Federal Aviation Administration

Transition Plan to Unleaded Aviation Gasoline

JULY 2026, VERSION 1.0

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EXECUTIVE SUMMARY

The 2024 FAA Reauthorization Act (the Act) Section 827 directed the Federal Aviation Administration (FAA) to continue to partner with industry and other Federal government stakeholders in carrying out the mission of the industry-government initiative, Eliminate Aviation Gasoline Lead Emissions (EAGLE), and take such actions as may be necessary to facilitate:

- Safe elimination of the use of leaded aviation fuels by piston-engine aircraft in the United States by the end of 2030 (end of 2032 for Alaska) without adversely impacting the safe and efficient operation of the applicable, general aviation (GA) fleet
- Approval of the use of unleaded alternatives to leaded aviation gasoline for use in all piston-engine aircraft types and piston-engine models
- Implementation of the requirements relating to the continued availability of aviation gasoline
- Efforts to make unleaded aviation gasoline widely available for purchase and use at airports in the National Plan of Integrated Airport Systems (NPIAS)
- Development of a Transition Plan to Unleaded Aviation Gasoline (Transition Plan)

The FAA is providing this document to comply with the Act and provide a nationwide plan to support a safe and orderly transition to unleaded fuels. This plan recognizes that many of the factors that affect the ultimate transition are market driven and the decisions made by private individuals and companies could have a significant influence on the ultimate transition. The FAA also acknowledges that a comprehensive transition plan cannot be developed until all the necessary information is available. Key outstanding questions include: what are the unleaded fuels? what are the costs and consequences to aircraft owners transitioning to an unleaded fuel? And, are the unleaded fuels intermixable?

The Transition Plan is intended to provide an overview of and considerations in the following areas:

- The fuel evaluation and authorization activities already undertaken by the EAGLE initiative
- Efforts toward evaluation and development of necessary airport infrastructure
- Efforts to address supply chain and other logistical barriers inhibiting the timely distribution of unleaded aviation gasoline(s) to airports
- Outreach efforts to educate and update piston-engine aircraft owners and operators, airport operators, and other members of the general aviation community on the potential benefits, availability, and safety of unleaded aviation gasoline, and
- Efforts to establish best practices for impacted personnel to protect them against exposure to lead when conducting related operations.

The information contained in this document is intended to be leveraged by relevant stakeholders (see Appendix C, Table 12 for a comprehensive list of potential stakeholders) to facilitate a structured, safe, timely, coordinated, and orderly transition from 100 low-lead (LL) aviation gasoline to its unleaded replacement(s). The information in the Transition Plan is based on recommendations in the congressionally mandated 2021 National Academies of Sciences, Engineering, and Medicine (NASEM) report, "Options for Reducing Lead Emissions from Piston Engine Aircraft," as well as the recommendations from the "Unleaded Avgas Transition Aviation Rulemaking Committee (UAT ARC)." Both documents were developed in coordination with specialists representing a breadth of industry knowledge and experience in the affected areas. The FAA plans four main phases as shown in Figure 1. Based on public comments on the draft of this plan and on other industry feedback, this Transition Plan outlines FAA's approach to the transition and focuses on the first phase of the activities to obtain the data that is missing to inform the details of the rest of the transition. This Transition Plan will be updated after the first phase is complete, tentatively in late 2027.

Figure 1 – Four Phases of the National Transition to Unleaded Fuel

The four-phased approach for the transition to unleaded fuels recognizes the impact that market factors will have on the demand and supply of unleaded fuels as FAA and industry progress from fuel authorizations to the full national transition.

Three candidate unleaded fuels are in various stages of obtaining FAA approvals or authorizations for use in piston-engine aircraft. That work must be completed in Phase 1. Recognizing that the market will select the fuel(s) and that there are additional factors beyond FAA authorization of the fuel for use in aircraft that affect the market, Phase 1 also includes comparison testing and reporting to facilitate more informed decision-making by the end users. Furthermore, FAA recognizes that there are significant technical and policy challenges to resolve before moving forward into Phase 2 of the transition. These challenges include potential for aircraft modifications, compatibility of the fuels, timelines and alignment with regulatory requirements, and cost considerations. In order to facilitate the transition, FAA will provide an updated Transition Plan at the end of Phase 1 highlighting progress and resolution of critical issues and their impact on later phases of the transition.

The second phase of the transition will provide time for the market to gain experience with the various unleaded fuels. Lessons learned from early market experience can be used to facilitate further market integration when more airports and aircraft are expected to adopt unleaded fuels.

Phase 3 is the National Transition in all states except Alaska. During Phase 3, all aircraft and all airports (outside of Alaska) are expected to leverage lessons learned from Phases 1 and 2 and switch to unleaded fuel(s). Due to unique challenges, the Alaska transition (described in more detail later) is anticipated to be the fourth and final phase of transition.

Development and dissemination of best practices, providing guidance, and continued communications are the ongoing activities that are vital to the successful transition. These activities are expected to take place throughout the entire transition, supporting both short and long-term goals during each phase. These activities ensure all stakeholders are engaged and informed, contributing to a safe and efficient transition.

The undersigned industry members of the Eliminate Aviation Gasoline Lead Emissions (EAGLE) initiative support a smart, safe, and orderly transition to an unleaded aviation fuel future. Established in 2022, EAGLE is a comprehensive government-industry initiative created to eliminate lead from aviation gasoline without adversely impacting the safe and efficient operation of the existing general aviation fleet.

Collectively, we acknowledge and appreciate the FAA's efforts to develop, release for comment, and publish the *Transition Plan for Unleaded Aviation Gasoline.*

The *Transition Plan for Unleaded Aviation Gasoline* establishes an initial framework for moving away from leaded fuel and outlines a process to identify, evaluate, and address unresolved issues and challenges. The FAA's recognition that this framework will need further evaluation and modification will help ensure the plan remains responsive to new information, testing data, and market realities.

A successful transition must preserve the reliability, safety, and accessibility that pilots, aircraft owners, service providers, airports, and communities depend upon every day. The plan acknowledges challenges going forward with such issues as fuel compatibility and commingling, storage and distribution infrastructure, liability concerns, regulatory clarity, and possible aircraft and engine modifications. Further testing, analysis, and demonstration of the three high-octane unleaded fuels will continue to provide valuable data in these areas.

The FAA's ongoing evaluation of unleaded fuels reflects the serious work needed to ground this transition in safety, data, and operational reality. The *Transition Plan for Unleaded Aviation Gasoline* will be updated as the transition progresses, facilitating a coordinated process to work through technical, operational, infrastructure, and marketplace challenges.

As EAGLE members, we remain committed to working with the FAA to address these challenges responsibly and support the shared goal of eliminating lead from aviation gasoline.

Aircraft Owners and Pilots Association (AOPA)
American Association of Airport Executives (AAAE)
American Petroleum Institute (API)
Experimental Aircraft Association (EAA)
General Aviation Manufacturers Association (GAMA)
National Air Transportation Association (NATA)
National Association of State Aviation Officials (NASAO)
National Business Aviation Association (NBAA)
Vertical Aviation International (VAI)

IMPACT OF THE PUBLIC COMMENT PROCESS

The FAA released a Draft Transition Plan to Unleaded Aviation Gasoline for a 60-day public comment period from January 12 – March 13, 2026. The agency appreciates stakeholders' contributions, insights, and constructive feedback. The FAA has updated this version of the Transition Plan to Unleaded Aviation Gasoline (V1.0) to include additional details and clarification in several areas. Four of the most significant areas of update in response to the public comments are: 1) Progress update on Phase 1, Fuel Authorizations and Comparison, 2) Commitment to release an updated Transition Plan, V2.0, at the conclusion of Phase 1, in late 2027, 3) Development of frequently asked questions (FAQs), and 4) publishing a document summarizing public comments. Additional updates and clarification can be seen most directly in the following sections of the updated plan: 2.2, 3.1, 3.3, 5.1, 5.3, 6.1, 6.4, 6.6, 9.1, and Appendices A-I.

Additional information about each of the four areas is highlighted below:

Phase 1 Progress Updates

Public feedback emphasized a wide range of areas including the potential for modification of some aircraft, mixing of unleaded fuels, timelines and alignment associated with regulatory requirements, as well as cost considerations that will affect later phases of the transition. Many of these areas are still under development but should be completed during Phase 1. Recognizing the need to provide ongoing information and guidance during Phase 1 and after the release of this Transition Plan to Unleaded Aviation Gasoline V1.0, regular updates will be provided on the flyEAGLE.org website as new information and guidance in these areas become available, and as items are resolved.

Updated Transition Plan, Version 2.0

The second activity will be the development and release of an updated Transition Plan. Once Phase 1 has reached its conclusion, FAA will publish an updated Transition Plan (Transition Plan to Unleaded Aviation Gasoline V2.0). This update will summarize the data regarding fuel performance, availability, and compatibility. This update will define the schedule and activities in Phases 2, 3 and 4 of the transition.

Frequently Asked Questions (FAQs)

During its review, FAA recognized that some public comments reflected areas where FAA needs to provide additional clarification on the transition to unleaded fuels. FAA is creating a comprehensive questions and answers document for the public that will address areas that it identified for additional clarification. FAA expects to release this document during Phase 1 on the flyEAGLE.org website and will update it as needed.

Public Comment Summary document

Lastly, FAA will provide a "Public Comment Summary" document. During Phase 1, FAA plans to share a summary of the substantive comments it collected during the draft Transition Plan's 60-day public comment period and its disposition of those comments. This summary will be provided separately from Phase 1 progression updates, or any other resources related to the Transition Plan.

1. INTRODUCTION

1.1 TRANSITION TO UNLEADED FUELS

Currently, aviation gasoline (AvGas) is the only transportation fuel in the United States that contains TetraEthyl Lead (TEL), a lead-based additive that has been added to AvGas since 1921 to boost octane ratings and prevent engine damage and knocking at higher power settings. As of Summer 2026, 100-octane low lead (100LL) is the most used AvGas for spark-ignition piston-powered aircraft. Many piston-engine aircraft designs are best suited for 100LL. However, in response to mandates in FAA's 2012[1], 2018[2], and 2024 reauthorization acts, FAA has undertaken transition efforts from 100LL to unleaded aviation fuels.

Currently, there is a single source TEL provider for the U.S. market. This provider has indicated an eventual end of production of the TEL additive. The only other potential sources for TEL could lead to reliance on sources such as China, resulting in potential supply chain concerns as well as long-term availability issues. In addition, concerns expressed by local communities about exposure to lead are motivating FAA and aviation community to seek alternative lead-free fuels.

The following are examples of the transition enabling government-industry actions over the years:

In 2012, FAA authorized the Unleaded AvGas Transition Aviation Rulemaking Committee (UAT ARC) to investigate, prioritize, and summarize the current issues relating to the transition to an unleaded AvGas, and to recommend the actions necessary to investigate and resolve these issues. The committee was comprised of key stakeholders from the General Aviation (GA) community including aviation trade/membership associations, aircraft and engine manufacturers, petroleum and other fuel producers, and U.S. government agencies such as the Environmental Protection Agency (EPA) and FAA. The UAT ARC produced a comprehensive report[3] and made them available to the public. Pursuant to these recommendations, FAA and industry established a program called Piston Aviation Fuels Initiative (PAFI)[4] to support the evaluation of candidate unleaded fuels to replace approved leaded AvGas. The ultimate objective of the program is to qualify a fleet-wide solution.

Congress has supported the transition to the unleaded fuels by including two sections in FAA Reauthorization Act of 2018, (Pub. L. 115-254), Section 177 to commission a consensus report by NASEM, and Section 565 to provide an alternate pathway to the traditional Type Certification/Supplemental Type Certification (TC/STC) process.

More recently, in February 2022, several general aviation industry associations, the American Petroleum Institute (API), and FAA established the Eliminate Aviation Gasoline Lead Emissions (EAGLE)[5] initiative with a goal to "Eliminate the use of leaded aviation fuels for piston-engine aircraft in the United States by the end of 2030 (2032 for Alaska) without adversely impacting the safe and efficient operation of the existing GA fleet." This public-government initiative was formed in response to the NASEM 2021 report mentioned in the previous paragraph. The EAGLE initiative provides a framework to coordinate and align a wide range of research and development efforts, fuel testing and evaluation activities, and other actions needed for the transition to unleaded AvGas. For more information, please refer to the EAGLE website.

In 2023, the EPA issued its final Endangerment Finding[6] that engine emissions of lead from certain aircraft cause or contribute to lead air pollution that may reasonably be anticipated to endanger public health and welfare under the Clean Air Act. The EPA's final Endangerment Finding provides detailed context on lead emissions and impacts, information on statutory text and regulatory authority, and data supporting the scientific basis for the

[1] FAA Modernization and Reform Act of 2012 (Pub. L. 112-95)
[2] PUBLIC LAW 115–254—OCT. 5, 2018
[3] UAT-ARC Final Report – Body[3] UAT-ARC Final Report – Appendices
[4] PAFI - Background and Program Update
[5] EAGLE Website
[6] U.S. EPA - Final Endangerment Finding Regarding Lead in Aviation Gasoline

final finding, including details of health and welfare effects and links to referenced studies. Under the Clean Air Act, EPA's role in regard to lead emissions from aircraft engines is to make a finding on whether such emissions endanger public health or welfare; whereas FAA's role is to prescribe standards related to fuel or fuel additives in response to an EPA finding. As such, health-related topics in this context are not within FAA's authority.[7] For this reason, EPA's lead Endangerment Finding will continue to serve as FAA's health-based resource throughout the transition to an unleaded AvGas future.

In 2024, Congress directed FAA to work with EAGLE to transition to unleaded AvGas by the end of 2030 outside of Alaska, and by the end of 2032 in Alaska. Congress also directed FAA to require airport owners and operators to not restrict the continued use of 100LL until the earlier of 2030 (2032 for Alaska), or when a replacement fuel meets a predefined criteria described in Section 770, Grant Assurances, in the FAA Reauthorization Act of 2024 (the Act).

The three sections in FAA Reauthorization Act of 2024 (PL 118-63), that support the transition to an unleaded AvGas future are: Section 770, Grant Assurances[8]; Section 771, Aviation Fuel in Alaska[9]; and Section 827, EAGLE Initiative[10]. The full text of these provisions is in Appendix F: Applicable Federal Statutes. This document will reference key provisions of each of these sections.

[7] 42 USC 7571 and 49 USC 44714
[8] 2024 Reauthorization Act, Section 770, Grant Assurances
[9] 2024 Reauthorization Act, Section 771, Aviation Fuel in Alaska
[10] 2024 Reauthorization Act, Section 827, EAGLE Initiative

2. BACKGROUND

2.1 LEAD IN AVIATION (100-OCTANE LOW LEAD)

As previously stated, 100LL is the primary fuel utilized by spark-ignition piston-engine aircraft. As of Summer 2026, there were approximately 222,000 spark-ignition piston engine aircraft registered with FAA, of which approximately 175,000[11] were estimated to be actively flying. These aircraft consumed an estimated 180 million gallons of 100LL in 2023 per the Energy Information Administration (EIA)[12]. These aircraft include airplanes and helicopters with a standard airworthiness certificate, light-sport category aircraft (LSCA) with a special airworthiness certificate, and a variety of aircraft with an experimental airworthiness certificate. Reference EAGLE's Interactive Toolkit at flyeagle.org for insightful statistics about the airports currently carrying 100LL, as well as the replacement fuel(s), AvGas supply logistics, sales volumes, piston fleet, and more. A sample of the information contained in EAGLE's Interactive Toolkit is shown in Figure 2.

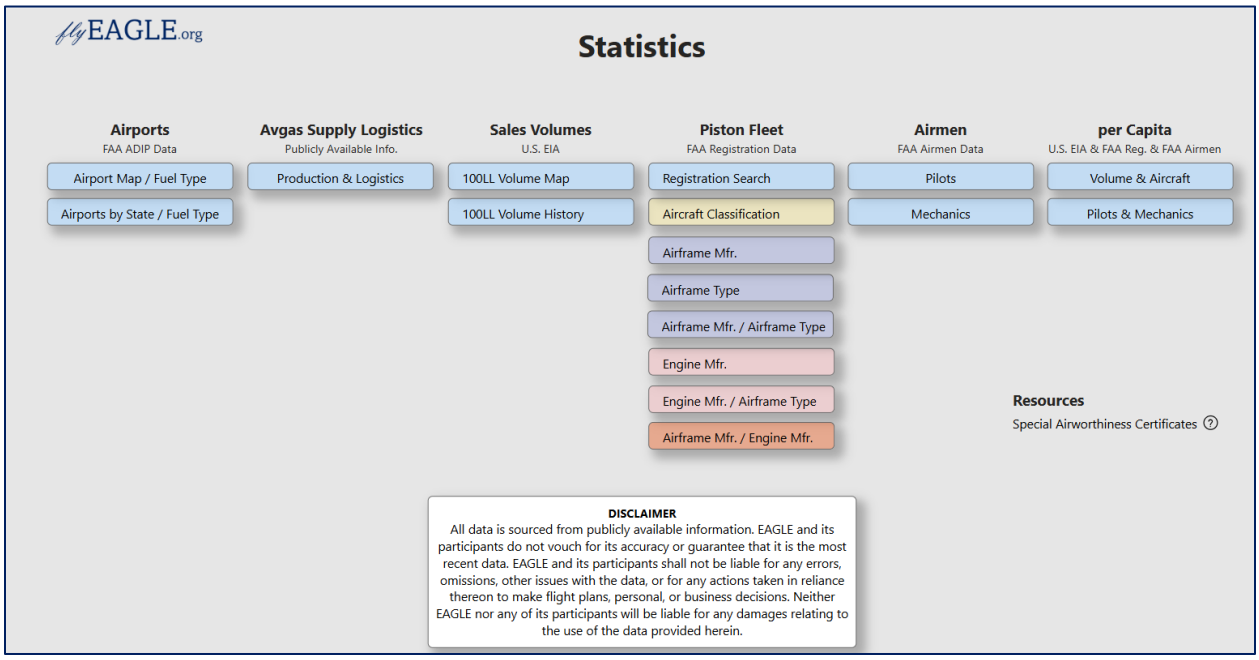
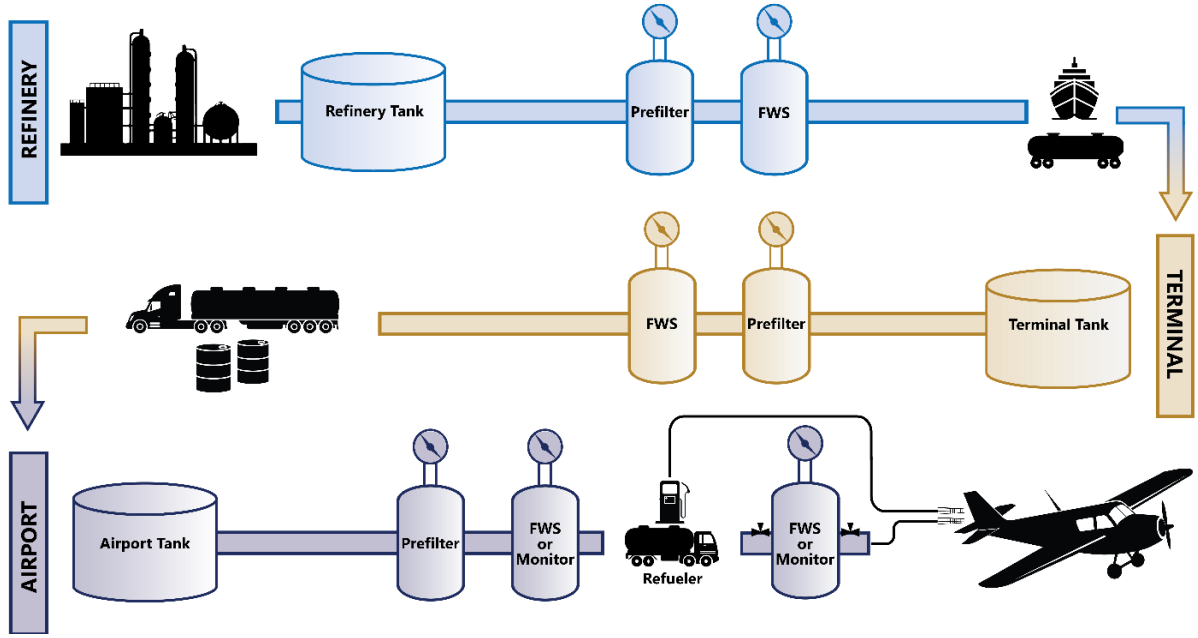


