

Pendulum Stand for Detonation-Based Thruster Impulse Measurement

Noah Hudson Mentor: Dr. John Bennowitz

Department of Mechanical and Aerospace Engineering

Project Overview

Project goal: Design thrust stand to measure the total impulse of a detonation-based thruster operating in a single pulse mode.

- Total impulse is used for delta-v calculations.
- Thrust stand design incorporates an inverted-hanging pendulum configuration.
- Calibration system is based on an impact pendulum technique.

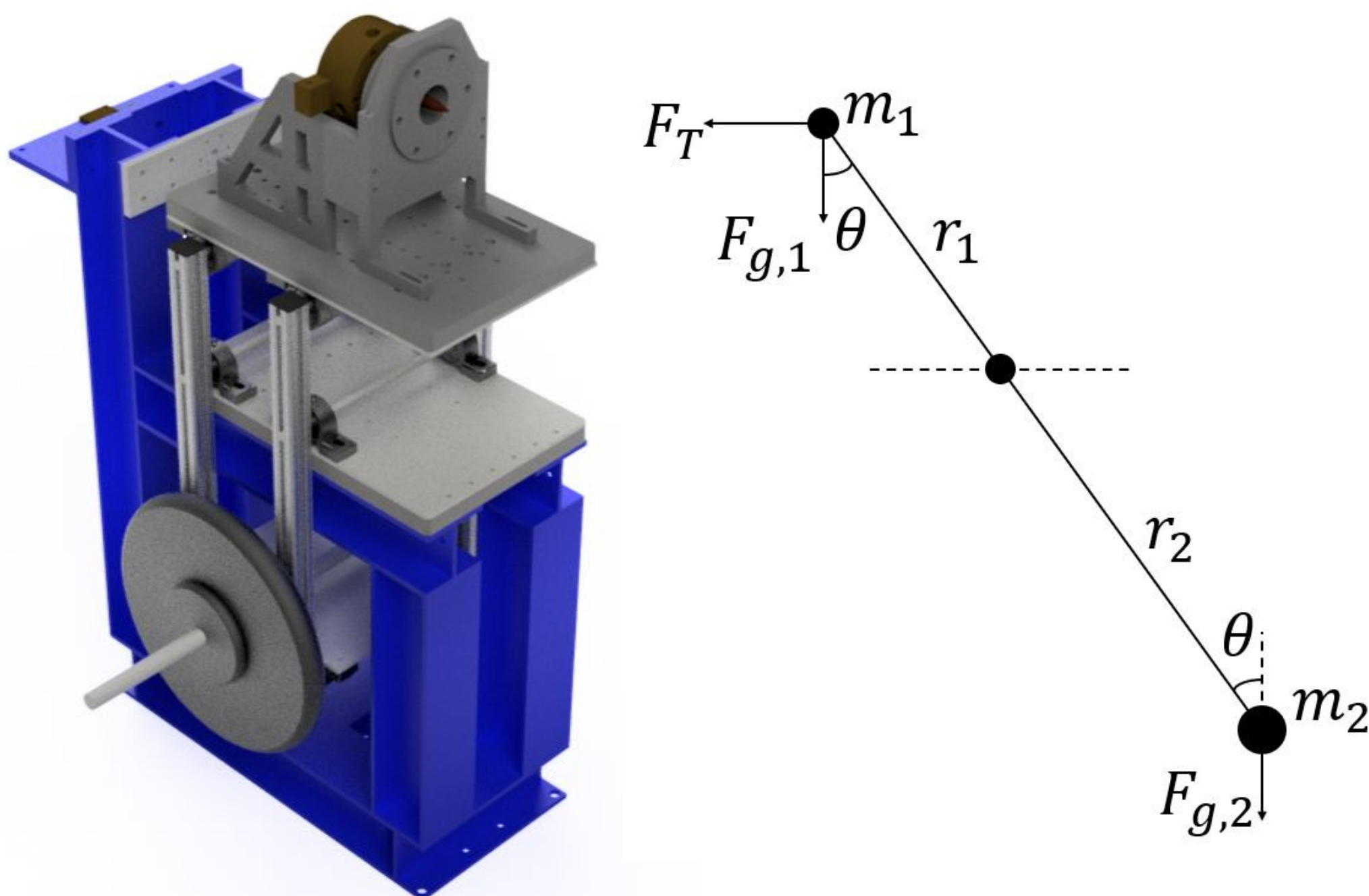


Fig. 1: a) Thrust stand render with detonation-based thruster mounted. b) Free body diagram of the stand.

