Path to a Lead-Free Aviation System

Author FAA/Industry Coalition

Date Wednesday, March 16 – Thursday, March 17, 2022

Table of Content

Day 1: March 16

National Academy of Sciences, Engineering and Medicine Remarks
EAGLE Framework Overview, Objectives and Outcome
Regulation, Policy and Programmatic Activities Pillar Session
Unleaded Fuel Evaluation and Authorization Pillar Session

Day 2: March 17

Fuel Infrastructure & Deployment Pillar Session
Research, Development, and Innovation Pillar Session
EAGLE Quad Charts
EAGLE Next Steps

EagleULFuel@aopa.org

This meeting is an industry-sponsored event. It is not intended to be a forum for providing consensus stakeholder advice or recommendation to the government; rather, we welcome individual perspectives on issues discussed.

Path to a Lead-Free Aviation System: 4 EAGLE Pillars

Supply Chain Infrastructure & Deployment

Research, Development, and Innovation

Unleaded Fuel Evaluation and Authorization

Regulation, Policy, and Programmatic Activities

Presentation by
Dr. Amy R. Pritchett to follow

Transportation Research Board

Consensus Study Report:

Options for Reducing Lead Emissions from Piston-Engine Aircraft

Presenter:
Dr. Amy Pritchett, The Pennsylvania State University

March 16, 2022

National Academy of Sciences Chartered by Congress in 1863

"…The Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science…" 1863 Charter of the National Academy of Sciences

Committee's Statement of Task

In Section 177 of the FAA Reauthorization Act of 2018, Congress called for an Academies study of aviation gasoline that includes assessment of:

- Existing non-leaded fuel alternatives to the aviation gasoline used by piston-powered general aviation aircraft;
- Ambient lead concentrations at and around airports where piston-powered general aviation aircraft are used; and
- Mitigation measures to reduce ambient lead concentrations, including:
  - Increasing the size of run-up areas,
  - Relocating run-up areas,
  - Imposing restrictions on aircraft using aviation gasoline, and
  - Increasing the use of motor gasoline in piston-powered general aviation aircraft.

Study Committee

Amy Pritchett, The Pennsylvania State University, *Chair*

Brian German, Georgia Institute of Technology

Jack Griffith, NAS, University of North Carolina

Kimberly Kenville, University of North Dakota

Marie Lynn Miranda, University of Notre Dame

Robert Mitchell, NAE, Northrop Grumman Aerospace Systems (*retired*)

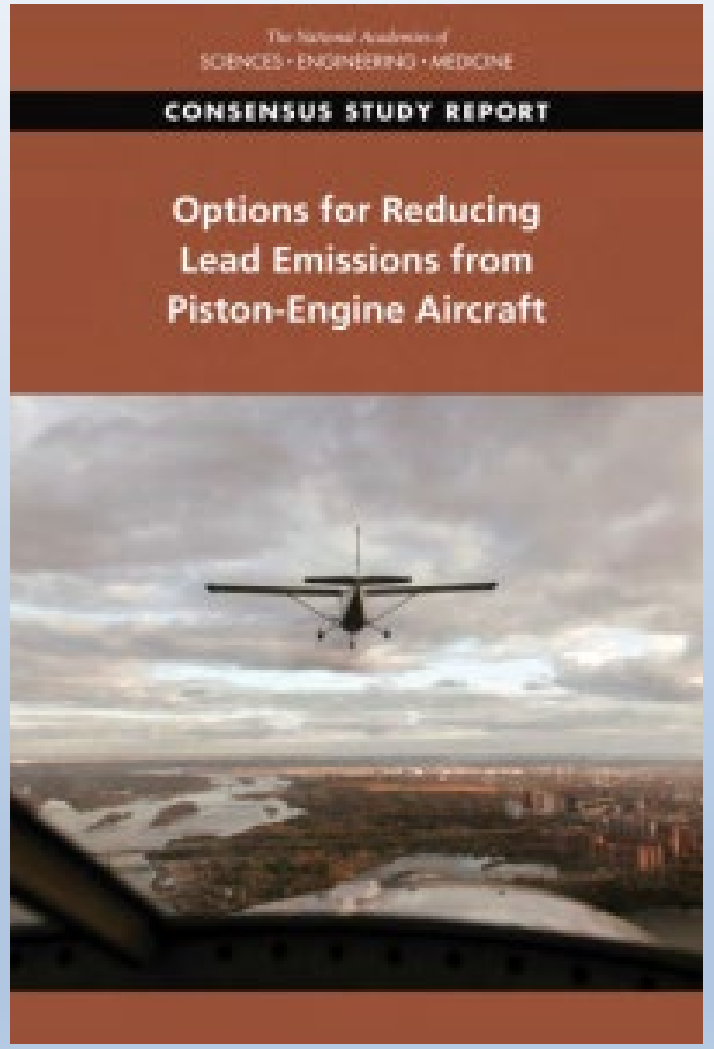
Glenn Passavant, Ingevity Corporation (*retired*)

Bernard Robertson, NAE, Daimler Chrysler Corporation (*retired*)

Jay Turner, Washington University

Asciatu Whiteside, Dallas/Fort Worth International Airport

Findings and Recommendations



Piston Engine Aircraft

Roughly 170,000 piston engine aircraft registered in USA

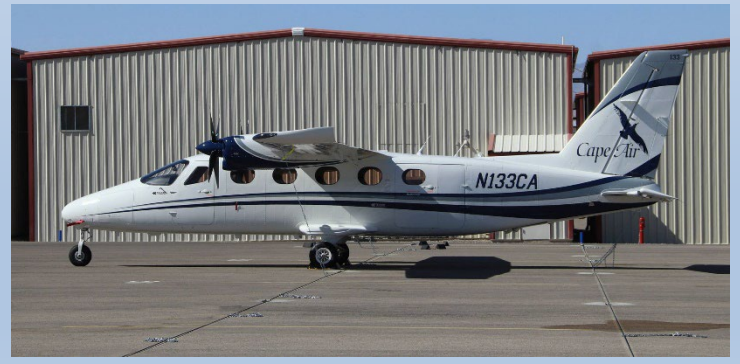
Serve many different purposes

- Personal and recreational flying
  ~ 75% of the fleet and ~ 50% of hours flown.
- Business, government, and commercial purposes
  ~25% of the fleet, ~ 50% of hours flown, and consumes more than half of all the avgas.

Annual fleet turnover is very low, ~ 900 new aircraft added per year.

- Average aircraft age ~ 50 years.
- Retrofitting can require extensive and expensive testing and FAA certification.

Built 1935 – Still In Use



13,100 Different Airports

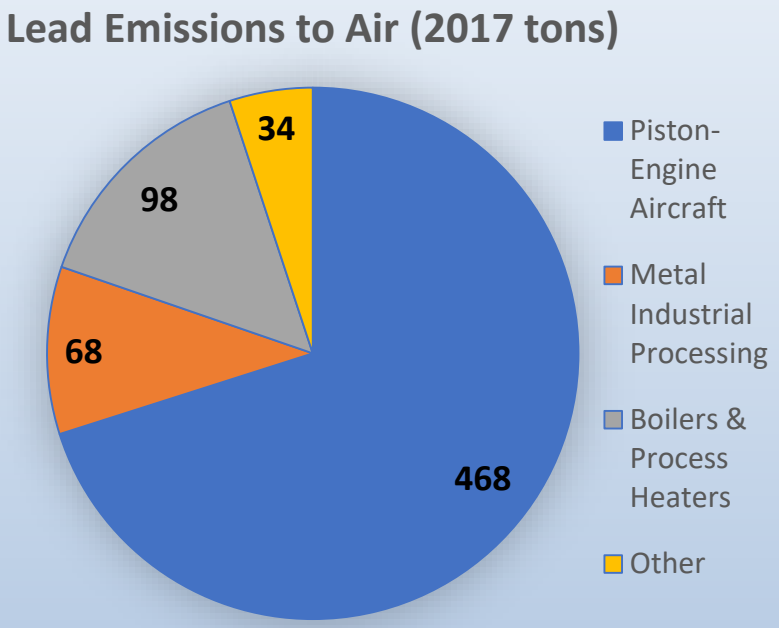
- ~ 75% of fleet is based at 3,300 airports
  - Mostly publicly owned
  - Are in the National Plan of Integrated Airport Systems (NPIAS) and receive federal assistance.

- ~ 25 % of fleet is based at 9,800 airports.
  - Many are very small, with limited capability to add fueling infrastructure or assess lead impact of airport layout.

- Wide variations in proximity to people, number of operations, fueling infrastructure, etc.

Lead Emissions from Piston Engine Aircraft

- Lead persists.
- Emitted lead accumulates.
- In the past, (civil) piston engine aircraft weren't the largest source…
- … but they are now



Ambient Lead Concentrations Near Airports

- Safe levels of human lead exposure are not known.
- Importance of reducing lead exposures measures to reduce or eliminate:
  - Lead emissions and/or
  - Zones of high airborne lead concentration.
- See Ch 3 for recommendations to EPA and others for better understanding of exposures near airports and assessing effectiveness of airport-specific mitigations.

Some Actions That Cannot Widely Help

- Imposing restrictions on aircraft using avgas would not be a viable sole mitigation. Restricting their use, especially high-performance aircraft, would have far-reaching ramifications for many critical functions, including:
  - Transportation, particularly in remote regions,
  - Medical transport, and
  - Pilot training.

- Automobile gasoline is not a viable unleaded alternative to avgas.
  - Ethanol, which is added to motor gasoline, may cause vapor lock and is corrosive to aircraft components.
  - Without ethanol, automobile gasoline does not meet minimum octane requirements.

A Multi-Pathway Approach

There is currently no single known technical solution that is certain to be available in the near-term.

A multi-pathway approach is needed:

- Ultimate development of a drop-in fuel (recognizing uncertainty in if/how/when it will succeed).
- Ultimate development of new propulsion technologies.
- Interim mitigation pathways focused on modifying airport operations and practices and on using existing fuels and aircraft.

Implementation will require the participation of many across a diverse industry involving private, corporate and public entities, including: pilots; airport managers and personnel; fuel suppliers; and aircraft propulsion and airframe manufacturers.

Broad Coordination

Recommendation 4.1: FAA should:

- Coordinate its efforts to reduce lead pollution and exposures at airports with those of other federal agencies that have key responsibilities for protecting public health, safety, and the environment at airports, including OSHA, as well as EPA.

- Collaborate with those agencies to explore the regulatory and programmatic means within their respective jurisdictions that can be brought to bear and combined in a complementary manner to reduce lead emissions and exposures at airports.

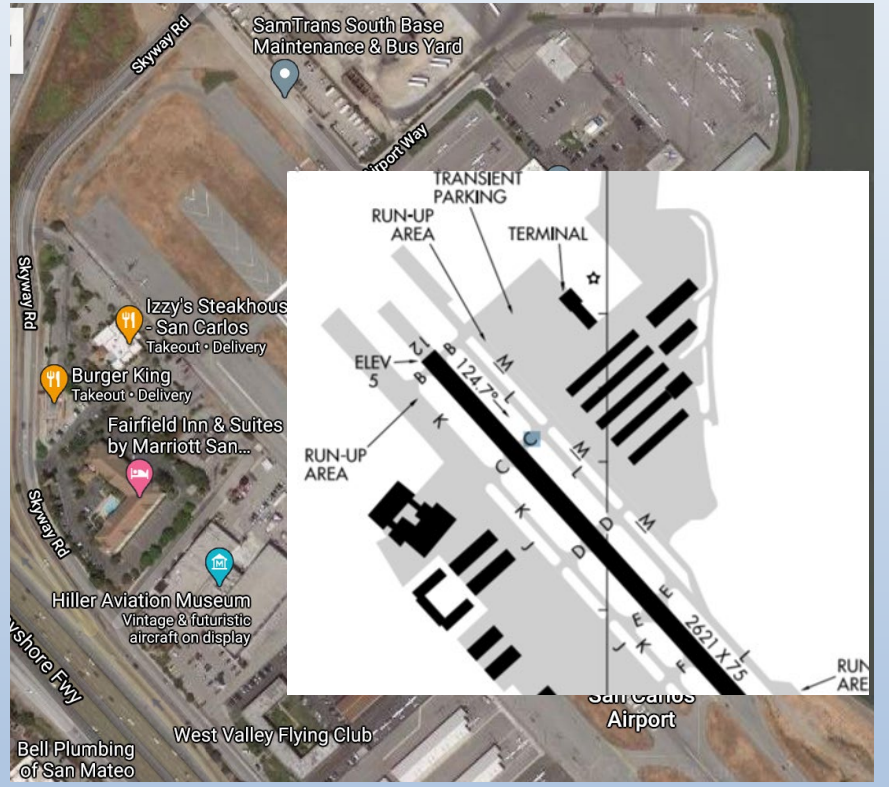
Pilot and Airport Personnel Practices

There is scarce mention of lead health hazards in FAA-related materials for flight training, aircraft maintenance, and airport management and guidelines for refueling to avoid spills and emissions.

<u>Recommendation 4.2</u>: FAA should initiate an ongoing campaign for education, training, and awareness of avgas lead exposure that is targeted to GA pilots, aircraft technicians, and others who work at airports.

Aircraft Operations at Airports

Recommendation 4.3:
FAA should update its guidance on the location of run-up areas to reflect the results of research since the latest interim guidance was issued in 2013



Existing Specified Fuels and Fleet

100VLL has the same octane rating as 100LL, nearly 20% less lead content, and could be used by all piston-engine aircraft. It is not currently being produced.

Recommendation 5.1: FAA should research public policy options for motivating refiners to produce and airports to supply 100VLL.

At least 57% of the current fleet could use UL94, which is the only existing grade of unleaded avgas. It would require a second supply chain and fuel distribution system across the nation. Consequently, widespread availability of UL94 is likely to be restricted to a portion of airports that have or can afford to add the required fueling facilities.

Recommendation 5.2: FAA should research public policy options to enable and encourage greater use of available unleaded avgas (UL94).

Interim reductions in lead emissions while searching for an unleaded solution:

- If all suitable aircraft use UL94, lead emissions would be reduced by up to 30%.
- If higher-performance aircraft were also to use 100VLL, reductions in lead emissions could exceed 40%.

Existing Specified Fuels and Fleet

Recommendation 5.3: A mechanism should be established for facilitating the increased availability of existing grades of unleaded avgas across the fleet. Congressional involvement would likely be needed, such as by providing incentives:

For pilots to use existing unleaded avgas, and

For more small airports to add requisite fuel storage and dispensing capacity.

New Lead-Free Fuels

Although it has not yet yielded a viable replacement, the Piston Aviation Fuels Initiative (PAFI) has led to the development of a fuel testing and evaluation process, prompted supplier interest in developing replacement fuels, and sought solutions to many challenges associated with supplying an unleaded replacement fuel.

Recommendation 6.1: FAA should continue to collaborate with the GA industry, aircraft users, airports, and fuel suppliers in the search for and deployment of an acceptable and universally usable unleaded replacement fuel.

Lead-Free Propulsion Systems

- Incentives are needed to develop new technologies to expand use of lead-free means of propulsion.
- The slow turnover rate of GA fleet would limit the transition to new technologies without new incentives.
- Long timeline – need to start now

Recommendation 6.3: FAA initiatives should be used to promote the development, testing, and certification of safe and environmentally desirable lead-free emerging propulsion systems (e.g., diesel, electric, and jet fuel turbine engines) for use in GA aircraft, including the requisite airport refueling and recharging infrastructure.

- Include collaborations with industry and other government agencies, such as NASA.
- Congressional encouragement and provision of resources may be required.

Transition to Lead-Free Propulsion Systems

Recommendation 6.2: A clear goal should be established that all newly certified gasoline-powered aircraft after a certain point in time (e.g., within 10 years) are approved to operate with at least one ASTM-approved unleaded fuel

- An additional amount of time should be identified by which all newly produced gasoline-powered aircraft, including those currently produced with older type certificates, would attain that same goal.
- Congressional action may be required to establish the goal and timeframes.

Summary of Mitigations

Considerations	Airport Operations and Practices		Existing Specified Fuels and Fleet		New Lead-Free Technologies (Fuels–Propulsion Systems)		
	Aircraft Operations at Airports	**Pilot and Airport Personnel Practices**	**100VLL**	**UL94 for low-performance aircraft**	**UL94 in all new aircraft**	**100+UL in all aircraft**	**New Propulsion Systems**
Potential Reduction in Lead Exposures	Small & variable, depends on individual airport	Small & variable, could be important for aircraft technicians	Up to 20% reduction (could be >40% if combined with UL94 use by low-perform aircraft)	Up to 30% reduction (could be >40% if combined with 100VLL use by other aircraft)	~0.5% reduction per year	100% reduction	~0.5% reduction per year
Time Frame for Lead Reduction Benefits if Started Soon	Near-term	Near-term	Near- to mid-term	Mid-term	Far-term for appreciable reductions	Unknown, may require technical breakthrough	Depends on cost, innovation rate, & applicability to GA fleet
Focus of Implementation	Airport Management	FAA Flight Stds, pilot instruction and training programs, GA community	Fuel supply chain, especially refiners	Fuel supply chain esp at airports	Engine and aircraft makers	Fuel supply chain, esp fuel developers; engine and aircraft makers	Technology developers, aircraft manufacturers, aircraft owners
Possible Policy Actions for Facilitating Implementation	Provide data and tools for analysis and identifying operations changes	Provide training and education materials, engage in awareness campaigns	Directives and/or incentives, perhaps focused on refiners	Incentives for airports to add fueling capacity, eased FAA certification	Directives and/or incentives applicable to GA industry	Public–private collaborative (PAFI-like) for R&D, testing, and certification	R&D support, FAA certification, incentives for aircraft owners to incur expense
Main Sources of Uncertainty in Effective Implementation	Variability in airport- specific factors	Potential to affect practices	Refiner capacity to meet tighter lead specifications	Feasibility of second fuel supply chain, certification	Ability to design suitable engines for all high-performance aircraft	Potential to meet fuel performance requirements	Rate of innovation, certification challenge, cost and owner interest
Ancillary Benefits and Concerns	Greater lead awareness & interest in lead-free fuels and propulsion	Greater lead awareness & interest in lead-free fuels and propulsion				Environmental and health impacts related to other fuel components	Changes in pollutants, including GHGs over life cycle

In Closing

Key message: A lead mitigation strategy depending on an unleaded drop-in fuel has a high degree of uncertainty of success.

Instead, a multi-pronged approach is required.

Near and mid-term mitigations can reduce lead emissions and exposures.

Other longer-term technical developments have the potential for much larger impacts.

Report is available on line at: https://www.nap.edu/read/26050

Questions?

Supplemental Information

Committee Activities

Held multiple meetings of the full committee and subgroups for information gathering and deliberation.

Heard presentations from representatives of FAA, EPA, state agencies, aircraft and engine manufacturers, airports, fixed base operators who dispense aviation fuel, small airplane operators, suppliers and developers of aviation fuel, and environmental research community.

Obtained a substantial amount of written information from FAA, EPA, and other relevant organizations.

