Lunar Electromotive Launcher

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Motivation

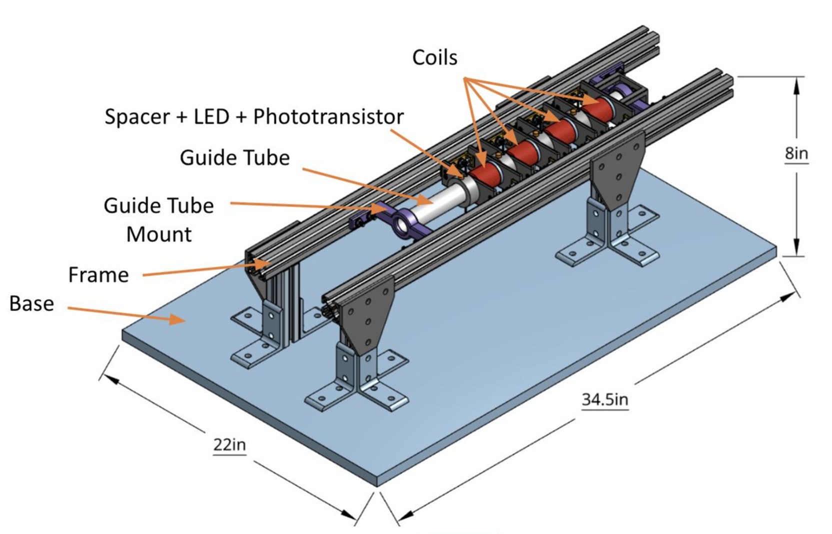
- The Lunar Electromotive Launcher is designed for lunar in-situ resource utilization.
- Electromagnetic systems are more cost efficient than chemical rockets.
- Using electromotive systems, lunar ice can be transported and then used to create oxygen and hydrogen fuels for spacecraft .

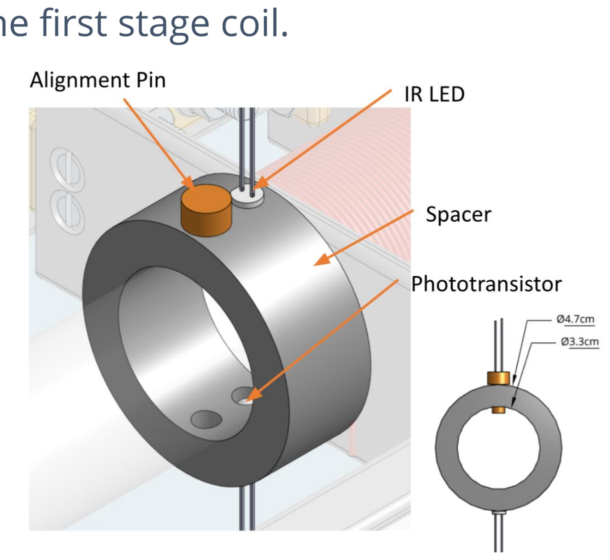
Requirements

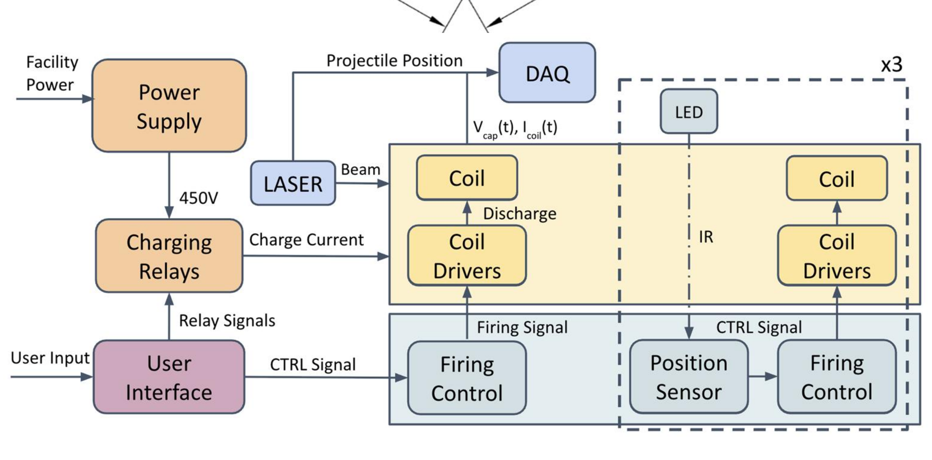
- Evaluate the feasibility of a lunar induction coilgun for cargo launch from the Moon's South Pole.
- Develop and validate a lunar coilgun system capable of launching 6,000 kg payloads at 2,353 m/s (±1%) through a 1.6 m bore.
- Maintain strict operational limits: ≤7,500 m/s^2 acceleration, 16-hour launch cadence, and 1° targeting precision.
- Prove feasibility through subscale testing and simulation validation while meeting lunar constraints for our full-scale design.

