

## S&T Campaign: Sciences for Maneuver Energy and Propulsion

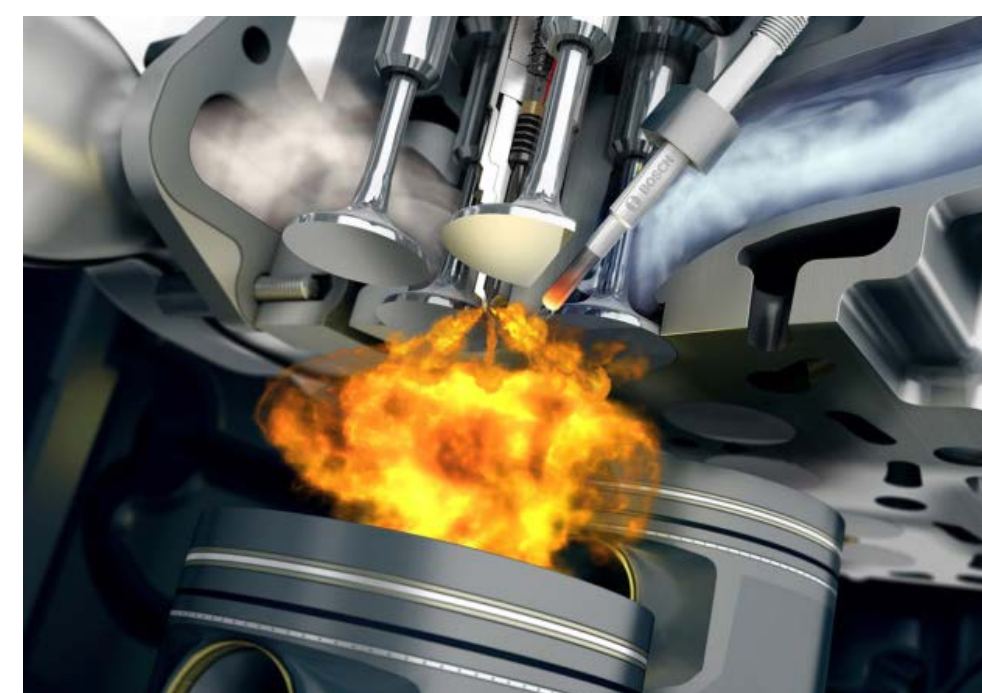
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## Research Objective

Develop innovative propulsion component technologies by improving fuel-air mixing and combustion to extend the operation capabilities of Unmanned Aircraft Systems (UAS).