Design

- Engine is positioned above the pendulum pivot with a counterweight below to restrict the pendulum movement.
- Pendulum displacement is measured with a laser sensor and is used to find the impulse.
- Calculations are based on: $L = l\omega$
- With sufficient counterweight, the design can measure the thrust for both a single pulse and continuous operation.

References

1. Thoreau, Peter and Little, Justin. *Development of the SPACE Lab Thrust Stand for Millinewton Thrust Measurement*. International Electric Propulsion Conference, 2019, <https://electricrocket.org/2019/715.pdf>.
2. Shepard, J.E., et al. *Impulse of a Single Pulse Detonation Tube*. California Institute of Technology, 2002.

Acknowledgements

The author would like to thank Kaito Durkee, Raj Dave, and McClellan Buckhalter for their help with this project. All RCEU projects were sponsored in part by the Alabama Space Grant Consortium, the UAH Office of the President, Office of the Provost, Office of the Vice President for Research and Economic Development, the College of Science, the College of Arts, Humanities, and Social Sciences, and the College of Education.

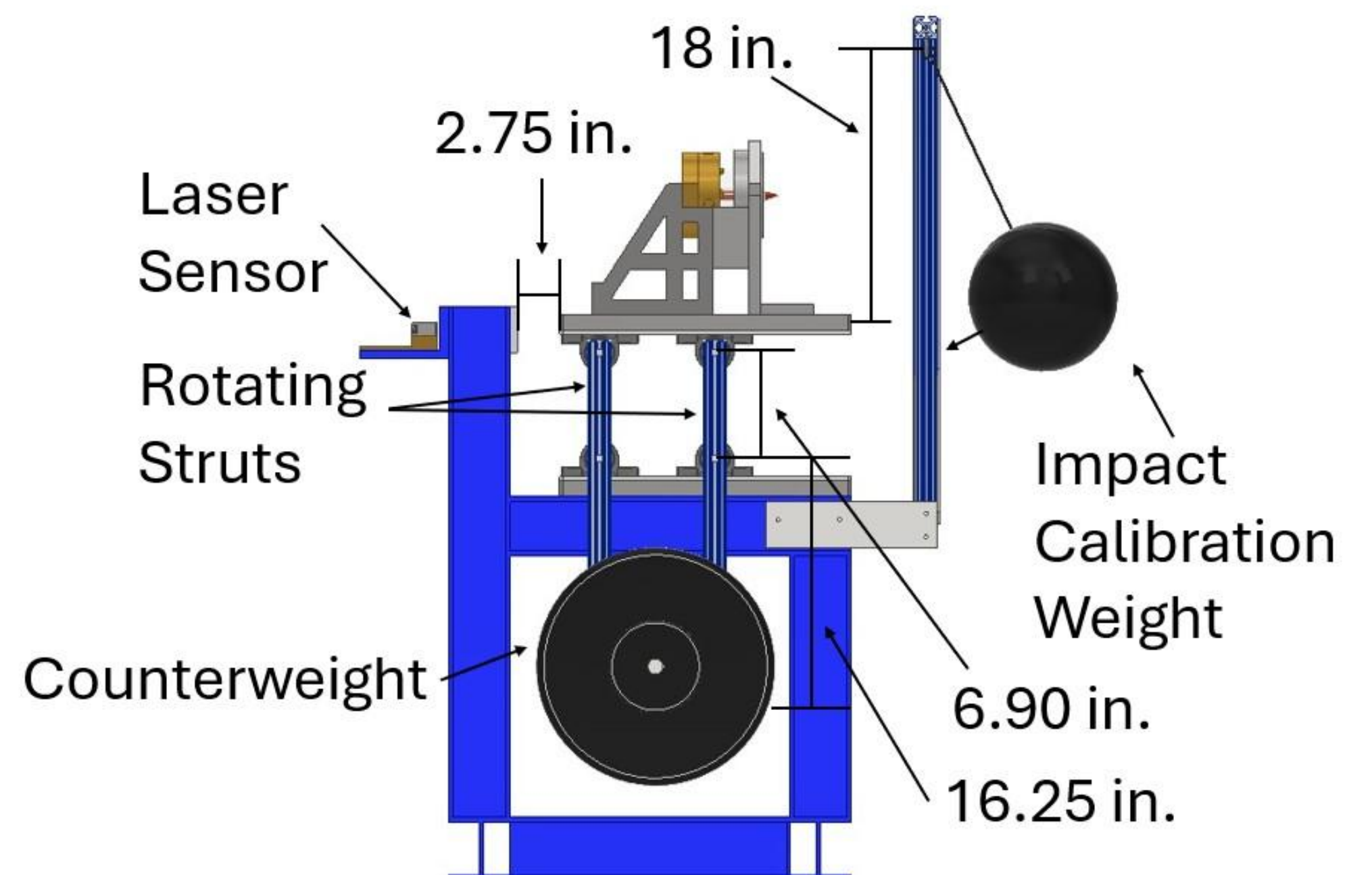


Fig. 2: Thrust stand side view with parts labeled.