Image: EAGLE-created; used with permission

Figure 2 – EAGLE's Interactive Toolkit: Piston Engine Aircraft-Focused Dashboard

100LL has a well-established and effective process for the production and distribution of the fuel, ensuring product quality from initial production to its utilization in an aircraft. Figure 3 illustrates the scope and complexity of the 100LL distribution system and the critical entities that are required to bring the fuel from production to final distribution. Each of these entities has an important role in the transition to unleaded fuel, ranging from refiners scaling the production of unleaded fuel to meet fleet demands, to distributors safely moving the fuel to the local airports for use by aircraft owners and operators.

[11] FAA Research Data: Aerospace Forecasts
[12] U.S. Product Supplied of Aviation Gasoline (Thousand Barrels)



(FWS – Fuel Water Separator)
Image: FAA created; adapted from Cross-industry Group – Unleaded AvGas Development

Figure 3 – Current 100LL Distribution System

The U.S. has a vast network of GA airports that supply AvGas, highlighted in Figure 4. The most up to date information is available via the Airport Master Record, which can be found in the FAA's Airport Data and Information Portal (ADIP) Database. These locations range from large fuel handling and distribution centers in Texas to small airfields in remote sections of Alaska. The modes and methods of distribution to all these locations have evolved in alliance with the GA demands for each region. The transition to unleaded fuels expects to leverage the existing distribution pathways and ensure that the unleaded fuel is available at all locations that currently distribute AvGas.

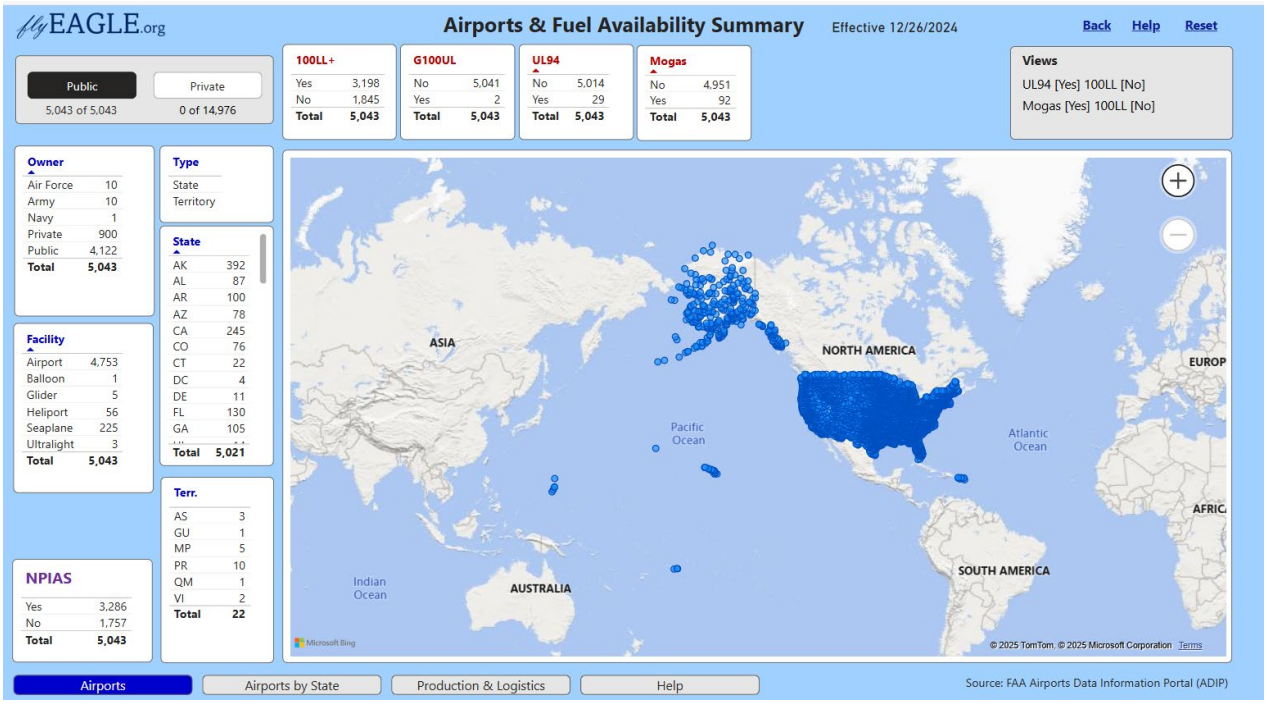


Image: ***FAA, December 2024***

Figure 4 – General Aviation Airports Across the U.S. that Supply Aviation Gasoline

As seen in the earlier figures, the introduction of new fuel to the GA fleet as a replacement for 100LL will directly impact every spark-ignition piston-engine aircraft, pilot, owner, FBO, and the entirety of their supporting

infrastructure. As the industry turns to unleaded fuel, the engagement of the various stakeholders that are integral components of this complex and robust system will be critical to achieve a safe and efficient transition to unleaded fuels.

2.2 UNLEADED FUEL DEVELOPMENT

Finding replacement unleaded fuel involves in-depth testing and evaluation of many fuel characteristics such as performance, detonation resistance, materials compatibility, durability, maintenance impacts, and the potential need for related aircraft alterations. Critical market considerations such as fuel availability and quality control of the fuel make the task even more complex.

This document focuses on the transition to aviation gasoline for use as a replacement for 100LL. There are other unleaded fuels that are available via STC for UL91/94 (ASTM D7547) and ethanol-free mogas/automobile gasoline (ASTM D4814/EN228) that are approved for use in most low performance engines and aircraft registered in the US. However, the motor octane rating for these fuels is insufficient for the high-performance portion of the fleet.

As of Summer 2026, in the U.S., there are three high-octane unleaded fuels at various stages of development and deployment. These fuels are shown in Table 1. Additional information concerning these fuels is provided in Table 2 in Section 4.2.

UNLEADED FUEL	FUEL PRODUCER	WEBSITE
G100UL	General Aviation Modifications, Inc. (GAMI)	https://gami.com/
100R	Swift Fuels	https://www.swiftfuelsavgas.com/
UL100	LyondellBasell/VP Racing	https://vpracingfuels.com https://www.lyondellbasell.com/

Table 1 – High-octane unleaded fuels

One area of significant interest has been the development of a "drop-in" unleaded aviation gasoline specification, similar to what the industry has done for synthetic jet fuel specifications (commonly referred to as sustainable aviation fuel, or SAF). In the case of synthetic jet fuel, once the synthetic blend component (Specification ASTM D7566) is added to the petroleum jet fuel (Specification ASTM D1655), the blended product is considered the same grade as the petroleum jet fuel (ASTM D1655) because the blended fuel meets all of the same specification requirements as the petroleum jet fuel. The feasibility of a "drop-in" fuel is discussed in detail in Section 3.2 of the 2012 FAA UAT ARC Final Report. The primary challenge is that the unleaded fuels contain no lead and therefore cannot meet Table 1 properties of ASTM D910 specification for 100LL. As stated in the UAT ARC Final Report, "There has been extensive testing to find a fuel that meets all of the current ASTM D910 leaded aviation gasoline specification properties for 100LL, satisfies the safety and performance requirements of engines and aircraft, is compatible with the existing infrastructure, and poses no additional compositional issues. Thus, the fuel would have been considered a drop-in fuel, and if such a fuel had been available, it is likely the industry would have transitioned to this fuel once it became available to the General Aviation market." The FAA has determined that a drop-in replacement for 100LL is not feasible.

2.3 GOVERNMENT AND INDUSTRY COLLABORATIONS

2.3.1 PAFI

In response to the UAT ARC recommendations and Section 910 of the FAA Modernization and Reform Act of 2012, FAA established the PAFI program at the FAA Technical Center in Atlantic City, New Jersey in 2014. This program's goal was to identify candidate unleaded AvGas, to generate qualification and certification data on

those fuels, and to support fleet-wide certification of the most promising fuel(s). At the time of PAFI's inception, it was recognized that broad approval of a novel fuel composition for use in piston-engine aircraft was unprecedented in the fleet. This recognition greatly influenced the approach and structure of the PAFI program.

Approval of fuel(s) for use in piston-engine aircraft is complicated by numerous factors, ranging from technical challenges related to fuel performance and aircraft-fuel compatibility, to the logistics associated with the production, delivery and storage of fuels for use. As a result, PAFI relied on coordinated activities among the various stakeholders to define and implement test and evaluation of candidate fuels for the existing fleet, production and distribution infrastructure. After pursuing a variety of different possible fuel chemistries, the program determined that there is no feasible unleaded fuel that would comply with the 100LL fuel specification and meet the performance requirements of all aircraft engines. Additionally, in the vetting of numerous fuel candidates, the program was successful in documenting testing considerations, lessons learned, and best practices in FAA and industry's search for the ultimate replacement unleaded fuel(s)[13]. These experiences have been carried forward into the current PAFI program, which is finalizing testing of UL100 and 100R for the Fleet Authorization process described in greater detail in section 3.3.2.

2.3.2 EAGLE

As mentioned in previous sections, GA industry associations, the API, and FAA established the EAGLE initiative in 2022 with the goal to "Eliminate the use of leaded aviation fuels for piston-engine aircraft in the United States by the end of 2030 without adversely impacting the safe and efficient operation of the existing GA fleet". In response to the congressionally directed NASEM 2021 consensus study report, "Options for Reducing Lead Emissions from Piston-Engine Aircraft," the EAGLE initiative focuses on a multi-faceted approach to reduce and eliminate lead emissions by way of four integrated pillars, highlighted in Figure 5 along with the EAGLE members:

Image: TOP: EAGLE-created; BOTTOM: EAGLE member logos used with permission

Figure 5 – Four EAGLE Pillars and Members of EAGLE

[13] Piston Aviation Fuel Initiative (PAFI) - White Paper
Fuel Development and Testing Lessons Learned
PAFI Fuel Development and Testing Best Practices
PAFI Fuel Development and Testing Considerations

The four EAGLE pillars are committed to the following:

- Facilitate supply chain and infrastructure readiness for commercial market acceptance and deployment of unleaded aviation fuels from refining to distribution into the aircraft. Provide options for airports wanting to pursue near-term reductions of lead emissions.
- Conduct research and development on technical solutions or modifications that may be necessary for certain aircraft to safely facilitate transitioning to unleaded fuel.
- Support the development and deployment of viable unleaded fuel(s) to replace 100LL that meets the safety needs of the fleet; this includes fuels assessed through both Fleet Authorization and fuels going through the traditional FAA Type Certification program.
- Support governmental, regulatory, and programmatic activities focused on safely transitioning to an unleaded replacement and eliminating lead emissions from aircraft engines.

The EAGLE initiative supports the goal of safely eliminating lead in AvGas used by piston-engine aircraft by addressing fuel production and distribution concerns, in addition to identifying and addressing any gaps in efforts undertaken by government and industry toward the lead-free AvGas future.

3. ROLE OF FAA IN THE TRANSITION TO UNLEADED FUEL

3.1 RESEARCH AND DEVELOPMENT

3.1.1 FAA RESEARCH

As mentioned earlier in the document, FAA has supported technical efforts for unleaded fuel development and deployment since the early 1990s. Previous efforts have focused on testing octane boosters and unleaded fuels by evaluating their performance, including knock, in aircraft engines. These efforts are summarized in Appendix H: Early FAA Research Activities Related to Unleaded Fuels.

Beginning in 2014, FAA technical effort transitioned to the PAFI program. The PAFI program leveraged lessons learned, testing capabilities, and test methods developed from previous efforts to continue the development of unleaded fuels and develop a pathway for fleet wide approval of unleaded fuel for use in piston-engine aircraft.

The FAA Reauthorization Act of 2018 directed FAA to continue to utilize the PAFI program to identify unleaded fuels and work with industry partners through cooperative research and development to explore additional unleaded fuel candidates.

In addition to support for PAFI, FAA has continued to support research and development with current efforts focused on sensitivity testing for engine operability, engine octane demand, support for potential in-service issues, and the comparative assessment discussed in Section 5.2. The impacts of these activities will directly support Phases 1 and 2 of the Transition Plan.

3.1.2 FLEET RESEARCH

The aviation industry has also supported research activities for the development of unleaded fuels. Of note is the Coordinating Research Council (CRC) Report No AV-7-07, which highlights the evaluation of 279 experimental test fuels, engine testing on nearly 80 unleaded fuel blends, and comparisons between engine testing on leaded and unleaded fuels. This report documents a significant portion of the industry initiative to facilitate the evaluation and development of unleaded fuel prior to the initiation of the PAFI program. Copies of the report are available at www.crcao.org.

3.2 AUTHORITY TO REGULATE FUEL

Historically, FAA has not regulated or established regulatory standards related to aircraft fuel. However, with the EPA Endangerment Finding related to lead emissions, FAA must exercise its authority to prescribe standards for the composition or chemical or physical properties of a fuel or fuel additive. 49 USC 44711 (a)(9) prohibits the manufacture, delivery, sale, or offer for sale of fuel that is in violation of FAA fuel composition requirements once they are established. These two provisions grant FAA the authority to prescribe and enforce fuel standards and will represent a shift in FAA's role with respect to the regulation of aviation fuels as the transition to unleaded fuels takes place. This authority is addressed further in section 10.2.

3.3 PATHWAYS TO AUTHORIZE USE OF FUEL

The FAA has always authorized the use of fuels for specific aircraft and engines. Currently, FAA utilizes two processes to authorize the use of fuel: (1) Fleet Authorization and (2) traditional Type Certificate (TC) or Supplemental Type Certificate (STC) approval.

3.3.1 FAA TYPE CERTIFICATION (TC)/SUPPLEMENTAL TYPE CERTIFICATION (STC) PROCESS

When approving or authorizing aircraft and engines under the TC process, FAA has always included corresponding limitations to identify the fuel that is approved for use in that aircraft or engine. As with any aircraft modification, companies may revise that approval by amending the TC (if the company holds the TC approval) or obtaining STC approval. TC/STC approval may be limited to individual aircraft and engine types, or it could be granted for a broad range of applicable types of aircraft and engines by creating an approved model list (AML) STC that bundles FAA approval of an STC across many aircraft models into a single approval.

This process requires the applicant to establish that each model of aircraft and aircraft engine for which approvals are requested are compliant to FAA regulations when using the alternate fuel. Each applicant adopts or develops a means of compliance with the regulations. Performance equivalence to 100LL is not required, and the compatibility of a fuel with the supply infrastructure is outside the scope of FAA's evaluation for the TC/STC process. The applicant retains ownership of the compliance data. Stakeholders who wish to utilize STCs developed for unleaded fuels should contact the developer of the STC for technical information.

The amended TC/STC process only applies to type certificated engines and aircraft.

TC and STC policy is governed by 14 CFR Part 21. The implementation of those requirements, including specific guidance on obtaining an approval to use a new fuel, is addressed in FAA Advisory Circulars (AC) 21-40A, AC 20-180, AC 20-24D, and FAA Order 8110.4C. AC 20-24D, Appendices 2 and 3 contain applicable Airworthiness Regulations for which an applicant should demonstrate compliance through testing, analysis, or similarity for the addition of a fuel to engine or aircraft operating limitations.

The TC/STC process can be used to approve any change in the aircraft design, use of fuel, or a combination of the two. Two fuel developers, GAMI and Swift Fuels, have elected to use this process to enable the use of their fuels in aircraft. GAMI has obtained STC AML approval for all spark-ignition engines and airplanes to use G100UL. Swift Fuels initially obtained an engine STC for Lycoming IO-360-L2A engines and airplane STC for Cessna 172 R/S and has received an expanded engine and airplane AML. These approvals cover the same aircraft that were previously approved for the use of UL94.

Other companies have obtained approvals for their fuel to operate on engines previously approved to operate on 100LL. For example, several aircraft and engine design approval holders modified their designs to authorize the use of UL94, a fuel defined by an industry consensus standard (ASTM D7547).

