

# FAA CLEEN II Technologies

## Rolls-Royce Program Overview, Unlimited Rights/Public

Presented to: CLEEN Consortium, Atlanta GA

By: Brad Belcher, Program Manager

Date: May 4, 2016

<i>Jurisdiction</i>	<i>Export Classification Rating</i>	<i>Date</i>
United States	NO TECHNICAL DATA	04/28/2016 by BDB

Trusted to deliver excellence

Public Release Approval V161046



Rolls-Royce

# Elevator Speech

Under CLEEN II, Rolls-Royce is developing an advanced Rich-Quench-Lean (RQL) combustion system employing advanced fuel injection and mixing technologies that will provide significant reduction in emissions while simultaneously enabling the increase in Turbine Entry Temperature required by advanced engine cycles. We will build upon prior Rolls-Royce development to demonstrate emission reductions in two phases ultimately targeting NOx emission levels 65% below CAEP/8.

Rolls Royce will support the development and introduction of renewable alternative fuels under CLEEN II by working with the FAA to select an acceptable alternative jet fuel, then test it back-to-back with conventional fuel to assess the fuel impact on combustor performance and emissions. Rolls Royce will also assess elastomeric seal material compatibility with the fuel using the innovative Elastocon rig capability developed and demonstrated under CLEEN I.



# Project Purpose and Description

**Rolls Royce Corporation is pleased to partner with the Federal Aviation Administration (FAA) Continuous Lower Energy, Emissions and Noise (CLEEN) II Aircraft Technology and Alternative Jet Fuel Development program, to address the following goals:**

- 40% fuel burn reduction**
- 65% CAEP8 nitrous oxide (NOx) reduction**
- Alternative fuels feasibility**

**Rolls Royce will address these challenges in the CLEEN II program with efforts in the following areas:**

- Advanced RQL Low NOx Combustion System**
- Alternative Jet Fuel Test and Evaluation (Area A)**



# Project's Expected benefits

**Rolls Royce offers leading technologies in areas of cycle efficiency improvement, emissions reduction, and alternative fuels that work together in future engine architectures to provide significant contributions to the CLEEN II goals.**

**This approach leverages the substantial technical developments and financial commitments of Rolls Royce to deliver significant value to the CLEEN II program.**

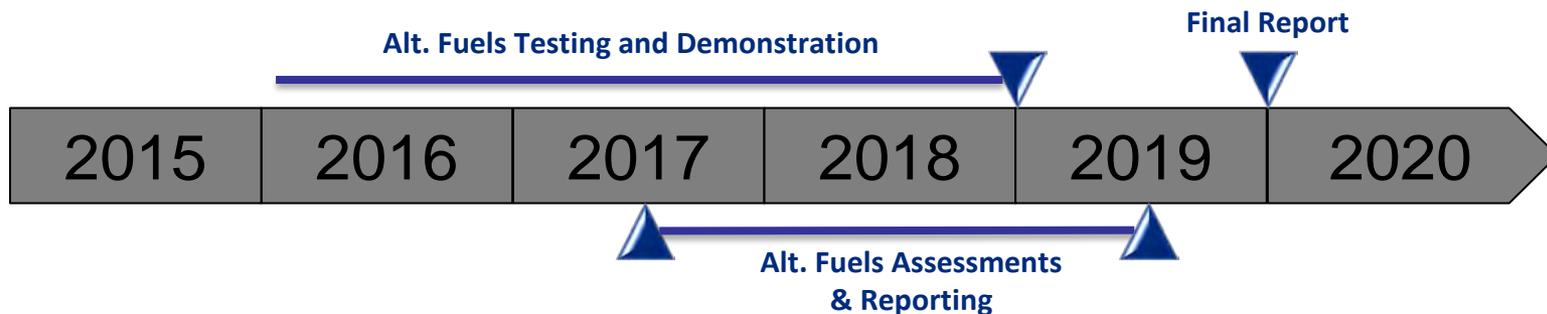
**These environmentally friendly technologies target component and system optimization, and will position Rolls Royce for fleet engine retrofit opportunities as well as new product applications.**

**Further, because of their broad applicability, we will be well-positioned to implement the technologies developed under CLEEN II in multiple civil engine products before 2026, accelerating their penetration into the commercial aircraft fleet.**

