Piston Aviation Fuels Initiative (PAFI)

Stakeholders Workshop

Presented by: Dave Atwood and Monica Merritt

March 18, 2014

Federal Aviation Administration

Objective

- Coordinating Research Council
- Unleaded Avgas Transition Aviation Rulemaking Committee, (UAT ARC)
  - Issues
  - Recommendations & Key Accomplishments
- Why Replacement Fuels for General Aviation
- Piston Aviation Fuels Initiative, (PAFI)
- Piston Aviation Fuels Initiative Steering Group (PSG)
- Screening Information Request (SIR), Candidate Fuels, and Tech Center Testing
- Canada and US Collaboration
- Fleet Wide Certification

Coordinating Research Council

- The purpose of the CRCAGC research was not to formulate a commercial blend but to conduct research available to industry as a means of facilitating industry evaluation of unleaded avgas alternatives.

- Two working groups were formed:
  - Unleaded Aviation Gasoline Development Group (UADG)
    - Goal: 100% Transparency
      - Replacing 100 low-lead (100LL) “gold standard” aviation gasoline
    - Full-scale engine evaluation of potential unleaded components
  - Octane Rating Group (ORG)
    - Goal: Determine fleet octane requirement for unleaded fuels
    - Legacy fleet designed, tested and certified on available leaded fuel

Coordinating Research Council Research (UADG)

- Focus on motor octane (MON)
  - Developed matrix of high-octane potential blend components such as: renewables (ethanol), aromatic hydrocarbons (*tert*-Butylbenzene, toluene), oxygenates (ETBE), aromatic amines (*meta*-Toluidine), alkylates (super, aviation, motor), manganese based additive (MMT)
    - Created 202 high-octane unleaded fuel formulations for full ASTM D-910 aviation gasoline specification laboratory analyses (funded by FAA TC)
    - Analytical modeling and statistical analysis of laboratory test results used to select 30 blends for FAA TC full-scale engine detonation testing (50 gallons each)
      - Determine MON vs. full-scale engine performance and blend composition
      - Compare MON unleaded to leaded fuel performance
      - "Full-Scale Engine Knock Tests of 30 Unleaded, High-Octane Blends", DOT/FAA/AR-04/25
    - Results from first 30 blends were used to create 47 new blends for FAA TC full-scale engine detonation testing (e.g. eliminated ethanol, mmt)
      - "Full-Scale Engine Detonation Tests of 47 Unleaded, High-Octane Blends", DOT/FAA/AR-08/40

Coordinating Research Council Research

- **Significant findings from FAA TC tests of 77 unleaded matrix fuels**
  - Unleaded blends required > 2 MON more to perform equal to the 100LL leaded aviation gasoline engine performance
  - For an unleaded blend to perform as well as the 100LL required 10% v/v aromatic amine, regardless of the MON, or other composition
    - Oxygenates, alcohols, toluene, and super alkylates would not get you there
    - Use of amines —specialty chemical, potential toxicity issues
    - No blend with MON equal to or less than the 100LL performed as well as the 100LL —significant safety issue
    - Results spurred further research comparing leaded and unleaded fuels
  - Two engines were tested using high and mid-octane fuels of same MON and supercharge rich rating made from typical aviation gasoline components
    - "High-Octane and Mid-Octane Detonation Performance of Leaded and Unleaded Fuels in Naturally Aspirated, Piston, Spark Ignition Aircraft Engines", DOT/FAA/AR-TN07/5
      - Mid-octane unleaded aviation fuels required 2 to 3 more MON to perform equal to leaded aviation fuels in full-scale engine
      - High-octane unleaded aviation fuels required 4 more MON to perform equal to leaded aviation fuels in full-scale engine

Coordinating Research Council Research

- **ASTM International Avgas Specification D 910 Task Force**
  - Engine data showed significant differences between leaded and unleaded fuels of the same octane
  - Task force recommended creating new unleaded aviation gasoline specifications
    - Mis-fueling was a stated safety concern
  - “High-Octane and Mid-Octane Detonation Performance of Leaded and Unleaded Fuels in Naturally Aspirated, Piston, Spark Ignition Aircraft Engines”, FR AR-TN07/5

Coordinating Research Council Research

Coordinating Research Council FAA TC Very-Low Lead Fuels Full-Scale Engine Testing

- Near term 20% reduction in current leaded avgas
- 2017 EPA date for state compliance with 90% reduced Pb NAAQS standard
- Used “worst-case” naturally aspirated engine
- Multiple fuels of varying Pb levels, production fuel base alkylate
- FAA TC fuel survey