Aircraft and engine modifications may go beyond using the fuel itself and may be motivated by other factors such as increased efficiency, the ability to utilize lower octane fuels, or to lower maintenance. Some examples include changes to ignition timing and replacement of certain materials within the fuel system. The TC/STC process can also be used to install anti-detonation injection systems, electronic ignition systems, or even to replace a spark-ignition piston engine with a compression-ignition engine. Compression-ignition can take advantage of the widespread availability of Jet A fuel, including synthetic or sustainable jet fuels.

Note that for any change that involves a change to the engine, there must be a corresponding change to the aircraft approval to reference the modified engine.

3.3.2 FAA FLEET AUTHORIZATION PROCESS

The Fleet Authorization process is a result of the FAA Reauthorization Act of 2018, Section 565, that directs FAA to adopt "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." The Fleet Authorization process does not result in the issuance of an STC or modification of the TC; it is a unique process for allowance of the use of a qualified replacement unleaded aviation gasoline. The Fleet Authorization process is described in detail in FAA policy statement and outlined in Figure 6.

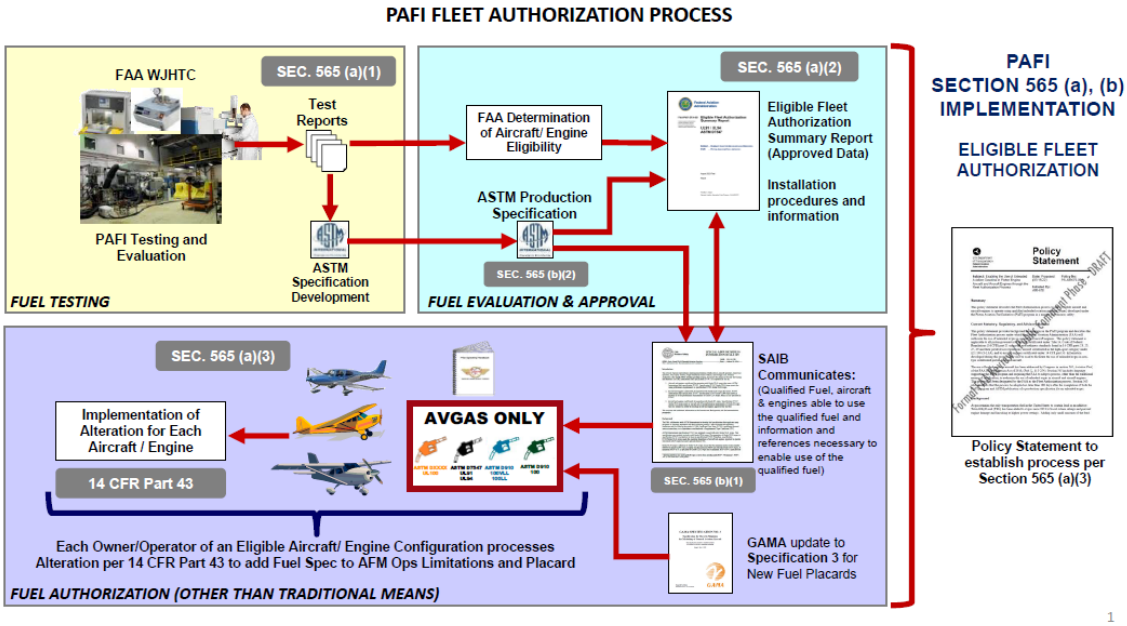


Figure 6 – PAFI Fleet Authorization Process

The Fleet Authorization process is intended to enable a broad use of unleaded AvGas as a replacement fuel for 100LL in the fleet. The eligible aircraft that may use the unleaded AvGas is determined during the Fleet Authorization process and identified in the Fleet Authorization itself. The FAA leads the evaluation of fuel in this process and conducts necessary tests under the PAFI program. The PAFI program is overseen by FAA and coordinated through a collaborative government/industry body of technical experts as a part of the PAFI Technical Advisory Committee (TAC). TAC members include aircraft and aircraft engine manufacturers, aviation fuel distributors and producers, and other stakeholders in the aviation fuel industry. The PAFI testing also addresses the compatibility of the fuel with the supply chain. As noted in the white paper, "Factors Affecting the Commercial Sale of Emerging Unleaded Aviation Fuels" published by the National Air Transportation Association (NATA), it is "imperative that new fuels are tested with the materials they interact with throughout the supply chain. Just as aircraft owners and operators need assurances that the use of an alternative fuel will not compromise the integrity of any component of their aircraft nor void applicable warranties, the same is true for fuel distributors, transport companies, airports, and FBOs, who rely on ASTM International specifications to minimize or eliminate the potential for degradation or contamination of either the fuel itself or the equipment used to transport, handle, and dispense it."

Testing for the Fleet Authorization process consists of engine performance, detonation, and durability testing, testing of materials found in engines, aircraft (including experimental amateur built and LSCA aircraft), fuel distribution systems, flight testing, propeller testing, and many other associated components. Detailed information about the testing protocols utilized can be found at flyEAGLE.org. Additionally, the data obtained through testing can be used to support development of the ASTM International production specification for the candidate fuel, a requirement for Fleet Authorization under FAA Reauthorization Act of 2018.
In addition to authorizing the use of fuel in an engine or aircraft with a standard airworthiness certificate, the Fleet Authorization process can authorize the use of fuel in aircraft with special airworthiness certificates and provide data for owners of aircraft with an experimental airworthiness certificate to safely use the fuel.

To summarize the Fleet Authorization process, FAA will authorize the use of qualified unleaded AvGas based on test data for aircraft and aircraft engines from the PAFI program and other sources as set forth in this policy statement and described below:

- In general, when the candidate fuel has successfully completed testing and evaluation and the ASTM International production specification has been published, FAA-approved data will be documented in the Eligible Fleet Authorization Summary Report (EFASR). The candidate fuel is then qualified as replacement fuel.
- The FAA will determine the make and model of aircraft and aircraft engines that can safely operate with the qualified unleaded AvGas and summarize that information along with other crucial information necessary to enable the use of the qualified fuel in the EFASR.

  The FAA will then issue a Special Airworthiness Information Bulletin (SAIB) to identify the qualified fuel, specify the aircraft and engines eligible to use the qualified fuel, and provide references and other information to accomplish the alteration necessary to enable the use of the fuel.
- The person performing the alteration is responsible for verifying the eligibility of the aircraft and aircraft engine for use of the qualified fuel. That person will also be responsible for performing all required actions and completing all required documentation in accordance with the information referenced in the SAIB and applicable regulations. This includes installation of fuel placards, Aircraft Flight Manual Supplement revisions, and associated logbook entries for the aircraft and aircraft engine.
- For aircraft with special airworthiness certificates in the light-sport category, FAA may determine that alterations described in the SAIB meet the applicable and current consensus standard for the aircraft and authorize them accordingly. Such alterations meet the requirement specified in 14 CFR 91.327(b)(5) and no additional authorization from the manufacturer is required.

LyondellBasell/VP Racing's proposed fuel, UL100, and Swift Fuel's 100R are both utilizing the Fleet Authorization process. The anticipated completion for Fleet Authorization is 2027.

Other fuel developers may elect to use the Fleet Authorization process at some point.

3.3.3 AIRCRAFT ALTERATIONS

Regardless of the process used, individual aircraft owners must take specific actions to implement the authorization to use unleaded fuel in their aircraft. Every aircraft will involve an alteration to include, at a minimum, a placard change, a Pilot's Operating Handbook (POH) supplement, and a logbook entry. Some aircraft may require modification as well (change to airframe or engine and corresponding FAA Form 337). Fuel limitations are indicated on a placard near the fuel tank access and are documented in the approved aircraft flight manual. Each individual aircraft owner or operator must alter the placard and any associated limitations and may need to make other aircraft alterations to ensure compatibility with a particular fuel.

The information below highlights the alteration processes for use by various portions of the fleet:
:

- For aircraft with a standard airworthiness certificate, this is an aircraft alteration that is accomplished under 14 Code of Federal Regulations (CFR) part 43 and must be performed by an authorized mechanic, repairman, or certificated repair station (14 CFR 43.3). The authorized person confirms the applicability of the approval or authorization to that specific aircraft, replaces the fuel placard, revises the flight manual and instructions for continued airworthiness as appropriate, and records the alteration action per 14 CFR 43.9. If other aircraft changes are required so the aircraft can use the fuel, they would be made as part of this alteration. If the aircraft alteration is a major change, the alteration is also signed off by an individual with inspection authorization (IA) and reported to FAA on Form 337 per 14 CFR 43.7 and 43.9.
- For special airworthiness light-sport category, this is an alteration that is accomplished under 14 CFR part 43 and must be performed by a light-sport repairman (14 CFR 65.107) or mechanic (14 CFR 65.73). The light-sport repairman or mechanic confirms the applicability of the approval or authorization to that specific aircraft, replaces the fuel placard, and revises the flight manual and instructions for

continued airworthiness as appropriate. If other aircraft changes are required so the aircraft can use the fuel, they would be made as part of this alteration.

- For aircraft with a special experimental airworthiness certificate including experimental light-sport and amateur-built aircraft, the pilot can determine the eligibility of a fuel for their aircraft and replace a fuel placard as appropriate. For aircraft with an experimental certificate, owners are responsible for ensuring their aircraft is compatible with the new fuel. Owners may obtain data to support that determination from a Fleet Authorization or from a fuel offeror for fuels approved for use under TC/STC.

3.3.4 FUEL SPECIFICATIONS

Historically, one of the key industry roles has been the development of standards for the refining, blending, and distributing of AvGas and other transportation fuels including motor gasoline, diesel, and jet fuel. These standards are developed and maintained collaboratively by the petroleum, liquid fuels, and aviation industries. These standards facilitate the international handling of petroleum products and have been a key factor in the consistent and safe production, sale, transportation, and use of aviation fuel. Aviation fuel has been self-regulated through these standards. ASTM International has served as the primary body for this process in the U.S., resulting in standards with industry understanding and consensus. The industry consensus process allows producers, distributors, providers, users, and many other aviation fuels subject matter experts (SMEs) to conduct peer review assessments in the establishment of testing standards and fuel production specifications. The FAA participates in the review and approval as one of the many stakeholders to ensure that the specification is adequate for use in aircraft and engine approvals. The FAA authorizes the use of these fuels by reference to the industry standard in the approval documents.

The FAA allows for an alternative to industry specifications when approving or authorizing the use of fuel. An independent specification is developed and maintained outside of an industry consensus process. The FAA reviews the independent specification and approves it once it is found to provide an equivalent level of property, performance, and quality control as specifications outlined in relevant regulations and standards[14].

For fuels approved under the TC/STC pathway, FAA allows fuel offerors to rely on either the industry consensus specification or independent fuel specification, as long as the requirements described in AC 20-24D are met for the independent fuel specification. GAMI has developed an unleaded fuel with an independent specification. That fuel has been produced at volumes exceeding 1 Mgals and is currently available at four airports as of Summer 2026. Other industry stakeholders may require additional considerations to support business decisions for expanded deployment and use of the fuel.

Fuels pursuing FAA Fleet Authorization are required to obtain an industry consensus specification. Two producers are at various stages of obtaining the industry consensus standard with Swift Fuels obtaining a production specification in September of 2025 and LyondellBasell/VP Racing obtaining a test fuel specification in December of 2025.

An industry consensus standard provides advantages over an independent specification with respect to market acceptance. The consensus process provides for independent peer review and understanding of a new fuel and is widely relied upon by aircraft and aircraft engine manufacturers, airports, and FBOs for risk assessment, warranty support, and market acceptance. As noted in section 3.3.2, NATA's publication "Factors Affecting the Commercial Sale of Emerging Unleaded Aviation Fuels" discusses the advantage of the industry consensus standard at length.

3.4 AIRCRAFT FUEL AUTHORIZATIONS

Depending on the type of airworthiness certificate for each aircraft, the following types of actions will be required to enable the usage of unleaded fuels:

[14] AC 20-24D - Approval of Propulsion Fuels, Additives, and Lubricating Oils

3.4.1 STANDARD AIRWORTHINESS CERTIFICATE AIRCRAFT

Aircraft owners with aircraft that have a standard airworthiness certificate must take specific actions to implement changes to the aircraft via applicable Fleet Authorization documentation, Original Equipment Manufacturer (OEM) Service Bulletins, or installation of an STC. For aircraft with a standard airworthiness certificate, these changes must be performed by a certificated mechanic or authorized entity (see 14 CFR § 43.3), and any STC installation must comply with the requirements of the TC/STC.

3.4.2 SPECIAL AIRWORTHINESS CERTIFICATE AIRCRAFT – PRIMARY, LIMITED, PROVISIONAL, RESTRICTED, AND MULTIPLE

Aircraft owners with aircraft that have a special airworthiness certificate must take specific actions to implement changes to the aircraft via applicable Fleet Authorization documentation, OEM Service Bulletins, or installation of an STC. For aircraft with a special airworthiness certificate, these changes must be performed by a certificated mechanic or authorized entity (see 14 CFR § 43.3), and any STC installation must comply with the requirements of the TC/STC. STCs may not be applicable to all aircraft in these categories.

3.4.3 SPECIAL AIRWORTHINESS CERTIFICATE AIRCRAFT – LIGHT SPORT CATEGORY AIRCRAFT (SLSA)

FAA's Fleet Authorization can authorize the use of unleaded fuel for SLSA aircraft. Additionally, the original manufacturer of the SLSA aircraft may also determine that unleaded fuel is acceptable and notify their customers of a need for any corresponding aircraft alterations. There is not currently an independent pathway available for the utilization of a fuel STC for SLSA aircraft – the STC holder must coordinate the addition of the fuel STC with the original manufacturer.

3.4.4 SPECIAL AIRWORTHINESS CERTIFICATE AIRCRAFT – EXPERIMENTAL INCLUDING EXPERIMENTAL AMATEUR BUILT AND OPERATING LIGHT-SPORT CATEGORY AIRCRAFT (ELSA)

Owners of experimental aircraft must individually determine appropriate unleaded fuels to use in their aircraft. Many experimental aircraft have engines and fuel systems in common with aircraft with standard airworthiness certificates. For fuels authorized under FAA's Fleet Authorization process, owners of experimental aircraft can utilize data provided in the fleet authorization documentation to evaluate the usage of the fuel on their aircraft. For fuels approved under the STC process, owners of experimental aircraft will need to contact the holder of the STC for the appropriate data to evaluate the usage of that fuel on their aircraft.

4. APPROACH AND HIGH-LEVEL OVERVIEW

4.1 TRANSITION OVERVIEW

As discussed in the Executive Summary, the transition is anticipated to proceed through four phases to support the safe elimination of the use of leaded aviation fuels. The following section discusses a high-level approach to each of the phases and the critical actions that are anticipated during each phase. This section is followed by in-depth discussion of each of the phases contained within their own independent section, providing more detail and context of each of the phases. Specific activities are planned for the first phase, and this Transition Plan will be updated during Phase 2 to address the specific activities and schedules for Phases 3 and 4.

Additionally, the plan for the National Transition to Unleaded Aviation Gasoline is built around several core ideas that guide and shape the phases and the specific actions, which are anticipated to occur during those phases. Those core ideas are as follows:

- Federal regulations will be necessary to eliminate the use of 100LL.
- The marketplace will select the fuel, or fuels, that replace 100LL.
- Airports and service providers (e.g., FBOs)[15] should not be required to invest in additional tankage solely to accommodate the transition period.
- National Transition should be structured to be easily adapted as additional information that could impact the transition becomes available and uncertainties related to the transition are reduced.

This plan proposes four main phases of the transition as shown in Figure 7.

Image: FAA created

Figure 7 – Four Phases of the National Transition to Unleaded Fuel for the GA Fleet

4.2 PHASE 1 – FUEL AUTHORIZATIONS AND COMPARISON

The first phase will compile the data that is required to develop specific plans for the rest of the transition. It will address two prerequisites to the transition: what are the approved fuels, and how do the fuels compare?

Three replacement unleaded fuels are in various stages of obtaining FAA authorizations or approvals. Two of these fuels have been deployed for demonstration or limited use by early adopters. FAA authorizations or approvals must be completed in this phase. Recognizing that the market will select the fuel(s), there are additional factors such as the availability of data about the replacement fuels that affect the market beyond FAA authorization or approval. Phase 1 also includes fuel(s) comparison testing and reporting.

During this phase, currently approved fuels will continue to progress toward and into Phase 2 as stakeholders gain initial experience with those fuels. The activities for approvals and authorization are shown in Table 2. The

[15] Not all airports provide fuel. Instead, they rely on service providers (e.g., FBOs) to deliver fuels.

completion of those fuel approvals and authorizations is a priority and is projected to be complete by Spring 2027.

Unleaded Fuel	FAA Authorization Pathway	Current Status (Summer 2026)
LyondellBasell UL100	• Fleet Authorization – Planned • ASTM International Test Fuel Specification D8631	• Engine Testing – In progress • Materials Testing – In progress • Flight Testing – In progress
GAMI G100UL	• AML STC • Independent Specification G100UL Avgas-12C9	• Engine AML STC – SE01966WI • Airplane AML STC – SA01967WI • Rotorcraft AML STC – In progress
Swift Fuels 100R	• STC • ASTM International Production Specification D8603	• Initial Airplane STC – SE045652CH • Expanded Engine AML STC – SA04651CH • Expanded Airplane AML STC – In progress

Table 2 – Fuel approval or authorization status

This phase also includes comparative testing of the candidate fuels in areas that have been identified by market stakeholders as important to their consideration in adopting a fuel. This will include FAA-funded comparative testing under identical conditions to allow direct comparisons between fuels. For example, stakeholders have requested performance and detonation characteristics in high-performance engines, and material compatibility test results including materials used outside of aircraft approvals, such as in the supply chain and unique materials in aircraft with an experimental airworthiness certificate.

A particular concern that has been raised by stakeholders is the effect of co-mingling the various unleaded fuels and 100LL. All fuels in Table 2 are approved or targeting approval to mix with 100LL in the aircraft tank. Co-mingling of the unleaded fuels is not supported by any fuel offeror. The FAA recognizes there may be significant operational challenges and risks if multiple fuels are authorized for the same aircraft but cannot be co-mingled. This scenario would likely introduce a risk of regional market segmentation that could become a significant barrier to National Transition. It could also increase the risk of misfuelling, raising safety concerns. For these reasons, FAA will conduct co-mingling testing of the various fuels during Phase 1 to determine the technical viability of co-mingling unleaded fuels. This information will be used to support future policy efforts focused on the co-mingling of unleaded fuels. The fuel offerors are encouraged to also evaluate the co-mingling of fuels as they become available.