Small Engine Altitude Research Lab



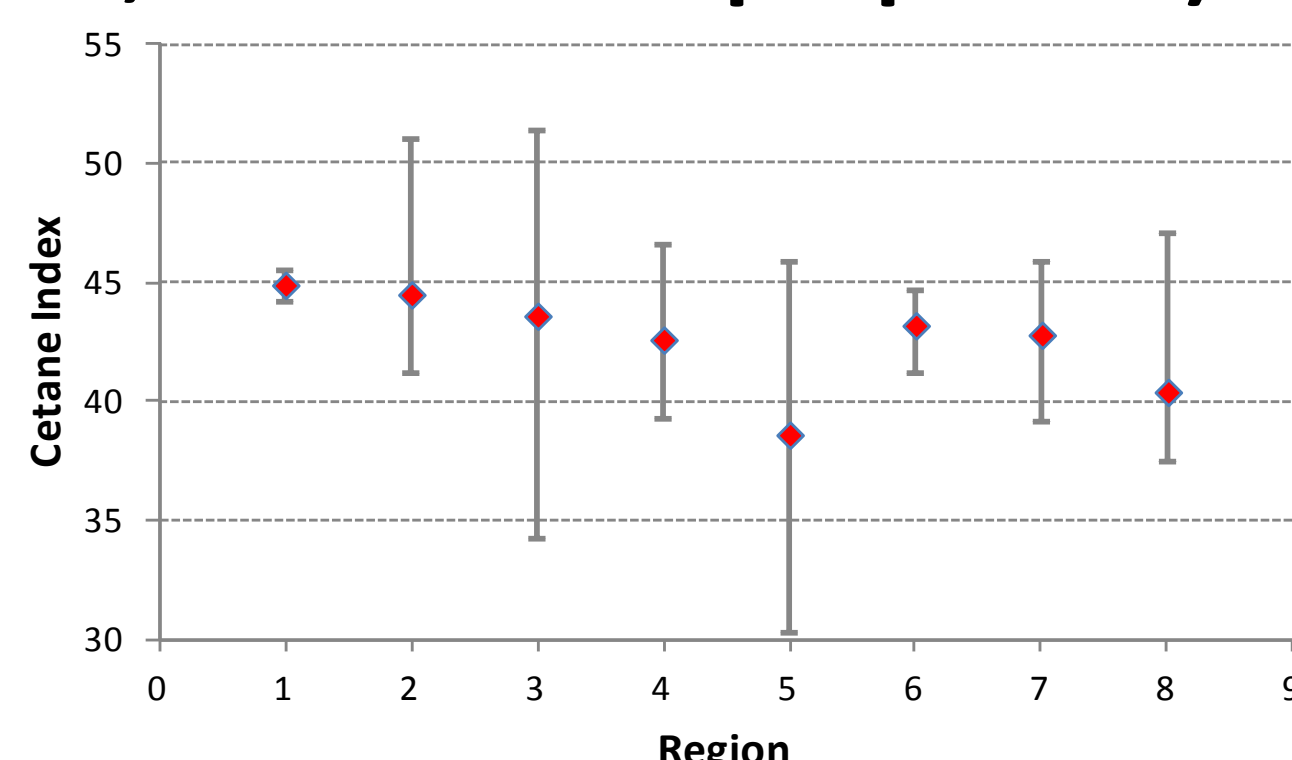
Engine Combustion

## Challenges

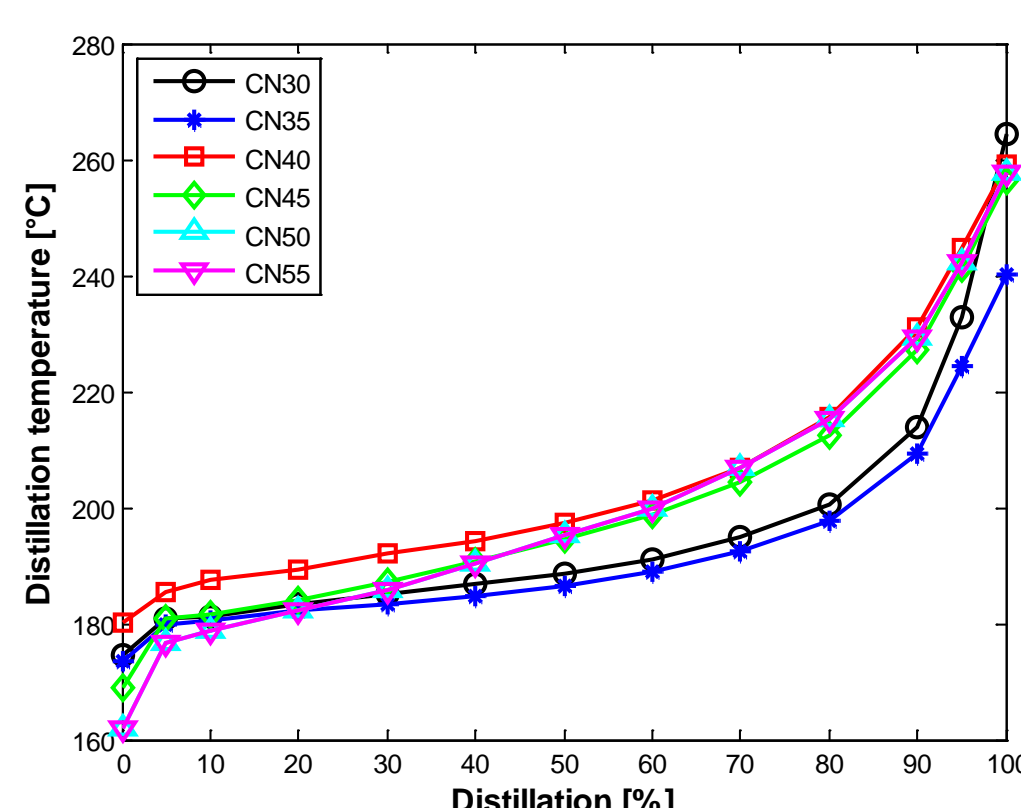
- Existing engines suited for the power demands of UAS were designed for ground use. These engines experience erratic combustion at high altitudes.
- Small engines exhibit larger heat losses that are detrimental to efficient combustion.
- Small engines need shorter liquid and vapor penetration lengths. These engines require micro or novel nozzle concepts. Current state-of-the-art nozzle drilling technologies are limited to  $\sim 70\mu\text{m}$  without compromising nozzle quality.
- Fuel physical and chemical properties are difficult to control independently (i.e., interrelated properties).