CRC Research Report, Oct. 2010

CRC Report No. 657

INVESTIGATION OF
REDUCED TEL CONTENT
IN COMMERCIAL100LL AVGAS

REPORT
CRC PROJECT NO. CA-67-2010

OCTOBER 14, 2010

CRC

COORDINATING RESEARCH COUNCIL, INC.
3650 MANSELL ROAD·SUITE 140·ALPHARETTA, GA 30022

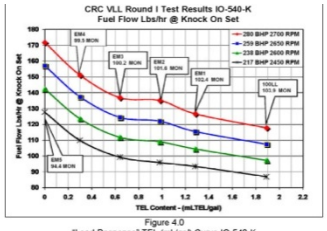


Figure 4.0
“Lead Response” TEL (mL/gal) Curve IO-540-K

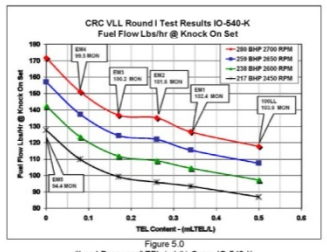
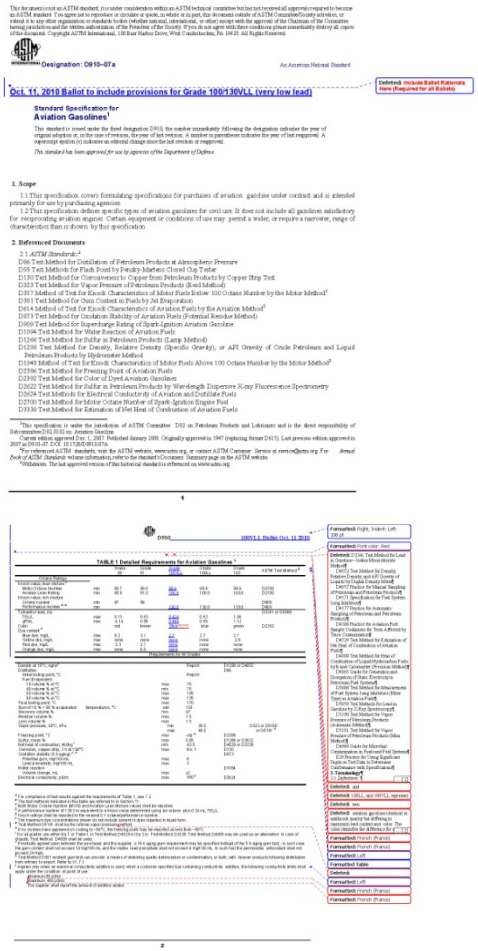


Figure 5.0
“Lead Response” TEL (mL/L) Curve IO-540-K

Page 18 of 50 Version 4.0 Oct. 14, 2010

ASTM 100VLL Added to D910



Designation: D910–07a

Oct. 11, 2010 Ballot to include provisions for Grade 100/130VLL (very low lead)

Standard Specification for
Aviation Gasolines

1. Scope

2. Referenced Documents

TABLE 1 Detailed Requirements for Aviation Gasolines

FAA's Unleaded Avgas Transition Aviation Rulemaking Committee (UAT ARC)

- Charter signed by FAA Administrator 1/31/2011
- The UAT ARC was tasked with investigating the current issues relating to the transition to an unleaded fuel, and recommend the tasks necessary to investigate and resolve these issues
- The UAT ARC membership included FAA (Certification, Office Environment & Energy, & Tech Center) & EPA; manufacturers Lycoming, Continental, Cirrus, Cessna, etc; operator group AOPA, manufacturer group GAMA, EAA, fuel distributors and producer groups NATA, API, and fuel developers producers Exxon, GAMI, Shell, Swift

5 Key UAT ARC Issues Identified

- No Unleaded replacement fuel
- No program for fleet-wide introduction of replacement AVGAS
- No Market driven reason to introduce a replacement fuel
- No FAA policies or test procedures for fleet wide certification of a replacement unleaded fuel
- No standardized communication method to industry and end user