This phase is anticipated to conclude once all fuel approvals and authorizations have been finalized and the fuels comparison is completed. The activities in this phase will provide critical information concerning the aircraft alterations that may be needed for each fuel and the scope of potential changes in the supply chain for each fuel. Actions to be completed during this phase are shown in Table 3, organized by focus area. They will be described in more detail in subsequent sections.

PHASE 1: FUEL AUTHORIZATIONS AND COMPARISON (Projected Completion Spring 2027)
 **Fuel** • Complete fleet approval via Fleet Authorization • Approve STCs for unleaded fuels
 **Research** • Perform comparative testing between unleaded fuels and 100LL • Test co-mingling between new unleaded fuels

Table 3 – Phase 1 actions

4.3 PHASE 2 – GAINING MARKET EXPERIENCE

The second phase of the transition would provide time for the market to gain experience with the various unleaded fuels. Lessons learned from early market experience can be used to facilitate further market integration during the second phase of transition when more airports, service providers and aircraft are expected to adopt unleaded fuels. The lessons learned through Phase 2 of the transition will be directly applicable to the third phase of the transition.

In Phase 2 of the transition, FAA and industry expect to see increased consumption of unleaded fuel(s) and expanded locations well beyond the early adopters, providing an opportunity to gain further market adoption and experience. Since 100LL will continue to be available nationwide during this phase, the expansion of unleaded fuels will be at airports where the infrastructure available to supply more than one AvGas or through supplemental means such as added infrastructure or fuel trucks.

While every fuel undergoes representative testing prior to being authorized, there is potential for in-service challenges to arise due to the breadth of aircraft and engine designs, materials, and operations. Every reported issue involves a combination of a fuel in an aircraft/engine, and it can be challenging to differentiate the root cause for issues. For example:

- In October 2023, the University of North Dakota reported a concern with the usage of UL94 and valve seat recession (VSR) in Lycoming engines. Lycoming has initiated efforts to understand the cause of VSR. In an update provided in April 2024, Lycoming shared the results of their efforts. It indicated that UL94 may impact VSR under certain conditions. However, the influence of fuel characteristics and combustion dynamics is a complex issue, making it difficult to determine a possible root cause.
- In December 2024, AvWeb reported that G100UL unleaded fuel appears to damage aircraft paint under specific circumstances, according to a California Airframe and Powerplant Mechanic (A&P) who conducted his own compatibility tests on it and 100LL. The mechanic also said new nitrile O-rings swelled beyond certified limits when submerged in the unleaded fuel for five to six days. GAMI recommends replacing nitrile components with those made of silicone or fluoropolymer elastomers.
- In June 2024, Cirrus released Service Advisory SA24-14, identifying specific concerns with G100UL causing the degradation of fuel tank sealant. Again, multiple factors ranging from substrate preparations through fuel chemistry all potentially play a role in the observed degradation, making the root cause determination difficult despite continued efforts by both the fuel developer and Cirrus.

To facilitate investigations, FAA requested increased reporting concerning unleaded fuel experience through an SAIB issued in March 2025. Accurate and complete reporting of user experiences will be invaluable throughout Phase 2 and will inform the National Transition in Phase 3. Reported issues will need to be investigated by the relevant aircraft, engine, and fuel entities. To the extent the resources are available, affordable, and recognizing the scope of this challenge, FAA will also conduct testing to support investigations.

Phase 2 will also provide experience in producing, distributing, and storing unleaded fuel(s).
Phase 2 is projected to conclude by mid-to-late 2028, providing at least one year for gaining market experience prior to initiating the National Transition away from 100LL. Table 4 highlights the actions for Phase 2, also organized by focus area.

Finally, Phase 2 will include an updated Transition Plan to reflect the information gained from Phase 1 and early market acceptance, and initiation of the FAA proposed regulations for the Phase 3 and 4 National Transition. At that time, detailed information will be available that enables individual aircraft owners to understand what National Transition to unleaded fuel means to them. The ability to mix fuels together will also have been determined to be feasible, or procedures put in place to assure flight safety if some fuels cannot be mixed. Industry engagement and feedback throughout this phase is critical.

PHASE 2: GAIN MARKET EXPERIENCE (Projected Completion Fall 2028)	
	Fuel • Increased consumption of unleaded fuels • Potential in-service challenges experienced and reported • Provide initial insights into the price of the replacement unleaded fuels
	Research • Reported issues investigated by relevant aircraft, engine and fuel stakeholders, as well as FAA (to the extent affordable), root cause determined (where possible), and mitigated
	Infrastructure • Initiate efforts to examine and potentially expand fuel storage infrastructure • Support transition readiness activities at airports, and by service providers with the infrastructure available to supply more than one AvGas through added infrastructure or fuel trucks • Provide experience in producing, distributing and storing fuel
	Prepare for Phase 3 • Update Transition Plan (V2.0) • Propose Regulations

Table 4 – Phase 2 actions

4.4 PHASE 3 – NATIONAL TRANSITION

Phase 3 will involve a National Transition to replace 100LL with unleaded fuels outside of Alaska. The National Transition will be influenced by Phase 1 and Phase 2 activities as well as progress by FAA to prescribe standards for the composition or chemical or physical properties of a fuel or fuel additive for the regulation of aviation fuels containing lead. A key to phasing out 100LL at any given airport will be well-coordinated efforts by various stakeholders. Here are some sample actions that will require synchronization:

- Aircraft owners and operators of the aircraft that operate out of or frequent a given airport will seek predictability in the available fuels, as well as the details of the required alterations to use the fuel.
- Fuel producers and suppliers will look to finalize fuel(s) supply to airports and FBOs.
- Airports, FBOs, and the supply chain will sell 100LL until there is a competitive unleaded alternative or until federal regulations prohibit its sale.
- Airports and FBOs will sell replacement fuel that can support most aircraft either using or frequenting their location, as long as it can be produced and delivered in a timely and reliable manner.

Some aircraft in the active fleet may require modifications beyond placarding and flight manual revisions to use a replacement unleaded fuel(s). It is important to align the transition activities in a manner that allows a reasonable timeframe to complete these modifications. Support of this activity will require focused guidance and coordination with repair facilities to facilitate National Transition.

While some airports or service providers will begin selling unleaded fuel in Phase 2, the majority of airports and many FBOs may not have the ability to offer more than one AvGas. At those airports, the transition to unleaded fuel cannot be gradual and must happen in a clear and controlled manner. Key milestones for Phase 3, in the order in which they are expected, include what is shown in Figure 8:

Figure 8 – Key milestones in Phase 3

The transition at airports that can offer more than one fuel is considerably easier and provides more time for the aircraft owners to plan for and complete alterations before 100LL ceases to be available. However, depending on the market experience gained during Phases 1 and 2, or factors unique to their location, individual airports and/or FBOs may ultimately adopt a different unleaded alternative to replace 100LL with the one they offered initially. Therefore, even airports/FBOs with multiple fuels should adhere to the same timeline by announcing their ultimate replacement fuel(s) at Milestone B, as shown in Figure 8 above. The actions to execute during Phase 3 to enable a successful National Transition to unleaded fuels are highlighted in Table 5.

The duration of Phase 3 will be informed by the Phase 1 activities, particularly the detailed insight of any aircraft modifications associated with the transition to various fuels. The time between Phase 3 Milestone B and Milestone D needs to be sufficient to allow those modifications to take place. Additional time to Milestone E affords time to use up any remaining 100LL.

PHASE 3: NATIONAL TRANSITION
Fuel • Fuel suppliers decide the unleaded fuel(s) they plan to offer and make appropriate arrangements (including Alaska) • Airports/FBOs announce the specific unleaded fuel(s) that will be available at the airport as a 100LL replacement (including Alaska) (e.g., update the Airport Master Record and Chart Supplement) • Aircraft owners (outside of Alaska) complete alterations to use alternate fuels • First wave of airports/FBOs outside of Alaska cease selling 100LL and switch to an unleaded replacement (outside of Alaska) • Full transition of distribution and storage infrastructure • Last wave of airports/FBOs outside of Alaska cease selling 100LL and switch to an unleaded replacement • 100LL in the supply chain is consumed and/or phased out
Aircraft • Aircraft owners (outside of Alaska) complete alterations to use alternate fuels
Infrastructure • Full transition of distribution and storage infrastructure

Table 5 – Phase 3 actions

4.5 PHASE 4 – ALASKA TRANSITION

Piston engine aircraft in Alaska provide a broad array of critical transportation for which there is no alternative. To ensure that Alaska can transition without adversely impacting those services, Congress provided additional time for Alaska to complete its transition (see Section 771 of The Act).

Alaska does not have dedicated refineries or producers, so Milestone A in Figure 9 (Suppliers decide on the unleaded fuel(s) they plan to offer) in Phase 3 will trigger the onset of the transition in Alaska. While the sequence of events in Alaska is the same, a longer transition period is needed, particularly due to the seasonal nature of fuel delivery (summer) and any aircraft alterations (winter). Providing a longer period to perform aircraft alterations ensures there is no conflict between altering the aircraft or providing essential services, given the challenges posed by executing aircraft alterations in Alaska. In addition, the highly seasonal nature of Alaska's consumption of AvGas may impact its ability to consume residual 100LL during the winter months. A unique issue for Alaska due to logistics constraints of some locations is that some FBOs may need to co-mingle 100LL and an unleaded replacement within a tank at high volume ratios prior to the point-of-sale to the aircraft, which will require appropriate testing protocols to ensure that the blended fuel is compliant to the expected characteristics. Following the National Transition schedule, appropriate recommended milestones for Alaska are shown in Figure 9, with key activities listed in Table 6:

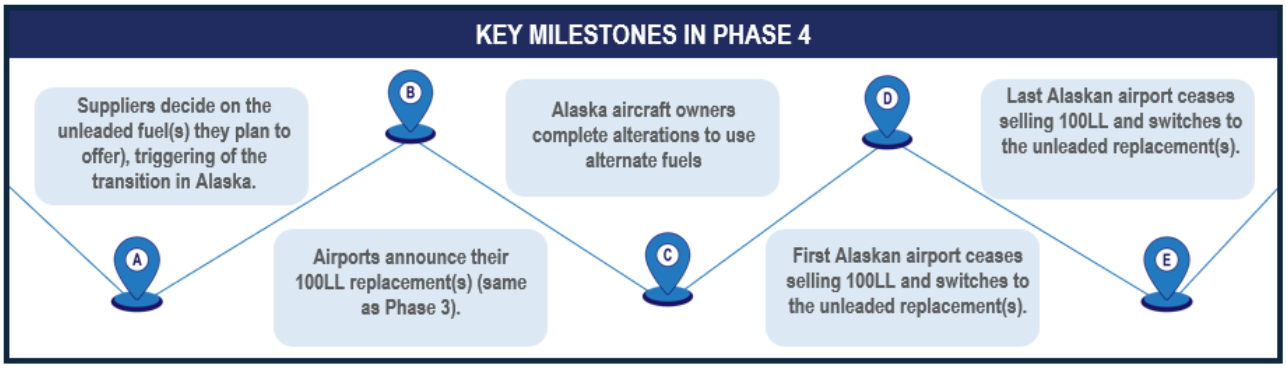


Figure 9 – Key milestones in Phase 4

PHASE 4: ALASKA TRANSITION
Fuel • Fuel suppliers decide the unleaded fuel(s) they plan to offer, triggering the transition in Alaska • Airports/FBOs announce the specific unleaded fuel(s) that will be available at the airport as a 100LL replacement (including Alaska) (e.g., update the Airport Master Record and Chart Supplement) • Aircraft owners (outside of Alaska) complete alterations to use alternate fuels • Annual unleaded fuel volume moved to Alaska • First wave of airports/FBOs outside of Alaska cease selling 100LL and switch to an unleaded replacement (outside of Alaska) • Full transition of distribution and storage infrastructure • Last wave of airports/FBOs outside of Alaska cease selling 100LL and switch to an unleaded replacement • 100LL in the supply chain is consumed and/or phased out in Alaska
Aircraft • Aircraft alterations complete across the fleet in Alaska
Infrastructure • Resolution of infrastructure fuel blending limitations for 100LL and unleaded fuels

Table 6 – Phase 4 actions

5. TRANSITION PLAN DEEP DIVE: PHASE 1 – FUEL AUTHORIZATION AND COMPARISON

5.1 FUELS: STATUS AND PLANS FOR AUTHORIZATIONS

One of the primary activities of Phase 1 is the approval or authorization of unleaded fuels for widespread use across the fleet of GA aircraft. As mentioned previously, there are currently three fuels that are in the various stages of approval, authorization, distribution and early sales. Please refer to section 4.3, Gaining Market Experience, for some in-service challenges documented to date.

The subsections below highlight the current (as of Summer 2026) status of each of the fuels, supported by information from the fuel developer. Please check the various websites associated with each developer and flyEAGLE.org for the most up to date information.

5.1.1 GENERAL AVIATION MODIFICATIONS, INC. (GAMI) G100UL

GAMI G100UL AvGas (Specification 12C9) is approved for use in nearly all the aircraft found in the FAA TC database via STC SA01967WI. G100UL AvGas is also approved for use in 100% of all the aircraft spark-ignition piston engines found in FAA TC database, with STC SE01966WI. G100UL AvGas has been successfully operated in a Commemorative Air Force WWII, R-2800 powered "Warbird." GAMI is fully engaged in support of rotorcraft approval for G100UL AvGas. Additionally, several aircraft with an experimental airworthiness certificate have been modified and approved to use G100UL with GAMI providing data to support the use of G100UL on the aircraft with an experimental airworthiness certificate.

G100UL AvGas has already been produced in a large commercial volume (> 1 million gallons) and distributed the fuel to aircraft using the existing FBO/airport infrastructure. Currently, G100UL AvGas is deployed and available for sale at two airports in California, one in Mississippi, and one in Texas. The most recent information on G100UL can be found at G100UL.com.

5.1.2 LYONDELLBASELL/VP RACING UL100

LyondellBasell and VP Racing Aviation (VPRA) are seeking FAA fleet approval under FAA/Industry PAFI Test Program for their jointly developed fuel, UL100. UL100 successfully passed the initial set of tests and has been in the full-scale PAFI testing program since the end of 2024. On-going testing efforts are focused on three critical areas: engine testing, aircraft flight testing, and materials compatibility. Status of all testing activities is available at flyEAGLE.org.

LyondellBasell/VP Racing received an ASTM International test fuel specification, D8631-25, "Standard Specification for Unleaded Aviation Gasoline Test Fuel Containing Ethers," targeting a production specification in Fall of 2026. This is a requirement under the Fleet Authorization approval process. UL100 is anticipated to complete the full-scale testing in Fall 2026 and Fleet Authorization in Spring 2027. The fleet authorization process will support traditional type certificated engines, airplanes and rotorcraft along with enabling authorization of the fuel in light-sport category aircraft and providing technical data to support the use of the fuel in aircraft with an experimental airworthiness certificate.

Currently, VP Racing Aviation is fully operational, producing the fuel in bulk and distributing to PAFI Technical Advisory Committee members as needed for testing. VPRA has also considered the challenges of supplying Alaska and international markets. For the latest information on UL100 visit VPRA and LyondellBasell.

5.1.3 SWIFT FUELS 100R

Swift Fuels AvGas (100R) is currently approved for use in >1000 piston engines (STC SA04651CH) and corresponding airframes. Swift Fuels began the deployment of 100R in November 2024 following FAA's

approval of the initial 100R STC in September 2024. 100R has been actively utilized on FAA-approved aircraft located at multiple US flight schools.

Swift Fuels certification work is being completed in tranches to allow critical segments of the unleaded AvGas market to utilize FAA-approved fuels once the certification work is completed. Swift Fuels also recently entered the PAFI program and is participating in ongoing efforts and data collection in support of Fleet Authorization of 100R.

In addition to certification efforts, Swift Fuels received an ASTM International production specification, D8603-25 Standard Specification for High-Octane Unleaded Aviation Gasoline Containing ETBE, effective October 2025. The ASTM International industry consensus body maintains oversight of the fuel standard impacting the global supply chain. The specification will be maintained as long as the fuel remains active in the commercial marketplace. As previously mentioned, Swift Fuels began the deployment of 100R in November 2024 following FAA's approval of the initial 100R STC in September 2024. Additionally, Swift Fuels began the deployment of 100R internationally in early January 2025 following FAA's approval of the initial 100R STC in September 2024 using existing bi-lateral arrangements with various regulatory bodies. More information can be found at Swift Fuels.

5.2 FUELS: COMPARATIVE ASSESSMENT

The FAA will compare proposed high-octane unleaded fuels to FBO 100LL and minimum specification 100LL. This comparison will look at critical materials properties, detonation characteristics, and critical fit-for-purpose properties. The initial assessment will also be utilized to inform a subsequent phase of comparative assessments, which will leverage the initial learning to develop additional testing, examine engine durability, and test the comingling compatibility of various unleaded fuels. Additionally, the data will be made available to all stakeholders to provide information on fuel performance and characteristics to support stakeholders in their assessment of the fuel for a safe and efficient transition to unleaded fuel(s).

Additional details of the initial comparative testing are described in Tables 8-10 in Appendix B: FAA Comparative Assessment.

Testing is planned on up to three 100-octane, unleaded fuels as they can be obtained (GAMI G100UL, Swift Fuels 100R, and LyondellBasell UL100) and three leaded reference fuels (FBO 100LL, a minimum specification 100LL fuel, and a high-aromatic blend 100LL [min 15% aromatic by volume]). Each of the leaded fuels will serve as a reference fuel for comparison for that block of testing. Engine detonation, materials compatibility, and laboratory analytical testing and evaluation will be performed targeting key engines and materials that act as bellwethers for unleaded fuel analysis.

The testing is divided into four blocks, with block one focusing on fuel fit for purpose and composition, block two focusing on engine testing, block three focusing on materials testing, and block four involving a toxicological assessment. The testing in block one will be performed on the neat unleaded fuels, referenced leaded fuels, 50-50 blends of unleaded fuels and FBO 100LL, and 50-50 blends of two unleaded fuel candidates.

