Unleaded AVGAS Transition Aviation Rulemaking Committee

FAA UAT ARC
Final Report
Part II Appendices

Unleaded AVGAS
Findings & Recommendations

17 February 2012

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Note: The appendices contained in this UAT ARC Final Report Part II support the UAT ARC Final Report Part I Body.

Appendix A
UAT ARC Charter

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Effective Date: **JAN 3 1 2011**

SUBJ: Unleaded Avgas Transition Aviation Rulemaking Committee

1. Purpose of this Charter. This charter establishes the Aviation Rulemaking Committee (ARC) for Unleaded Avgas Transition pursuant to the authority of the Administrator of the Federal Aviation Administration (FAA) under Title 49 of the United States Code (49 U.S.C.) section 106(p)(5). This charter also outlines the committee's organization, responsibilities, and tasks.

2. Audience. The audience for this charter includes employees within the Office of the Associate Administrator for Aviation Safety, the Office of the General Counsel, the Office of Aviation Policy, International Affairs, and Environment, and aviation industry representatives from the general aviation community, including aviation fuel specialists.

3. Background. Aviation gasoline (avgas) is the only remaining transportation fuel in the United States that contains lead. Environmental regulations have led to the global replacement of all other leaded transportation fuels with unleaded alternatives. Over 160,000 piston-engine aircraft rely on this fuel for safe operation. The lead additive in avgas protects piston engines against damaging detonation (or engine knock) at the higher power levels required by aircraft. Operation with inadequate fuel performance can result in engine failure and aircraft accidents. Impending environmental regulations along with production and distribution issues threaten the continued availability of leaded avgas.

Historically, the FAA has played a key role in industry initiatives to develop and deploy unleaded fuels for piston-engine aircraft. Testing and investigation of unleaded fuel formulations has been performed by the FAA's William J. Hughes Technical Center since the mid 1990s. The Aircraft Certification Service has supported several projects to approve unleaded aviation fuels, and the FAA participates in aviation fuel industry research and specification-writing organizations. In recognition of the importance of this effort, the FAA has established a Flight Plan initiative to "continue working with the General Aviation (GA) community to test, adopt, and certify a new aviation gasoline fuel standard."

Various elements of the GA community have voiced their concerns with the potential consequences of a disruption of the supply of lead-containing avgas. This would have significant economic consequences that would impact a large number of people.

In July 2010, the FAA was approached by the GA Coalition[1] to take a leadership role in the industry efforts to develop and deploy an unleaded avgas. This Unleaded Avgas Transition ARC charter is being established in response to this request.

4. Organization and Administration of the Unleaded Avgas Transition ARC. We will set up a committee of members of the general aviation community, including aviation fuel specialists with diverse viewpoints. FAA participation and support will come from all affected lines-of-business. Where necessary, the committee may set up specialized work groups that include at least one committee member and invited subject matter experts from industry and government.

The charter is set up as follows:

a. The committee sponsor is the Manager, Engine and Propeller Directorate, who:

(1) Appoints members of organizations to the committee, at the manager's sole discretion;
(2) Receives all committee recommendations and reports;
(3) Selects industry and FAA co-chairpersons for the committee; and
(4) Provides administrative support for the committee, through the Aircraft Certification Service

b. The co-chairpersons will:

(1) Determine (with other committee members) when a meeting is required (a quorum is desirable at all committee meetings, but not required);
(2) Arrange notification to all members of the time and place of each meeting;
(3) Draft an agenda for each meeting and conduct the meeting;
(4) Keep the meeting minutes; and
(5) Provide status updates to the Manager, Engine and Propeller Directorate, at periodic intervals over the duration of this charter.

5. Committee Membership.

a. The committee will consist of approximately 10 to 20 members, selected by the FAA, representing aviation associations, aircraft and engine manufacturers, petroleum and other fuel producers, environmental groups, FAA and other Government entities, and other aviation industry participants.

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[1] The GA Coalition is comprised of the General Aviation Manufacturers Association (GAMA), the Aircraft Owners and Pilots Association (AOPA), the Experimental Aircraft Association (EAA), the National Air Transportation Association (NATA), and the American Petroleum Institute (API). These organizations represent the key stakeholders in the aviation industry such as aviation consumers, manufacturers, fuel producers and distributors.

b. Each member or participant on the committee should represent an identified part of the aviation community and have the authority to speak for that community. Membership on the committee will be limited to promote discussions. Active participation and commitment by members will be essential for achieving the committee objectives and for continued membership on the committee. The committee may invite additional participants as subject matter experts to support specialized work groups.

6. Public Participation. Persons or organizations that are not members of this committee and are interested in attending a meeting must request and receive approval in advance of the meeting from a committee co-chairperson.

7. Committee Procedures and Tasks.

a. The committee provides advice and recommendations to the Manager, Engine and Propeller Directorate, ANE-100. The committee acts solely in an advisory capacity.

b. Committee tasks include, but are not limited to, the following:

(1) Investigate, prioritize, and summarize the current issues relating to the transition to an unleaded avgas.

(2) Consider the following factors when performing this activity:

(i) Aircraft and engine performance requirements for unleaded avgas
(ii) Properties and composition of unleaded avgas
(iii) Airworthiness approval of unleaded avgas
(iv) Environmental impacts of unleaded avgas
(v) Distribution infrastructure issues relating to unleaded avgas
(vi) Production issues relating to unleaded avgas
(vii) Economic issues relating to unleaded avgas
(viii) Communication with the diverse population of users

(3) Identify the key issues and recommend the tasks necessary to investigate and resolve these issues.

(4) Upon completion of this study, the Unleaded Avgas Transition ARC will provide recommendations for collaborative industry-government initiatives to facilitate the development and deployment of an unleaded avgas with the least impact on the existing piston-engine aircraft fleet. These should include, but not be limited to, the following items:

(i) A recommendation for an industry-government framework and top-level plan.
(ii) A recommendation for an organizational structure, funding mechanisms, and top-level work scope for this framework and plan.

(iii) Proposed timelines based on the complexity and priority of the recommendations.
(iv) Specific implementation plans and processes to ensure that recommendations meet these objectives.

(5) The committee will provide reports with written recommendations to the Director of the Aircraft Certification Service, as appropriate.

c. The committee may propose additional tasks as necessary to the Manager, Engine and Propeller Directorate, for approval.

d. The ARC will submit a report detailing recommendations for task b.(4) not later than 6 months from the effective date of this charter. The charter may be extended up to 6 months beyond the expiration date, if it is in the interest of the FAA to do so.

8. Cost and Compensation. The estimated cost to the Federal Government for the Unleaded Avgas Transition ARC is approximately $7,500. All travel costs for government employees will be the responsibility of the government employee's organization. Non-government representatives, including the industry co-chair, serve without government compensation and bear all costs related to their participation on the committee.

9. Availability of Records. Records, reports, agendas, working papers, and other documents made available to, prepared for, or prepared by the committee will be available for public inspection and copying at the FAA Engine and Propeller Directorate, 12 New England Executive Park, Burlington, MA 01803, consistent with the Freedom of Information Act, 5 U.S.C. 552. Fees will be charged for information furnished to the public according to the fee schedule in 49 CFR part 7.

10. Committee Term. This committee becomes an entity on the effective date of this charter. The committee will remain in existence for a term of 6 months unless its term is ended sooner or extended.

11. Distribution. This charter is distributed to director-level management in the Office of the Associate Administrator for Aviation Safety; the Office of the Chief Counsel, the Office of Aviation Policy, International Affairs, and Environment, and the Office of Rulemaking.

J. R. Babbitt

J. Randolph Babbitt
Administrator

Federal Aviation Administration

Memorandum

Date:	June 16, 2011
To:	Manager, Engine and Propeller Directorate, ANE-100
From:	Chairmen, Unleaded Avgas Transition Aviation Rulemaking Committee (UAT ARC)
Prepared by:	Mark Rumizen, Rulemaking & Policy Branch, ANE-111
Subject:	ACTION: Request for Extension of the UAT ARC Charter

The charter for the UAT ARC became effective on January 31, 2011. This charter specified a duration of six months for the committee to complete its assigned tasks. These assigned tasks are intended to culminate with the issuance of a final report with recommendations by this specified end date of July 31, 2011. We are requesting a six month extension of the charter of this committee to January 31, 2012.

After a considerable effort to select the membership and organize the first meeting, the UAT ARC convened its first meeting March 17, 2011. The committee continued its fast pace over the next two months leading up to the most recent meeting beginning on May 17, 2011. At that meeting, the committee evaluated its status against the original completion date of July 31, 2011, and there was strong consensus that an additional six month extension was needed for the following reasons:

- The two month start-up phase was unexpected, however, it was necessary to select the appropriate membership and organize the first meeting.
- The enormity of this task that has challenged the General Aviation (GA) industry for two decades warrants a longer tenure for this committee. This was revealed during the enthusiastic and lengthy discussions that were necessary for the committee to identify a go-forward plan.
- The membership from the General Aviation industry faces challenges to allocating resources to this task while continuing their business activities in the current difficult economic environment.
- The committee will need to divert resources from its assigned task to support our participation in a public forum at the EAA AirVenture in Oshkosh on July 27, 2011.

2

We consider a six month extension of the charter to be necessary for the UAT ARC to complete its assigned task, and we believe it to be in the best interest of the FAA for the UAT ARC to do this.

Therefore, in accordance with paragraphs 7.d and 10 of the UAT ARC charter, dated January 31, 2011, we are requesting an extension of the term of the charter by six months to January 31, 2012.

Your consideration would be greatly appreciated.

M.A. [signature] for
Robert Ganley, Co-Chairman

[signature]
Ron Wilkinson, Co-Chairman

Approve/Disapprove: [signature]
Peter White, Acting Manager, ANE-100

6/14/11
Date

Appendix B
UAT ARC Membership
&
Antitrust Guidelines

Unleaded Aviation Gasoline Transition
Aviation Rulemaking Committee (ARC) Membership
March 2011 – January 2012

Organization	Name
FAA – Engine & Propeller Directorate, Aircraft Certification Service	Peter White, Sponsor
FAA – Engine & Propeller Directorate, Aircraft Certification Service	Robert Ganley, FAA Co-Chair
General Aviation Industry Engineering Consultant	Ron Wilkinson, Industry Co-Chair
FAA - Engine & Propeller Directorate, Aircraft Certification Service	Mark Rumizen
FAA – Emission Division, Office of Environment and Energy	Warren Gillette
FAA - Aviation Research & Technology Development Office, William J. Hughes Technical Center	Dave Atwood
EPA – Environmental Protection Agency	Mike Samulski/Rich Wilcox / Glenn Passavant/Matt Spears
AOPA – Aircraft Owners and Pilots Association	Rob Hackman
GAMA – General Aviation Manufacturers Association	Walt Desrosier
EAA – Experimental Aircraft Association	Doug Macnair
Lycoming	Mike Kraft
Continental Motors	Johnny Doo
Cirrus Aircraft	Paul Fiduccia
Cessna Aircraft	Nathaniel Diedrich
API – American Petroleum Institute	Prentiss Searles
Shell	Rob Midgley
ExxonMobil	Roger Gaughan
NATA – National Air Transportation Association	Mike France
Swift Enterprises	Jon Ziulkowski
GAMI - General Aviation Modifications, Inc.	Tim Roehl
Clean 100 Coalition	Robert Ragar/Jon Sisk

AVS Quality Management System	QPM # ARM-001-015	Revision 38
Title: ARM Committee Manual	Effective: 9/12/11	Page 30 of 98

Appendix B to Part II: Anti-trust Guidelines for Committees

Participants should observe the following guidelines:

Meetings and Gatherings

 These guidelines apply to any meeting or gathering of competitors, so they apply at meetings with other trade associations or government representatives; and at gatherings, such as Committee dinners that may follow a meeting.
 Avoid any discussions or conduct that might violate the antitrust laws or even raise an appearance of impropriety.
 At meetings, limit discussions and materials to agenda topics (unless additional topics and materials have been approved by counsel).
 Discontinue the discussion and consult with counsel whenever questions regarding antitrust compliance arise.
 Do not stay at a meeting, or any other gathering, if discussions mentioned below are taking place.

Information

 No discussion or sharing of any company's confidential or proprietary information;
 No discussion or agreements, either explicit or implicit, regarding prices of particular products or services of a company;
 No forecasting of prices for goods or services;
 No discussion of any company's purchasing plans for particular products or services;
 No discussion of any company's specific merger/divestment plans, market allocation, development plans, inventories and costs (only publicly available information should be discussed or shared);
 No sharing or discussion of specific company compliance costs, unless information is publicly available;
 Do not share information that your company considers to be confidential or sensitive, even if that information does not fit in any other category above.
 Any discussion regarding potential economic scenarios that may arise must be limited to generalities. There should be no discussion of how individual companies intend to respond to potential economic scenarios or government action.

Vendors and Products

 There shall be no agreement or discussion regarding the purchase or sale of a product or service – purchasing and selling decisions are independent company decisions.
 There shall be no agreement by all companies to use a product/service or that one product/service is preferred.
 There shall be no agreement by all companies not to use a product/service or that one product/service is not preferred.
 Individual companies may share fact-based experiences but should not make explicit recommendations for or denunciations of a vendor at advisory committee meetings.
 All discussions related to vendor products and services must be grounded in facts.
 Do not make disparaging remarks about vendors.
 Do not make subjective comments if there is no factual basis.
 You may share information based on facts.

Appendix C
List of Abbreviations

LIST OF ABBREVIATIONS

AC	Advisory Circular (FAA)
AFM	Airplane Flight Manual
AFPM	American Fuel & Petrochemical Manufacturers
AOPA	Aircraft Owners & Pilots Association
API	American Petroleum Institute
ARC	Aviation Rulemaking Committee
ARL	Aviation Gasoline Readiness Level
ASTM	American Society for Testing and Materials
AVGAS	Aviation Gasoline
BMEP	Brake Mean Effective Pressure
CAA	Clean Air Act
CAAFI	Commercial Aviation Alternative Fuels Initiative
Cert	Certification (FAA)
C&Q	Certification & Qualification
CRC	Coordinating Research Council
DAH	Design Approval Holder (FAA)
DEPLOY	Deployment Stage (PAFI)
EAA	Experimental Aircraft Association
E&T	Environment & Toxicology
EPA	Environmental Protection Agency
EXP	Experimental
FAA	Federal Aviation Administration
FAA EPD	FAA Engine & Propeller Directorate
FAA OEE	FAA Office Environment & Energy
FAA TC	FAA Tech Center
FAR	Federal Aviation Regulation
FBO	Fixed Base Operator
FFP	Fit for Purpose
FOE	Friends of the Earth
FRL	Fuel Readiness Level
GA	General Aviation
GAMA	General Aviation Manufacturers Association
GARA	General Aviation Revitalization Act
I&E	Impact & Economics
IFS	Initial Flight Screening (USAF)
MOA	Memorandum of Agreement
MON	Motor Octane Number (ASTM D 2700)

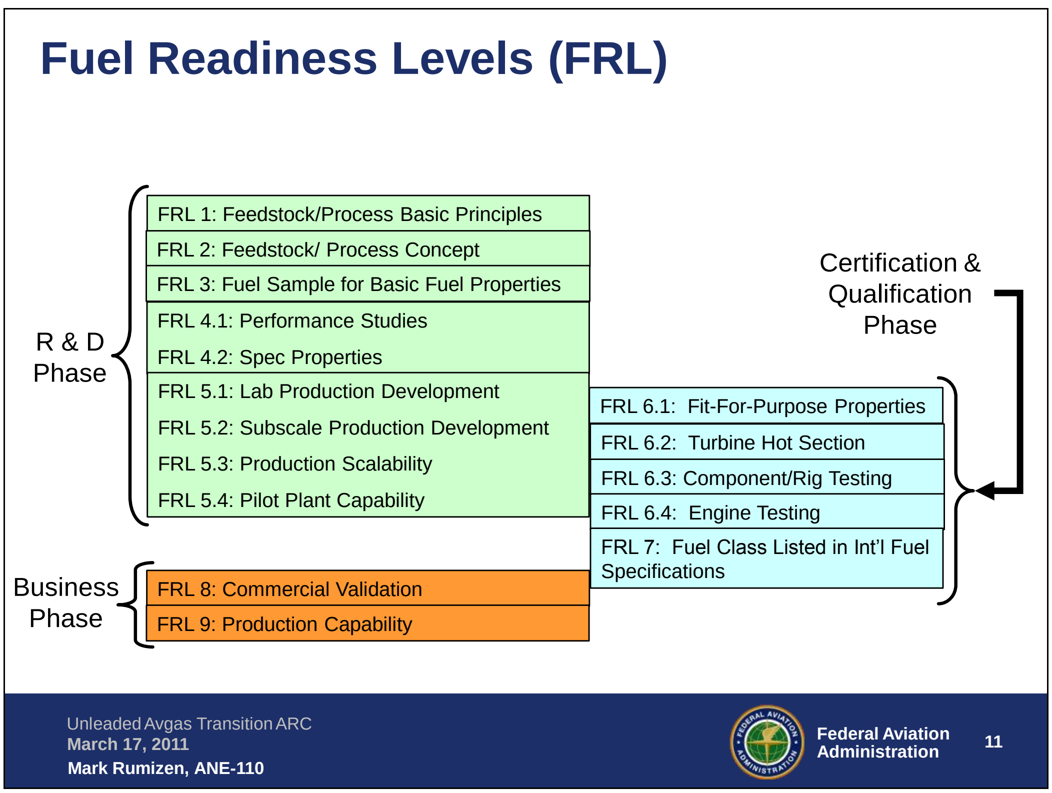
MSDS	Material Safety Data Sheet
MTBE	Methyl-Tertiary Butyl Ether
NAAQS	National Ambient Air Quality Standard
NATA	National Air Transportation Association
ODC	Other Direct Costs
OEE	Office of Environment & Energy (FAA)
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
PAFI	Piston Aviation Fuel Initiative
P&D	Production & Distribution
Pb	Lead (chemical symbol)
PC	Production Certificate (FAA)
PN	Performance Number (ASTM D 909)
POH	Pilot Operating Handbook
PREP	Preparatory Stage (PAFI)
PROJ	Project Stage (PAFI)
PSG	PAFI Steering Group
RFM	Rotorcraft Flight Manual
RFP	Request for Proposal (FAA)
RGL	Regulatory and Guidance Library (FAA)
SAE	Society Automotive Engineering
SAIB	Special Airworthiness Information Bulletin (FAA)
S-LSA	Special Light Sport Aircraft
SME	Subject Matter Expert
SR	Supercharged Rich
STC	Supplemental Type Certificate (FAA)
Subcon	Subcontract
TC	Type Certificate (FAA)
TCDS	Type Certificate Data Sheet (FAA)
T&E	Test & Evaluation
TEL	Tetraethyl Lead
UAT ARC	Unleaded AVGAS Transition Aviation Rulemaking Committee
UL	Unleaded
VLL	Very Low Lead
100LL	100 Octane Low Lead AVGAS

Appendix D
CAAFI
Background

CAAFI Overview

Alternative fuels are a global priority not only with aviation gasoline but also in the area of jet (turbine) fuel. The Commercial Aviation Alternative Fuels Initiative (CAAFI) is an aviation industry coalition which has been established to facilitate and promote the development and deployment of alternative aviation fuels for commercial aviation. The FAA, the Airport Council International-North America (ACI-NA), the Airlines for America (A4A, formally the Air Transport Association for America, ATA), and the Aerospace Industries Association (AIA) are the four organizations which form the leadership of CAAFI. The FAA serves as the sponsor; an executive director is funded by the FAA. The public may access information on CAAFI at www.caafi.org.

Significance of CAAFI is the implication of serving as a model for a similar or a derivative framework for unleaded aviation gasoline; however, there are significant differences between the jet fuel and aviation gasoline communities and technical aspects. CAAFI works with a drop in replacement fuel. A work product of CAAFI has been the definition of fuel readiness levels (FRL) which have similar significance for aviation gasoline. The following chart identifies the CAAFI FRL.



Commercial Aviation Alternative Fuels Initiative®

Supporting solutions for secure and sustainable aviation

Visit us at www.caafi.org

"I'm directing [the U.S. government] to work with the private sector to create advanced biofuels that can power not just fighter jets, but also trucks and commercial airliners."
President Barack Obama
(March 30, 2011)

"A new approach [should utilize] pre-established market outlets [and] customer purchase commitments...with a concerted effort directed to our military and airline industry."
Growing America's Fuel, President's Biofuels Interagency Working Group (Feb. 3, 2010)

"[The] U.S. aviation industry is eager for an entirely new fuel dynamic and will be an enthusiastic purchaser."
ATA letter to President-Elect Obama (Jan. 16, 2009)

The Commercial Aviation Alternative Fuels Initiative® (CAAFI) seeks to enhance energy security and environmental sustainability for aviation through alternative jet fuels. As a coalition of U.S. commercial aviation interests, CAAFI is a focal point for engaging with the emerging alternative fuels industry. It enables its diverse stakeholders to build relationships, share and collect data, identify resources, and direct research, development and deployment of alternative fuels.

CAAFI is sponsored by the Federal Aviation Administration (FAA) and three trade associations: the Aerospace Industries Association (AIA), the Air Transport Association of America (ATA) and the Airports Council International-North America (ACI-NA). CAAFI stakeholders include all elements of the international commercial-aviation industry, fuel suppliers, universities and U.S. government agencies.

CAAFI Goals and Objectives

CAAFI aims to promote the development and deployment of alternative fuels that offer equivalent levels of safety and compare favorably with petroleum-based jet fuel on cost and environmental bases, with the specific goal of enhancing the security of North American energy supply.

Aviation is well positioned to pursue alternative fuels. The industry is international in scope, has a highly networked supply chain with concentrated nodes of demand, and has a unique capacity to function in an aligned and coordinated manner.

The four CAAFI teams – Fuel Certification and Qualification, Environment, Business and Economics, and Research and Development – meet regularly to share progress, identify gaps and hurdles, determine next steps for the earliest possible development and deployment of jet fuel alternatives, and expand global engagement.

Accomplishments

- Approval by ASTM International for synthesized hydrocarbon jet fuels from FT and HEFA processes
- Sugar and cellulose jet fuels testing underway
- Fuel Readiness Level endorsed as a best practice by the International Civil Aviation Organization
- Completion of aviation-fuel-specific greenhouse gas lifecycle analyses (LCAs) for multiple fuels
- Unified R&D roadmaps to inform investment decisions by the public and private sectors
- Initial pre-purchase agreements announced by 15 airlines with two alternative-fuel suppliers
- Formation of strategic alliance between airlines (via ATA) and the Defense Logistics Agency (DLA), creating "single market" for alternative jet fuel
- Over 50 energy suppliers engaged in development and deployment discussions
- Aviation a priority for "concerted effort" for biofuel deployment by U.S. government
- "Farm to Fly" resolution between ATA, Boeing and USDA to accelerate commercial availability of sustainable aviation biofuels in the United States
- Won 2010 *Air Transport World* Joseph S. Murphy Industry Service Award

CAAFI Team Leads

Mark Rumizen (FAA) — Fuel Certification/Qualification

Lourdes Maurice (FAA) & Nancy Young (ATA) — Environment

John Rau (American Airlines) — Business and Economics

Michael Lakeman (Boeing), Mike Epstein (GE) & Stephen Kramer (Pratt & Whitney) — Research and Development

CAAFI Administration

Richard L. Altman,
Executive Director

Nathan L. Brown (FAA),
Strategy & Implementation Advisor

Kristin C. Lewis (RITA/Volpe),
Research & Technical Advisor

CAAFI Sponsors

Aerospace Industries Assoc. (AIA)

Air Transport Association (ATA)

Airports Council International-North America (ACI-NA)

Federal Aviation Administration

Supporting solutions for secure and sustainable aviation www.caafi.org Rev 6/13/2011

Appendix E
PAFI Preparatory Stage Work Scope
Implementation Plans Including Cost Estimates

Note……….Appendix E contains the individual implementation plans for each PAFI - FAA task which supports the Preparatory Stage.

1. Certification & Qualification Support Tasks
2. Test & Evaluation Support Tasks
3. Production & Distribution Support Tasks
4. Impact & Economics Support Tasks
5. Environment & Toxicology Support Tasks

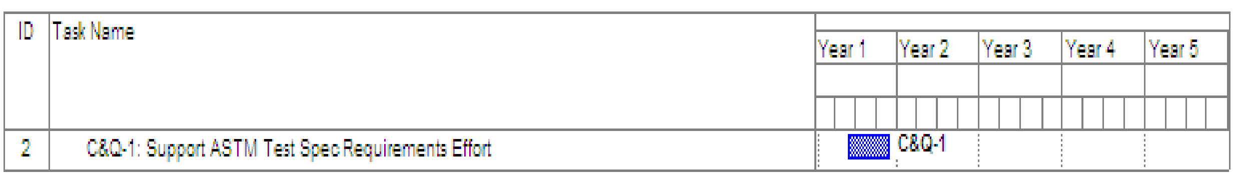
1.0 CERTIFICATION & QUALIFICATION IMPLEMENTATION PLANS, PREPARATORY STAGE

1.1 C&Q TASK PREP-C&Q-1

TASK: Support ASTM Test Spec Requirements Effort
WORKSCOPE: Support ASTM Task Force effort to develop Standard Practice
ITEM No: **PREP-C&Q-1**
LEAD ORGANIZATION: ASTM
DELIVERABLE: ASTM Standard Practice; Evaluation of New AVGAS
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-C&Q-1			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		• Participate in TF activities • Contribute to document content • Support ASTM balloting process • Reconcile ballot comments	• Participate in TF activities • Contribute to document content • Support ASTM balloting process • Reconcile ballot comments
Estimated Cost	$0	$18K	$18K

TIMELINE:

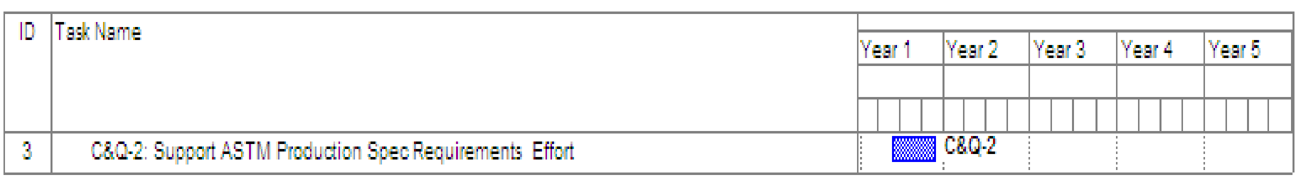


1.2 C&Q TASK PREP-C&Q-2

TASK: Support ASTM Production Spec Requirements Effort
WORKSCOPE: Support ASTM Task Force effort to develop Standard Practice
ITEM No: **PREP-C&Q-2**
LEAD ORGANIZATION: ASTM
DELIVERABLE: ASTM Standard Practice; Evaluation of New AVGAS
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-C&Q-2			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		• Participate in TF activities • Contribute to document content • Support ASTM balloting process • Reconcile ballot comments	• Participate in TF activities • Contribute to document content • Support ASTM balloting process • Reconcile ballot comments
Estimated Cost	$0	$18K	$18K

TIMELINE:



1.3 C & Q TASK PREP-C&Q-3

TASK: Develop Phase 1 Entrance Criteria

WORKSCOPE: Prepare PAFI Document specifying criteria for entrance into Phase 1, based on ARLs and ASTM Standard Practice. Document to be used by FAA review board to rate the fuel for entrance into Phase 1.

ITEM No: **PREP-C&Q-3**

LEAD ORGANIZATION: PAFI

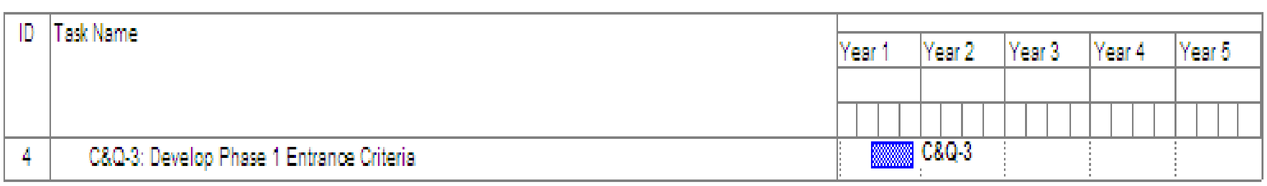
DELIVERABLE: PAFI Phase 1 Entrance Criteria

TIMELINE: See Below

COST ESTIMATE: See Below

PAFI TASK PREP-C&Q-3			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		• Lead task group • Coordinate with the FAA review board • Review ASTM Standard Practice • Review/Expand ARL Definitions and associated criteria	• Participate in task group • Contribute to document content
Estimated Cost	$0	$12K	$7K

TIMELINE:



1.3.1 PREP-C&Q-3 SUPPLEMENTAL INFORMATION

The Entrance Criteria for Phase 1 will consist of laboratory test methods and target results. This criteria will be based on the test methods and information described in section 6.2 of ASTM International Standard Practice, "Standard Practice for the Evaluation of New Aviation Gasolines and New Aviation Gasoline Additives" and the ARLs. This document will be provided to the FAA Review Board to use to rate the candidate fuels for entrance into Phase 1. The criteria from the ASTM document will consist of the following elements:

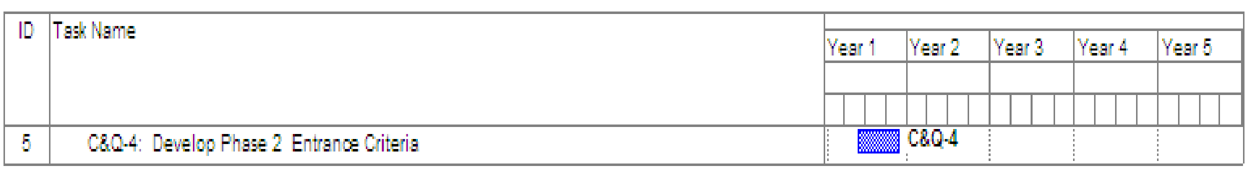
1. ***Pilot Production Report*** - A report describing the simulated production, pilot plant ramp up and/or production capability, to confirm that adequate production capacity is available to support the test and analyses of this procedure. Ideally, several batches of fuel should be produced to reflect a range of specification properties to support "worst-case" testing of fuel for the below requirements.
2. ***Basic Specification Properties*** - These should be based on, but not be limited to D910 Table 1 properties. The basic specification property results for evaluation of additives should be compared to the corresponding data for the base fuel.
3. ***Fuel Composition*** - Detailed chemical analysis of hydrocarbons and trace materials. The composition of additives should be defined to the extent necessary to establish conformance of the products used for testing.
4. ***Fit-For-Purpose Properties Part 1 (FFP-1)*** - The following FFP-1 tests should be performed to further evaluate the fuel properties. The test results should be compared to the corresponding data for D910 100LL fuels.
5. ***Materials Compatibility Part 1*** - Soak testing of key airplane and engine fuel system elastomers, seals and other non-metallic parts to measure property changes such as % volume change, hardness, tensile strength, etc.

1.4 C&Q TASK PREP-C&Q-4

TASK: Develop Phase 2 Entrance Criteria
WORKSCOPE: Prepare PAFI Document specifying criteria for entrance into Phase 2 based on ARLs and ASTM Standard Practice. Document to be used by FAA review board to rate the fuel for entrance into Phase 2.
ITEM No: **PREP-C&Q-4**
LEAD ORGANIZATION: PAFI
DELIVERABLE: PAFI Phase 2 Entrance Criteria
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-C&Q-4			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		• Lead task group • Coordinate with FAA review board • Review ASTM Standard Practice • Review/Expand ARL Definitions	• Participate in task group • Contribute to document content
Estimated Cost	$0	$14K	$14K

TIMELINE :



1.4.1 PREP-C&Q-4 SUPPLEMENTAL INFORMATION

The Entrance Criteria for Phase 2 will require a successfully balloted ASTM Test Specification and the results of the expanded laboratory testing of Phase 1. This criteria will be based on the test methods and information described in section 6.3 of ASTM International Standard Practice DXXXX, “Standard Practice for the Evaluation of New Aviation Gasolines and New Aviation Gasoline Additives” and the ARLs. This document will be provided to the FAA Review Board to use to rate the candidate fuels for entrance into Phase 2. The criteria from the ASTM document will consist of the following elements:

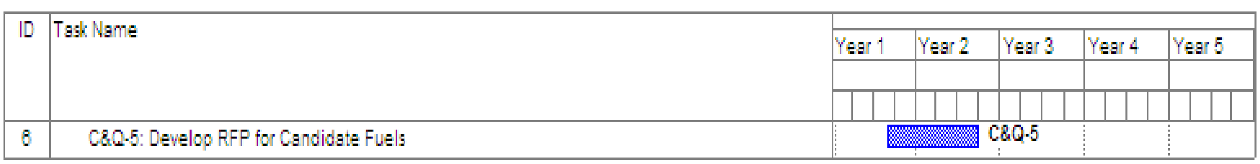
1. ***Production Report*** - A report describing the production process used to make the test fuel. The fuel used in the following testing should be produced from representative production processes, including the fuel’s blending components. Fuel produced for this phase should be derived from an integrated process from feedstock to finished fuel. Chemical facsimiles of production fuel, or fuel produced in a manner not representative of finished production routes, are not acceptable for this testing phase.
2. ***Fit-For-Purpose Properties Part 2 (FFP-2)*** - FFP-2 includes additional properties relating to engine and aircraft operability and performance, as well as properties relating to fuel handling and distribution. These properties include an evaluation of both the toxicity of the fuel and the exhaust emissions of the fuel. The data generated during this testing should be compared to corresponding data for ASTM D910 100LL fuel properties and should show that the test fuel is less toxic than leaded fuel.
3. ***Materials Compatibility Part 2*** - Engine and aircraft fuel system polymer and metallic materials that are exposed to fuel should be evaluated for compatibility with the new fuel. The results of the compatibility testing should be compared to corresponding results or service experience of existing fuels.
4. ***Component Testing*** - Evaluation of fuel performance on key components and systems such as capacitance fuel gauging systems will be evaluated.
5. ***Engine Testing*** - Limited engine testing covering basic performance and operability may be required.
6. ***Aircraft Testing*** - Limited aircraft testing covering basic performance and operability may be required.
7. ***Preliminary Feasibility Assessments*** - Objective evaluation of production, distribution, environmental and business factors related to the candidate unleaded AVGAS.

1.5 C&Q TASK PREP-C&Q-5

TASK:	Develop RFP for Candidate Fuels.
WORKSCOPE:	Prepare and issue an FAA RFP Document describing the FAA criteria for selection of candidate unleaded fuels for participation in the FAA Tech Center testing program Base on ARLs, ASTM Standard Practice and FAA Airworthiness Standards.
ITEM No:	**PREP-C&Q-5**
LEAD ORGANIZATION:	FAA
DELIVERABLE:	FAA RFP
TIMELINE:	See Below
COST ESTIMATE:	See Below

PAFI TASK PREP-C&Q-5			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		• Lead task group • Coordinate with FAA contracting organization • Review ASTM Standard Practice • Review/Expand ARL Definitions • Review FAA Cert Testing requirements	
Estimated Cost	$0	$24K	$0

TIMELINE :



1.5.1 PREP-C&Q-5 SUPPLEMENTAL INFORMATION

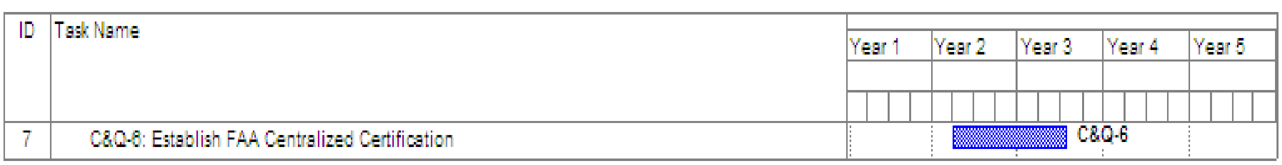
The RFP will be based on the Phase 1 and Phase 2 screening criteria. It will solicit candidate unleaded fuel producers to provide fuel for participation in the FAA Tech Center Phase 1 and Phase 2 testing. It will be structured in two phases, with a reduced number of candidate fuels participating in the Phase 2 testing. The RFP will not offer a monetary award, but rather offer test data that can be used for the ASTM specification development process and the FAA certification process.

