LANL Team 1- Design of Sled Track Vehicle

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Mission

LANL requested the design of a sled track vehicle to carry test articles on a narrow-gauge sled track while meeting strict performance and weight requirements.

System Requirements:
- Vehicle weight cannot exceed 200 lbs.
- Capable of carrying test articles up to 500 lbs.
- Designed to accelerate to 150 ft/s within 50 feet.
- Adjustable for varying test article sizes and weights.
- Engineered for a narrow-gauge sled track.
- Built to withstand multiple tests per day.

Our team assiduously designed and engineered a cutting-edge, high-performance sled track vehicle that not only met but surpassed client specifications, ensuring reliability, adaptability, and precision.

Research

Our team investigated materials, mechanical systems, and design principles to meet the project's strict requirements.
- Explored 6061 aluminum for its high strength-to-weight ratio and machinability (Glemco).
- Determined the best temper classification for welded joints of 6061 aluminum (Guzman, 2019).
- Analyzed sled vehicles and launch platforms capable of supporting heavy dynamic loads, including roller coaster wheel assemblies that are designed for high-load conditions (Weisenberger, 2024).
- Studied steam catapult systems for efficient short-distance acceleration principles (Naval Marine Archive, Rodríguez-García et al.).
- Researched modular sled systems with adjustable fixtures inspired by theme park ride vehicles for quick reconfiguration referencing rail vehicle standards to ensure precision and safety (Weisenberger, 2024).
- Reviewed industrial compressor systems and launch equipment designed for high-cycle operation and fatigue resistance (CONX SC80, Naval Marine Archive).

References

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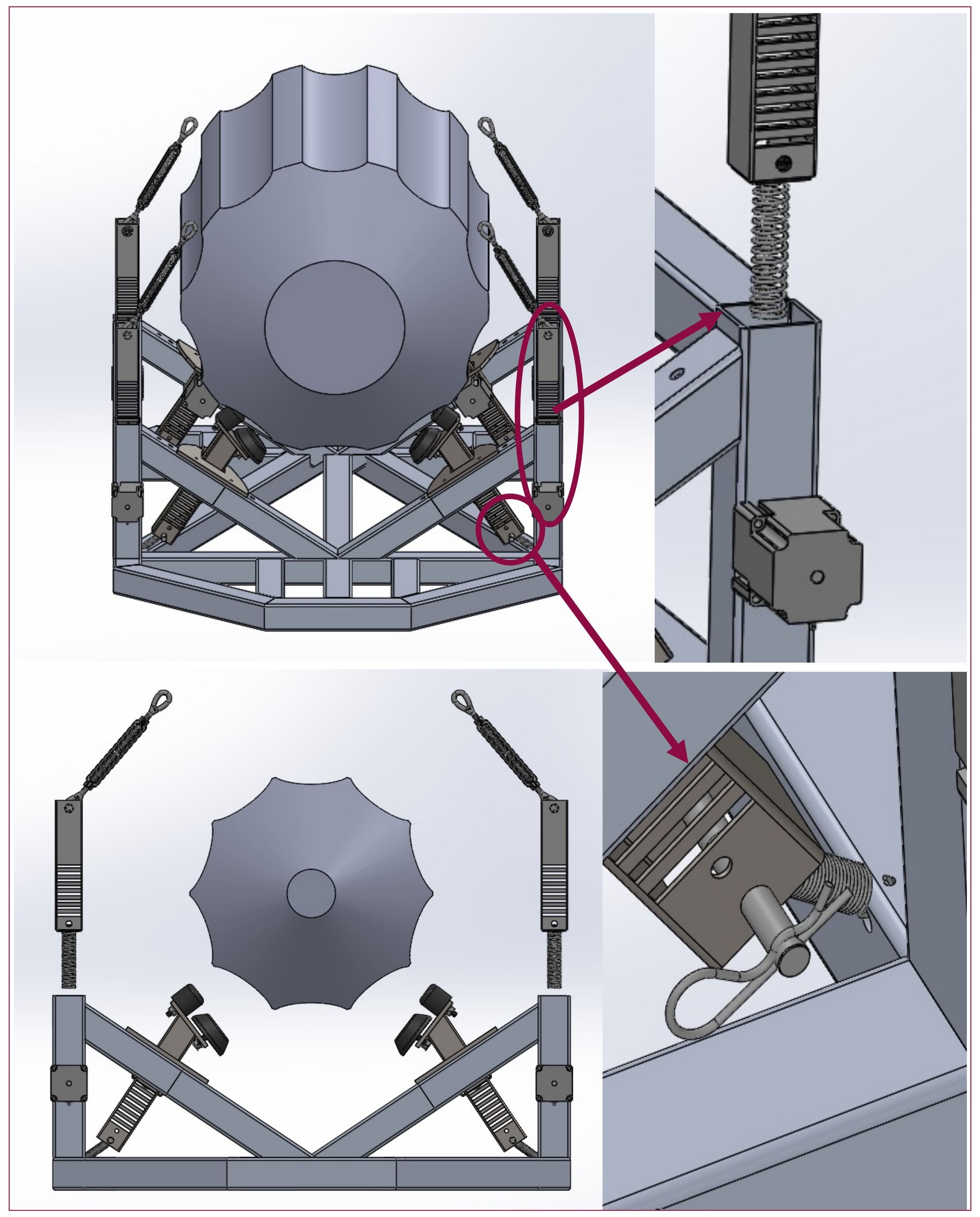
Final Design



