Modifications to Solar Titan-130 Combustion Systems for Efficient, High Turndown Operation

DE-EE0008415

SwRI, Solar Turbines, EPRI, UC Irvine, Georgia Tech

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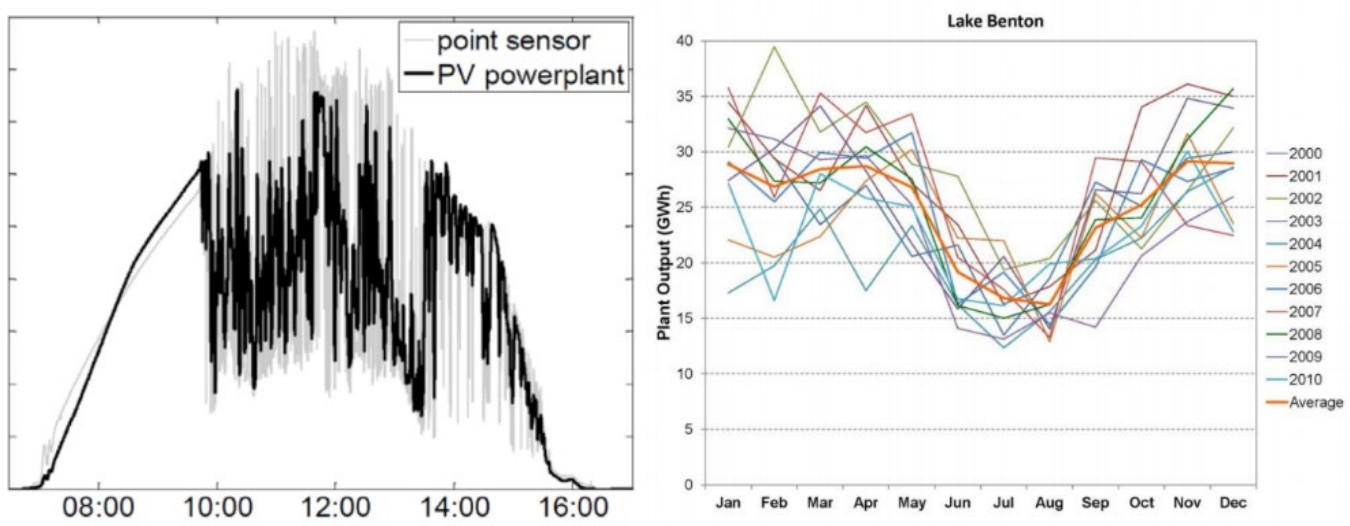
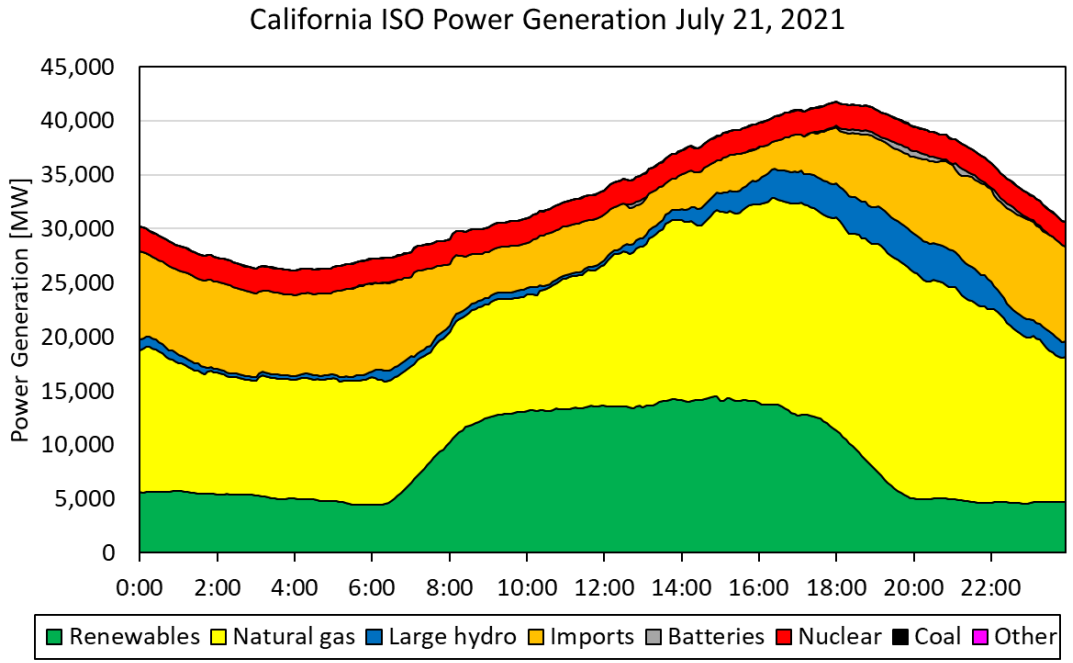
This presentation provides an overview of the work to modify a Solar Titan-130 to enhance high turn-down operations.

- Project Motivation
- Accomplishments in BP1
- Current Status of BP2

Increased renewable power generation offers an opportunity for small- to medium-scale CHP.