1.6 C&Q TASK PREP-C&Q-6

TASK:	Establish FAA Centralized Certification
WORKSCOPE:	Develop plan for FAA to designate one ACO for oversight of aviation gasoline certification projects. Review FAA policy and procedures and coordinate with FAA management, and other FAA supporting organizations. Include FAA Cert FTEs from other directorates.
ITEM No:	**PREP-C&Q-6**
LEAD ORGANIZATION:	FAA
DELIVERABLE:	FAA Centralized Certification Plan
TIMELINE:	See Below
COST ESTIMATE:	See Below

PAFI TASK PREP-C&Q-6			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Internal FAA issue, so almost exclusively an FAA task.	• Lead task group • Review FAA policy • Consult with FAA supporting organizations and management • Obtain FAA mgt approval	• Limited input to document
Estimated Cost	$0	$23K	$2K

TIMELINE :



1.6.1 PREP-C&Q-6 SUPPLEMENTAL INFORMATION

The FAA Centralized Certification Support Plan will cover the following elements:

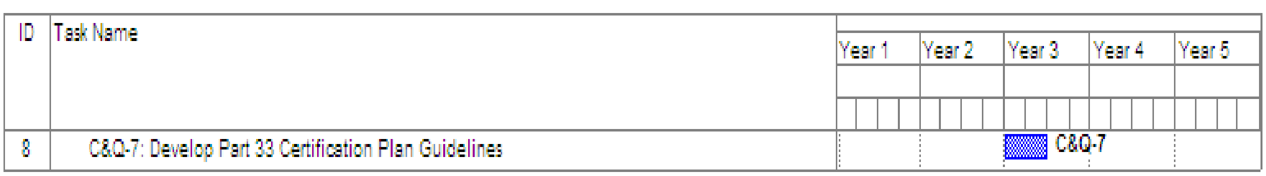
1. Geographic location of the designated FAA facility.
2. Organizational level and management structure of assigned FAA group.
3. Knowledge/Skills/Experience requirements for FAA staff.
4. Office-level job aids defining procedures for interfacing with PAFI, FAA Review Board, and Fuel Producer applicant.
5. Reference documents to support certification projects.

1.7 C&Q TASK PREP-C&Q-7

TASK:	Develop Part 33 (Engine) Certification Plan Guidelines.
WORKSCOPE:	Define applicable FARs and compliance requirements that are compatible with PAFI fuel development concept. Review FAA Part 33 certification policy and procedures and coordinate with FAA Tech Center. Obtain FAA management approval of template certification plans.
ITEM No:	**PREP-C&Q-7**
LEAD ORGANIZATION:	FAA
DELIVERABLE:	FAA Part 33 (Engine) Certification Plan Guidelines
TIMELINE:	See Below
COST ESTIMATE:	See Below

PAFI TASK PREP-C&Q-7			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Primarily FAA task, but will seek input from other PAFI members	• Lead task group • Review FAA Part 33 policy • Coordinate with R&D development of Phase 2 test methods • Consult with industry stakeholders • Obtain FAA mgt approval	• Moderate input to document
Estimated Cost	$0	$18K	$7K

TIMELINE :



1.7.1 PREP-C&Q-7 SUPPLEMENTAL INFORMATION

The FAA 14 CFR Part 33 (Engine) Certification plan guidelines will contain descriptive abstracts of certification testing and/or analysis requirements for the following regulations. The Part 33 compliance plan should be coordinated with the test procedures to be developed for the FAA Tech Center to make maximum use of the tests performed to show compliance.

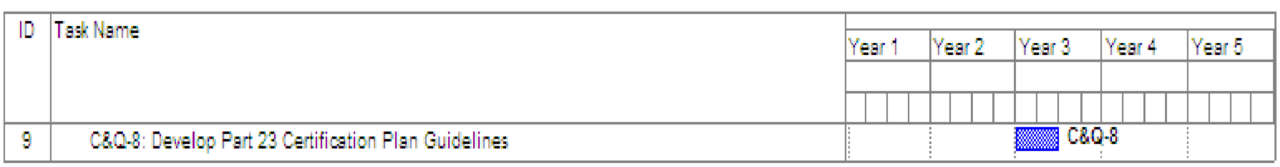
§ 33.4	Instructions for Continued Airworthiness
§ 33.5	Instruction manual for installing and operating the engine
§ 33.7	Engine ratings and operating limitations
§ 33.15	Materials
§ 33.17	Fire prevention
§ 33.19	Durability
§ 33.21	Engine cooling
§ 33.28	Engine control systems
§ 33.35	Fuel and induction system
§ 33.43	Vibration test
§ 33.45	Calibration test
§ 33.47	Detonation test
§ 33.49	Endurance test
§ 33.51	Operation test
§ 33.53	Engine component test
§ 33.55	Teardown inspection
§ 33.57	General conduct of block tests

1.8 C&Q TASK PREP-C&Q-8

TASK: Develop Part 23 (Aircraft) Certification Plan Guidelines.
WORKSCOPE: Define applicable FARs and compliance requirements that are compatible with PAFI fuel development concept. Review FAA Part 23 certification policy and procedures and coordinate with FAA Tech Center. Obtain FAA management approval of template certification plans.
ITEM No: **PREP-C&Q-8**
LEAD ORGANIZATION: FAA
DELIVERABLE: FAA Part 23 (Aircraft) Certification Plan Guidelines
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-C&Q-8			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Primarily FAA task, but will seek input from other PAFI members	• Lead task group • Review FAA Part 23 policy • Coordinate with R&D development of Phase 2 test methods • Consult with industry stakeholders • Obtain FAA mgt approval	• Moderate input to document
Estimated Cost	$0	$18K	$11K

TIMELINE:



1.8.1 PREP-C&Q-8 SUPPLEMENTAL INFORMATION

The FAA 14 CFR Part 23 (Aircraft) Certification plan guidelines will contain descriptive abstracts of certification testing and/or analysis requirements for the following regulations. The Part 23 compliance plan should be coordinated with the test procedures to be developed for the FAA Tech Center to make maximum use of the tests performed to show compliance.

Part 23 Regulations

§ 23.23	Load distribution limits
§ 23.25	Weight limits
§ 23.29	Empty weight and corresponding center of gravity
§ 23.53	Takeoff performance
§ 23.63	Climb: General
§ 23.69	Enroute climb/descent
§ 23.77	Balked landing
§ 23.343	Design fuel loads
§ 23.603	Materials
§ 23.863(b)(2)	Flammable fluid fire protection
§ 23.901(f)	Auxiliary power unit
§ 23.903	Engines
§ 23.939	Powerplant operating characteristics
§ 23.943	Negative acceleration
§ 23.951	General (fuel system)
§ 23.955	Fuel flow
§ 23.959	Unusable fuel supply
§ 23.961	Fuel system hot weather operation
§ 23.963	Fuel tanks: General
§ 23.965	Fuel tank tests
§ 23.969	Fuel tank expansion space
§ 23.973(e)(f)	Fuel tank filler connection
§ 23.975	Fuel tank vents and carburetor vapor vents
§ 23.979	Pressure fueling system
§ 23.993	Fuel system lines and fittings
§ 23.997	Fuel strainer or filter
§ 23.1001	Fuel jettisoning system
§ 23.1011	General (oil system)
§ 23.1041	General (cooling)
§ 23.1043	Cooling tests
§ 23.1045	Cooling test procedures for turbine powered airplanes
§ 23.1047	Cooling test procedures for reciprocating engine powered airplanes
§ 23.1305	Powerplant instruments
§ 23.1337	Powerplant instruments installation
§ 23.1501	General
§ 23.1521	Powerplant limitations
§ 23.1522	Auxiliary power unit limitations

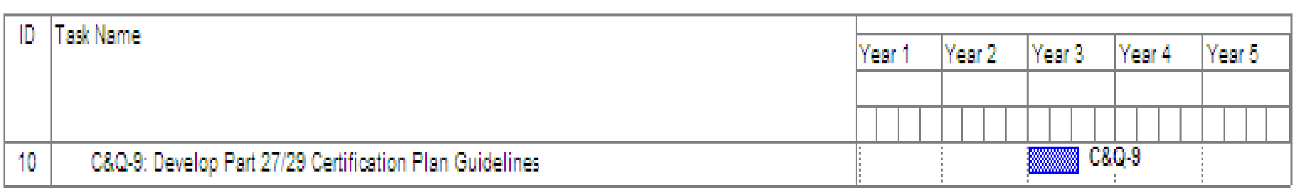
§ 23.1529	Instructions for Continued Airworthiness
§ 23.1541	General (markings and placards)
§ 23.1549	Powerplant and auxiliary power unit instruments
§ 23.1557(c)	Powerplant fluid filler openings
§ 23.1581	General (airplane flight manual)
§ 23.1583	Operating limitations
§ 23.1585(i)	Operating procedures

1.9 C&Q TASK PREP-C&Q-9

TASK: Develop Part 27/29 (Rotorcraft) Certification Plan Guidelines.
WORKSCOPE: Define applicable FARs and compliance requirements that are compatible with PAFI fuel development concept. Review FAA Part 27/29 certification policy and procedures and coordinate with FAA Tech Center. Obtain FAA management approval of template certification plans.
ITEM No: **PREP-C&Q-9**
LEAD ORGANIZATION: FAA
DELIVERABLE: FAA Part 27/29 (Rotorcraft) Certification Plan Guidelines
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-C&Q-9			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Primarily FAA task, but will seek input from other PAFI members	• Lead task group • Review FAA Part 23 policy • Coordinate with R&D development of Phase 2 test methods • Consult with industry stakeholders • Obtain FAA mgt approval	• Moderate input to document
Estimated Cost	$0	$18K	$5K

TIMELINE:



1.9.1 PREP-C&Q-9 SUPPLEMENTAL INFORMATION

The FAA 14 CFR Part 27/29 (Rotorcraft) Certification plan guidelines will contain descriptive abstracts of certification testing and/or analysis requirements for the following regulations. The Part 27/29 compliance plan should be coordinated with the test procedures to be developed for the FAA Tech Center to make maximum use of the tests performed to show compliance.

Part 27 Regulations

§ 27.25	Weight limits
§ 27.27	Center of gravity limits
§ 27.29	Empty weight and corresponding center of gravity
§ 27.45	Performance (General)
§ 27.49	Performance at minimum operating speed
§ 27.51	Takeoff
§ 27.65	Climb: All-engines operating
§ 27.67	Climb: One-engine-inoperative
§ 27.75	Landing
§ 27.603	Materials
§ 27.863(b)(2)	Flammable fluid fire protection
§ 27.903	Engines
§ 27.903(d)	Restart capability
§ 27.939	Turbine engine operating characteristics
§ 27.951	General (fuel system)
§ 27.955	Fuel flow
§ 27.959	Unusable fuel supply
§ 27.961	Fuel system hot weather operation
§ 27.969	Fuel tank expansion space
§ 27.975	Fuel tank vents
§ 27.997	Fuel strainer or filter
§ 27.1011(b)	General (oil system)
§ 27.1041	General (cooling)
§ 27.1043	Cooling tests
§ 27.1045	Cooling test procedures
§ 27.1305	Powerplant instruments
§ 27.1337	Powerplant instruments
§ 27.1521	Powerplant limitations
§ 271529	Instructions for Continued Airworthiness
§ 27.1541	General (markings and placards)
§ 27.1557(c)	Miscellaneous markings and placards
§ 27.1581	General (rotorcraft flight manual)
§ 27.1583	Operating limitations
§ 27.1585(e)(f)	Operating procedures

Part 29 Regulations

§ 29.25	Weight limits
§ 29.27	Center of gravity limits
§ 29.29	Empty weight and corresponding center of gravity
§ 29.45	Performance (General)
§ 29.49	Performance at minimum operating speed
§ 29.51	Takeoff data: general
§ 29.53	Takeoff: Category A
§ 29.63	Takeoff: Category B

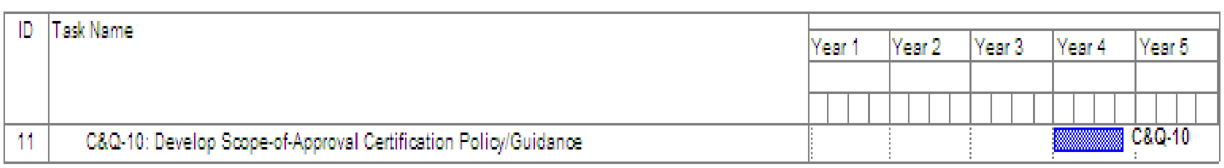
§ 29.65	Climb: All-engines operating
§ 29.67	Climb: One-engine-inoperative
§ 29.77	Landing decision point (LDP): Category A
§ 29.79	Landing: Category A
§ 29.83	Landing: Category B
§ 29.85	Landing: balked landing: Category A
§ 29.603	Materials
§ 29.863(b)(2)	Flammable Fluid Fire Protection
§ 29.901(c)(d)	Auxiliary power unit
§ 29.903	Engines
§ 29.903(e)	Restart capability
§ 29.923(p)	Rotor drive system and control mechanism tests
§ 29.939	Turbine engine operating characteristics
§ 29.951	General (fuel system)
§ 29.955	Fuel flow
§ 29.959	Unusable fuel supply
§ 29.961	Fuel system hot weather operation
§ 29.969	Fuel tank expansion space
§ 29.975	Fuel tank vents and carburetor vapor vents
§ 29.979	Pressure refueling
§ 29.997	Fuel strainer or filter
§ 29.1001	Fuel jettisoning system
§ 29.1011(b)	General (oil system)
§ 29.1041	General (cooling)
§ 29.1043	Cooling tests
§ 29.1045	Climb cooling test procedures
§ 29.1047	Takeoff cooling test procedures
§ 29.1049	Hover cooling test procedures
§ 29.1305	Powerplant instruments
§ 29.1337	Powerplant instruments
§ 29.1521	Powerplant limitations
§ 29.1522	Auxiliary power unit limitations
§ 29.1529	Instructions for Continued Airworthiness
§ 29.1541	General (markings and placards)
§ 29.1557(c)	Miscellaneous markings and placards
§ 29.1581	General (rotorcraft flight manual)
§ 29.1583	Operating limitations
§ 29.1585(e)(f)	Operating procedures
§ 29.1587	Performance information

1.10 C&Q TASK PREP-C&Q-10

TASK: Develop Scope-of-Approval Certification Policy/Guidance.
WORKSCOPE: Develop guidelines to facilitate the fleet-wide approval of aircraft/engine sub-population based on non-model parameters.
ITEM No: **PREP-C&Q-10**
LEAD ORGANIZATION: FAA
DELIVERABLE: FAA Policy for Fleet-wide Approval of Aviation Fuel
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-C&Q-10			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	FAA task, but will seek input from other PAFI members	• Recruit FAA SME's from Standards Staffs of Assigned Directorates • Consult with industry stakeholders • Review FAA regulatory vehicles for accommodating broad-based approvals • Obtain FAA mgt approval	• Moderate input to document
Estimated Cost	$0	$48K	$14K

TIMELINE:



1.10.1 PREP-C&Q-10 SUPPLEMENTAL INFORMATION

The policy should address the following key elements.

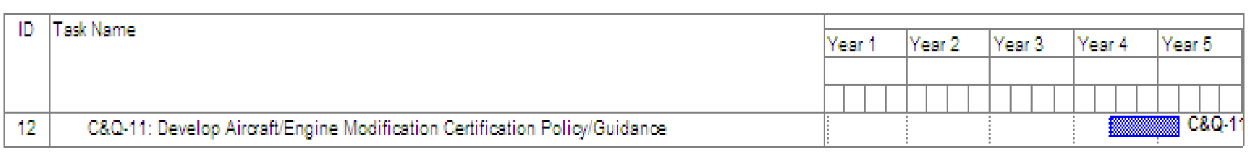
1. Accommodate STC approval of engines/aircraft identified in terms of performance or other design parameters.
2. The approval should be based on data generated during the Phase 2 FAA Tech Center testing and the recommendation for scope of approval contained in the FAA Tech Center Phase 2 reports.
3. The existing fleet of type certificated engines and aircraft need to be identified and bracketed in terms of performance and other relevant parameters.
4. The policy should accommodate both CAR and FAR certification bases.
5. The policy should accommodate orphaned and abandoned products.

1.11 C&Q TASK PREP-C&Q-11

TASK: Develop Aircraft/Engine Modification Certification Policy/Guidance
WORKSCOPE: Develop procedures/guidance to facilitate certification of out-of-scope aircraft/engines requiring modifications.
ITEM No: **PREP-C&Q-11**
LEAD ORGANIZATION: FAA
DELIVERABLE: FAA Procedures/Guidance for Certification Approval of Aircraft/ Engine Modifications
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-C&Q-11			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	FAA task, but will seek input from other PAFI members	▪ Recruit FAA SME's from Standards Staffs of Assigned Directorates ▪ Consult with industry stakeholders ▪ Review FAA concepts for expediting approvals ▪ Identify approval classes to manage issue ▪ Obtain FAA mgt approval	• Moderate input to document
Estimated Cost	$0	$48K	$14K

TIMELINE:



1.11.1 PREP-C&Q-11 SUPPLEMENTAL INFORMATION

The policy should address the following key elements:

1. Develop classes of approvals, such documentation-only changes, minor hardware changes/adjustments such as seals/o-rings or timing changes, and major hardware changes.
2. The policy should accommodate both CAR and FAR certification bases.
3. The policy should accommodate orphaned and abandoned products.
4. Investigate means for accommodating broad-based approvals.
5. Identify any other means for expediting approvals

2.0 TEST & EVALUATION IMPLEMENTATION PLANS PREPARATORY STAGE

The following in-kind examples are applicable to T&E support of PAFI for the preparatory stage, Tasks T&E-1 through T&E-6 as defined in this Appendix E, and for the project stage Tasks T&E-7 through T&E-11 as described in Appendix F.

Examples of in-kind contributions from industry:

- Equipment – aircraft, engines
- Accessories – vacuum pumps, generators, tachometers, etc.
- Parts – fuel systems, cylinder assemblies, turbo systems, exhaust and intake systems, ignition systems, etc.
- Instrumentation – sensors, electronic DAQ, interface conditioners
- Machining and tooling services – welding, tubing bending, machining, cylinder sensor assembly, bracket manufacturing, hose manufacturing, etc.
- Engineering support – engineering expertise and experience
- Documentation- test article specifications, installation drawings
- Materials – gaskets, o-rings, seals
- Measurements and Overhauls
- Fuel and oil analyses methods

The following represents an estimate of the industry in-kind support required to support the FAA Test & Evaluation program Tasks T&E-1 through T&E-11. The following table further segregates the industry in-kind cost estimate into engine, aircraft, and labor categories. As identified above, the industry in-kind participation represents support furnished to the FAA Test & Evaluation Program and does not include industry non-recurring engineering costs.

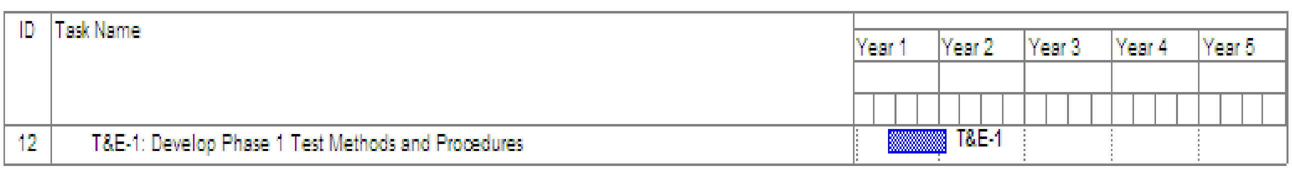
PAFI Industry In-Kind Test & Evaluation Support Estimated Annual Cost								
Task	**Description**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**
Prep-T&E-1	Labor	$75K						
Prep- T&E -1	Materials	$100K						
Prep- T&E -2	Materials		$50K					
Prep- T&E -3	Labor		$25K					
Prep- T&E -4	Labor		$400K	$200K				
Prep- T&E -4	Materials		$345K	$115K				
Prep- T&E -5	Aircraft			$600K	$900K			
Prep- T&E -5	Engines			$300K	$100K			
Prep- T&E-5	Materials			$145K	$45K			
Prep- T&E -6	Labor		$33K	$17K				
Prep- T&E -7	Labor			$300K				
Proj- T&E -7	Materials			$60K				
Proj- T&E -8	Labor			$50K				
Proj- T&E -9	Labor				$475K	$900K		
Proj- T&E -9	Materials				$990K	$500K		
Proj- T&E -10	Labor					$25K	$25K	
Proj- T&E -11	Labor						$640K	$1,260K
Proj- T&E 11	Materials						$324K	$650K
Total ($1,000)		$175	$853	$1,787	$2,510	$1,425	$1989	$1,910

2.1 T&E TASK PREP-T&E-1

TASK: Develop Phase 1 Test Methods & Procedures
WORKSCOPE: FAA Tech Center works with other PAFI members to develop methods & procedures based upon ASTM document guidance.
TASK No: **PREP- T&E -1**
LEAD ORGANIZATION: FAA Tech Center
DELIVERABLE: Lab test methods & procedures; rig test methods & procedures
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-T&E-1			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Coordinate with ASTM TF document Guidance Section 6.2 (FFP lab tests and rig tests).	FAA Tech Center works with other PAFI members to develop lab methods/procedures based on ASTM document guidance. Develop rig tests to identify impact of properties on fuel/ lubrication systems.	Active engineering expertise /support /in-kind toward developing rig and laboratory test procedures and methods. Impact of fuel properties on engine/airframe, fuel systems.
Estimated Cost	$0	$940K	$175K

TIMELINE:



2.1.1 PREP-T&E-1 SUPPLEMENTAL INFORMATION

The standardized fit-for-purpose (FFP) properties test methods and procedures will consist of ASTM D910 specification laboratory test methods, specific fuel-related laboratory tests, material compatibility, toxicology, and rig tests. This testing will be partly based on the test methods and information described in section 6.2 of ASTM International Standard Practice DXXXX, "Standard Practice for the Evaluation of New Aviation Gasolines and New Aviation Gasoline Additives". The test procedures will consist of the following elements.

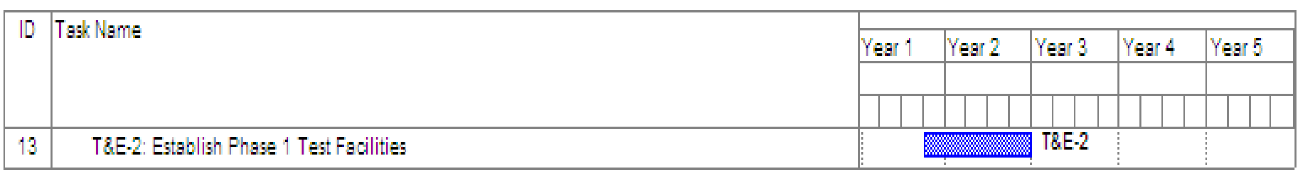
1. ***Basic Specification Properties*** - These should be based on, but not be limited to D910 Table 1 properties. The basic specification property results for evaluation of additives should be compared to the corresponding data for the base fuel.
2. ***Fuel Composition*** - Detailed chemical analysis of hydrocarbons and trace materials. The composition of additives should be defined to the extent necessary to establish conformance of the products used for testing.
3. ***Fit-For-Purpose Properties (FFP)*** - This testing may address issues related to cold fuel flowability, flame speed, heat of combustion, fuel nozzle spray patterns, fuel/oil interaction, co-mingling with current fuels, and lubricity. Novel fuels with unique properties may require additional FFP test procedures. The test results should be compared to the corresponding data for D910 100LL fuels.
4. ***Rig Test Procedures*** - Development of rig test procedures may require construction of test rigs and collection of empirical data for validation and standardization of procedures.
5. ***Materials Compatibility*** - Development of procedures for soak testing of key production and delivery systems, airplane and engine fuel system elastomers, seals and other non-metallic parts to measure property changes such as % volume change, hardness, tensile strength, etc.
6. ***Toxicology*** - Procedures to be used to develop procurement documents for the evaluation of the toxicological effects of proposed novel fuels. This data should be compared to literature for the current leaded aviation fuels found in ASTM International specification D910.

2.2 T&E TASK PREP-T&E-2

TASK: Establish Phase 1 Test Facilities
WORKSCOPE: FAA Tech Center procures necessary equipment and contracts to support Phase 1 testing.
TASK No: **PREP-T&E-2**
LEAD ORGANIZATION: FAA Tech Center
DELIVERABLE: Test equipment and subcontracts
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-T&E-2			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Identify equipment. Procure equipment. Identify experts. Contract facilities.	FAA Tech Center identifies and procures necessary equipment and subcontracts to support Phase 1 testing.	Provide engineering expertise/ support /in-kind to establish laboratory and rig tests, identify experts.
Estimated Cost	$0	$ 6.65M	$50K

TIMELINE:



2.2.1 PREP-T&E-2 SUPPLEMENTAL INFORMATION

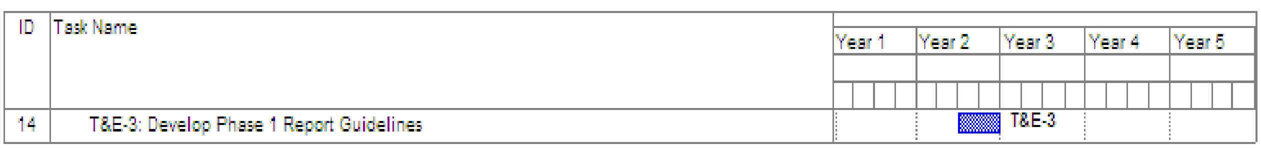
Establishing facilities includes procurement of necessary laboratory and rig equipment, materials compatibility and toxicology contracts, independent fuel and lube laboratory contracts, and contract labor to design, machine, assemble and construct rig tests. Rigs may be constructed to investigate cold fuel flowability, flame speed effects such as valve seat recession, fuel nozzle spray patterns, fuel/oil interaction effects, co-mingling with current fuels, and fuel lubricity. Novel fuels with unique properties may require additional rig construction.

2.3 T&E TASK PREP-T&E-3

TASK: Develop Phase 1 Report Guidelines
WORKSCOPE: FAA Tech Center works with other PAFI members to standardize report content and format.
TASK No: **PREP-T&E-3**
LEAD ORGANIZATION: FAA Tech Center
DELIVERABLE: Phase 1 report guidelines
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-T&E-3			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Identify Analyses Methods, and Statistical Content Documentation	FAA Tech Center works with other PAFI members to standardize report content and format.	Provide engineering support to help develop guidelines including analyses methods, content, procedures
Estimated Cost	$0	$ 120K	$25K

TIMELINE:

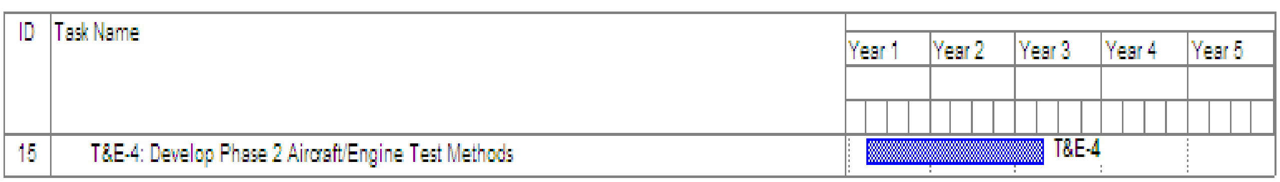


2.4 T&E TASK PREP-T&E-4

TASK: Develop Phase 2 Engine & Aircraft Test Methods
WORKSCOPE: FAA Tech Center works with other PAFI members to develop methods &procedures based on ASTM document guidance
TASK No: **PREP- T&E-4**
LEAD ORGANIZATION: FAA Tech Center
DELIVERABLE: Test Methods
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-T&E-4			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Coordinate with ASTM TF document Guidance Section 6.3 and certification central office.	FAA Tech Center works with PAFI members to develop test methods & procedures based upon ASTM document guidance.	Provide engineering expertise/support/in-kind support to establish engine and airframe test procedures; help identify experts.
Estimated Cost	$0	$ 3.65M	$1.06M

TIMELINE:



2.4.1 PREP-T&E-4 SUPPLEMENTAL INFORMATION

Establishing standard testing procedures for engine and aircraft includes testing listed in section 6.3 of ASTM International Standard Practice DXXXX, "Standard Practice for the Evaluation of New Aviation Gasolines and New Aviation Gasoline Additives", and FAA engine and aircraft airworthiness standards, and at a minimum includes:

1) ***Instrumentation & Test Facility Requirements*** - Test procedures will be specifically adopted for use with the instrumentation, equipment, fuel delivery systems, and facilities at the FAA Tech Center and for specific fuels. Test methods will not be broadly adoptable to other facilities using other equipment and methods.

2) ***Engine Testing*** - A portfolio of engine tests on designated engine models will be performed to evaluate composition, volatility, fluidity, combustion, corrosion, and stability properties of the fuel.

3) ***Aircraft Testing*** - A portfolio of aircraft tests on designated engine models will be performed to evaluate composition, volatility, fluidity, combustion, corrosion, and stability properties of the fuel.

4) ***Certification Requirements*** - Aircraft and engine test procedures should incorporate certification requirements for engine/aircraft/propeller systems listed previously under Qualification & Certification Tasks PREP-C&Q-7,-8, and -9.

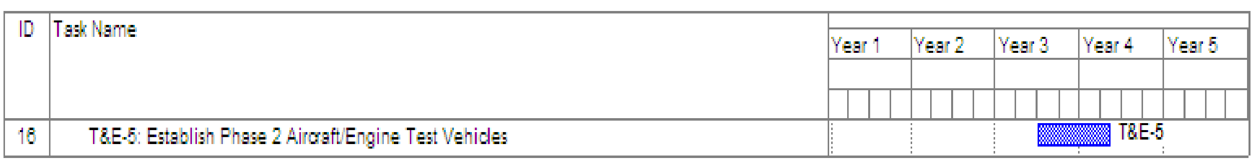
5) ***Test Results*** - Test results to be compared against test results on ASTM D910 fuels.

2.5 T&E TASK PREP-T&E-5

TASK:	Establish Phase 2 Engine & Aircraft Test Articles
WORKSCOPE:	FAA Tech Center procures necessary equipment to support Phase 2 testing.
TASK No:	**PREP- T&E-5**
LEAD ORGANIZATION:	FAA Tech Center
DELIVERABLE:	Engines & Aircraft Available to support testing
TIMELINE:	See Below
COST ESTIMATE:	See Below

PAFI TASK PREP-T&E-5			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Full envelope, in-flight, rig. Emissions is not FFP but to be performed.	FAA Tech Center identifies and procures necessary equipment and facilities to support Phase 2 testing	Provide test engines/ airframes, parts, instrumentation, expertise. Provide engineering support to identify test facilities/ engines/ airframes.
Estimated Cost	$0	$ 8.755M	$2.09M

TIMELINE :



2.5.1 PREP-T&E-5 SUPPLEMENTAL INFORMATION

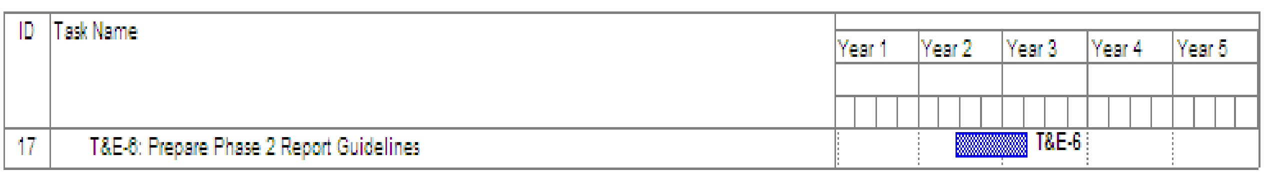
Establishing Phase II testing facilities includes procurement of necessary materials, equipment, test articles, contract labor support, FAA personnel, independent laboratory contracts for fuel and lube analyses. Outsourced contracts for flight testing and specialty component engine testing may be required. Emissions testing equipment will be procured.

2.6 T&E TASK PREP-T&E-6

TASK: Prepare Phase 2 Report Guidelines
WORKSCOPE: FAA Tech Center works with PAFI members to standardize test report content and format.
TASK No: **PREP-T&E-6**
LEAD ORGANIZATION: FAA Tech Center
DELIVERABLE: Phase 2 Report Guidelines
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-T&E-6			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Identify Analyses Methods Statistical Content Documentation	FAA Tech Center works with other PAFI members to standardize report content and format	Provide engineering support to help develop guidelines, analyses methods, content, procedures
Estimated Cost	$0	$50K	$50K

TIMELINE:



3.0 P & D IMPLEMENTATION PLANS, PREPARATORY STAGE

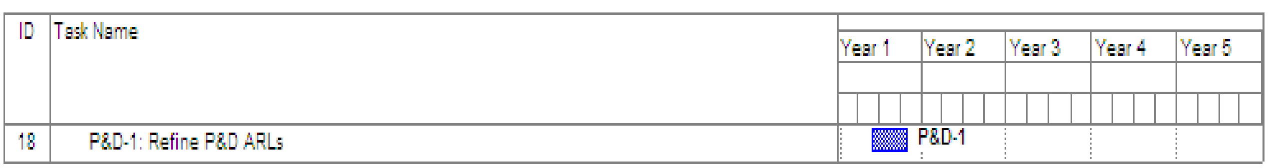
3.1 P&D TASK PREP-P&D-1

TASK: Refine Production & Distribution ARLs
WORKSCOPE: Fully Define Production/Distribution Related ARL's

TASK No: **PREP-P&D-1**
LEAD ORGANIZATION: PAFI
DELIVERABLE: Defined ARL's
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-P&D-1			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Organize workgroup. Refine ARL's relating to production & distribution; including defining criteria for meeting an individual ARL step – Identify and recruit Industry participants.	Participate as member of PSG. Provide supporting data when requested.	Participate in work group. Contribute to document content.
Estimated Cost	$0	$0	$23K

TIMELINE:



3.1.2 PREP-P&D-1 SUPPLEMENTAL INFORMATION

This task is a direct PAFI task that will be accomplished during the preparatory stage. The purpose of this task is to further define ARL's relating to production & distribution; including defining criteria for meeting an individual ARL step. ARL definitions will need to be specific enough to provide validation of completion of the step, including standardized data presentation but broad enough to account for novel processes. This task will be completed by an industry/PAFI workgroup.