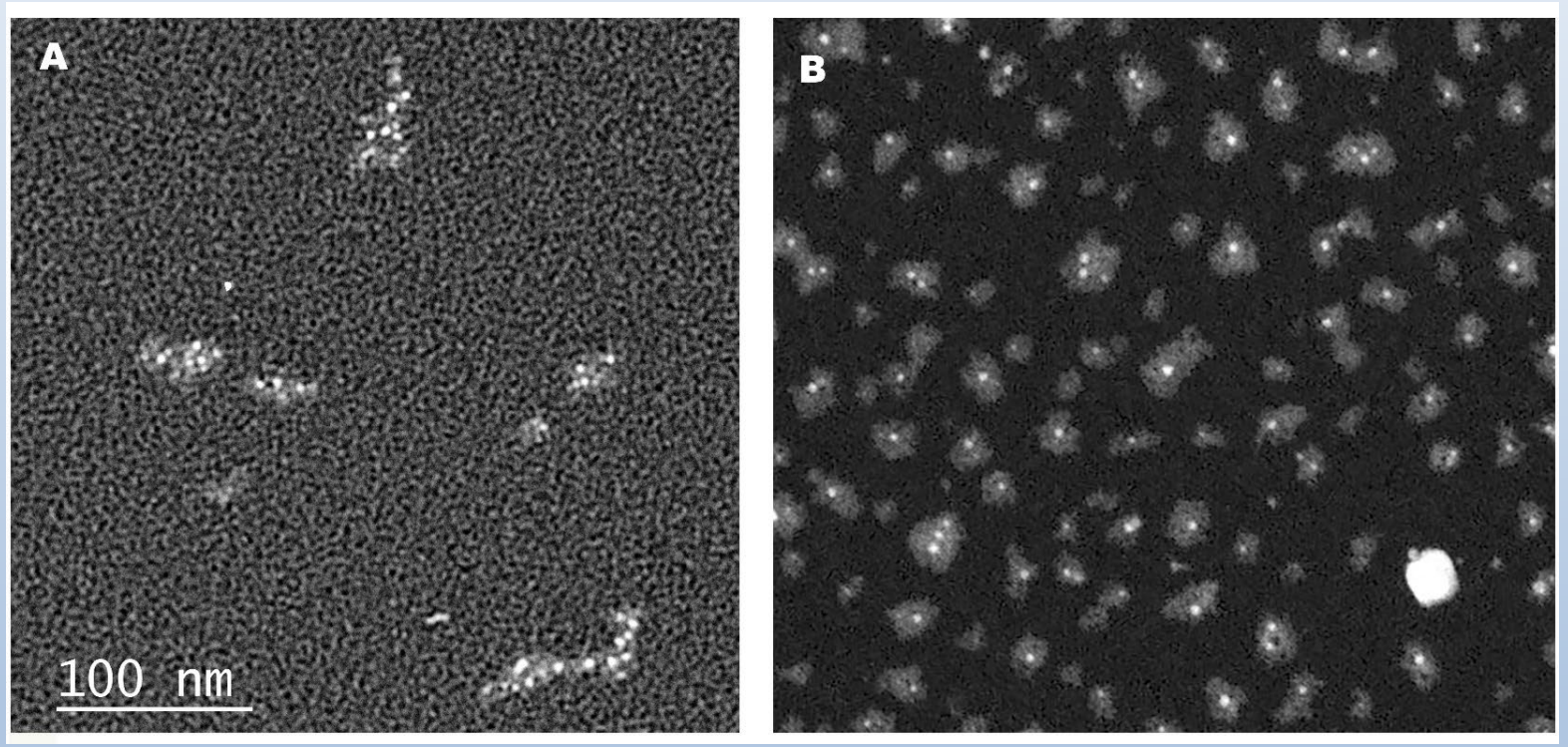
Report Reviewers

Review was overseen by **David Allen**, NAE, University of Texas, and **Chris Hendrickson**, NAE, Carnegie Mellon University

- **Fred Cornforth**, ConocoPhillips (retired)
- **Shanetta Griffin**, Columbus Regional Airport Authority
- **Bruce Lanphear**, Simon Fraser University
- **Lourdes Maurice**, DLM Global Solutions
- **Neil Paton**, NAE, Howmet Corporation (*retired*)
- **Robert Olislagers**, Centennial Airport
- **Ann Richart**, Nebraska Department of Transportation
- **Noelle Eckley Selin**, Massachusetts Institute of Technology
- **Alan Washburn**, NAE, U.S. Naval Postgraduate School (*retired*)
- **Ron Wilkinson**, AvSouth LLC

Unique Aspects of Aviation Emissions

Aviation emissions may have unique attributes, e.g., smaller particle size than automotive emissions



(A) Automotive (B) Aircraft

Image courtesy of Jack Griffith, committee member

Lead-Free Propulsion Systems

Small aircraft pose unique engineering challenges: propulsion systems have to be small, light-weight and reliable.

- Miniaturize systems used by larger aircraft (diesel, turboprop, turbogenerator)
- Look to new electric and alternate fuel engines

Currently, these technologies are typically not certified for broad use.

Certification and retrofit costs can be prohibitive.

Examples:

https://www.pbsaerospace.com/our-products/tp-100-turboprop-engine

http://www.boeing.com/aboutus/environment/environmental_report/_inc/flash-2-1-2.html

Mitigations at Specific Airports

Assessing the feasibility and effectiveness of airport-specific mitigations would benefit from an improved understanding of individual airport characteristics.

Modeled airborne lead concentrations at Richard Lloyd Jones Jr. Airport in Tulsa, Oklahoma

Mitigations at Specific Airports

Recommendation: EPA should conduct more targeted monitoring and enhanced computational modeling of airborne lead concentrations at airports of potential concern, as indicated by its recent screening study, to evaluate aircraft operations that are main contributors to lead hot spots and design airport-specific mitigation measures.

- Additional monitoring and modeling should include airports with airborne lead concentrations exceeding the concentration of the lead National Ambient Air Quality Standards, and airports with lead concentrations lower, but approaching, the NAAQS.

Airborne Particles Containing Lead

Lead in piston-engine aircraft exhaust can occur in particles smaller than the lead particles observed in automobile exhaust.

Recommendation: EPA and NIEHS should sponsor research to improve the understanding of the physical state of the lead-containing particles to inform future studies of atmospheric transport and deposition, human exposure, and health risks of lead emissions form GA aircraft.

- Include emissions from various types of GA-aircraft piston engines, e.g., turbocharged engines, using fuel formulations of different lead content, including an existing grade of avgas with a lower lead content (100VLL).

Routes of Lead Exposure

Past emissions from piston-engine aircraft that deposited to soil and other surfaces can contribute to present-day lead exposures at locations within and near airports.

Recommendation: EPA and NIEHS should sponsor research to enhance the understanding of lead exposure routes and their relative importance for people living near airports and working at them.

- Include studies, such as observations of blood lead levels among children, in communities representing a variety of geographic settings and socioeconomic conditions that are designed to examine the effectiveness of the lead mitigation strategies over time.

Eliminate Aviation Gasoline Lead Emissions Initiative

Today's Meeting Objectives

1. Describe the EAGLE initiative
2. Define potential activities under each pillar
3. Exchange information
4. Share constructive input
5. Garner initial commitments towards a safe, lead-free aviation future
6. Discuss next steps

Agenda Snapshot

Day 1: March 16

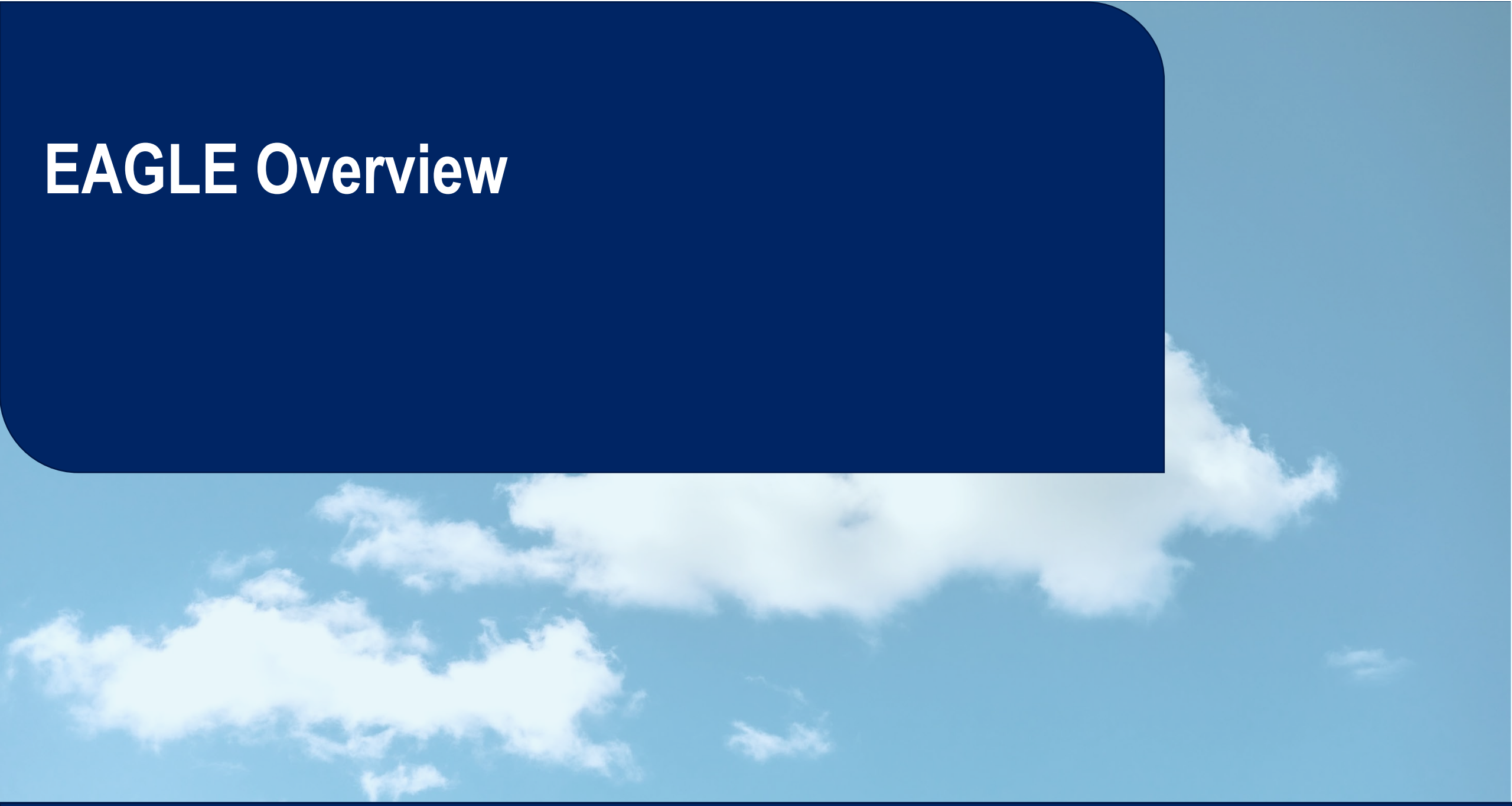
1000 – 1200	Opening Session
1200 – 1300	Lunch (Provided)
1300 – 1430	Regulation, Policy and Programmatic Activities Pillar Session
1430 – 1500	Break
1500 – 1630	Unleaded Fuel Evaluation and Authorization Pillar Session
1730 – 1930	Stakeholder Reception

Day 2: March 17

0930 – 1030	Business Fuel Infrastructure and Implementation Pillar Session
1030 – 1115	Research, Development, and Innovation Pillar Session
1115 – 1145	Break
1145 – 1230	EAGLE Next Steps
1230	Meeting Adjourns

This meeting is an industry-sponsored event. It is not intended to be a forum for providing consensus stakeholder advice or recommendation to the government; rather, we welcome individual perspectives on issues discussed.

EAGLE Overview



Outline

Current State of Affairs

EAGLE Objectives and Strategic Framework

Pillar Interdependencies and Notional Line

Current State of Affairs (1 of 2)

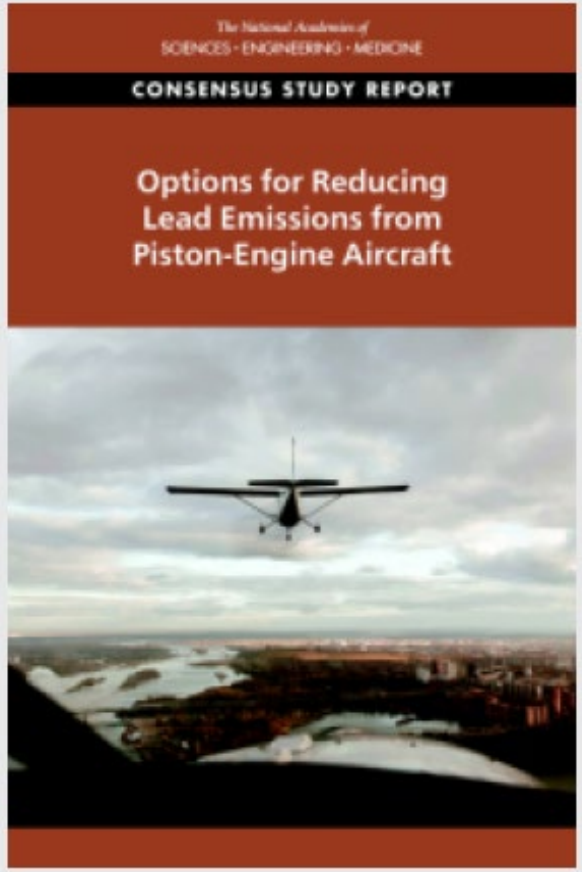
- Overwhelming scientific data states that there is **no safe level of lead** in human blood
- The **EPA is evaluating** whether emissions from piston-engine aircraft operating on leaded fuel contribute to air pollution that endangers public health or welfare
- EPA plans to issue a **proposal for public review and comment in 2022** and take final action in 2023
- The **most common leaded aviation fuel** available today is 100 octane low lead aviation gasoline (or "**100LL**")
- UK-based company Innospec Inc. is world's **single source of tetra-ethyl lead (TEL)**
- This is an **international topic** with global implications
  - Current efforts in Europe to ban TEL
  - Activities to reduce lead exposure also exist in Canada

Current State of Affairs (2 of 2)

- Approximately **222,609 piston-engine aircraft** are registered with the FAA
- About **180 million gallons of 100LL is consumed annually in the United States**
  - Results in ~ 350 tons of lead emissions (emitted from engine exhaust as lead dibromide)
- A clear **need for state and local governments to** understand the national process and **assist with the plans** to eliminate leaded aviation gasoline in a safe and expedient manner

Report to Congress – *Released January 12, 2021*

- **Section 177** of the FAA Reauthorization Act of 2018, called on FAA to commission this study by a committee of the National Academies of Sciences, Engineering and Medicine (NASEM).
- The study considers:
  a) Ambient lead concentrations at and around airports where piston-engine aircraft are used,
  b) Existing nonleaded fuel alternatives to avgas used by piston-engine general aviation aircraft; and
  c) Mitigation measures to reduce ambient lead concentrations, including increasing the size of run-up areas, relocating run-up areas, imposing restrictions on aircraft using avgas, and increasing the use of motor gasoline.
- **Report Conclusion**: The removal of leaded aviation gasoline in the United States will require a combination of integrated efforts from industry, government, and Congress.



http://nap.edu/26050

Unleaded Aviation Gasoline Roadmap Framework

Unleaded Fuel Evaluation and Authorization

Regulation, Policy, and Programmatic Activities

Research, Development, and Innovation

Current State	Focus Areas	Future State
No current unleaded fuel qualifies as a drop-in replacement for 100LL avgas	**Piston Aviation Fuels Initiative (PAFI)**	Qualified drop-in unleaded fuels available
Type certification required for engines and aircraft to use different fuels	**Streamlined approval process**	Non-traditional fleet wide approval process
Unleaded fuels are not widely available at airports	**Improve fuel infrastructure / UL options**	Multiple unleaded fuels are available
Engines and aircraft do not satisfactorily operate with fuels less than 100 octane	**Engine/aircraft modifications**	All aircraft and engines can use unleaded fuel
Engines and aircraft do not satisfactorily operate with fuels less than 100 octane	**Engine replacement – technology**	All aircraft and engines can use unleaded fuel

Leaded avgas is not a new issue. What is different today?

- NASEM Report To Congress
  - First time recognition that an integrated government/industry effort is needed to remove leaded avgas
- There may not be a single solution set
  - To date, PAFI work since 2014 has not identified a single, drop-in unleaded fuel solution that complies with ASTM standards
  - A Multilayered approach is needed per NASEM Report
    - Unleaded fuels
    - Engine modifications
    - New technological developments are present today that reduce reliance upon leaded avgas
- Sense of Urgency – 2030
  - Arc of governmental regulatory efforts dictate a quick transition

Eliminate Aviation Gasoline Lead Emissions Initiative

Introduction to the EAGLE Strategic Framework

EAGLE Goal

Eliminate the use of leaded aviation fuels for piston-engine aircraft in the United States by the end of 2030 without adversely impacting the existing GA fleet

Path to a Lead-Free Aviation System: 4 EAGLE Pillars

Supply Chain Infrastructure & Deployment

Research, Development, and Innovation

Unleaded Fuel Evaluation and Authorization

Regulation, Policy, and Programmatic Activities

Pillar A: Supply Chain Infrastructure & Deployment – Outcomes

Supply Chain Infrastructure & Deployment

- Work will focus on:
  - **Supporting standards and regulatory pathways** to market, for the qualification, production and deployment of new unleaded fuel(s)
  - Supporting government incentive and policy programs to accelerate transition to new unleaded fuel(s)
  - Environmental, Social and Governance (ESG) outreach
- Throughout the transition to unleaded fuels, this pillar **addresses the complexities of maintaining 100LL availability** and safe deployment of new fuel(s) from the refinery to the wing.
- Includes **education, training, awareness and outreach** responsibilities.

Pillar B: Research, Development, and Innovation – Outcomes

Research, Development, and Innovation

- **Facilitate transition** to unleaded replacement fuel by mitigating potential impacts on existing fleet of aircraft and enabling innovation
- **Address safety and technical challenges** associated with high-performance engine use of unleaded fuels
  - Research and testing of advanced technology designs
- Focus on effective and timely **FAA certification**
- Includes **education, training, awareness, and outreach** responsibilities

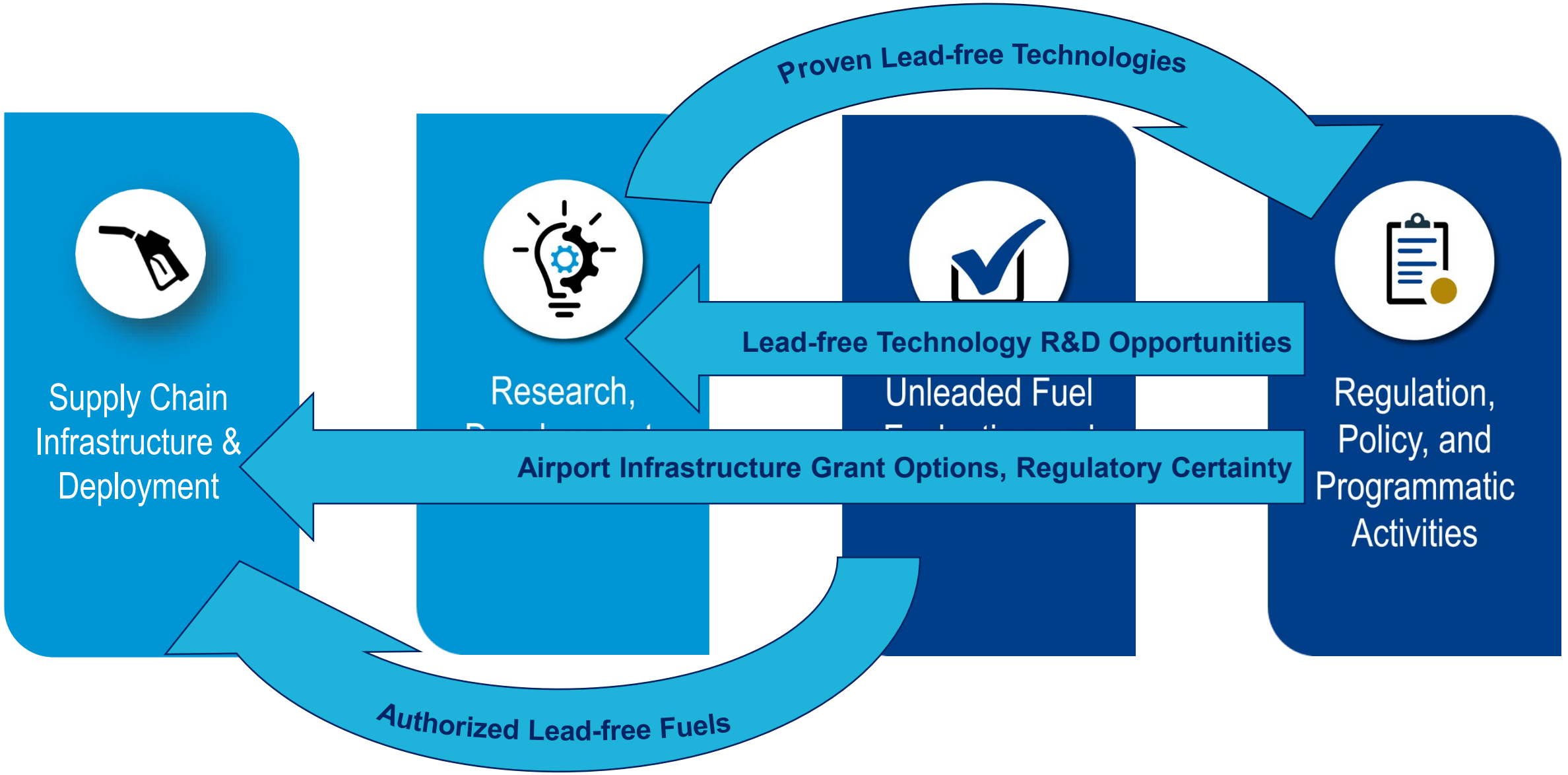
Pillar D: Regulation, Policy, and Programmatic Activities – Outcomes

