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Optical Alignment System for Ducted Fuel Injection

PRESENTED BY

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8362 Intern Symposium

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About me

- From San Mateo, CA
- College of San Mateo: 2015 – 2018
- UC Merced:
  - BS Mechanical Engineering, December 2020
  - Member of the Rocketry division in school chapter of the American Institute of Aeronautics and Astronautics (AIAA)
  - Undergraduate research assistant in piezoelectric road energy harvesting and low-cost Stirling engine for energy storage projects

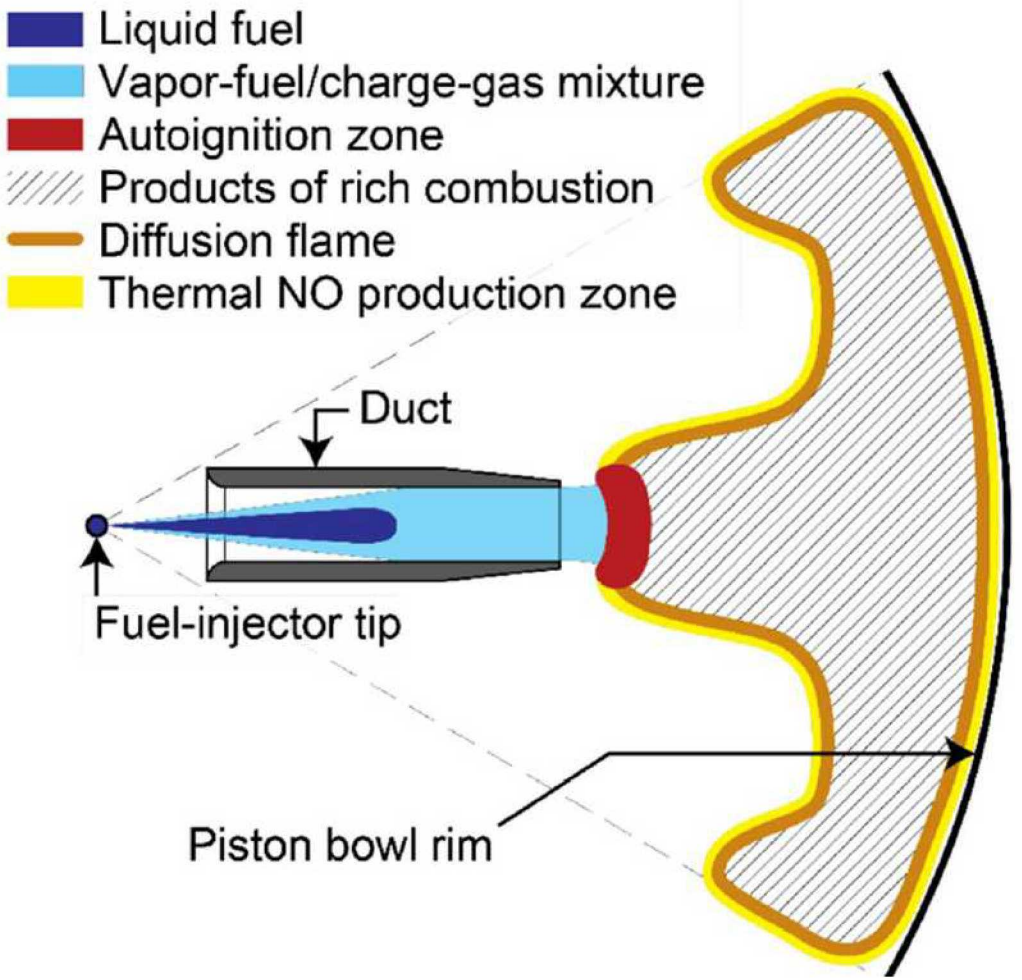
Presentation Outline

- Overview
- Current alignment method
- Design criteria
- New system introduction
- Procedure walkthrough
- New system components and placement
- Advantages of the new system