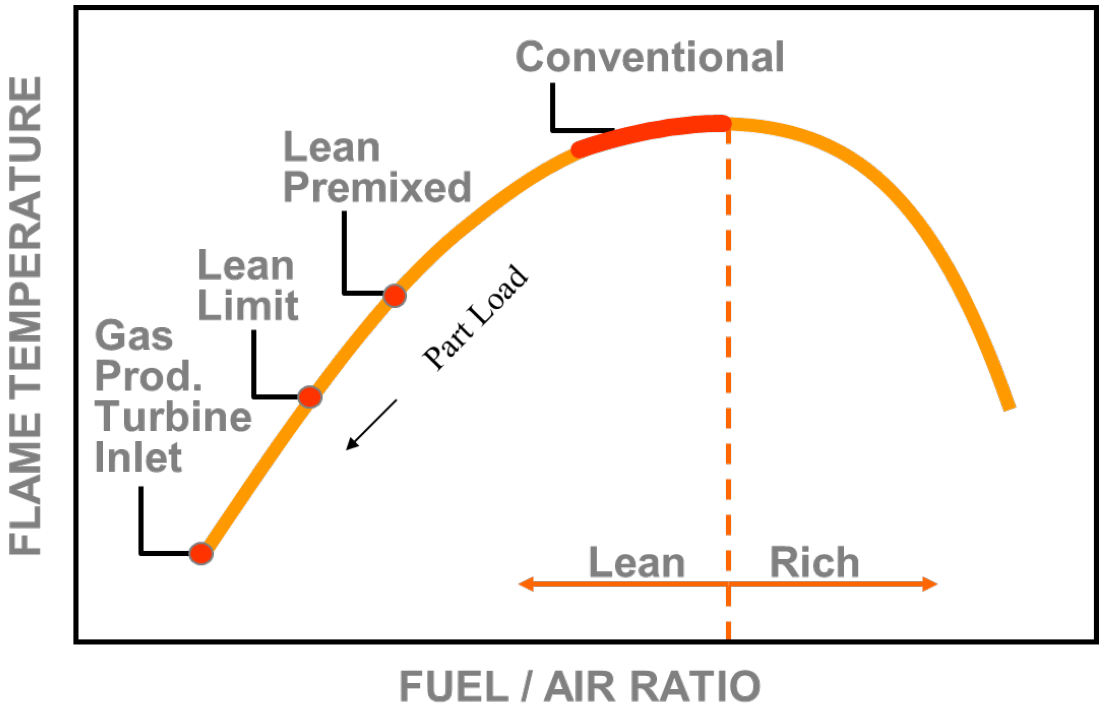


Solar PV Daily Variability (top left) and Wind Farm Annual Variability (top right)

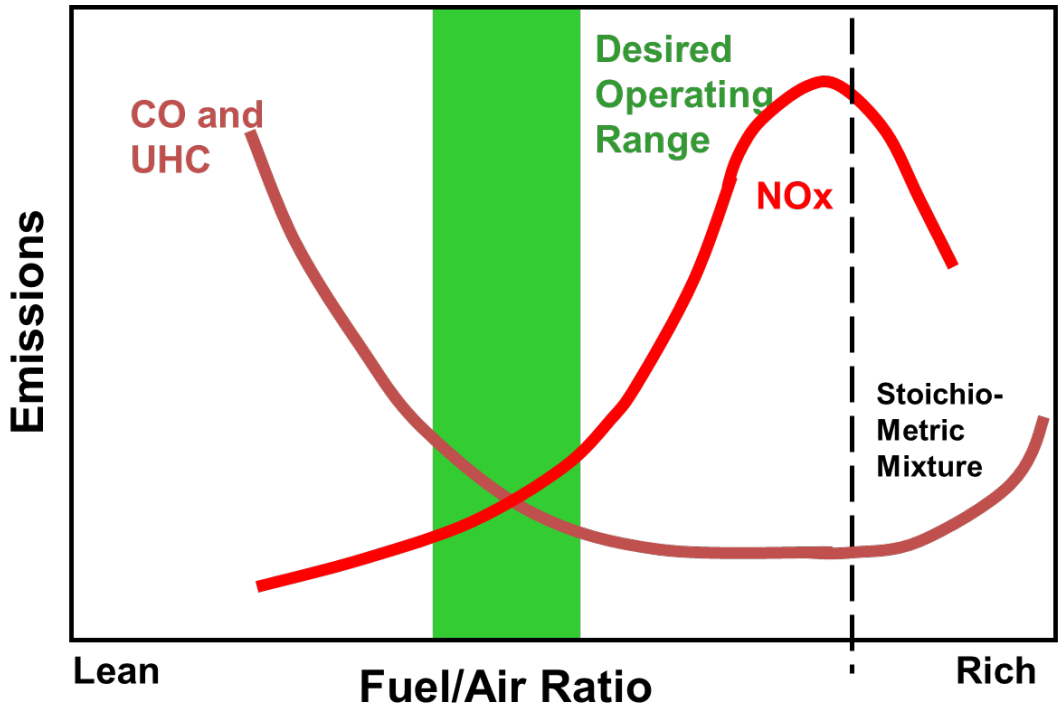


Operating a gas turbine-based CHP at part load would allow for a significant “spinning reserve” that could be available to local grid support.

Operating at part-load presents some technical challenges.



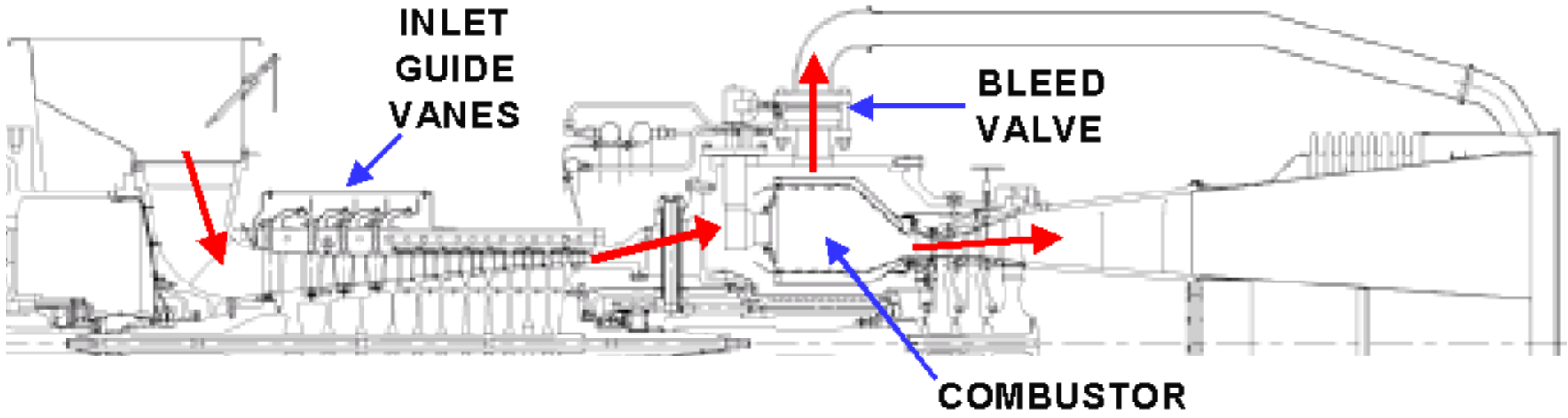
Dry low emission (DLE) combustion systems operate *close* to the lean extinction limit (or lean blowout (LBO)).