5.3 EXPLORATION AND IMPLEMENTATION OF ALTERNATE ENGINE TECHNOLOGIES

It is expected that most of the stakeholder community will transition to unleaded fuels, however, some stakeholders may wish to explore alternative solutions or technology. Some examples of these alternative solutions or technology include hybrid electric, or replacement of a spark-ignition piston engine with compression-ignition engines that can take advantage of the widespread availability of Jet A fuel. Many of these alternative solutions are in continued development and looking to expand to additional engine classes and airframes in the future.

6. TRANSITION PLAN DEEP DIVE: PHASE 2 – GAINING MARKET EXPERIENCE

6.1 SUPPLY CHAIN AND LOGISTICS BARRIERS

As part of this Transition Plan, Section 827(b)(1)(D) of the Act directs an assessment of "efforts to address supply chain and other logistical barriers inhibiting the timely distribution of unleaded aviation gasoline." FAA, through collaboration with industry and EAGLE stakeholders, has identified and captured known supply chain and logistical barriers, shown in Table 7.

Ideally, the impacted stakeholders will actively address all the identified items during transition Phases 1 and 2. However, until all fuels are available, production and distribution scale to regional levels, and a larger portion of aircraft have been altered, stakeholders may not realize a full understanding of the supply chain and logistical barriers or the efficacy of the proposed risk mitigations. This area should be a continued area of focus as the transition to unleaded fuels evolves. Additional resources related to applicable guidance materials and standard practices related to aviation fuels can be found in Appendix G: Guidance Material and Standard Practices.

BARRIER	RISK	POTENTIAL MITIGATION
Fuel co-mingling	• Unleaded fuels are unable to co-mingle with one another • Lack of guidance on co-mingling unleaded fuels and 100LL for infrastructure	• Plan for appropriate comparative testing early • Work with fuel developers and distributors early to put a plan in place • Each unleaded fuel may be safely co-mingling with 100LL in the aircraft
Additional storage requirements	• Insufficient 100LL supply during the transition • Insufficient planning/budgeting	• Maintain 100LL supply during the transition • Plan for upfront costs early. Distributors who provide fuel trucks may need to undertake software upgrades, changes to signage and other compliance items in adherence to their contracts • Coordinate the transition at each airport so an FBO can switch from 100LL to a replacement fuel without additional storage infrastructure
Fuel composition and continuity	• Replacement fuel sponsor does not disclose the components used to manufacture a new unleaded fuel, leading to uncertainties about its safety and continuous availability • Insufficient supplies could lead to delays in acceptance; excess supply could compromise the fuel integrity by aging	• Work with the fuel sponsor to obtain necessary information under a non-disclosure agreement (NDA) or similar arrangement • Encourage the fuel sponsor to seek industry consensus • Encourage key transition decisions early so that fuel developers, distributors, FBOs, airports and others plan for sufficient supply
Fuel composition and materials compatibility	• Lack of insight into the testing program leads to uncertainties as to the replacement fuels' compatibility with the existing transportation and storage materials • Concerns with fuel aging	• Identify the differences in test methodology, prioritize the differences and potentially test for major items • Perform testing to understand unleaded fuel aging in different environments and storage conditions
Logistics/continuity of the supply chain	• Not all refineries accept and co-mingle a replacement fuel, leading the distributors to costly	• Communication and collaboration between fuel suppliers and FBOs and airports • Coordinated transition decisions

BARRIER	RISK	POTENTIAL MITIGATION
	detours and a potential breach of their FBO contracts requiring them to fulfill the terms timely • These factors could lead to distributor/FBO reluctance to transition to replacement fuels	
Price of the replacement unleaded fuels	• Price under full production is unknown	• Potential federal, state, local subsidies • Economies of scale
Liability	• Most FBO liability insurance covers the cost of the fuel alone and not the repercussions directly related to an incident • OEM warranties	• Work with the key industry players early to mitigate these concerns • Encourage fuel developers to attain a consensus standard, which facilitates fuel quality control and provides stakeholders better understanding of the replacement fuel, reducing liability concerns
Communication and transition timing	• Confusion, uncertainties, inefficient flight routes, expensive detours, inadequate infrastructure, etc.	• Managed early engagement with all impacted stakeholders to understand their expected transition timing, anticipated mechanisms for transition, plans for their respective municipalities, etc. • Focused engagement in Phase 2 to develop detailed plans for Phase 3 and 4
Market Differentiation	• Market fractures on factors such as price and/or performance	• Communication and collaboration between fuel suppliers, FBOs and airports, and operators • Educate on misfuelling risk of multiple fuels at location

Table 7 – Supply chain and logistics barriers

6.2 FUELS: INCREASING UNLEADED FUEL PRODUCTION

Any unleaded fuel producer should create a robust production management plan with a timeline and sufficient detail to facilitate production in support of the transition. This plan should include management of change in the transition from 100LL to unleaded fuel(s). Other factors to consider are the modification or addition of production equipment, handling and storage of unleaded fuel, internal process control, training to produce unleaded fuels, and compliance with all other applicable regulations. These processes can take considerable time to bring production online (>24 months) as producers evaluate market demands, existing production capabilities, and potential reallocation of resources for production, handling, distribution, and storage of unleaded fuel.

Throughout Transition Phase 2, production of unleaded fuels should be increasing toward meeting the full annual demand of the GA fleet. Based on total annual usage of 100LL and future projections, a total estimated fuel volume of approximately 180 Mgal of unleaded fuel would be required by the end of 2032.

In addition to economic considerations in transitioning to the production of unleaded fuels, many large-scale refiners and producers have indicated that the industry's acceptance of the unleaded fuel(s) is a significant factor in their decision to move forward with that fuel. Acceptance by the aviation industry could be indicated by OEMs' approval for usage of the fuel on their equipment or the development and acceptance of a voluntary industry consensus specification. Fuels without an industry specification will need to address additional considerations required by industry stakeholders to support business risk decisions for deployment and use.

Additionally, fuel producers and developers should work with airports and FBOs to identify locations that have the capacity to support multiple unleaded fuels and look to develop regional markets to further enhance unleaded fuel availability and grow market experience. The sooner these replacement fuels are accepted at scale, the sooner large-scale producers can evaluate the market demand with increased fidelity.

6.3 FUELS: 100LL PHASE OUT INITIATION

As viable replacement unleaded fuels gain user acceptance, a critical element to an orderly transition will be a timely decision on when 100LL sales will discontinue. Understanding the transition activities planned for each phase allows for certainty in the marketplace when planning for the discontinuation of 100LL. Major players in this process will be the fuel distributors, airports, FBOs, fuel retailers, the sole producer of TEL (see Section 2.1), and the ultimate end users, including the ones with unique needs such as the Alaska community. This plan projects the discontinuance of 100LL will be at the conclusion of Phase 3 (outside Alaska), and the conclusion of Phase 4 in Alaska.

Phasing out 100LL fuel should be closely aligned with the increased production of unleaded fuel(s) to meet market demand and capacity. Airports and FBOs will have a critical role in phasing out 100LL and facilitating usage of unleaded fuel(s). Coordination with the TEL producer is important to ensure that a sufficient volume of TEL is available to support the transition through its entirety, including the extended transition in Alaska.

Fuel producers will have to ensure their production and storage capacity for 100LL is aligned with the phase out dates for 100LL. It should be noted for non-Alaskan United States locations, that there is an approximate 9 to 18-month supply of 100LL in the system at any given time. Alaskan operations typically receive a limited supply of 100LL during specific time periods, usually once per year. This will require careful coordination with respect to volumes for production and delivery to Alaskan operators.

Relative to a safe transition, it is essential to note that through the Act, Congress mandated that federally obligated airport owners/operators continue to make 100LL available while replacement fuels are developed and deployed. This statutory requirement was implemented as Grant Assurance 40, Access to Leaded Aviation Gasoline.

To support this legislative mandate and grant assurance, FAA Office of Airports released a Q&A document, which was updated on December 10, 2025, clarifying the Grant Assurance 40 and prohibiting airports from restricting 100LL availability until an alternative fuel meets the established criteria.

6.4 FUELS: COMINGLING OF UNLEADED FUELS

The FAA and industry are working to determine the full extent to which unleaded fuels can be safely co-mingled with each other via FAA's comparative testing efforts described in section 5.2 and appendix B, tables 8-10. Unleaded fuels can be safely co-mingled with 100LL in the tank of the aircraft. Comparative Assessment will further examine critical material properties, detonation characteristics, and critical fit-for-purpose properties of co-mingled unleaded fuels. The data will be made available to all stakeholders and provide information on fuel performance and characteristics to support their assessment of the fuel for a safe and efficient transition to unleaded fuels.

If unleaded fuels cannot be mixed, FAA will work with EAGLE to develop appropriate safety mitigations for the fleet. This would also create a significant barrier to the National Transition, necessitating either duplicate infrastructure to support multiple fuels (depending on the aircraft operator's preference) or the market forces converging on a single (or multiple compatible) fuel.

The misfueling measures that airports and FBOs are expected to undertake to support new fuels may also help mitigate comingling concerns. Additionally, comingling of fuels presents unique challenges for Alaska. See Section 8.4 for further discussion on this topic.

6.5 FUELS: INITIAL DELIVERIES INTO ALASKA

As discussed previously, Alaska presents unique challenges and opportunities in the transition to unleaded fuel(s). Bulk fuel is typically moved into the state via a single delivery, once per year, and then distributed to additional locations. As part of the transition, fuel developers should determine an initial location or region with the storage capacity to distribute both 100LL and the unleaded alternative. Getting fuel into the state as early as possible will provide opportunities to identify unique challenges and reduce the risk to the full transition at later dates.

Having early utilization of initial deliveries will allow stakeholders to pilot the use of the fuel and gather first-hand experience about the utilization of the fuel in the Alaskan operational environment. Early utilization may facilitate the development of the enabling infrastructure to supply and deliver fuel throughout the distribution system for Alaska. It may also allow producers to explore pathways for increasing production and deliveries to the region.

6.6 INFRASTRUCTURE: FUEL STORAGE AND DISTRIBUTION INFRASTRUCTURE

During Phase 2 in the transition, the goal is to encourage safe, early adoption of unleaded AvGas variants at U.S. airports, while maintaining the availability of 100LL. As of Summer 2026, airports, operators, and industry are still very early in the transition with approximately 3,200 U.S. airports reporting sales of 100LL (includes public use and private facilities),[16] and of those, 2,741 airports in the National Plan of Integrated Airport Systems (NPIAS)[17] report selling 100LL. See Appendix D: Airports and FBO Resources; Airports – Actions to Support a Transition to Unleaded Fuels.

NOTE

NPIAS airports are eligible for Federal funding under the Airport Improvement Program (AIP). The FAA is authorized to provide funding for some aircraft fueling systems such as fuel farms for an additional fuel type not currently offered. This provides opportunities for airports to support early transition.

As of Summer 2026, a total of 212 airports offer unleaded AvGas variants. Eighty of these are NPIAS airports that offer unleaded AvGas variants.

At this stage in the transition, airports and service providers are encouraged to take early action by offering initial unleaded fuel types while maintaining 100LL. Airports or service providers that have more than one tank available for AvGas are ideal locations to support the early transition, as a new unleaded fuel can be offered along with 100LL. Airports or service providers that do not have that capacity should consider other options, such as using a fuel truck, skid-mounted system, fuel trailer, or bowser. Alternately, some airports or service providers have spare transition-enabling infrastructure that can be leveraged to support an early transition.

Each airport and service provider will have to intentionally evaluate its unique operating scenarios, available infrastructure, and plan for a safe transition.

There are scenarios that may encourage early adopters to offer unleaded fuel(s) prior to the National Transition. These scenarios include federal regulatory actions[18], responding to community pressure, responding to a specific customer or set of customers with a demand for unleaded AvGas (e.g., flight schools that have a compatible aircraft fleet), and lastly, the desire of some airports to lead as early adopters.

[16] FAA ADIP Database

[17] Current NPIAS Airports

[18] U.S. EPA - Final Endangerment Finding Regarding Lead in Aviation Gasoline

FAA grant programs i.e., the Airport Improvement Program (AIP) and Infrastructure Investment and Jobs Act (IIJA) can support transition-enabling infrastructure. IIJA and AIG allocated funds can be used on sponsor-owned revenue producing aeronautical support facilities such as fuel farms. For additional information, see the IIJA page and FAQs[19] It is also important to recognize the role of state aviation agencies as implementation partners supporting airport transition efforts. This includes state-administered airport funding and technical assistance programs that support airports. Airports should be coordinating closely with their state aviation agencies to facilitate a safe and predictable transition in Phase 3 or 4.

Existing airport equipment, procedures, markings, and training are specific to the characteristics of the current 100LL fuel. The physical and chemical differences of an unleaded replacement fuel may have negative safety or operational impacts that require mitigations or changes to processes and equipment. Deployment of a new unleaded fuel to airports requires that the storage tanks be ready for the new product (clean, compatible, labeled properly for receiving), that the delivery trucks are available/ready, that required placards and labeling are in place, and that training has been implemented at the airport and FBOs to ensure dispensing of the correct fuel to the specified aircraft.

There are several considerations in ensuring that airports and FBOs are ready to safely receive, store, and deliver a new unleaded fuel to the specified aircraft. Considerations include the following:

- Decals and labeling
- Aircraft fill ports, trucks, and pumps
- Training – education and awareness
- Fuel dispensing nozzle size
- Aircraft "fuel sumping"
- Comingling
- Personnel health and safety
- Compatibility with 100LL
- Storage tanks – cleaning
- Fuel color identification
- HAZMAT
- Multiple fuels

It will be important to address differences from 100LL fuel and implement the necessary changes to efficiently and safely support the implementation of a new unleaded fuel.

6.7 PLANNING FOR PHASE 3 AND 4

As discussed previously, FAA will release Transition Plan to Unleaded Aviation Gasoline V2.0 during Phase 2 of the Transition. This updated Transition Plan will highlight the resolution of technical and policy challenges for aircraft modifications, compatibility of the fuels, timelines and alignment with regulatory requirements, cost considerations, and other Phase 1 and 2 items. Additionally, the updated version of the Transition Plan will provide details for Phases 3 and 4 of the transition regarding timelines, milestones, and regulatory actions, such as the status of FAA's efforts to establish standards under 49 USC 44714. The updated Transition Plan will also explore any new barriers or technical challenges to the transition to unleaded fuels discovered in Phases 1 and 2.

[19] https://www.faa.gov/iija/faq/IIJA_FAQs.pdf

7. TRANSITION PLAN DEEP DIVE: PHASE 3 – NATIONAL TRANSITION

7.1 USE CASES

Four hypothetical use cases were identified to illustrate the potential scenarios tied to the National Transition occurring for unleaded fuels. These scenarios are designed to be illustrative to potential paths forward in National Transition. Each scenario has a brief description of the scenario and is followed by the necessary Phase 3 actions, described in greater detail in subsequent sections. The scenarios also highlight potential challenges faced by critical stakeholders. Given the significant variation among the scenarios, FAA is deferring detailed planning for Phase 3 and 4 until after Phase 1 is complete and the applicable scenario can be identified.

SCENARIO 1: SINGLE FUEL

The industry has reached the National Transition phase, and the market has settled on a single fuel.

Actions needed:

- Unleaded fuel production capacity meets fleet demand
- Aircraft owner/operators have sufficient data to understand the alterations required for their aircraft
- Aircraft alterations are completed
- Unleaded fuel(s) distributed to the airports/FBOs

Challenges:

- Timing with transition from 100LL to unleaded fuel(s)
- Lead time/potential costs of aircraft alteration

Stakeholders:

- Fuel producers
- Fuel distributors
- Airports/FBOs
- Aircraft owner/operators

SCENARIO 2: COMPATIBLE FUELS

The industry has reached the National Transition phase. The market has settled on a single fuel or determined that all three fuels can be co-mingled and provide equivalent performance.

Actions needed:

- Unleaded fuel production capacity meets fleet demand
- Airports/FBOs identify fuel(s) selections for their locations
- Aircraft owner/operators have sufficient data to understand the alterations required for their aircraft
- Aircraft alterations are completed
- Unleaded fuel(s) distributed to the airports/FBOs
- Supply market may be challenged to support multiple fuels

Challenges:

- Timing with transition from 100LL to unleaded fuel(s)
- Lead time/potential costs of aircraft alteration

Stakeholders:

- Fuel producers
- Fuel distributors
- Airports/FBOs
- Aircraft owner/operators

SCENARIO 3: INCOMPATIBLE FUELS

The industry has reached the National Transition phase. There are multiple unleaded fuels available, but the fuels cannot be co-mingled, or different fuels require different aircraft alterations, and fuel availability may vary by location.

Actions needed:

- Unleaded fuel production capacity meets fleet demand
- Airports/FBOs identify fuel(s) selections for their location
- Aircraft owner/operators have sufficient data to understand the alterations required for their aircraft
- Aircraft alterations are completed
- Unleaded fuel(s) distributed to the airports/FBOs

Challenges:

- Fragmented market with multiple choices
- Misfuelling risk/multiple fuels at locations
- In transit refueling (the aircraft's authorized fuel may not be available along the flight path)
- Complex supply and distribution chain
- Timing with transition from 100LL to unleaded fuel(s)
- Lead time/potential costs of aircraft alteration
- Supply market may be challenged to support multiple fuels
- Insufficient storage capacity to support multiple fuels, leading to reduction in the geographic availability of refueling options for an individual aircraft owner/operator

Stakeholders:

- Fuel producers
- Fuel distributors
- Airports/FBOs
- Aircraft owner/operators

SCENARIO 4: MARKET DIFFERENTIATION

The industry has reached the National Transition phase. The market fractures on factors, such as on price and/or performance where those owners who prioritize aircraft performance (in the more demanding engines/aircraft) use one fuel while the rest of the fleet uses one or more alternative fuel(s). The fuels cannot be co-mingled.

Actions needed:

- Unleaded fuel production capacity meets fleet demand
- Airports/FBOs identify fuel(s) selections for their locations
- Aircraft owner/operators have sufficient data to understand the alterations required for their aircraft
- Aircraft alterations are completed
- Unleaded fuel(s) distributed to the airports/FBOs
- Infrastructure capacity for two fuels where needed

Challenges:

- Fragmented market with multiple choices
- Misfuelling risk/multiple fuels at locations
- In transit refueling, (the aircraft's authorized fuel may not be available along the flight path)
- Complex supply and distribution chain
- Timing with transition from 100LL to unleaded fuel(s)
- Lead time/potential costs of aircraft alteration
- Market may be challenged to support multiple fuels

Stakeholders:

- Fuel producers
- Fuel distributors
- Airports/FBOs
- Aircraft owner/operators

7.2 FUELS: UNLEADED FUEL PRODUCTION MEETS DEMAND

Building on the factors outlined in Section 6.2, Increasing Unleaded Fuel Production, it is imperative that a sufficient volume of replacement fuel is available to accommodate an increased demand in all transitioning locations. This translates to roughly 180 Mgal of annual unleaded fuel by the end of 2032. This will help the airports and FBOs in their task to cease the distribution and sale of 100LL and fully switch to an unleaded replacement.