Overview

- Ducted Fuel Injection (DFI) is a proposed strategy to attenuate soot by injecting fuel through a tube within the combustion chamber of a mixing-controlled compression-ignition engine to enhance fuel/charge gas mixing

- For optimal performance, the fuel spray and the duct must be aligned



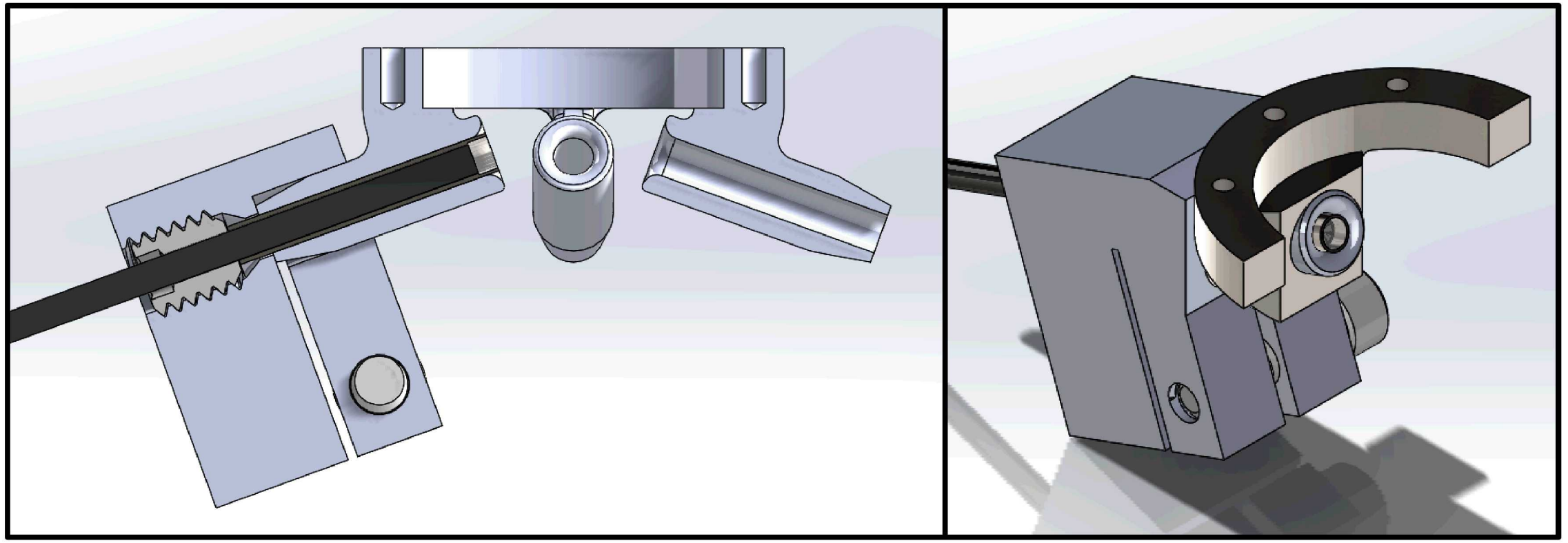
Current Alignment Method

- A silicone plug, inserted into one of the ducts, is used as a target for the fuel injector. Calipers are used to approximate the distance between the marking and the center of the plug. The duct can then be rotated left and right and spacers are added or removed to calibrate the alignment
- This system relies on the judgement of the person performing the alignment

Design Criteria for a New System

- The alignment process must be less subjective and more repeatable
- This system must enhance the accuracy of the alignment
- Must be adaptable to both integrated and modular duct assemblies
- Must be easy to set up and implement