Related AVGAS Readiness Levels (ARL):

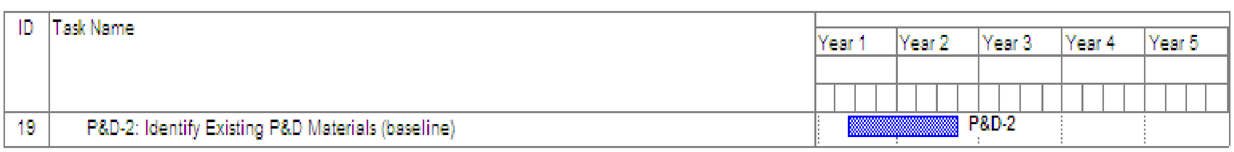
ARL 1 - Fuel Definition
ARL 2 – Material Safety Review
ARL 3- Basic Fuel Properties and Composition
ARL 6.1 - Preliminary Production & Distribution Assessment
ARL 7 – Pilot Production Capability
ARL 10 – Pilot Production Capability
ARL 12.1 - Final Production & Distribution Assessment
ARL 13 – Initial Production Capability
ARL 15 – Production Scale-Up

3.2 P&D TASK PREP-P&D-2

TASK: Identify Existing Production & Distribution Materials (Baseline)
WORKSCOPE: Develop report detailing materials used in P&D
TASK No: **PREP-P&D-2**
LEAD ORGANIZATION: PAFI
DELIVERABLE: Data Base & Final Report
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP- P&D-2			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Organize workgroup to prepare report summarizing component materials used in existing production & distribution system for use by candidate fuel developer.	Participate as member of PSG. Provide supporting data when requested.	Participate in work group. Contribute to document content.
Estimated Cost	$0	$0	$20K

TIMELINE:



3.2.1 PREP-P&D-2 SUPPLEMENTAL INFORMATION

This task will be a direct PAFI task completed during the preparatory stage. The purpose of this task is to develop a database of materials used in the production and distribution process for which compatibility testing may need to be completed. This task will be completed by an industry/PAFI workgroup.

Note: ASTM International Standard Practice, "Standard Practice for the Evaluation of New Aviation Gasolines and New Aviation Gasoline Additives" currently contains a listing of aircraft and aircraft engine materials than would need to be tested in order to establish "fit for purpose" properties for a new aviation gasoline fuel. Identical materials used in the production and distribution system could be excluded from this task as compatibility would already be established. Additional materials identified under this task would be forwarded to the ASTM committee overseeing the Standard Practice for consideration of inclusion in future revisions.

Cataloging of materials should include:

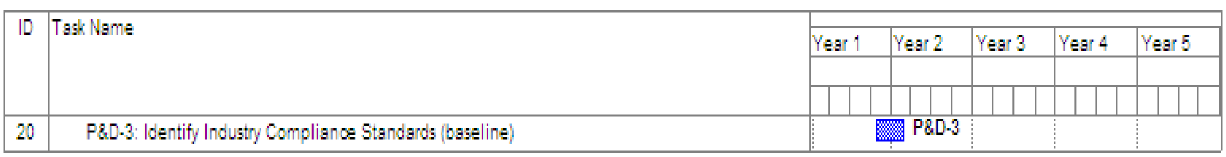
- Production Systems
- Distribution Systems
    - Rail transportation
    - Barge transportation
    - Over-the-road truck transportation
    - Pipeline transportation
    - Transfer systems (pumps & associated equipment)
    - On-airport storage & delivery systems
    - Filtration & water separation systems

3.3 P&D TASK PREP-P&D-3

TASK: Identify Industry Compliance Standards (Baseline)
WORKSCOPE: Assess third party non-ASTM standards for compliance issues
TASK No: **PREP-P&D-3**
LEAD ORGANIZATION: PAFI
DELIVERABLE: Final Report
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-P&D-3			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Organize workgroup to Prepare list of applicable industry compliance standards (UL, NFPA, EI) for use by candidate fuel developer	Participate as member of PSG. Provide supporting data when requested.	Participate in work group. Contribute to document content.
Estimated Cost	$0	$0	$85K

TIMELINE:



3.3.1 PREP-P&D-3 SUPPLEMENTAL INFORMATION

This task is a direct PAFI task that will be completed by an industry/PAFI workgroup in the preparatory phase. This task will involve the identification and assessment of third-party non-ASTM standards/codes/requirements that may affect the deployment of an unleaded gasoline including:

- National Fire Protection Association Standard on Aircraft Refueling – NFPA 407
- Energy Institute Aviation Fuel Handling Publications
- Underwriters Laboratories Listing/Recognition/Classification Requirements
- Military Standards
- European Aviation Safety Agency standards and regulations
- Canadian General Standards Board

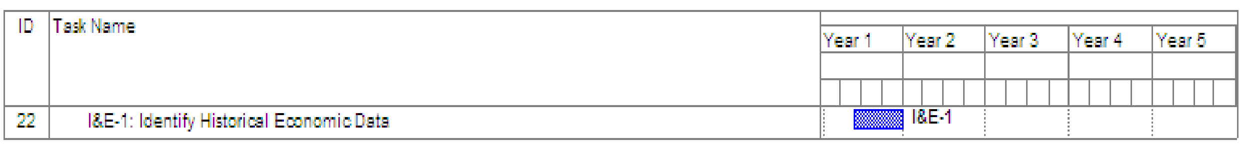
4.0 IMPACT & ECONOMICS IMPLEMENTATION PLANS PREPARATORY STAGE

4.1 I&E TASK PREP-I&E-1

TASK: Identify Historical Economic Data
WORKSCOPE: Prepare report of historical AVGAS prices
TASK No: **PREP-I&E-1**
LEAD ORGANIZATION: FAA
DELIVERABLE: Final Report
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-I&E-1			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Oversight. Oversee the development of historic data report.	Participate as member of PSG. Provide supporting data when requested.	Provide supporting data when requested.
Estimated Cost	$30K	$0	$30K

TIMELINE:



4.1.1 PREP-I&E-1 SUPPLEMENTAL INFORMATION

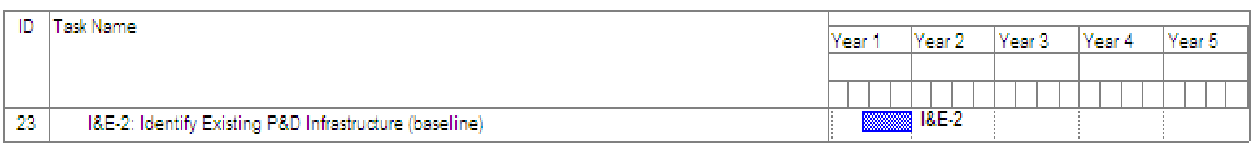
Task I&E-1 occurs during the PAFI Preparatory Stage and has the objective of providing economic analysis of the historic AVGAS price.

4.2 I&E TASK PREP-I&E-2

TASK: Identify Existing Production & Distribution Infrastructure (Baseline)
WORKSCOPE: Prepare assessment of existing fuel production & distribution infrastructure
TASK No: **PREP-I&E-2**
LEAD ORGANIZATION: FAA
DELIVERABLE: Final Report
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-I&E-2			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Oversight. Oversee the development of report on existing fuel production & distribution infrastructure	Participate as member of PSG. Provide supporting data when requested.	Provide supporting data when requested.
Estimated Cost	$60K	$0	$60K

TIMELINE:



4.2.1 PREP-I&E-2 SUPPLEMENTAL INFORMATION

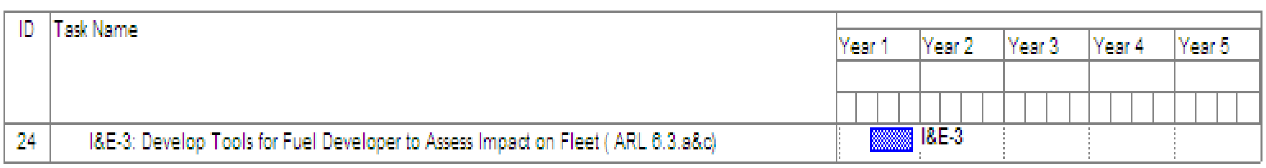
Task I&E-2 occurs during the PAFI Preparatory Stage and has the objective of documenting historic AVGAS storage and distribution costs. A report will be provided in support of developing business plans which will be utilized in developing the analysis-audit-validation tool in I&E-4.

4.3 I&E TASK PREP-I&E-3

TASK: Develop Tools for Fuel Developer to Assess Impact on Fleet (ARL 6.3.a & c)
WORKSCOPE: Development of tools & guidelines to assess impact of fuel changes
TASK No: **PREP-I&E-3**
LEAD ORGANIZATION: FAA
DELIVERABLE: Final Report
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP- I&E-3			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Oversight. Develop & identify tools & guide- lines for fuel developer to assess impact of fuel changes on fleet to include the extent of modifications.	Participate as member of PSG. Provide supporting data when requested.	Provide supporting data and analysis when requested.
Estimated Cost	$60K	$0	$60K

TIMELINE:



4.3.1 PREP-I&E-3 SUPPLEMENTAL INFORMATION

Task I&E-3 occurs during the PAFI Preparatory Stage and has the objective of developing tools and guidelines to enable assessment of impact of a fuel change on the fleet. Work scope is creation of a process or criteria which would support the applicable ARL and provide tools for PAFI to assess impact of a fuel change. A report will be provided in support of developing business plans which will be utilized in developing the analysis-audit-validation tool in I&E-4. Areas to be addressed include the following.

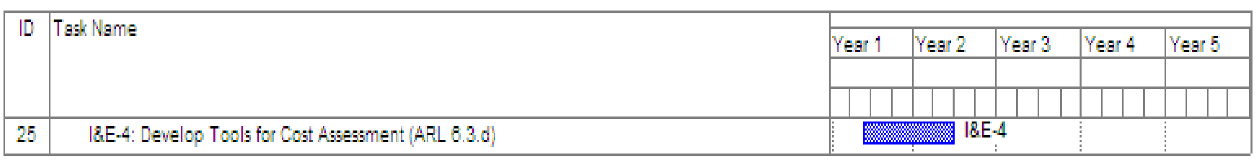
- Materials compatibility
- Performance (takeoff distance, climb performance, etc.)
- Limitations (weight, temperature, operating, etc.)
- Number of aircraft impacted

4.4 I&E TASK PREP-I&E-4

TASK: Develop Tools for Cost Assessment (ARL 6.3.d)
WORKSCOPE: Development of an analysis/audit/validation tool/process/criteria to assess the validity of fuel developer's economic assumptions and factors for economic claims
TASK No: **PREP-I&E-4**
LEAD ORGANIZATION: FAA
DELIVERABLE: Final Report
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-I&E-4			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Oversight. Oversee the development of the methods and /or guidelines to enable assessment, validation of economic claims.	Participate as member of PSG. Provide supporting data when requested.	Provide supporting data when requested.
Estimated Cost	$60K	$0	$0

TIMELINE:



4.4.1 PREP-I&E-4 SUPPLEMENTAL INFORMATION

Task I&E-4 occurs during the PAFI Preparatory Stage and has the objective of developing methods and/or guidelines which would enable PAFI to assess and validate a fuel developer's economic claims. The purpose of this activity is to also provide potential fuel developers with the criteria by which their assumptions and estimates utilized in their business plans will be evaluated.

The analysis-audit-validation tool will rely on the information developed by fuel developers utilizing the tools developed in I&E 1-3.

5.0 ENVIRONMENT & TOXICOLOGY IMPLEMENTATION PLANS, PREPARATORY STAGE

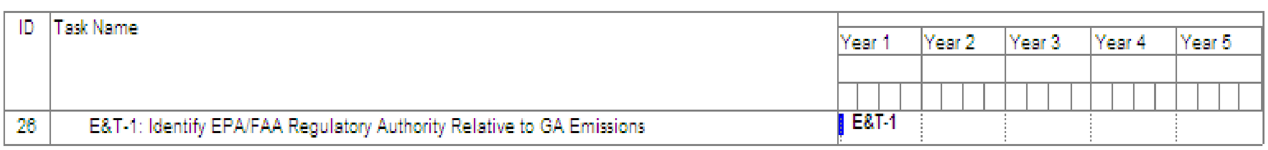
5.1 E&T TASK PREP-E&T-1

TASK: Identify EPA/FAA Regulatory Authority Relative to GA Emissions
WORKSCOPE: Document FAA & EPA authority and obligations as related to General Aviation emissions
TASK No: **PREP-E&T-1**
LEAD ORGANIZATION: PAFI
DELIVERABLE: Final Report
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-E&T-1			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Sharing of information.	Document FAA & EPA authority and obligations as related to General Aviation emissions.	Review FAA & EPA information and provide input.
Estimated Cost	$0	$0	$0

TIMELINE:

Task completed by UAT ARC. See Appendix I for results.

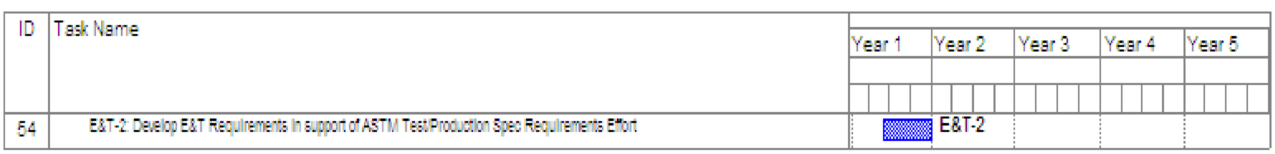


5.2 E&T TASK PREP-E&T-2

TASK: Develop E&T Requirements in Support of ASTM Test/Production Spec Requirements Effort
WORKSCOPE: Add environmental and toxicology requirements in ASTM TF responsible for dev of ASTM New Fuel Std Practice
TASK No: **PREP-E&T-2**
LEAD ORGANIZATION: PAFI
DELIVERABLE: Final Report
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-E&T-2			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	E&T support of overall ASTM effort. Oversee development of resources. Share information with ASTM & PAFI. Inclusion into ASTM Standard Practice.	Review and comment on results. Participate in ASTM Task Force in adopting Standard Practice.	Review and comment on results. Participate in ASTM Task Force in adopting Standard Practice.
Estimated Cost	$0	$100K	$0

TIMELINE:



5.2.1 PREP-E&T-2 SUPPLEMENTAL INFORMATION

It is anticipated that FAA and PAAFI will continue to support development of the ASTM Standard Practice.

5.3 E&T TASK PREP-E&T-3

TASK:	Develop Protocol & Criteria for environmental and toxicological properties relative to current fuels
WORKSCOPE:	Develop Protocol & Criteria for environmental & toxicological properties related to current AVGAS
TASK No:	**PREP-E&T-3**
LEAD ORGANIZATION:	PAFI
DELIVERABLE:	Guidance in screening of candidate fuels with respect to E&T
TIMELINE:	See Below
COST ESTIMATE:	See Below

PAFI TASK PREP-E&T-3			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	E&T effort supportive to overall PAFI and ASTM effort. Oversee development of metrics. Share information with ASTM and PAFI.	Develop Protocol & Criteria for environ-mental & toxicological properties related to current AVGAS.	Review and comment on results. Participate in ASTM Task Force in adopting standard practice.
Estimated Cost	$0K	$100K	$0K

TIMELINE:

ID	Task Name	Year 1	Year 2	Year 3	Year 4	Year 5
55	E&T-3: Develop Protocol and Criteria for E&T Assessment (ARL 6.2)	E&T-3				

5.3.1 PREP-E&T-3 SUPPLEMENTAL INFORMATION

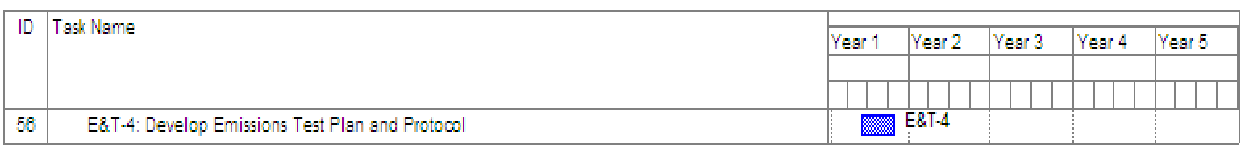
This work is expected to inform PAFI of any concerns associated with adoption, use, and handling of candidate fuels relative to other fuels that are widely available in the market.

5.4 E&T TASK PREP-E&T-4

TASK: Develop emissions test plan and protocol
WORKSCOPE: Develop input & guidance to PAFI to develop a test plan and protocol for exhaust emissions testing
TASK No: **PREP-E&T-4**
LEAD ORGANIZATION: PAFI
DELIVERABLE: Guidance in screening and testing of candidate fuel emissions
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PREP-E&T-4			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	E&T effort supportive to overall fuel test program. Oversee dev of metrics. Share information with ASTM and PAFI.	Develop input & guidance to PAFI to develop a test plan and protocol for exhaust emissions testing.	Review and comment on results. Participate in ASTM task force in adopting standard practice.
Estimated Cost	$0	$100K	$0

TIMELINE:



5.4.1 PREP-E&T-4 SUPPLEMENTAL INFORMATION

This Task will provide an emissions test plan and protocol for candidate fuels based on their identity. For instance, if candidate fuels are radically different in composition than 100LL, or may contain additives such as metals, PAAFI should be aware of potential changes in emissions. Testing will be conducted at the FAA Tech Center with the possibility of using EPA resources or a contractor if test requirements are beyond capabilities of the Tech Center.

Appendix F
PAFI Project Stage Work Scope
Implementation Plans Including Cost Estimates

Note……….Appendix F contains the individual implementation plans for each PAFI task which supports the Project Stage.

1. Certification & Qualification Support Tasks
2. Test & Evaluation Support Tasks
3. Production & Distribution Support Tasks
4. Impact & Economics Support Tasks
5. Environment & Toxicology Support Tasks

1.0 CERTIFICATION & QUALIFICATION IMPLEMENTATION PLANS, PROJECT STAGE

1.1 C & Q TASK PROJ-C&Q-12

TASK: Establish FAA Review Board

WORKSCOPE: Identify, recruit and contract technical specialists to serve on the FAA Review Board to review candidate unleaded fuels for acceptance into FAA Tech Center test program.

TASK No: **PROJ-C&Q-12**

LEAD ORGANIZATION: FAA

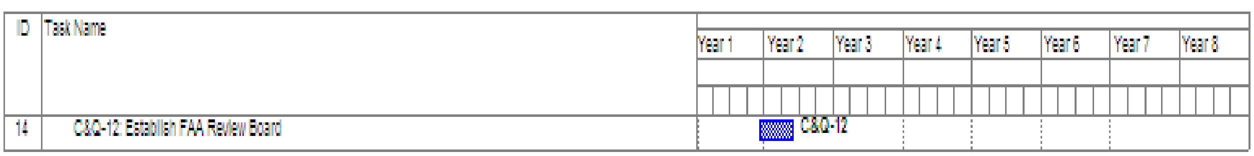
DELIVERABLE: FAA Review Board members.

TIMELINE: See Below

COST ESTIMATE: See Below

PAFI TASK PROJ-C&Q-12			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		▪ Develop contracting or other agreement method to recruit board members ▪ Conduct board member selection process	
Estimated Cost	$0	$18K	$0

TIMELINE :



1.1 PROJ-C&Q-12 SUPPLEMENTAL INFORMATION

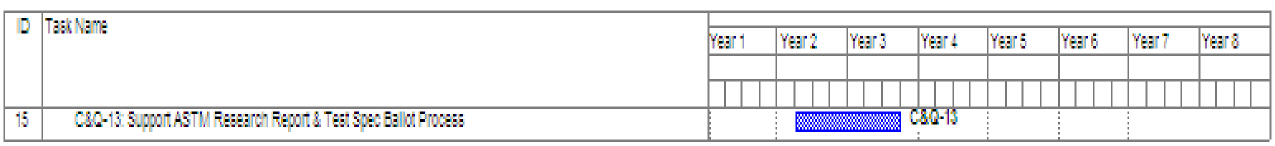
The FAA will develop Memorandums of Agreement (MOA) and recruit members of the FAA Review Board. The procedure will require contracting support and a means to advertise the need for board members. The FAA will interview potential board members and select the leading candidates.

1.2 C & Q TASK PROJ-C&Q-13

TASK: Support ASTM Research Report and Test Spec Ballot Process
WORKSCOPE: Support ASTM Task Force effort to ballot report and spec and to address ballot comments.
TASK No: **PROJ-C&Q-13**
LEAD ORGANIZATION: ASTM
DELIVERABLE: ASTM Test Specification for a New AVGAS
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PROJ-C&Q-13			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		▪ Participate in TF activities ▪ Contribute to document content ▪ Support ASTM balloting process ▪ Reconcile ballot comments	▪ Participate in TF activities ▪ Contribute to document content ▪ Support ASTM balloting process ▪ Reconcile ballot comments
Estimated Cost	$0	$45K	$45K

TIMELINE :

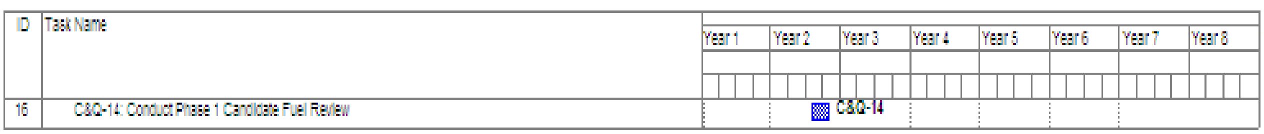


1.3 C & Q TASK PROJ-C&Q-14

TASK: Conduct Phase 1 Candidate Fuel Review
WORKSCOPE: FAA Review Board reviews and selects candidate unleaded fuels for Phase 1 testing
TASK No: **PROJ-C&Q-14**
LEAD ORGANIZATION: FAA
DELIVERABLE: Candidate fuel ratings/rankings.
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PROJ-C&Q-14			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		FAA works with candidate fuel applicant. ▪ Review screening data submitted by candidate fuel applicants for entry into Phase 1 testing. ▪ Rank/rate each candidate fuel	
Estimated Cost	$0	$45K	$0

TIMELINE :



1.3.1 PROJ-C&Q-14 SUPPLEMENTAL INFORMATION

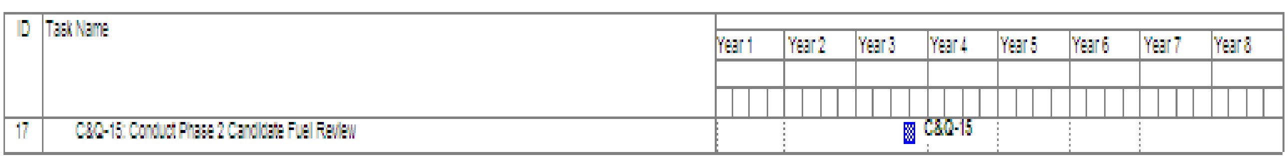
The FAA Review Board will review fuel property data and other information relating to the ARLs provided by the candidate fuel producer. The review board will rank the candidate fuels based on this review. Up to 10 fuels will then be given entrance to the Phase 1 test program. The producers of those fuels will need to provide 10 gallons of fuel to conduct Phase 1 testing.

1.4 C & Q TASK PROJ-C&Q-15

TASK:	Conduct Phase 2 Candidate Fuel Review
WORKSCOPE:	Identify, recruit and contract technical specialists to serve on the FAA Review Board to review candidate unleaded fuels for acceptance into FAA Tech Center test program.
TASK No:	**PROJ-C&Q-15**
LEAD ORGANIZATION:	FAA
DELIVERABLE:	FAA Review Board members.
TIMELINE:	See Below
COST ESTIMATE:	See Below

PAFI TASK PROJ-C&Q-15			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		▪ Review Phase 1 data generated by FAA Tech Center for entry into Phase 2 testing. ▪ Rank/rate each candidate fuel	
Estimated Cost	$0	$45K	$0

TIMELINE :



1.4.1 PROJ-C&Q-15 SUPPLEMENTAL INFORMATION

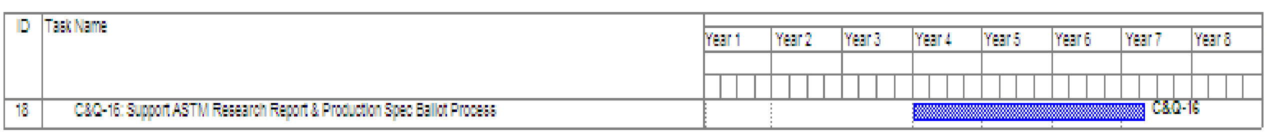
The FAA Review Board will review fuel property data provided by the FAA Tech Center from Phase 1 testing and other information relating to the ARLs provided by the candidate fuel producer. The review board will rank the candidate fuels based on this review. The top 5 fuels will then be given entrance to the Phase 2 test program. The producers of those fuels will need to provide 10,000 gallons of fuel to conduct Phase 2 testing.

1.5 C & Q TASK PROJ-C&Q-16

TASK: Support ASTM Research Report and Production Spec Ballot Process
WORKSCOPE: Support ASTM Task Force effort to ballot report and spec and to address ballot comments.
TASK No: **PROJ-C&Q-16**
LEAD ORGANIZATION: ASTM
DELIVERABLE: ASTM Production Specification for a New AVGAS
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PROJ-C&Q-16			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		▪ Participate in TF activities ▪ Contribute to document content ▪ Support ASTM balloting process ▪ Reconcile ballot comments	▪ Participate in TF activities ▪ Contribute to document content ▪ Support ASTM balloting process ▪ Reconcile ballot comments
Estimated Cost	$0	$45K	$45K

TIMELINE :

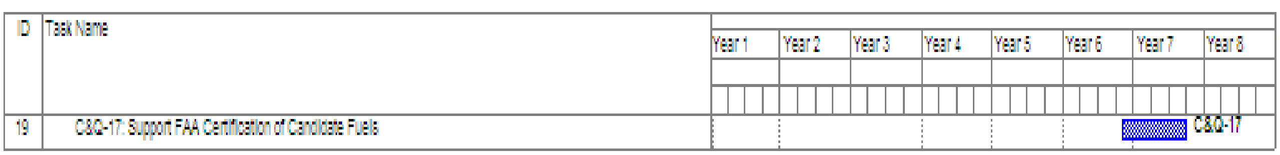


1.6 C & Q TASK PROJ-C&Q-17

TASK: Support FAA Certification of Candidate Fuels
WORKSCOPE: Review Tech Center reports and other data submitted by applicant and issue certification approval for in-scope fleet of aircraft and engines.
TASK No: **PROJ-C&Q-17**
LEAD ORGANIZATION: FAA
DELIVERABLE: FAA STCs for a New AVGAS
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PROJ-C&Q-17			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		FAA works with candidate fuel applicant. ▪ Finalize/refine compliance requirements with applicant. ▪ Review FAA Tech Center reports and other data submitted by applicant ▪ Finalize scope of approval. ▪ Issue FAA STC with agreed scope of approval	No support required
Estimated Cost	$0	$1,380K	$0

TIMELINE :



2.0 TEST & EVALUATION IMPLEMENTATION PLANS, PROJECT STAGE

2.1 T&E TASK PROJ-T&E-7

TASK: Conduct Phase 1 Testing
WORKSCOPE: Test fuel samples using laboratory equipment
TASK No: **PROJ-T&E-7**
LEAD ORGANIZATION: FAA Tech Center
DELIVERABLE: Test results
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PROJ-T&E-7			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		FAA Tech Center conducts Phase 1 Testing of fuel samples using lab and rig equipment.	Provide engineering support, in-kind equipment support, and data analyses/review.
Estimated Cost	$0	$ 1.0M	$360K

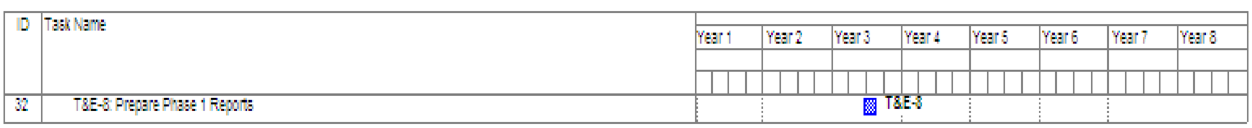
TIMELINE :

2.2 T&E TASK PROJ-T&E-8

TASK: Prepare Phase 1 Reports
WORKSCOPE: Compile data and prepare reports
TASK No: **PROJ-T&E -8**
LEAD ORGANIZATION: FAA Tech Center
DELIVERABLE: Test Report
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PROJ-T&E-8			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		FAA Tech Center compiles data, generates reports, solicits input, incorporates changes, and communicates with PAFI & fuel developer.	Provide engineering analyses and input to reports.
Estimated Cost	$0	$60K	$50K

TIMELINE :



2.3 T&E TASK PROJ-T&E-9

TASK: Conduct Phase 2 Testing
WORKSCOPE: Test fuel in engines and aircraft
TASK No: **PROJ-T&E-9**
LEAD ORGANIZATION: FAA Tech Center
DELIVERABLE: Test results
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PROJ-T&E-9			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		FAA Tech Center conducts testing, executes and monitors related subcontracts. Communications with PAFI and fuel developer.	Provide engineering support, in-kind equipment support and data analyses/review.
Estimated Cost	$0	$ 16.23M	$2.865M

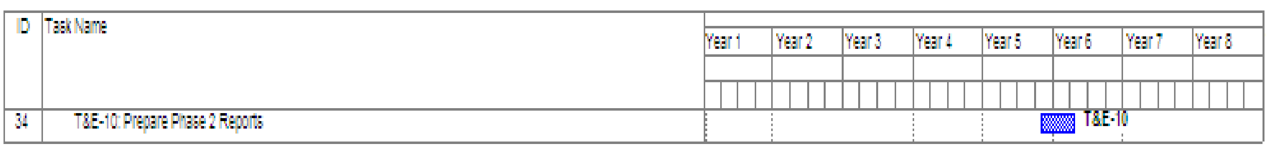
TIMELINE:

2.4 T&E TASK PROJ-T&E-10

TASK: Prepare Phase 2 Reports
WORKSCOPE: Compile data and draft report
TASK No: **PROJ-T&E-10**
LEAD ORGANIZATION: FAA Tech Center
DELIVERABLE: Test Report
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PROJ-T&E-10			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		FAA Tech Center generates reports, solicits input, incorporates changes, communications with PAFI & fuel developer.	Provide engineering analyses and input to reports.
Estimated Cost	$0	$910K	$50K

TIMELINE:

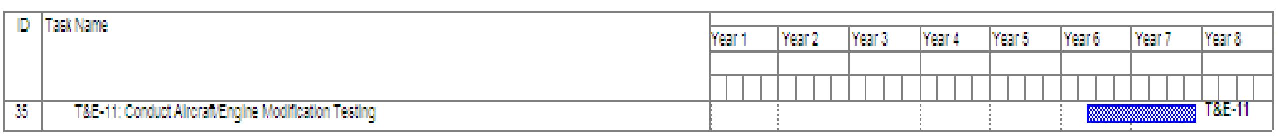


2.5 T&E TASK PROJ-T&E-11

TASK: Conduct Aircraft/Engine Modification Testing
WORKSCOPE: Test engine and aircraft modifications
TASK No: **PROJ-T&E-11**
LEAD ORGANIZATION: FAA Tech Center
DELIVERABLE: Test Report
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK PROJ-T&E-11			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles		FAA Tech Center conducts testing, executes and monitors related subcontracts. Communications with PAFI and fuel developer.	Provide engineering support, in-kind equipment support and data analyses and review.
Estimated Cost	$0	$12.85 M	$2.874M

TIMELINE:



2.5.1 PROJ-T&E-11 SUPPLEMENTAL INFORMATION

Limited engine and aircraft modification testing will be performed with fuels that meet a pre-determined threshold of fleet satisfaction. This testing will require significant industry in-kind support by means of engineering expertise, test pilots, parts, engine overhauls and measurements.

3.0 PRODUCTION & DISTRIBUTION IMPLEMENTATION PLANS PROJECT STAGE

There are currently no “Production & Distribution” tasks identified for the PAFI Project Stage.

4.0 IMPACT & ECONOMICS IMPLEMENTATION PLANS PROJECT STAGE

4.1 I & E TASK PROJ-I&E-5

TASK: Develop Tools for Fleet Impact Assessment (ARL 6.3.a & c)

WORKSCOPE: PAFI oversight and advocacy role. In addition to developing tools and methods to assesses the impact, PAFI in an advocacy role will also utilize this information to explore options for addressing & minimizing the impact of the portion of the fleet not addressed by a candidate's proposal.

TASK No: **PROJ-I&E-5**

LEAD ORGANIZATION: PAFI

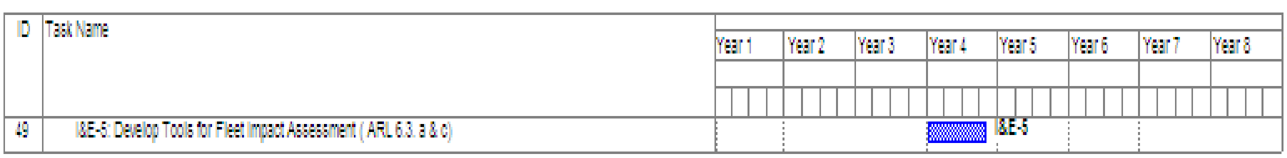
DELIVERABLE: Ongoing during project phase

TIMELINE: See Below

COST ESTIMATE: See Below

PAFI TASK PROJ- I&E-5			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Develop/identify tools and methods for fuel developers and PAFI to assess the impact of the segments of the fleet not addressed by candidate fuels.	Participate as member of PSG Provide supporting data when requested.	Provide supporting data when requested.
Estimated Cost	$60K	$0	$60K

TIMELINE:



4.1.1 PROJ-I&E-5 SUPPLEMENTAL INFORMATION

Task I&E-5 is a PAFI Oversight and Advocacy role which provides for the development of the tools discussed beginning during the PAFI preparatory stage and actual assessments implemented in support of ARL 6.3.in the phase 1 project stage.

ARL Section 6.3.c (Preliminary Business Plan) specifies the following.

"*c. Applicability: Define fleet satisfaction concept relative to either actual aircraft cross section as defined in the FAA Aviation Fuels Reciprocating Engine Aircraft Fleet Fuel Distribution Report or BMEP/detonation propensity as defined by TBD report*"

5.0 ENVIRONMENT & TOXICOLOGY IMPLEMENTATION PLANS PROJECT STAGE

There are currently no "Environment & Toxicology" tasks identified for the PAFI Project Stage.

Appendix G
PAFI Deployment Stage Work Scope
Implementation Plans Including Cost Estimates

Note……….Appendix G contains the individual implementation plans for each PAFI task which supports the Deployment Stage.

1. Certification & Qualification Support Tasks
2. Test & Evaluation Support Tasks
3. Production & Distribution Support Tasks
4. Impact & Economics Support Tasks
5. Environment & Toxicology Support Tasks

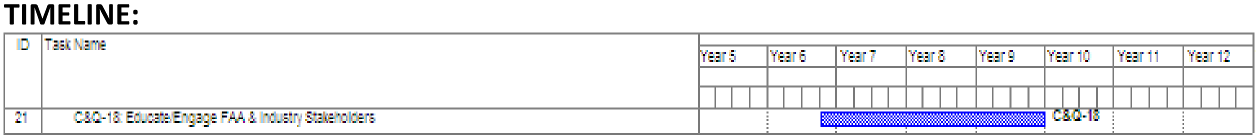
1.0 CERTIFICATION & QUALIFICATION IMPLEMENTATION PLANS, DEPLOYMENT STAGE

1.1 C & Q TASK DEPLOY-C&Q-18

TASK: Educate/Engage FAA & Industry Stakeholders Owners/Operators
WORKSCOPE: Communicate new fuel certifications and field approval requirements.
TASK No: **DEPLOY-C&Q-18**
LEAD ORGANIZATION: FAA
DELIVERABLE: FAA SAIB describing new AVGAS approvals
TIMELINE: Post Project Stage
COST ESTIMATE: See Below

PAFI TASK DEPLOY-C&Q-18			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	FAA publishes SAIB and meets with other FAA organizations.	• Develop and issue SAIB describing new fuel approval scope and referenced documents • Meet with Flight Standards (AFS) and Airports organizations to facilitate communication to airports and other facilities	No support required
Estimated Cost	$0	$12K	$0

TIMELINE:



Note: the timeframe for deployment could be significantly longer than shown depending upon impact of the new fuel.