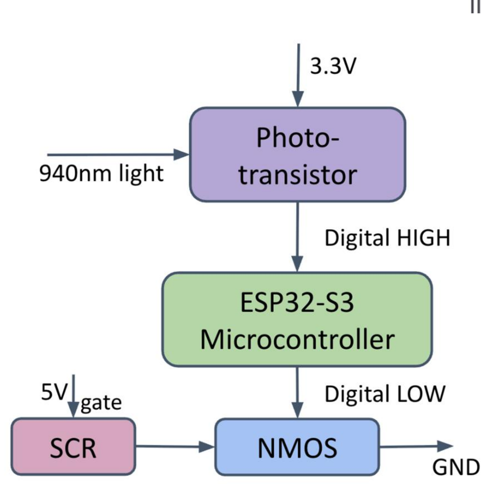
Subscale Testbed

- Our induction launcher uses electromagnetic coils to accelerate our projectile.
- High energy capacitor banks provide rapid discharge to our coils, allowing quick current pulses to each coil stage, generating a large magnetic field.
- Modular coilgun design allows controlled testing of multiple parameters to verify simulation accuracy.
- The varied parameters we can change include number of coil stages (1-4), capacitor bank voltage and capacitance, armature winding thickness, and starting position of armature with respect to the first stage coil.