A Novel Approach

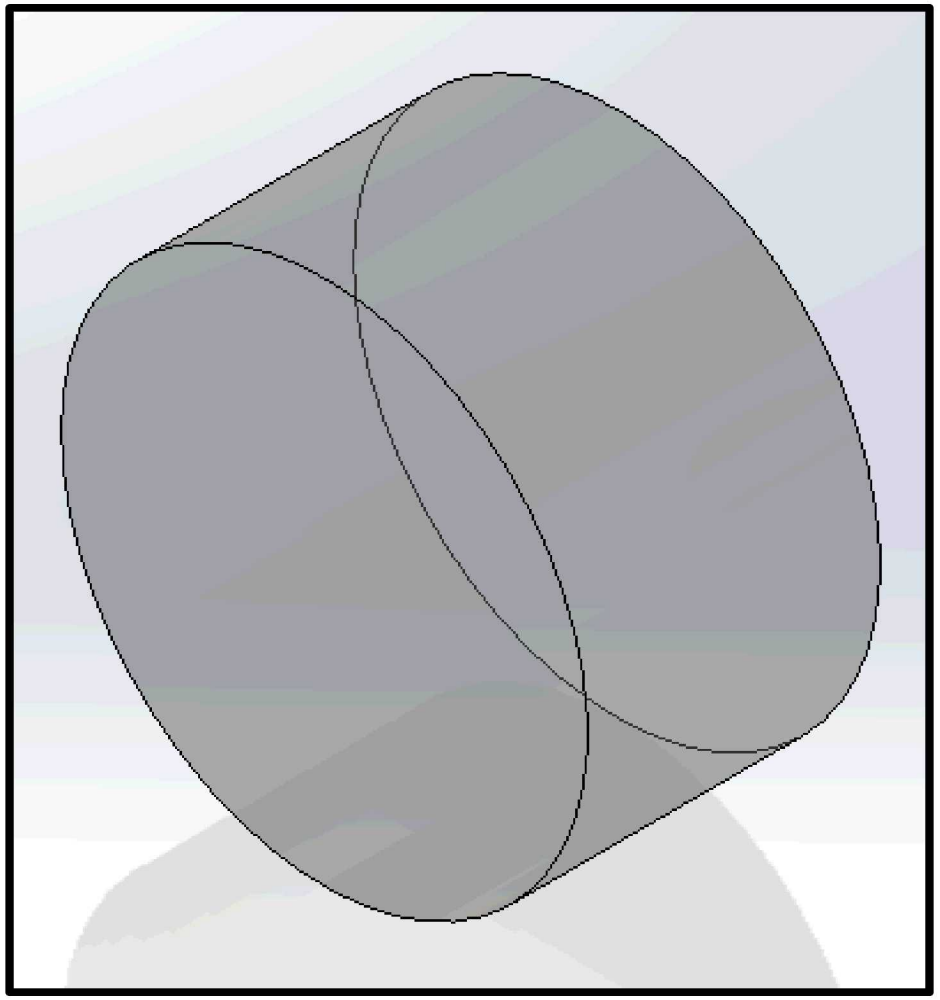


Optical Alignment Procedure

The alignment is performed with the engine cold and verified with the engine warm

1. Set up the computer for imaging and assemble the fiberscope and mounting fixture outside of the engine
2. Install the fiberscope and mounting fixture onto a selected duct inside the engine
3. Fire a high-pressure fuel spray onto the target window and capture an image of the target window
4. Transfer the image to an analysis software on the computer and determine the alignment
5. Add spacers or rotate duct to adjust the height and rotational alignment. Repeat Steps 3-5 until satisfactory alignment is achieved. May need to clean the target window between spray events
6. Remove the alignment components from inside the engine and clean

Target window



- Allows for viewing of the fuel-spray impingement at the duct entrance plane
- Protects the fiberscope lens and illumination from fuel-spray event