1.1.1 DEPLOY-C&Q-18 SUPPLEMENTAL INFORMATION

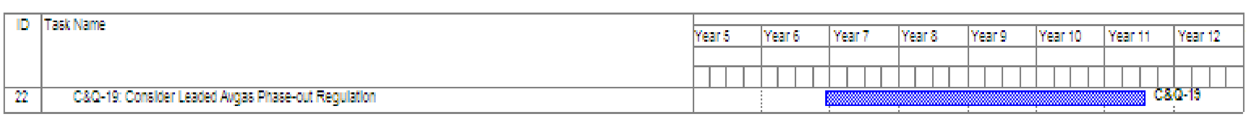
The FAA PAFI member will develop and issue an SAIB describing the scope of approval and any other information for the initial candidate fuel approval. This SAIB will be updated with each new fuel approval. The FAA PAFI member will also coordinate with FAA Flight Standards and Airports divisions to arrange for communication of the new fuel approvals at industry seminars and other venues.

1.2 C & Q TASK DEPLOY-C&Q-19

TASK:	Consider Leaded AVGAS Phase-Out Regulation
WORKSCOPE:	Once unleaded AVGAS with least impact on the fleet has been identified, the FAA may consider both short term and long term regulatory action to facilitate the transition to unleaded AVGAS in consultation with the EPA.
TASK No:	**DEPLOY-C&Q-19**
LEAD ORGANIZATION:	FAA
DELIVERABLE:	FAA Regulations for Existing and New Production Fleets
TIMELINE:	Post Project Stage
COST ESTIMATE:	See Below

PAFI TASK DEPLOY-C&Q-19			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	FAA coordinates with EPA and potentially engages in rulemaking process to issue new regulations.	• EPA actions necessary prior to FAA regulatory task • FAA may initiate rulemaking project to develop, review, and issue new regulations	Review notice of proposed rulemaking.
Estimated Cost	$0	$2M	$36K

TIMELINE:



Note: the timeframe for deployment could be significantly longer than shown depending upon impact of the new fuel.

1.2.1 DEPLOY-C&Q-19 SUPPLEMENTAL INFORMATION

The FAA will consult with the EPA to determine what, if any, regulatory action should be considered to facilitate the transition to an unleaded AVGAS. One potential eventuality would be that EPA may issue an Endangerment Finding and new emissions standard against lead in AVGAS. If this is the case, the FAA would need to issue an NPRM followed by a Final Rule to establish new fuel lead emission standards.

2.0 TEST & EVALUATION IMPLEMENTATION PLANS DEPLOYMENT STAGE

There are currently no "Test & Evaluation" related tasks defined at this time in support of the PAFI Deployment Stage.

3.0 PRODUCTION & DISTRIBUTION IMPLEMENTATION PLANS, DEPLOYMENT STAGE

3.1 P&D TASK DEPLOY-P&D-4

TASK: Establish PAFI Role in Deployment Phase
WORKSCOPE: Identify the role PAFI may play in facilitating deployment of fuel
TASK No: **DEPLOY-P&D-4**
LEAD ORGANIZATION: PAFI
DELIVERABLE: PAFI work plan for fuel specific deployment
TIMELINE: Deployment Stage
COST ESTIMATE: See Below

PAFI TASK DEPLOY-P&D-4			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Lead working group to develop PAFI role in deployment.	Participate as member of PSG.	Participate in working group to develop PAFI role in fuel deployment.
Estimated Cost	$3K	$0	$15K

TIMELINE:

ID	Task Name	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
41	P&D-4: Establish PAFI Role in Deployment Phase	P&D-4							

Note: the timeframe for deployment could be significantly longer than shown depending upon impact of the new fuel.

3.1.1 DEPLOY-P&D-4 SUPPLEMENTAL INFORMATION

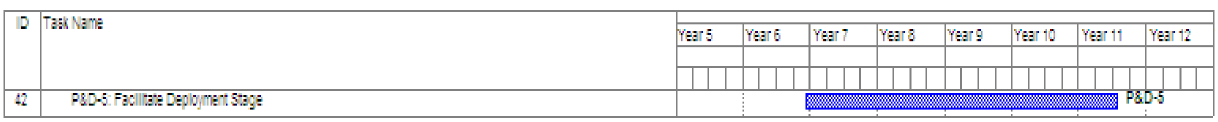
This task is a direct PAFI task that will be completed each time a fuel reaches the deployment phase of the ARL's. The purpose of this task is to define additional tasks that PAFI can accomplish in support of the deployment of a specific fuel. This task is necessary due to the fact that deployment of a specific fuel will be dictated by that fuel's intrinsic properties, including materials compatibility, production processes and compatibility with existing fuels. This task will also involve significant anti-trust considerations. This task will be completed by an industry/PAFI workgroup.

3.2 P&D TASK DEPLOY-P&D-5

TASK: Facilitate Deployment Stage
WORKSCOPE: Facilitate compliance with third party non-ASTM standards/codes/requirements
TASK No: DEPLOY-P&D-5
LEAD ORGANIZATION: **PAFI**
DELIVERABLE: Advocacy
TIMELINE: Post Project Stage
COST ESTIMATE: See Below

PAFI TASK DEPLOY-P&D-5			
Implementation Plan Item	**General**	**FAA**	**Other PAFI Members**
Roles	Interact with third party compliance entities to facilitate deployment.	Participate as member of PSG.	Interact with third-party compliance entities to facilitate deployment of fuel.
Estimated Cost	$5K	$0	$39K

TIMELINE:



Note: the timeframe for deployment could be significantly longer than shown depending upon impact of the new fuel.

3.2.1 DEPLOY-P&D-5 SUPPLEMENTAL INFORMATION

This task is a PAFI advocacy task that will be completed in the deployment phase. The purpose of this task will be to facilitate compliance with the third-party organizations that issue codes/standards/requirements that affect deployment of an unleaded fuel (identified in the final report for task PREP-P&D-3). This task will be completed by advocacy from PAFI and industry.

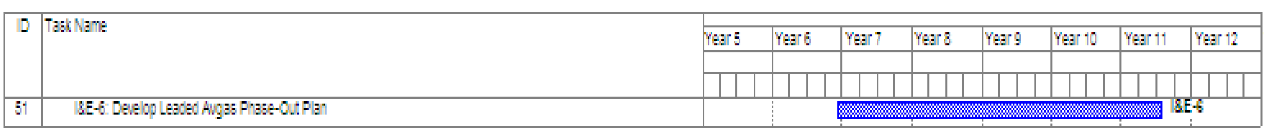
4.0 IMPACT & ECONOMICS IMPLEMENTATION PLANS, DEPLOYMENT STAGE

4. 1 I&E TASK DEPLOY-I&E-6

TASK: Develop Leaded AVGAS Phase-Out Plan
WORKSCOPE: PAFI advocacy role. Facilitate deployment by working with FAA to plan phase out of leaded AVGAS & transition to unleaded AVGAS
TASK TYPE: Advocacy
TASK No: **DEPLOY-I&E-6**
LEAD ORGANIZATION: PAFI
DELIVERABLE: Advocacy & guidance
TIMELINE: See Below
COST ESTIMATE: See Below

PAFI TASK DEPLOY- I&E-6			
Implementation Plan Item	**PAFI**	**FAA**	**Other PAFI Members**
Roles	Oversight. PAFI advocacy role. Facilitate deployment by working with FAA to plan phase out of leaded AVGAS & transition to unleaded AVGAS.	Assist in leaded AVGAS phase out. FAA and EPA coordinate as appropriate under respective authorities and obligations.	Assist in leaded AVGAS phase out.
Estimated Cost	$30K	$0	$0

TIMELINE:



Note: the timeframe for deployment could be significantly longer than shown depending upon impact of the new fuel.

4.1.1 DEPLOY-I&E-6 SUPPLEMENTAL INFORMATION

This Task develops a plan for phase out of 100LL & transition to unleaded fuels. Task I&E-6 is a PAFI oversight task which occurs during the PAFI Deployment Stage and has the objective of coordinating transition to a new AVGAS and phase out of the 100LL AVGAS. PAFI will work with EPA and FAA to phase out LL AVGAS. Quality and properties of the ultimate fuel will drive the implementation.

5.0 ENVIRONMENT & TOXICOLOGY IMPLEMENTATION PLANS DEPLOYMENT STAGE

There are currently no "Environment & Toxicology" tasks identified for the PAFI Deployment Stage.

Appendix H
Research & Development Aspects Related to Aviation Gasoline

1) Specification, fit-for-purpose, and environmental property issues

The following table H-1 covers in greater detail specification, fit-for-purpose properties, and environmental issues for a new fuel and their impact on engine and aircraft safety, performance, and operability. The determination of which of these parameters will require the most extensive testing is dependent on the complexity of any proposed fuel. If a proposed fuel uses novel components there may be additional testing required to ensure the fuel is fit for the purpose it is intended and that it safely performs in engines and aircraft.

Table H-1. Specification, Fit-for-purpose, and Environmental Fuel Property Issues.

Category	***Parameter***	***Issues***
	Specification Properties	
Combustion	Octane (MON)	Performance loss and engine damage
	Net heat of combustion (mass)	Aircraft range and power output and fuel stoichiometry
Fluidity	Freezing point	Fuel delivery at cold temperatures and aircraft operating limitations
Volatility	Distillation 10%	Cold start, engine restart, and vapor lock
	Distillation 40%	Vapor lock and hot fuel performance at altitude
	Distillation 50%	Warm-up and transient throttle changes
	Distillation 90%	Fuel mal-distribution; combustion chamber, fuel system, and intake manifold deposits
	Distillation end point	Fuel mal-distribution; incomplete combustion; oil dilution considerations; combustion chamber, fuel system, intake manifold, and turbocharger deposits
	Distillation sum of 10+50%	Carburetor icing and vapor lock
	Reid vapor pressure	Vapor lock, cold start, and engine restart
	Density	Aircraft weight and balance, range, performance charts, fuel tank design, fuel loading, thermal expansion, fuel gauging, and fuel metering device considerations
Corrosion	Sulfur content	Corrosion and operability
	Metals	Corrosion, combustion deposits, operability and toxicology
Contaminants	Water tolerance	Freezing, filter plugging, corrosion, water drop-out, phase separation, and water solubility of key fuel components
Additives	Dye	Deposits, additive interaction, and grade identification
Stability	Potential gum	Deposits, valve sticking, and carburetor /injector fouling

Additional Fit-For-Purpose Properties		
Co-mingling with legacy fleet infrastructure	Materials compatibility	Lap shear, cohesion, volume swell, tensile strength, elongation, tape adhesion, hardness, excess softness, peel strength, laminar sheer, compression set, resistivity, corrosion, embrittlement
	Lubricating oil interaction	Fuel dilution, combustion products can affect oil lubricating properties
	Co-mingling with 100LL	Forwards and backwards compatibility
	Lubricity	Engine durability and operability
	Dielectric constant	Fuel gauging systems
	Electrical conductivity	Dissipation of electrical charge buildup in fuel
Combustion	Flame speed	Effective ignition timing, exhaust gas and valve temperatures, power output, peak cylinder pressures, fuel consumption, and aircraft cooling requirements. May affect crankshaft torsional vibration, bearings and crankshaft, and crankcase stresses
	Inlet and combustion deposits	Inlet valve life and closure, engine pre-ignition tendency and potentially progressive engine octane demand increase
Fluidity	Latent heat of vaporization	Carburetor icing; modification of MON test to account for cooler combustion air temps
Other Properties - Environmental		
Environment	Exhaust, evaporative, and air toxic emissions	Fuel should not be worse than 100LL

2) Fuel Chemistry Impact on Engine Detonation

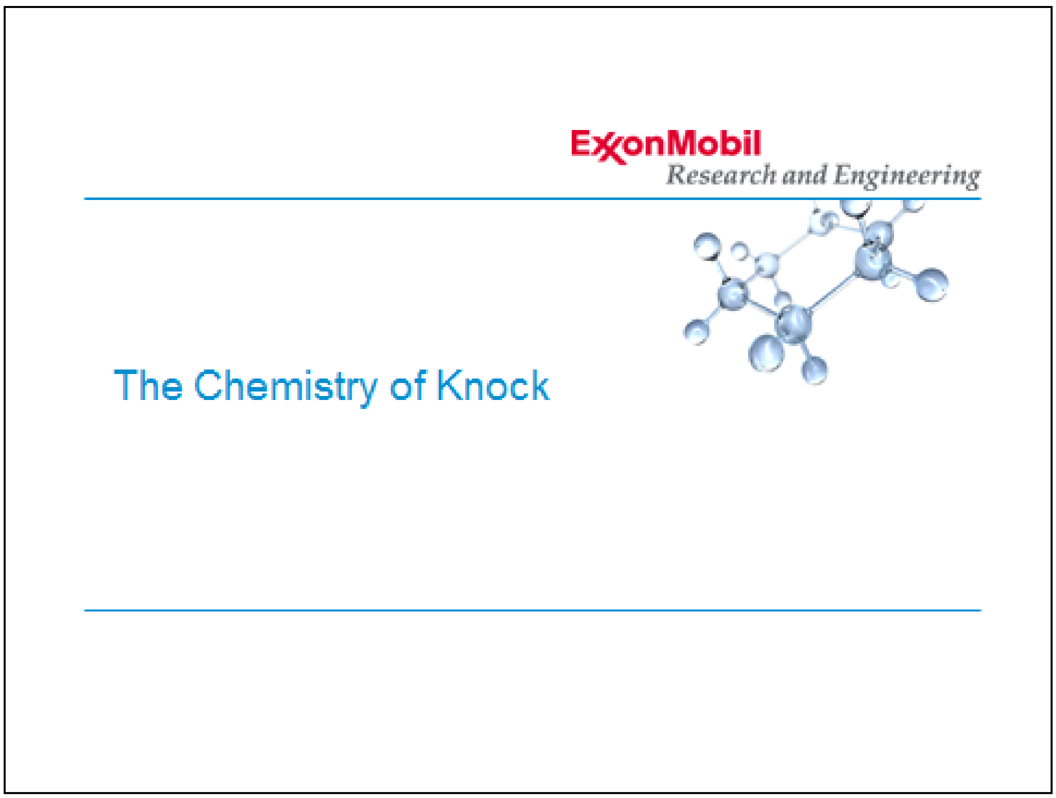
The ExxonMobil Research and Engineering Company representative to UAT ARC provided an extensive and detailed presentation on why octane is so important and why the lead additive TEL is so effective in quenching free radical formation. This presentation also illustrates why it is so difficult to replace the relatively small amount of TEL added with other chemicals. This presentation is provided below and addressed the following questions:

- What is knock?
- How is a fuel rated in terms of knock?
- How does a fuel affect knock susceptibility?
- What is chemical mechanism of knock at a molecular level?

- Why don't unleaded fuel MON and Supercharge Rich ratings guarantee engine satisfaction?

The presentation also included a web-link to a video illustration of the chain reaction kinetics of the knock event. Conclusions and take away points from the Exxon presentation are summarized as follows.

- MON performance is dependent upon engine condition and fuel composition
- Octane quality for new unleaded fuels could be defined by a single detonation test standard
- Knock performance of a new unleaded fuel must be correlated to the MON rating
- Unleaded fuels demonstrate significantly more detonation sensitivity to changing engine operating conditions



Outline

- What is Knock?
- How is a fuel rated in terms of knock?
- How does a fuel affect knock susceptibility?
- What is going on at a molecular level?
- Why don't UL fuel MON & SR ratings guarantee engine satisfaction?

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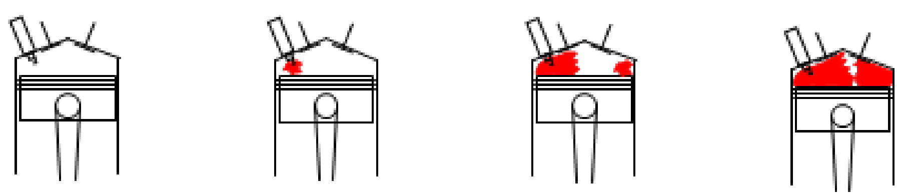
Knock is Abnormal Combustion

- Spark Knock (End-gas knock)
  - Undesired ignition of end-gases after spark
  - Controllable by changing spark timing
  - Two pressure waves collide, creating a spike in cylinder pressure



- Hot-spot preignition
  - Ignition occurs before the spark, usually as a result of a hot spot in the cylinder

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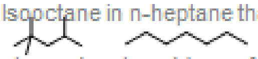
Scales Developed to Quantify A Fuels Knocking Tendency

- RON/MON Utilize a Waukesha CFR F1,F2 Single Cylinder Engine
  - Fuels are given the rating of the volume% Isooctane in n-heptane that has the same knock behavior



  - Scales to extend beyond range 0-100 have been developed (use of toluene, m-toluidine, etc)
  - Compression ratio set so test fuel gives standard knock intensity
  - Fuel is rated by interpolating based on knock intensity between two reference fuels
  - RON (ASTM D2699)
    - 600 rpm
    - Air intake 125 F
  - MON (ASTM D2700)
    - 900 rpm
    - Air intake 100 F
    - Intake mixture temperature: 300 F
- At 100 octane RON = MON

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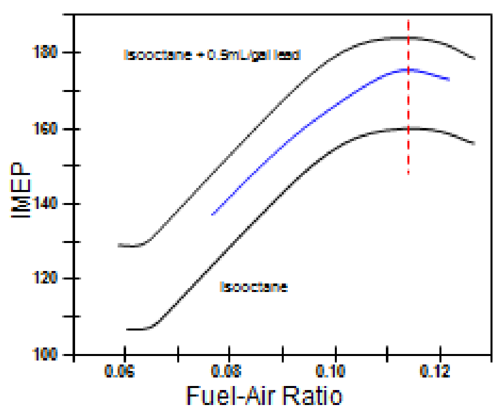
Supercharged Rich Rating (ASTM D909)

- Waukesha CFR F-4 engine
  - 1800 rpm
  - Compression ratio 7:1
  - Air intake 225 F
- Designed to simulate high load take-off
- Knock limited maximum IMEP for a fuel is plotted against Fuel-Air ratio.
  - Two reference fuels are plotted as to bracket the test fuel
  - Lead equivalence is interpolated at $IMEP_{max}$ for test fuel, which is correlated with a performance number
- SR rating of 120 indicates delivery of 20% more knock limited power than fuel rated at 100



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Fuel Composition And Knock

- Paraffins (Alkanes)
  - More branching increases octane number (less knock)
  - Longer main-chain decreases octane number (more knock)
- Olefins (Alkenes)
  - Not much effect on knocking for an isolated double bond
  - Di-, Tri-olefins have less knocking tendency than corresponding paraffins
- Naphthenes (Cycloalkanes)
  - Knock much more than corresponding aromatics
  - Smaller rings and fewer rings decrease knocking
  - There is not a simple comparison between naphthenes and paraffins
- Aromatics
  - Greatly reduced knocking tendency relative to paraffins

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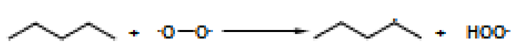
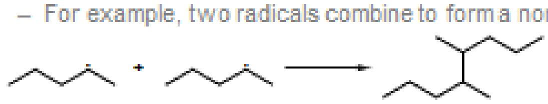
Combustion is Fundamentally a Radical Process

- Initiation (slow process)



- Propagation (fast process)
  - Keeps the reaction going
  - One radical produces a single different radical

- Termination
  - Slows/ends the reaction
  - For example, two radicals combine to form a non-radical



- And… Chain branching – one radical produces three

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Simplified Rate Equations are Useful for Understanding Combustion

$M \xrightarrow[k_1]{} R^\bullet$ — Initiation [M = reactant; R• = radical]

$M + R^\bullet \xrightarrow[k_2]{} \alpha R^\bullet + M'$ — Propagation and chain-branching [α=ratio of chain branching to propagation; slightly >1 for combustion]

$M + R^\bullet \xrightarrow[k_3]{} P + R^\bullet$ — Product formation (propagation) [P=product]

$X_{n\geq 3} + R^\bullet \xrightarrow[k_n]{} I_n$ — Termination Steps [X = terminating source, e.g., Pb, R•, cyl wall; I = Terminated product]

$$\frac{d[P]}{dt} = k_3[M][R^\bullet]$$

Rate of product formation = constant x reactant concentration x radical concentration

$$\frac{d[R^\bullet]}{dt} = k_1[M] + k_2(\alpha-1)[M][R^\bullet] - [R^\bullet]\sum_n k_n[X_n]$$

$$\frac{d[P]}{dt} = \frac{k_3 k_1 [M]^2}{\sum_n k_n[X_n] - k_2(\alpha-1)[M]}$$

Rate equation assuming R• is in steady-state

Critical knock threshold; chain reaction occurs when denominator → 0

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Visualization of Chain Reaction Kinetics

- Chain reaction

http://www.youtube.com/watch?v=HmbzJGf90Xc&feature=related

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Steady-state assumption breaks down when reaction becomes explosive

Critical threshold for this event is when denominator of rate equation is zero, in other words when:

$$\sum_n k_n[X_n] = k_2(\alpha_{critical} - 1)[M]$$

$$\alpha_{critical} = 1 + \frac{\sum_n k_n[X_n]}{k_2[M]}$$

Rate of termination events

Rate of propagation events

Three ways to prevent explosive reaction (ensure you are always below critical limit):

- Reduce chain-branching ratio α so it is below $\alpha_{critical}$
- Increase termination events
- Decrease propagation rate

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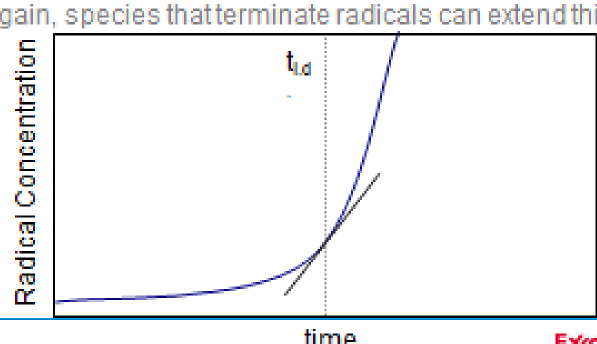
Additional factor to knock is the ignition time

- Previous analysis looked simply at conditions which radical concentration is no longer in steady-state
  - This allows reaction to rapidly increase in rate (explosion/knock)
  - Initiation rate does not determine this condition
- Initiation rate does influence the delay time (induction period) for the reaction to build a sizable concentration of radicals
  - Again, species that terminate radicals can extend this induction period



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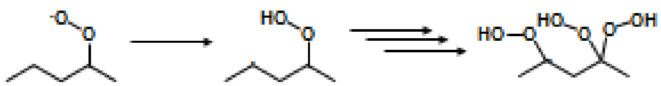
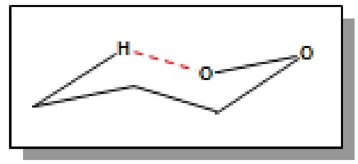
Highly Branched Compounds

- Isooctane and triptane have high octane numbers
  - n-alkanes can form di-, tri- peroxides easily

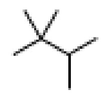


•Favorable 6-membered transition state allows this



  - Substitution (e.g. methyl groups) makes this 6-membered ring unfavorable, and thus the reactions are slowed
  - Compounds with three CH_2 groups in a row can form these peroxides during the cool flame, and thus provide many chain-branching species in an entropic explosion.
  - Isooctane, triptane lack three CH_2 groups in a row

Isooctane



triptane

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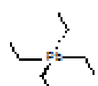
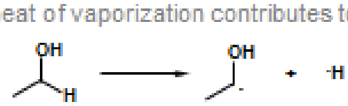
Lead More Efficient in Capturing Radical Intermediates

- Tetraethyl Lead



  - During the compression stroke, decomposes into lead and lead oxides and combustible short–lived ethyl radicals
    - effectively intercepts radicals
  - Very effective at chain-debranching/chain terminating
  - May act catalytically, either homogenously or on surface of nano-particles
  - Dibromoethane is used as a lead scavenger
- Organic octane boosters (not catalytic)
  - Alcohols: C-H bond alpha to Oxygen is relatively weak.
    - Forms a more stabilized radical via donation of lone pair, which is more persistent
    - Alcohol heat of vaporization contributes to charge cooling



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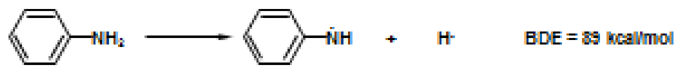
Lead More Efficient in Capturing Radical Intermediates (continued)

- Organic octane boosters (not catalytic)
  - Amines: Have a relatively labile N-H bond which forms a persistent radical



- Fuels with organic octane boosters transition into heavy knock quickly
  - Once critical threshold met, organic compound becomes part of chain reaction
    - Combusted lead still captures radicals (catalytic levels) where organic compounds (% of fuel blend) may contribute to the abnormal combustion process
    - Contrast

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UL & Leaded Fuels Of The Same MON May Not Provide The Same Octane Performance

- CFR engine conditions can significantly differ from full scale engine conditions
  - RPM, Intake air & Intake mixture temps., cylinder head temp. etc.
- Empirically determined that D2700 engine operating conditions are adequate to ensure that leaded fuels will deliver the necessary octane performance required by full scale engines
  - Lead works to increase the time to the onset of knock and slows the chain-reaction rate
- UL fuels demonstrate significantly more sensitivity to changing engine operating conditions
  - Higher MON performance required to compensate for organic octane boosters inability to slow the chain-reaction rate
  - Organic octane boosters primarily function by increasing the time to the onset of knock

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- Perdih, A.;Perdih, F. *Acta Chim. Slov.*, **2006**, *53*, 306-315.
- Benson, S. I. *J. Phys. Chem.*, **1988**, *92*, 1531-1533.

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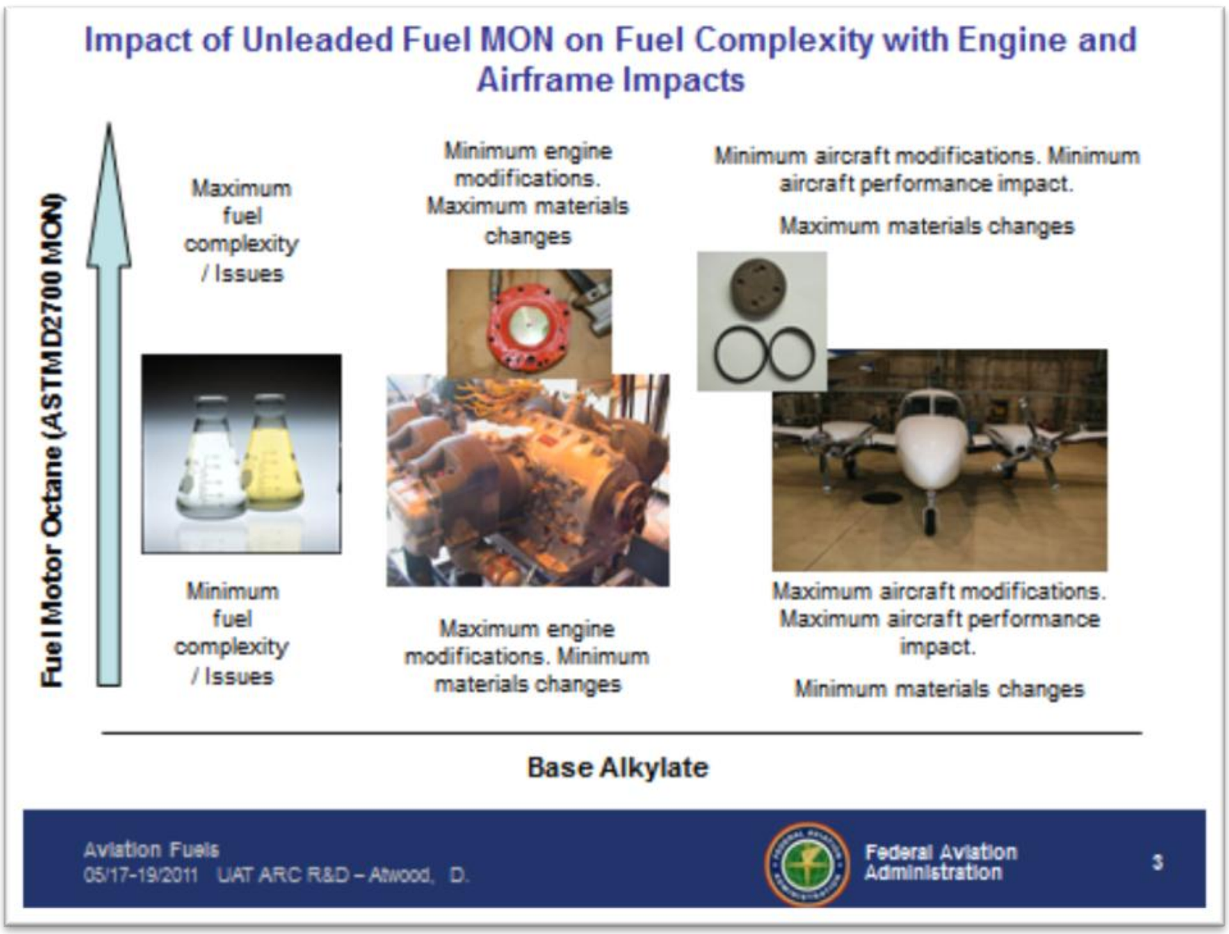
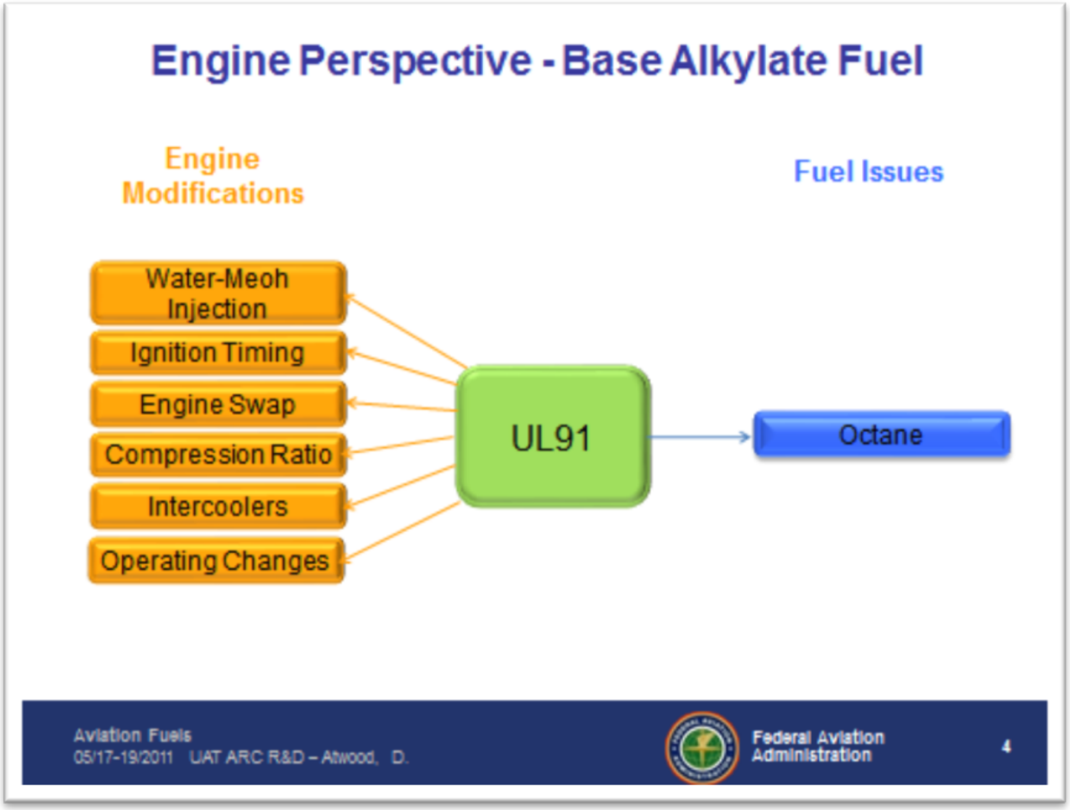
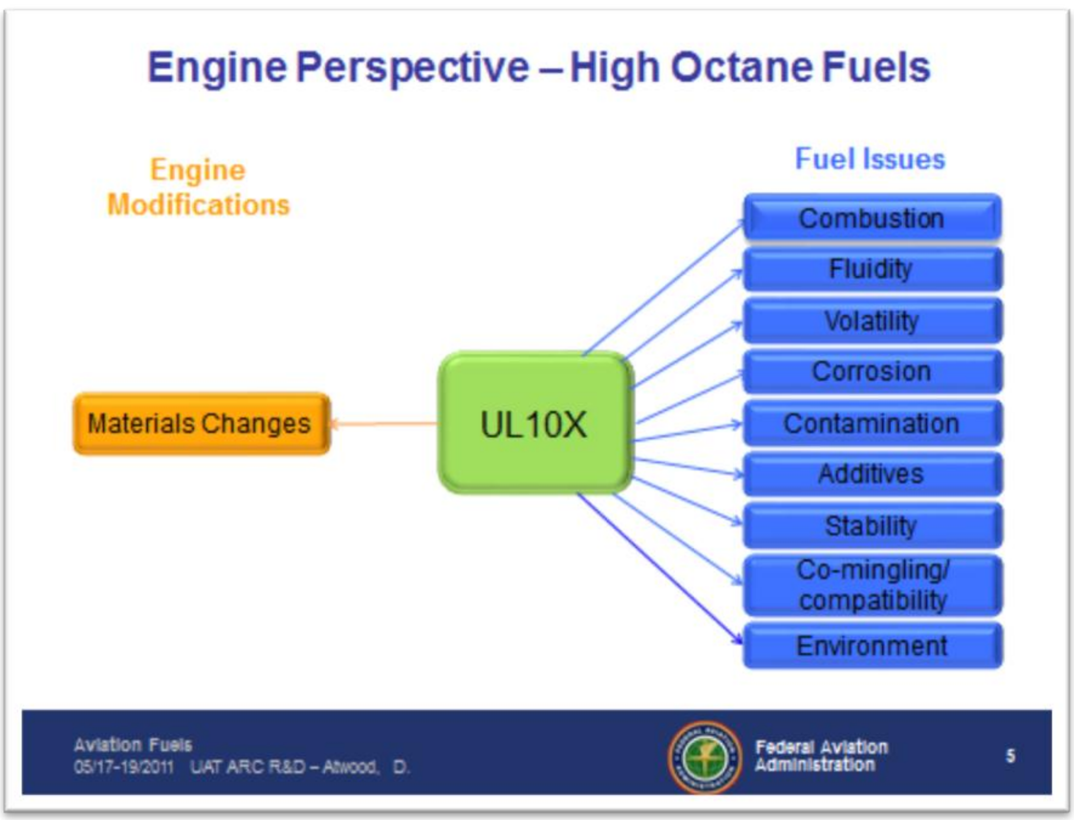
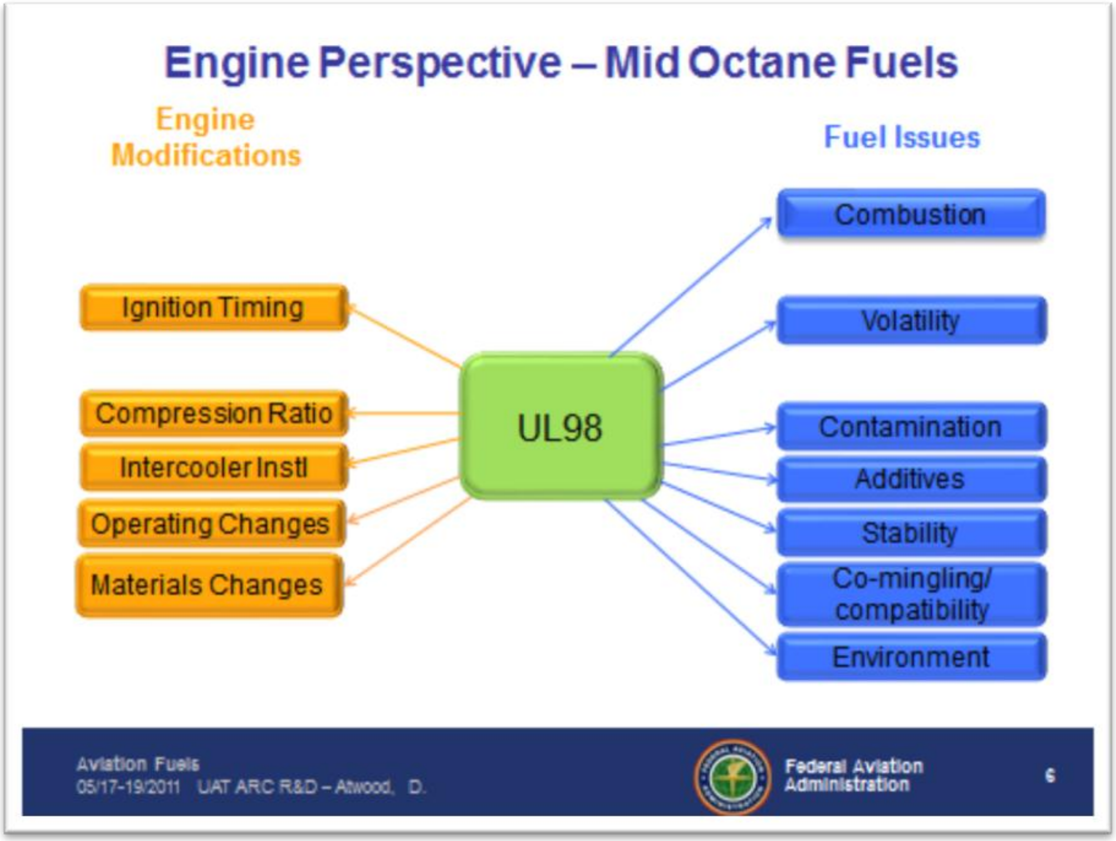
3) Impact of Unleaded Fuel Octane Requirement on Fuel Complexity

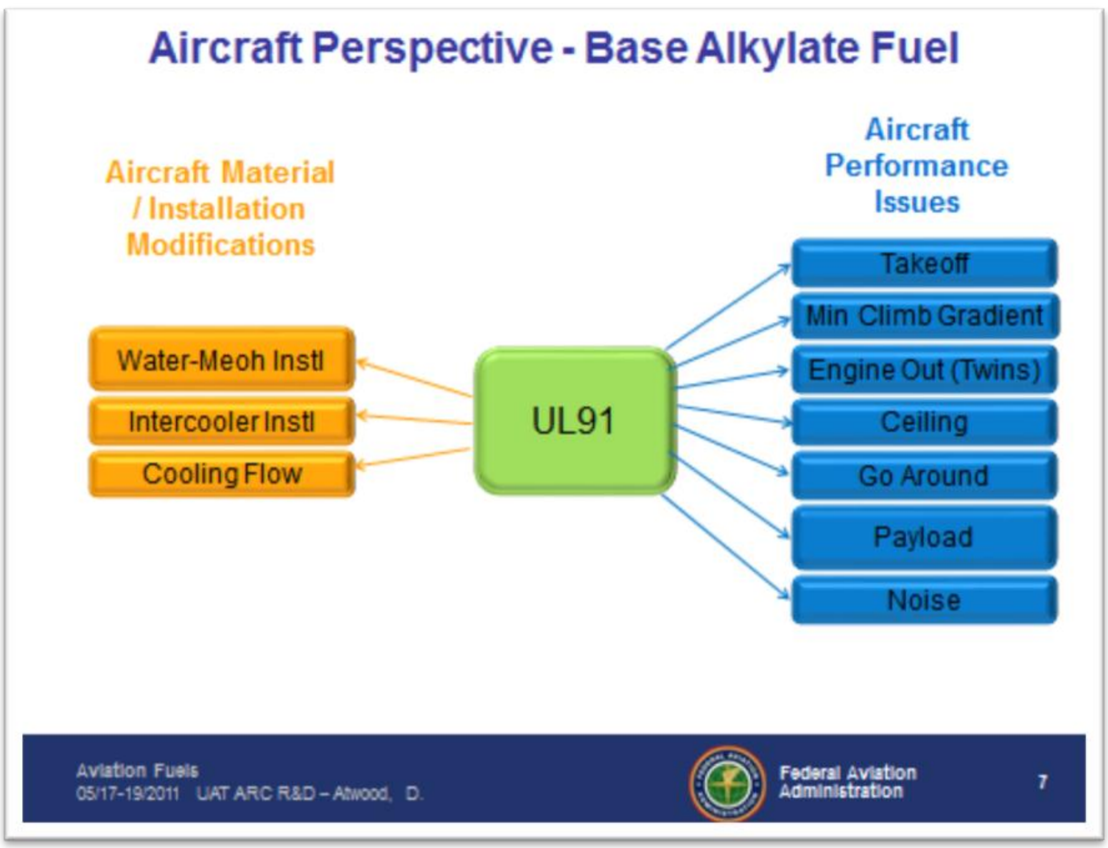
UAT ARC members representing the FAA Technical Center, Cessna Aircraft Company, and ExxonMobil Research and Engineering Company provided a presentation on the relationship between fuel motor octane quality, fuel complexity, and the impact on engine and aircraft performance which is repeated as follows.