- **Complete** test and evaluation of candidate replacement fuels for 100 Low Lead (100LL) aviation fuel
- **Identify** at least one unleaded fuel acceptable for widespread use
- **Institutionalize** fleet authorization process for unleaded fuels
- Includes **education, training, awareness, and outreach responsibilities.**

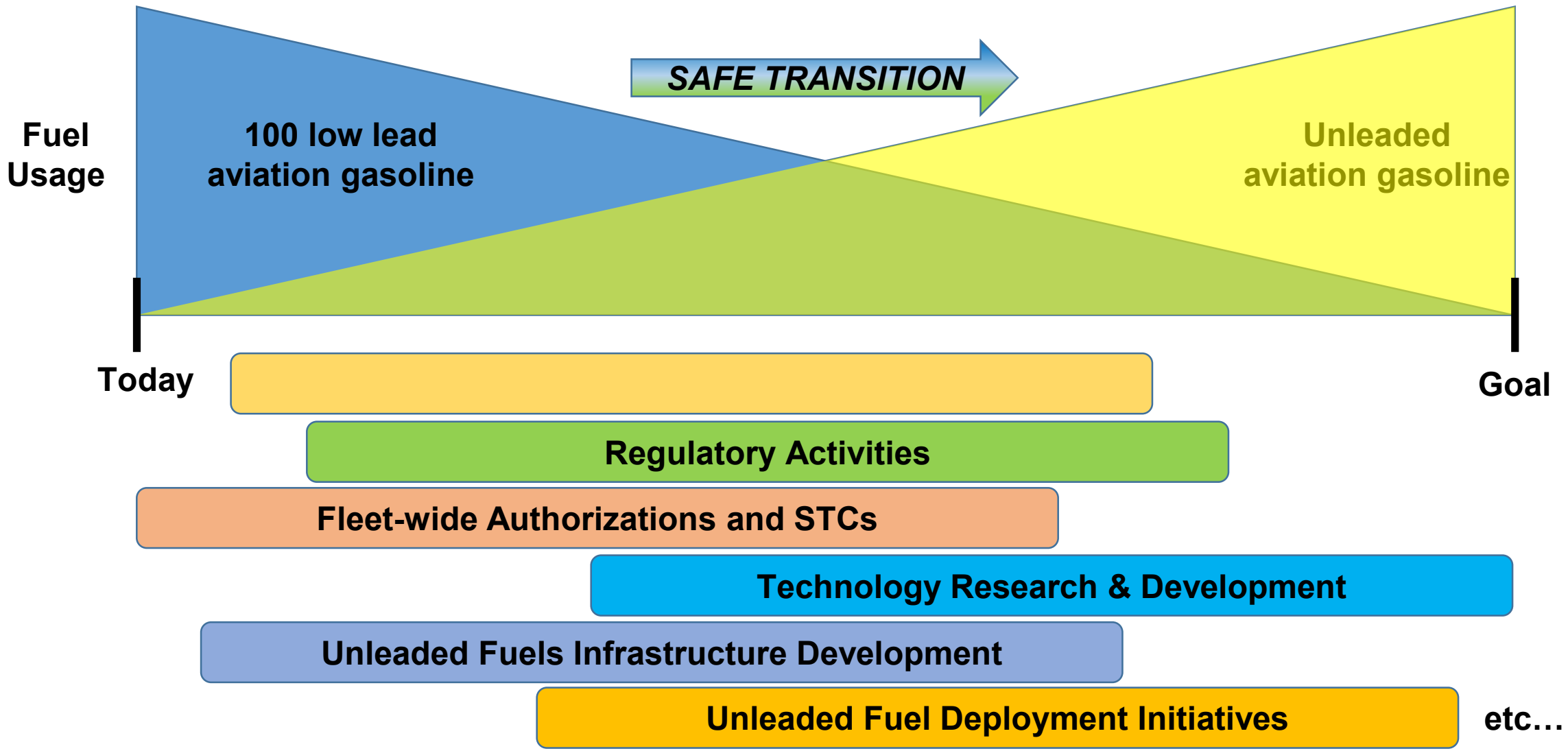
Pillar D: Regulation, Policy, and Programmatic Activities – Outcomes

- Work is focused on government efforts:
  - **Regulatory processes** for EPA and FAA
  - Policies that affect **funding for airport fueling infrastructure**
  - Programmatic activities that **reduce or eliminate reliance upon leaded aviation fuels**
- Includes **education, training, awareness, and outreach responsibilities**

Pillar Interdependencies – Example (not exhaustive)

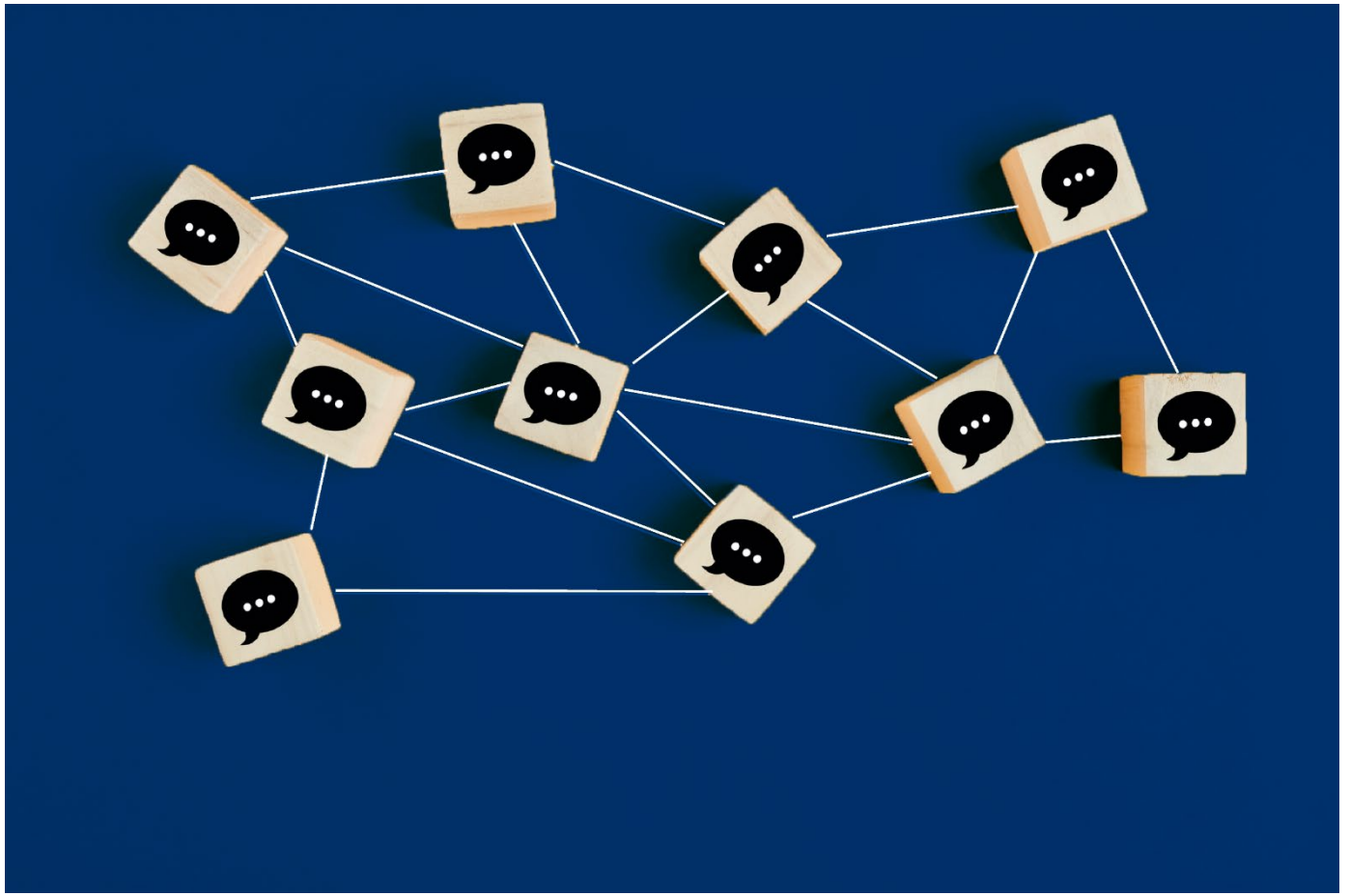


Notional Safe Transition to an Unleaded Aviation Future



Thank You!

Discussion



Pillar D: Regulation, Policy, and Programmatic Activities

Author Government Agencies contributing to Pillar D

EAGLE Pillars

Supply Chain Infrastructure & Deployment

Research, Development, and Innovation

Unleaded Fuel Evaluation and Authorization

Regulation, Policy, and Programmatic Activities

Pillar D Outline

Regulation, Policy, and Programmatic Activities

- Overview of Pillar D
- Overview of EPA/FAA Regulatory Authorities
- FAA Potential Programs Regarding Technology Solutions
- Airport Context and Activities

Overview of Pillar D Within the EAGLE Initiative

- Regulation, Policy, and Programmatic Activities
  - Government-led Pillar
  - Focused on Government Activities that Address:
    - Lead emissions from piston-engine aircraft
    - Leaded aviation gasoline

- Interdependencies with Other Pillars
  - Pillar A Influences:
    - Provides regulatory certainty that drives no-leaded actions across the sector
    - Offers programmatic support to airport fueling infrastructure
    - Potential to offer programs that are complementary solutions sets to unleaded fuel (e.g., engine retrofits)
    - Potential to offer programs that are additional solution sets to unleaded fuel (e.g., engine swaps)
  - Pillar B Influences:
    - Potential to incentivize industry development of no-lead technologies

Regulation, Policy, and Programmatic Activities

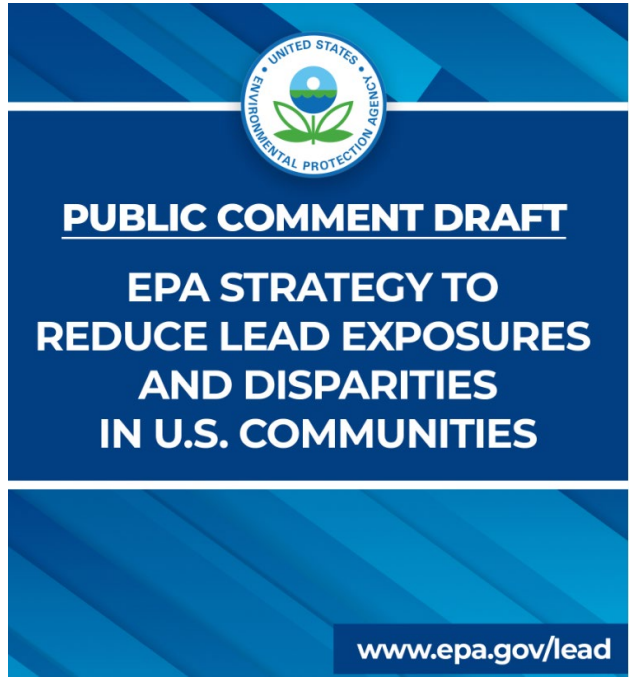
Overview of EPA & FAA Regulatory Authorities

Children's Health is an EPA Priority

- EPA has longstanding concern regarding the potential impact of lead emissions from these aircraft on communities living near airports and as such, we have been working for years to evaluate this source of lead to the environment.

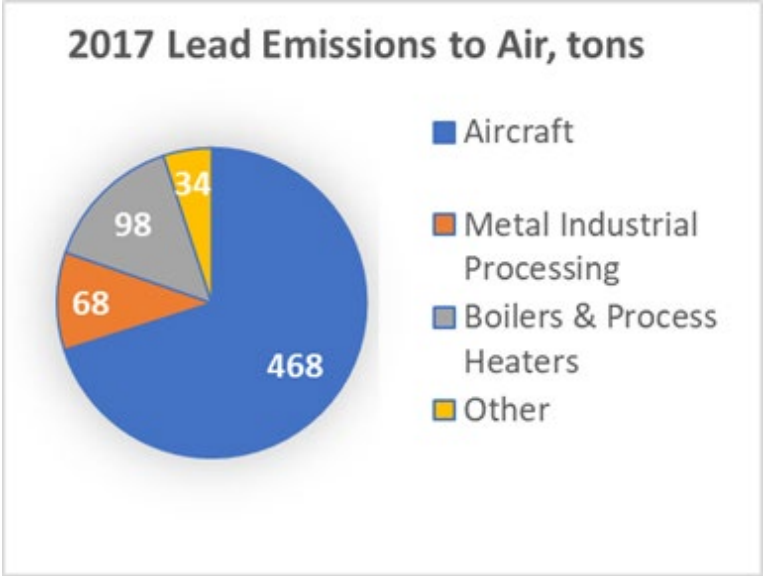
- It is one of the EPA Administrator's highest priorities to reduce children's exposure to lead, and this issue in particular poses concerns regarding environmental justice for those who live near airports.

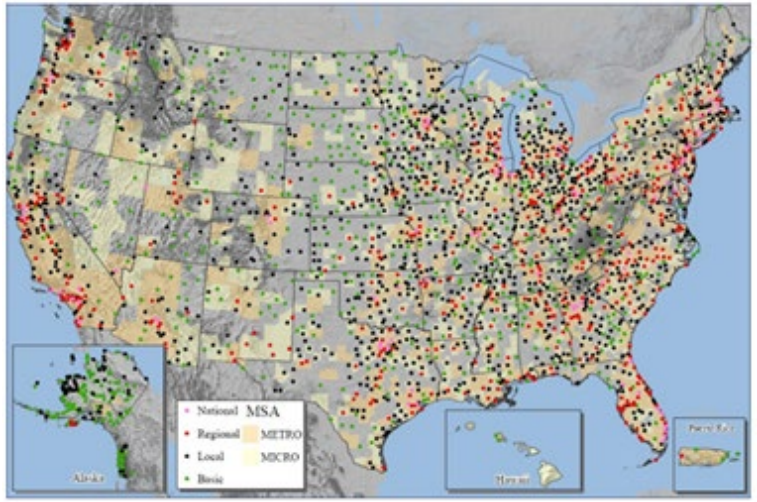
- EPA has developed the draft Strategy to Reduce Lead Exposures and Disparities in U.S. Communities which describes EPA's and government-wide approaches to strengthen public health protections from the harmful effects of lead.



EPA's Analysis of Aircraft Lead Emissions

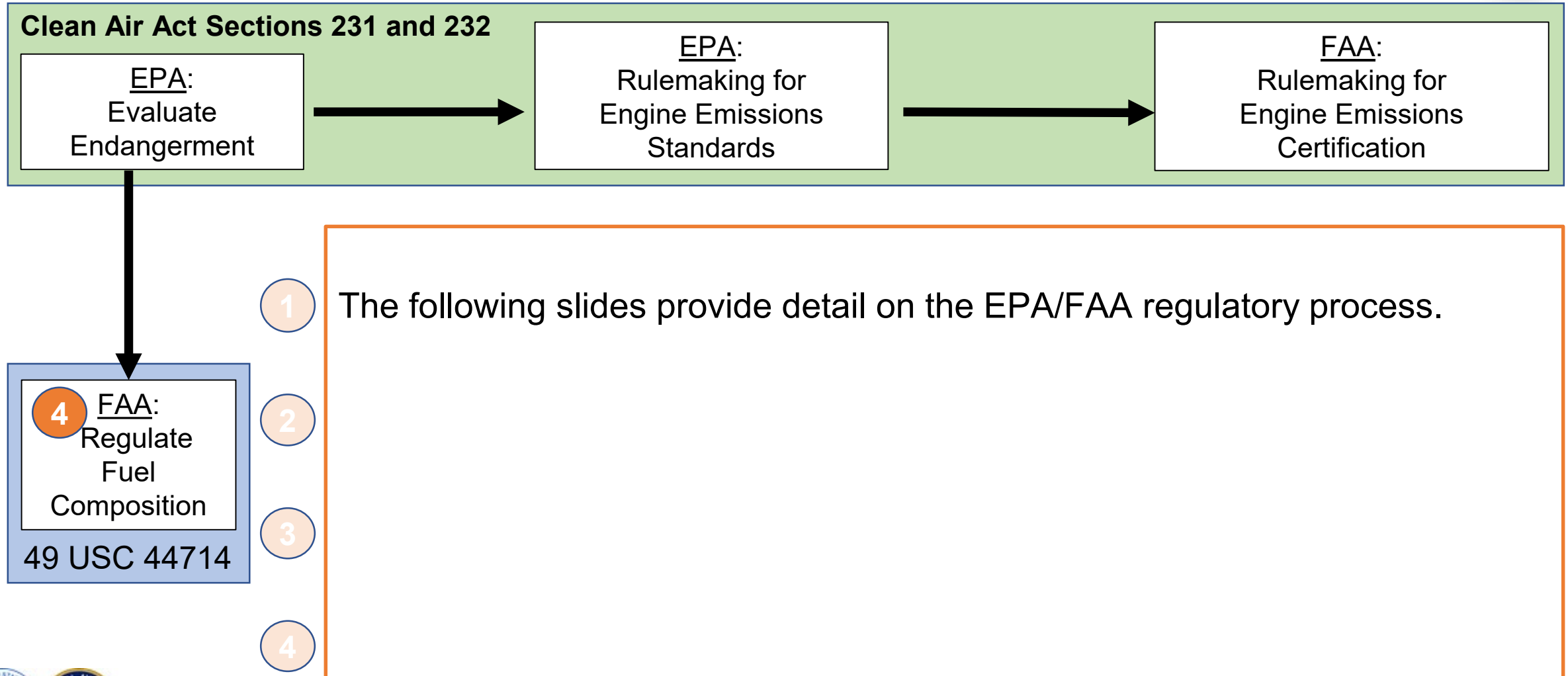
- Inventory assessment conducted every three years.
- Air quality monitoring at airports to evaluate attainment of the lead National Ambient Air Quality Standard.
- Air quality modeling to understand areas of high lead concentration and the gradient in concentrations.
- National Analysis of Populations Residing Near or Attending School Near U.S. Airports.
  - 5 million people, including 340,000 children live near airports
- Model-extrapolated Estimates of Airborne Lead Concentrations at U.S. Airports.