CO and UHC can increase at part-load operating conditions.

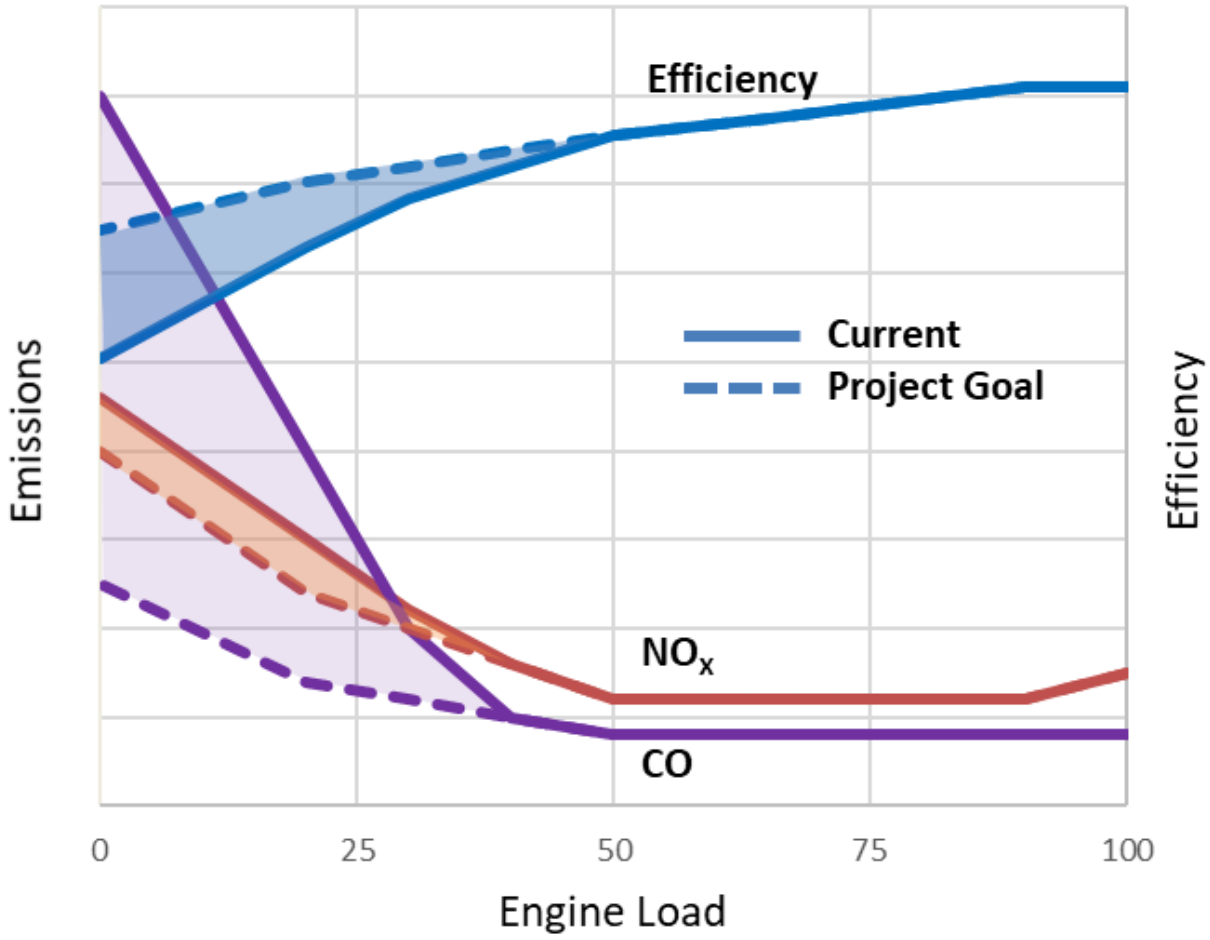
Current high turn down operation of the T130 requires the use of variable inlet guide vanes (IGV)

- At high turn down operation (greater than 50%) the combustion becomes too lean and unstable (see previous slide)
- To combat this, air flow through the combustor is reduced by using inlet guide vanes or compressor bleed
- Both of these solutions yield efficiency penalties



The project goal is to *extend* the operating limits of a Solar T130.

- Develop a combustion system capable of allowing high gas turbine efficiency over a wide range of loads while maintaining emissions compliance.
- Improve overall gas turbine performance by increasing combustor performance at low loads
  - Decreasing compressor bleed and IGV use
  - Reduce CO and UHC emissions
- The increased efficiency will decrease cost to operate small scale CHP gas turbines
- Increase market penetration of small/medium sized CHP systems for grid support