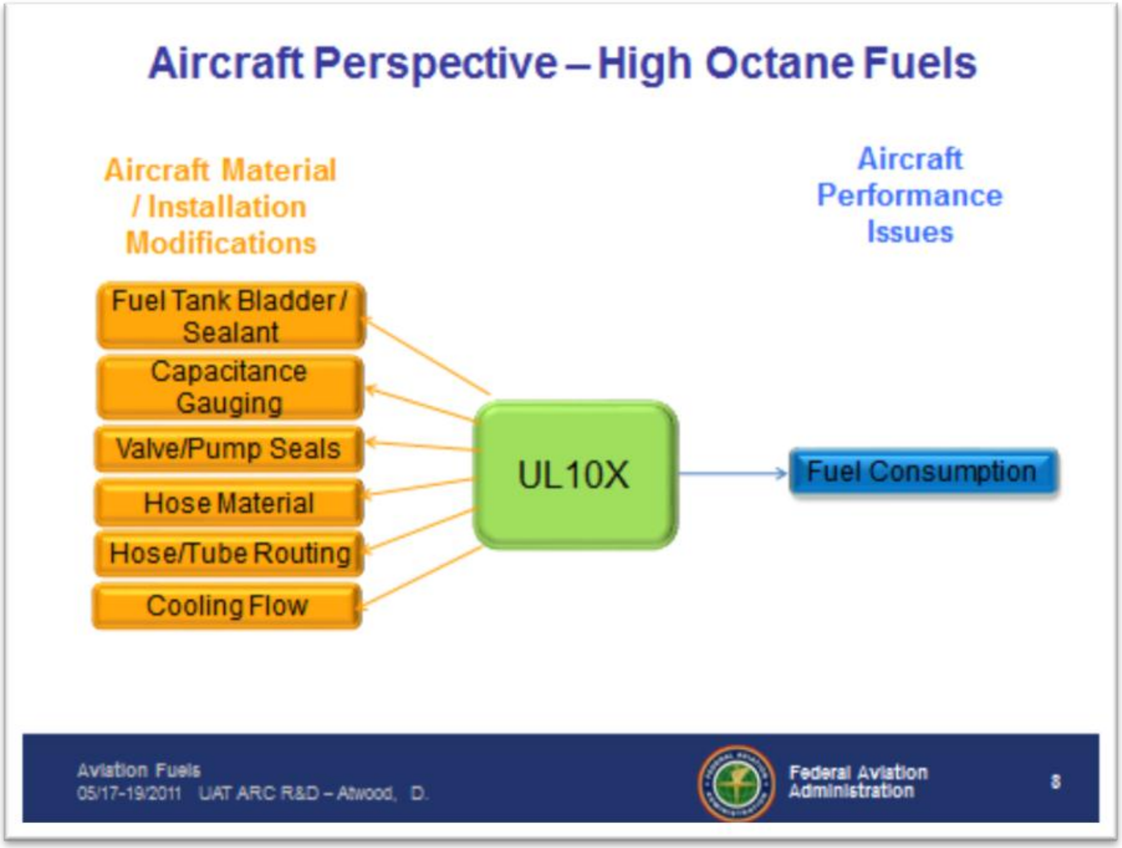


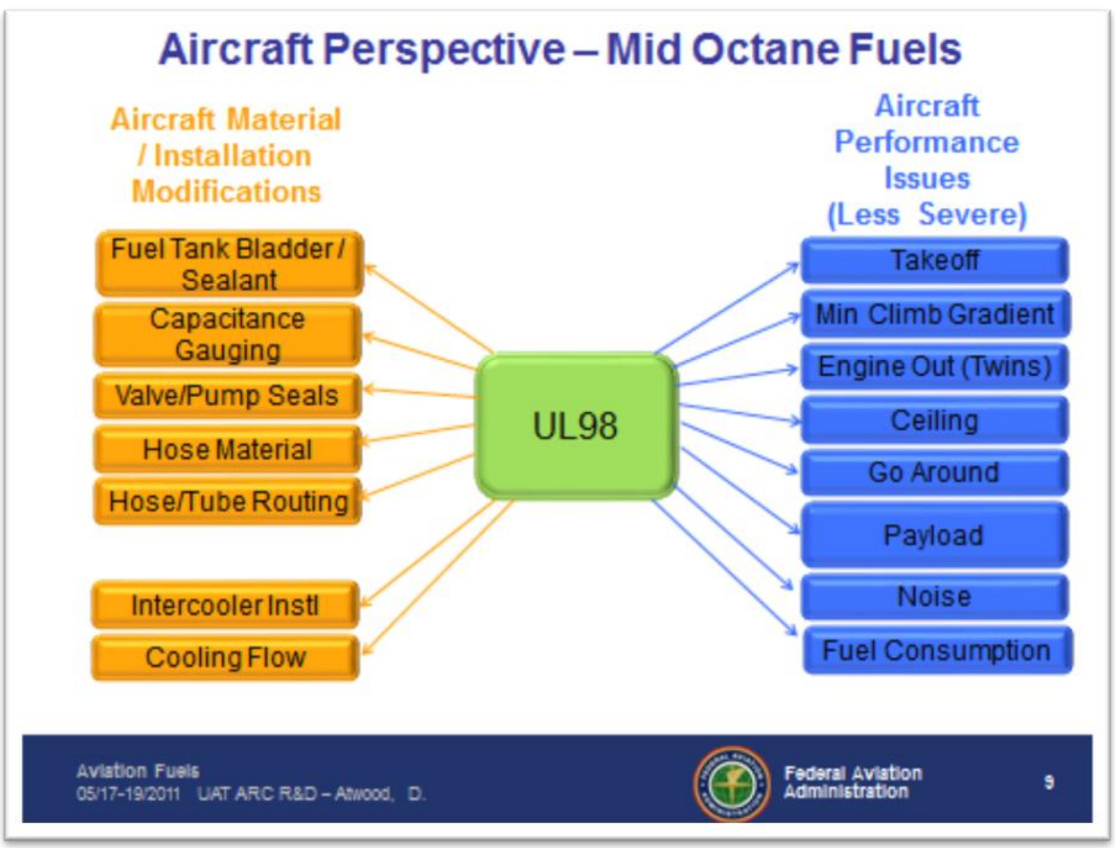

Engine Perspective - Base Alkylate Fuel
Engine Modifications
Fuel Issues
Water-Meoh Injection
Ignition Timing
Engine Swap
Compression Ratio
Intercoolers
Operating Changes
UL91
Octane
Aviation Fuels
05/17-19/2011 UAT ARC R&D – Atwood, D.
Federal Aviation Administration
4


Engine Perspective – High Octane Fuels
Engine Modifications
Fuel Issues
Materials Changes
UL10X
Combustion
Fluidity
Volatility
Corrosion
Contamination
Additives
Stability
Co-mingling/ compatibility
Environment
Aviation Fuels
05/17-19/2011 UAT ARC R&D – Atwood, D.
Federal Aviation Administration
5


Engine Perspective – Mid Octane Fuels
Engine Modifications
Fuel Issues
Combustion
Ignition Timing
Volatility
UL98
Compression Ratio
Contamination
Intercooler Instl
Additives
Operating Changes
Stability
Materials Changes
Co-mingling/ compatibility
Environment
Aviation Fuels
05/17-19/2011 UAT ARC R&D – Atwood, D.
Federal Aviation Administration
6


Aircraft Perspective - Base Alkylate Fuel
Aircraft Performance Issues
Aircraft Material / Installation Modifications
Takeoff
Min Climb Gradient
Water-Meoh Instl
Engine Out (Twins)
UL91
Intercooler Instl
Ceiling
Cooling Flow
Go Around
Payload
Noise
Aviation Fuels
05/17-19/2011 UAT ARC R&D – Atwood, D.
Federal Aviation Administration
7


Aircraft Perspective – High Octane Fuels
Aircraft Material / Installation Modifications
Aircraft Performance Issues
Fuel Tank Bladder / Sealant
Capacitance Gauging
Valve/Pump Seals
Hose Material
Hose/Tube Routing
Cooling Flow
UL10X
Fuel Consumption
Aviation Fuels
05/17-19/2011 UAT ARC R&D – Atwood, D.
Federal Aviation Administration
8


Aircraft Perspective – Mid Octane Fuels
Aircraft Material / Installation Modifications
Aircraft Performance Issues (Less Severe)
Fuel Tank Bladder / Sealant
Capacitance Gauging
Valve/Pump Seals
Hose Material
Hose/Tube Routing
Intercooler Instl
Cooling Flow
UL98
Takeoff
Min Climb Gradient
Engine Out (Twins)
Ceiling
Go Around
Payload
Noise
Fuel Consumption
Aviation Fuels
05/17-19/2011 UAT ARC R&D – Atwood, D.
Federal Aviation Administration
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4) Detonation Issues, their potential impact and related issues

The following are detonation issues that were defined during deliberations of the UAT ARC R&D Focus Group.

Detonation Issue #1	*Problem Statement*	An unleaded fuel possessing the same MON as a leaded fuel (that defines a given engine minimum octane requirement) may not provide a full-scale engine the octane performance it requires.
	Justification	Motor octane number values must correspond to the minimum octane performance required by a given full-scale engine (that it was intended for) to ensure it is fit for purpose.
	Impact	The solution may involve requiring an unleaded fuel to meet a MON value different (e.g. higher) than the minimum octane value the engine was originally certified on to ensure equivalent full-scale engine performance.
	Related Issues	• Requiring higher octane values for unleaded fuels may result in the use of greater amounts of specialty chemicals, impacting other properties that may move the fuel out (or further out) of specification. • Use of mixtures of high octane components may result in significant antagonistic and synergistic effects of octane response.
	Path	May require blend model relating fuel composition to both fuel MON and full-scale engine detonation performance in a high-octane demand engine.

Detonation Issue #2	*Problem Statement*	An unleaded fuel possessing a supercharged rich (SR) octane value significantly higher than a leaded fuel, known to satisfy a given full-scale engine, may not provide the same engine the octane performance it requires.
	Justification	Supercharge rich octane values must correspond to the requirements of a full-scale engine to ensure the fuel is fit-for-purpose.
	Impact	The solution may involve dropping the supercharge rich octane requirement for an unleaded fuel, or satisfy a more relevant requirement to ensure equivalent full-scale engine performance.
	Related Issues	• Use of mixtures of high octane components may result in significant antagonistic and synergistic effects of octane response. • Many unleaded fuels using aromatics have resulted in exceedingly high SR values, which do not correlate with engine anti-knock performance.
	Path	TBD. May be a good fit for either an ASTM TF or a CRC research project.

Detonation Issue #3	*Problem Statement*	Current FAA Advisory Circular AC33.47-1, providing guidance for detonation testing, includes outdated test equipment and analyses methods.
	Justification	Equipment and detonation analyses methods need to be updated to ensure proper FAA guidance reflective of current technology.
	Impact	There is no assurance that different facilities are quantifying and assessing detonation in a manner that allows test results to be compared between facilities. Assessing detonation must be reproducible and repeatable.
	Related Issues	• Detonation instrumentation and combustion instability measurement methods have not been standardized or correlated among the FAA Tech Center, engine DAH, and others. • There is no agreement on what constitutes limiting detonation among FAA Tech Center researchers, engine DAH, and others
	Path	Establish coordinated test plan with engine DAH and FAA TC. Results feed into certification.

Detonation Issue #4	*Problem Statement*	Detonation instrumentation and combustion instability measurement methods have not been standardized or correlated among the FAA Tech Center, engine DAHs, and others.
	Justification	Equipment and detonation analyses methods need to be compatible to ensure a common understanding of fuel anti-knock response.
	Impact	There is no assurance that different facilities are quantifying and assessing detonation in a reproducible and repeatable manner that would allow test results to be compared and correlated.
	Related Issues	There is no agreement on what constitutes limiting detonation among FAA Tech Center researchers, engine DAHs, and others.
	Path	Establish coordinated test plan with DAHs and FAA TC

Detonation Issue #5	*Problem Statement*	There is no agreement on what constitutes a limiting detonation threshold among FAA Tech Center Researchers, engine DAHs, and others.
	Justification	Limiting detonation needs to be defined and standardized.
	Impact	Arbitrary, unsubstantiated, and inconsistent limiting detonation levels may lead to greater deviations from important safety and fuel performance specification properties.

	Related Issues	Detonation margins should account for inconsistent fuel detonation onset response signatures.
	Path	Establish coordinated test plan with DAHs and FAA TC. Limiting detonation threshold feeds into Issue #3. Results feed into certification for AC 33.47 revision.

Detonation Issue #6	*Problem Statement*	Detonation onset response for unleaded fuels is different from leaded fuels and can affect detonation margin.
	Justification	Limiting detonation levels should take into account the differences in detonation onset rates with engine operating changes.
	Impact	Reduced detonation margins may be realized when a fuel demonstrates greater detonation intensity increases due to changes in engine operating conditions.
	Related Issues	Increased detonation margin may lead to use of greater amounts of more exotic components thus decreasing operational safety margins in other important specification and fit-for-property areas.
	Path	Establish coordinated test plan with DAHs and FAA TC. Limiting detonation threshold feeds into Issue #3. Results feed into certification for AC 33.47 revision.

Detonation Issue #7	*Problem Statement*	A large percentage of the fleet may require engine and/or airframe modifications to compensate for the reduced octane performance of unleaded fuels.
	Justification	Research is needed to demonstrate equipment/methods to compensate for necessary octane requirement reduction.
	Impact	• There may be significant impact on the fleet, with some engines and airframes being unable to accommodate significantly reduced octane fuels. • There may be significant impact to cost of ownership/operation and exhaust emissions.
	Related Issues	Extensive fleet modifications may require considerable recertification efforts.
	Path	See Roadmap

Appendix I
Background on Environmental Regulations Related To Aviation Gasoline

Environmental Considerations

During the UAT ARC deliberations, the EPA representative of the Office of Transportation and Air Quality provided a presentation which summarized the EPA's position and status regarding lead emissions from piston engine aircraft. The EPA presentation addressed the following topics.

- EPA's role and responsibility in the Clean Air Act
- The National Ambient Air Quality Standard for Lead
- The Advance Notice of Proposed Rulemaking (ANPR)
- Next Steps

In 2006, the Friends of Earth (FOE) petitioned the EPA to do the following.

- "Make a finding under the Clean Air Act (CAA) that lead emissions from General Aviation aircraft engines cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare and issue proposed emission standards for such lead emissions or, alternately,
- If the Administrator of the EPA believes that insufficient information exists to make such a finding, commence a study and investigation under the CAA of the health and environmental impacts of lead emissions from General Aviation aircraft engines, including impacts to humans, animals, and ecosystems, and issue a public report on the findings of the study and investigation."

"Take-Away Points" from the EPA presentation are summarized as follows.

EPA "Take Away Points"

- "EPA has not proposed to ban AVGAS."
- "EPA has a duty to respond to FOE's request that we evaluate the question of endangerment and we are focused on that issue."
- "EPA is at the first step of a long process and has made no decisions."
- "EPA recognizes the value of piston-engine aircraft in the U.S., including Alaska.
- As part of any future assessment of control measures, EPA would consider safety, fuel supply, and economic impact issues including effects on small businesses."
- "EPA is committed to working closely with FAA, States, Industry, and user groups to keep piston-engine aircraft flying in an environmentally acceptable and safe manner throughout the U.S."
- EPA is committed to FAA's ARC process and will provide input and contribute where we are able."

The following link provides additional information on EPA lead AVGAS work.

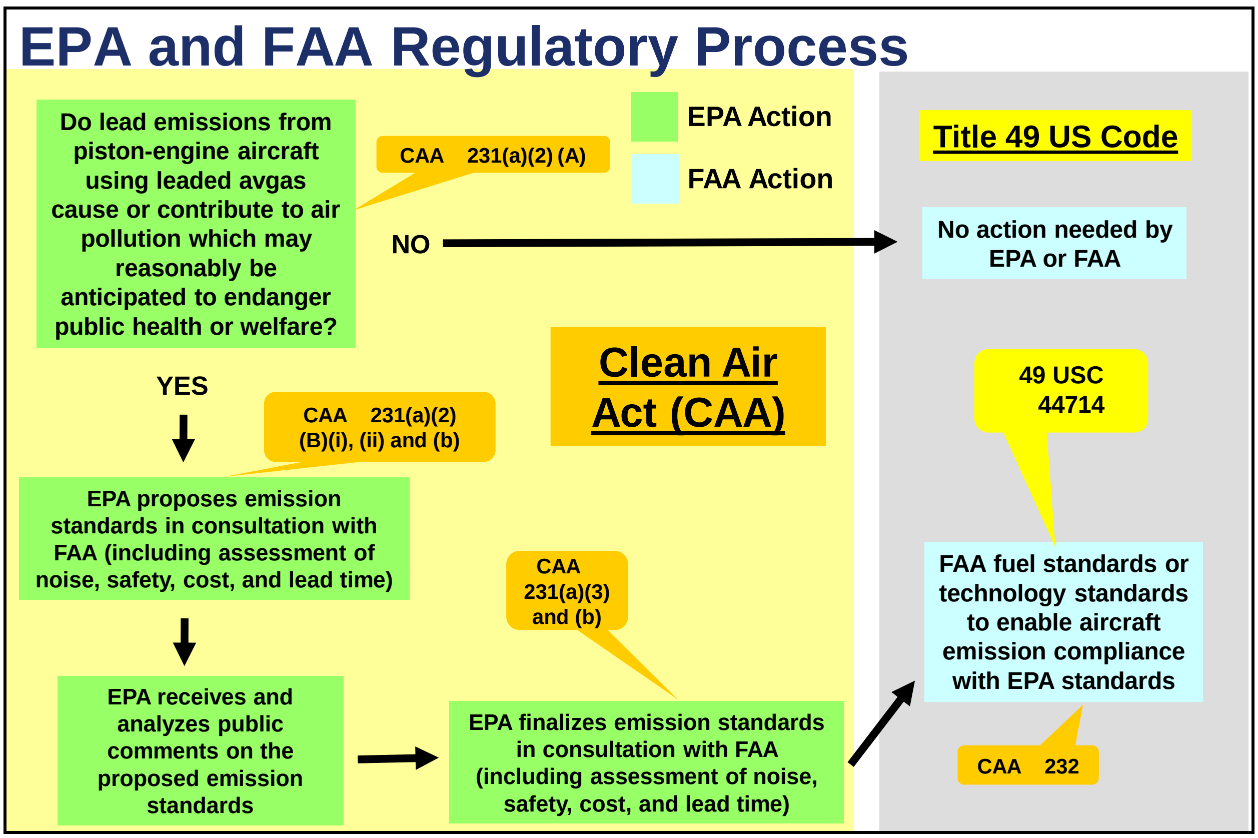
www.epa.gov./otaq/aviation.htm

The following link provides additional information on the NAAQS relative to lead.

www.epa.gov/air/lead/

Fuel & Emissions Regulations

ARC discussions included the statutory responsibilities of the EPA and FAA as related to regulatory control of piston engine exhaust emissions. In the event of a positive endangerment finding, the EPA must consider aircraft engine emission standards and the EPA and FAA must work in consultation so that necessary and appropriate considerations are given to safety, noise, costs, and the ability and time needed to implement new technology. Only the FAA can issue regulatory standards for the affected aviation products. A subsequent discussion focused on the question of how the EPA and FAA work together on emissions regulations for aviation products. The latter discussion was captured as a "Bin Item" relative to interpretation of 49 USC 44714. The following chart illustrates the statutory interaction between the FAA and the EPA regarding leaded AVGAS.



If a draft proposed standard would significantly increase noise or adversely affect aircraft safety, then the draft standard would not be proposed or promulgated by EPA. Moreover, if the President, after notice and opportunity for a public hearing disapproves a proposed or promulgated standard on the basis of a finding by the Secretary of Transportation that such standard would create a hazard to aircraft safety; the proposed or promulgated standard shall not apply.

Excerpts from both the Clean Air Act and the U.S. Transportation Code that identify EPA and FAA authority to regulate aircraft emissions and fuel are included at the end of this Appendix.

Potential Impact of Environmental Regulatory Activity

During the UAT ARC deliberations, the impact of regulatory action was assessed in terms of near term and long term considerations as follows.

- Near Term – Monitoring for Lead at Airports to Evaluate Compliance with the National Ambient Air Quality Standards (NAAQS) for Lead
- Long Term – Endangerment Finding on Lead from General Aviation

In 2008, the EPA strengthened the national ambient air quality standards (NAAQS) for lead, by revising the standards to a level 10 times tighter than the previous standard in order to improve health protection for at-risk groups, especially children. Related to this revision, under EPA regulations lead monitoring is required at 15 General Aviation airports by the end of 2011. Each State will be looking to reduce all sources of lead in non-attainment areas. A positive finding of endangerment from aircraft engine lead emissions under the Clean Air Act requires the EPA to propose the establishment of lead emission standards which raises concerns regarding the impact on GA.

UAT ARC discussions addressed the interaction of the EPA and the FAA, and the need to fully understand the statutory aspects which are tools available to industry; regulatory considerations influence the ARC "road map". The EPA intends to determine whether aircraft engine lead emissions cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare, and, if EPA determines that they do, the EPA is required to prescribe aircraft engine emission standards and the FAA is required under the U.S. Transportation Code to regulate fuel specifications in order to control or eliminate emissions that have been found to cause endangerment. Considerations must be given to safety, noise, costs, and the ability and time needed to implement new technology. As a result, the EPA and FAA must work in consultation to ensure both appropriate standards and aircraft safety. It was discussed that the EPA does not have regulatory authority to regulate fuels used exclusively in aircraft. The need to have the FAA and EPA move forward collaboratively is essential to the outcome. A good understanding is required so that the industry can transition to a new fuel either with, or without, an endangerment finding.

Clean Air Act (CAA) Excerpt Which Identifies EPA Authority

As discussed in Section 3.7, the EPA is authorized under section 231(a)(2)(A) of the CAA (42 U.S.C. § 7571(a)(2)(A)) to determine if aircraft engine lead emissions cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare (referred to here as the "endangerment finding". Furthermore, if the EPA makes a positive endangerment finding, then the EPA would be required under CAA section 231(a)(2)-(3) to prescribe standards applicable to the emissions of lead from General Aviation engines, and the Secretary of Transportation would be required under CAA section 232 to prescribe regulations to ensure compliance with such standards (42 U.S.C. § 7572). The following is an excerpt of the applicable sections of the CAA.

"CAA TITLE II - EMISSION STANDARDS FOR MOVING SOURCES

Part B - Aircraft Emission Standards

Sec. 231. Establishment of standards.

Sec. 231. (a)(1) Within 90 days after the date of enactment of the Clean Air Amendments of 1970, the Administrator shall commence a study and investigation of emissions of air pollutants from aircraft in order to determine-

(A) the extent to which such emissions affect air quality in air quality control regions throughout the United States, and

(B) the technological feasibility of controlling such emissions.

(2) The Administrator shall, from time to time, issue proposed emission standards applicable to the emission of any air pollutant from any class or classes of aircraft engines which in his judgment causes, or contributes to, air pollution which may reasonably be anticipated to endanger public health or welfare.

(3) The Administrator shall hold public hearings with respect to such proposed standards. Such hearings shall, to the extent practicable, be held in air quality control regions which are most seriously affected by aircraft emissions. Within 90 days after the issuance of such proposed regulations, he shall issue such regulation with such modifications as he deems appropriate. Such regulations may be revised from time to time.

(b) Any regulation prescribed under this section (and any revision thereof) shall take effect after such period as the Administrator finds necessary (after consultation with the Secretary of Transportation) to permit the development and application of the requisite technology, giving appropriate consideration to the cost of compliance within such period.

(c) Any regulations in effect under this section on date of enactment of the Clean Air Act Amendments of 1977 or proposed or

promulgated thereafter, or amendments thereto, with respect to aircraft shall not apply if disapproved by the President, after notice and opportunity for public hearing, on the basis of a finding by the Secretary of Transportation that any such regulation would create a hazard to aircraft safety. Any such finding shall include a reasonably specific statement of the basis upon which the finding was made.
[42 U.S.C. 7571]"

"Sec. 232. Enforcement of standards.

Sec. 232. (a) The Secretary of Transportation, after consultation with the Administrator, shall prescribe regulations to insure compliance with all standards prescribed under section 231 by the Administrator. The regulations of the Secretary of Transportation shall include provisions making such standards applicable in the issuance, amendment, modification, suspension, or revocation of any certificate authorized by the Federal Aviation Act or the Department of Transportation Act. Such Secretary shall insure that all necessary inspections are accomplished, and, may execute any power or duty vested in him by any other provision of law in the execution of all powers and duties vested in him under this section.

(b) In any action to amend, modify, suspend, or revoke a certificate in which violation of an emission standard prescribed under section 231 or of a regulation prescribed under subsection (a) is at issue, the certificate holder shall have the same notice and appeal rights as are prescribed for such holders in the Federal Aviation Act of 1958 or the Department of Transportation Act, except that in any appeal to the National Transportation Safety Board, the Board may amend, modify, or revoke the order of the Secretary of Transportation only if it finds no violation of such standard or regulation and that such amendment, modification,
or revocation is consistent with safety in air transportation.
[42 U.S.C. 7572]

Sec. 233. State standards and controls.

Sec. 233. No State or political subdivision thereof may adopt or attempt to enforce any standard respecting emissions of any air pollutant from any aircraft or engine thereof unless such standard is identical to a standard applicable to such aircraft under this part.
[42 U.S.C. 7573]"

U.S. Transportation Code Excerpt Which Identifies FAA Authority

In the event of EPA action, as discussed in Section 3.7, the FAA would be required under section 44714 of the U.S. Transportation Code to prescribe standards for the composition or chemical or physical properties of AVGAS to control or eliminate aircraft lead emissions (49 U.S.C. § 44714). The following is an excerpt of 49 U.S.C. § 44714.

§ 44714 TITLE 49—TRANSPORTATION Page 902

(D) the lack of ready access by law enforcement officials to information contained on the forms.

(2) The Administrator of the Federal Aviation Administration shall prescribe regulations to carry out paragraph (1) of this subsection and provide a written explanation of how the regulations address each of the deficiencies and abuses described in paragraph (1). In prescribing the regulations, the Administrator of the Federal Aviation Administration shall consult with the Administrator of Drug Enforcement, the Commissioner of Customs, other law enforcement officials of the United States Government, representatives of State and local law enforcement officials, representatives of the general aviation aircraft industry, representatives of users of general aviation aircraft, and other interested persons.

(e) AUTOMATED SURVEILLANCE TARGETING SYSTEMS.—

(1) IN GENERAL.—The Administrator shall give high priority to developing and deploying a fully enhanced safety performance analysis system that includes automated surveillance to assist the Administrator in prioritizing and targeting surveillance and inspection activities of the Federal Aviation Administration.

(2) DEADLINES FOR DEPLOYMENT.—

(A) INITIAL PHASE.—The initial phase of the operational deployment of the system developed under this subsection shall begin not later than December 31, 1997.

(B) FINAL PHASE.—The final phase of field deployment of the system developed under this subsection shall begin not later than December 31, 1999. By that date, all principal operations and maintenance inspectors of the Administration, and appropriate supervisors and analysts of the Administration shall have been provided access to the necessary information and resources to carry out the system.

(3) INTEGRATION OF INFORMATION.—In developing the system under this section, the Administration shall consider the near-term integration of accident and incident data into the safety performance analysis system under this subsection.

(Pub. L. 103–272, § 1(e), July 5, 1994, 108 Stat. 1194; Pub. L. 104–264, title IV, § 407(b), Oct. 9, 1996, 110 Stat. 3258.)

HISTORICAL AND REVISION NOTES

Revised Section	Source (U.S. Code)	Source (Statutes at Large)
44713(a)	49 App.:1425(a).	Aug. 23, 1958, Pub. L. 85–726, § 605(a), (b), 72 Stat. 778.
	49 App.:1655(c)(1).	Oct. 15, 1966, Pub. L. 89–670, § 6(c)(1), 80 Stat. 938; Jan. 12, 1983, Pub. L. 97–449, § 7(b), 96 Stat. 2444.
44713(b)	49 App.:1425(b) (1st sentence).	
	49 App.:1655(c)(1).	
44713(c)	49 App.:1425(b) (last sentence).	
	49 App.:1655(c)(1).	
44713(d)(1) ..	49 App.:1303 (note).	Nov. 18, 1988, Pub. L. 100–690, § 7214, 102 Stat. 4434.
	49 App.:1425(c).	Aug. 23, 1958, Pub. L. 85–726, 72 Stat. 731, § 605(c); added Nov. 18, 1988, Pub. L. 100–690, § 7206(a), 102 Stat. 4426.

HISTORICAL AND REVISION NOTES—CONTINUED

Revised Section	Source (U.S. Code)	Source (Statutes at Large)
44713(d)(2) ..	49 App.:1401 (note).	Nov. 18, 1988, Pub. L. 100–690, § 7207(a) (1st sentence), (b), 102 Stat. 4427.

In subsections (a)–(c), the word "Administrator" in section 605(a) and (b) of the Federal Aviation Act of 1958 (Public Law 85–726, 72 Stat. 778) is retained on authority of 49:106(g).

In subsection (a), the word "overhaul" is omitted as being included in "repair". The word "prescribed" is added for consistency in the revised title and with other titles of the United States Code. The words "A person operating, inspecting, overhauling, or maintaining the equipment shall comply with those requirements, regulations, and orders" are substituted for 49 App.:1425(a) (last sentence) to eliminate unnecessary words.

In subsection (b), before clause (1), the words "be charged with the duty . . . of" are omitted as surplus. In clause (1), the words "in use" are substituted for "used by an air carrier in air transportation" to eliminate unnecessary words. The words "as may be necessary" and "for operation in air transportation" are omitted as surplus.

In subsection (c), the words "in the performance of his duty", "used or intended to be used by any air carrier in air transportation", and "a period of" are omitted as surplus.

In subsection (d)(1), before clause (A), the words "not used to provide air transportation" are substituted for section 7214 of the Anti-Drug Abuse Act of 1988 (Public Law 100–690, 102 Stat. 4434) because of the restatement.

In subsection (d)(2), the words "Not later than September 18, 1989" and "final" are omitted as obsolete. The words "Administrator of Drug Enforcement" are substituted for "Drug Enforcement Administration of the Department of Justice" because of section 5(a) of Reorganization Plan No. 2 of 1973 (eff. July 1, 1973, 87 Stat. 1092). The words "Commissioner of Customs" are substituted for "United States Customs Service" because of 19:2071.

AMENDMENTS

1996—Subsec. (e). Pub. L. 104–264 added subsec. (e).