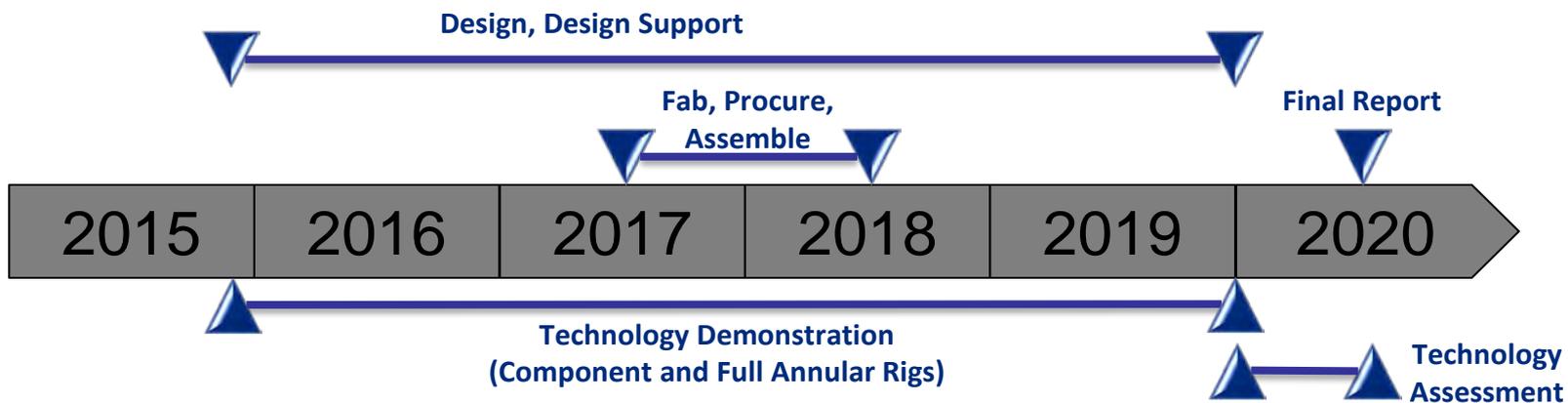


# Program Status Schedule

## Alternative Fuels



## Advanced RQL Low NOx Combustion System

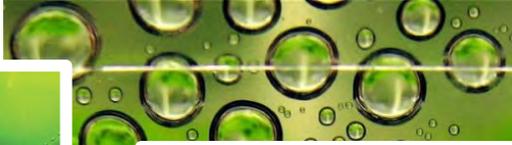
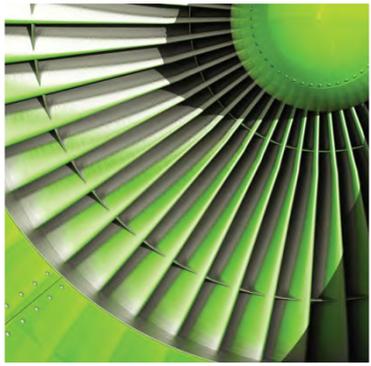


# CLEEN Technologies

CLEEN Technology Name	Goal Impact	Benefits and Application
Alternative Jet Fuel Test and Evaluation (Area A)	Alternative Fuels	Promote the development and introduction of viable, renewable alternative fuels to achieve the NextGen Air Transportation System goals.
Advanced RQL Low NOx Combustion System	NOx Reduction	Demonstrate a RQL combustor with 65% reduced NOx relative to CAEP/8 limits.



# Alternative Jet Fuel Test and Evaluation



## Benefits:

- *Enhanced tools for predicting fuel performance to support reduced cost and timescale of approvals*
- *Greater data and test capability to support environmental benefits (i.e., local air quality, increasing regulations)*
- *Renewable, synthetic alternative jet fuel for aerospace gas turbine engine applications will provide reduced aerospace environmental impact and increased energy security.*
- *The outcome of this program will complement the work being carried out by the CAAFI and ASTM Aviation Fuel groups for the evaluation and qualification of viable alternative fuels.*

## Objectives:

- *Promote the development and introduction of viable renewable alternative fuels-NextGen Air Transportation systems goals*
- *Improved tools for predicting fuel performance and understanding:*
  - *Fuel chemistry/properties relationship upon combustor performance, operability and emissions*
  - *Low aromatic fuel effects on elastomer behavior*
- *Data generated will aid in ASTM certification*

## Work Statement:

- *Utilize combustion rigs and the low NOx combustor to assess the fuel impact on performance, operability and emissions*
- *Assess elastomeric seal performance using the innovative Elastocon rig*
- *Conduct back-to-back engine testing to fully characterize engine performance and emissions.*

## Risks/Mitigations:

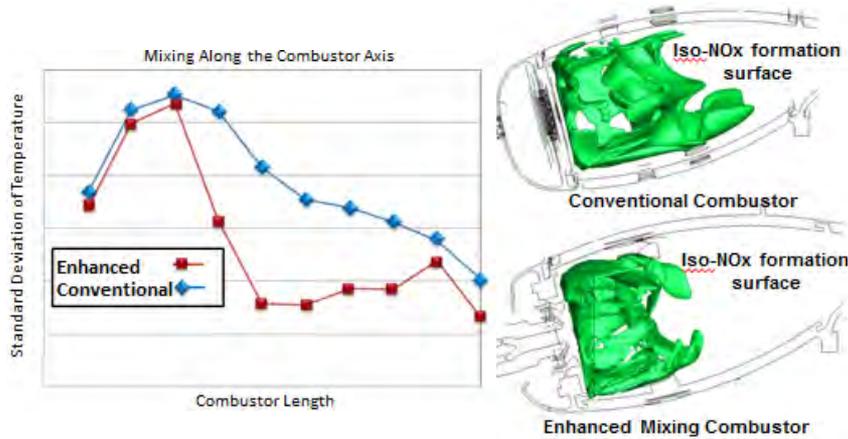
- *Demo engine not available in time / Identify alternate test vehicle*
- *Insufficient quantities of fuel available for engine test / TBD (need input from fuel source)*

## Accomplishments/ Milestones:

- Program kick-off



# Advanced RQL Low NOx Combustion System



## Anticipated Benefits:

- Significant NOx reduction
- Negligible operability impact
- Highly cost effective
- Technology capable of broad product insertion

## Risks/Mitigation Plans:

- Rigs planned for component and system development

8

## Objectives:

- Implement advanced wall cooling, innovative fuel injection, and novel mixing aerodynamics to reduce NOx pollutant emissions to levels 65% below the CAEP8 guidelines.

## Work Statement:

- Design an enhanced rapid quench, rich burn combustion system and demonstrate system performance

## Accomplishments/ Milestones:

- Launched preliminary design

# Summary

- **Rolls-Royce has launched CLEEN II efforts**
  - *Alternative Jet Fuel Test and Evaluation (Area A)*
  - *RQL Low NOx Combustion System*
  
- **Rolls-Royce CLEEN II efforts will directly address FAA CLEEN program goals**
  - *Promote the development and introduction of viable, renewable alternative fuels to achieve the NextGen Air Transportation System goals.*
  - *Demonstrate a RQL combustor with 65% reduced NOx relative to CAEP/8 limits.*