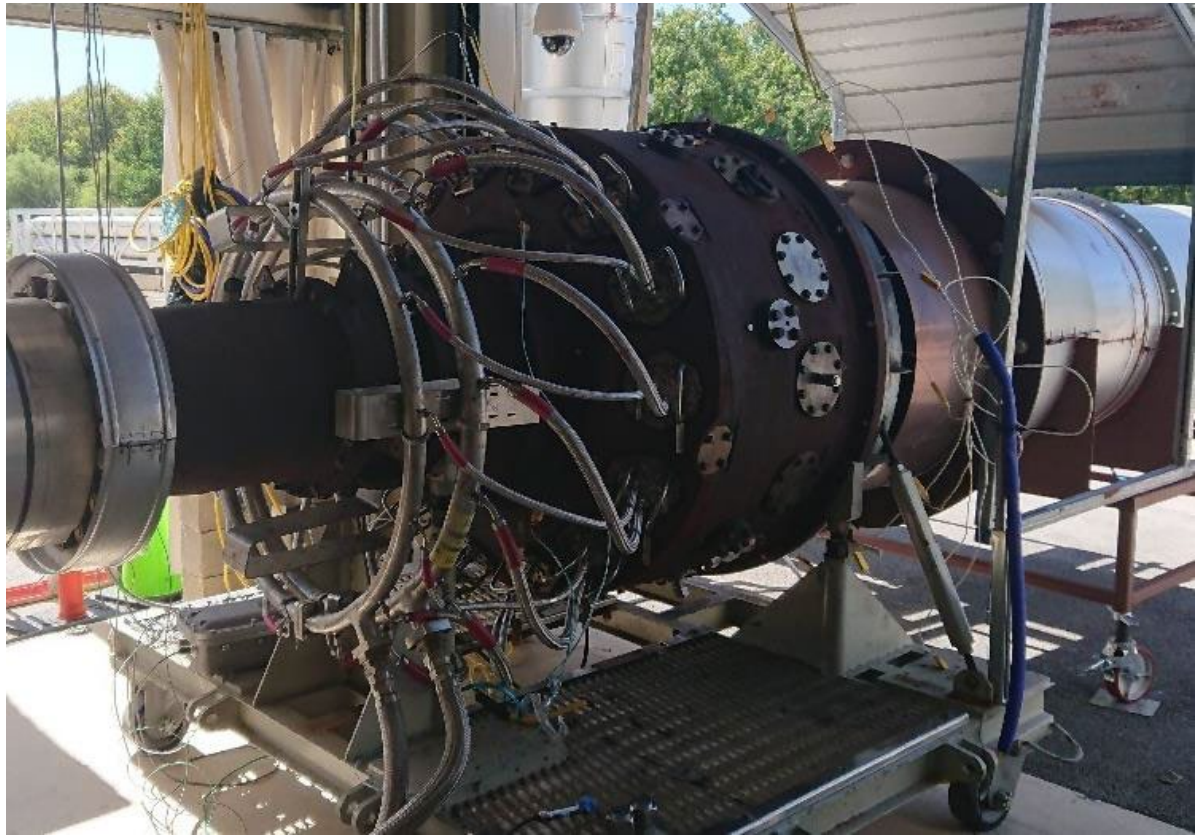


Concepts to improve high turndown performance were selected and one concept was tested in BP1.

- Efficiency improvements to the gas turbine by improved combustor performance will pursue two lines in inquiry
  - What can be done to improve part load performance of the current system?
  - What level of performance can be achieved with a new combustion system?
- Concept Selection (SwRI, Solar, UCI)
- Detailed Design (Solar)
- Validation testing (SwRI, Solar, GT)
- Benefits study (EPRI, Solar, UCI)

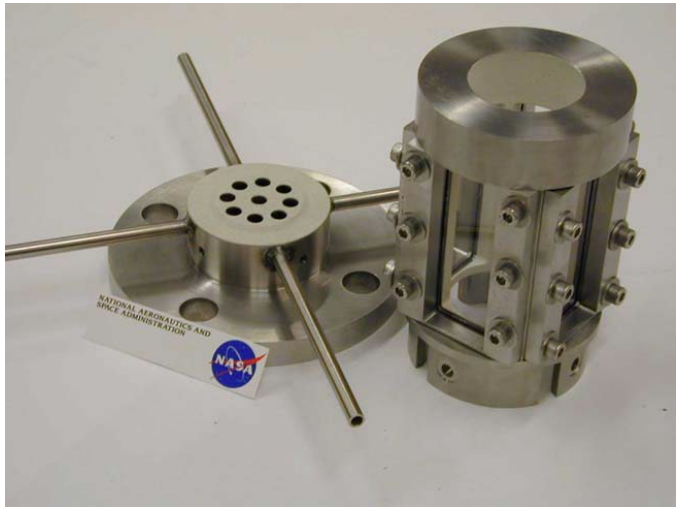
Atmospheric combustion tests were conducted in BP1 with the existing T130 combustion system

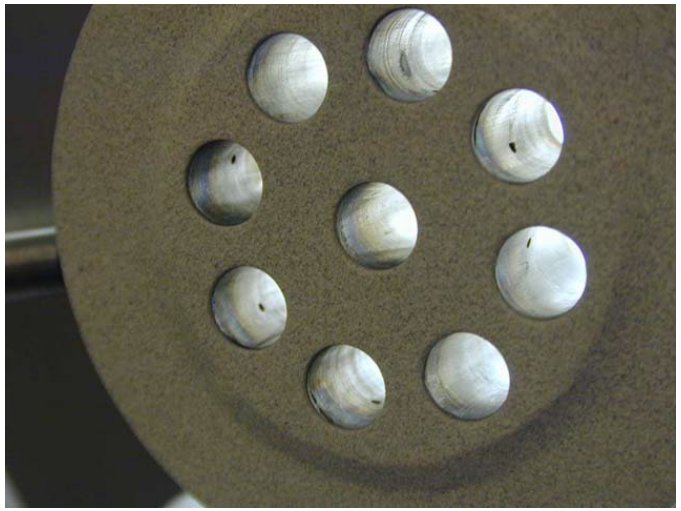
- Atmospheric tests investigated: load percent, **hydrogen (H_2) content**, pilot flow
- Goal: identify whether LBO limit can be extended