EFFECTIVE DATE OF 1996 AMENDMENT

Except as otherwise specifically provided, amendment by Pub. L. 104–264 applicable only to fiscal years beginning after Sept. 30, 1996, and not to be construed as affecting funds made available for a fiscal year ending before Oct. 1, 1996, see section 3 of Pub. L. 104–264, set out as a note under section 106 of this title.

TRANSFER OF FUNCTIONS

For transfer of functions, personnel, assets, and liabilities of the United States Customs Service of the Department of the Treasury, including functions of the Secretary of the Treasury relating thereto, to the Secretary of Homeland Security, and for treatment of related references, see sections 203(1), 551(d), 552(d), and 557 of Title 6, Domestic Security, and the Department of Homeland Security Reorganization Plan of November 25, 2002, as modified, set out as a note under section 542 of Title 6.

§ 44714. Aviation fuel standards

The Administrator of the Federal Aviation Administration shall prescribe—

(1) standards for the composition or chemical or physical properties of an aircraft fuel or fuel additive to control or eliminate aircraft emissions the Administrator of the Environmental Protection Agency decides under section 231 of the Clean Air Act (42 U.S.C. 7571) endanger the public health or welfare; and

(2) regulations providing for carrying out and enforcing those standards.

(Pub. L. 103–272, § 1(e), July 5, 1994, 108 Stat. 1195.)

HISTORICAL AND REVISION NOTES

Revised Section	*Source (U.S. Code)*	*Source (Statutes at Large)*
44714	49 App.:1421(e).	Aug. 23, 1958, Pub. L. 85–726, 72 Stat. 731, § 601(e); added Dec. 31, 1970, Pub. L. 91–604, § 11(b)(1), 84 Stat. 1705; Nov. 9, 1977, Pub. L. 95–163, § 15(b)(1), 91 Stat. 1283.

In this section, before clause (1), the words "and from time to time revise" are omitted as surplus. In clause (1), the words "establishing" and "the purpose of" are omitted as surplus.

§ 44715. Controlling aircraft noise and sonic boom

(a) STANDARDS AND REGULATIONS.—(1)(A) To relieve and protect the public health and welfare from aircraft noise and sonic boom, the Administrator of the Federal Aviation Administration, as he deems necessary, shall prescribe—

(i) standards to measure aircraft noise and sonic boom; and

(ii) regulations to control and abate aircraft noise and sonic boom.

(B) The Administrator, as the Administrator deems appropriate, shall provide for the participation of a representative of the Environmental Protection Agency on such advisory committees or associated working groups that advise the Administrator on matters related to the environmental effects of aircraft and aircraft engines.

(2) The Administrator of the Federal Aviation Administration may prescribe standards and regulations under this subsection only after consulting with the Administrator of the Environmental Protection Agency. The standards and regulations shall be applied when issuing, amending, modifying, suspending, or revoking a certificate authorized under this chapter.

(3) An original type certificate may be issued under section 44704(a) of this title for an aircraft for which substantial noise abatement can be achieved only after the Administrator of the Federal Aviation Administration prescribes standards and regulations under this section that apply to that aircraft.

(b) CONSIDERATIONS AND CONSULTATION.—When prescribing a standard or regulation under this section, the Administrator of the Federal Aviation Administration shall—

(1) consider relevant information related to aircraft noise and sonic boom;

(2) consult with appropriate departments, agencies, and instrumentalities of the United States Government and State and interstate authorities;

(3) consider whether the standard or regulation is consistent with the highest degree of safety in air transportation or air commerce in the public interest;

(4) consider whether the standard or regulation is economically reasonable, technologically practicable, and appropriate for the applicable aircraft, aircraft engine, appliance, or certificate; and

(5) consider the extent to which the standard or regulation will carry out the purposes of this section.

(c) PROPOSED REGULATIONS OF ADMINISTRATOR OF ENVIRONMENTAL PROTECTION AGENCY.—The Administrator of the Environmental Protection Agency shall submit to the Administrator of the Federal Aviation Administration proposed regulations to control and abate aircraft noise and sonic boom (including control and abatement through the use of the authority of the Administrator of the Federal Aviation Administration) that the Administrator of the Environmental Protection Agency considers necessary to protect the public health and welfare. The Administrator of the Federal Aviation Administration shall consider those proposed regulations and shall publish them in a notice of proposed regulations not later than 30 days after they are received. Not later than 60 days after publication, the Administrator of the Federal Aviation Administration shall begin a hearing at which interested persons are given an opportunity for oral and written presentations. Not later than 90 days after the hearing is completed and after consulting with the Administrator of the Environmental Protection Agency, the Administrator of the Federal Aviation Administration shall—

(1) prescribe regulations as provided by this section—

(A) substantially the same as the proposed regulations submitted by the Administrator of the Environmental Protection Agency; or

(B) that amend the proposed regulations; or

(2) publish in the Federal Register—

(A) a notice that no regulation is being prescribed in response to the proposed regulations of the Administrator of the Environmental Protection Agency;

(B) a detailed analysis of, and response to, all information the Administrator of the Environmental Protection Agency submitted with the proposed regulations; and

(C) a detailed explanation of why no regulation is being prescribed.

(d) CONSULTATION AND REPORTS.—(1) If the Administrator of the Environmental Protection Agency believes that the action of the Administrator of the Federal Aviation Administration under subsection (c)(1)(B) or (2) of this section does not protect the public health and welfare from aircraft noise or sonic boom, consistent with the considerations in subsection (b) of this section, the Administrator of the Environmental Protection Agency shall consult with the Administrator of the Federal Aviation Administration and may request a report on the advisability of prescribing the regulation as originally proposed. The request, including a detailed statement of the information on which the request is based, shall be published in the Federal Register.

(2) The Administrator of the Federal Aviation Administration shall report to the Administrator of the Environmental Protection Agency within the time, if any, specified in the request.

Appendix J
General Aviation Coalition
Response to EPA ANPR

COMMENTS OF THE GENERAL AVIATION AVGAS COALITION

ON THE ADVANCE NOTICE OF PROPOSED RULEMAKING ON LEAD EMISSIONS FROM PISTON-ENGINE AIRCRAFT USING LEADED AVIATION GASOLINE

EPA DOCKET NO. EPA–HQ–OAR–2007–0294

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I. INTRODUCTION

On April 28, 2010, the Environmental Protection Agency ("EPA") published in the Federal Register an "Advance Notice of Proposed Rulemaking on Lead Emissions from Piston-Engine Aircraft Using Leaded Aviation Gasoline" (the "ANPR"). 75 Fed. Reg. 22440. The General Aviation AvGas Coalition (the "Coalition") respectfully submits the following comments on the ANPR.

The Coalition is comprised of associations that represent industries, businesses, and individuals that would be directly impacted by any finding made by the EPA in regard to lead emissions from piston-engine aircraft, corresponding aircraft emissions standards, and related changes to the formulation of aviation gasoline. Coalition membership includes the Aircraft Owners and Pilots Association ("AOPA"), the Experimental Aircraft Association ("EAA"), the General Aviation Manufacturers Association ("GAMA"), the National Air Transportation Association ("NATA"), the National Business Aviation Association ("NBAA"), the American Petroleum Institute ("API") and the National Petrochemical and Refiners Association ("NPRA"). Together, these organizations represent general aviation aircraft owners, operators, and manufacturers, and the producers, refiners, and distributors of aviation gasoline.[1]

Since the establishment of the first National Ambient Air Quality Standard ("NAAQS") for lead in 1978, the general aviation and petroleum industries have been committed to safely reducing lead emissions from piston powered aircraft. Today, 100 octane low lead ("100LL") aviation gasoline (or "avgas") contains 50 percent less lead than it did when the lead NAAQS were first introduced, dramatically reducing lead emissions from general aviation. In addition, the general aviation industry is aggressively working to further reduce the lead content of avgas, by an additional 20 percent from the already low 100LL standard. Ultimately, the general aviation community is committed to an unleaded future and has engaged in extensive research seeking a feasible unleaded alternative to today's leaded aviation gasoline. However, the technical challenges of removing lead from aviation gasoline are formidable. Despite extensive efforts, no unleaded replacement has been found and approved that provides adequate and comparable safety and performance to 100LL. But work on this important issue continues and is accelerating, with new efforts to study and develop alternative aviation fuels.

While the aviation and petroleum industries are committed to seeking near-term additional reductions in the lead content of aviation gasoline, the ANPR concerns the Coalition for several reasons. First, the EPA is not actually obligated to make any determination on lead emissions from aircraft engines, as asserted in the ANPR. Second, any such finding would be premature because—as the EPA itself observes—the EPA currently lacks sufficient data to make a careful, reasoned determination. Third, what limited data and modeling do exist indicate that lead emissions from piston engine aircraft do not cause or contribute to any violation of the new, protective lead NAAQS. Finally, ongoing efforts to reduce lead content of avgas and new lead emissions data are likely to alter the EPA's analysis of lead emissions from piston engine aircraft. Given the widespread impact of the actions described in the ANPR, any determination related to lead emissions from piston-engine aircraft must be supported by sound and complete data. As explained in the following comments, the Coalition does not believe that the present body of data is adequate to support any such finding.

[1] Appendix A contains additional information about Coalition members.

II. BACKGROUND

A. Regulatory History

Under Section 231 of the Clean Air Act ("CAA"), the EPA has the authority to regulate aircraft emissions. In October, 2006 the environmental group Friends of the Earth ("FOE") filed a "Petition for Rulemaking Seeking the Regulation of Lead Emissions from General Aviation Aircraft Under § 231 of the Clean Air Act." In response to that petition, the EPA issued the ANPR on April 28, 2010. 75 Fed. Reg. 22440. While the EPA has yet to promulgate lead emissions standards specific to aircraft engines, lead emissions are already subject to extensive regulation under the CAA.

Through a series of actions beginning in 1973, the EPA reduced and then ultimately eliminated lead from automotive gasoline in 1996.[2] In 1976 the EPA listed lead as a "criteria pollutant" and then issued the first NAAQS for lead in 1978.[3] The aviation industry responded by reducing the maximum lead content of aviation gasoline by 50 percent to the present 100LL standard in use today. As a result of these actions, we have witnessed a "dramatic improvement" in air quality, [4] and a 99 percent decrease in total lead emissions—from 74,000 tons in 1980 to 2,000 tons in 2008.[5] And since 2008, lead emissions from avgas have dropped by another 28 percent, to approximately 550 tons per year.[6]

In addition to this sharp decline in lead emissions, the EPA recently strengthened the NAAQS for lead by a factor of ten.[7] 73 Fed. Reg. 66964 (Nov. 12, 2008). The new lead NAAQS are the result of a four-year effort during which the EPA conducted extensive analysis of the human health and ecological risks associated with lead, including "full-scale human exposure and health risk assessments." 73 Fed. Reg. 66966-68. As required by the CAA, the resulting NAAQS were set without regard to costs and at a level that is protective of human health, including sensitive groups, "with an adequate margin of safety." CAA § 109(b); 42 U.S.C.A. § 7409(b). In promulgating the new NAAQS, the EPA discussed this requirement at length and ultimately concluded that the new lead NAAQS "standard of 0.15 µg/m3 . . . is requisite to protect public health, including the health of sensitive groups, with an adequate margin of safety." 73 Fed. Reg. 67006. In the recent ANPR, there is no evidence that lead emissions from avgas have caused any violation of this new, highly protective standard.[8]

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[2] This process began with EPA rulemaking and culminated with a Congressional ban in 1996. *See Regulation of Fuels and Fuel Additives*, 38 Fed. Reg. 1254 (Dec. 4, 1973); *Regulation of Fuels and Fuel Additives; Gasoline Lead Content*, 50 Fed. Reg. 9386 (March 7, 1985); *Prohibition on Gasoline Containing Lead or Lead Additives for Highway Use*, 61 Fed. Reg. 3832 (Feb. 2, 1996).

[3] *See* 43 Fed. Reg. 46246 (Oct. 5, 1978).

[4] 75 Fed. Reg. 22446.

[5] EPA, *Air Quality Trends*, *available at* http://www.epa.gov/airtrends/aqtrends.html.

[6] 75 Fed. Reg. 22446. At present levels, lead emissions from avgas represent less than one percent of total 1980 lead emissions.

[7] EPA lowered primary lead NAAQS standard from 1.5 micrograms per cubic meter (µg/m3), to 0.15 µg/m3. The prior standard had been in effect since 1978.

[8] *See* 75 Fed. Reg. 22465-67 (discussing "The Lead NAAQS and Lead Emissions From Piston-Engine Aircraft").

B. Statutory Framework

Section 231 of the CAA grants the EPA authority to make findings related to emissions of air pollutants from aircraft, and to establish aircraft emissions standards in consultation with the Federal Aviation Administration ("FAA"). *See* CAA § 231, 42 U.S.C.A. 7571. This structure grants initial authority to the EPA to make endangerment findings, establishes a collaborative process by which the EPA consults with the FAA to establish emissions standards, and ultimately requires the FAA to implement and enforce the emission standards by prescribing fuel and fuel additive standards. Each of these three steps constitutes a distinct rulemaking process:

> Step 1: The EPA may make a finding that a particular air pollutant emitted from aircraft engines "causes, or contributes to, air pollution which may reasonably be anticipated to endanger public health or welfare." CAA § 231(a)(2)(A), 42 U.S.C.A. 7571(a)(2)(A).
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> Step 2: Once the EPA determines that a pollutant endangers public health or welfare, the EPA must consult with the FAA to establish aircraft engine emission standards. CAA § 231(a)(2)(B)(i); 42 U.S.C.A. 7571(a)(2)(B)(i). Emission standards cannot "significantly increase noise and adversely affect safety." CAA § 231(a)(2)(B)(ii); 42 U.S.C.A. 7571(a)(2)(B)(ii). The President may veto any standard that the Secretary of Transportation finds would create a hazard to aircraft safety. CAA § 231(c); 42 U.S.C.A. 7571(c).
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> Step 3: The FAA is responsible for prescribing and enforcing fuel standards to implement any emissions standards promulgated by the EPA under CAA Section 231. *See* 49 U.S.C.A. 44714. This requires the FAA to promulgate new fuel standards after the EPA creates emission standards under the CAA.

The ANPR represents step one in the above process. While the EPA must involve the FAA in steps two and three, nothing prevents the EPA from seeking data, guidance, or other information from the FAA at the endangerment finding stage.

C. The Societal and Economic Impacts of General Aviation and Piston-Engine Aircraft

General aviation (or "GA") is a key component of our nation's transportation infrastructure and economy. There are 5,261 public-use airports that can be directly accessed by general aviation aircraft—more than ten times the number of airports served by scheduled airlines. These public use airports are the only available option for fast, reliable, flexible air transportation to small and rural communities in every corner of the country. General aviation directly supports jobs in these communities, provides a lifeline for small to mid-sized businesses, and provides critical services to remote cities and towns, particularly in time of natural disaster or crisis. As a result, general aviation is uniquely situated to serve some of the public's most crucial transportation needs.

The economic impact of general aviation is also significant. General aviation contributes to the U.S. economy by creating output, employment, and earnings that would not otherwise occur. Direct impacts, such as the purchase of a new aircraft, multiply as they trigger transactions and create jobs elsewhere in the economy (*e.g.*, sales of materials, electronics, and a wide range of other components required to make and operate an airplane). Indirect effects accrue as general aviation supports other facets of the economy, such as small business, rural economies, and tourism. Directly or indirectly, general aviation accounted for over 1.25 *million* jobs in 2005 (with collective earnings exceeding $53 billion) and contributed over $150 *billion* to the U.S. economy.[9]

Any regulatory action by the EPA related to lead emissions will directly affect general aviation. Without appropriate consideration of aviation safety, technical feasibility, and economic impact, a transition to an unleaded replacement for 100LL could have a significant impact upon the viability and long-term health of the general aviation industry. To gauge this impact, the general aviation engine and aircraft manufacturers are currently performing a fleet-wide assessment to determine the effects of any transition to currently available lower-octane unleaded avgas fuels.[10]

Initial findings, based on an analysis of 72.2 percent of the FAA type certified active fleet of piston engine aircraft, indicate that approximately 57,000 aircraft would be unable to operate on the lower-octane unleaded avgas. This represents 34 percent of the fleet, including most twin-engine airplanes. While some of these aircraft and engines could be modified to operate safely with a lower-lead fuel, this would require either a reduction in horsepower or some degree of engine replacement.[11] Importantly, a large portion of these aircraft are operated in business or commercial service with high utilization. As a result, aircraft unable to operate on the lower-octane unleaded avgas represent a high proportion of total general aviation flight hours. This translates directly to a significant economic impact upon general aviation and other related sectors, such as airport operations, sales of fuel, maintenance, parts, and services to these aircraft operators.

In order to better quantify and understand these impacts, an analysis of engines and aircraft by make/model is currently being cross-referenced with FAA activity data regarding general aviation operations in 2008. This will allow quantification of flight hours, type of operation, and fuel consumption. The resulting impact analysis will provide an important baseline on the safety, technical, and economic effects associated with transitioning to potential replacements for the current 100LL standard. Results are expected within the next several months. Once complete, these results will be provided to the EPA for consideration in regard to the ANPR and any future aircraft engine emissions standards.

D. Historical and Current Efforts to Reduce Lead in Avgas and Related Safety Considerations

There is no demonstrated unleaded replacement for 100LL avgas that meets the safety and operational requirements of the entire fleet. Unlike the transition away from leaded gas in

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[9] MergeGlobal, Inc, *General Aviation's Contribution to the U.S. Economy*, at 2 (May, 2006), *available at* http://www.gama.aero/files/ga_contribution_to_us_economy_pdf_498cd04885.pdf (accessed August 27, 2010). These conservative figures do not measure all of general aviation's significant net benefits to the U.S. economy.

[10] A lower octane replacement for 100LL would be considered a worst case scenario because octane rating is a key property of avgas having the greatest impact upon engine power and aircraft performance. High performance aircraft engines require a minimum of 100 octane in order to safely produce rated horsepower.

[11] These replacements would entail a bigger engine displacement with lower compression ratio.

automobiles, performance issues in aircraft have life-and-death consequences for pilots and passengers. Those living underneath flight paths also face risks associated with potential accidents caused by poorly performing aircraft. While the general health risks associated with lead are well documented, we must also ensure the safe operation of approximately 163,000 general aviation aircraft.[12]

There have been significant historical and current efforts to develop an unleaded high-octane aviation gasoline that maintains the properties necessary for the safe operation of aircraft engines. Tetra-ethyl lead ("TEL") is a lead compound that raises octane, which reduces gasoline's tendency to suddenly and instantaneously ignite from compression (also known as detonation or "knocking") during a reciprocating engine's combustion cycle. Sustained detonation can cause catastrophic engine failure. There is a direct relationship between the amount of horsepower a high-performance aircraft engine can produce and the octane level it requires to operate safely. In addition, the alloys used in aviation engine construction are chosen for their durability and synergistic relationship with the lubricating properties of lead. As a result, engine wear and maintenance issues arise in the absence of leaded fuel. Increased maintenance has an economic impact, but also raises safety concerns due to the increased potential for engine component failure. The current avgas specification, ASTM D910, defines the acceptable limits for several physical and performance properties necessary for an aviation gasoline to ensure safe operation of aircraft across a broad range of very demanding conditions. The TEL additive and high-octane rating it provides is just one of several safety issues that must be addressed when developing a lower-lead or unleaded alternative to 100LL. Appendix B provides a more complete discussion of these and other safety issues related to avgas formulation and impact upon engine and aircraft safety certification.[13]

With these and other safety considerations in mind, the aviation industry has engaged in efforts to reduce lead emissions from avgas. As the public became concerned with the health risks associated with lead emissions in the early 1970's, the general aviation industry responded by engaging in an extensive research effort. That effort resulted in a 50 percent reduction in the lead content of avgas and the 100LL standard in use today.

Testing of alternative general aviation fuels has been conducted at the FAA Aviation Fuel and Engine Test Facility ("AFETF") in cooperation with the Coordinating Research Council ("CRC") unleaded avgas research group, and individual refiners. Although no "drop-in" replacement for 100LL avgas has been identified and approved for use in the entire fleet, much has been learned about the effects of lead in avgas and the impact of its removal on engine performance and durability. The FAA AFETF and CRC have published technical reports on the results of unleaded avgas research activities and more data is forthcoming.

The CRC is continuing efforts to develop an unleaded alternative to 100LL and has undertaken an evaluation of whether a near-term reduction in lead emissions from general aviation is possible by further reducing the amount of lead in avgas. The FAA is also continuing to support the AFETF's research on alternative fuels for general aviation. The President's

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[12] *See* FAA, *General Aviation and Part 135 Activity Surveys – CY 2008* (2009), *available at* http://www.faa.gov/data_research/aviation_data_statistics/general_aviation/CY2008/.
[13] *See* Appendix B for a more complete discussion of these and other safety issues related to avgas formulation.

budget for the 2011 fiscal year proposed $2 million annually for five years to fund additional research and development of alternative general aviation fuels. Congress has also expressed support for this research—the House and Senate Transportation Appropriations Bills fully fund the FAA's research program on alternative fuels for general aviation and specifically recognizes its importance and requests FAA to detail in future budgets the resources necessary to implement a transition to unleaded avgas. Appendix C provides additional details on these and other efforts to reduce or eliminate lead in avgas.

III. COMMENTS ON THE ADVANCE NOTICE OF PROPOSED RULEMAKING

The ANPR indicates that the EPA is focused on a perceived obligation to make an endangerment finding related to lead emissions from avgas. However, such a determination is not required by the FOE petition or the CAA. Moreover, any such finding would be premature because the EPA lacks sufficient data to make a careful, reasoned determination at this time. There is limited data and modeling on lead emissions from avgas, and current data indicates no violation of the new, highly protective lead NAAQS. When additional information becomes available as a result of new monitoring requirements and additional fuel studies discussed above, the EPA will be in a better position to evaluate lead emissions from piston-engine aircraft. In the meantime, the general aviation community stands ready to support additional data collection and research efforts.

A. EPA Is Not Required to Make an Endangerment Finding

Neither the CAA nor the FOE Petition requires the EPA to make an endangerment finding. First, nothing in the Clean Air Act requires the EPA to make a finding related to lead emissions from avgas.[14] In fact, Section 231 of the CAA begins by stating that the EPA "shall commence a study and investigation of emissions of air pollutants from aircraft" to determine the affect of such pollution and the "technological feasibility of controlling" aircraft emissions. CAA § 231(a)(1). Second, the ANPR is the EPA's response to a petition that requests that the EPA *either* make a finding that emissions from leaded avgas represent a danger to human health and the environment *or* commence a study to enable the Agency to make such a determination. 75 Fed. Reg. 22444. As discussed below, continued study is necessary given the limited data currently available to the EPA and the lack of any showing that lead emissions from avgas contribute to any violation of the NAAQS. Accordingly, a decision to engage in continued study and analysis of this important issue is a correct and logical response to the FOE Petition.

B. EPA Has Inadequate and Insufficient Data to Make an Endangerment Finding

1. <u>Current Monitoring Data is Limited and Inadequate</u>

The ANPR sets out the information that the EPA has available to consider while making any finding under Section 231 of the CAA. The ANPR also makes it clear that the Agency currently has inadequate or insufficient information from which it could find that leaded avgas endangers the public health or welfare.

[14] The EPA has recently affirmed the discretionary nature of findings under Section 231 of the CAA. *See* EPA's Motion to Dismiss, *Center for Biological Diversity v. U.S. EPA*, No. 10-985 (D.C. Cir. Aug. 20, 2010).

The EPA acknowledges that its "current database for ambient lead concentrations . . . at airports is severely limited." 75 Fed. Reg. 22459. Ambient air concentration data for lead is limited to "samples collected on or near five airports," two of which are located in Canada. 75 Fed. Reg. 22457. Beyond these five data points, the EPA currently lacks any data on lead emissions at or around airports. In addition, there has been no significant analysis of background levels of lead in and around airports, which typically are areas with relatively intensive past road traffic (using leaded fuel), or any discussion of other potential contributors to ambient lead concentrations from nearby industrial activities, surface disturbances, and other sources.

In addition to a lack of monitoring data, the ANPR identifies only a single study that has evaluated lead concentrations at airports. The study, at the Santa Monica municipal airport in Santa Monica, CA "is the only study to date . . . that provides ambient concentrations relevant for comparison to the Lead NAAQS." *Id.* While the EPA is currently developing a modeling approach based on this study to evaluate lead concentrations at other airports, that model is not yet complete and has not been validated against actual monitoring data at other airports. And before any model based on the Santa Monica study can be applied to other airports, the study itself recommends that the EPA conduct extensive additional research, including a survey on landing and takeoff operations, collecting hourly data on piston-engine aircraft operations, and compiling information on stationary sources within 20 kilometers of each airport that the model is applied to.[15] Without this additional data, the EPA is currently unable to accurately apply the Santa Monica study, or a model based upon it, to other airports.

As the ANPR notes, additional data is forthcoming as a result of new lead monitoring requirements and the EPA is planning new air quality modeling efforts. 75 Fed. Reg. 22465. These activities will help address the deficiencies outlined above. In the meantime, the limited data and modeling available to the EPA makes it difficult or impossible to accurately quantify lead emissions and any contribution that piston-engine aircraft make to ambient lead concentrations.

2. <u>The Current NAAQS of Lead are Protective of Human Health and Welfare and Current Data Shows No Exceedance Due to Aircraft Emissions</u>

The EPA recently lowered the NAAQS for lead by a factor of ten—a 90 percent reduction—to assure protection against lead-related public health and welfare effects. 73 Fed. Reg. 66970–67007 (Nov. 12, 2008). The EPA notes that although there is no definition of "public health" in the CAA, the EPA has looked at "morbidity, including acute and chronic health effects, as well as mortality" when establishing NAAQS. 75 Fed. Reg. 22445. The EPA also notes that the term "welfare" has an expansive definition. *Id.* As discussed above, the EPA gave careful consideration to a broad range of health and welfare effects when establishing the new lead NAAQS in 2008. The EPA ultimately set the lead NAAQS at a level designed to "provide increased protection for children and other at-risk populations." 75 Fed. Reg. 22448.

In the ANPR, the EPA discusses the health and welfare effects of lead in the context of the 2008 lead NAAQS. 75 Fed. Reg. 22447-52. These health and welfare effects are well

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[15] *See* ICF International & T&B Systems, *Development and Evaluation of an Air Quality Modeling Approach for Lead Emissions from Piston-Engine Aircraft Operating on Leaded Aviation Gasoline*, at 72-73 (Feb., 2010) (discussing conclusions of the Santa Monica study).

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documented. With its comprehensive and detailed knowledge of these effects derived from nearly forty years of experience with regulating lead emissions, the EPA designed the 2008 lead NAAQS to be protective of human health "with an adequate margin of safety," as mandated by the CAA. 73 Fed. Reg. 67006; CAA § 109(b); 42 U.S.C.A. § 7409(b).

Despite recently lowering the lead NAAQS to this new, highly protective level, the EPA has no data demonstrating that avgas emissions cause or contribute to any violation of the NAAQS. In fact, the only multi-site monitoring analysis that EPA has available, near the Santa Monica airport, shows that there is no exceedance of the revised lead NAAQS, even with the monitor placed where lead concentrations are expected to be the highest. In fact, the monitored lead emissions from that site were 50 percent *below* the revised NAAQS. Monitoring data at four other airports yields a similar result, with no demonstrated exceedance of the lead NAAQS, based on reported average lead concentrations that are approximately 80 percent *below* the lead NAAQS. 75 Fed. Reg. 22457-59

The current NAAQS are designed to be protective of human health with a margin of safety, and the EPA has no data demonstrating that lead emissions from avgas cause or contribute to any exceedance of the lead NAAQS. While the EPA plans to make new attainment and non-attainment designations for lead by January 2012, the EPA is not currently in a position to evaluate any contribution that piston-engine aircraft may make to any non-attainment of those standards, especially given the very limited data and modeling on lead emissions from avgas currently available. Until such time as the EPA has new data confirming that lead emissions contribute to a violation of the lead NAAQS, an endangerment finding is unwarranted and inconsistent with the fact that the newly revised NAAQS are being met.

3. The EPA's Current Lead Emissions Inventory is Insufficient to Support a Cause and Contribute Finding

In addition to finding that air pollution "may reasonably be anticipated to endanger public health or welfare," the EPA must also find that lead from avgas "causes, or contributes to" that pollution. CAA §231(a)(2)(A); 42 U.S.C.A. 7571(a)(2)(A). Even though this "cause and contribute" clause does not contain a "significance" threshold, the EPA must still quantify emissions before determining that they cause or contribute to air pollution.

Despite this requirement, the EPA is currently unable to accurately quantify lead emissions from avgas. In the ANPR, the EPA bases the National Emissions Inventory ("NEI") for lead emissions from avgas on Department of Energy ("DOE") fuel volume estimates. But the sources of that data are unknown and currently unverified, and the EPA states that it is "working to identify the source(s) of the information used to derive DOE fuel volume estimates." 75 Fed. Reg. 22453. Moreover, the EPA "currently cannot estimate the fraction of total lead emissions these estimates comprise since the inventories for all other sources of lead to air are not yet in the draft 2008 NEI." *Id.* In other words, avgas fuel volumes, the corresponding emissions inventory for avgas, and any contribution to total lead emissions from avgas that the EPA relies on in the ANPR are speculative.

The EPA is also basing its current lead emissions estimates and contribution percentages on outdated 2005 data. *Id.* Without an accurate inventory of lead emissions from avgas and an

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accurate overall lead inventory against which to compare those emissions, it is impossible for the EPA to quantify how these emissions cause, or contributes to, air pollution that could endanger public health or welfare. Until the EPA has more reliable data quantifying lead emissions in general and from avgas in particular, it cannot reasonably support a "cause and contribute" finding.

C. Additional, Rigorous Study is Required to Support an Endangerment Finding

1. Any Finding is Premature Because Additional Data on Lead Emissions is Forthcoming

The EPA's revised lead NAAQS requires extensive state-level monitoring, reporting and air modeling of lead emissions. Approximately 135 of these monitors came online only this year. As the EPA points out in the ANPR, it will not have enough data to make complete lead attainment and non-attainment designations until January 2012. The EPA should wait to obtain this required data and analyses so that it has adequate information on which to base any determination about lead emissions from avgas.

The FAA will also generate additional information that will aid the EPA's analysis. In collaboration with the general aviation community, the FAA has committed to test, adopt, and certify a new aviation gasoline fuel standard as set forth in the 2009-2013 Flight Plan. To further this effort, the President's budget for fiscal year 2011 proposed $2 million annually for five years to fund the FAA's research and development of alternative fuels for general aviation. This effort will generate valuable data on the effects of lead in avgas that will aid the EPA's evaluation of lead emissions from piston-engine aircraft.

2. The EPA Should Continue to Work with the General Aviation Industry, the Federal Aviation Administration, and Other Stakeholders

The EPA has solicited public comments and has engaged in open discussions with industry trade associations, the CRC, the FAA, fuel producers, and airframe/engine manufacturers during this rulemaking process. The Coalition appreciates this dialogue and recommends that the EPA continue to work with these and other stakeholders.

By engaging with the general aviation industry, the EPA can gain valuable data to inform current and future regulatory processes related to lead emissions from avgas. For example, efforts are underway to evaluate the feasibility and impacts of converting to an unleaded fuel.[16] While the general aviation industry is willing to continue such efforts and share the results with the EPA, reliable data cannot be developed overnight. Because the general aviation industry is effectively a collection of many large and small businesses, compiling information requires a sustained effort involving many different entities. Recognizing these challenges, the signatories to this petition are willing to share additional data with the EPA as it becomes available. In turn, the EPA should continue to engage with the general aviation industry during this regulatory process.

[16] These efforts and resulting information are discussed above and in Appendices B and C.

In addition to engaging with the general aviation industry, the EPA should work with other government entities that can contribute valuable data and expertise to a study of emissions from piston-engine aircraft. In particular, the FAA has considerable expertise on this issue, as Congress recognized when it made the FAA a partner in the standards-setting process. And while the CAA does not mandate that the EPA include the FAA in a study of aviation emissions, it does require that the EPA consult with the FAA before imposing any new requirements that could impact the safety of general aviation. *See* CAA § 231(a)(2)(B)(i); 42 U.S.C.A. 7571(a)(2)(B)(i). This requirement springs from the FAA's statutory jurisdiction and responsibility over all matters that may affect aviation safety.

To better collect and organize various sources of information, the EPA should create a Federal Advisory Committee that includes members of the general aviation industry, the FAA, and other concerned parties. Given the limited availability of data and studies on lead emissions from avgas, these groups will play a valuable role in collecting, aggregating, and analyzing all available data to ensure that any determination is made using the best possible information. The EPA should also consider engaging the Science Advisory Board ("SAB") to design an appropriate study on lead emissions from avgas. The EPA has extensive experience with this process and routinely utilizes SAB expertise when designing and implementing environmental studies. SAB participation will help to assure that any study or modeling is conducted in a transparent manner and in accordance with accepted scientific methods.

The EPA could further ensure that the roles of all affected governmental and non-governmental stakeholders are considered by engaging in Negotiated Rulemaking under the Administrative Procedure Act. *See* 5 U.S.C.A. §§ 561-570. Negotiated Rulemaking provides a working forum to facilitate consensus and can incorporate a "negotiated rulemaking committee" under the Federal Advisory Committee Act. 5 U.S.C.A. § 565.

By engaging with stakeholders and the SAB, the EPA will ensure that it relies on the best available data and science in a process that is open, collaborative, and able to create consensus across the many stakeholders in this important issue.

3. <u>Additional Data and Analysis is Required to Support OMB Review of this Significant Regulatory Action</u>

As the EPA points out in the ANPR, this is a "significant regulatory action" subject to review by the Office of Management and Budget ("OMB"). 75 Fed. Reg. 22468; Executive Order 12866, 58 Fed. Reg. 51735, Oct. 4, 1993. During this review process, OMB requires an assessment and quantification of the benefits and costs of any EPA determination and of "reasonably feasible alternatives." *Id.* In order to justify any determination related to avgas emissions, the EPA must demonstrate that it has quantified the benefits and costs related to such determination. As discussed above, the EPA currently lacks adequate data to make a full assessment of the costs and potential benefits of any determination. In addition, the EPA has not yet addressed any "reasonably feasible alternatives," such as reducing lead emissions from other sources or further strengthening the generally applicable NAAQS. Accordingly, additional data and analysis will aid the EPA in the OMB review process by helping to demonstrate the costs and benefits of any determination and why that determination is preferable to all other "reasonably feasible alternatives."

D. Future Considerations Regarding Aircraft Engine Emissions Standards

The ANPR describes considerations regarding emission engine standards and requests comment on approaches for transitioning the piston-engine fleet to unleaded avgas. As the EPA recognized in the ANPR, "[c]onverting in-use aircraft/engines to operate on unleaded aviation gasoline would be a significant logistical challenge, and in some cases a technical challenge as well." 75 Fed. Reg. 22468. In recognition of this challenge and in response to the EPA's request, Appendices D and E provide additional information and recommendations regarding possible future rulemaking by the EPA and the FAA to establish new standards to reduce or eliminate lead emissions from general aviation aircraft, and to transition the in-use fleet to an unleaded avgas.

IV. CONCLUSION

For the general aviation community, any regulation of aircraft emissions is a safety of flight issue. Small changes to aviation fuel can have life and death consequences for pilots, passengers, and those living underneath flight paths. The EPA has recognized that safety is paramount when addressing aircraft emissions, observing that "there is an added emphasis [in § 231] on the consideration of safety. Therefore, it is reasonable for EPA to give greater weight to considerations of safety in this context than it might in balancing emissions reduction, cost, and energy factors under other [CAA] provisions."[17] The prominence of safety reinforces the need to proceed carefully, and to make a determination only when such action is well supported by data and careful analysis.

