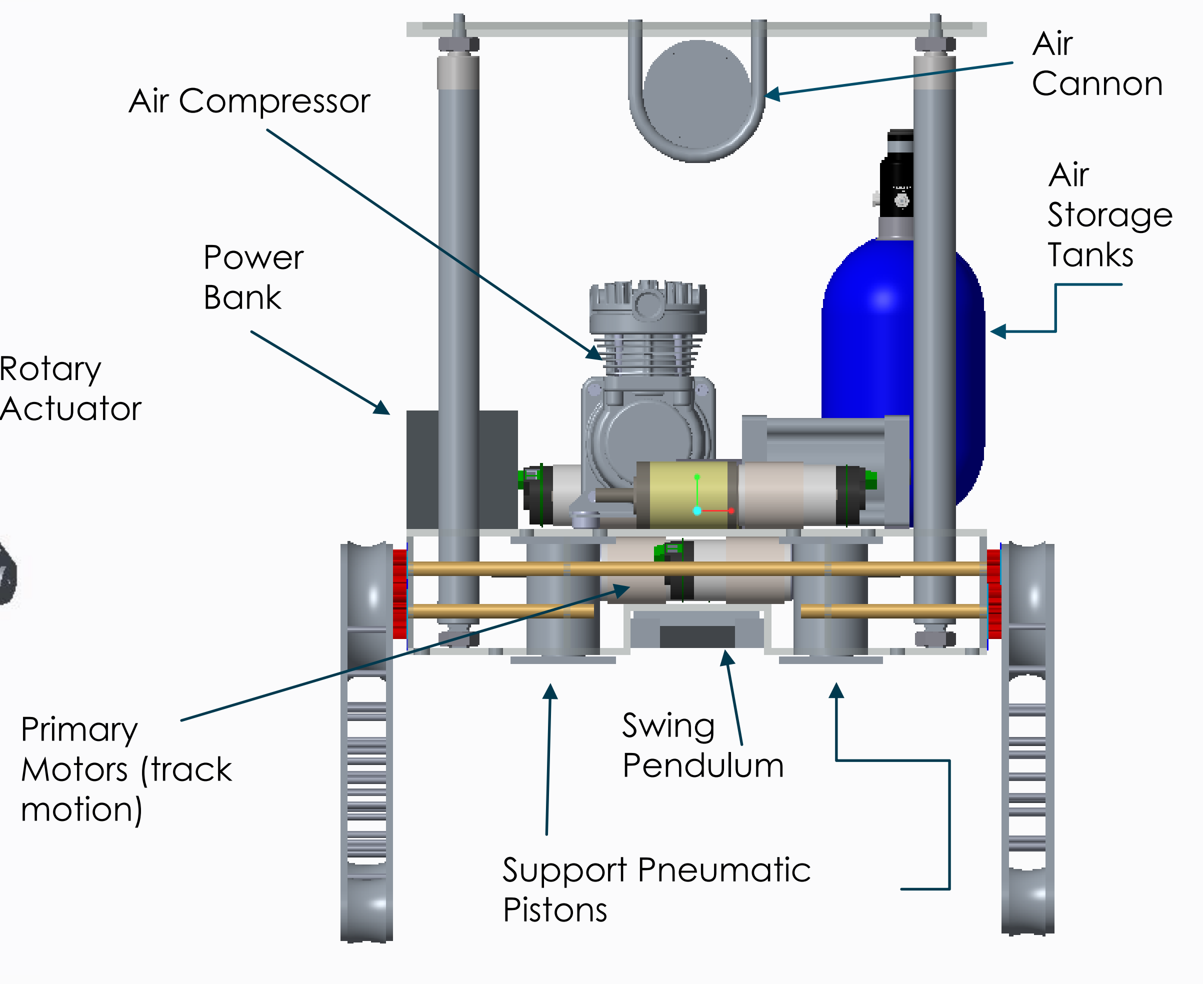


Figure 14: Front view of preferred design

Project Summary

- Competition
  - 5 events
  - Project Scope

- Research and Brainstorming
  - Chaos platform
    - Combined benefits of whegged and tracked motion

- Design Selection
  - Dual power sources
    - DC electric and Pneumatic

Where We Are Going

- Short-Term Goals
  - Prototyping
    - Event Prototyping
  - Finalizing Component Selection
    - Order necessary parts
  - Stress/Failure Analysis
    - Machining/Manufacturing

- Long-Term Goals
  - Assembly
  - Preliminary platform testing
  - Functioning platform by mid-December

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Questions?