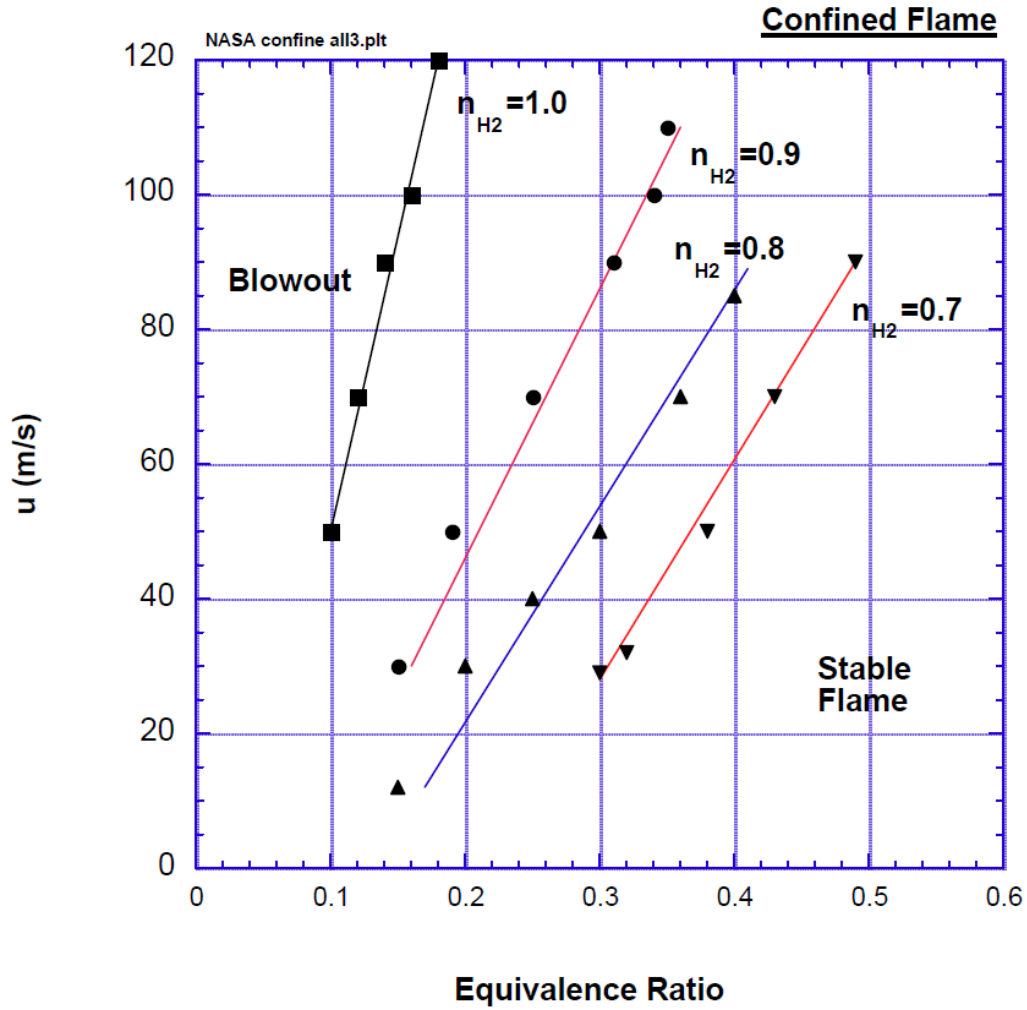


Annular Atmospheric Combustor Test Rig

The addition of H_2 has been shown to extend the LBO limit in previous works.

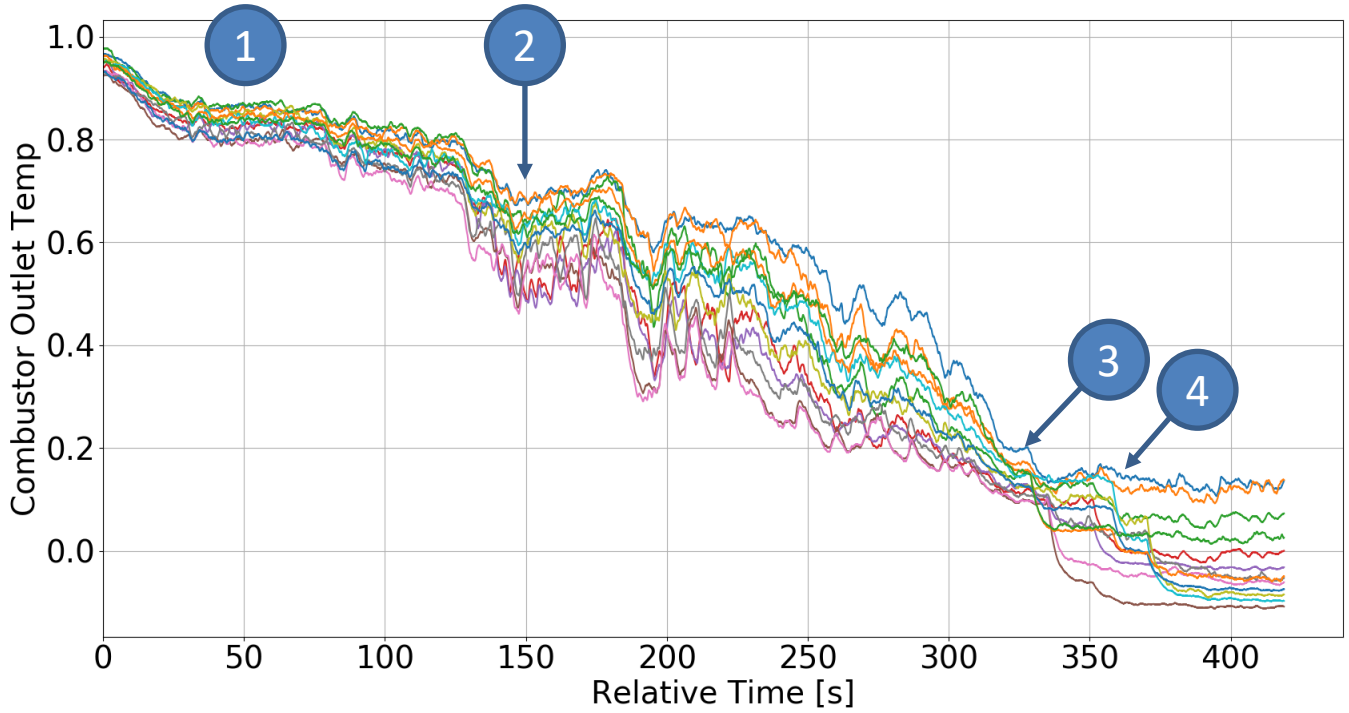






Schefer, Robert W. *Evaluation of NASA lean premixed hydrogen burner*. No. SAND2002-8609. Sandia National Lab.(SNL-NM), Albuquerque, NM (United States); Sandia National Lab.(SNL-CA), Livermore, CA (United States), 2003.