The current data set is seriously limited and shows no exceedance of the highly protective lead NAAQS due to aircraft emissions. Additional data that will become available over the next few years will help to provide the EPA with a better understanding of lead emissions from avgas. And the general aviation industry is already engaged in research efforts on lower-lead alternatives to the current 100LL standard. Before making any determination related to lead emissions from piston-engine aircraft, the EPA should collect this new information, design a more comprehensive study, and evaluate avgas emissions using a more comprehensive data set. The EPA should also continue to engage with stakeholders and seek the expertise of the SAB and the FAA. And, by establishing a formal Advisory Committee and engaging in Negotiated Rulemaking, the EPA can facilitate stakeholder involvement and build consensus throughout the rulemaking process. A decision to continue research into this important issue before making any determination is consistent with the Clean Air Act, responsive to the Friends of the Earth Petition, and will help to ensure that the EPA's ultimate decision appropriately protects pilots and the public.

[17] 70 Fed.Reg. at 69,676 (promulgating new NOx emissions standards for aircraft). The EPA's emphasis on safety was upheld by D.C. Circuit in *National Association of Clean Air Agencies v. EPA*, 489 F.3d 1221 (2007).

Respectfully submitted,

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APPENDIX A

About The General Aviation Avgas Coalition

The Aircraft Owners and Pilots Association (AOPA)

The Aircraft Owners and Pilots Association is a not-for-profit individual membership organization of more than 415,000 pilots and aircraft owners. AOPA's mission is to effectively serve the interests and needs of its members as aircraft owners and pilots and establish, maintain, and articulate positions of leadership to promote the economy, safety, utility, and popularity of flight in general aviation aircraft. Representing two thirds of all pilots in the United States, AOPA is the largest civil aviation organization in the world.

The Experimental Aircraft Association (EAA)

The Experimental Aircraft Association is a non-profit individual membership organization of 170,000 pilots and aircraft owners with a wide range of aviation interests and backgrounds. EAA's mission is dedicated to providing aviation access to all who wish to participate. As part of that, EAA is committed to protecting the right to fly and own recreational aircraft, promoting opportunities to experience and enjoy aviation, preserving aviation history and heritage, and preparing for tomorrow and future generations of aviators. EAA has chartered approximately 1,000 Chapters which promote local aviation activities in their communities and regions.

The General Aviation Manufacturers Association (GAMA)

The General Aviation Manufacturers Association represents over 65 of the world's leading manufacturers of fixed-wing general aviation airplanes, engines, avionics, and components. In addition to building nearly all of the general aviation airplanes flying today, GAMA member companies also operate aircraft fleets, airport fixed-based operations, pilot training, and maintenance facilities worldwide.

The National Air Transportation Association (NATA)

The National Air Transportation Association, the voice of aviation business, is the public policy group representing the interests of aviation businesses before Congress, federal agencies and state governments. NATA's 2,000 member companies own, operate and service aircraft. These companies provide for the needs of the traveling public by offering services and products to aircraft operators and others such as fuel sales, aircraft maintenance, parts sales, storage, rental, airline servicing, flight training, Part 135 on-demand air charter, fractional aircraft program management and scheduled commuter operations in smaller aircraft. NATA members are a vital link in the aviation industry providing services to the general public, airlines, general aviation and the military.

The National Business Aviation Association (NBAA)

Founded in 1947 and based in Washington, DC, the National Business Aviation Association is the leading organization for companies that rely on general aviation aircraft to help make their businesses more efficient, productive and successful. The Association represents more than 8,000 Member Companies of all sizes and located across the country.

The American Petroleum Institute (API)

The American Petroleum Institute is the only national trade association that represents all aspects of America's oil and natural gas industry. Our more than 400 corporate members, from the largest major oil company to the smallest of independents, come from all segments of the industry. They are producers, refiners, suppliers, retailers, pipeline operators and marine transporters, as well as service and supply companies that support all segments of the industry.

The National Petrochemical and Refiners Association (NPRA)

The National Petrochemical & Refiners Association is a national trade association based in Washington, D.C. representing more than 450 members, including virtually all U.S. refiners and petrochemical manufacturers. Our members supply consumers with a wide variety of products used daily in their homes and businesses. These products include gasoline, diesel fuel, home heating oil, jet fuel, lubricants, and the chemicals that serve as "building blocks" for everything from plastics to clothing to medicine to computers and many other products essential to maintaining and improving the nation's quality of life.

APPENDIX B

SAFETY AND OTHER CONSIDERATIONS RELATED TO AVGAS REFORMULATION AND REPLACEMENT OF 100LL

Avgas formulation and performance properties have a significant impact upon aviation engine performance and must be suitable for aircraft use under a wide variety of operating conditions. Aircraft/engines are designed and tested for operation using a specific avgas specification/grade and type certificated by the FAA as meeting all applicable minimum airworthiness safety standards. There are many safety and other considerations that must be made related to an unleaded avgas replacement for 100LL, particularly if there is any reformulation affecting the composition and properties of avgas to which the entire in-use fleet of aircraft/engines have been certificated by the FAA. This Appendix provides a summary of the safety considerations related to avgas reformulation and FAA certification of aircraft/engines as well as other considerations related to an unleaded avgas replacement for 100LL.

A. Safety Considerations Related to Avgas Reformulation

ASTM D910, *Standard Specification for Aviation Gasolines* defines the composition and properties of the following specific types of aviation gasoline for civil use: Grade 80; Grade 91; Grade 100; and Grade 100LL (although 100LL is predominantly the only avgas available at airports today). The following issues are a few of the many additional challenges faced when developing a new avgas standard. Each parameter represents a critical safety of flight characteristic that must be considered in the operation of general aviation aircraft.

1. <u>Octane</u>

Octane is a measure of the anti-detonation (also known as anti-knocking) properties of gasoline which is its resistance to sudden and instantaneous ignition from compression (also known as detonation or "knocking") during a reciprocating engine's combustion cycle. Sustained detonation can cause catastrophic engine failure. A high-performance engine has a higher compression ratio and requires higher-octane fuel. The advantage of a high performance aircraft engine is that it provides higher horsepower ratings for a given engine weight.

Most research on a potential replacement for leaded avgas to-date has focused on attaining the 100 motor octane requirement for the fleet of existing general aviation aircraft because it determines the ability for the existing engines to safely use the fuel. A fuel's octane rating has a direct correlation to a given engine's ability to produce its maximum rated power, which in turn affects a number of aircraft safety factors including take-off distance, climb rate, hot weather performance, and load carrying capability. Any reduction in power brought about by a change in the octane rating or energy density of a new fuel requires re-certification of the aircraft and engine by the FAA; a tremendously expensive and labor intensive activity for which neither government nor industry has the capability or resources to complete.

But while octane is a critical consideration, it is only one of many fuel characteristics that affect the development of a safe and viable replacement for 100LL avgas.

2. Distillation Curve

One of the most important and informative properties for engines operating on complex fluid mixtures is the distillation (or boiling) curve of the fuel. Simply stated, the distillation curve is a graphical depiction of the boiling temperature of a fluid mixture plotted against the volume fraction distilled. Distillation curves are used commonly in the design, operation and specification of liquid fuels such as gasoline, diesel fuel, rocket propellant, and gas turbine fuel to ensure proper vaporization of the fuel and good air/fuel mixing prior to combustion. Measurement of the initial temperatures and the examination of the distillation curves can serve as methods to evaluate the operational parameters of fuels, such as cold/hot/altitude start capabilities, fuel system icing, dynamics of acceleration, vapor pressure/susceptibility to vapor lock and carburetor icing.

3. Vapor Pressure

Vapor pressure is a measure of a fuel's volatility, or how readily the fuel will vaporize. Vapor lock occurs when the liquid fuel changes state from liquid to gas while still in the fuel delivery system. This disrupts the operation of the fuel pump, causing loss of feed pressure to the carburetor or fuel injection system, resulting in transient loss of power or complete engine stalling. Restarting the engine from this state may be difficult or impossible. The fuel can vaporize due to being heated by the engine, by the local climate or due to a lower boiling point at high altitude. The higher the volatility of the fuel, the more likely it is that vapor lock will occur. Avgas has a lower and constant vapor pressure compared to automotive gasoline, which keeps avgas in the liquid state at high-altitude, preventing vapor lock.

4. Water Separation and Freeze Point

Water solubility in hydrocarbon fuels is a function of their composition and temperature. For a given composition lower temperatures reduce the solubility of water in the fuel. Current avgas dissolves only a very small amount of water at ambient temperatures. Therefore there is relatively little water to separate and freeze as the fuel cools at altitude. Additionally there are additives that can be used with avgas which partition any water that does separate from the fuel and lower the freezing point of the water.

Freeze point and water shedding are characteristics of a fuel that depend largely on the composition of the fuel. Solids that form from water or fuel freezing can impede flow of fuel through filters and screens, starving the engine and reducing its power or in extreme cases stalling an engine.

Because avgas is a mixture rather than a pure substance, there is not a temperature at which the entire fuel turns from a liquid to a solid. Freeze point for an aviation fuel is the temperature at which crystals begin to form, actually at which the last crystal melts as the fuel is warmed, to avoid super cooling phenomena. Freeze point for avgas should be below the temperature where an aircraft will operate long enough for fuel flow to be impacted by crystal formation from the dry fuel.

Water separation is a particularly important trait in aviation gasolines because the fuel systems are vented to the atmosphere and significant changes in altitude and temperature promotes condensation of water in the fuel tanks which must settle out of suspension readily so that it can be drained prior to flight to prevent loss of power due to water and/or ice contamination..

5. Energy Density / Weight

Energy is the ability to do work. Per kilogram of mass or volume, different substances release different amounts of energy when combusted. In other words they have different energy contents. Energy density can be defined by the amount of energy per gallon or per pound of fuel. The higher the energy density, the more energy may be stored or transported for the same amount of volume or weight. Because aircraft have fixed volume fuel tanks and are limited in total weight for takeoff, both volumetric and gravimetric energy density are important parameters of a new fuel. A lower energy density fuel directly translates to either reduced range, reduced power, or a combination of the two. Increased fuel weight equates to reduced load carrying capability, decreased rate of climb at a given loading or reduced range of the aircraft.

6. Stability

Stability of a fuel can be defined as the resistance or the degree of resistance to chemical change or degradation. When gasoline is not stored correctly over a period of time, gums and varnishes may build up and precipitate from the gasoline. Gums and sediment may build up in the fuel tank, lines, and carburetor or fuel injection components making it harder to start the engine and cause rough operation of the engine. This could be a problem for aircraft as some are typically parked without use for long periods of time. Additionally, because aviation gasoline is not produced and sold in large quantities, fuel is often stored for extremely long periods of time before being delivered to the aircraft for use.

7. Corrosiveness

A fuel's corrosiveness directly relates to the material compatibility issues that such a fuel would have on metal fuel system components including aircraft fuel tanks, fuel lines, and internal engine components.

8. Conductivity

The conductivity of a fuel is a measure of the ability of a fuel to dissipate static electric charge. Conductivity is important because in a low conductivity fuel electrical charges can accumulate and ultimately lead to dissipation in the form of a spark. This in turn is a fire safety hazard. Aircraft naturally build up static charges by virtue of the friction involved in their passage through the atmosphere and the fuel needs to be able to equalize the electrical charges between aircraft components so as to prevent sparking.

9. Toxicity

All hydrocarbon fuels are toxic to one degree or another but aviation gasoline and any future unleaded fuel cannot exhibit any unusual or significantly increased toxicity traits that could affect persons handling the fuel, maintaining the aircraft, or impair flight crews in flight through inhalation of harmful vapors.

10. Composition

Specifications define the composition of aviation gasoline to limit maximum content of certain chemicals in order maintain desired properties and ensure it is suitable for civil aircraft use under a wide variety of operating conditions. For example, D910 limits the total aromatic content which relates to material compatibility issues of certain aircraft fuel system components made from natural rubbers and some polymeric substances

B. Safety Considerations Related to Aircraft/Engine and FAA Certification

As discussed previously a variety of physical and performance properties necessary for an aviation gasoline such as octane, vapor pressure, distillation curve and water separation must be considered. However, fuel properties are just the beginning of all the considerations necessary to ensure the safe operation of general aviation aircraft. General aviation engines and aircraft are specifically designed, built and tested for operation using a specific avgas specification which is certified by the FAA as meeting all applicable minimum airworthiness safety standards in 14 C.F.R. Federal Aviation Regulations ("FAR").

FAR part 33 prescribes airworthiness standards for aircraft engines including the establishment of engine ratings and operating limitations relating to horsepower, temperatures, pressures, component life and fuel grade or specification. The engine design and construction must minimize the development of an unsafe condition of the engine between overhaul periods which must be demonstrated through rigorous block tests. This includes operation throughout the full envelope of extreme conditions the engine is expected to encounter in service and demonstration of the engines ability to start in extreme cold/hot temperatures and altitudes. Fuel properties such as vapor pressure, freeze point and distillation curve directly affect these engine performance envelopes. The most important performance range for an engine is horsepower and the safety critical limiting factor is detonation. The octane level of avgas is a measure of protection against the onset of detonation so the higher the octane the higher the horsepower that is possible from a particular engine and vice-versa. FAR section 33.47 requires a test program to ensure that an aircraft engine can operate without destructive detonation throughout its full range of operation. In addition, each engine is subject to a prescriptive endurance test and inspection to ensure reliability and continued airworthiness necessary for safety. FAA issuance of an engine Type Certificate which identifies a fuel grade or specification as a limitation constitutes approval of the fuel for that particular make and model of engine.

FAR parts 23 and 27 prescribes minimum airworthiness standards for normal category airplanes and normal category rotorcraft, respectively (which are the aircraft typically powered by piston-engines). This includes demonstration of minimum aircraft performance requirements such as takeoff runway length, climb, speeds and distance over a range of conditions such as maximum weight/payload, maximum outdoor temperatures and airport altitudes up to 10,000 feet. The critical performance envelopes and operational safety limitations for an aircraft established by these tests are directly dependent upon the installed engine and particularly the rated horsepower it provides. The FAA Type Certificate for an airplane or rotorcraft specifies the approved engine installation and identifies the fuel grade or specification as a limitation which constitutes approval of the fuel for that particular make and model of aircraft.

In addition, FAR parts 33, 23 and 27 require materials compatibility testing to substantiate that the fuel is compatible with all engine and aircraft materials to ensure that there are no safety and airworthiness impacts upon components and parts such as pistons, valves, turbochargers, carburetors, pumps, hoses, gaskets, seals, fuel tanks, structure, sealants etc.

Each new make and model of engine and aircraft introduced into the fleet was specifically designed, tested and FAA certificated with 100LL (or equivalent ASTM D910 leaded avgas). Aviation fuel has a direct and significant impact upon both the engine and aircraft performance and compliance with the applicable FAA safety standards. Therefore, the range of safety considerations for a viable unleaded fuel to replace 100LL is a much greater challenge due to the broad range of in-use engines and aircraft that have already been certified. An alternative fuel that has any difference in physical, chemical or performance properties from 100LL raises potentially significant safety implications that will have to be carefully evaluated with respect to both the engine and aircraft. The FAA Advisory Circular AC 20-24 describes the procedures for approving the qualification of new fuels for in-use certificated aircraft engines. It essentially requires re-certification through the same engine tests and inspections discussed above for those airworthiness and performance requirements affected by fuel properties that are different from the existing 100LL.

C. Other Considerations Related to an Unleaded Avgas Replacement

Although safety is paramount, there are many other considerations for a viable unleaded avgas replacement for 100LL. We must ensure that an unleaded avgas is more environmentally acceptable than the fuel it is intended to replace and does not introduce any new environmental concerns today or in the foreseeable future. As discussed in Appendix C, some of the most promising early research for unleaded avgas centered on the use of ethers such as ETBE, MTBE and TAME as octane enhancers to replace lead. These chemicals were being widely used at the time in automotive gasoline but have been all but banned from use in the U.S. due to concerns about ground water contamination and other reported health issues. Aircraft emissions must also be environmentally acceptable so due consideration needs to be made regarding CO_2, NOx, VOCs, carcinogens, and any other potential areas of interest. In addition, consideration of potential human health impact of unleaded avgas will need to be made regarding matters such as handling, storage, venting, toxicity and water solubility.

Another key consideration for a viable unleaded avgas replacement for 100LL is the economic impact. This includes both the upfront costs to transition to an unleaded avgas as well as the long term cost impact of operating on a new fuel. The EPA recognizes in the ANPR that converting in-use aircraft/engines to operate on unleaded aviation gasoline would be a significant logistical challenge, and in some cases, a technical challenge as well. As discussed previously, a change to the approved avgas or modifications to engines and aircraft require FAA certification to ensure compliance with applicable airworthiness safety standards necessary for safety. The FAA certification process is comprehensive and requires significant investment of resources, expertise and time to complete. The cost and resource impact upon both industry and government can be extremely significant depending upon the level of effort and number of modifications that may be necessary to support a transition of the in-use fleet to an unleaded avgas. However, the closer the physical and performance properties of an unleaded avgas to 100LL, the less upfront economic impact there would be, particularly with respect to octane rating since it is a critical fuel property for aircraft engines to maintain rated horsepower which is critical for high performance aircraft to maintain their operational safety limitations. Another potentially significant upfront cost for an unleaded avgas is the impact upon the fuel production and distribution infrastructure and level of modifications/investment that may be necessary. Long-term economic impacts that should be considered are the cost of unleaded avgas per gallon and any potential impact on aircraft/engine operating and maintenance costs. These are ongoing costs incurred by entire in-use fleet for the foreseeable future.

An unleaded avgas that works in aircraft is not a viable replacement for 100LL if it poses environmental and health concerns; would not be produced and made available where and when needed; or imposes significant economic impact that threatens the long-term viability or sustainability of general aviation in the U.S. Due to the relatively small size of the avgas market and the need for a dedicated distribution system for safety controls, the Coalition believes there can only be one avgas and that any future unleaded replacement must accommodate the entire fleet. Additional information on the challenges presented by a dual-fuel approach are discussed in Appendix E.

APPENDIX C

HISTORIC AND CURRENT EFFORTS TO REDUCE LEAD IN AVGAS

A. Development of The Current 100LL Standard

Lead in aviation gasoline has been an environmental concern since the passage of the CAA in 1970. As a result, industry voluntarily began an initiative to reduce the amount of lead in avgas during the 1970's. After extensive research, it was determined that the fuel specification could be altered to reduce the maximum amount of TEL from 4.24 grams of tetra-ethyl lead per gallon to 2.12 grams without significantly affecting the safety of the current fleet of aircraft. This effort reduced the lead content of avgas by half and resulted in the 100LL standard in use today.

The safety of aviation products is strongly influenced by the design margins established for that product. FAA regulations require that aviation products are certified to standards which ensure the required levels of flight safety. For example, the majority of the reciprocating engine models which power the current general aviation fleet were certified to FAA standards which required that the lean limit fuel flow be 12 percent greater than the leanest fuel flow resulting in detonation. All engineering parameters of an aircraft have safety margins built in so, although the overall safety of the fleet was not affected by the reduction in lead content, the lead reduction did diminish the anti-detonation margin of safety in piston powered aircraft.

The reduction of lead also set off a series of safety and durability problems due to the reduction in lubricating qualities that lead provides in engines. In the years following the switch to 100LL, several aircraft have experienced materials compatibility issues such as fuel leakages due to deterioration of seals in the fuel system. Additionally many aircraft experienced valve seat issues due to the reduction of lubrication delivered by the lead. Valve seats often end up being cracked or worn due to thermal stress, thermal shock or mechanical stress. Lead in avgas adds protection against such stresses.

B. Research into Unleaded Avgas Alternatives

Twenty years ago, Congress enacted the 1990 CAA amendments. This action—combined with a series of market forces involving the production, handling, and storage of leaded fuels—produced significant concern about the future availability of high-octane aviation gasoline. The most serious issue at the time was the perceived requirement to develop a suitable unleaded replacement for leaded 100LL aviation gasoline that would satisfy the needs of the existing fleet of piston powered aircraft. This effort would involve laboratory research, materials compatibility testing, test cell and flight testing, standards writing, and possible recertification of some or all of the existing fleet of piston powered aircraft. No wholesale technological change of this magnitude had ever been attempted in civil aviation history. In addition, there was significant question at the time whether the petroleum and aviation industries had the necessary resources or financial incentive to invest in this undertaking, particularly the recertification of an aging existing fleet of general aviation aircraft. Still, the general aviation industry reached a consensus in the early 1990's that research should be conducted, employing all possible resources, to find a drop-in unleaded alternative to 100LL.

1. The ASTM International Process

ASTM International, originally known as the American Society for Testing and Materials ("ASTM"), was formed over a century ago and is one of the largest voluntary standards development organizations in the world and a trusted source for technical standards for materials, products, systems, and services. Known for their high technical quality and market relevancy, ASTM International standards have an important role in the information infrastructure that guides design, manufacturing and trade in the global economy. The ASTM committee that oversees the standards for aviation fuels is a consensus-driven member committee made up of stakeholders that have a material interest in aviation fuel such as oil companies, additive producers, original equipment manufacturers ("OEM"), STC providers, and any other concerned participants. The initial work to identify an unleaded aviation fuel began through the ASTM, where the standards for aviation fuels are developed and maintained, in early 1990s.

After a great deal of work there it became evident that the ASTM process, while ideal for the development and maintenance of standards, was not intended or suited for coordinating wholesale research programs. With this in mind, the aviation and petroleum industries submitted a request to the CRC to take on the program of developing an unleaded high-octane aviation gasoline to replace 100LL. In the meantime, work continued at ASTM on specific technical questions concerning the criticality of certain fuel specification limits and qualities. The two programs were populated by many of the same professionals from the aviation and petroleum industries and were closely coordinated to support one another.

2. The Coordinating Research Council process

The CRC is a non-profit organization that directs, through committee action, engineering and environmental studies on the interaction between automotive/other mobility equipment and petroleum products. The formal objective of CRC is to encourage and promote the arts and sciences by directing scientific cooperative research to develop the best possible combinations of fuels, lubricants, and the equipment in which they are used, and to afford a means of cooperation with the government on matters of national or international interest within this field.

A panel was formed under the sponsorship of the CRC with the objective of developing a method to consistently rate aircraft engine octane requirement under harsh repeatable conditions and to determine the general aviation fleet octane requirements. In order to accomplish this objective, the Octane Rating Group had to develop two ASTM standard practices, or methods, to consistently rate aircraft engine octane requirements under harsh, repeatable conditions representative of the operational environment. These methods were used to determine the unleaded fuel octane requirement of the general aviation fleet.

Considering the research and testing required to identify a drop-in fuel, the Unleaded Aviation Gasoline Development Panel was organized under the sponsorship of the CRC and was formed with the objective of conducting research and testing that would facilitate development of the next generation aviation gasoline – a high octane unleaded aviation gasoline as an environmentally compatible, cost effective replacement for the current ASTM D910 100LL fuel. This panel acted as a steering committee, providing oversight and direction for research and testing and supported an interactive, collaborative process with the goal of the development of an aviation gasoline that would meet the requirements of both the existing and future general aviation fleet. Safety, reliable operation, and environmental awareness were the driving principles. Membership of the CRC Unleaded AVGAS Development Panel currently consists of over 60 individuals representing over 40 different organizations and includes representatives from the airframe manufacturers, engine manufacturers, fuel producers, FAA, AOPA, EAA, GAMA, and other interested parties.

Recognizing the large size of the CRC Unleaded AVGAS Development Group and its diverse membership, methods were evolved to facilitate progress. Formation of small Task Groups working as a subset of the CRC Development Group, use of a single lab for blending and analysis, and allocation of the FAA Technical Center engine test facility as the primary test resource were significant factors in achieving this goal. Parallel test programs at the FAA Technical Center and at Cessna Aircraft using different engines to test 30 unleaded blends further enhanced the research process and methods. These factors contributed to facilitating progress of the collaborative effort wherein Task Group members provided base fuels, blend components, and technical guidance with actual engine testing performed by the FAA Technical Center.

3. Challenges Discovered During the Coordinating Research Council Process

From a technical standpoint, the process of identifying an unleaded avgas proved to be far more daunting than any imagined in 1990. To date no unleaded formulation has been found that can meet the octane needs of the existing fleet of high-performance aircraft engines while also maintaining the other necessary safety qualities of an aviation gasoline such as vapor pressure, hot and cold starting capabilities, material compatibility, water separation, corrosiveness, storage stability, freeze point, toxicity and a host of other necessary traits.

Some of the most promising early research centered on the use of ethers such as ETBE, MTBE and TAME as octane enhancers. These chemicals were being widely used at the time in automotive gasoline as oxygenates for environmental reasons. While there was some promising work in this area in raising octane, the goal of 100 motor octane was never reached and efforts in this area have proved largely fruitless because ethers have been all but banned from use in the United States due to concerns raised over ground water contamination and other reported health issues. Other areas of research have focused on the development of super-alkylates as the base stock for aviation gasoline and the use of amines and metal compounds other than lead as possible additives. So far, none has provided a satisfactory solution.

As literally hundreds of unleaded fuel blends were proposed and tested some fundamental questions began to emerge about the qualities of leaded versus unleaded fuels such as whether an unleaded gasoline of a given octane rating would perform in an aircraft engine in an equivalent manner to a leaded gasoline of the same octane rating. While it would seem that the experience of the transition from leaded to unleaded automotive gasoline would have covered this ground, fundamental question such as this had never been answered or the results quantified. In the end the answer was a definitive and surprising no. Leaded and unleaded fuels of the same octane rating do not provide the same level of anti-knock and detonation protection. This is but one example among many of the complex work that has been necessary to provide a technical understanding of the problem and a foundation on which a solution can be based. These are not academic exercises for the sake of knowledge but rather critical data in support of flight safety.

Other areas of research have been focused on the fleet of aircraft engines themselves. Historically, all of the piston aircraft engines in the world have been developed, tested and certificated to work on a fuel of known qualities and octane rating. Once shown to work with a margin of safety using the fuel available and largely unchanged since the 1940's the certification process was complete from a fuel standpoint. No one has ever made any attempt to determine the actual octane needs of the piston engine fleet and such a determination was unnecessary as long as the engines worked on the 100 octane fuel that has been available. For the first time, significant laboratory controlled testing of aircraft engines was required to determine the actual octane needs of the piston engine fleet in order to answer the question of how low octane could be dropped before the safety margin against destructive detonation would be compromised or eliminated entirely. As one would expect the answers varied with each make and model of engine, but in many instances every bit of the anti-detonation characteristics of the 100LL was required in order to safely operate the engine. This lead to the conclusion that for a percentage of the fleet, any reduction in octane would have a serious impact on the safety and utility of the aircraft.

4. Coordinating Research Council Research Results

In June 2010, the CRC submitted their final report on the research results on "Unleaded, High-Octane Aviation Gasoline." In excess of 279 experimental unleaded high octane blends were formulated and tested by the CRC UL AVGAS Development Group. After all of the research and testing the UL Development Panel did not identify a transparent replacement for the 100LL AVGAS product however there were significant "lessons learned." Among those lessons learned were:

- Although full scale engine tests indicated some blends were capable of providing knock free operation in the test engine, these blends represented the use of specialty chemicals which may require further evaluation with respect to environmental impact.

- Although some experimental blends of specialized components were shown to exceed the 100LL specification of 99.6 MON minimum, such formulations are very different as compared to the current ASTM D 910 product and potentially compromise other important fuel properties and specifications.

- Leaded and unleaded Avgas of the same octane number do not perform the same in engines - Leaded avgas offers greater octane satisfaction in full size engines when compared to unleaded products of similar laboratory MON.

- Test results indicated a minimum unleaded octane requirement greater than 100 MON is needed for naturally aspirated engines and higher for turbocharged engines depending upon engine power output and configuration.

C. Ongoing and Future Efforts to Reduce Lead in Avgas

The CRC is continuing efforts to develop an unleaded alternative to 100LL and has established a new research initiative to evaluate the current D910 specification to determine what properties, other than octane, can be expanded without compromising safety. The avgas specification defines several physical and performance properties, all important to aircraft/engine safety and performance, which is why unleaded avgas research conducted to date focused on the development of a drop-in replacement for 100LL that matched all the properties. However, a drop-in replacement has not been identified so determining the ability to expand avgas properties other than octane provides greater opportunities for the development of a high-octane unleaded avgas. The CRC has begun research to determine the critical safety values of all of the performance specification parameters to identify areas of flexibility.

The CRC has also established a new task group to evaluate reducing the amount of lead in avgas while maintaining all other properties to determine whether a near-term reduction in lead emissions from general aviation is possible. The data analysis and drafting of the reports are currently being finalized, but initial findings indicate the acceptability of a 20 percent reduction in lead content. If the findings in the final report are consistent, it will be used as the basis for a ballot proposing a change to the D910 specification to reduce maximum TEL content for 100LL by 20 percent for consideration at the ASTM December 8, 2010 meeting.

The FAA is also continuing its efforts to reduce or eliminate lead emissions from general aviation. In collaboration with the general aviation community, the FAA has committed to test, adopt, and certify a new aviation gasoline fuel standard as set forth in the 2009-2013 Flight Plan. To further this effort, the President's FY 2011 budget submission not only reinstates, but proposes to significantly increase funding for unleaded avgas research efforts and the AFETF.

The FAA RE&D budget includes a new research program item A11.m for "NextGen – Alternative Fuels for General Aviation" with $2 million annually for five years. Activities include assessment of very-low-lead avgas and potential high-octane unleaded fuels along with development of the test and evaluation methods necessary to support certification approvals for the existing fleet to transition to a future unleaded avgas. The FAA states that the primary goal of this research is the elimination of lead emissions from piston powered aircraft. Various alternatives to achieve this goal will be explored, including:

- Investigation of unleaded replacement alternatives to current leaded avgas (100LL) used in piston engines. To the greatest extent possible the replacement alternative(s) should be equivalent in performance to 100LL and be a seamless, transparent change to a general aviation pilot.
- Technologies for modification of piston engines to enable their safe operation using unleaded fuel.
- Qualification and certification methodologies for alternative fuel safety performance.
- Investigation of fleet lead emissions which will support evaluation of various approaches to for achieving emissions reductions.

Congress has also recognized the importance and supported moving forward with unleaded avgas initiatives. The House Transportation/Housing and Urban Development Appropriations Bill, FY 2011 fully funds the FAA's new initiative to research and test new unleaded fuels and piston engine modifications to seek a safe alternative to the currently utilized leaded avgas. The Committee report accompanying the Bill states that:

> "The Committee recognizes the need for FAA to implement a program to develop aircraft engine emissions and airworthiness regulatory standards and policies to remove lead from the fuel used in piston engine aircraft. This program should be coordinated with current industry initiatives established to transition the piston engine aircraft fleet to reduced lead or unleaded fuel. The FAA should collaborate in this effort with industry groups representing aviation consumers, manufacturers, fuel producers and distributors, EPA and other relevant agencies as appropriate. FAA should also take proper account of aviation safety, environmental improvements, technical feasibility and economic impact on the current and future general aviation fleet. The Committee recognizes that this program will have a resource impact on the FAA and expects FAA to detail in future budgets the resources necessary to implement this program including certification."

APPENDIX D

FUTURE CONSIDERATIONS REGARDING AIRCRAFT ENGINE EMISSIONS STANDARDS

In addition to describing and inviting comment on the current data to support the EPA's endangerment and cause or contribute finding, the ANPR also describes considerations regarding emission engine standards and requests comment on approaches for transitioning the piston-engine fleet to unleaded avgas. This Appendix provides additional information and recommendations from the Coalition regarding possible future rulemaking by the EPA and the FAA.

The aviation and petroleum industries have been working together to tackle the technological barrier of producing an unleaded aviation gasoline that mirrors the performance and property characteristics of 100LL. Thus far, no "drop in" unleaded solution has been identified to replace 100LL. The EPA recognizes this in the ANPR when stating that transitioning in-use aircraft/engines to operate on unleaded aviation gasoline would be a significant logistical and technical challenge and would likely require FAA safety certification. It is clear that compromises will have to be made and the challenge is to identify where those compromises can be made with the least impact on safety, cost, availability and aircraft performance.

A. Assessment of Reduced Lead Avgas for Near-Term Reductions in Lead Emissions

A technical and regulatory process to develop and implement a transition to an unleaded avgas that adequately considers aviation safety, technical feasibility and economic impact will require several years. Therefore, the aviation and petroleum industries have been assessing the feasibility of replacing 100LL with a "very-low-lead" formulation in order to provide near-term reductions in lead emissions inventory from general aviation which could be implemented in time to support National Ambient Air Quality Standards for Lead compliance activities. The CRC has established a new task group to evaluate reducing the amount of lead in avgas while maintaining all other properties necessary for a "drop in" replacement to determine whether a near-term reduction in lead emissions from general aviation is possible. The data analysis and drafting of the reports are currently being finalized, but initial findings indicate the potential of a 20% reduction in lead content. If the findings in the final report are consistent, it will be used as the basis for a ballot proposing a change to the D910 specification to provide for a 100 octane very low lead avgas with a 20 percent reduction in the maximum TEL content from today's 100LL. This ballot is expected to be considered at the ASTM December 8, 2010 meeting.

B. Program to Facilitate Unleaded Avgas Replacement for 100LL

The Coalition is working with the FAA to develop and implement a comprehensive program to facilitate the qualification of an unleaded avgas replacement for 100LL and safe transition of the in-use fleet. We believe that FAA's role is critical in this effort given that the FAA has the statutory authority and sole responsibility for implementing standards for aircraft including the approval of an unleaded avgas and safety certification of engines and aircraft that use it. This program should be coordinated with current industry initiatives and collaborate with industry groups representing aviation consumers, manufacturers, fuel producers and distributors, the EPA and other relevant agencies as appropriate. This program should work first and foremost to ensure aviation safety and to take proper account of technical feasibility, environmental improvements, economic impact on the current and future general aviation fleet, as well as fuel production and distribution, to ensure the sustainability and growth of general aviation.

C. Consideration of Approaches for Transitioning the Fleet to Unleaded Avgas

A clearly defined transition plan from 100LL to a replacement unleaded avgas is necessary to provide a common timeline to all stakeholders including manufacturers, operators, FAA, EPA, NGOs, etc. A transition plan with appropriate timeframes will also foster the appropriate level of investment and R&D necessary to ensure the continued safety and viability of general aviation. However, a viable unleaded avgas replacement for 100LL must first be identified in order to consider the following elements of a transition plan: availability of FAA approval and certification policy and resources to enable the transition, new production engine and aircraft cut-in to be able to operate on unleaded avgas, the development and availability of modifications to transition existing aircraft, and unleaded avgas production and distribution. Another important consideration that will have a significant impact upon the transition and measures necessary to ensure safety is the ability for 100LL and the unleaded avgas to comingle in both the distribution infrastructure and in aircraft operation. Transitioning newly-manufactured and in-use aircraft to be able to operate on unleaded avgas by some future date will require that they be able to operate on both 100LL and unleaded avgas, or a blend thereof, until the avgas available at airports across the country also transitions.

However, the overall approach for transitioning the fleet to an unleaded avgas depends upon whether the existing 100LL leaded fuel could be phased down over time as an unleaded avgas is introduced (dual-fuel transition used for automotive gasoline) or if the transition from a 100LL to an unleaded avgas would need to happen all at once. The EPA recognizes the significant challenges for supply, distribution and storage of avgas since annual demand is very small in comparison to motor gasoline yet its use is as geographically widespread. Appendix E provides detailed information regarding the challenges of a dual-fuel approach. The stark differences between aviation gasoline (avgas) and automotive gasoline usage and distribution make a dual-fuel transition approach impossible.