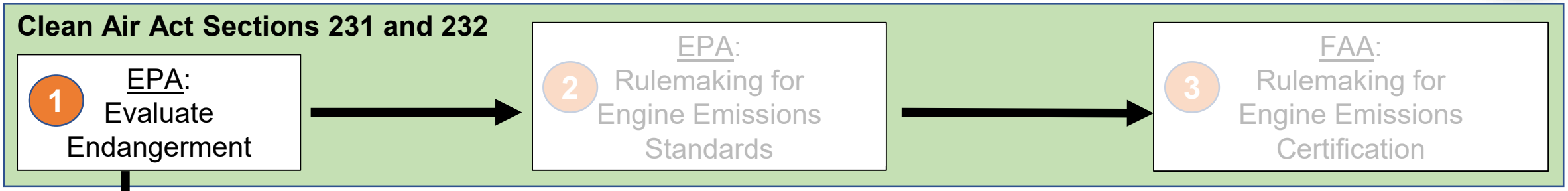


https://www.epa.gov/regulations-emissions-vehicles-and-engines/epas-data-and-analysis-piston-engine-aircraft-emissions

EPA & FAA Authorities Regarding Aircraft Lead (Pb) Emissions

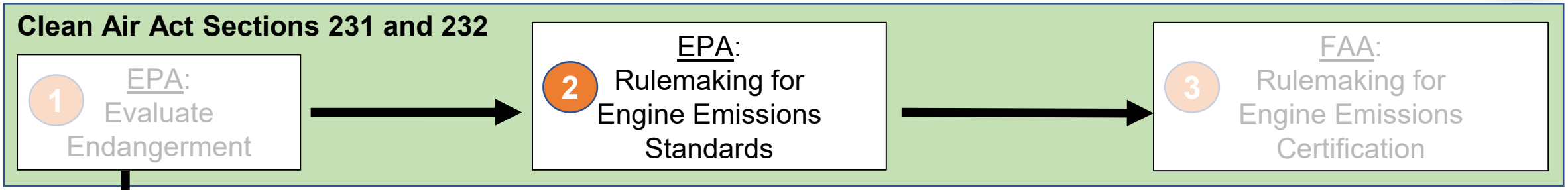


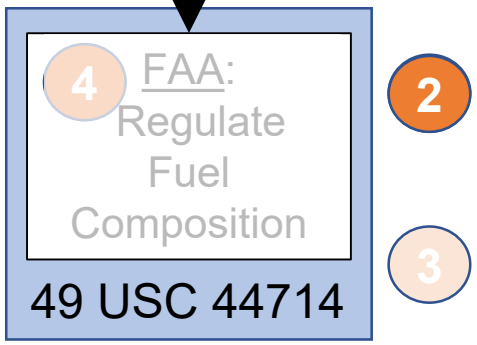
EPA & FAA Authorities Regarding Aircraft Lead (Pb) Emissions



- EPA is developing a proposal under the Clean Air Act regarding whether lead emissions from piston-engine aircraft cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare
  - For convenience, we refer to this action collectively as the "endangerment finding"
- We're currently planning to issue this proposal in 2022
- The proposal will undergo public notice & comment. After evaluating comments on proposal, we plan to issue any final decision in 2023.
- A positive finding triggers a duty for EPA to propose and promulgate engine emission standards
  - EPA's consideration of the endangerment finding is a first step toward application of EPA's and FAA's statutory authorities to address lead pollution from aircraft

EPA & FAA Authorities Regarding Aircraft Lead (Pb) Emissions

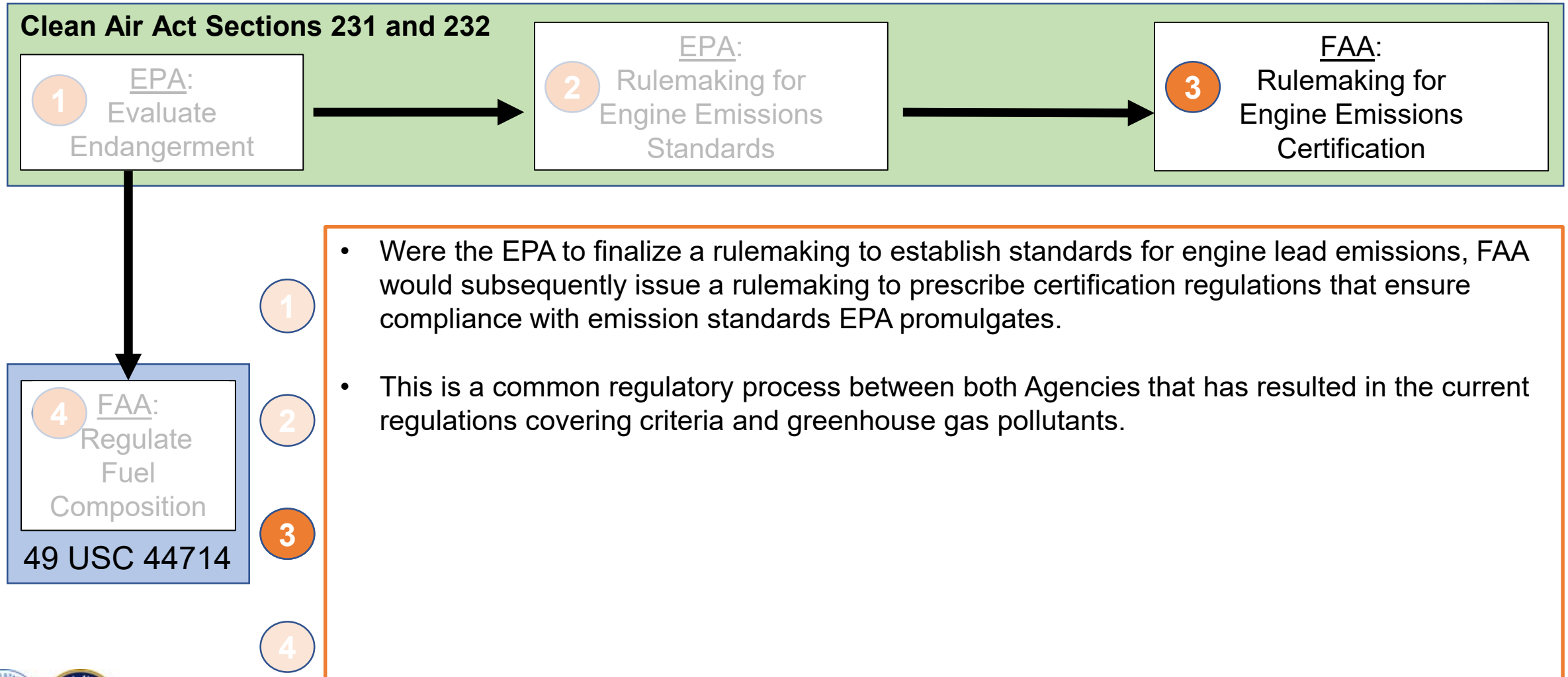




1
2
3
4

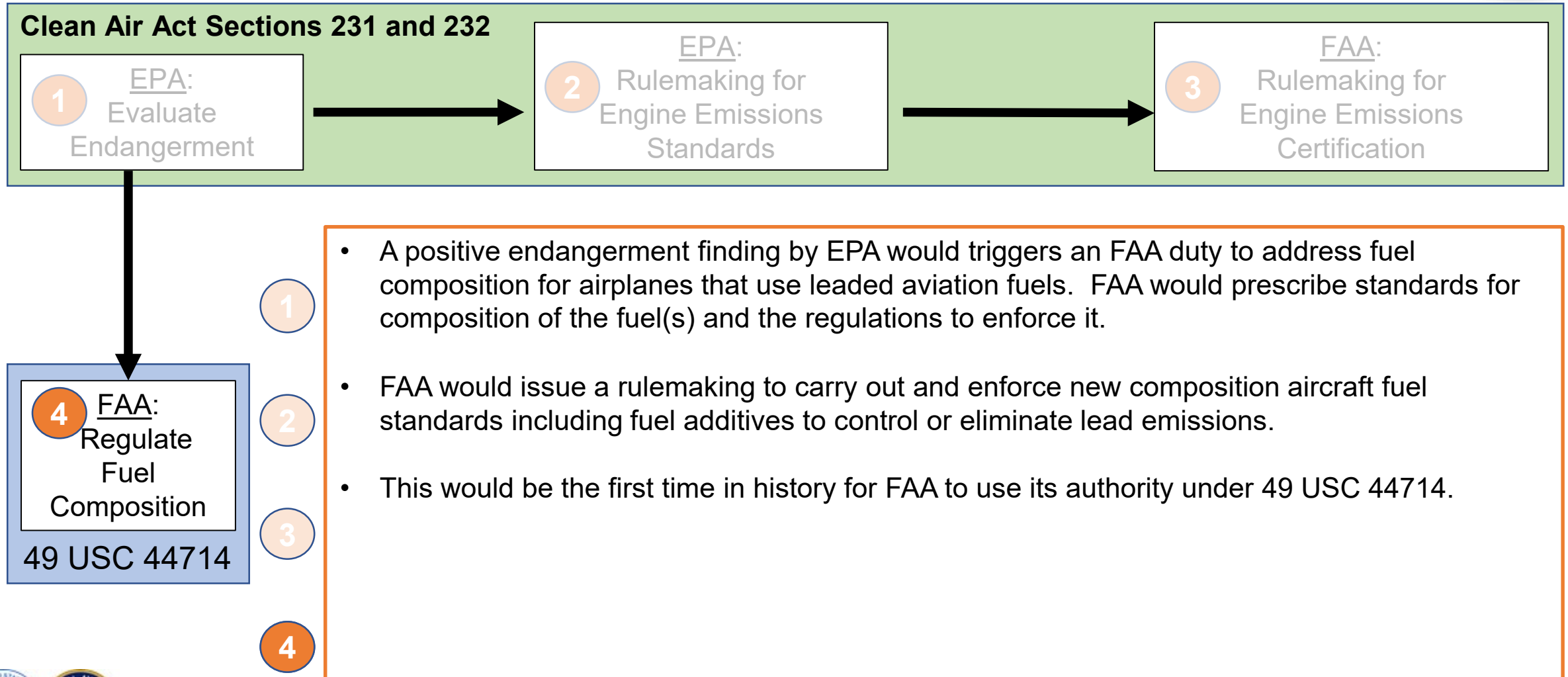
- Any subsequent regulatory action would involve EPA and FAA working together and carefully considering technology, safety, noise, and economic impacts, including effects on small businesses
- The potential rulemaking process for emission standards would provide opportunities for industry, NGOs, and other interested parties to provide their input through public review and comment
- EPA has authority to set emission standards for new and in-use aircraft engines
- Engine emission standards must not cause a significant increase in noise and adversely affect safety, and shall take effect after such period as necessary to permit the development and application of the requisite technology, giving appropriate consideration to the cost of compliance within such period

EPA & FAA Authorities Regarding Aircraft Lead (Pb) Emissions



- Were the EPA to finalize a rulemaking to establish standards for engine lead emissions, FAA would subsequently issue a rulemaking to prescribe certification regulations that ensure compliance with emission standards EPA promulgates.
- This is a common regulatory process between both Agencies that has resulted in the current regulations covering criteria and greenhouse gas pollutants.

EPA & FAA Authorities Regarding Aircraft Lead (Pb) Emissions



- A positive endangerment finding by EPA would triggers an FAA duty to address fuel composition for airplanes that use leaded aviation fuels. FAA would prescribe standards for composition of the fuel(s) and the regulations to enforce it.
- FAA would issue a rulemaking to carry out and enforce new composition aircraft fuel standards including fuel additives to control or eliminate lead emissions.
- This would be the first time in history for FAA to use its authority under 49 USC 44714.

Regulation, Policy, and Programmatic Activities

Potential programs regarding technology solutions

Potential FAA Programs Under EAGLE

- NASEM recommendation: “FAA initiatives, including collaborations with industry and other government agencies such as NASA should be used to promote the development, testing, and certification of safe and environmentally desirable lead-free emerging propulsion systems.”

- FAA Research & Development opportunities
  - Create Government/Industry financial partnerships with:
  - Original Equipment Manufacturers (OEMs) to
    - Develop no-lead technologies
    - Develop engine retrofit options
    - Develop engine swap options
  - Fuel manufacturers to develop sustainable fuel options
- Conduct engine emissions testing
- Flight schools transition to unleaded fuels

ASCENT Center of Excellence

For 18 years, FAA Office of Environment and Energy has relied on university centers of excellence to:

- Provide knowledge to inform decision making on environment and energy matters;
- Enable the introduction of innovative solutions to cost-effectively mitigate the environmental impacts of aviation; and
- Support the instruction of hundreds of professionals with knowledge of the environmental challenges facing aviation

ASCENT Research Portfolio

- In 2013, the FAA established ASCENT to conduct research on environment and alternative jet fuels
- Portfolio covers broad range of topics on alternative jet fuels, emissions, noise, operations, and analytical tools
- Over 80 research projects with over $1.5M annual budget

For more information: https://ascent.aero/

Lead Universities:
Washington State University (WSU)
Massachusetts Institute of Technology (MIT)*

Core Universities:
Boston University (BU)*
Georgia Institute of Technology (Ga Tech)*
Missouri University of Science and Technology (MS&T)*
Oregon State University (OSU)
Pennsylvania State University (PSU)*
Purdue University (PU)*
Stanford University (SU)*
University of Dayton (UD)
University of Hawaii (UH)
University of Illinois at Urbana-Champaign (UIUC)*
University of North Carolina at Chapel Hill (UNC)*
University of Pennsylvania (UPenn)*
University of Tennessee (UT)
University of Washington (UW)

Multiple international partners

Advisory Committee (57 orgs)
5 airports
4 airlines
9 NGO/advocacy
8 aviation manufacturers
10 feedstock/fuel manufacturers
21 R&D, service to aviation sector

ASCENT Support
Federal Aviation Administration
Transport Canada
NASA
Environmental Protection Agency
Defense Logistics Agency - Energy
U.S. Dep't of Energy
U.S. Dep't of Agriculture
Air Force Research Laboratory

FAA COE research requires 100% cost share. This has led to significant collaboration among universities, industry, and international research programs

Example: Continuous Lower Energy, Emissions, & Noise (CLEEN) Program

- FAA-led public-private partnership with 100% cost share from industry
- Reducing fuel burn, emissions and noise via aircraft and engine technologies and alternative jet fuels
- Conducting ground and/or flight test demonstrations to accelerate maturation of certifiable aircraft and engine technologies

For more information on CLEEN Program: http://www.faa.gov/go/cleen

	Phase I	Phase II	Phase III
Time Frame	2010-2015	2016-2020	2021-2026
FAA Budget	~$125M	~$100M	~$100M+
Noise Reduction Goal	25 dB cumulative noise reduction cumulative to Stage 5 and/or reduces community noise exposure (new goal for Phase III)		
Fuel Burn Goal	33% reduction	40% reduction	-20% re: CAEP/10 Std.
NO_X Emissions Reduction Goal	60% landing/take-off NO_X emissions (re: CAEP/6)	75% landing/take-off NO_X emissions (-70% re: CAEP/8)	
Particulate Matter Reduction Goal	-	-	Reduction relative to CAEP/11 Std.
Entry into Service	2018	2026	~2031

Transitioning Flight Schools to UL Avgas – Considerations

Aircraft
- Fleet mix
- Existing STCs / Service Bulletins or Service Instructions

Infrastructure & Logistics
- Fuel availability
- Fuel storage facilities
- Fueling procedures
- Volume of fuel used

Overarching Considerations
- Safety protocols
- Costs
- Education & training
- Stakeholder coordination

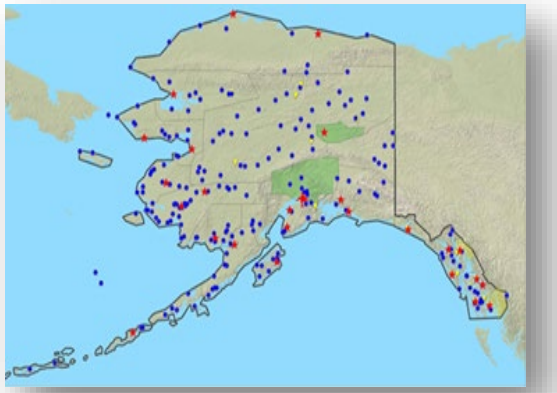
Regulation, Policy, and Programmatic Activities

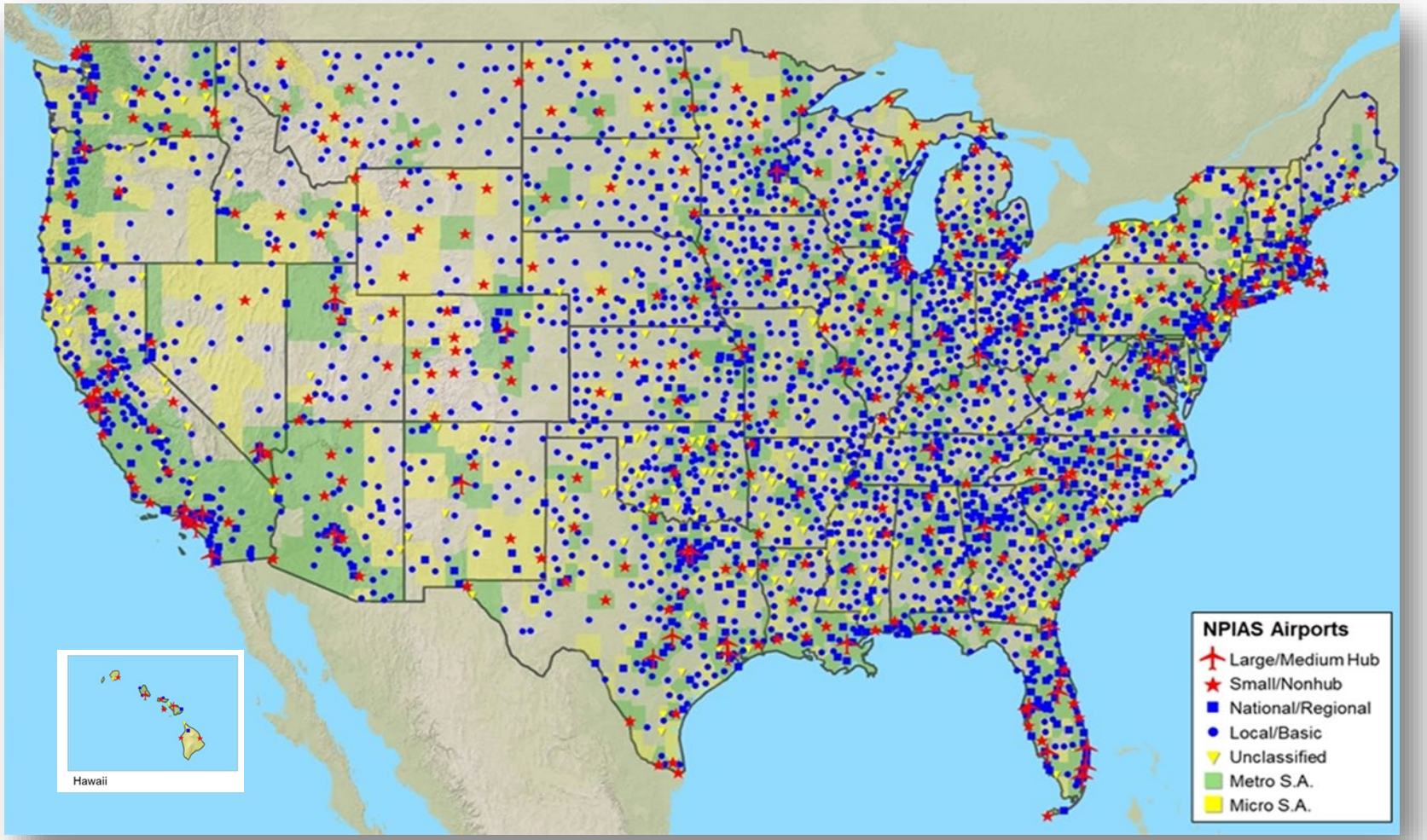
Airport Context and Activities

Airport Context and Activities

- Airport Context
- Airport Fuel Infrastructure
- Transition-enabling Infrastructure
- Guidance Updates
- Immediate Actions

Airport Context





3,304 NPIAS airports*

- 396 Primary
- 2,908 Non-Primary (GA)

(*Source: 2021-2025 NPIAS)

Airport Fuel Infrastructure Context

Airport Activities

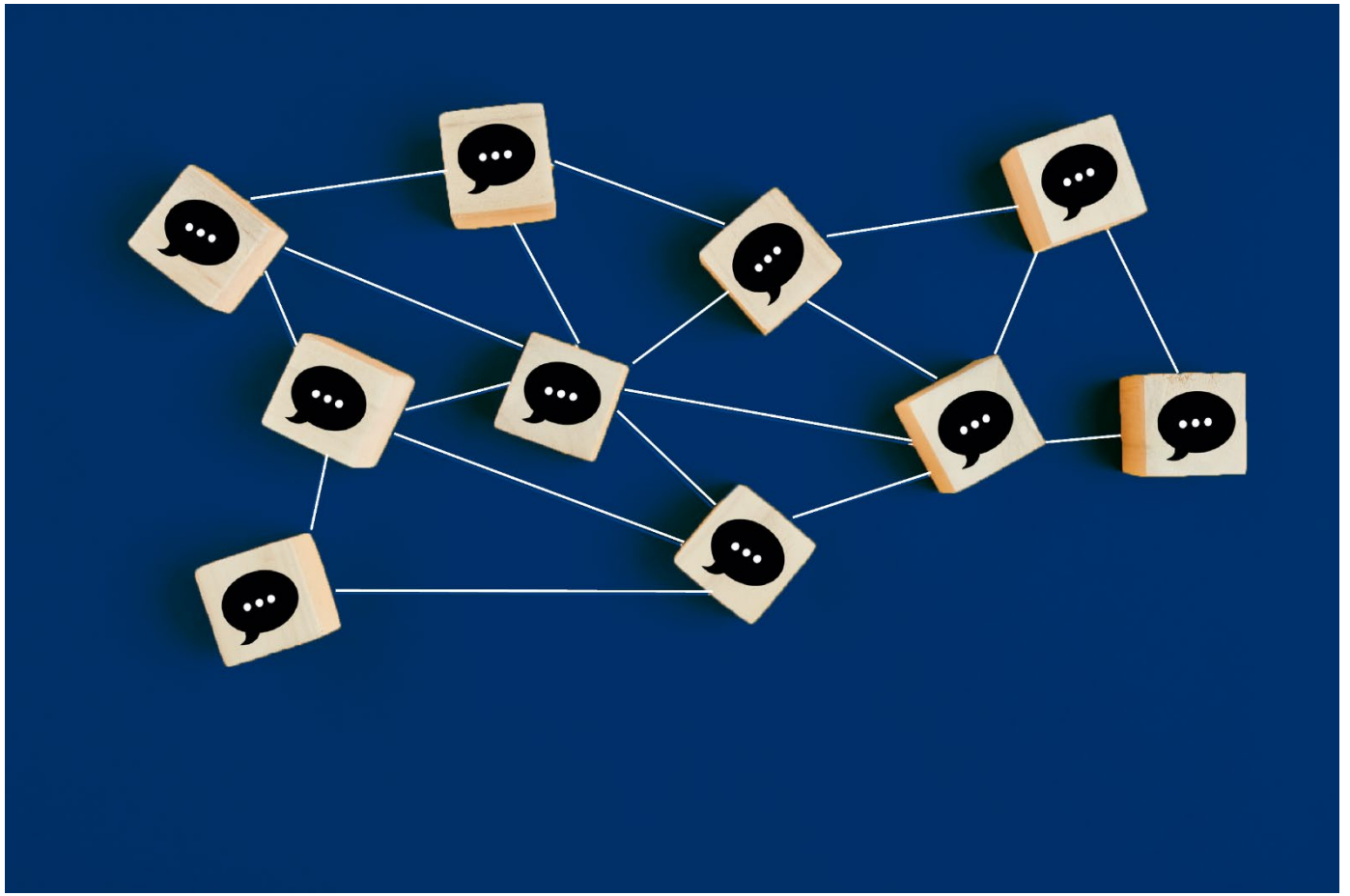
- Transition-enabling Infrastructure
  - The FAA is authorized to provide limited grant funding for aircraft fueling systems (fuel farms)
    - Help certain Non-Primary (General Aviation) airports become self-sufficient through fuel sales
    - Increase efficiency at certain commercial service airports and reduce fuel truck emissions
  - Need to support multiple fuel types to implement EAGLE and transition to a lead free future

- Guidance Updates
  - The FAA has already made updates to draft guidance in response to NAS recommendations
    - Documented that engine run-ups can contribute to lead concentrations near run-up areas and provides recommendations (AC 5300-13B, *Airport Design*)

- Immediate Actions (in alignment with NAS recommendations)
  - Airport owners / operators and pilots can implement simple mitigation measures
    - Increase distance between pre-flight / maintenance run-up locations and people on and off airport
    - Consider wind direction in run-up area choice
    - Post “exhaust fume” warning signs
    - Minimize engine idle time and run-up time
    - Promote airport and pilot awareness

Thank You!