Combustor outlet temperature was monitored to identify the onset of LBO.



Thermocouples at the combustor outlet were used to detect LBO.

With the addition of H2, the LBO limit was extended.

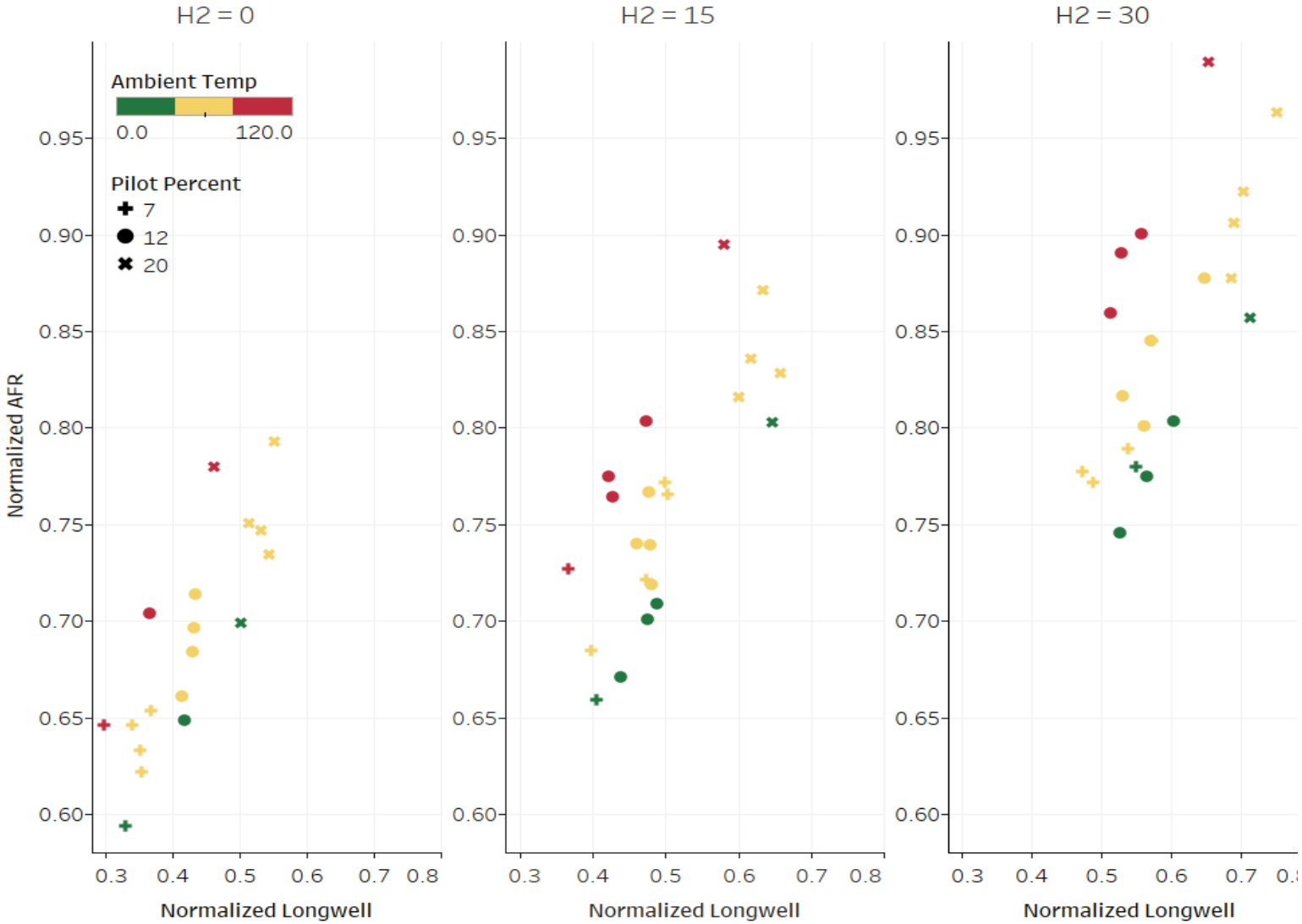
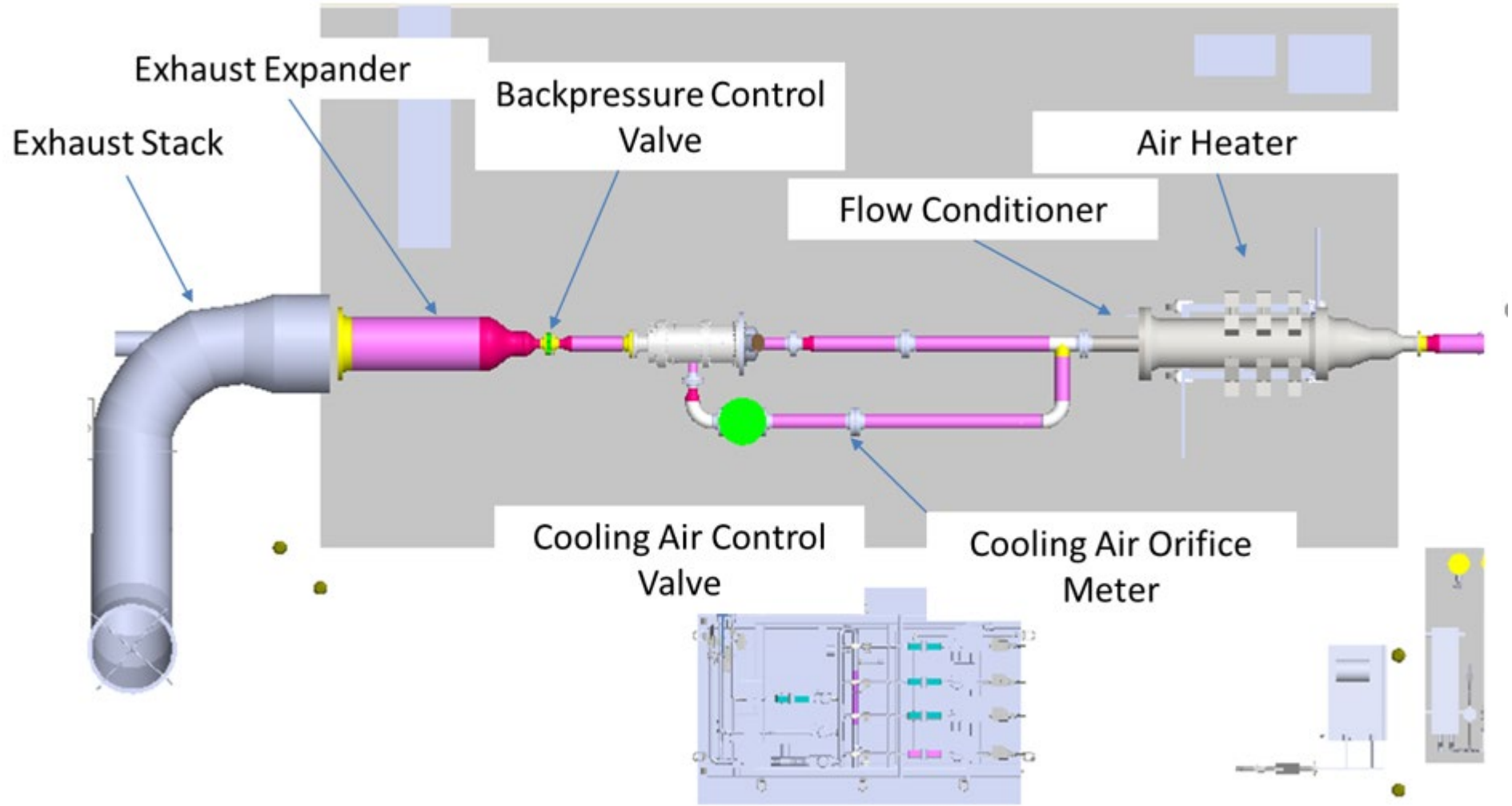
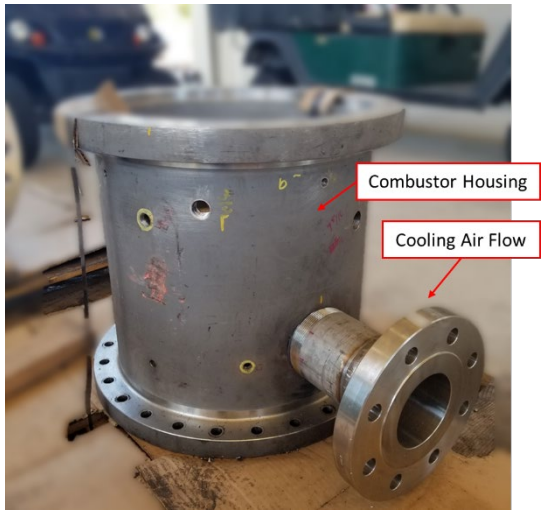