Calibration

- Calibration system incorporates a large mass at the end of an impact pendulum.

Calibration Range: 1-15 N-s

- High-speed imaging will determine the velocity of the mass pre- and post-impact for use in the total impulse calculation.

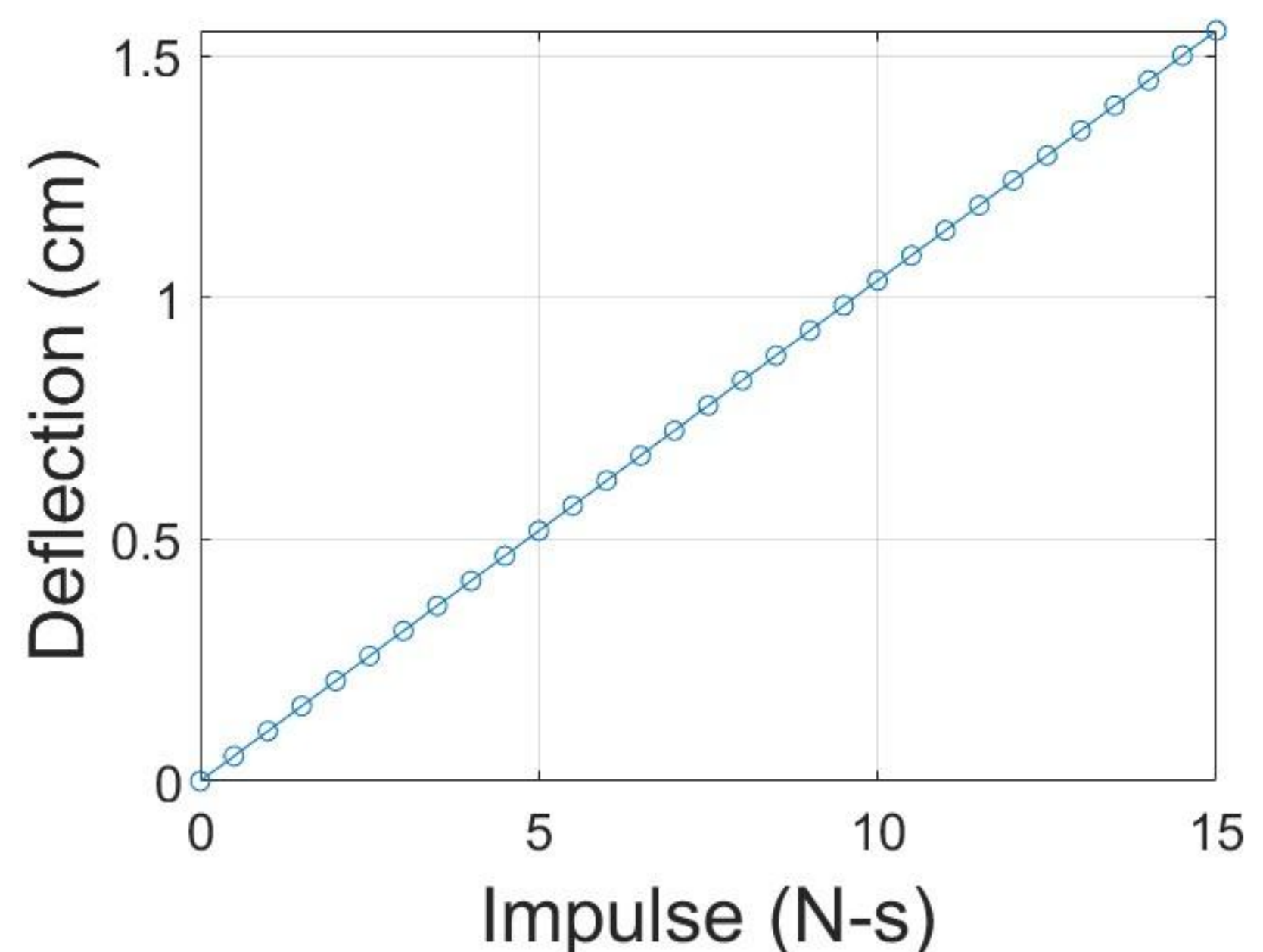


Fig. 3: Synthetic calibration curve.

Impact

- Will allow the total impulse for small-scale detonation engines to be quantified.
- Small-scale detonation engines provide higher fuel efficiency to enable longer duration space missions.
- Multimode thruster operation offers greater versatility for propulsion system.