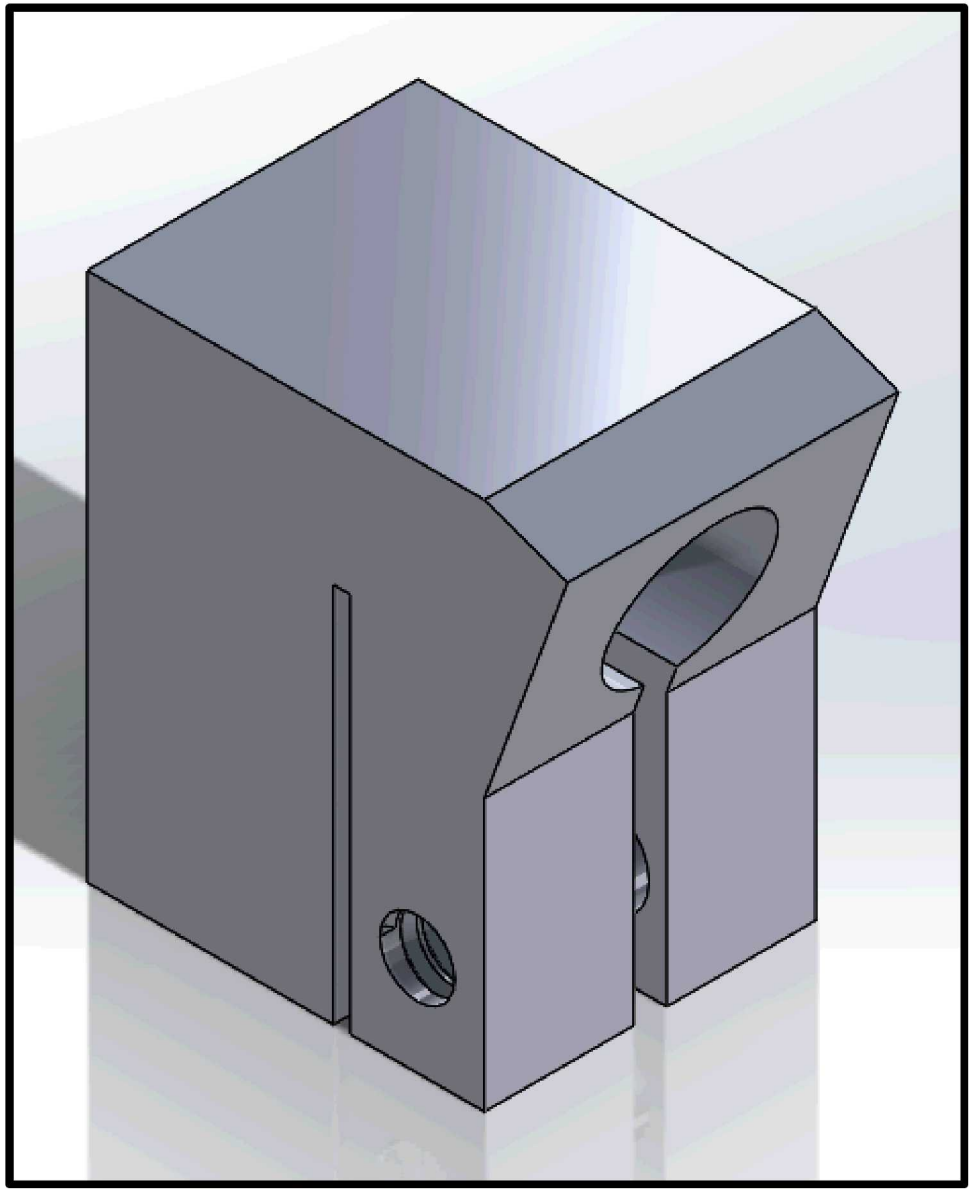
Fiberscope and Camera

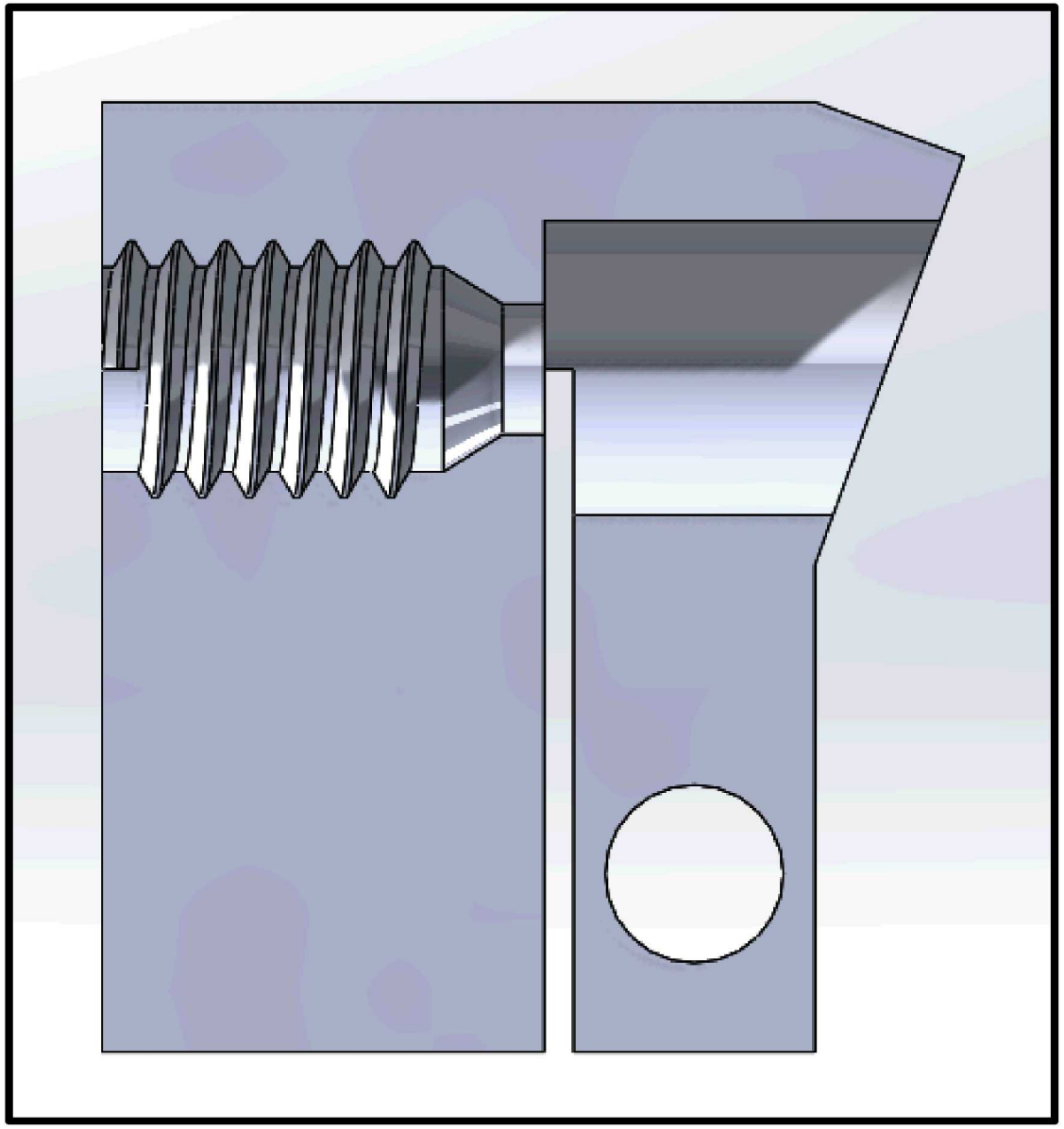
- The fiberscope images the spray event inside the combustion chamber
- An LED-based white/UV light source is utilized for image illumination
- A high-speed camera captures the images of the spray event from the fiberscope