3 main components allow for operation of the system:

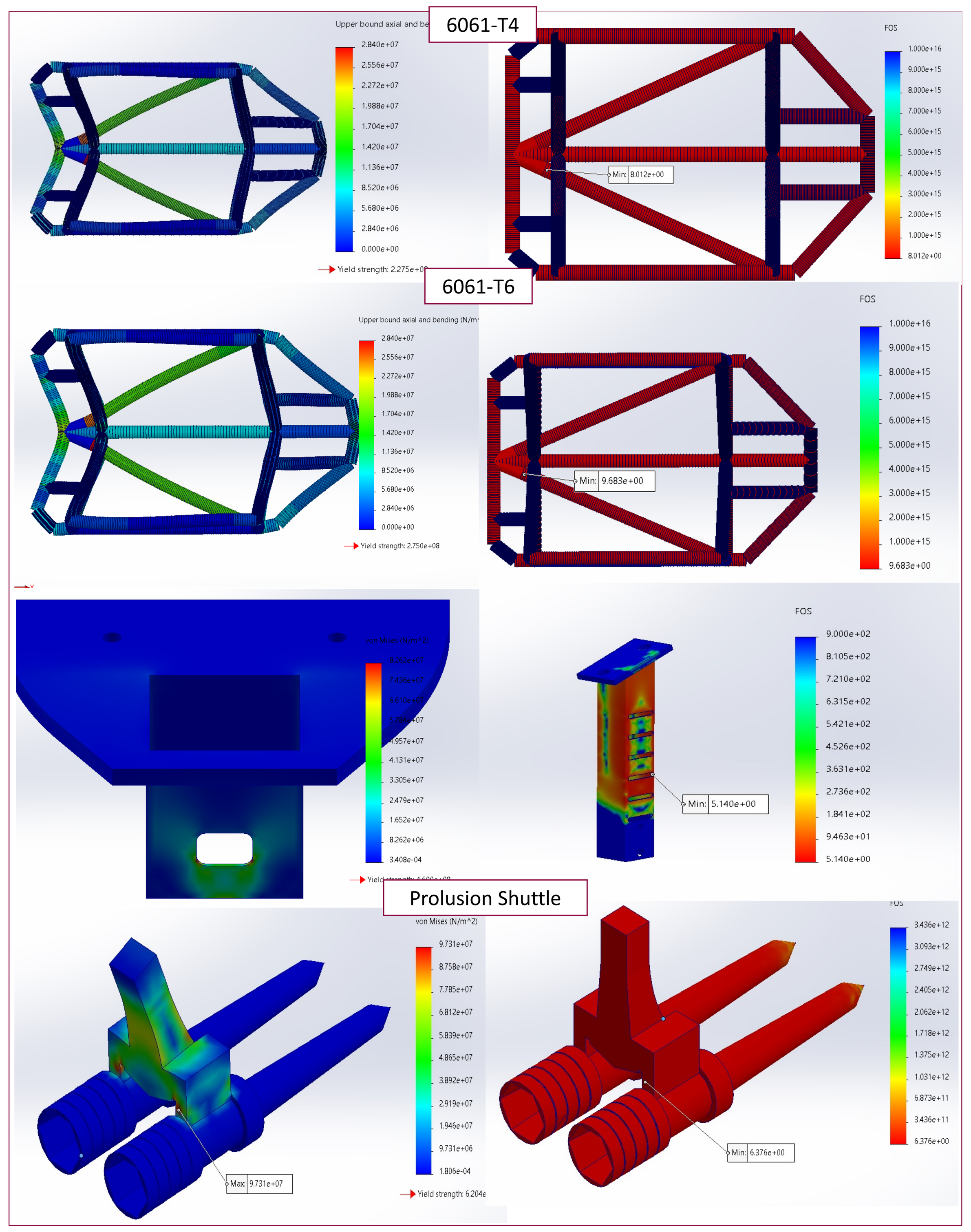
1. **Release Mechanism:**
   - The release mechanism is purely powered by mechanically, utilizing the potential stored energy of springs to disengage contact points with the device under test.
   - The disengagement occurs simultaneously to allow the object to free-fall without any imparted moment on the object that would affect its projectile trajectory.
2. **Electronic Detection System:**
   - Laser distance sensors are being used to measure the speed and distance of the vehicle and determine when to release the vehicle on an onboard microcontroller.
   - Velocity and distance conditions must be met before the system sends a disengagement signal.
3. **Propulsion System:**
   - A compressed air powered piston launches the vehicle
   - The initial velocity is controlled by the pressure difference in the storage chamber.