It is anticipated that some regions of the country may transition sooner. California has passed its own state-level legislation banning the sale of leaded fuel as of January 1, 2031[20]. Other states like Colorado are developing resources to incentivize an early transition to unleaded fuels.

It is anticipated that full-scale production and distribution of unleaded fuels should initiate during Phase 2 of the transition. This timing will allow producers and distributors to observe the market demands and drivers, evaluate the aviation industries' acceptance of unleaded fuels, scale production capabilities, and execute on the best and most efficient path toward full scale production. Increasing production will support all the Milestones in Phase 3 (see section 4.4, National Transition), ultimately with production meeting demand in order to meet Milestone E (the last wave of airports outside of Alaska cease selling 100LL and switch to an unleaded replacement) for National Transition.

[20] CA Senate Bill 1193 - Airports: leaded aviation gasoline

7.3 INFRASTRUCTURE: STORAGE AND DISTRIBUTION

By Phase 3 in the transition, the early adopters will have taken action to offer unleaded variants and shared lessons learned with their counterparts at other airports throughout the country. The remaining airports may be at various stages of transitioning to unleaded fuels. Airports may have implemented the recommended short-term actions (see Appendix D: Airport and FBO Resources), as well as executed Milestones A and B. Under scenario 1, airports will be able to switch from the supply of 100LL to an unleaded alternative without additional storage requirements. The final 100LL delivery will need to occur with adequate time to deplete the 100LL storage prior to Milestone E (The last wave of airports outside of Alaska cease selling 100LL), and the initial delivery of the replacement unleaded fuel timed to arrive as the 100LL is consumed. Small amounts of residual 100LL may be offloaded to temporary storage such as a fuel truck or co-mingled with the replacement fuel if supported by co-mingling testing.

Under scenarios 2 and 3, the FBO would have to decide to either offer multiple unleaded fuels or select a replacement fuel that would not be usable by the entire fleet. The primary unleaded fuel that replaces 100LL in storage would occur following the same approach as in scenario 1. Storage provisions for more than one fuel would depend on the volume that is required.

Regardless of the timing of their individual transitions, all airports are encouraged to utilize the many resources available to them to facilitate a safe and orderly transition. Please refer to the list in Appendix D: Airport and FBO Resources.

7.4 FLEET READINESS: ACTIVE FLEET ALTERED FOR UNLEADED USAGE

Given the requirement that aircraft will need to be altered to use unleaded fuel(s), it is important that the alterations are aligned to the transition phases to allow a reasonable timeframe to complete these critical steps, allowing for an orderly and safe transition. As discussed in Section 4.4 National Transition, it is recommended that airports and FBOs communicate their plans for a replacement fuel (Milestone B) so aircraft owners can determine what alteration they should make. Aircraft owners should complete necessary alterations for their aircraft to use alternate fuels in alignment with Milestone C. It is anticipated that Milestone D will follow closely with Milestone C completion.

Aircraft may have to address alterations based on the unleaded fuel their owners select. These alterations could be as simple as placard changes and updating the aircraft flight manual supplement (AFMS) or could be more in-depth, requiring engine hardware modifications such as replacement of an engine, installation of new engine pistons, the installation of anti-detonation injection systems, ignition timing changes, or significant changes to operating limitations.

The transition at airports that can offer unleaded fuel early in the process provides more time for aircraft owners to plan for and complete alterations before 100LL is no longer available. Another consideration is the airports that may, through market experience gained, ultimately adopt a replacement unleaded fuel that differs from the one(s) they offered in the early days of the transition. For this reason, even the airports, FBOs, and fuel suppliers with multiple fuels should be encouraged to adhere to the same National Transition timeline by announcing their definitive replacement fuel(s) in alignment with Milestone B (see Section 4.4 National Transition), to provide sufficient opportunity for aircraft alterations to be completed. Owners and operators should also acknowledge that while their base airport may transition early, fuel availability at other airports while the transition is ongoing could result in scenarios such as those highlighted above and may impact transient refueling.

7.5 FUELS: 100LL IN SUPPLY CHAIN CONSUMED (ALASKA EXCEPTION)

As shown in Section 4.4, National Transition, and throughout this transition document, a recommended transition schedule would result in airports ceasing to offer 100LL fuel in full alliance with the Act. The consumption of 100LL will also be closely aligned with Milestone E (The last wave of airports outside of Alaska cease selling 100LL) as the final airports cease selling 100LL and switch to an unleaded replacement.

With this timing in mind, production and distribution stakeholders should leverage their internal processes and knowledge of the system to ensure adequate amounts of 100LL and replacement fuels are available throughout the transition. They must balance this need with a requirement to consume the existing 100LL throughout the supply chain, in alignment with the schedules of airports and FBOs ceasing the distribution and sale of 100LL. This will require close coordination and communication between all impacted stakeholders, including producers, distributors, and local fuel providers.

7.6 FUELS: EXPANDED DELIVERIES INTO ALASKA

Opportunities to leverage increasing production and distribution will become more readily available as the National Transition continues. Additionally, building on the lessons learned during the initial replacement fuel deliveries in Alaska (see Section 4.5), distributors serving the unique needs of the Alaskan community may be able to increase the volume of unleaded fuel moving into the state and potentially expand distribution to new locations. These activities should be aligned with Airports and FBOs Milestone B, announcing their 100LL fuel replacement. Additionally, these increased activities should account for the time needed to modify part of the fleet before using the new replacement fuel. Milestones C and D of the Alaska Transition are directly impacted by the expansion of fuel availability in Alaska. While Alaska has more time to execute Milestones C-E of the Transition, early fleet experience lowers the risk to the planned timeline.

8. TRANSITION PLAN DEEP DIVE: PHASE 4 – ALASKA TRANSITION

8.1 FLEET READINESS: ACTIVE ALASKAN FLEET ALTERED FOR UNLEADED USAGE

In alignment with Sections 3.3.4 Aircraft Alterations, 7.3 Fleet Readiness: Active Fleet Altered for Unleaded Usage, and recommended timelines from Section 4.5 Alaska Transition, Alaska will need to follow a similar course of action for the alteration of active aircraft. Given challenges associated with the logistics, and capacity of repair and maintenance shops in Alaska, it is critical that the alternation process initiates as soon as feasible once the airport and FBO identify the unleaded fuel(s) that will replace 100LL (Milestone B). This will require additional levels of coordination amongst FBOs and airports, repair and maintenance shops, and aircraft owner/operators. To support this, Alaskan airports should be encouraged to adhere to the same timeline as the National Transition for Milestones A and B.

8.2 FUELS: ANNUAL UNLEADED FUEL VOLUME MOVED INTO ALASKA

The uniqueness of the aviation fuel supply in Alaska will require a very proactive and well-planned approach. Given the timing and volumes of fuel needs in Alaska (~8.5 Mgal), it is recommended that activities for providing the volume required for statewide usage be developed and coordinated 24 months before ceasing the use of 100LL in December 2032. This timing will provide ample opportunity for distribution through the system as well as limit impacts from infrastructure challenges.

8.3FUELS: UNLEADED FUEL DISTRIBUTED THROUGHOUT ALASKA

Individual schedules for transition will be supported by the available infrastructure, ability to alter the fleet, and timing of fuel availability locally considering the unique challenges specific to Alaska. One approach could consider two different delivery phases of large volumes to enable a more flexible transition. The first phase would be to distribute as much fuel as possible to locations which could support transitioning 18-24 months prior to 2032, with a second effort looking to distribute fuel to those locations that have not obtained the fuel 6-18 months before the 2032 target date.

In order to achieve Milestone E of the Alaskan Transition, unleaded fuels must be available throughout the state.

8.4 INFRASTRUCTURE: FUEL BLENDING LIMITATIONS

Alaska poses unique challenges with infrastructure, fuel logistics, and distribution. As a result of these challenges, Alaska may require additional technical and policy support regarding the blending of 100LL with unleaded fuels. Many of Alaska's remote locations only have one central storage tank that holds a significant volume of fuel over a long period of time. It may not be possible to reduce the amount of 100LL in those tanks for a fuel swap without risking Alaska's critical flight operations.

MITIGATING A FORESEEABLE BARRIER

There is potential for single tank locations that may need to blend large volumes of 100LL and unleaded fuel to minimize operational risk associated with fuel supply. This could be a one-time allowance during the transition period to allow safe and efficient operations to continue while supporting the transition to unleaded fuels. The FAA will continue to consider how to address potential regulatory or policy challenges associated with the Alaska transition. In addition, stakeholders will need to address potential technical challenges prior to Alaska beginning its broad transition.

9. RISKS TO TRANSITION

Section 6.1 of the Transition Plan highlights specific risks and barriers associated with the supply chain and logistics as well as potential mitigations. The remainder of this section focuses on three overarching risks, cost, liability, and schedule, while highlighting the high-level factors impacting each of those risks. Early actions to address these issues will be key to a successful transition to unleaded fuels.

9.1 COST

A variety of costs may be associated with the transition, although the potential magnitude of impact will likely evolve over time and may be influenced by the number of unleaded fuels in the market. Potential costs include the purchase of STCs, aircraft alterations, and airport infrastructure modifications. Conversely, there is potential for reduced maintenance costs from the use of unleaded fuels, such as extended oil change intervals and spark plug maintenance intervals. Most importantly, there is a risk associated with the lack of availability of TEL, which would result in these costs plus the additional cost of operational disruptions caused by an uncoordinated transition away from 100LL.

As described in Section 5.2, FAA is in the process of authorizing fuels and performing comparative testing of the three candidate fuels. Until this testing is complete, the extent to which aircraft and engines will need specific modifications under the different fuels is not fully known. The costs and associated implications are critical considerations for the update of this Transition Plan in Phase 2. Also, the extent to which these costs will be borne by aircraft owners and operators versus fuel producers and distributors and governmental entities choosing to subsidize transition impacts is unknown at this time.

For example, some states and local airports have made efforts to mitigate some of the cost associated with new unleaded fuel. In the state of Colorado, House Bill 24-1235 provides tax credits to aircraft owners to offset the expenses of obtaining certification to use unleaded fuel and offers financial grants to airports to facilitate the transition.[21] Airports and FBOs have also incentivized the use of unleaded fuel through subsidies for price differentials, STCs, and mechanic costs (see Appendix D, ACRP, "Transitioning to Unleaded Aviation Gasoline: A Guide and Tools"). Other states and stakeholders may follow these early examples to reduce impacts in the general aviation sector.

9.2 LIABILITY

The introduction of new fuels has generated concern, as the industry has been built around the usage of 100LL for the last several decades with limited usage of unleaded fuels to date. The FAA has heard concerns and received comments from various stakeholders regarding how they will mitigate potential liability associated with introducing new unleaded fuel(s) into the system. These stakeholders include OEMs and STC holders, fuels producers and distributors, and airports and FBOs. The potential liability concerns result from the introduction of new fuel to the well-established marketplace. This concern was highlighted in a UAT ARC recommendation requesting that "a mechanism be developed to mitigate the liability exposure of design approval holders (DAH) due to modification of the type design of their products in approving a new aviation gasoline."

In addition, FAA has received concerns about potential incompatibility or misfuelling of unleaded fuels, particularly if there are multiple, incompatible fuels for use. Liability is a critical area that affected stakeholders will need to resolve as failure to resolve the issues tied to liability risk can potentially result in delays to the transition to unleaded fuel(s). For more information about FAA's plans to address these concerns, please refer to section 6.4 Fuels: Comingling of Unleaded Fuels earlier in this document.

9.3 SCHEDULE (CRITICAL PATH)

Possibly the most significant risk to transitioning to unleaded fuel is the schedule. The critical path forward can be distilled down to four critical items as seen in Figure 10: fuels production, fuel infrastructure, fleet readiness,

[21] See The State of Colorado, House Bill 24-1235

and supporting policy—all supporting a market-driven transition. Should there be significant scheduling delays in any one of these four areas, it would not only put the other areas at risk but would also put the entire transition timeline at
risk. Acknowledging this risk and the potential severity of the impact helps emphasize the critical nature of all the actions described throughout the four phases of the Transition Plan. Factors to help mitigate these risks include the development of multiple fuel solutions, the ability of fuels to utilize existing infrastructure, and the development and distribution of the Transition Plan highlighting the critical task to support each phase of the transition. It also illustrates the criticality of engagement across the impacted stakeholder community and initiatives like EAGLE to push forward for a successful transition to unleaded fuels in the proposed time frame.

This Transition Plan will be updated based on the results of Phase 1 and early experience in Phase 2 to develop a realistic schedule for Phases 3 and 4.

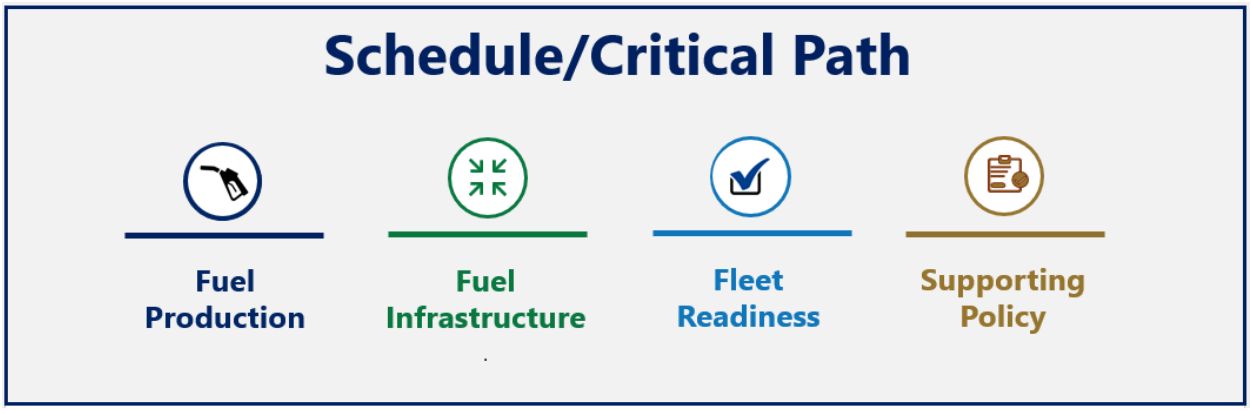


Image: FAA created

Figure 10 – Schedule/Critical Path for Transitioning to Unleaded Fuel

10. REGULATORY ACTIVITIES

The EPA's positive Endangerment Finding will require FAA to conduct rulemaking in support of removing lead as a fuel component of aviation gasoline and as a fuel additive (49 U.S.C. 44714). FAA will continue to evaluate whether any new regulations, amendments to any existing regulations, or updates to any orders, such as Order 2150.3C, FAA Compliance and Enforcement Program, are needed to address new fuel standard requirements.

10.1 RULEMAKING

The FAA plans to initiate the rulemaking, required by 49 USC 44714, once sufficient information is available to do so. Under this plan, FAA expects this will occur during Phase 2, after data is available concerning the alternative unleaded fuels and after initial experience is gained in Phase 1. A proposed rulemaking could address the schedule for Phases 3 and 4 and the costs of a proposed regulation and potential alternatives

The FAA is assessing whether a rule to implement the mandate under 49 USC 44714 to establish standards for unleaded fuel would propose that those standards only reference industry consensus standards. There are several precedents for FAA referencing industry consensus standards in regulations (e.g., Final Rule for Modernization of Special Airworthiness Certificates (MOSAIC)).[22] Practically, this would result in a regulation in which FAA specifies that unleaded fuels must comply with an industry standard that limits lead to an allowable amount, in alignment with FAA's authority previously described in section 3.2. There is sufficient time for all candidate fuels to obtain a consensus standard by the end of Phase 3.

10.2 ENFORCEMENT OF FAA-PRESCRIBED FUEL STANDARDS

Key elements of the successful National Transition to unleaded AvGas include the ability to enforce any statutes or regulations that establish a fuel standard and then prohibit the development, blending, distribution, or sale of fuel that violates the standard. The FAA has existing statutory authority to both develop a fuel standard and enforce any FAA-prescribed fuel standards (49 U.S.C. 44714).

The FAA has different mechanisms it can use to enforce the standards. For instance, FAA has authority to conduct investigations, issue orders, and amend, modify, suspend, or revoke a certificate, including an STC (49 U.S.C. 40113; 49 U.S.C. 44709(b)(1)(A)). The FAA's statutes also prohibit the development, blending, delivery, sale, or offer for sale of a fuel that violates a regulation related to the fuel standard established under Section 44714 (49 U.S.C. 44711(a)(9)). For violations of these provisions, FAA has the authority to issue civil penalties. See 49 U.S.C. 46301 (a) and (d).

For additional rulemaking considerations, please reference Appendix E: Additional Rulemaking Resources.