Coupler tube

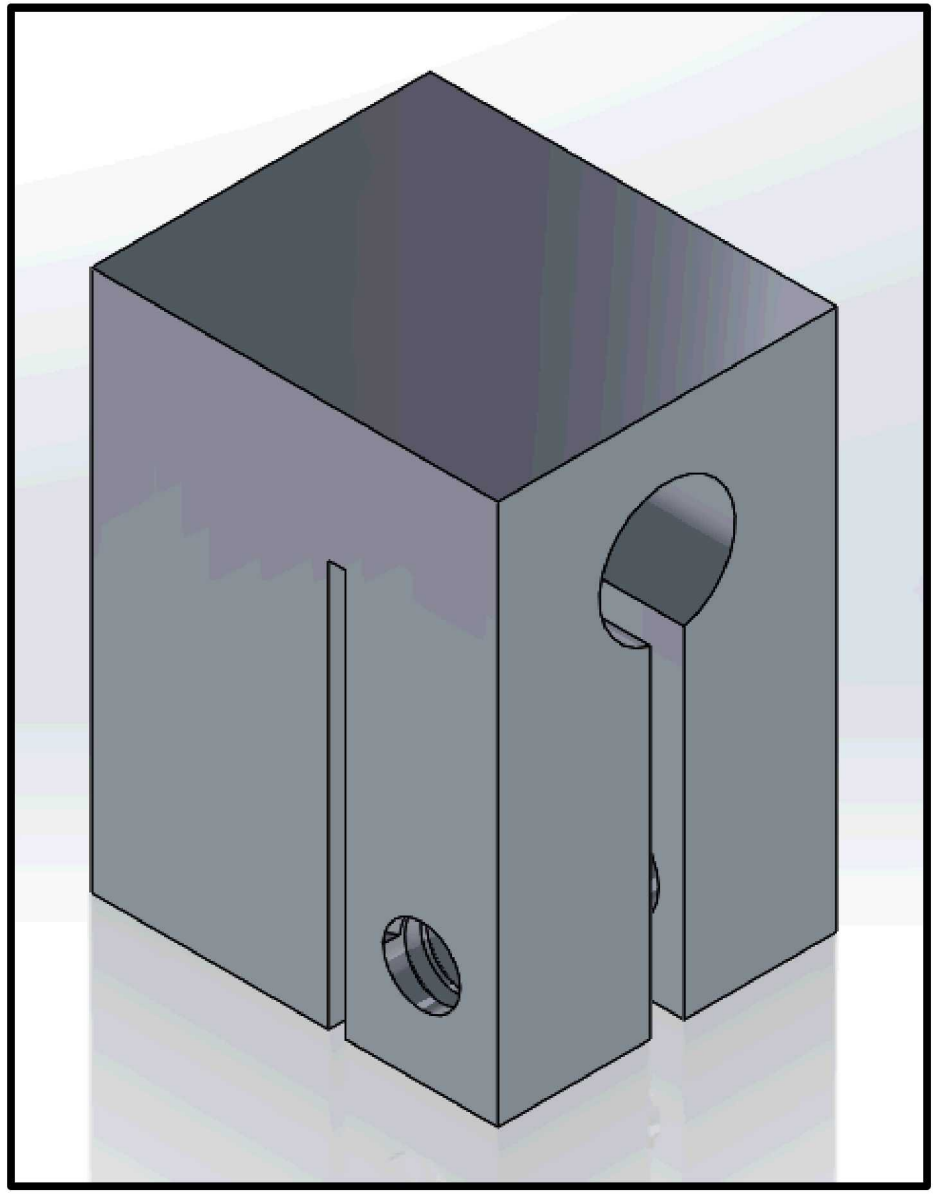
- Couples the target window and the fiberscope for easy insertion and removal
- Counterbore design to ensure alignment between the window and the duct axis