UAT ARC Unleaded Avgas Transition Concept

PAFI

Industry Technical Support

Support

Fuel Developer

Data

Avgas Readiness Levels (ARLs)											
1	2	3	4	5	6	7	8	9	10	11	12

ARLs			
13	14	15	16

Data

Preparatory Stage

Fuel

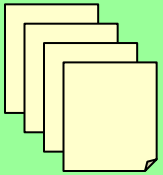
Project Stage

Data

FAA Centralized Certification

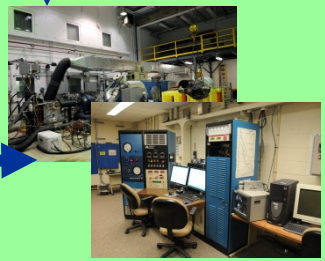
Deployment Stage

FAA

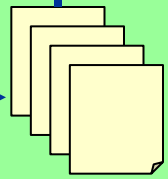


Procedures, Methods, Policy, Screening Criteria

Review Board



FAA Tech Center

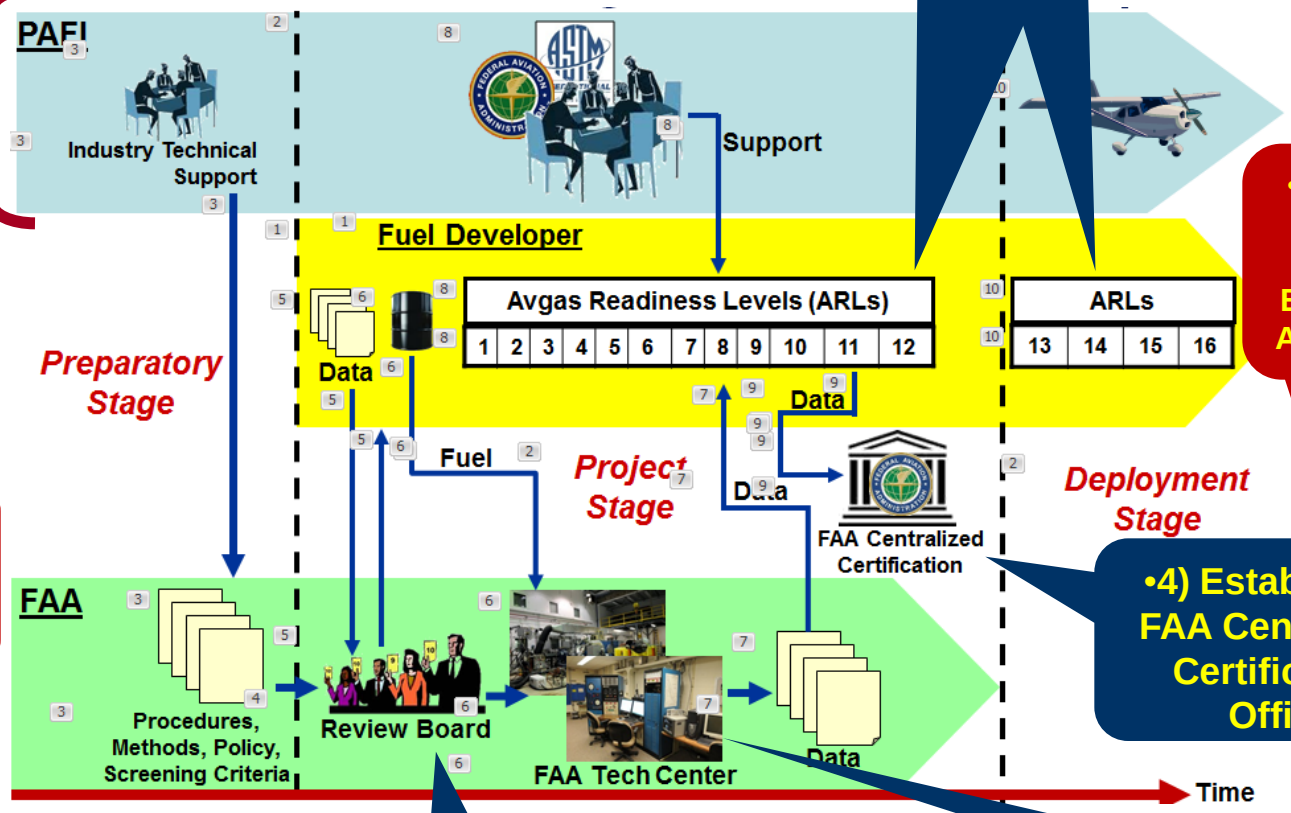


Data

Time

2014 2016 2018

Implementation of UAT ARC 5 Key Recommendations & Accomplishments



•1) Implement "Fuel Development Roadmap – AVGAS Readiness Levels (ARL)"

•5) Establish the Piston Aviation Fuel Initiative (PAFI)

•FAA Fuels Program Office Established August 2012

•PAFI Steering Group (PSG) Charter Signed February 2013

•4) Establish an FAA Centralized Certification Office

•FAA Technical Evaluation Committee (TEC) Established February 2014

•3) Establish an FAA Review Board

•FAA SIR Issued June 2013

•2) Centralized Testing of Candidate Unleaded Fuels at the FAA Tech Center

Replacement Fuels for General Aviation

Why is PAFI program necessary?