APPENDIX E

CHALLENGES OF A DUAL FUEL TRANSITION APPROACH

On January 10, 1973, the EPA required that unleaded fuel for automotive uses be made available by mid-year 1974. This requirement began a process that ended in 1996 when the EPA finalized rules for a complete ban on the use of lead in automotive fuels. The 1973 requirement created a dual availability of leaded and unleaded automotive fuel, a strategy that has been suggested as a solution to reduce the amount of lead used in general aviation. Stark differences between aviation gasoline and automotive gasoline usage and distribution, however, make this strategy impossible.

While the introduction of additional grades of fuel was a sound strategy for the reduction of lead use in the automotive industry, there are serious challenges to and concerns with the application of that strategy to aviation. Increased costs, lowered availability and decreased safety combine to make a dual fuel solution, or transitional solution, to the issue of lead use in aviation unworkable.

The challenges facing the production, transportation and distribution of aviation gasoline in a dual fuel environment was summarized in the Aviation Gasoline Survey – Summary Report released in June of this year by API:

> "A key result from the survey indicated that no company [current avgas producer] would provide both 100LL and an unleaded avgas at the same time. The survey asked what infrastructure issues might become a problem in selling a dual fuel (that is, 100LL and unleaded avgas). All of the respondents indicated problems in maintaining duplicate distribution systems during the phase in, having to add new tanks to handle two fuels and cross contamination issues."

The first point that must be noted when understanding the impossibility of a dual fuel solution for aviation is the very low volume of avgas produced, and therefore used, in comparison to overall transportation fuel. According to the U.S. Energy Information Administration, avgas production accounts for only 0.1 percent of overall transportation fuel production.

A. Production, Transportation and Distribution

In most cases, avgas is currently delivered to distribution terminals from manufacturers then shipped via over-the-road trailer to on-airport fuel service providers. Significant difficulties exist today, in a single-grade avgas environment, in finding space for avgas storage at delivery terminals. Fuel storage capacity at terminals is limited and due to the very specific quality requirements of aviation fuels, as opposed to automotive and other fuels, dedicated tankage is required, meaning terminals must make a business decision as to whether to supply avgas. Many terminals, due to the very low throughput of avgas, in comparison to other products, have chosen not to supply avgas at all. The limited number of terminals that do supply avgas are serving an ever-increasing area, leading to increasing shipping costs to the final user.

The existing challenges of avgas distribution would be exacerbated by the introduction of a second grade of avgas as the current throughput is split into two distinct products. The limited tankage available at supply terminals would become more problematic as terminals would be required to segregate leaded and unleaded avgas. Terminals would be required to evaluate their existing storage availability, apply the lowered throughput per tank, and make a determination if a business case exists to supply avgas. Some terminals would be expected to exit the supply chain while some may, due to limited storage availability, choose to supply only one of the available grades. Terminals that chose to continue to supply avgas, either one or both grades, would see reduced revenue per storage tank due to the reduced throughput per tank, leading to possible higher storage and delivery rates for downstream customers.

Over-the-road trucking companies that handle delivery of avgas from supply terminals to airport facilities would also be affected in a dual grade avgas environment. Due to the strict segregation requirements for aviation fuels, tanker trailers would need to be avgas grade dedicated or trailers would need to be steam cleaned every time a grade change occurred. The cost of additional tanker trailer dedication or ongoing steam cleaning would add even more cost to the delivery of avgas.

B. On-Airport Fuel Service Providers

In a dual grade avgas environment, on-airport fuel service providers, known as fixed base operators ("FBOs"), would experience significant negative effects in addition to the possible higher cost from supply terminals. FBOs currently have storage capabilities for one grade of avgas and would be required, due to the need to segregate different grades of aviation fuel, to construct or purchase additional infrastructure to handle additional grades. This additional infrastructure would include storage tanks, filtration systems and associated piping and fuel delivery vehicles. Many existing airport or FBO storage facilities have been designed for current needs and would not have room for additional storage tanks. These facilities would need to be completely redesigned or separate facilities for the new grade of avgas would need to be built.

In addition to infrastructure costs, FBOs would also face additional manpower costs. Unlike its automotive counterparts, aviation fuel and the equipment used to store and handle it must undergo a continuous regimen of quality control testing and inspection. Each storage tank, or fuel delivery vehicle, must undergo specific daily, monthly, quarterly and annual inspection to maintain compliance with industry standards. A single tank or fuel delivery vehicle can require up to 214 man-hours or more per year to maintain quality standards.

Faced with a dual grade avgas environment, FBOs would be forced to make a business decision as to whether to supply both grades or only one of the two possible grades. The low overall volume of avgas throughput combined with the higher per gallon manpower cost for into plane delivery (an individual avgas fuel sale tends to be a factor of 10 or more, in gallons, less than that of jet fuel) would likely lead to many FBOs choosing to supply only one of the possible grades of avgas. Further complicating the decision would be the long-term strategy relating to dual grade use. If the introduction of a second grade of avgas is envisioned to be a transition strategy, as it was in the automotive world, FBOs would be forced to amortize the cost of the additional infrastructure over a far shorter period of time than most other large scale capital investments.

While it is expected that many FBOs would choose not to carry additional grades of avgas, some would more than likely not have a choice. The airport sponsor (owner) could require, through amended minimum standards or other mechanisms, that FBOs supply both grades of avgas to ensure that the airport attracts a wide class of users. FBOs at these airports would be required to carry both grades regardless of whether it is profitable to do so.

FBOs carrying both grades of avgas would experience significant changes in inventory management as their overall avgas throughput is split between two distinct products. The delivery of avgas by tanker trailer severely limits the ability of FBOs to modify shipping amounts. FBOs choosing to receive avgas in smaller quantities would still pay the same shipping charge as a full load. The end result is either that avgas at FBOs would spend more time in storage, tying up more capital in inventory, or the FBO would accept smaller quantities of avgas, incurring increased shipping and delivery costs.

C. Safety and Operational Considerations

The introduction of multiple grades of avgas also presents significant operational and safety issues. As airports, supply terminals and FBOs make business decisions as to whether to carry both grades of fuels, the result could likely be reduced availability of certain grades of avgas at specific airports. This patchwork of fuel availability stands to impose significant burdens on aircraft operators, as those operators eliminate from use airports not carrying the correct grade of fuel.

From an FBO perspective, a leading safety concern is misfueling. Misfueling refers to the delivery of the incorrect grade of fuel, or incorrect quantity, to an aircraft. Misfueling is a serious safety concern and has led to aircraft accidents in the past. The industry has worked hard to eliminate misfueling through the use of selective spouts and aircraft filler ports to segregate avgas and jet fuel. The introduction of a second grade of avgas would reintroduce the serious dangers of misfueling. Aircraft requiring lead could be subject to serious engine damage or failure in the event that the aircraft was inadvertently fueled with unleaded avgas and/or lower octane avgas.

Appendix K
ASTM Background

ASTM Background
UAT ARC Assessment

The American Society for Testing and Materials (ASTM International) was formed in 1898 for the purpose of collecting, standardizing and disseminating technical knowledge. The main committee on Petroleum Products and Lubricants was formed in 1904 with the first commercial aviation gasoline (Avgas) specification being issued in 1942. The significance of this is that ASTM, as a consensus organization, has been involved from the first commercial Avgas product. ASTM remains open to all parties involved with Avgas, ensuring the inclusion of those interested in maintaining the myriad aspects of Avgas. Having this wide range of input ensures the development of a robust specification. This input spans from production, testing, storage and transportation to commercial and government end users throughout the world.

ASTM produces an annual book of standards that include test methods, specifications, practices, guides and special technical publications including manuals directly related or specific to Avgas.

Commercially in the US, ASTM Avgas standards are widely used to describe fuel quality for purchases under contract by purchasing agencies.

With regard to the US government, Public Law PL 104-113 directs *"all Federal agencies and departments to use technical standards that are developed by voluntary consensus standards bodies, using such technical standards to carry out policy objectives or activities determined by the agencies and departments."* Moreover, most state and local agencies use ASTM standards when regulating fuel quality. The US military specification MIL-G-5572 was dropped in 1989 and now buys its Avgas to ASTM D910.

Commercially, outside of the US, ASTM or UK Defense Standardization standards (Def. Stan.) are used. The choice typically depends on individual country practices and is often specified in international contracts. Specific to fuel, Avgas is either specified by ASTM D910 or Def. Stan. 91-90 (formerly DERD 2485).

There are three main places where the specification is applied. The first is at the point of manufacture, where the fuel must meet the specification before the producer can ship the product. The second is at the point of custody transfer, where the fuel must meet the specification whenever title is transferred from one party to another (e.g., refinery to ship or barge). The third is at the point where the fuel is being loaded into an aircraft.

As stated above, representatives from those involved with myriad aspects of Avgas constitute the membership of the key committees. Members are classified as users, producers or general interest. A user member represents an organization which purchases or uses the product (e.g., Aircraft operators, Engine, Airframe and accessory manufacturers etc.). A producer member represents an organization that manufactures or sells Avgas. A general interest member is one that does not fit into the user or producer categories (e.g., pipeline, research organizations, independent labs, consultants etc.). Specific to committee representation, all voting committees must have a combined majority of user and general interest members over producer members. The current ratio of users and general interest members to producers is on the order of 2 to 1. Moreover, each organization has a single vote at each voting level. The main committee (D2; Petroleum Products), the product subcommittee (J; Aviation Fuel) and the working section (J2; Spark Ignition and Compression Ignition Aviation Engine Fuels) constitute the levels relevant to Avgas. The actual writing of a standard or specification takes place at the section level.

ASTM standards or specifications are voted on by written ballot. Balloting for a new or revised standard begins at the subcommittee level and progress through main committee and society ballots. At each level a member can cast a negative ballot, citing technical objections. For a negative to be valid it must be technically based. Each negative must be discussed and formally voted on. If a negative is considered persuasive the ballot fails, but equally, if a negative is voted non-persuasive by the group of voting members, the ballot passes.

The above description of ASTM International should make clear the need for any new fuel development to occur in concert with ASTM, as safety of flight is maximized by addressing innumerable issues related to fuel production, handling and distribution. In addition, ASTM specifications would guarantee uninterrupted transport and transfer of a new Avgas domestically and internationally. Current aviation fuel products, including Avgas, possess an ASTM specification. An ASTM specification would also eliminate potential issues with Federal, State and local government agencies that purchase or regulate any aviation fuel.

The FAA is a key voting member in ASTM and is currently collaborating with the aviation industry to develop policies, methods, and specifications to facilitate the introduction of alternative aviation fuels. Any new policies and or methods will need to be thoroughly vetted and any new fuel evaluated well beyond current specification properties. Quality control, safety and ground support equipment compatibility are a few of many important issues related to a new Avgas that will need to be evaluated to ensure any new fuel will remain fit-for-purpose.

ASTM, in cooperation with the FAA, recently introduced a “Test Specification” designation allowing new developmental fuels to rapidly progress through the ASTM process. Moreover, it provides a standard which can be used to ensure each batch of a potential new fuel remains consistent batch to batch throughout the fuel and engine testing process.

Appendix L
UAT ARC
Member Dissenting Opinion
& ARC Response

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December 19, 2011

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Dear Bob,

GAMI appreciates the opportunity of detailing the issues surrounding the impact of requiring an FAA certification path that mandates multiple fuel specification approvals being developed and approved through the ASTM organization as part of a "fleet-wide" certification plan. It is currently being contemplated that this ASTM approval process would require both a "Test" specification and a "Production" specification approval prior to acceptance into or completion of an FAA sponsored test program for a new fuel. In spite of the recognized value of the feedback from the industry this plan contemplates, experience has shown that this plan is fraught with pitfalls virtually assured to delay or prevent the successful approval of a new fuel to support fleet of piston aircraft requiring a high octane, unleaded alternative fuel. Those obstacles are detailed below:

1. Intellectual Property Concerns

The fuels industry has been notorious for in-fighting over intellectual property fuel formulation issues. Early on, Task Force meetings for G100UL demonstrated that concern. During Task Force telecons, multiple members of the task force objected to the inclusion of specifying the chemical composition (in percentage terms) in addition to the performance properties of the fuel. The specific stated reason was that if percentage chemical compositions were included in the specification, that would aid the owners of the intellectual property for the G100UL fuel in asserting that IP.

The removal of the chemical composition puts the onus of proof on the holder of the Intellectual Property to prove that the producer has/has not violated the Intellectual Property in the absence of a Licensing Agreement. Further, certain Task Force members (current avgas producers) stated strongly that they would not support the inclusion of chemical compositional requirements as a part of the fuel specification at a time when the FAA was insisting that the chemical composition be precisely defined for the STC project. Unfortunately, the FAA then changed its previous position (which

REQUIRED percentage chemical composition boundaries in the specification) and actively supported the objecting task force members.

Many of these parameters are "balanced" against each other and represent "choices" by GAMI as to what GAMI has determined is optimal given all the considerations, i.e. chemical compatibility, engine performance, economic factors, etc. Although it might be nice to know if some of those performance numbers or compositions could be favorable altered, the pursuit of that represents an endless "science experiment".

2. Endlessly Complex Test Program Being Developed ASTM Where FAA Guidance Already Exists

There is an ongoing ASTM task force involved in developing a guidance document "*Standard Practice for the Evaluation of New Aviation Gasolines and New Aviation Gasoline Additives* ". This guidance has been in development for many (10+) years and grown in complexity as input from members has continued to suggest a broad scope of tests to be considered in qualifying a new fuel. In spite of the good will involved in developing a comprehensive set of tests developed to provide good assurance of suitability of a new fuel, there are numerous new tests contemplated by this document for which there is neither a reference specification noted nor accept/reject criteria defined. Many of these requirements have found their way into this document without data to support the inclusion, or new tests are being defined that are absent of proof of method. At the most recent ASTM meeting in December 2011, I asked what the Task Force intended to include with respect to documenting the need for the additional tests, specifying reference test specifications and determining accept/reject criteria guidance and was told that it had been agreed upon that those will not be defined as a part of the document. It was said that the fuel sponsor should do whatever tests it determines is appropriate, compare to results on 100LL and then bring those results for review by the ASTM body who will determine the adequacy of the tests and the results as it relates to approval of the "Test" and "Production" specifications. This provides the likely opportunity to "second" guess the test methods or arbitrarily evaluate results if "slightly worse" is the result without reference to actual proven use in the aircraft/engine in accordance with current FAA guidance. This leads the fuel sponsor to an endless round of "what if you tested it this way" or "maybe that's not good enough-try it again a little different".

An example of this is documented in early G100UL Task Force telecons. Task force members stated that as a part of the test fuel specification development process, GAMI should undertake an extended development program to try to define other new and unknown "performance tests" that would be an alternative to the percentage chemical composition requirements or that GAMI should determine whether the proposed specification performance limits could or should be further extended based upon what the airframe or engines might tolerate. This approach represents an endless test program that is outside the scope of the approval of the specification as defined by the fuel developer/sponsor.

Currently this document includes numerous criteria which have never been a part of engine or fuel certification and for which there is no established data to determine accept/reject criteria for that parameter. Examples of this include engine tear-down tests for exhaust valve creep life response, flame speed, lubricity to name a few of those that have not been a part of either the avgas fuel specifications nor the engine testing. There is no certainty that this Task Force will successfully complete this guidance in any reasonable period of time to support either a successful adoption of a Test Specification or a Production Specification of a new fuel, both of which are anticipated to be required for the new certification process being defined to be completed. Besides, the FAA's Advisory and Regulatory Material has been used successfully for the issuance of approvals of fuels, lubricants and engines for a long time without significant service problems.

3. Excessive Time Frame/Costs for Completion

The prescribed guidance referenced above would substantially increase the time frame needed to complete tests, reports results, receive feedback and revise formulations if needed due to ASTM meeting only twice a year. The scope of tests contemplated represents a very broad and comprehensive application to the fleet that may or may not be in the designed applicability of the fuel a contemplated by the fuel sponsor. Both the extended time frame as well as the broad scope of tests dramatically increases the cost of fuel development.

The ASTM document involves numerous engines being tested for significantly extended times for durability testing. Previous FAA guidance has established the acceptance of 150 hour "Block Test" times to evaluate durability considerations. No data exists to substantiate why such extended time frames being proposed are required while copious data exists to establish why 150 hour block tests are adequate. Limited application STCs, i.e. for TN IO-550N engine in Cirrus SR22 should not have to test other engines to satisfy a "world-wide" application consideration. These are marketing considerations and should not be a part of a required FAA certification process. The applicant should have the opportunity to define the scope of his product's use.

4. Economic/Compatibility Challenges with Current Producers

Additional ASTM history has shown that unless fuel formulation falls within established manufacturing methods/equipment, progress will be likely undermined by the current producers during the ASTM specification process. Supposedly, within the ASTM specification development process, only "technical" issues can be raised as valid (substantive) concerns but it was stated by one of the ASTM members at a recent unleaded avgas meeting that there would be the likelihood of non-technical (i.e. marketing) reasons driving the issuance of "contrived" technical issues as a means of stalling the progress of a fuel that is not what the producers may want to produce. An example of this would be the recent attempt for approval for an aviation gasoline that had included the use of ETBE as an additive. In spite of ETBE being a commonly available industrial product with defined purity, in the absence of an ASTM specification for that material, the fuel sponsors were forced to initiate the development of an ASTM specification for the ETBE as an additive which has significantly delayed the approval of the test specification. This particular fuel specification has been in works for over six years. In the absence of agreement on the market applicability the approval of a "Production" specification is unlikely.

The GA industry is in "crisis mode" for want of a suitable replacement fuel combined with the residuals from a severe recession. As long as the existing producers can exert their muscle through ASTM in preventing the certification of a new fuel, they can limit the opportunity for a free market approach to consideration of a new fuel. Why are we choosing now to invent obstacles to the successful certification of a fuel in order to facilitate their preferred production/delivery method? A candidate fuel producer should have autonomy with respect to defining the quality of the fuel being considered. Perhaps the candidate fuel producer is interested in satisfying the entire fleet of GA aircraft, perhaps not.

5. Inability to Agree Upon Minimum Acceptable Detonation Margin/Test Methods

As the octane rating of the fuel is directly influenced by the lead content, the specific detonation test methods and margins established by those methods is a key consideration in determining the acceptability of any candidate fuel. Every piston aircraft engine currently certified has successfully undergone detonation testing as a part of the engine TC program.

Although detonation testing and determination of detonation limited operation has been an established part of engine certification without a history of service difficulties, the ASTM Task Force has determined that now is an appropriate time to revisit the basics of how these measurements are done and reestablishing new more conservative thresholds for acceptance. The OEM engine producers share concern here as neither of the two dominant engine OEMs have implemented this type of equipment as a part of their own engine certification. As a sidebar to this discussion is the newfound concern that the minimum octane performance of the fuel at the current stated 100MON may now be insufficient to establish suitable "margins" when the specification is clear as to the minimum acceptable MON values. The industry, and GAMI in particular has been trying for 18 months to simply get a "first meeting" organized to begin to explore the concept of "how good is good enough" (which meeting has yet to occur).

6. In Conflict with OMB Guidance

As previously submitted in greater detail, there is an Office of Management & Budget mandate, Circular A-119, (that required federal agencies to recognize that an agency requirement to use ASTM (or other consensus) standards, "if improperly conducted, can suppress free and fair competition; impede innovation and technical progress; exclude safer or less expensive products; or otherwise adversely affect trade, commerce, health, or safety."

On page 5 of the OMB document is found the following language:

f. **What considerations should my agency make when it is considering using a standard?**

When considering using a standard, your agency should take full account of the effect of using the standard on the economy, and of applicable federal laws and policies, including laws and regulations relating to antitrust, national security, small business, product safety, environment, metrication, technology development, and conflicts of interest. Your agency should also recognize that use of standards, if improperly conducted, can suppress free and fair competition; impede innovation and technical progress; exclude safer or less expensive products; or otherwise adversely affect trade, commerce, health, or safety. If your agency is proposing to incorporate a standard into a proposed or final rulemaking, your agency must comply with the "Principles of Regulation" (enumerated in Section 1(b)) and with the other analytical requirements of Executive Order 12866, "Regulatory Planning and Review."

It is clear that the imposition of an ASTM requirement offers considerable opportunity to materially affect free and fair competition; impede innovation and technical progress; exclude safer or less expensive products; or otherwise adversely affect trade, commerce, health, or safety and as such should be reconsidered.

7. Inappropriate and Excessive Use of Federal Funds

Use of federal funds in this process represents an unfair competition with industry's self-funded efforts to develop/certify a fuel. In the event federal funds are used to develop and support a process that *facilitates* or i*ncentivizes* persons or entities in the development of new fuel formulations which may be in competition with other industry's self-funded efforts (i.e. investment in testing facilities, fuel development R and D , etc.) is unfair competition and prohibited by law. It has been established that the market will develop and bring forth for certification, fuels for consideration in the absence of federal subsidy.

Funding requirements for the anticipated "fleet-wide" certification plan requiring ASTM approvals as a part of that adds to the considerable total amount contemplated for this purpose. Creation of acceptable alternatives offers the opportunity for expedited solutions and a meaningful reduction in funding requirements.

Best regards,
GAMI

Tim Roehl
President

DATE: January 27, 2012

SUBJECT: UAT ARC Response to GAMI Dissenting Opinion

REFERENCE: General Aviation Modifications, Inc. (GAMI) Memorandum, no subject, dated December 19, 2011 (attached)

INTRODUCTION

The UAT ARC is tasked to provide recommendations to facilitate the development, approval and deployment of an unleaded aviation gasoline with the least impact on the largest possible segment of the existing fleet.

UAT ARC is recommending the utilization of the ASTM International aviation fuel specification process as an integral element of the unleaded avgas development and transition plan. This recommendation is based on the fact that ASTM Aviation Fuel Production Specification are relied on today to support the safe and efficient production and commercial exchange of bulk aviation fuels on a US interstate and international basis. As the scope of the UAT ARC tasking and recommendations includes deployment, stipulation of a globally accepted third-party consensus standard is a necessary consideration to facilitate an unleaded aviation gasoline transition.

In addition, a key recommendation of the UAT-ARC addresses centralized FAA testing of candidate unleaded fuels to generate standardized qualification and certification data. The data will be used by the fuel developer to support both ASTM specification development and FAA fleet-wide certification approval. This will reduce total overall costs and improve efficiencies by eliminating the need for redundant and time consuming testing. Government and industry-in-kind contributions will be used to fund the centralized testing.

The viability of the unleaded avgas development and transition plan presented in this report relies on the integration and inclusion of the ASTM fuel specification process. Consequently, the above recommendations were overwhelmingly supported by 19 of 20 members of the UAT ARC.

The referenced memorandum documents the one dissenting opinion which objects to utilizing the ASTM process. The FAA Committee Manual (ARM-001-015) states that if a dissenting member presents a written objection, the ARC documents its position relative to the objection with the reason why the ARC chose and retains its position and that the documentation shall be submitted to the FAA as part of the ARC's recommendations (Part II, Chapter 6).

Arguments supporting the use of ASTM International fuel specifications are presented throughout the UAT ARC report. In addition, the following documents the position of the other 19 members of the UAT ARC who support this recommendation.

SUMMARY

The dissenting opinion presented in the referenced memorandum can be generally characterized as opposition to the linkage of the ASTM consensus-based standards process to acceptance into or completion of an FAA sponsored test program. As envisioned in the UAT ARC recommendations, FAA sponsorship would provide a means to convey tangible benefits to potential fuel candidates.

The referenced memorandum states that inclusion of ASTM consensus based standards would present a plan "fraught with pitfalls virtually assured to delay or prevent the successful approval of a new fuel to support fleet of piston aircraft requiring a high octane, unleaded alternative fuel." It identifies seven issues relating to this position.

The other 19 members of the UAT ARC support the use of the ASTM consensus-based processes. This overwhelming majority of members believe that this will not present unnecessary delays or prevent the successful approval and deployment of a new unleaded aviation fuel. On the contrary, inclusion of ASTM consensus-based standards is essential to ensure the overall success of the development and approval activities, and is a necessary element to enable deployment. Therefore, it should be included in the effort at every stage of the process. Furthermore, the breadth of industry expertise engaged in the ASTM consensus-based standard processes provides the best forum for objective peer review, which is essential to mitigating the numerous and broad safety, environmental and toxicology risks associated with the introduction of a novel unleaded aviation gasoline. It should be noted that other consensus based standards do exist, such as ISO and SAE, however, the ASTM standard system is used today for all aviation fuels distributed in the Americas and in many other areas of the world.

DISCUSSION

1. "Intellectual Property Concerns"

The referenced letter states that the "fuel industry has been notorious for in-fighting over intellectual property fuel formulation issues". This statement implies a broad, wide-ranging and well-established characteristic of ASTM. This opinion is inconsistent with the experience of those ARC members who have participated in the ASTM process. There are numerous precedents for ASTM standards and specifications that rely on IP controlled technology (e.g., ASTM D7719 – 11, Standard Specification for High Octane Unleaded Test Fuel relies on proprietary technology developed by Swift Enterprises, and ASTM D3241 - 11a Standard Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels relies on a proprietary "JFTOT" test unit).

Specific to the currently active GAMI G100UL ASTM fuel Task Force (TF), no formal objections of any kind have been made regarding the specification proposed by GAMI because a specification has not been submitted for balloting. Any objections, including FAA objections, would need to be deemed technically persuasive to prevail in the ASTM process. And, if they are found to be technically persuasive, then methods for appeal are clearly documented and supported by ASTM. Additionally, the FAA has been consistent regarding its requirements for both ASTM fuel specifications and for fuel operating limitations developed without support of an ASTM fuel specification.

2. "Endlessly Complex Test Program Being Developed by ASTM Where FAA Guidance Already Exists"

Historically, piston engines and aircraft have been optimized for the characteristics of the existing fuel specification, ASTM D910, Standard Specification for Aviation Gasolines, over millions of hours of accumulated operational experience. The challenge faced today by the industry and the UAT ARC is to reverse this traditional approach. This will require the approval of a novel composition unleaded avgas in a broad-based, or fleetwide manner for the existing engines and aircraft. This is an unprecedented and technically challenging undertaking that is a necessarily complex task with a broad scope. The draft ASTM document, "*Standard Practice for the Evaluation of New Aviation Gasolines and New Aviation Gasoline Additives,*" is being developed to support this task. Out of necessity, it must accommodate the variability of fuel formulations, and therefore will allow for some latitude in prescribing requirements. However, this document will provide enough definition to greatly reduce the uncertainty of how to progress through the ASTM process for developing a new avgas.

The task force established for this effort is building upon the widely successful development and issuance of a similar standard practice developed for jet fuel; ASTM D4054-09, "Guideline for the Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives." This document is a landmark document in the aviation fuel industry and was recently used to guide the approval process for jet fuel made from Hydroprocessed Esters and Fatty Acids (HEFA) blending components. The task force established to develop the equivalent version of this document for piston-engine fuels has made great progress in the 2 ½ years since its formation.

The current performance tests contained in ASTM specification D910 apply to the specific formulation of lead-containing avgas, but the test methods and pass/fail criteria defined in this specification are not necessarily suitable for the different chemical compositions of potential new unleaded avgas formulations. Therefore, investigation of the current and proposed new test methods, as well as the pass/fail criteria, is necessary.

FAA guidance deals with certification of aircraft/engines to existing fuel specs. The ASTM task force document deals with qualification of a new fuel for the existing fleet of aircraft and engines. FAA guidance for fuel specification development does not already exist. Current FAA guidance and regulations address engine and aircraft certification and specify operating limitation requirements for aviation fuel, but do not address the development of fuel specifications to be used for those operating limitations. Therefore, both the FAA guidance and the ASTM standard practice are needed to provide the best opportunity to identify the least impact fuel for the existing fleet.

3. "Excessive Time Frame/Costs for Completion"

As stated in the introduction of this document, the UAT ARC is tasked to provide recommendations to enable the development, approval and deployment of an unleaded aviation gasoline for the largest possible segment of the existing fleet. Limited scope approvals of a new fuel for one specified engine and airplane model are not within the scope of the tasking assigned to the UAT ARC and thus the recommendations do not address these limited-scope approvals. It should also be noted that the UAT ARC recommendations do not introduce impediments to the utilization of existing approval pathways for these limited-scope approvals.

As described in the response to item 2 above, the fleet-wide nature of the tasks assigned to the UAT ARC are significantly more difficult and challenging than a limited-scope approval. Consequently, the UAT ARC considers the referenced draft ASTM standard practice an indispensable tool for accomplishing this task.

The prescribed guidelines in the draft ASTM standard practice will reflect the data considered by the ASTM members to be necessary to support the development of a specification for a new avgas. These data requirements exist whether or not the document is ever published, so development of this document will actually decrease the time frame necessary to develop an ASTM fuel specification as it would provide a better defined path for fuel applicants.

Also as described in the response to item 2 above, FAA guidance deals with certification of aircraft and engines to existing fuel specifications, not with development of those fuel specifications. Likewise, specific FAA guidance regarding the 150 hour block test and durability requirements are applicable to FAA approval of specific engine models, and are not intended for the development of fuel specifications. The evaluation of long-term durability during engine certification is an FAA regulatory requirement specified in 14CFR Part 33.19. This evaluation can be accomplished by 150 hour endurance test, and if necessary, additional long-term testing or supporting analysis.

4. "Economic/Compatibility Challenges with Current Producers"

The UAT ARC considers the efficiency and technical robustness that has characterized the recent issuance of several key aviation fuel specifications a direct result of the objectivity and collaborative approach of the peer-review process employed by ASTM International aviation fuels subcommittee.

The ASTM consensus-based process provides for consideration of the interests of all stakeholders, including fuel producers, engine and airframe manufacturers, users and others. This results in criteria such as flight safety and performance influencing the final specification in the same manner as fuel cost and producibility. The UAT ARC considers the ASTM consensus-based process as a safeguard against the influence of parochial agendas that might result from an autonomous or independent specification development process. An autonomous process would negate the balance of interests provided by the ASTM process. This balance of interest ensures that fuel producibility issues do not take precedence over fuel performance or safety issues.

5. "Inability to Agree Upon Minimum Acceptable Detonation Margin/Test Methods"

The procedures and equipment used by the engine OEMs to measure detonation are designed to support engine certification, not the development of an aviation fuel specification. Comparison of ASTM test methods with the OEM certification compliance methods is inappropriate, as they are designed with different objectives in mind.

ASTM has already established knock-rating procedures (see ASTM D6424 and D6812) and it is likely that the ASTM standard practice will base any guidelines on these existing methods to evaluate the anti-knock capability of a new fuel, and to correlate the anti-knock performance of that fuel on a test bench with the performance on a full-scale engine. These methods will not necessarily establish "new more conservative thresholds for acceptance", but will strive to develop methods of fuel qualification that are accurately correlated to engine performance demands and inclusive of new technology for measuring detonation.

6. In Conflict with OMB Guidance

The referenced letter states that Office of Management and Budget Circular A-119 includes guidance advising Federal Agencies that "improper use of consensus standard may suppress free and fair competition, impede innovation and technical progress, exclude safer or less expensive products, or otherwise adversely affect trade, commerce, health or safety". The letter then states that the UAT ARC recommendation to include ASTM International aviation fuel specifications as an integral element of the FAA-funded fuel testing program "offers considerable opportunity to materially affect free and fair competition, impede innovation and technical progress, exclude safer or less expensive products, or otherwise adversely affect trade, commerce, health, or safety and as such should be reconsidered".

The UAT ARC concurs that *improperly conducted* procedures would present the issue identified in OMB Circular A-119. For this reason, the UAT ARC recommendation specifies participation in related ASTM activities, which in conjunction with the ASTM committee rules and appeal procedures will prevent improper conduct.

ASTM International bylaws are quite clear regarding the justification necessary to prevent issuance of a specification in response to objections submitted as negative ballots during the specification development process. Only negative ballots that are found by the committee or subcommittee to be technically persuasive are considered binding. If negative ballots submitted for a proposed fuel specification are found technically persuasive, then this confirms that the proposed fuel specification has serious technical issues or deficiencies. This ensures that the issuance of a proposed fuel specification cannot be impeded unless a valid technical reason exists that aviation safety will be adversely affected if the specification were to be issued.

Furthermore, reliance on the ASTM International consensus-based specifications for the FAA certification elements of the UAT ARC recommendations is consistent with the guidance contained in OMB Circular A-119. The purpose of Circular A-119, "Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities," is to "direct agencies to use voluntary consensus standards in lieu of government-unique standards except where inconsistent with law or otherwise impractical. Further, the circular states that the purpose of agency participation in a voluntary consensus standards activities is to, among other things, "Further such national goals and objectives as increased use of the metric system of measurement; use of environmentally sound and energy efficient materials, products, systems, services, or practices; and improvement of public health and safety."

7. Inappropriate and Excessive Use of Federal Funds

The referenced letter states that "the use of Federal funds to subsidize and incentivize persons or entities in the development of new fuel formulations which may be in competition with other industry's self-funded efforts is unfair competition and prohibited by law." The UAT ARC has taken great care to develop an open and fair process for selection of fuels for the FAA-funded testing program. This process is open to all companies, persons, or other entities that meet the objective technical criteria that will be developed to support this program. Prospective fuel producers will not be prohibited from participating in the FAA-funded fuel testing program unless they are unable to provide acceptable technical data in accordance with the criteria to be established for this program. As such, the FAA-funded fuel testing program recommended by the UAT ARC does not represent "unfair competition" nor is it prohibited by law.

CONCLUSION

UAT ARC has undertaken significant discussion and considered the dissenting opinion. It is our conclusion that the arguments presented in the dissent are not persuasive and that the UAT ARC report provides the best opportunity to identify an unleaded aviation gasoline(s) that will have the least impact to the existing fleet.

Appendix M
UAT ARC
Industry DAH Non-Recurring
Cost Estimates

Industry DAH Non-Recurring Cost Estimates

The following is an estimate of industry DAH non-recurring costs associated with development, certification, and retooling as may be necessary to accommodate changes to engine and aircraft models for approval to operate with unleaded aviation gasoline whose composition and performance properties represent an impact on current FAA approval status. The following are ROM (rough order of magnitude) estimates only and are dependent upon ultimate fuel quality and composition.

Assumptions

- Total non-recurring Development, Test, Certification, and Tooling cost per engine or aircraft model family except where noted
- Ranges based on complexity of change & scope of certification / range of model applicability
- Cert costs only (application, coordination, cert plan, and cert report only) start at approximately $10,000 for a 'simple' change (no more than 2-3 paragraphs, 1 or 2 model applicability)

Engine Level Changes

- Ignition system changes - no software or complex hardware: $50,000 to $500,000
- Engine compression ratio change – existing pistons: $100,000 to $500,000
- Engine compression ratio change – new pistons: $250,000 to $1,000,000
- Electronic Engine Control – single channel, mechanical backup: $250,000 to $1,000,000
- Derivative engine – combustion chamber, valve train, cylinder changes: $1,000,000 to $5,000,000
- Electronic Engine Control – dual channel: $5,000,000 to $10,000,000
    - Initial cost for testing, component development, and first certified application
    - $100,000 to $500,000 for each follow-on engine model or model family
- All new engine: $50,000,000 to $80,000,000

Aircraft Level Changes

- Induction or Exhaust system changes – excluding adding turbochargers or intercoolers: $50,000 to $250,000
- Fuel system changes to address material compatibility: $50,000 to $250,000
    - Initial cost for testing, component development, and the first certified application

  - $20,000 to $50,000 for each follow-on aircraft model or model family that can use the same compatibility data.
- Aircraft performance changes testing only – due to lower octane fuel or engine changes: $50,000 to $250,000
- Add turbocharger or intercooler to an engine installation: $250,000 to $1,000,000
- Firewall forward engine installation: $1,000,000 to $5,000,000
- Derivative aircraft – firewall forward engine installation + aircraft changes to address weight & balance, loads, and performance deltas: $2,000,000 to $10,000,000
- All new aircraft, single engine: $50,000,000 to $100,000,000

– End of Part II Appendices –