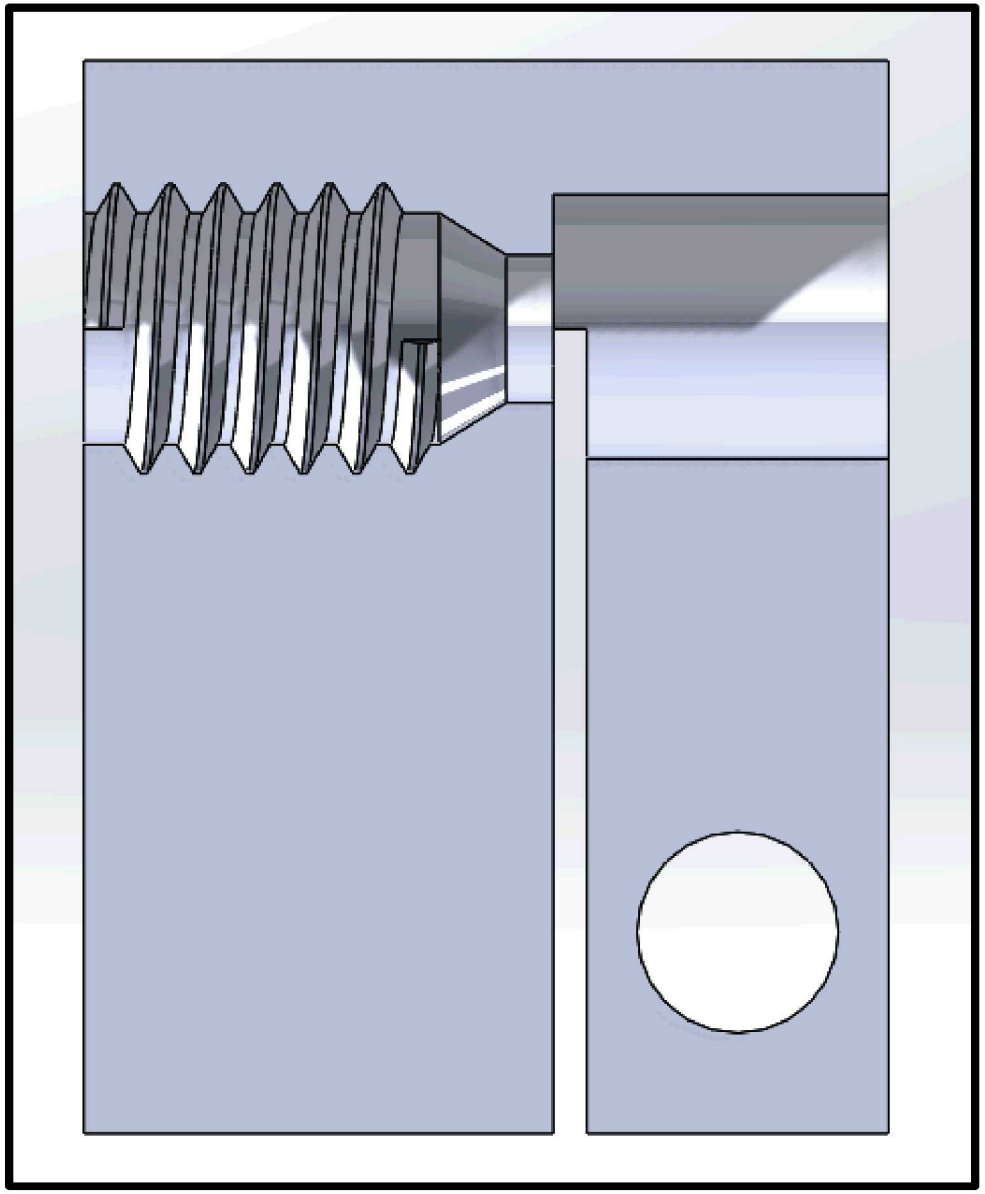
Mounting Block for Modular Duct Assembly