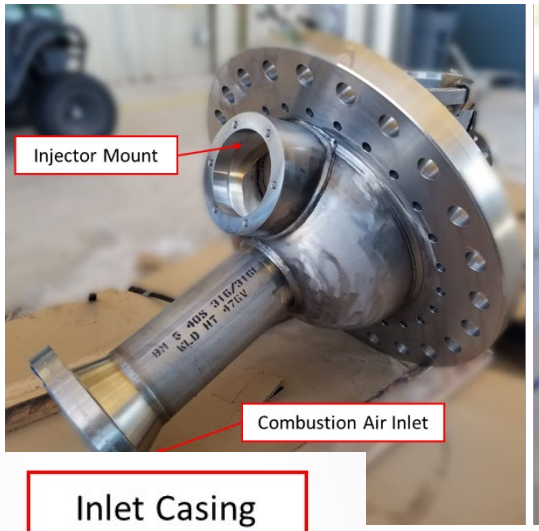
Figure 1. Results from Atmospheric Testing

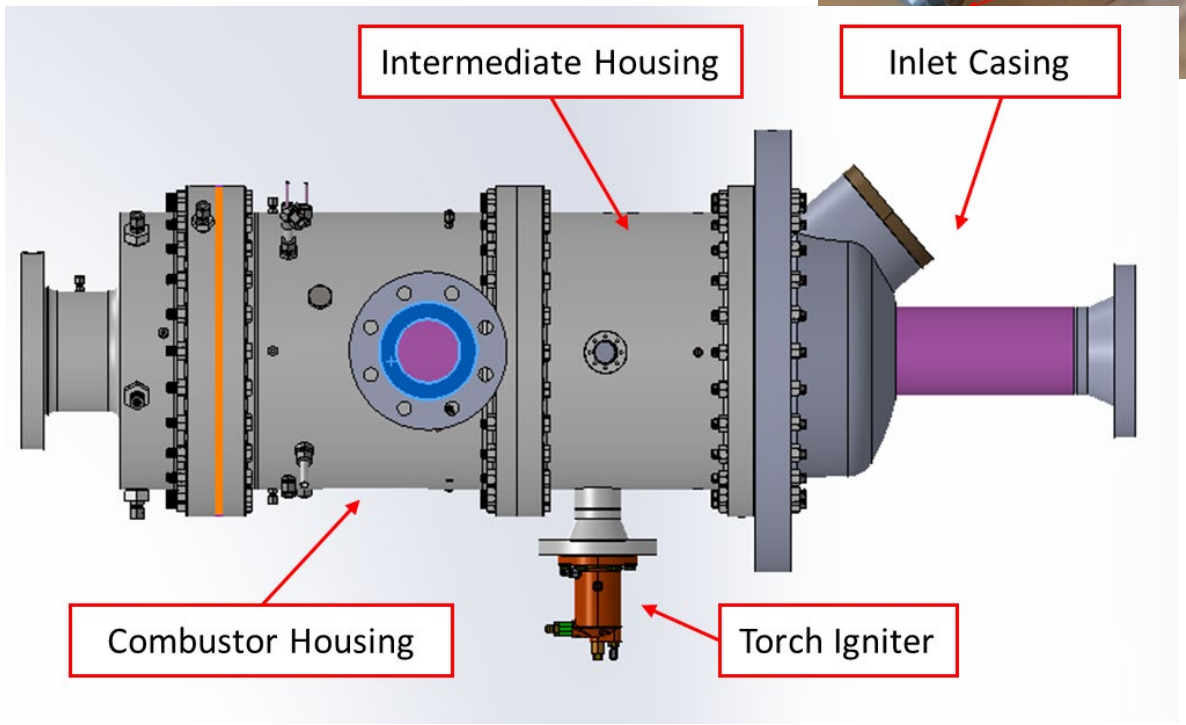
In the BP2 effort, a new injector concept will be tested in a pressurized combustor test rig.