Discussion



Unleaded Fuel Evaluation and Authorization

Presented by: Maria DiPasquantonio

FAA Aircraft Certification
Alternative Fuels Program

EAGLE Pillars

Supply Chain Infrastructure & Deployment

Research, Development, and Innovation

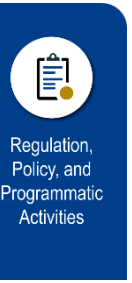
Unleaded Fuel Evaluation and Authorization

Regulation, Policy, and Programmatic Activities

Discussion Objectives

- Build **shared awareness and understanding** among participants of:
  - The Piston Aviation Fuels Initiative (PAFI) and its relationship to the fleet authorization process
  - Fuel Authorization Paths: PAFI and STC
  - Status of current PAFI and fleet authorization efforts
  - How PAFI fits into the EAGLE framework
- Provide an opportunity for **open dialogue**

Key NASEM Recommendation for Unleaded Fuel Evaluation & Authorization



(6.1) Provide viable unleaded replacement fuels through PAFI

(5.2) Encourage greater use of available unleaded fuels

(6.2) New certified aircraft operate on unleaded fuel

(6.2) New production aircraft operate on unleaded fuel

(6.2) R&D for modifications to existing aircraft for available UL avgas

(6.3) Promote non-gas powered options for GA aircraft

(5.1) Promote production and use of 100VLL

(5.3) Increased availability of existing grades of UL avgas (UL91/UL94)

Unleaded Aviation Gasoline Roadmap Framework

	Current State	Focus Areas	Future State
Unleaded Fuel Evaluation and Authorization	No current unleaded fuel qualifies as a drop-in replacement for 100LL avgas	**Piston Aviation Fuels Initiative (PAFI)**	Qualified drop-in unleaded fuels available
Regulation, Policy, and Programmatic Activities	Type certification required for engines and aircraft to use different fuels	**Streamlined approval process**	Non-traditional fleet wide approval process
Supply Chain Infrastructure & Deployment	Unleaded fuels are not widely available at airports	**Improve fuel infrastructure / UL options**	Multiple unleaded fuels are available
	Engines and aircraft do not satisfactorily operate with fuels less than 100 octane	**Engine/aircraft modifications**	All aircraft and engines can use unleaded fuel
Research, Development, and Innovation	Engines and aircraft do not satisfactorily operate with fuels less than 100 octane	**Engine replacement – technology**	All aircraft and engines can use unleaded fuel

Unleaded Fuel Evaluation and Authorization

Presented by: Tim Owen
FAA Aircraft Certification
Alternative Fuels Program

PAFI: The Foundation of UL Fuel Evaluation & Authorization: Unique Aspects

- **Focus** – Identify safe unleaded replacement fuels for 100 Low Lead
- **Approach** – Government and industry partnership
  - Relies on **partnership** expertise and resources
    - FAA William J. Hughes Technical Center
    - In-kind resources
  - Utilizes **non-traditional certification** means (the fleet authorization process)
  - **Collaborates** across government and industry
    - Consensus specification development – fuel production and quality control
    - PAFI Steering Group Management
    - Technical Advisory Committee
  - Engages aviation community through ongoing, open dialogue

PAFI
FAA / INDUSTRY COLLABORATIVE PROGRAM

PAFI Fuel Evaluation & Fleet Authorization Process

FUEL TESTING

FUEL EVALUATION & APPROVAL

FUEL AUTHORIZATION (OTHER THAN TRADITIONAL MEANS)

PSG
PAFI Steering Group

AOPA, EAA, Federal Aviation Administration, GAMA, NATA, NBAA

TAC
Technical Advisory Committee

Afton Chemical, bp, Continental, Cirrus Aircraft, EPIC, Calumet, Chevron, Lycoming, Mooney, Cape Air, ExxonMobil, Rotax, Piper, National Research Council Canada, Ethyl, Air Repair Inc., Commemorative Air Force, McCauley, Cessna, Beechcraft, haltermann solutions, Shell, Everts Air, innospec, Swift Fuels, Hartzell, Robinson, Federal Aviation Administration, MEGGiTT, DIXIE SERVICES, lyondellbasell, TotalEnergies, Enstrom, PRECISION AIRMOTIVE, ASTM International

PAFI Engagement Channel: PAFI Steering Group (PSG)

Federal Aviation Administration

Consensus Building: PAFI Technical Advisory Committee (TAC)

Fuel Components

Afton Chemical – Passion for Solutions

Calumet Specialty Products Partners, L.P.

Ethyl Corporation

haltermann solutions

innospec

lyondellbasell – Advancing Possible

Fuel Producers

bp

Chevron

ExxonMobil

lyondellbasell – Advancing Possible

Phillips 66

Shell

Swift Fuels

TotalEnergies

Engine & Propeller OEMs

AR Air Repair, Inc.

Continental Aerospace Technologies

Lycoming

Rotax

Hartzell Propeller Inc.

McCauley

MEGGITT

Precision Airmotive

Aircraft OEMs

Cirrus Aircraft

Mooney – We Love To Fly. Fast.

Piper – Freedom of Flight

Cessna – Beechcraft – By Textron Aviation

Robinson Helicopter Company

Enstrom Helicopter Corporation

Fuel Distributors

AVFUEL

EPIC Fuels

Government Agencies

Transports Canada / Transport Canada

National Research Council Canada – Canada's largest federal research and development organization

Federal Aviation Administration

Fleet Operators

Cape Air – We're Your Wings

Commemorative Air Force

Everts Air

Technical Support

Dixie Services – Old Fashioned Reliability

ASTM International – Helping our world work better

Critical Elements for Fleet Authorization Identified by PAFI

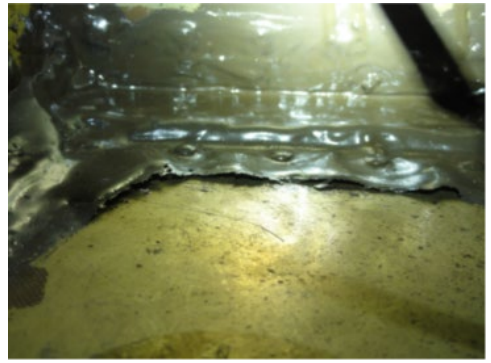
- Differences between ASTM D910 100LL and drop-in replacement UL fuel must be minimized and fully examined for the following **physical properties**:
  - Fuel Density
  - Aromatics Concentration
  - Materials Compatibility
  - Distillation Curve
  - Net heat of combustion
  - Freezing point
- **Detonation / durability** characteristics are equivalent or better than 100LL
- Confidence level is raised after fuels pass **initial** detonation, performance, durability, and materials compatibility **testing**
- Replacement UL fuel eliminates harmful lead in current 100LL

PAFI Engine Durability Issues

Deposits leading to premature engine durability issues

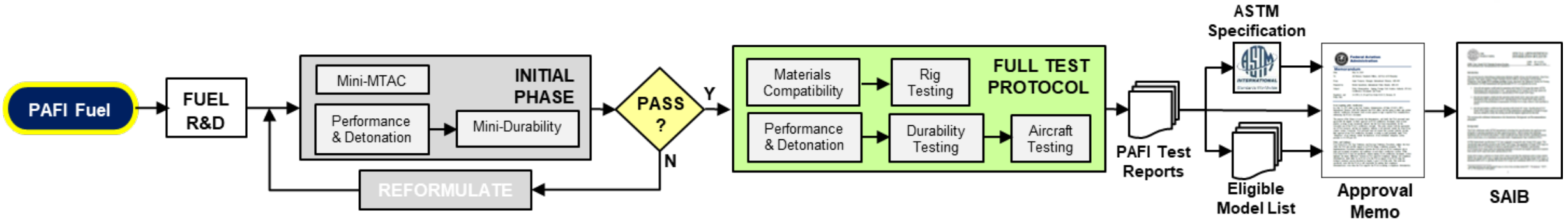
PAFI Materials Compatibility Challenges

Fuel tank and sealant compatibility



Paint and primer compatibility

Piston Aviation Fuels Initiative (PAFI) Update



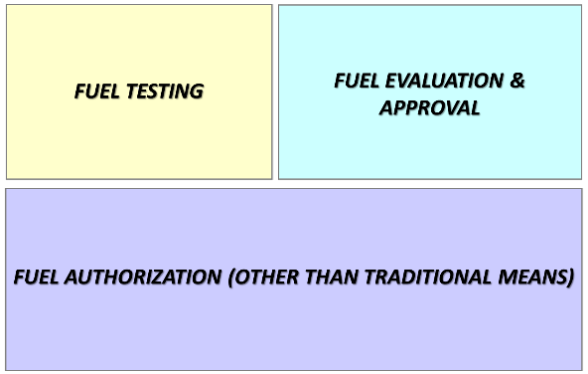
26

Fuel A Completed initial performance & detonation testing
Ready for mini-durability initial testing

Fuel B Completed R&D testing to optimize the formula for PAFI program
Ready for initial performance & durability testing

Two Paths to Fuel Authorization

Fleet Authorization per Section 565(a)(3)
Process other than traditional means of certification



PAFI per Section 565 (a)(3) → **Fleet Approvals**

TC, ATC or STC per Section 565(c)
Existing, normal certification processes

TC, ATC or STC per Section 565 (c) → **Engine/Aircraft Approvals**

2018 FAA Reauthorization Act, Section 565

SEC. 565. AVIATION FUEL.

(a) Use of Unleaded Aviation Gasoline. – The Administrator shall allow the use of an unleaded aviation gasoline in an aircraft as a replacement for a leaded gasoline if the Administrator—

1) determines that the unleaded aviation gasoline **qualifies as a replacement** for an approved leaded gasoline;

2) **identifies the aircraft and engines that are eligible** to use the qualified replacement unleaded gasoline; and

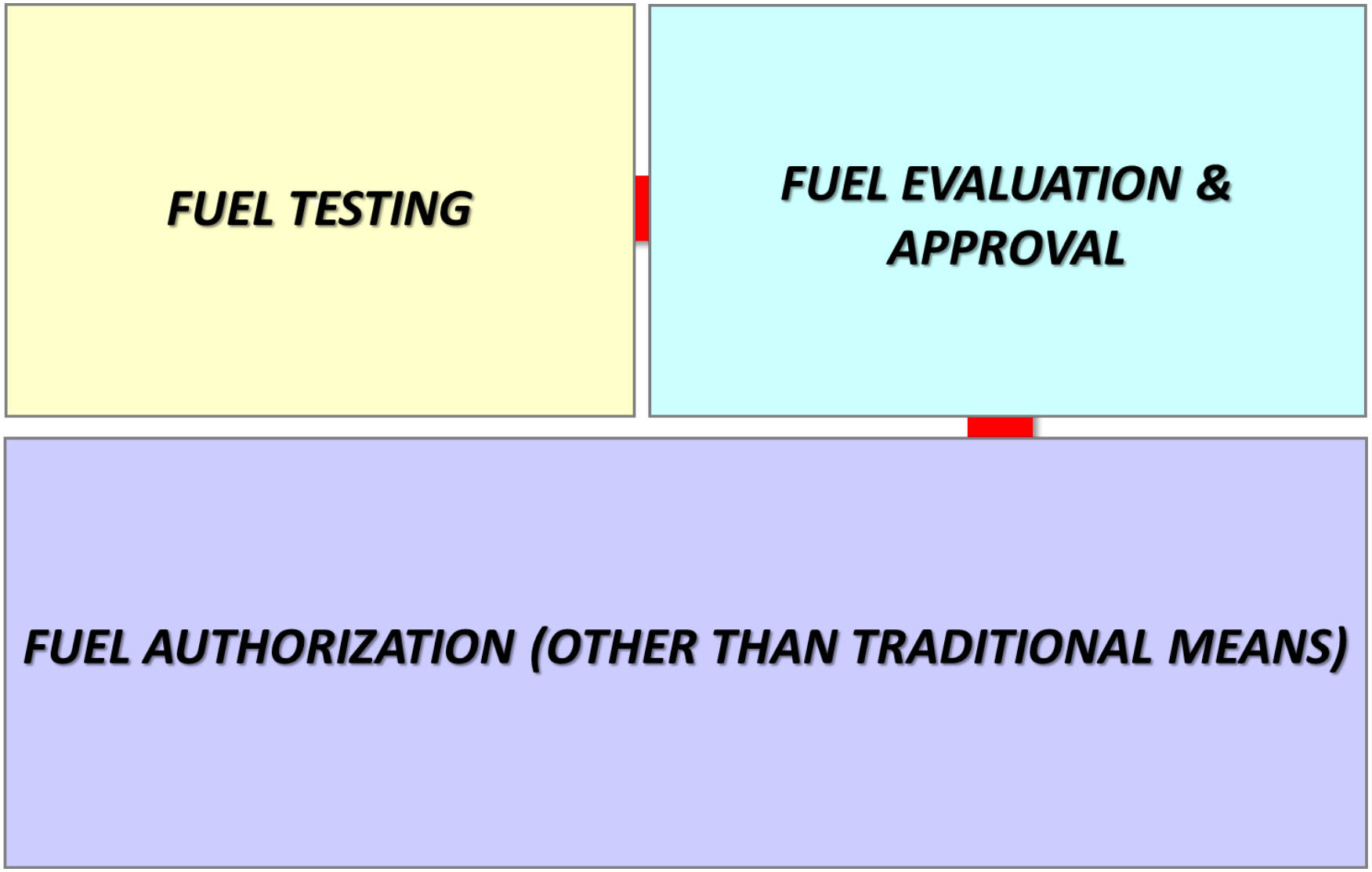
3) **adopts a process (other than the traditional means of certification**) to allow eligible aircraft and engines to operate using qualified replacement unleaded gasoline in a manner that ensures safety.

(b) Timing. – The Administrator shall adopt the process described in subsection (a)(3) not later than 180 days after the later of—

1) the date on which the Administration **completes the Piston Aviation Fuels Initiative**; or

2) the date on which **the American Society for Testing and Materials publishes a production specification** for an unleaded aviation gasoline.

Fuel Evaluation and Fleet Authorization Process



Fuel Authorization via STC – per Section 565 (c) – Traditional Path

SEC. 565. Aviation fuel.

(c) **Type Certification**.— Existing regulatory mechanisms by which an unleaded aviation gasoline can be approved for use in an engine or aircraft by **Type or Supplemental Type Certificate** for individual aircraft and engine types or by **Approved Model List Supplemental Type Certificate** providing coverage for a broad range of applicable types of aircraft or engines identified in the application shall continue to be fully available as a means of approving and bringing an unleaded aviation gasoline into general use in the United States. Such approvals shall be issued when the Administrator finds that the aircraft or engine performs properly and **meets the applicable regulations and minimum standards under the normal certification process.**

United States of America
Department of Transportation
Federal Aviation Administration

Supplemental Type Certificate

Number: SA01757WI

TC, ATC or STC per Section 565(c)
Existing, normal certification processes

Current Unleaded Fuels Authorized through STC Process

- **Existing Aviation Gasolines**
  - 82UL - STC
  - UL91
  - UL94 - STC
  - GAMI GI00UL - STC
  - Swift Fuels 100R - STC under development
- **Automotive Gasoline used for Aviation**
  - Petersen Aviation STC
  - EAA STC
- **Ethanol Fuel for Aviation (never commercialized)**
  - Baylor University STC
  - AGE-85

Benefits of Fuel Authorization – Both Pathways

- Immediate reduction of Pb in the environment from aviation gasolines
- Improved environmental stewardship
- Discovery of unanticipated issues
- Partial mitigation of state and local issues
- Evolution of production and distribution systems for unleaded fuels

PAFI Fleet Authorization per Section 565 (a), (b)

PAFI SECTION 565 (a), (b) IMPLEMENTATION

ELIGIBLE FLEET AUTHORIZATION

FUEL TESTING

SEC. 565 (a)(1)

PAFI Test Protocol

FAA WJHTC

PAFI Testing

Test Reports

ASTM Specification Development

FUEL EVALUATION & APPROVAL

SEC. 565 (a)(2)

FAA Determination of Transparent Fleet
- Fleet Eligibility -

Issued ASTM Specification

SEC. 565 (b)(2)

FAA Issues Eligible Fleet Summary and Supporting Data Report to AIR & FS

FUEL AUTHORIZATION (OTHER THAN TRADITIONAL MEANS)

SEC. 565 (a)(3)

Implementation of Minor Alteration for Each Aircraft / Engine

AVGAS ONLY

ASTM DXXXX UL100 | ASTM D7547 UL91 UL94 | ASTM D910 100VLL 100LL | ASTM D910 100

14 CFR Part 43

Each Owner/Operator of an Eligible Aircraft/Engine Configuration Processes Minor Alteration to Add Fuel Spec to AFM Ops Limitations and Placard

SEC. 565 (b)(1)

FAA Issues SAIB Communicating Use and Procedure for Minor Alteration for AFM and Placard Changes Logbook Entries

GAMA Updates Specification 3 for New Fuel Placards

FAA Issues Policy Memo to AIR & FS to Establish Approval Process Per Section 565 and Existing Processes