- EPA may make an Endangerment Finding relative to lead in avgas in the late 2014-early 2015 timeframe
  - A positive endangerment finding will initiate regulatory activity by the EPA and the FAA to eliminate or reduce lead emissions from aircraft
- A safe, unleaded alternative to 100LL avgas is essential for the Continued Operational Safety of the GA fleet
- US legislation (Section 910 of the Reauthorization Act) requires the FAA continue research and development activities into the qualification of an unleaded aviation fuel and safe transition to this fuel for the fleet of piston engine aircraft
- FAA Business Plan-Destination 2025 performance metric for 2018
  - A replacement fuel for leaded aviation gasoline is available by 2018 that is usable by most general aviation aircraft

Piston Aviation Fuels Initiative (PAFI)

- Mission: Facilitate the development and deployment of an unleaded AVGAS with the least impact on the existing piston-engine aircraft fleet. This is a govt/industry collaboration to ensure all stakeholders are involved in a coordinated approach to fleet wide implementation

- Established to develop a path forward for the identification, evaluation and fleetwide certification and deployment of the most promising unleaded replacement fuels

- Overcome the significant hurdles which have hindered past efforts to develop an unleaded avgas replacement

- Provides a sound process to ensure that this goal is achieved with a minimum of disruption to the general aviation industry and with the greatest likelihood of marketplace success

- The PAFI process involves a two phase testing program at the FAA's Technical Center

What is the PAFI program?

Purpose

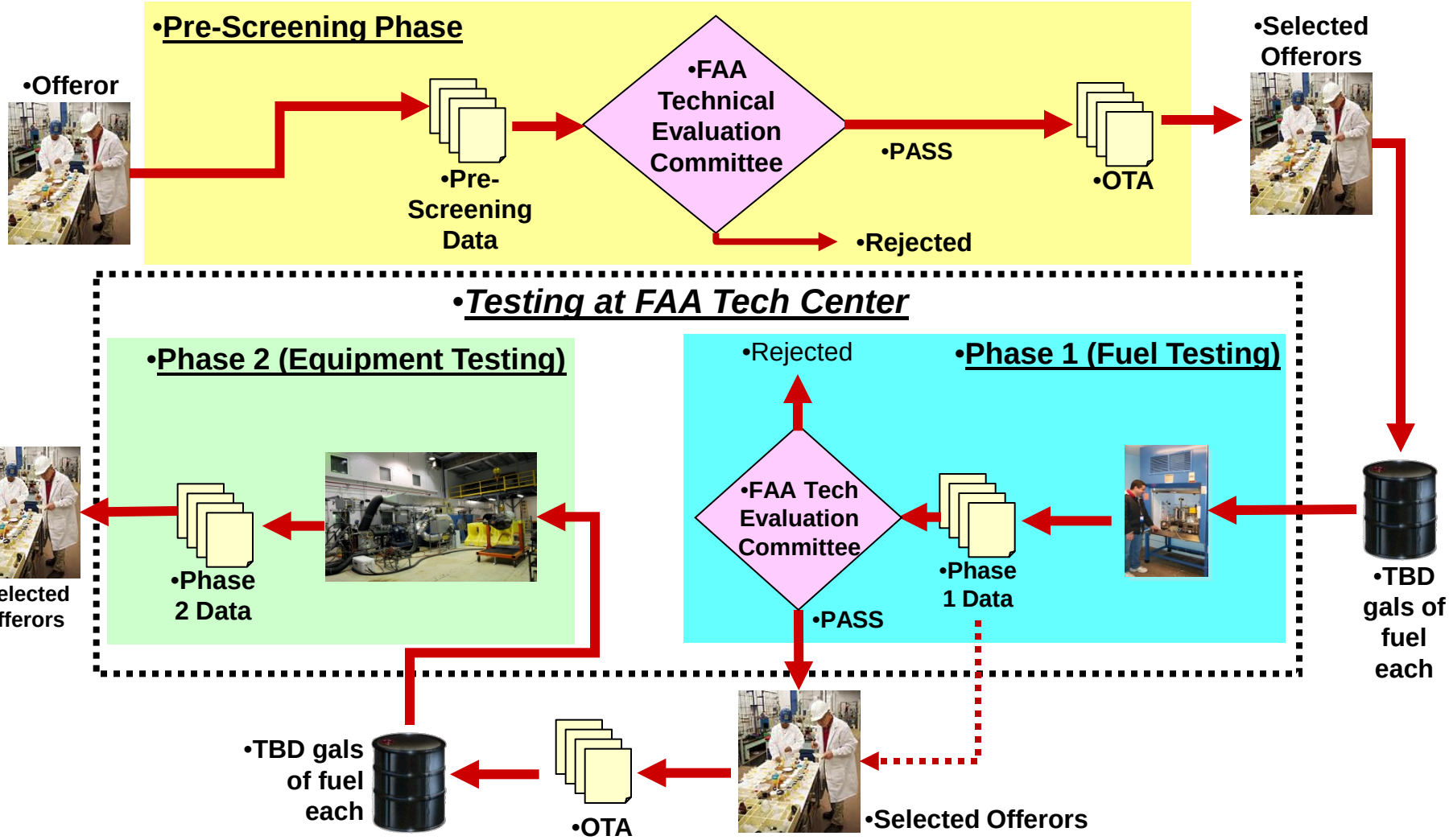
- Supporting the Development of a Safe Unleaded Replacement Fuel for 100LL
  - Developing test methods and procedures to evaluate UL fuels
  - Conducting fuel property testing of candidate UL fuels
  - Conducting rig, component, engine and aircraft testing of candidate UL fuels
  - Preparing standardized test reports to support fuel specification development and certification of GA fleet to operate on UL fuels
- Develop data for ASTM production specification and fleetwide certification
- Benefits
  - Reduction and eventual elimination of harmful lead emissions
  - Safe operation of aircraft and engines on replacement UL fuel(s)