[22] Final Rule for Modernization of Special Airworthiness Certificates

11. TRANSITION-ENABLING RESOURCES/APPENDICES

APPENDIX A: ACRONYMS

100LL	100 Octane Low Lead Aviation Gasoline
A&P	Airframe and Powerplant Mechanic
ACRP	Airport Cooperative Research Program
Act, The	2024 FAA Reauthorization Act
ADIP	Airport Data and Information Portal
AFM	Aircraft Flight Manual
AIG	Airport Infrastructure Grant
AIP	Airport Improvement Program
AIR	Air Certification Service
AC	Advisory Circular
AML	Approved Model List
AOPA	Aircraft Owners and Pilots Association
API	American Petroleum Institute
ASTM	ASTM International
AvGas	Aviation Gasoline (AvGas)
Bgal	Billion gallons
CFR	Code of Federal Regulations
CRC	Coordinating Research Council
DAH	Design Approval Holder
EAA	Experimental Aircraft Association
EAGLE	Eliminate Aviation Gasoline Lead Emissions
EFASR	Eligible Fleet Authorization Summary Report
EI	Energy Institute
ELSA	Experimental Airworthiness Certificates
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAAST	Federal Aviation Administration Safety Team
FBO	Fixed Base Operator
FWS	Fuel Water Separator
GA	General Aviation
GAMA	General Aviation Manufacturers Association
HAZMAT	Hazardous material
IA	Inspection Authorization
IIJA	Infrastructure Investment and Jobs Act
LL	Low lead (refers to the 100LL AvGas)
LSCA	Light-sport category aircraft
Mgal	Million gallons
MOGAS	Motor gasoline/Automotive gasoline
MON	Motor Octane Number
NASEM	National Academy of Sciences, Engineering, and Medicine
NATA	National Air Transportation Association
NBAA	National Business Aviation Association
NDA	Non-disclosure Agreement
NIST	National Institute of Standards and Technology
NPIAS	National Plan of Integrated Airport Systems
OEM	Original Equipment Manufacturer
PAFI	Piston Aviation Fuels Initiative
RON	Research Octane Number

SAE	Society Automotive Engineering
SAF	Sustainable aviation fuel
SAIB	Special Airworthiness Information Bulletin
SME	Subject Matter Expert
STC	Supplemental Type Certificate
TC	Type Certificate
TEL	Tetraethyl Lead
UAT ARC	Unleaded AvGas Transition Aviation Rulemaking Committee
UL	Unleaded
UL91	Unleaded Aviation Gasoline Grade 91
UL94	Unleaded Aviation Gasoline Grade 94
VPRA	VP Racing Aviation

APPENDIX B: FAA COMPARATIVE ASSESSMENT

Please note that information in this appendix is intended to provide additional details for Section 5.3 Fuels: Comparative Assessment.

As mentioned in section 5.3, The FAA plans to compare proposed high-octane unleaded fuels to FBO 100LL and minimum specification 100LL. The intent of this testing is not to generate data to support authorization or approval of fuels for use, but rather to provide the stakeholder community with a dataset comparing the performance of the unleaded fuels to that of 100LL.

BLOCK 1 TESTING: FIT FOR PURPOSE AND COMPOSITION

Table 8 shows planned activities for block 1 testing:

BLOCK 1 TESTING: FIT FOR PURPOSE AND COMPOSITION	
EFFORT	**SUMMARY**
Determine ASTM D910 Table 1 properties, + D7826 Table 1 Laboratory Tests – Basic Specification Properties and Laboratory Tests – Fit For Purpose Properties – Part 1	Compare and contrast leaded and unleaded fuel properties and verify conformity to their respective specifications prior to initiating engine and materials testing. REPORT: measured values aligned to fuel specification and D7826, detailed fuel composition will not be reported.
ASTM D6733 Gas Chromatography analysis + Additional precision chromatography methods to determine the concentration of components of increased interest e.g., benzene, toluene, oxygenates	Determine/confirm individual hydrocarbon components to support/confirm conformity to the fuel's specification (as applicable) and determine if any significant shifts occur because of additional testing. REPORT: Data aligned to compositional requirements of the specification.

Table 8 – Comparative testing: Fit for purpose and fuel composition

Engine tests will be conducted on the fuels in a back-to-back manner, and results will be used to identify similarities and differences in the fuels' performance. For the engine testing, the neat unleaded fuels, minimum specification 100LL, 100LL, 50%-50% blends of unleaded fuels with FBO 100LL and 50%-50% blends of two unleaded fuels will be used. Current efforts plan for six engine models to be included in the performance and detonation testing from the following PAFI test articles list: Lycoming TIO-540-J2B and IO-540-K1A5, Continental IO-550-D, TSIO-520-VB, O-470-U, and TIO 540-AJ1A.

BLOCK 2 TESTING: ENGINE TESTING

Table 9 below shows planned activities for block 2 testing:

BLOCK 2 TESTING: ENGINE TESTING	
EFFORT	**SUMMARY**
Performance testing	Evaluate sea level performance at rated and maximum continuous power settings and along constant speed lines in the range of normal cruise power settings for unleaded fuels as well as FBO 100LL. Perform dynamic fuel switching tests at rated power to obtain a direct comparison between FBO100LL and neat versions of each of the test fuels. REPORT: 1) Reproduce published curves from the engine OEM and plot verse all fuels, including FBO100LL. 2) Plot time-based parametric response curves while switching fuels
Limited detonation testing	Comparative testing of, minspec 100LL, and 50%-50% blend fuels on up to 3-6 Continental & Lycoming turbocharged and naturally aspirated engine models. Testing will be on a select subset of detonation test conditions and include critical altitude conditions for turbo-charged engine models. Naturally aspirated engine models will be tested at sea-level conditions only. REPORT: 1) Pressure/audio vs. time/cycle for each 2) Variation (percent difference) from FBO/Min. Spec

Table 9 – Comparative testing: engine testing

The materials testing will utilize neat unleaded fuels and high-aromatic 100LL.

BLOCK 3 TESTING: MATERIALS

Table 10 shows planned activities for block 3 testing:

BLOCK 3 TESTING: MATERIALS	
EFFORT	**SUMMARY**
Accelerated storage (PAFI Rig 4 Storage Stability)	This test simulates accelerated aging of fuels using a pressure vessel at elevated temperature. Post-test lab analysis of fuels. At week 3, 6, 9, and 12, 500ml fuel specimens will be tested for Karl Fisher moisture (D6304), Filterable and Adherent Insolubles (D4625), Potential Gum and Precipitate (D873), Net Heat of Combustion (D4809), Vapor Pressure (D5191), Lead, Sulfur, and Hydrogen Content, and GC-MS. At the end of 12

BLOCK 3 TESTING: MATERIALS	
EFFORT	**SUMMARY**
	weeks, the 5-gallon specimens will be tested for full ASTM D910 Table 1 properties. REPORT: Any differences from leaded fuel results. Post-test lab analysis of fuels. REPORT: Any differences from base composition.
Cold storage (PAFI Rig 5)	Store in ultra-low temp (-65F) for ~1 week. Inspect for visual separation. May perform post-test lab analysis of fuels. REPORT: Visual images, chemical analysis if phase separation observed.
Polysulfides – 3 total	28-day day elevated temp jar soak test. Measure volume swell, hardness, tensile, and elongation of the sealants. REPORT: 1) Values for above test.
Tygon tubing	28-day jar soak test at elevated and room temperatures. Measure hardness, volume swell(density) of the tubing. REPORT: 1) Values for above tests.
BunaN, fluorosilicone, Viton (o-rings)	28-day jar soak test at elevated and room temperatures. Measure hardness, volume swell (density), tensile elongation of o-rings. REPORT: 1) Values for above tests.
Bladder coupons	28-day jar soak test. Visual inspection of coupons for changes in condition or size (swell, density change) and analyze fuel for comparative compositional analysis (pre and post-test). Fuel test: GC composition, potential gum, and existent gum. REPORT: Visual images, differences from base composition.
Paint and Fabric	Fabric test – 48-hour contact exposure of constructed panels. Measure Tensile/elongation of lap joints and open fabric specimens.

BLOCK 3 TESTING: MATERIALS	
EFFORT	**SUMMARY**
	REPORT: Values for exposed and unexposed specimens. Comparison of change from unexposed value to high aromatic 100LL. Paint test – Drip test – time to drip up to 5 gallons – Adhesion test – jar soak 28 days Measure visual changes, changes in adhesion. REPORT: Changes in staining and adhesion.

Table 10 – Comparative testing: materials testing

TOXICOLOGICAL AND EXHAUST EMISSION ASSESSMENTS

Table 11 shows planned activities for block 1 testing:

TOXICOLOGICAL ASSESSMENT: UNLEADED FUELS AND 100LL	
EFFORT	**SUMMARY**
The toxicological assessments of aviation fuels will follow an environmental risk assessment framework, e.g., U.S. Environmental Protection Agency (EPA) human health and ecological risk assessment guidance (U.S. EPA 1989; 1998).	REPORT: Identify potential hazards and risk factors related to fuel operations, such as fuel releases, spills or emissions. Determine the potential for harm caused by the identified hazards. Determine how and to what extent humans and ecosystems could be exposed to identified hazards and determine the overall risk posed by identified hazards.

Table 11 – Comparative testing: toxicological assessment

APPENDIX C: BEST PRACTICES, EDUCATION, TRAINING, AND COMMUNICATION

As discussed in the introductory section, the efforts to transition to unleaded fuels have been ongoing, and as highlighted throughout the document, there are already numerous resources in place to inform stakeholders looking to transition to unleaded fuel.

In addition to reinforcing existing materials, this section will also focus on areas where continued communication and outreach are needed to enable the safe and efficient transition to unleaded fuel.

DEVELOP KEY STAKEHOLDERS AND PLAN THE OUTREACH

One of the early recommendations from the NASEM report was to develop a diverse list of key stakeholders, define their potential roles and responsibilities, and plan a tailored outreach throughout each phase of the transition. Many of these activities have been ongoing in support of the transition to unleaded fuels to date and will need to continue until the culmination of the transition to unleaded fuels.

STAKEHOLDER	ROLE
Industry, Aviation, Airport Associations – (e.g., AOPA, EAA, GAMA, NATA, NBAA, AAAE, ACI-NA)	• Member safety, compliance, education, outreach, advocacy. Specific examples include providing ongoing status updates • Collaboration with FAA; defining roles, responsibilities, and timelines for preparation and implementation of training curriculums
Fuel developers	• Publish lessons learned and best practices • Publish detailed and robust testing and certification plans • Provide stakeholders with details about the fuel specifications, development, and approval
Engine and aircraft OEMs	• R&D efforts to identify and implement necessary changes, etc. • Participation in rigorous testing efforts; in-kind and other support
Flight schools	• Reference published guidance for the transitioning of flight schools and other available resources to leverage existing lessons learned and facilitate a smooth transition at their location; reference listing of resources under Section 5.4.1 Airport and FBO Resources and Section 10.7.1 Fuel Handling Resources • End-user awareness, fuels compatibility, compliance, safety
Airports Communities	• Advocate for community concerns • Engage with the airport and other state and local leaders
Alaska Communities	• Advocate about the unique challenges specific to the Alaskan community • Advocate for Alaska specific operational validation standards such as extended cold-soak, storage duration, seasonal distribution constraints, and coverage of all commercial power plants • Engage with the relevant associations and state and local leaders to minimize impact to continued operations
Pilots and owner operators	• Comply with new requirements, implementation, ensuring compatibility and safety • Provide feedback and input on end user experience
Airframe and powerplant mechanics	• Support transition to unleaded fuels through implementation of aircraft alternations and/or modifications • Provide feedback and input on challenges and barriers impacting implementation
Fuel distributors/ airports/FBOs	• Safety, liability, and compliance with contract terms • FBOs are the "face of the industry"; FBO management of the new fuel implementation will be critical to the ultimate transition • Reference published guidance to transitioning airports/FBOs as documented in the ACRP 03-73 – Airport Guide: Understanding the Transition to Unleaded Aviation Gasoline - A Primer and Transitioning to Unleaded Aviation Gasoline: A Guide and Tools.

STAKEHOLDER ROLE

Other government entities (local, state, Tribal, international)	• Education, outreach, and advocacy • Publish/advocate lessons learned and best practices
State Aviation Agencies	• Policy development and implementation • Education, outreach, and technical training • State-administered airport funding, technical assistance programs, infrastructure development and planning. • Inspections and licensing of public-use airports
Federal government (e.g., EPA, FAA, Occupational Safety and Health Administration [OSHA])	• Collaboration with stakeholders • Education and outreach for safe transition • Policy development (e.g., Fleet Authorization Process, etc.) • Rulemaking and enforcement • Publish lessons learned and best practices • Public Health • Employee occupational health and safety
Standards bodies (e.g., ASTM, NFPA)	• Responsible for establishing criteria for achieving test and production specifications

Table 12 – Key stakeholders and their role in the transition to unleaded fuel

ONGOING ACTIVITIES IN RESPONSE TO THE NASEM REPORT AND RECOMMENDATIONS

In the "Options for Reducing Lead Emissions from Piston-Engine Aircraft" report referenced earlier in this document, NASEM highlighted a need for FAA to partner with prominent organizations within the GA community to initiate **an ongoing and continuous education, training, and awareness campaign** throughout the entire transition period. This is true regardless of the phase of the transition. Figure 11 shows some of the ways the EAGLE initiative has addressed and plans to continue to adhere to the NASEM recommendations:

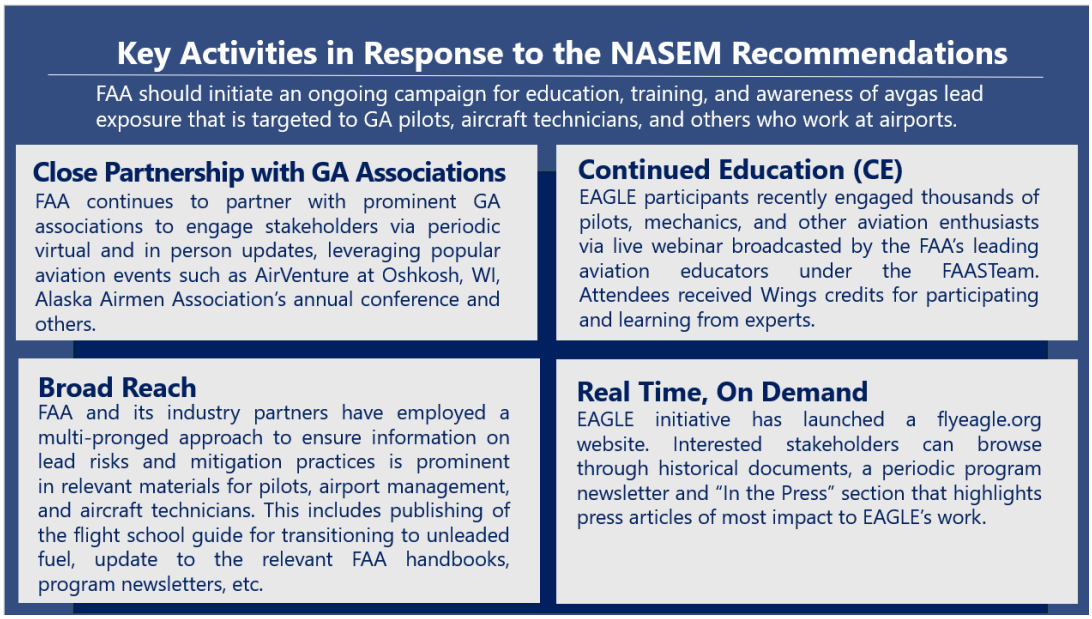


Image: FAA created

Figure 11 – Responding to NASEM Recommendations

TRANSITION GUIDANCE TO FLIGHT SCHOOLS (EAGLE)

Flight schools offer a unique opportunity to transition to unleaded fuels early in the process. They often use low compression, spark-ignition piston-engine aircraft that are or can be authorized to operate on an unleaded AvGas that is currently available.

In addition, flight schools often carry out high levels of activities near the airport (e.g., touch-and-go operations), which concentrates the area where emissions are released. Such concentrated emissions may extend more than half a mile from the end of the runway. Therefore, flight schools and those engaged in flight training make excellent partners in working with their FBO, airport operators and/or fuel suppliers to encourage the supply of unleaded AvGas and to coordinate on the early transition. Engagement with flight schools could support Phase 1 and Phase 2 activities in advance of the planned National Transition dates.

For these reasons, in July 2023, the EAGLE initiative published a guidance document titled "Guidance on Transitioning a Flight School to Unleaded Avgas" to support flight schools with their decision-making as they safely transition to unleaded AvGas. While this document may not fully cover unique aspects of all airport or FBO operations, it does offer a robust roadmap for common elements each flight school should evaluate during the transition.

Figure 12 shows the overall structure of the "Guidance on Transitioning a Flight School to Unleaded Avgas." It provides an overview of the overarching elements such as safety protocols, cost considerations, education, training, and a need for continued communications. It also describes three basic transition steps for a flight school to safely enable the use of unleaded AvGas.

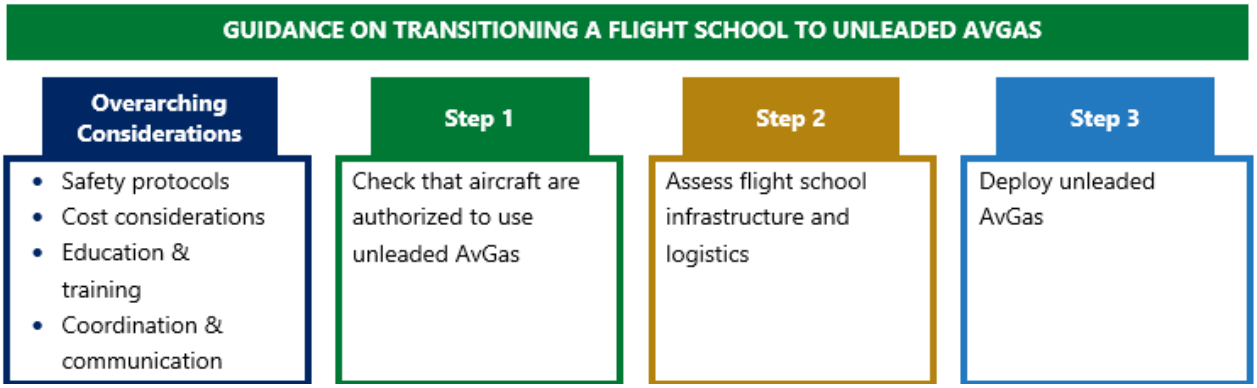


Image: FAA created

Figure 12 – Basic Transition Steps for a Flight School

Source: "Guidance on Transitioning a Flight School to Unleaded Avgas"

The EAGLE initiative believes that this flight school guidance document will help flight schools across the nation decide when to transition to unleaded fuels, while guiding them through the transition process.

PILOT AWARENESS

Maintaining safe operations for pilots, other operators at airports, and local communities is an essential part of a safe transition to unleaded fuel(s), along with improving the health of surrounding communities.

Airport managers, pilots, and aircraft owners will need to rely on their long-standing relationships to educate communities about plans to transition to unleaded fuels, as well as address safety concerns for those in the air and on the ground.

- Consider coordinating outreach activities with major aviation associations (e.g., American Association of Airport Executives [AAAE], AOPA, GAMA, NATA, NBAA, FAA Office of Energy and Environment [AEE], FAA Safety Team [FAAST]).
- Engage with relevant stakeholders (e.g., flight organizations, FBOs, airport communities).