Establishing the Process: Policy Memo


Federal Aviation Administration

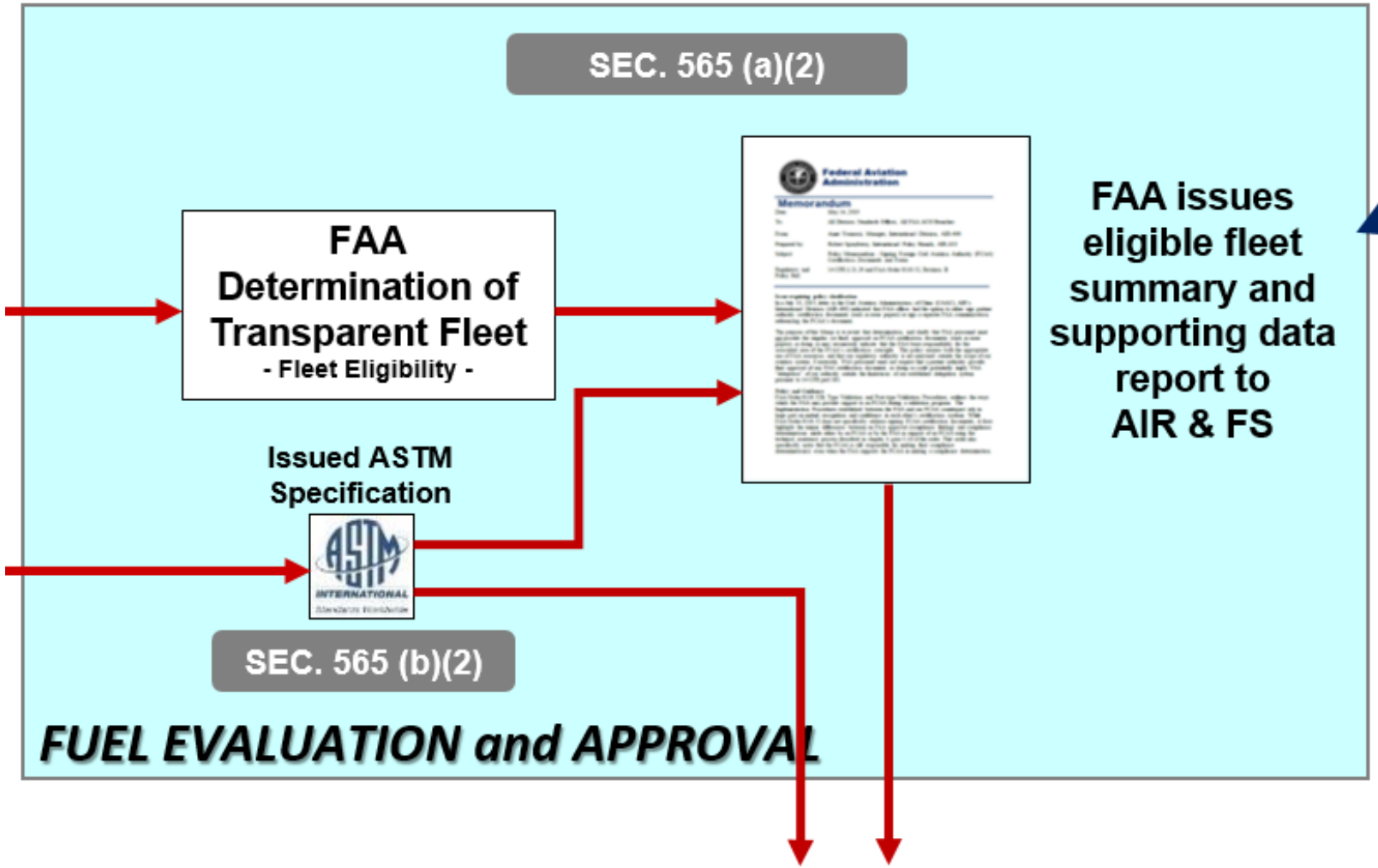
Memorandum

FAA issues policy memo to Aircraft Certification (AIR) & Flight Standards (FS) to establish non-traditional approval process per section 565

The FAA policy memo will:

- **Fully describe and document the fleet authorization process**
- **Be published in the Federal Register for public review and comment**

Fuel Evaluation & Approval



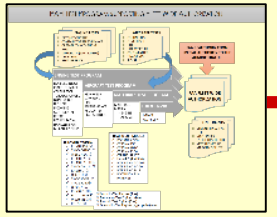
For each UL avgas, the eligible fleet summary will

- Identify the unleaded fuel by specification
- Identify the engine and aircraft models that are eligible to operate with the new fuel

Fuel Testing

SEC. 565 (a)(1)

PAFI
Test Protocol



FAA WJHTC

PAFI Testing

Test
Reports

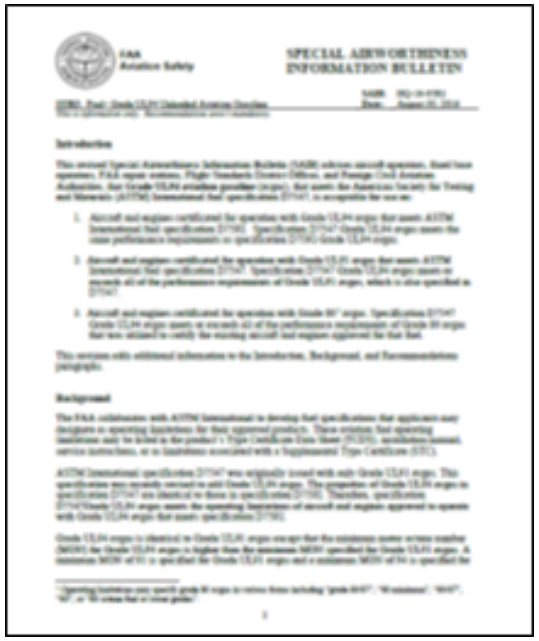
ASTM
Specification
Development

FUEL TESTING

Fuel Authorization (Other than Traditional Means)

Since our December discussion, the process has been simplified further and requires only a minor alteration by the owner/operator

The Communication Tool: SAIB



SPECIAL AIRWORTHINESS INFORMATION BULLETIN

FAA issues SAIB communicating use and procedure for alteration for AFM and placard changes

<u>For each UL avgas</u>, the Special Airworthiness Information Bulletin (SAIB) will provide:

- **Identification of the unleaded fuel by specification**
- **List of engine/aircraft models eligible to use the fuel**
- **Instructions to operators to complete the alteration process**
- **Aircraft Flight Manual Supplement (AFMS)**
- **Placard image & installation instructions**
- **Text for required logbook entries**

Initial Fleet Authorization of UL91 – Toward Unleaded Aviation Fuel Future

UL91 - no aircraft impacts and no materials compatibility issues

UL91 = 100LL *minus* TEL *minus* Blue Dye

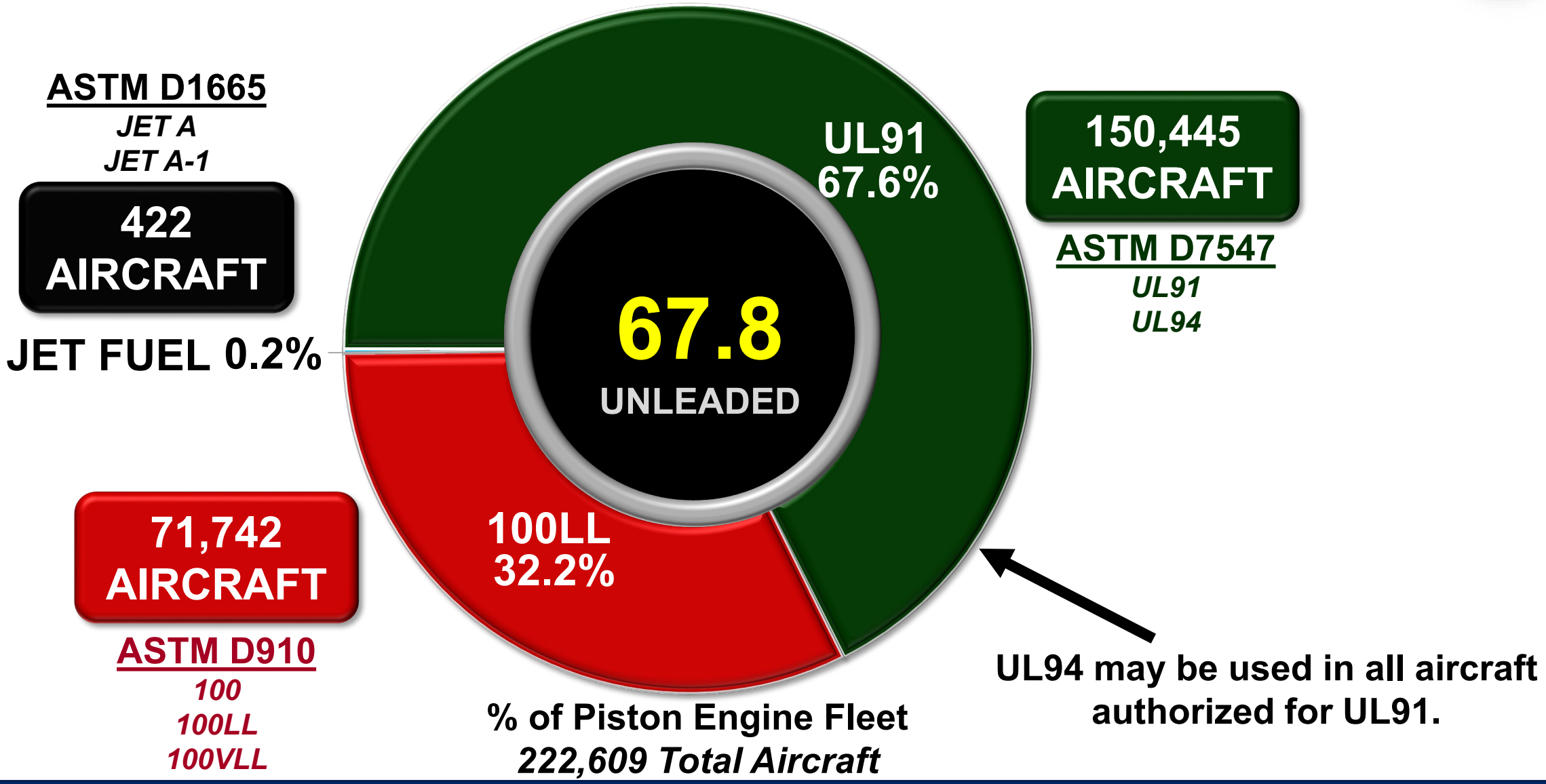
(All other physical properties are the same)

Compatible

Fuel MON determines detonation margin.

- No additional testing required
- No compatibility issues
- Initial use of Sec. 565 (a)(3) fleet authorization process
- UL94 may be used in all aircraft authorized for UL91

Fleet Authorization of UL91 Enables Unleaded Operation by 68.4% of Fleet



Desired Outcomes for Unleaded Fuel Evaluation & Authorization

- **Complete** PAFI test and evaluation of candidate replacement fuels for 100 Low Lead (100LL) aviation fuel
- **Identify** at least one unleaded fuel acceptable for widespread use
- **Institutionalize** fleet authorization process for unleaded fuels

Wrap Up

- **Testing** of candidate UL fuels is ongoing under the PAFI program
  - UL91 can be authorized for use by 67.6% of the current fleet of 222,609 aircraft
- **Two paths** to fuel authorization
- UL Fuel Evaluation and Authorization Pillar serves to enable other pillars
- **PAFI** is a foundational element of **EAGLE**

Additional Resources

Contact

Contact the FAA's Alternative Fuels Group: 9-AVS-AIR670-AVGAS@faa.gov

Note: Messages sent to this email address will be received by: Maria DiPasquantonio, Ansel James, Tim Owen, and Tia Cantrell

Useful Links

Final report of the Unleaded AVGAS Transition Aviation Rulemaking Committee (UAT ARC)

UAT-ARC Final Report (faa.gov) (https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/Avgas.ARC.RR.2.17.12.pdf)

UAT-ARC Final Report Part II Appendices (faa.gov) (https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/Avgas.ARC.RR.Appendix.2.17.12.pdf)

Section 565, Aviation Fuel, of the FAA Reauthorization Act of 2018 (Pub. L. 115-254)

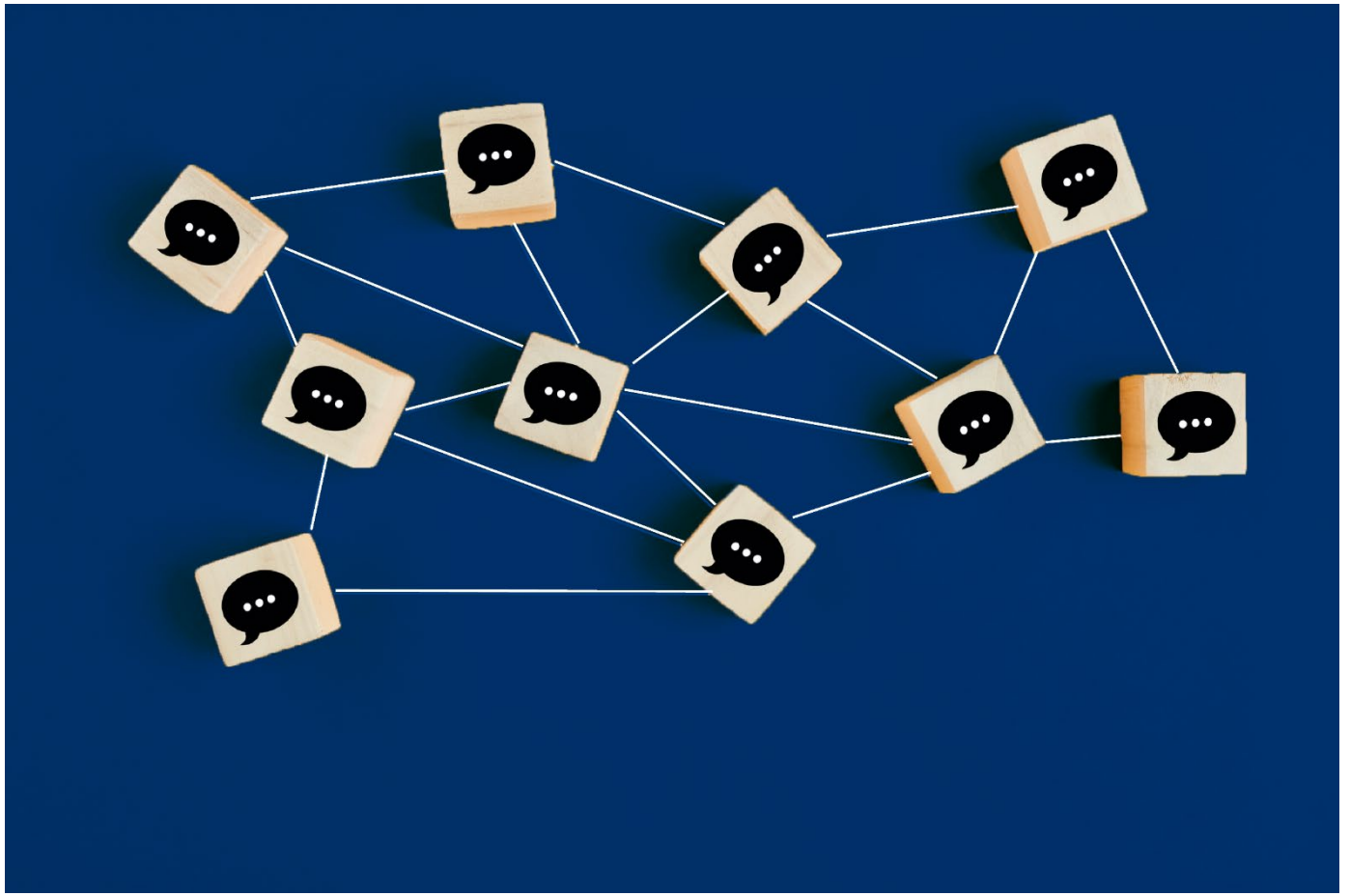
PUBL254.PS (house.gov) (https://uscode.house.gov/statutes/pl/115/254.pdf)

The National Academies Press, Options for Reducing Lead Emissions from Piston-Engine Aircraft

Options for Reducing Lead Emissions from Piston-Engine Aircraft | The National Academies Press (nap.edu) https://www.nap.edu/read/26050/chapter/1)

Thank You!

Discussion



Day 1 Wrap-Up

Path to a Lead-Free Aviation System

Author FAA/Industry Coalition

Date Wednesday, March 16 – Thursday, March 17, 2022

Day 2 Ramp-Up

Agenda Snapshot

Day 1: March 16

1000 – 1200	Opening Session
1200 – 1300	Lunch (Provided)
1300 – 1430	Regulation, Policy and Programmatic Activities Pillar Session
1430 – 1500	Break
1500 – 1630	Unleaded Fuel Evaluation and Authorization Pillar Session
1630 – 1700	Day 1 Wrap Up and Adjourn
1730 – 1930	Stakeholder Reception

Day 2: March 17

0930 – 1030	Business Fuel Infrastructure and Implementation Pillar Session
1030 – 1115	Research, Development, and Innovation Pillar Session
1115 – 1145	Break
1145 – 1230	EAGLE Next Steps
1230	Meeting Adjourns

This meeting is an industry-sponsored event. It is not intended to be a forum for providing consensus stakeholder advice or recommendation to the government; rather, we welcome individual perspectives on issues discussed.

Path to a Lead-Free Aviation System

Author FAA/Industry Coalition

Date Wednesday, March 16 – Thursday, March 17, 2022

Supply Chain Infrastructure & Deployment

Presented by: Prentiss Searles

EAGLE Pillars

Supply Chain Infrastructure & Deployment

Research, Development, and Innovation

Unleaded Fuel Evaluation and Authorization

Regulation, Policy, and Programmatic Activities

Summary

Supply Chain Infrastructure & Deployment

- Work will focus on:
  - supporting standards and regulatory pathways to market, for the qualification, production and deployment of new unleaded fuel(s)
  - supporting government incentive and policy programs to accelerate transition to new unleaded fuel(s)
  - Environmental, Social and Governance (ESG) outreach
- Throughout the transition to unleaded fuels, this pillar addresses the complexities of maintaining 100LL availability and safe deployment of new fuel(s) from the refinery to the wing.
- Includes education, training, awareness and outreach responsibilities.