PAFI Steering Group

- Purpose of the Piston Aviation Fuels Initiative Steering Group, (PSG):
  - To facilitate, coordinate, expedite promote and oversee PAFI based on the recommendations of the UAT ARC
- Members of PAFI PSG:
  - Aircraft Owners and Pilots Association (AOPA)
  - American Petroleum Industry (API)
  - Experimental Aircraft Association (EAA)
  - General Aviation Manufacturers Association (GAMA)
  - National Air Transportation Association (NATA)
  - National Business Aircraft Association (NBAA)
  - Federal Aviation Administration (AIR, AEE, Tech Center)

FAA Request for Candidate Fuels

- Solicit Candidate Unleaded Fuels for FAA Testing
- Issued June 2013, Closes July 2014



FAA Technical Center Testing Program

Phase 1

Evaluates candidate fuels for potentially show stopping issues

- Chemical makeup
- Performance properties
- Establish credible and peer-reviewed test protocols for ascertaining necessary fit-for-purpose data
- Fit for purpose testing across the ranges allowed by the fuel formulations (worse case formulations)
- Evaluate emissions and toxicology properties
- Evaluate business case for candidate fuels
  - Projected production
  - Availability
  - Distribution
  - Costs

FAA Technical Center Testing Program

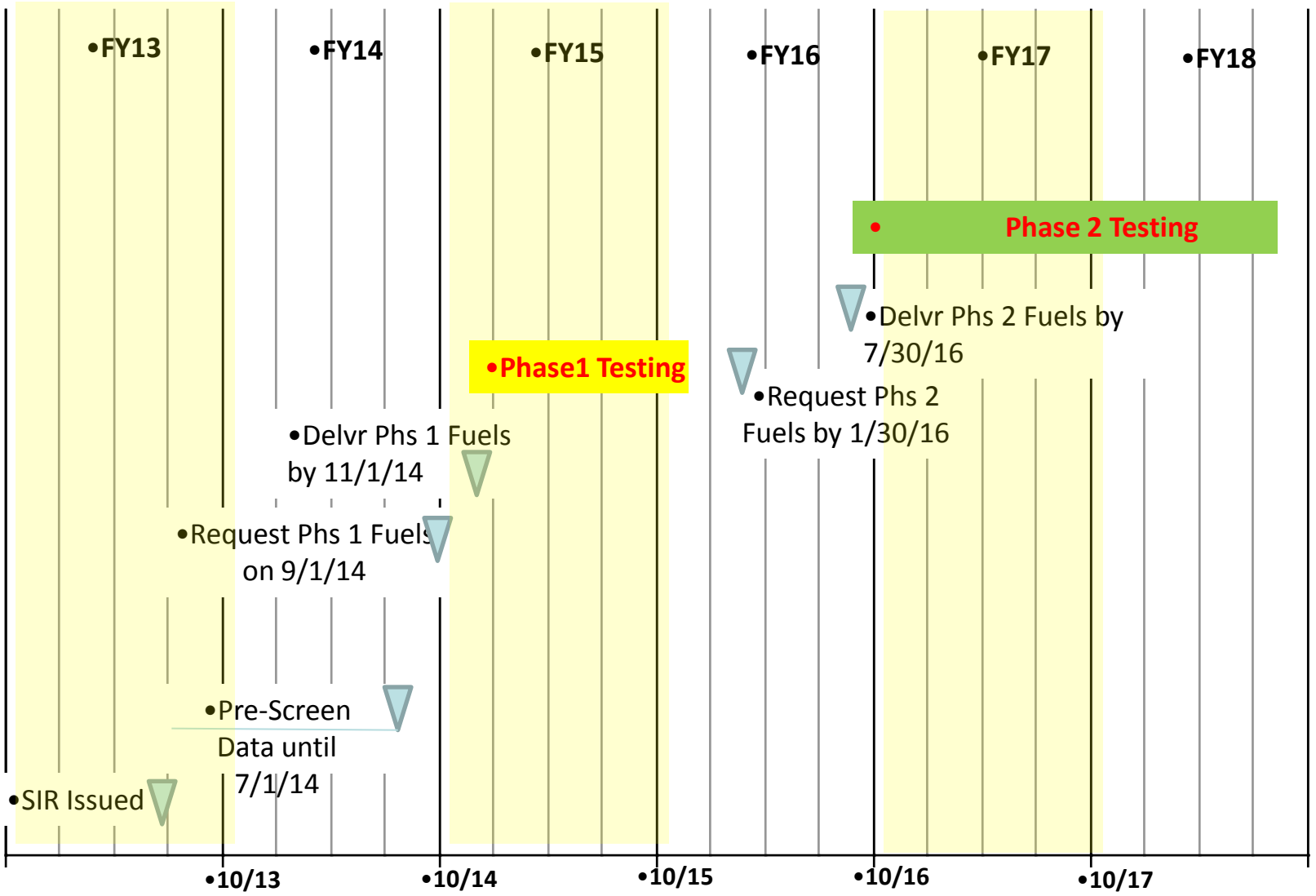
Phase 2

- Fuels to be tested at the engine and aircraft level to evaluate their suitability across as much of the existing fleet as possible

- Data collected from this testing will generate data that can be used to support the fleet wide approval of aircraft and engines including the orphaned fleet no longer supported by a manufacturer. This program is the most viable path to a fleet wide approval of new fuel formulations