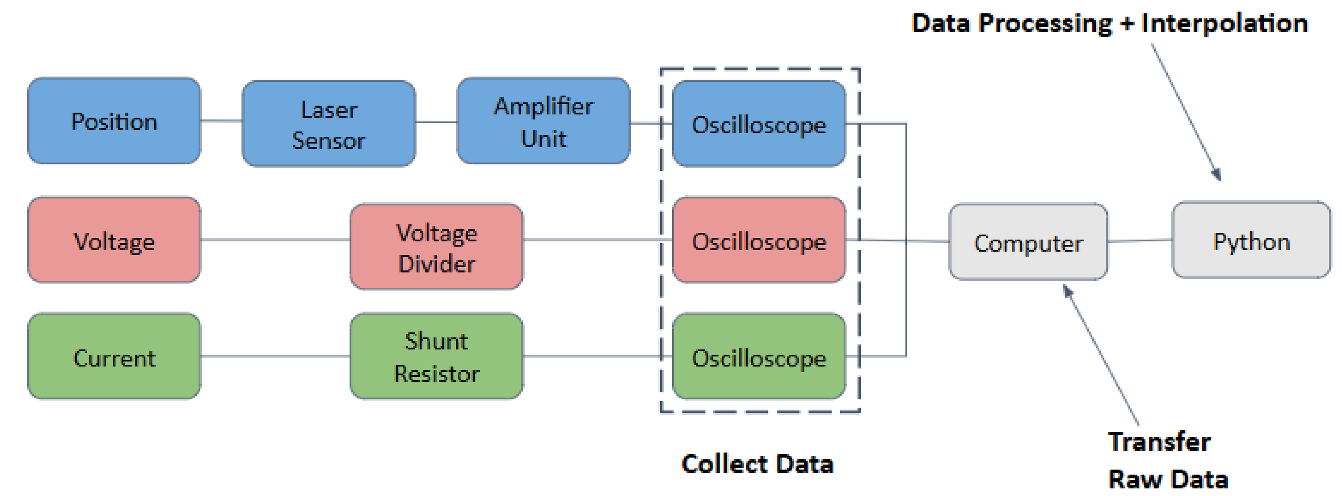






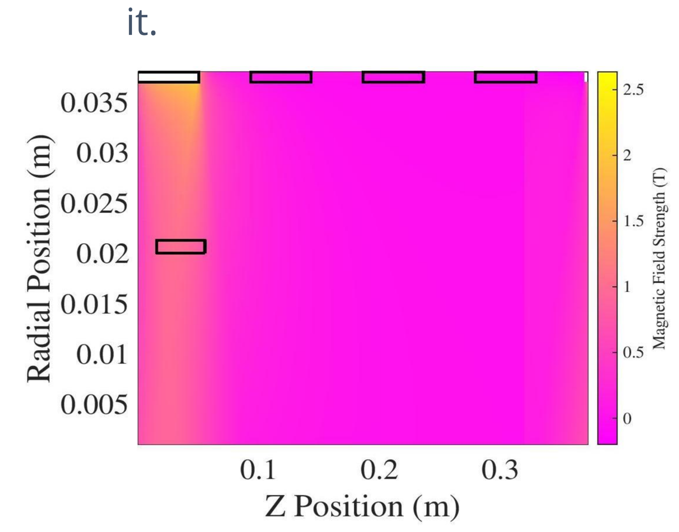
Data Collection

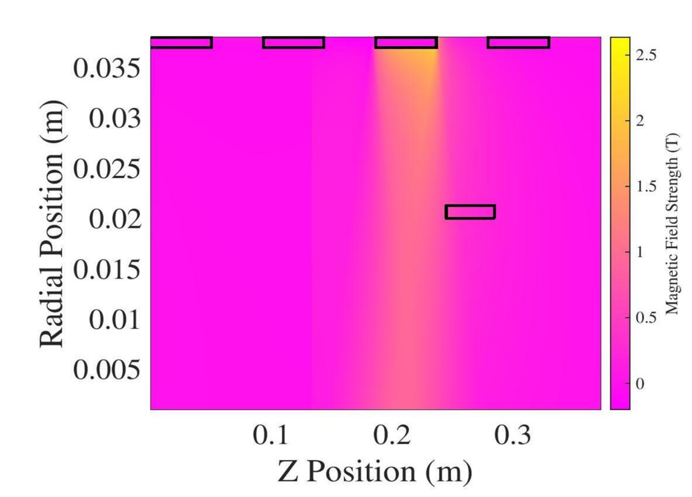
- Parameters being sampled include voltage across capacitor banks, current through our coils, and the position of our projectile.
- Once the Raw data is collected, it is transferred to a computer, where python is employed to interpolate the data to produce a constant time interval, filter out high frequency noise, and scale the data into relevant units based on external parameters

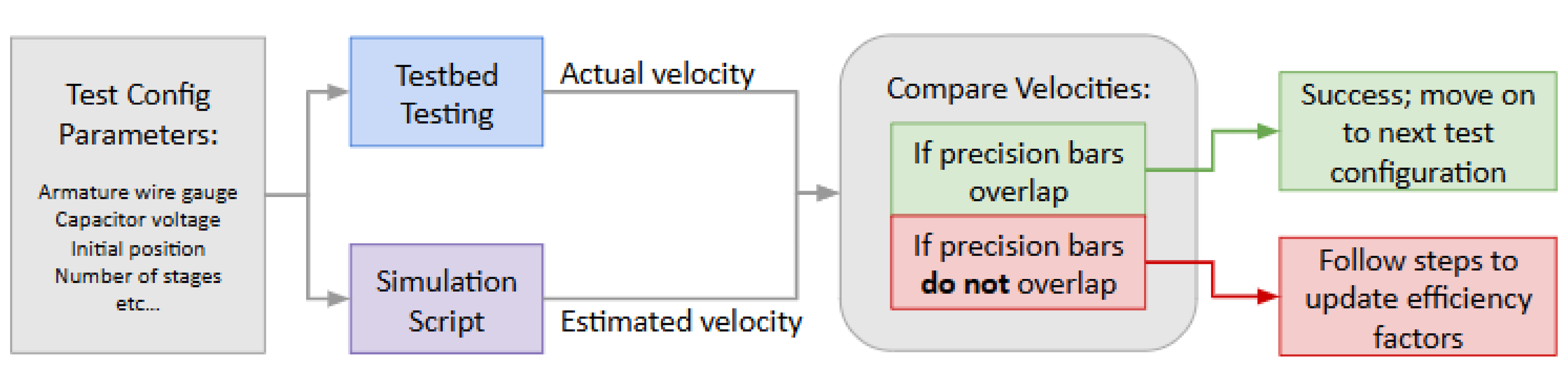


Simulation

- The simulation must model the electromagnetic physics behind a coil based launcher, most notably Faraday's Law of Induction and the Lorentz Force
- We must be capable of simulating the subscale testbed and the final conceptual design, which both rely on the same physical principles despite the vast differences in scale.
- Pictured below are two frames of an axisymmetric view of the simulated 4 stage subscale testbed. Each coil fires as the projectile passes by, accelerating it.