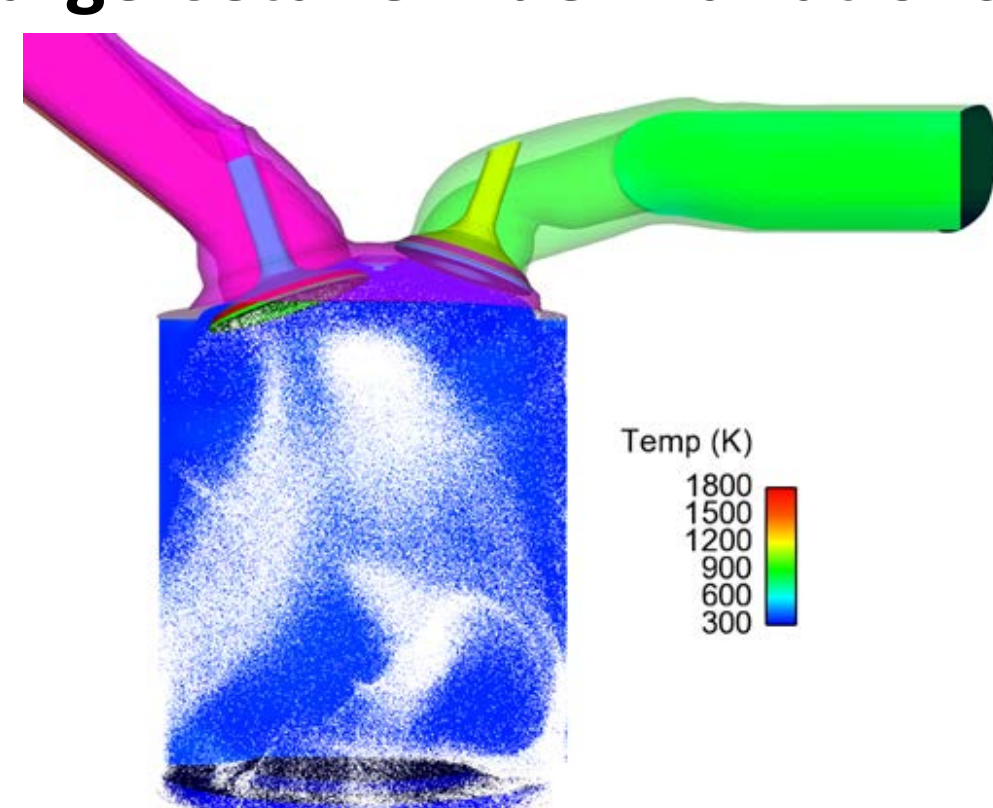
Opposed Piston Engine



Cetane Index (PQIS 2012): Large Cetane Index Variations



Distillation temperature ranges for fuels with varied cetane number



Direct Injection Fuel Spray Computational Fluid Dynamics (CFD)

## ARL Facilities and Capabilities Available to Support Collaborative Research

- Altitude chamber simulating from sea level to 25,000 ft and  $-40^{\circ}$  to  $130^{\circ}\text{F}$  temperatures with two AC dynamometers to handle 1 to 250 hp engines and speeds up to 30,000 rpm using an inline torque meter
- One dual-ended AC dynamometer system (302 hp, 535 nm, 11,000 rpm max) and two inline torque meters
- Three fuel benches for fuel conditioning and fuel consumption measurements
- Two advanced master data acquisition and control systems with full control of fuel injectors and actuators, and real-time combustion analysis and monitoring
- One Altech emissions bench, one AVL Opacimeter, and one combustion noise meter
- A variety of commercial and novel engines available for study, including diesel, optical, rotary and opposed piston
- Vibrational analysis of propulsion systems using accelerometer arrays; research-grade microphones for acoustic analysis
- Advanced 1-D and 3-D CFD engine analysis capabilities



Small Engine Combustion Research Lab



Thermal/Optical Engine

## Complementary Expertise/Facilities/Capabilities Sought in Collaboration

- Innovative new engine concepts and technologies
- High-temperature material expertise for small engine combustion applications
- Energy recovery system from engine exhaust and cooling system
- Advanced engine instrumentation and testing methods
- Advanced optical diagnostic techniques applied in optically accessible engines
- Innovative, high-pressure, fuel injection technologies
- Engine vibration and acoustic expertise
- Expertise in advanced combustion control algorithm development