- Data from the Phase 1 and Phase 2 testing can also be submitted for ASTM Production Specification, which will enable the fuels to be accepted in the marketplace in an orderly and comprehensive manner. FAA involvement in this step will ensure acceptance and adoption of the fuel with consumers and across the petroleum and aviation industry.

•SIR Schedule



Phase 2 Report

- The Phase 2 testing will result in reports containing data that can be utilized to obtain an ASTM production specification, and presented to the FAA for fleet wide certification

- Fleet wide Certification
  - Process will depend on the fuel – the closer the fuel is to current D910 fuel, the easier/simpler this effort can be

Canada and US Collaboration

- TCCA and the FAA continue to have discussions on the fuel program to help solve this global issue
- The FAA obtained $6M for funding this year for centralized testing in the US
- Canada & US wishes to collaborate on the identification and certification of unleaded fuels
- We will work together to identify the most effective portions of the program for Canadian participation
- The solution will mutually help Canada's 30,000 and the US 167,000 general aviation aircraft

Fleet wide Certification

- Form of Approval
  - Portion of fleet may be “drop-in” or transparent
    - Could issue a type of approval/statement of equivalency (not sure what type but in-work)
  - Portion of fleet may require design change
    - More complicated… (ATC, STC, option for modification of method above with contingencies??)
    - Non-traditional methods will require extensive coordination to ensure all requirements/needs are met
  - FAA is committed to develop a fleet wide approval methodology to align with PAFI schedule

Questions?

Address all SIR questions to Lori.Mclaughlin@faa.gov