Conceptual Design

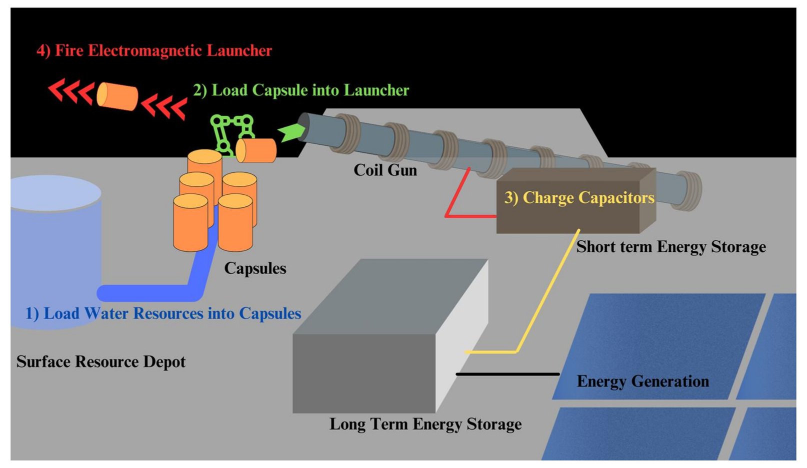
- The full scale conceptual design will be guided by the simulation once it is verified by the subscale mode. Initially, the simulation will rank the performance of five point designs:

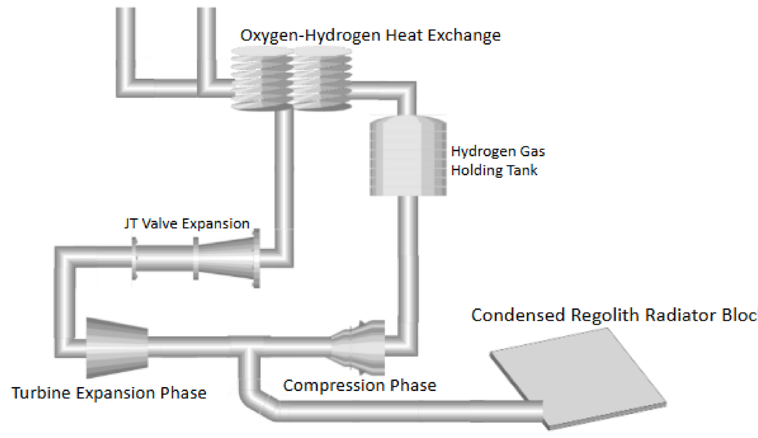
Baseline:

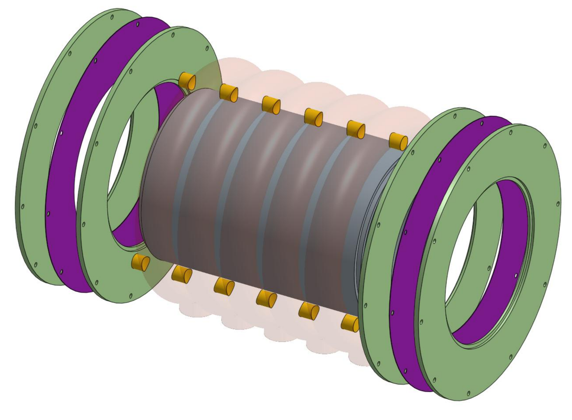
- MO
  - Payload: **up to 6000 kg***
  - Projectile velocity: **2353 ± 1%**
  - Maximum acceleration: **7500 m/s²**
- EM
  - Efficiency: **30%***
  - Coil material: **Pure copper**
  - Coil turns: **0.98**
- Geometry
  - Center radius: **0.98 m**
  - Inner radius: **0.80 m**
  - Stage width: **0.48 m***
  - Length: **339 m***

Closed designs for 5 configurations:

1. Baseline
2. Increased length: **750 m**
3. Half mass: **3000 kg**
4. Lower efficiency: **10%**
5. Double stage width: **0.96 m**







Future Work

- Verify simulation model with subscale test data
- Scale simulation to large-scale design
- Optimize switching system for multistage subscale design to increase efficiency
- Use verified simulation to optimize conceptual design parameters

Conclusion

- Designed a subscale induction coil model to produce data to verify simulation model
- Generated a MATLAB simulation model to test with data from subscale
- Produced a conceptual design of our full-scale model
- Evaluated the feasibility of full-scale model

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