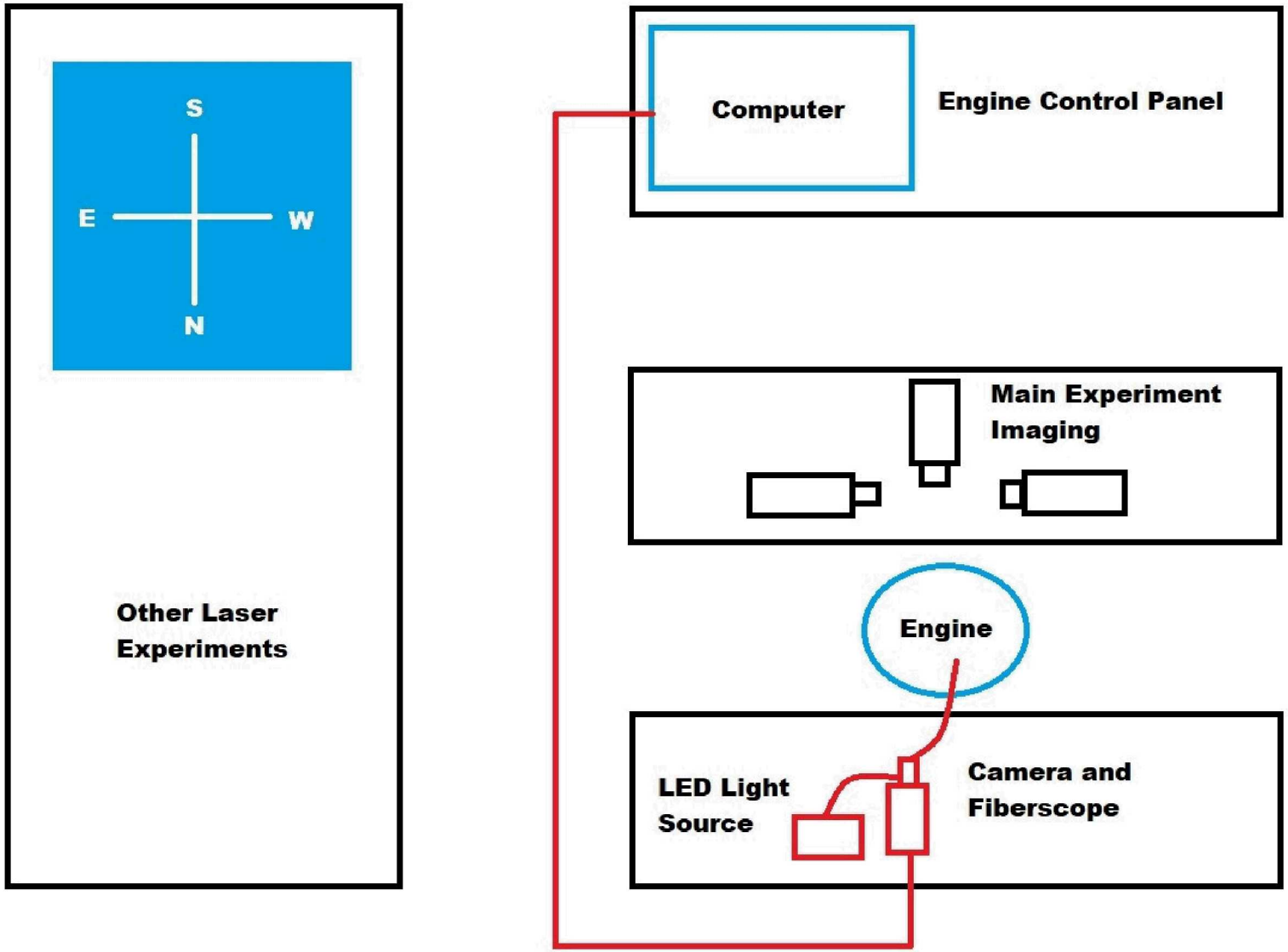


Mounting Block for Integrated Duct Assembly





Placement Diagram



Benefits of the New System

- Reduces dependence of accurate alignment on the experimenter by making the system digital
- Increases repeatability as the fiberscope and the target window can remain in the duct during alignment adjustments
- Is applicable for both integrated and modular duct assemblies
- May be set up and implemented by one person without needing to insert tools inside the engine

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Questions?