Objectives

Supply Chain Infrastructure & Deployment

- Evaluate and support program(s) that incentivize fuel producers and distributors, aircraft and engine manufacturers, and GA operators to accelerate development, qualification, deployment, and use of unleaded fuels
- Facilitate policy proposals at the Federal and State level to increase production and distribution – as well as enable and encourage greater use – of commercially viable replacement unleaded fuel
- Facilitate government policy, regulatory proposals and voluntary consensus standards that will support a commercially viable supply chain and quality-focused infrastructure for the deployment of unleaded fuel, including the promotion of free-market competition
- Evaluate environmental, social, and governance (ESG) commitments to help engage additional organizations and investors in this effort
- Support policy and regulatory proposals for maintaining 100LL availability and airport access to ensure safety during the transition across the country for use by general aviation aircraft

Integration and Coordination

Deployment Guide

Deployment Teams

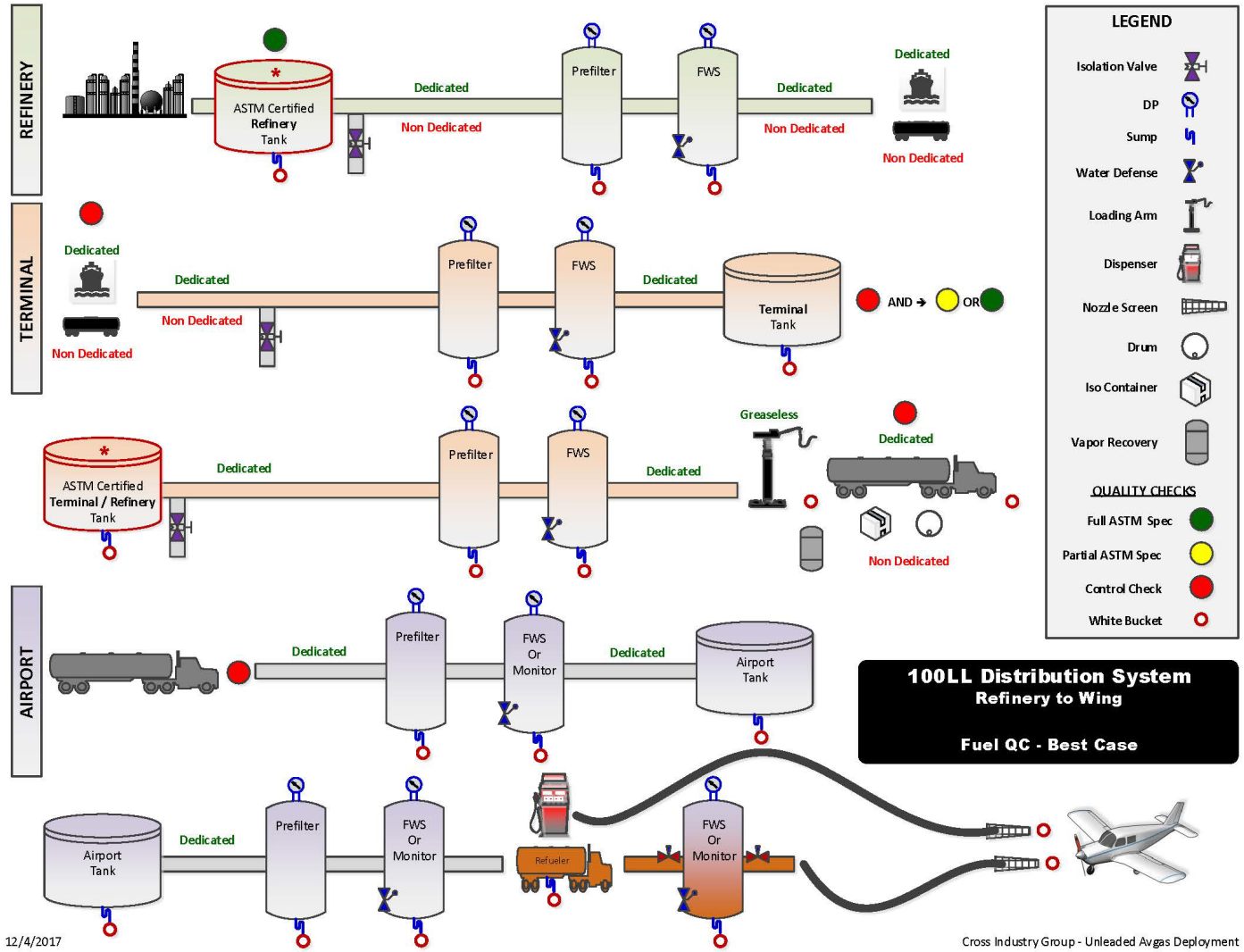
		Research, Development, and Innovation	Unleaded Fuel Evaluation and Authorization	Regulation, Policy, and Programmatic Activities
• Manufacturing Capability	☑			☑
• Distribution System	☑			☑
• Airports	☑			☑
• Aircraft Modifications	☑	☑	☑	☑
• Aircraft Fuels Regs. & Stds.	☑			☑
• Communication & Training	☑	☑	☑	☑
• State & Federal Legislative	☑		☑	☑
• International Communications	☑	☑		☑
• Safety Assurance	☑	☑	☑	☑

Approach

Supply Chain Infrastructure & Deployment

- Refinery to Wing
- Goal Oriented
- Pillar Coordination/Integration
- Stakeholder Engagement
- International Implications

100LL Distribution System



Infrastructure & Communication

Supply Chain Infrastructure & Deployment

- Develop Infrastructure Database
  - Refineries
  - Terminals
  - FBOs
  - Aircraft
  - Equipment
- Build Communication Channels

Supply Chain Infrastructure & Deployment

Why maintaining near-term 100LL availability is critical to flight safety – Mr. Doug Macnair (EAA)

Supply Chain Infrastructure & Deployment

Airport Infrastructure –
Mr. Robert Olislagers, AvInt, LLC (former CEO Centennial Airport)

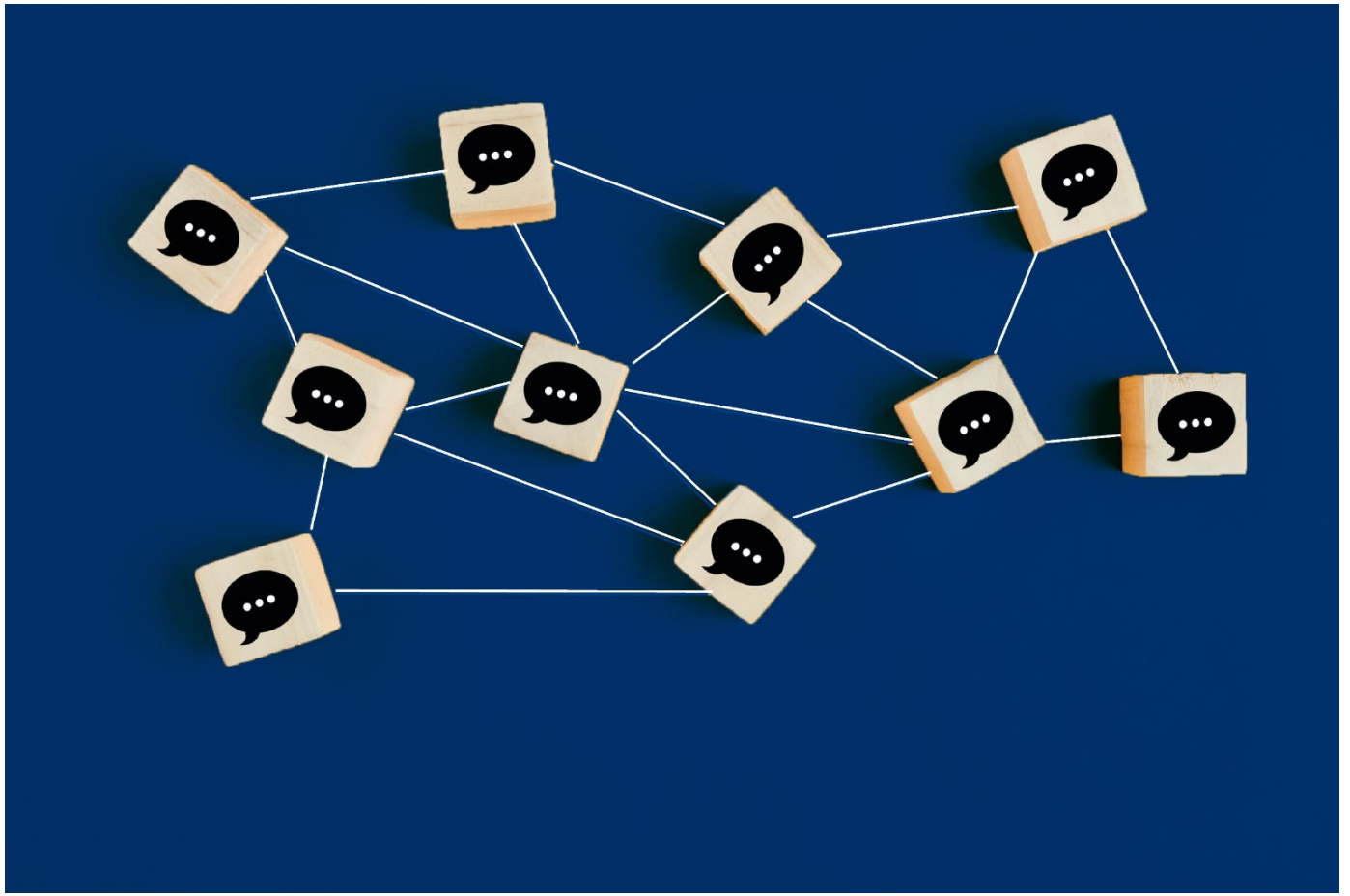
Airport Infrastructure

Supply Chain Infrastructure & Deployment

- Leaded Avgas Research Conducted at Centennial Airport
- Some of the Challenges Facing Airports While Transitioning to Unleaded Avgas

Thank You!

Discussion



Research, Development, and Innovation

Presented by: Walter Desrosier, GAMA

EAGLE Pillars

Supply Chain Infrastructure & Deployment

Research, Development, and Innovation

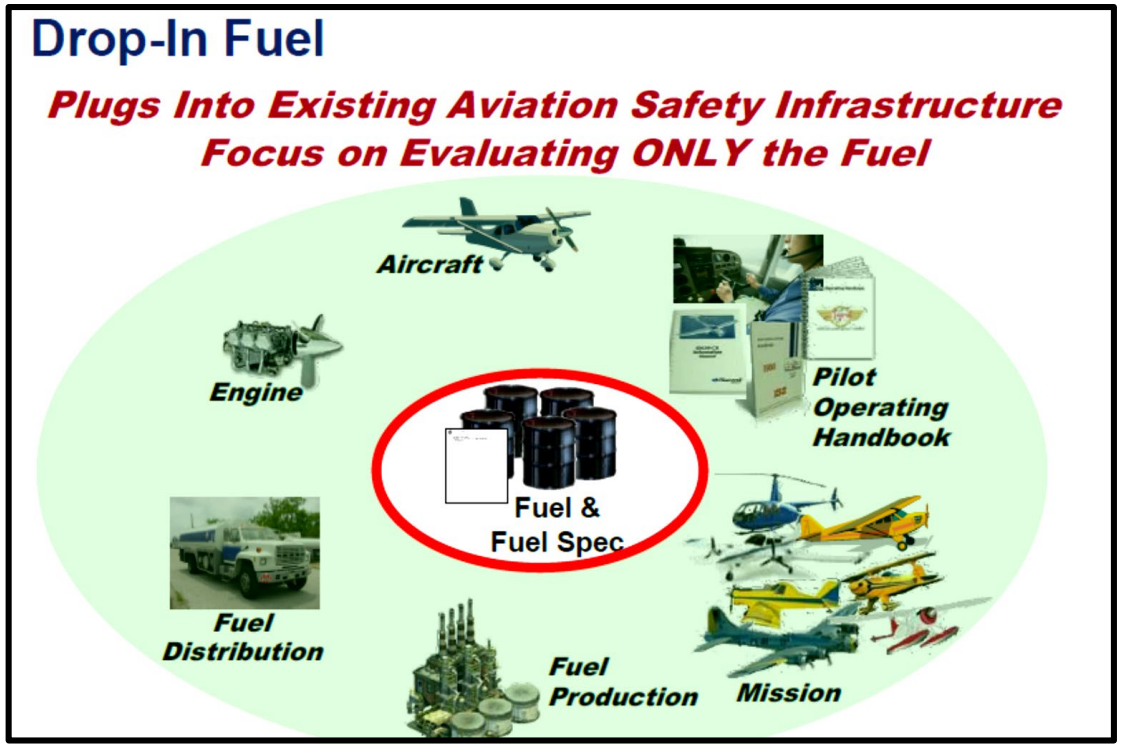
Unleaded Fuel Evaluation and Authorization

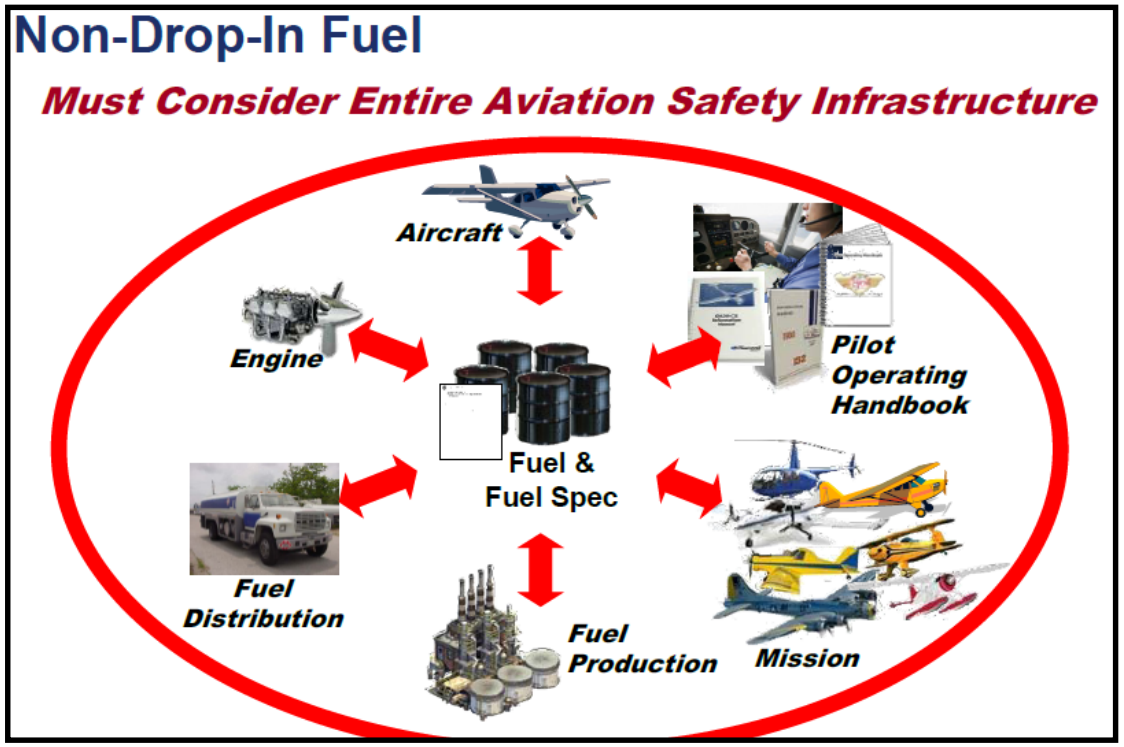
Regulation, Policy, and Programmatic Activities

Pillar B –Research, Development and Innovation

- **Facilitate Transition** to Unleaded Replacement Fuel by Mitigating Potential Impacts on Existing Fleet of Aircraft and Enabling Innovation
- **Address Safety and Technical Challenges** Associated with High-Performance Engine Use of Unleaded Fuels
  - Research and Testing of Advanced Technology Designs
- Focus on effective and timely **FAA certification**
- Includes **education, training, awareness, and outreach** responsibilities

R&D and Innovation: Pillar Interdependencies





R&D and Innovation: Pillar Interdependencies

Research & Development Across All Pillars and Stakeholders

Unleaded Fuel Evaluation and Authorization

- **Fuel Development**
- **Testing & Qualification**
- FAA Authorization / Approval

Business (Fuel) Infrastructure and Implementation

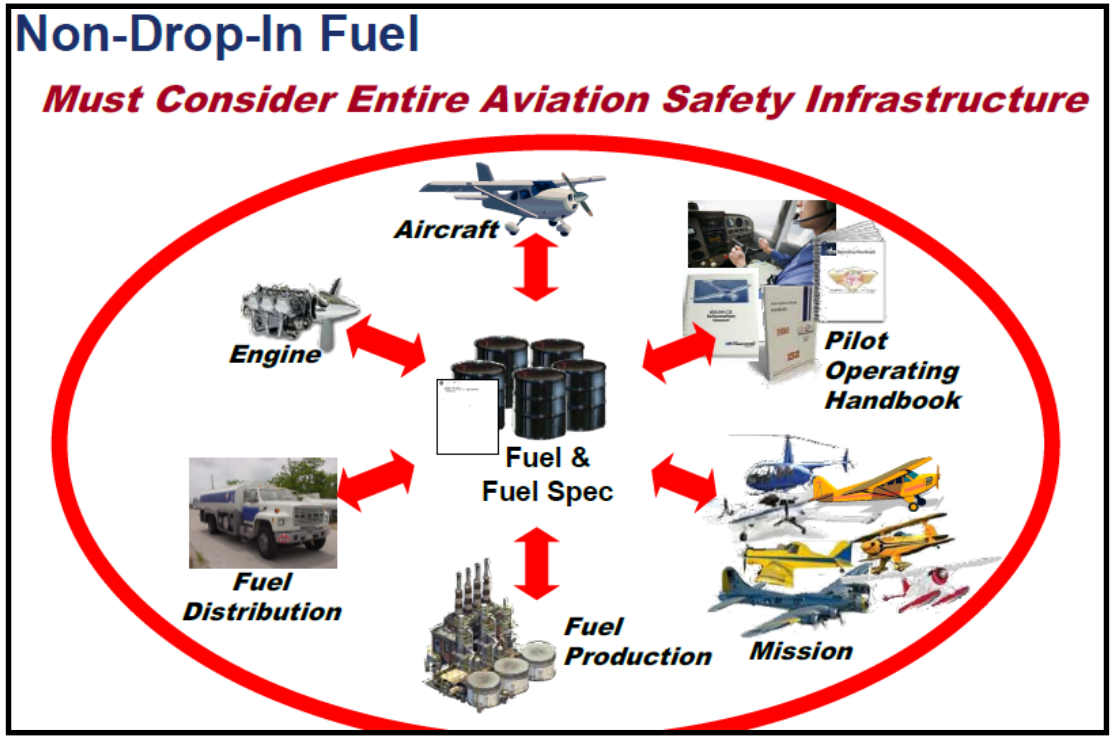
- Fuel Production & Distribution
- Business Aspects for Deployment

Research, Development, and Innovation

- Engine & Aircraft Technologies
- FAA Certification

Regulation, Policy, and Programmatic Activities

- Public Policy & Incentives
- Rulemaking



Facilitate Transition to Unleaded Replacement Fuel

Research, Development, and Innovation

- Mitigate potential impacts of unleaded fuel on existing fleet of aircraft
- Ensure continued safety of existing fleet of aircraft
- Facilitate product development and entry into service of new production and type design engine and aircraft
- Enable innovation

Research and Testing of Advanced Technology Designs

Research, Development, and Innovation

- FAA and Industry Collaboration on R&D and Testing of Advanced Technology & Design Concepts
- Address Safety and Technical Challenges Associated with High-Performance Engine Use of Unleaded Fuels - such as…
  - Octane detonation protection
  - Materials compatibility
  - Operational procedures
  - Engine monitoring
- Potentially Enable Existing Engines & Aircraft to Safely Operate Using Unleaded Replacement Fuel

Focus on Effective and Timely FAA Certification

- Potential Technology Solutions Requires FAA Certification
  - Deployment to broad range of make/model specific engine and aircraft
  - Incorporation into new production
  - Incorporation into future type design
- Collaborative FAA-Industry R&D and Innovation Must Include Consideration of Effective and Timely FAA Certification
  - Establishment of appropriate requirements
  - Evaluation of various acceptable means of compliance
  - Approval and authorization processes for efficient deployment

Planned PAFI Research and Development Activities

- FAA-identified **critical R&D** for unleaded fuel evaluation and authorization of unleaded fuels
- Close collaboration with R&D Pillar

R&D to Enable Greater Use of Lower-Outcome Unleaded Fuels

Propulsion Technology

NAS 6.3
UAT ARC 16

Aircraft / engine modifications to allow use of UL fuel with octane less than 100 for large part of the fleet

- Retarded / staggered ignition timing, reduce timing skew
- Electronic ignition / extended spark duration
- Higher pressure fuel injection systems
- Anti-detonation injection (ADI) systems (water / methanol)
- Electronic controls (EEC) AFR sensing, ignition, fuel
- Manifold air temperature reduction methods
- Cylinder head temperature reduction methods
- Turbo wastegate control improvements
- Detonation testing requirements evaluation
- Cooling climb requirements evaluation

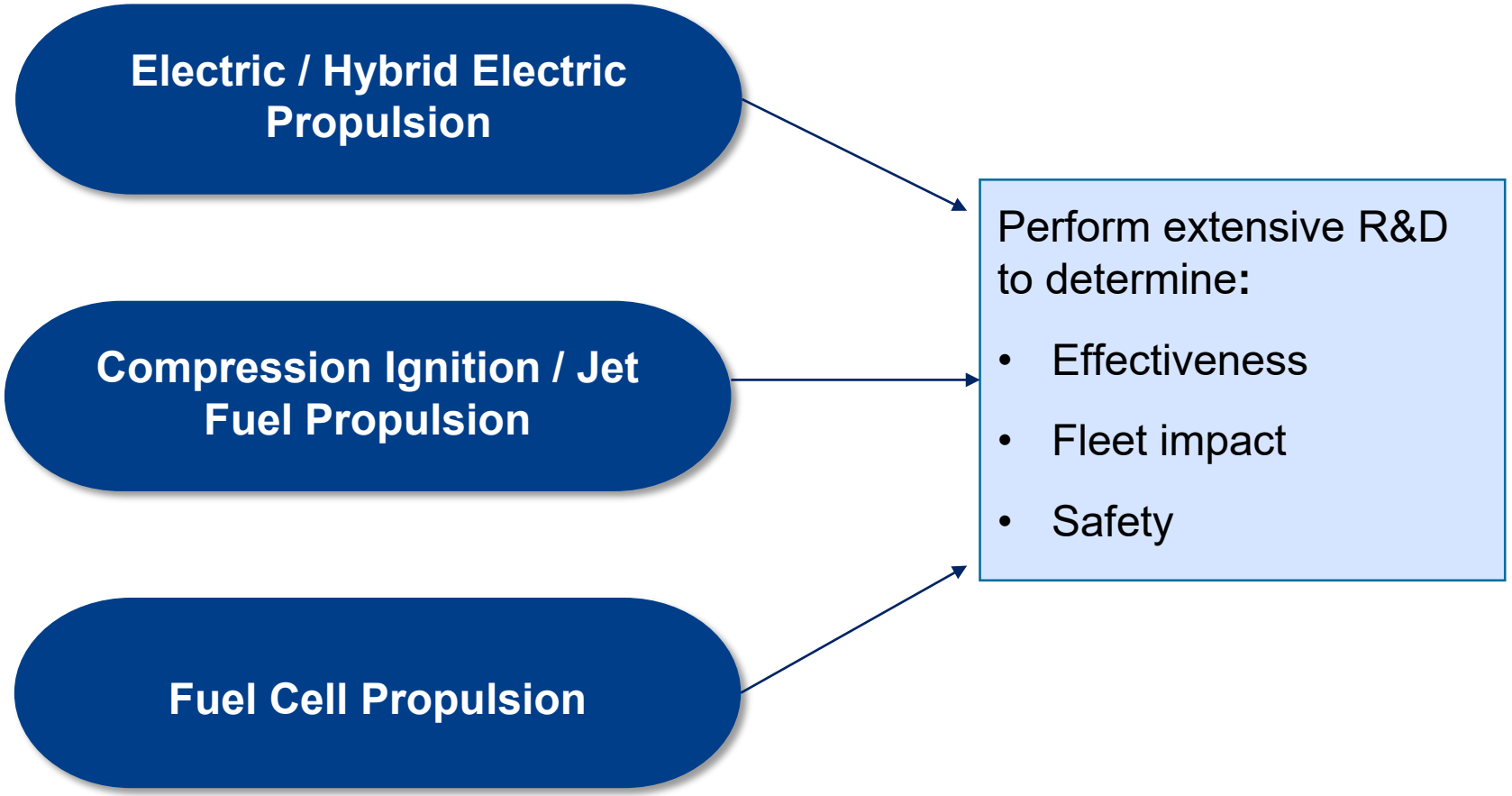
Extensive R&D effort to determine:

1. Quantify Effective Motor Octane Number (MON) Benefits
2. Assess Fleet Impacts
   Assess Safety Aspects

R&D of Alternate Propulsion Technologies

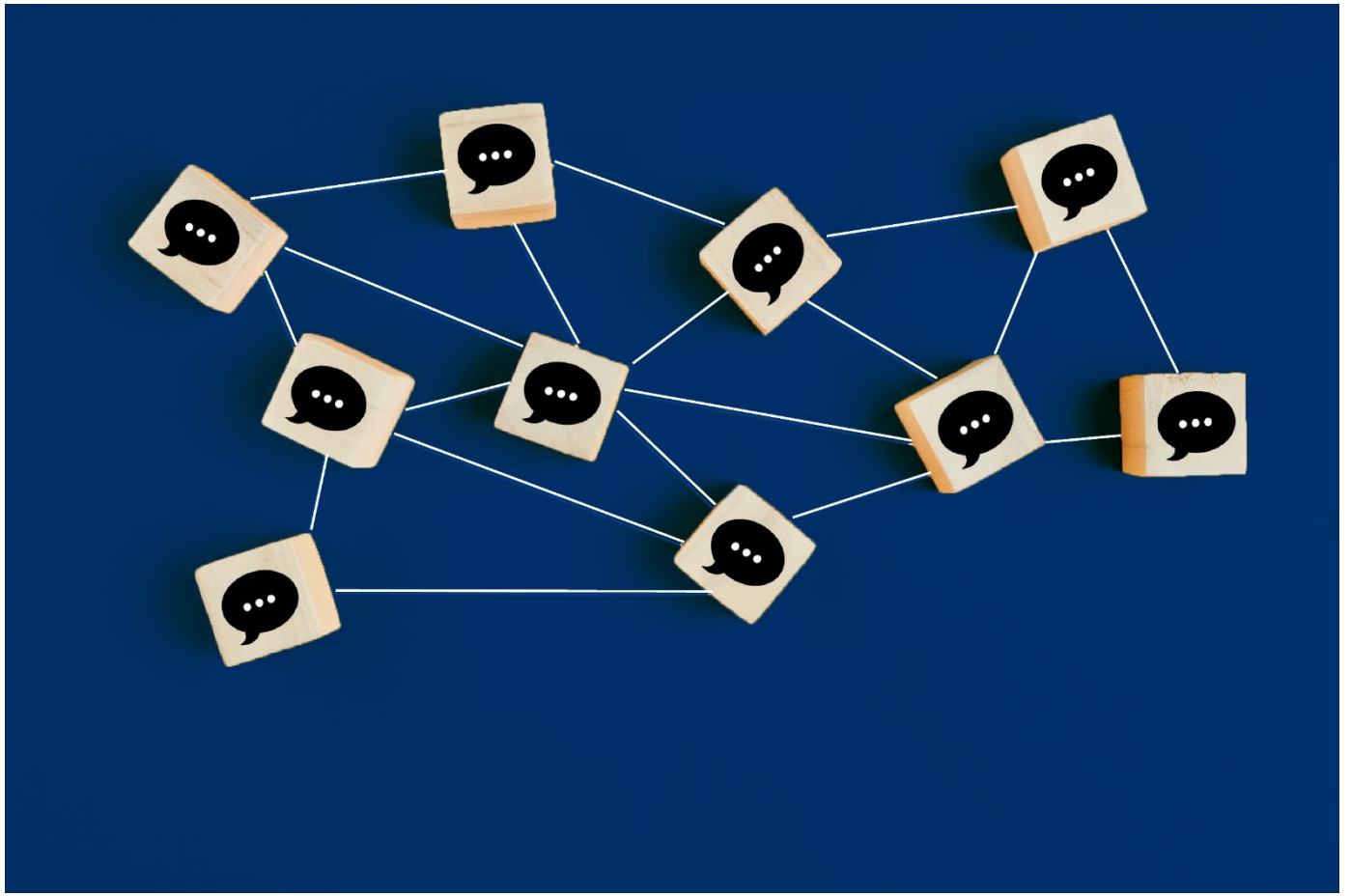
Other Propulsion Technologies

NAS 6.3

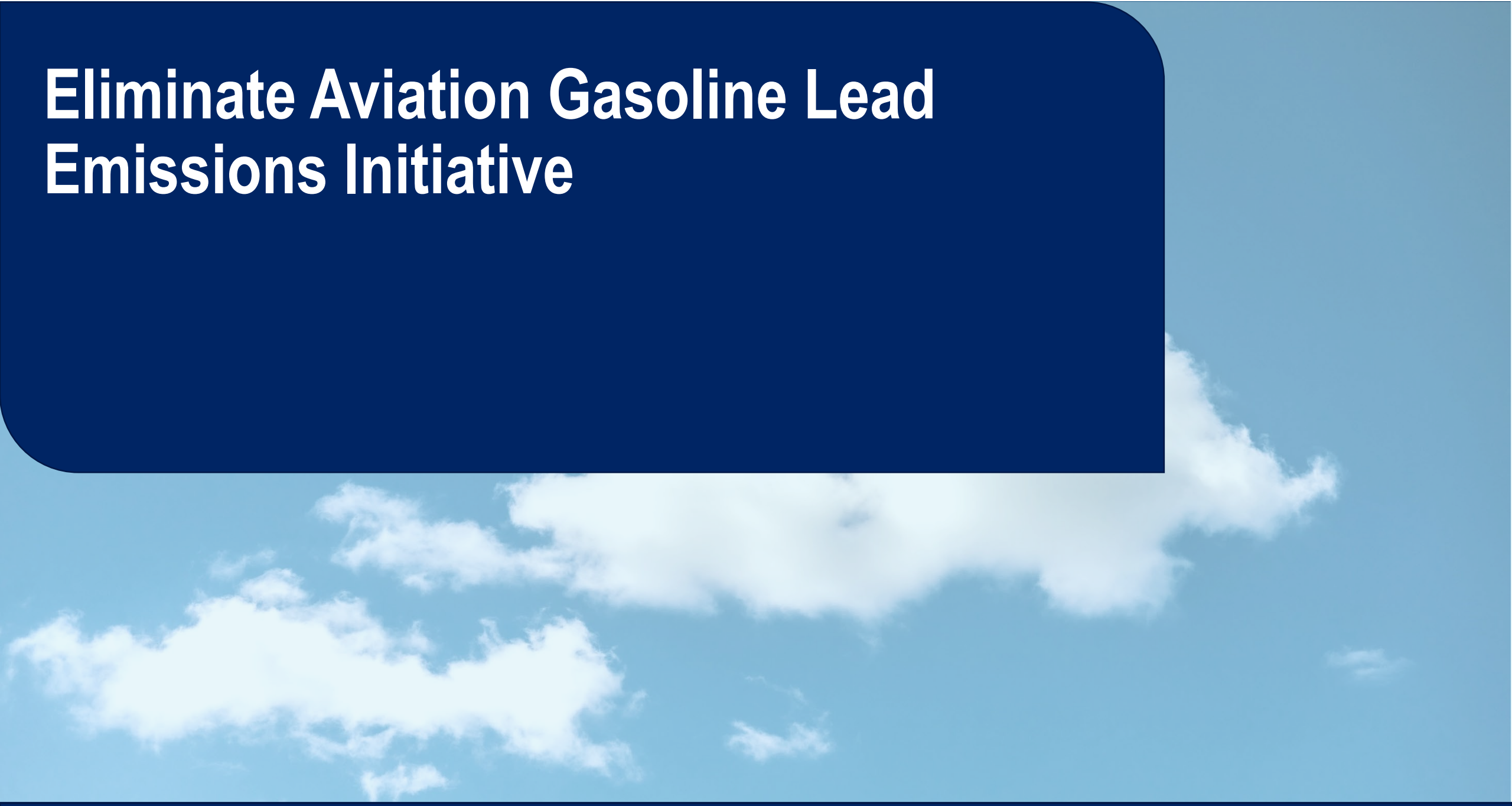


Thank You!

Discussion



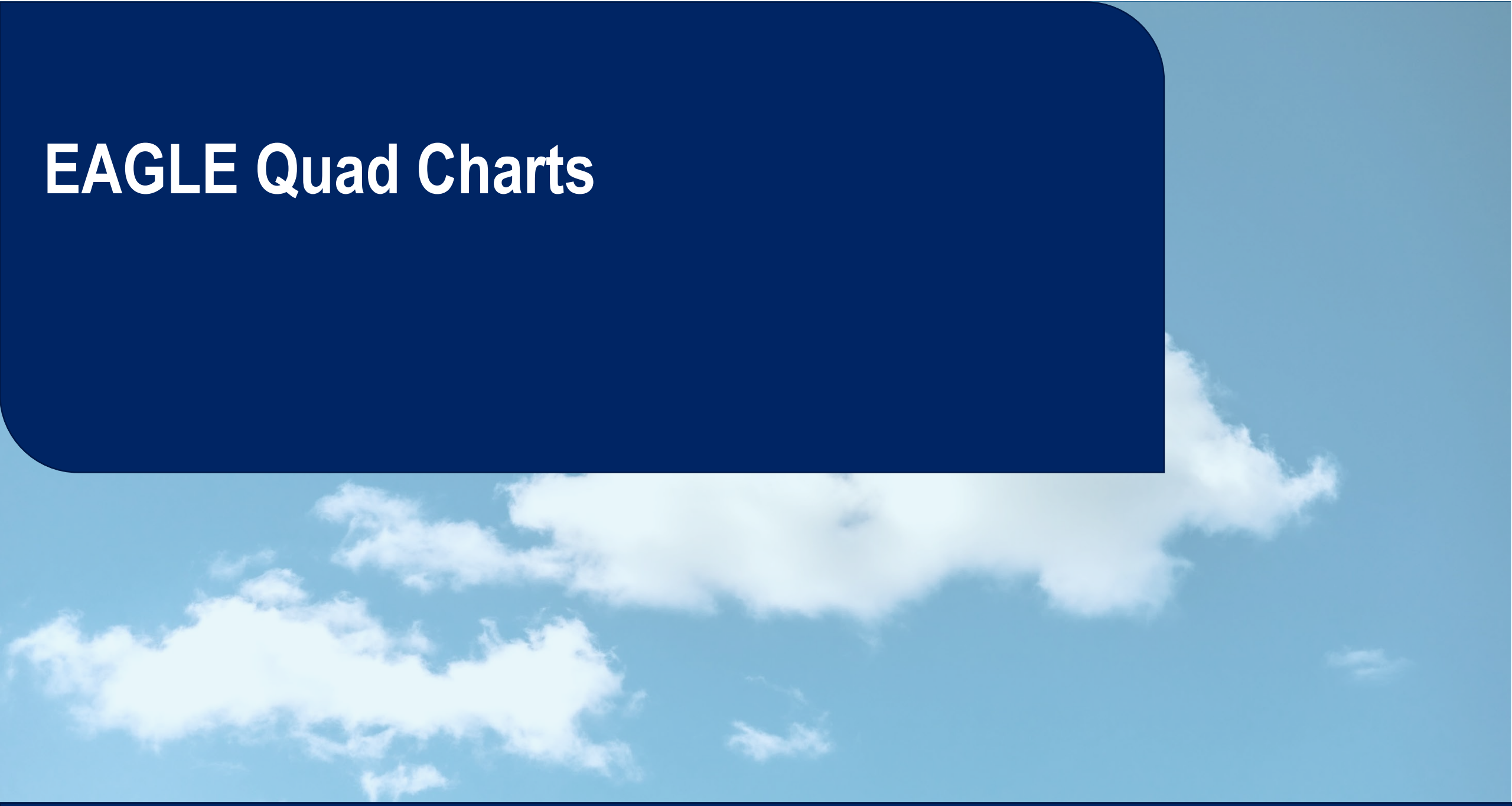
Eliminate Aviation Gasoline Lead Emissions Initiative



Meeting Objectives Met

- ✓ Describe the EAGLE initiative
- ✓ Define potential activities under each pillar
- ✓ Exchange information
- ✓ Share constructive input
- ✓ Garner initial commitments towards a safe, lead-free aviation future
- ✓ Discuss next steps

EAGLE Quad Charts



Pillar A Quad Chart: Business (Fuel) Infrastructure and Implementation

Pillar Objectives

- Evaluate and support program(s) that incentivize fuel producers and distributors, aircraft and engine manufacturers, and GA operators to accelerate development, qualification, deployment, and use of unleaded fuels
- Facilitate policy proposals at the Federal and State level to increase production and distribution – as well as enable and encourage greater use – of commercially viable replacement unleaded fuel
- Facilitate government policy, regulatory proposals and voluntary consensus standards that will support a commercially viable supply chain and quality-focused infrastructure for the deployment of unleaded fuel, including the promotion of free-market competition
- Evaluate Environmental, Social, and Governance (ESG) commitments to help engage additional organizations and investors in this effort
- Support policy and regulatory proposals for maintaining 100LL availability and airport access to ensure safety during the transition across the country for use by general aviation aircraft

Next Steps

- Develop framework to achieve EAGLE objectives and engage stakeholders
- Utilize Deployment Guide and Action Plan as a starting point while keeping in mind the EAGLE initiative is much more comprehensive
- Develop infrastructure database e.g. terminals, refiners, FBOs, aircraft, equipment etc.
- Develop communication channels beyond association members

Pillar Session Outcomes

- Shared awareness and understanding of approach to meet pillar and overall EAGLE objectives
- Stakeholder buy in and engagement going forward

Pillar Session Feedback

- Is it possible to limit lead emissions by leaning the mixture during run-up?
- Are there other approaches to reducing lead emissions during the transition (VLL)?
- Is it possible to reduce the number of flights at airports to reduce emissions?
- Can the FAA provide a tank or truck to an airport where resources are needed to bring an unleaded product to market?
- What is the focus of the pillar? Is it to advocate for resources for airports? If that is the focus, how will it ensure that municipalities do not compete with FBOs?
- Is it possible to modify a refinery to supply 100LL?
- Is there a process that will assess the components of a new fuel?
- What process is needed to achieve acceptance of STC fuels by the engine manufacturer/OEM requirements?
- What transparency and understanding of fuel components?

Pillar B: Research, Development and Innovation – Quad Chart

Pillar Objectives

- Understanding of R&D that is needed across all pillar activities across several stakeholders
- Focus is to facilitate transition to unleaded replacement fuel by mitigating impacts
    - Address safety & technical challenges of high-performance engine use of unleaded fuel and any deployment issues
- Effective and timely FAA certification essential to deployment of solutions

Pillar Session Outcomes

- Shared awareness and intended scope of R&D and innovation pillar activities
    - Mitigate potential impacts of UL fuel so that it can be a potentially viable replacement
- Share FAA UL fuel R&D program
- Solicit stakeholder inputs & engagement

Next Steps

- Identify interested stakeholders to participate
- Establish pillar working group & meeting schedule
- Identify R&D technology and process areas likely needed based on known fuel candidates
- Develop proposed workplan activities

Pillar Session Feedback

- Critical milestone is to identify potentially viable UL fuel replacement(s) for 100LL ASAP
    - Understanding of the safety & technical impacts that need to be mitigated (such as materials, operational procedures, etc)
- Initial R&D to address ability for high-performance engines to operate safely on a lower octane fuel

Pillar C Quad Chart: Unleaded Fuel Evaluation and Authorization

Pillar Objectives

- Provide Status of current PAFI efforts and fleet authorization process
- Describe Fuel Authorization Paths: PAFI and STC
- Discuss how PAFI fits into the EAGLE framework
- Provide opportunity for open dialogue

Pillar Session Outcomes

- ✓ Shared awareness and understanding:
  - ✓ PAFI and its relationship to Fleet Authorization and EAGLE.
  - ✓ The 2 Fuel Authorization Paths
  - ✓ Benefits of Fuel Authorization Pathways
- ✓ Engagement of stakeholders in continuing dialogue.

Next Steps

- Stakeholders identify interest in participating in this pillar
- Identify scope and timing for future Pillar working sessions and working groups
- Continue to progress PAFI testing and Fleet Authorization process
- Re-engage Technical Advisory Committee
- Coordinate with R&D and Regulatory Pillars on planned UL Fuel evaluation activities

Pillar Session Feedback

- Investigate options to accelerate PAFI testing, without compromising safety
- Explore gap analysis between STC and PAFI Process, based upon applicable data
- Continue outreach, education and awareness
- Transparency is key

Pillar D Quad Chart: Regulation, Policy, and Programmatic Activities

Pillar Objectives

- Understand the government regulatory process
- Understand policies that affect funding for airport fueling infrastructure
- Understand programmatic activities that reduce or eliminate reliance upon leaded aviation gasoline
- Education, awareness, training, and outreach

Pillar Session Outcomes

- Provided overview of EPA activities focused on lead
- Promote understanding of EPA/FAA Regulatory Authorities and processes underway
- Discussed programmatic activities that reduce reliance upon leaded aviation gasoline
- ASCENT Research Center of Excellence
- Experience with public-private partnership to develop clean technologies
- Transition of flight schools to unleaded fuels
- Identified airport fueling infrastructure needs

Next Steps

- Report out on progress for:
- EPA/FAA regulatory processes
- Policy updates that affect funding for airport fueling infrastructure
- Inform on flight school transitions to unleaded fuels
- Update on ASCENT activities
- Update on possible public-private partnerships to develop clean technologies

Pillar Session Feedback

- EAGLE activities will inform the rulemaking process. Any rulemaking will not affect safety.
- Need to provide rulemaking status to ensure regulatory certainty, noting that it is a deliberative government process.
- Concerns about mis-fueling, address going forward.
- Concerns about replacing TEL with another toxic chemical.
- Improved communication across all stakeholders is needed, including communities and state/local governments.
- Expanded grant funding eligibility is needed to support fuel infrastructure and fuel trucks necessary for the transition

EAGLE Key Takeaways:

- This is one of the most important issues in general aviation today
- EAGLE supports many current Administration priorities
- 2030 is an ambitious goal; the clock is ticking with a sense of urgency
- ALL perspectives need to be involved; no one will get us to the finish line alone
- Much work to do by many people, and we have the right teams in place
- “If this was easy, it would have been done already”

Next Steps:

- Press event with EAGLE meeting co-chairs:
  - Immediately following the Stakeholder Meeting
  - Video link will be made available
- Meeting summary and slides to be sent next week
- Request for participation by all in EAGLE and Pillar activities
- Next Stakeholder Meeting – sharing of progress, plans, cross-pillar collaboration and next steps.
  - June 23, 2022
  - Location: TBD, DC Metro Area; Hybrid
- Need your input:
  - EagleULFuel@aopa.org

Thank You for Attending!

EAGLE Email: EagleULFuel@aopa.org