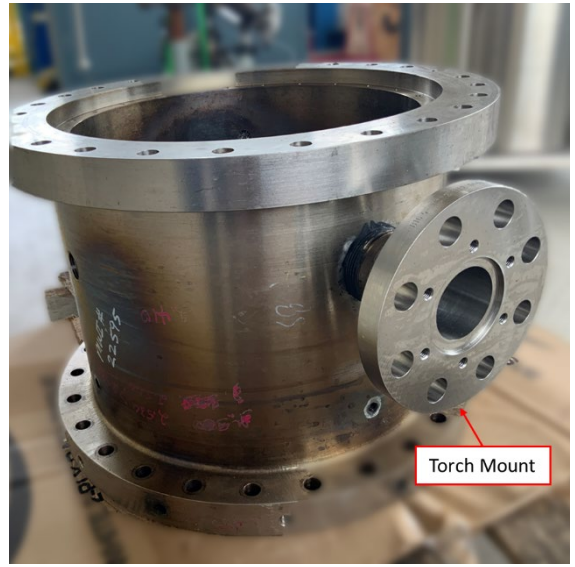


A high-pressure, single-injector rig was designed and fabrication is underway.

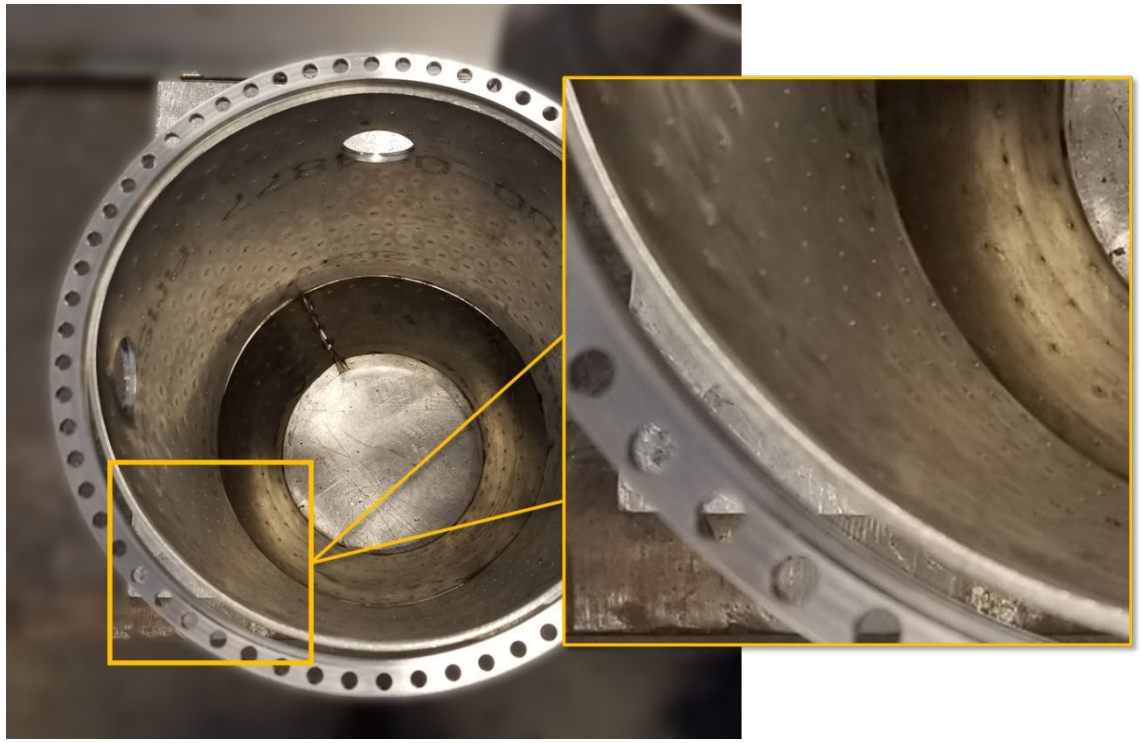








Current effort is focused on finalizing the combustor liner design.

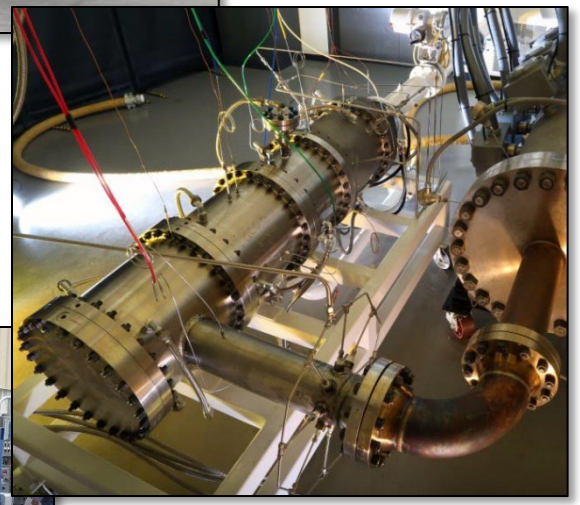


Initial attempt to manufacture the cooled, combustor liner yielded out-of-spec parts.

- Redesign to pursue AM
  - Hastelloy X
  - Geometry modifications to accommodate AM process
- Apply thermal barrier coating (TBC)
- Commissioning/Testing
  - Complete by end of CY2022

Acknowledge:

- Bob Gemmer and Aaron Yokum for their support of DE-EE008415
- Our project partners and contributors at Solar Turbines, EPRI, UC Irvine, Georgia Tech



Questions?