Validation Results

Sled Vehicle Frame:
- The vehicle's frame is designed to handle the expected environmental loading conditions to reach the target speed of 150 ft/s.
  - The factor of safety (FOS) for the required 25,000 N of propulsion force and the weight of the load utilizing 6061-T4 Aluminum is 8 FOS under extreme point load conditions.
  - The vehicle's stress conditions remain well under the materials yield strength after proper heat treatment for the Heat Affected Zones (HAZ) for T4 Classification.
  - Less critical components maintain at least a 5 FOS.

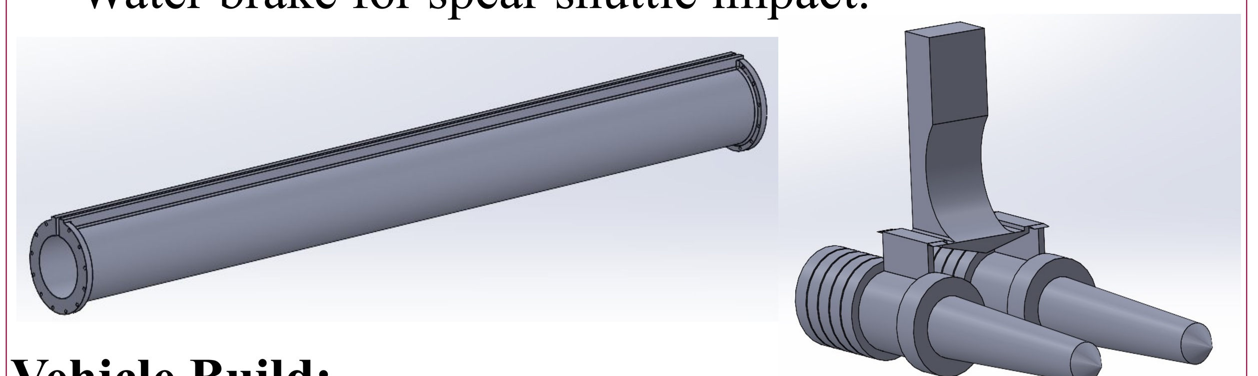
Propulsion System:
- The propulsion shuttle arm is designed to handle the required force that it transmits to the vehicle to reach the objective of 150 ft/s within 50 ft.
  - The factor of safety of the shuttle arm, after the propulsion force is 6.4 FOS.
  - This confirms the propulsion shuttle arm will maintain structural integrity during the required load of 25,000 N to reach 150 ft/s.

Full-Scale Validation Testing



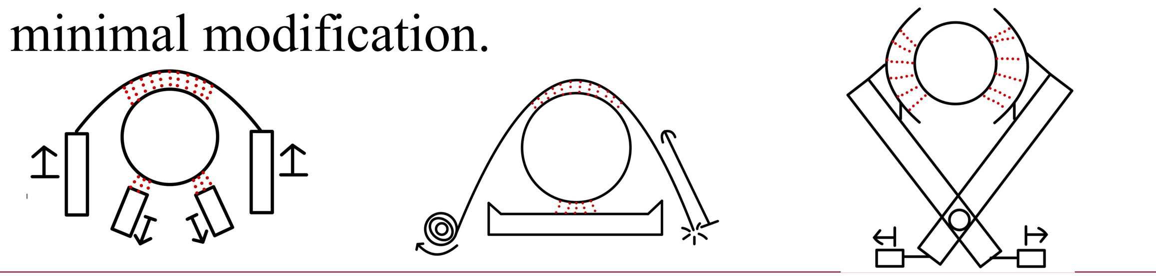
Concept Development

Compressed air shuttle catapult:
- 45 ft of serrated pressurized pipes.
- Shuttle being pushed by pressurized air, carrying the vehicle.
- Third-party air compressor and tank.
- Water brake for spear shuttle impact.



Vehicle Build:
- 6061-T4 aluminum square tubing welded and bolted together. This material was selected for its strength-to-weight ratio, and post-weld heat treatability.
- Two different ways of machining the square tubing:
  - Fully Welded:
    - Stronger structure and longer service life but has limited reparability and longer downtime.
  - Combination of Welded and Bolted:
    - Easier to repair and shorter downtime but slightly weaker and shorter run time.
- The designed vehicle is the base for the release mechanism and is below the 200 lbs weight limit.

Release Method:
- Minimal electronics, with no need for external systems like pneumatics.
- Reliable, with upper and lower contact points.
- Adaptable to differently shaped test articles with minimal modification.



Proposed Small – Scale Validation Methods

For future validation testing, we have designed a small-scale CAD model which includes the specifications:
- Vehicle Length: 2 ft.
- Vehicle Width: 1 ft (For 1 ft narrow-gauge track).
- Vehicle / test article weight: 10-25lbs.

Demonstrates the performance of:
- The release mechanism.
- The sled track vehicle, wheel assembly, and sled track all working together.