BEST PRACTICES FOR MINIMIZING LEAD EXPOSURE

The following list of resources and guidance is in alignment with Section 827(b)(1)(C) of the Act. It is derived from multiple reputable sources and available to various stakeholders in the GA community to help them understand the risks associated with lead and strategies for their mitigation. These resources are summarized in Table 13 and can be utilized in protecting the stakeholder community against exposure to lead.

SOURCE	RESOURCE AND LINK
CDC	Childhood Lead Poisoning Prevention Program
CDC-NIOSH	Pocket Guide to Chemical Hazards – Lead
EAGLE	Transitioning a Flight School to UL Avgas
Energy Institute	EI/JIG Standard 1597: Procedures for overwing fueling to ensure delivery of the correct fuel grade to an aircraft EI/JIG Standard 1530: Quality assurance requirements for the manufacture, storage and distribution of aviation fuels to airports
Environmental Protection Agency (EPA)	• For community members who are concerned about their children's exposure to lead, the first step is to talk to their doctors and get tested. EPA and the Agency for Toxic Substances and Disease Registry offer help from local Pediatric Environmental Health Specialty Units (PEHSUs) who have the expertise to evaluate children's environments holistically since there can be multiple sources of lead in a child's environment. • PEHSUs also offers additional information about lead exposure. • Information on actions community members can take to minimize potential lead exposure is also available here. • Information on EPA's final finding on aircraft lead emissions is available here.
FAA Handbook	• Aviation Maintenance Technician Handbook-Powerplant, Chapter 1 • Aviation Maintenance Technician Handbook-Airframe, Chapter 2
National Academies of Science	Options for Reducing Lead Emissions from Piston-Engine Aircraft
National Air Transportation Association (NATA)	• Unleaded Avgas Conversion Considerations for Aviation Fuel Providers • Safety Data Sheets (SDS) (100LL D910)
OSHA	Occupational Safety and Health Administration Fuel Handling and Storage
U.S. Department of Health and Human Services (USHS)	HeadStart.gov brochure, How to Protect Your Children from Lead Poisoning, to help community members and parents learn about the effects of unsafe levels of lead in blood and how to avoid lead exposure.
U.S. Health Systems (USHS), Centers fo Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH)	Exposures to Lead and Other Metals at an Aircraft Repair and Flight School Facility

Table 13 – Resources related to the safe handling of leaded fuels

FUEL HANDLING MANAGEMENT

Handling 100LL fuel has been well managed for decades. A new unleaded fuel requires assessment for unique or special handling criteria. For example, identify whether the fuel has any characteristic that would cause concern in development, blending or distribution that does not exist with 100LL, and if so, document its impact and mitigating steps.

One key element in avoiding misfueling is closely monitoring dye colors of the fuels when handling or utilizing them. Dye colors are assigned in respective ASTM International fuel production specifications and Energy Institute (EI) Standard 1542, Identification Markings for Dedicated Aviation Fuel development, blending and distribution facilities, airport storage, and mobile fueling equipment. Dye colors for piston-engine aircraft fuels are shown in Table 14:

FUEL	COLOR	SPECIFICATION
UL91	Red	ASTM D7547
UL94	Purple	ASTM D7547
UL100	Orange	ASTM D8631
100R	Green	ASTM D8603
G100UL	Yellow-green to green to blue-green	GAMI G100UL-12C9
100LL/100VLL	Blue	ASTM D910

Table 14 – Dye colors for piston-engine aircraft fuels

Fuel quality control currently utilizes EI Standard 1530 to manage custody transfer of 100LL. Under this standard, unleaded fuels should have an identified test for Quality Assurance/Quality Control (QA/QC) during custody transfer of a new unleaded product to ensure the product is unchanged during the movement of the fuel. For 100LL, this is currently achieved using the white bucket test and hydrometer measurements. Fuel developers and producers should address any new or modified processes to the current QA/QC if changes are required. During the transition period in which multiple AvGas formulations may be available, stakeholders will need to be aware of the potential for misfueling.

Misfueling refers to any time an incorrect fuel type (e.g., jet fuel versus AvGas) or fuel grade (lower octane unleaded AvGas versus 100LL) is delivered into an aircraft. In the case of the transition period to unleaded AvGas, this would mean misfueling an aircraft that is only authorized to use 100LL with unleaded AvGas. There is currently no grade selectivity among AvGas nozzle spouts or filler ports. Unleaded AvGas filler spouts correspond to the filler ports of aircraft that may still require a 100-octane AvGas.

NOTE

Fuel colors are being coordinated between ASTM International's specifications, placard specifications, and EI 1542. FAA ACs, SAIBs, and other FAA safety communications will emphasize avoiding misfueling by raising awareness of anti-misfueling devices and fuel colors.

FUEL HANDLING RESOURCES

There are several resources available to support safe fuel handing management during the transition; examples include:

- FAA Dynamic Regulatory System (DRS)

    - AC 20-116 Marking Aircraft Fuel Filler Openings with Color-Coded Decals
    - AC 20-122A Anti-Misfuelling Devices: Their Availability and Use
- NATA General Aviation Misfuelling Prevention Online Programhttp://www.nata.aero/education-and-training/misfueling-prevention-program
- "Transitioning a Flight School to UL Avgas," Appendix 3

APPENDIX D: AIRPORT AND FBO RESOURCES

TRANSITIONING TO UNLEADED AVIATION GASOLINE (ACRP Project 03-73)

In 2023, FAA, through the Airports Cooperative Research Program, initiated project 03-73, *Airport Guide for Transitioning to Unleaded AvGas* to answer the broad question: "What can we learn from airports working to offer unleaded AvGas and working to reduce lead emissions?" This research has resulted in a Primer[23], a document intended to provide airports with concise answers to eight key questions related to the transition to unleaded aviation gasoline, based on the latest information available at the time of its preparation in January 2025. One other document it produced is a Guide and Tools[24], The Guide was initiated to answer a broad, foundational question: What can be learned from airports that have transitioned or are planning to transition to unleaded aviation fuel, while continuing to provide 100LL? This guide is organized around that intent, with the goal of sharing best practices and lessons learned to support other airports as they plan and implement their own transitions. The research team assessed 48 airports that started offering unleaded fuel after 2011, and in 2024 it conducted case studies at seven of those airports that already offered or were considering offering unleaded AvGas. These airports included:

- Centennial Airport in Englewood, CO
- Long Beach Airport in Long Beach, CA
- Naples Airport in Naples, FL
- Rocky Mountain Metropolitan Airport in Broomfield, CO
- South St. Paul Airport in South St. Paul, MN
- Waco Regional Airport in Waco, TX
- Watsonville Municipal Airport in Watsonville, CA

Key topics the case studies analyzed included infrastructure, facility planning, construction, operations, presence of a flight school, fuel sales distribution, requirement for the industry consensus standard, offered incentives, unleaded fuel offer date, decision drivers, and the key dynamics that influenced the actions at the case study airports.

A resulting report is organized as shown in Figure 13:

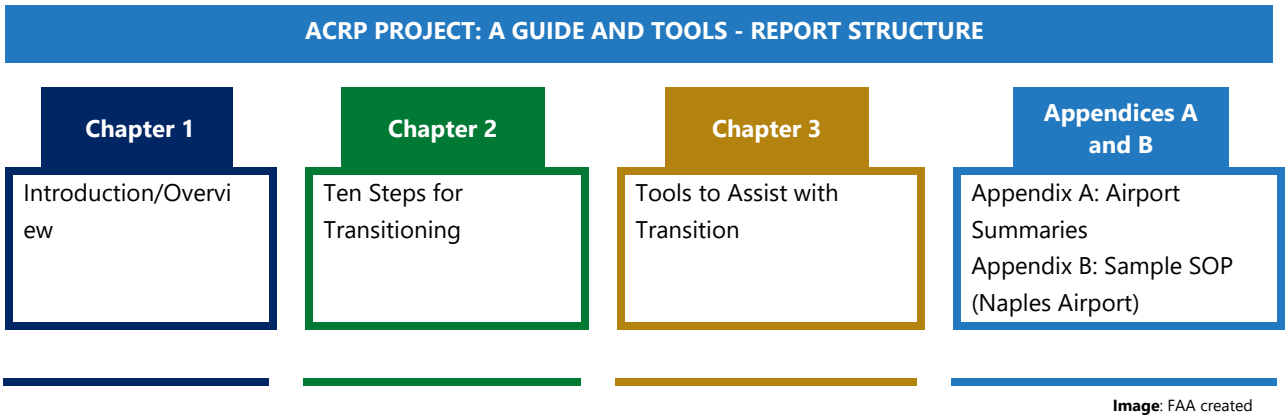


Image: FAA created

Figure 13 – ACRP Project 03-73 – A Guide and Tools - Report Structure

The results of the case studies across seven participating airports and two major Alaska stakeholders were summarized in a standardized and comparable manner. These results provide excellent insights for those

[23] ACRP 03-73: Understanding the Transition to Unleaded Aviation Gasoline - A Primer

[24] ACRP 03-73: Transitioning to Unleaded Aviation Gasoline: A Guide and Tools

wishing to assess the requirements for providing unleaded AvGas at their locality and understand some of the challenges and opportunities for the transition.

Among many insights gained from this research, it is notable that five of the seven case study airports leveraged existing fuel storage and dispensing infrastructure to support offering unleaded fuel. One airport procured a new tank, and another purchased a used fuel truck to support unleaded fuel storage and dispensing. Each of the case study airports took decisive actions to facilitate offering unleaded fuel, which exemplifies supporting actions needed to facilitate a safe National Transition.

In support of this phase, airports are encouraged to begin planning and taking enabling steps for a safe transition.

OTHER AIRPORT AND FBO RESOURCES

To enable a safe transition, there are ample resources available to support airports, service providers, and operators in their decision-making. The following is a representative sample of available resources:

- EAGLE website – https://flyeagle.org/
- FAA – FAA.gov – What can airports do in the short-term? National Air Transportation Association (NATA) – Unleaded Avgas Considerations for Aviation Fuel Providers
- National Air Transportation Association (NATA) – Unleaded Avgas Considerations for Aviation Fuel Providers
- NATA – Factors Affecting the Commercial Sale of Emerging Unleaded Aviation Fuels
- EAGLE – Guidance on Transitioning a Flight School to Unleaded Avgas
- National Academies – Consensus Report – Options for Reducing Lead Emissions

AIRPORTS – ACTIONS TO SUPPORT A TRANSITION TO UNLEADED FUEL

The FAA and industry are moving cooperatively, safely, and with purpose toward unleaded fuel(s). To support the orderly transition, airport operators are encouraged to implement several common near-term measures described below as they consider specific operational and safety needs unique to their airport:

Implement the following NASEM Recommendations:

- Work with aircraft owners and operators to minimize engine idling and run-up times.
- Relocate and distribute pre-flight and maintenance run-up locations.
- Offer alternative unleaded fuel to supplement AvGas sales.
- Promote airport and pilot awareness.

Assess Fuel Infrastructure and Incorporate Needs into the Airport's Planning Initiatives:

- Evaluate current fuel storage and dispensing systems to determine fuel infrastructure requirements to accommodate a new fuel. Explore the following questions:
- Does the airport have available infrastructure to support adding unleaded fuel while maintaining 100LL as required by the Act?
- If not, what infrastructure will be needed to support a seamless transition?

Analyze Costs:

Consider the costs associated with transitioning, including changes to infrastructure, staff training, signage, increased communications to airport users, insurance, and an initial unleaded fuel purchase.

Secure Funding

As mentioned in section 6.6, fuel storage and distribution infrastructure, through the Act, FAA has broader authority to support transition-enabling infrastructure. This includes storage tanks and airport-owned fuel trucks providing exclusively unleaded aviation fuels. Please refer to the IIJA FAQs website for further information.

Maintain 100LL Availability

The Act, Section 770, Grant Assurances, provides that 100LL shall remain available as mandated through the Act. To that effect, FAA Office of Airports updated a May 2025 a Q&A document on December 10, 2025, clarifying the Grant Assurance 40 and prohibiting airports from restricting 100LL availability until an alternate fuel meets the established criteria. As stated in the Q&A, prohibition of FAA authorized fuel at a federally obligated airport may place the sponsor in violation of Grant Assurance 22, Economic Nondiscrimination, or 23, Exclusive Rights.

Plan ways in which the airport will continue to offer 100LL throughout the transition period (see Appendix F: Applicable Federal Statutes, for the full text).

Disseminate Information

Keep airport personnel and users apprised of the planned activities and associated milestones for the transition to the unleaded AvGas and any changes they might expect such as changes in signage, placarding, or aircraft modifications.

As the transition grows closer, use newsletters, website updates, or other media to emphasize the benefits of unleaded AvGas and the upcoming transition milestones.

Plan the Transition

Create a timeline to include key milestones such as infrastructure changes, staff training, implementation strategy, and the introduction of unleaded AvGas at a given location, as well as when it may be both consistent with applicable laws and regulations and suitable to phase out 100LL.

Stress Safety

Train staff and airport users on safe handling, storage, dispensing, and intermingling of fuels (if applicable). Include prominently placed signage; oversee and ensure adherence to new procedures or safety measures.

Implement Fuel Management Procedures

Document and share standard operating procedures regarding how your facility handles the new fuel to provide a tangible reference and to set clear expectations.

Monitor and Evaluate the Transition Period

Carefully monitor the implementation of unleaded AvGas in your airport's operations and address concerns before scaling up to full implementation. Set up a feedback mechanism for staff and AvGas users to report any challenges during the transition. Have dedicated personnel responsible for reviewing and resolving those challenges.

APPENDIX E: ADDITIONAL RULEMAKING RESOURCES

Although the exact timing of the unleaded AvGas related rulemaking is not known at the time of publishing this Transition Plan, FAA has compiled the following information to inform interested stakeholders:

The EPA Aircraft Engine Emissions Standards

With EPA's 2023 Endangerment Finding, the EPA is now subject to a duty under 42 U.S.C. 7571 to propose and issue regulatory standards for lead emissions from certain aircraft engines. The EPA must consult with FAA on establishing aircraft engine emission standards. In the development of these standards, EPA will use the public rulemaking processes that include notice and public comment.

FAA Fuel Composition Rulemaking

With EPA's 2023 Endangerment Finding, FAA is now obligated under statute 49 USC 44714 to prescribe "standards for the composition or chemical or physical properties of an aircraft fuel or fuel additive" and to issue regulations to carry out and enforce those standards. The FAA can now regulate lead as a fuel component or as a fuel additive to control or eliminate aircraft emissions. This rulemaking would be codified in Title 14 of the Code of Federal Regulations.

FAA's Certification Standards

Once the EPA has promulgated lead emissions standards for aircraft engines, 42 U.S.C. 7572 requires FAA to prescribe regulations to ensure compliance with the standards prescribed by EPA under 42 U.S.C. 7571. The FAA is required to implement the EPA standards through its certification process. The scope of this rule is dependent upon the requirements that may materialize in rulemaking noted under the EPA Aircraft Engine Emissions Standards and FAA Fuel Composition Rulemaking, as necessary.

INITIATION OF FAA RULEMAKING

Early in the transition, without regulatory mandates, aircraft owners and operators may lack motivation to modify their aircraft to use an unleaded fuel that might be unavailable in sufficient quantities. Similarly, airports and FBOs may lack motivation to supply unleaded fuels that do not yet have an established market.

It is anticipated that FAA rulemaking would initiate during Phase 2 of the transition and continue to progress through most of the transition period, ultimately culminating in a final rule to support the transition to unleaded AvGas. The rulemaking process generally involves initiating, proposing, receiving comments, adjudicating said comments, and then finalizing a regulation.

APPENDIX F: APPLICABLE FEDERAL STATUTES

Included in Appendix F are applicable statutes related to deployment of a new unleaded fuel.

The FAA Reauthorization Act of 2024 (P.L 118-63)

Sec. 827. EAGLE Initiative

(a) EAGLE INITIATIVE. —

(1) IN GENERAL. —The Administrator shall continue to partner with industry and other Federal Government stakeholders in carrying out the Eliminate Aviation Gasoline Lead Emissions Initiative (in this section referred to as the "EAGLE Initiative") through the end of 2030.

(2) FAA RESPONSIBILITIES. —In collaborating with industry and other Government stakeholders to carry out the EAGLE Initiative, the Administrator shall take such actions as may be necessary under the authority of the Administrator to facilitate—

(A) the safe elimination of the use of leaded aviation gasoline by piston-engine aircraft by the end of 2030 without adversely affecting the safe and efficient operation of the piston-engine aircraft fleet;

(B) the approval of the use of unleaded alternatives to leaded aviation gasoline for use in all piston-engine aircraft types and piston-engine models;

(C) the implementation of the requirements of Section 47107(a)(22) of title 49, United States Code, as added by this Act, as such requirements relate to the continued availability of aviation gasoline;

(D) efforts to make unleaded aviation gasoline that is approved for use in piston-engine aircraft and engines widely available for purchase and use at airports in the National Plan of Integrated Airport Systems; and

(E) the development of a transition plan to safely enable the transition of the piston-engine general aviation aircraft fleet to unleaded aviation gasoline by 2030, to the extent practicable.

(3) ACTIVITIES. —In carrying out the responsibilities of the Administrator pursuant to paragraph (2), the Administrator shall, at a minimum—

(A) maintain a fleet authorization process for the efficient approval or authorization of eligible piston-engine aircraft and engine models to operate safely using qualified unleaded aviation gasolines;

(B) review, update, and prioritize, as soon as practicable, certification processes and projects, as necessary, for aircraft engines and modifications to such engines to operate with unleaded aviation gasoline;

(C) seek to facilitate programs that accelerate the creation, evaluation, qualification, deployment, and use of unleaded aviation gasolines;

(D) carry out, in partnership with the general aviation community, an ongoing campaign for training and educating aircraft owners and operators on how to safely transition to unleaded aviation gasoline;

(E) evaluate aircraft and aircraft engines to ensure that such aircraft and aircraft engines can safely operate with unleaded aviation gasoline candidates during cold weather conditions; and

(F) facilitate the development of agency policies and processes, as appropriate, to support the deployment of necessary infrastructure at airports to enable the distribution and storage of unleaded aviation gasolines.

(4) CONSULTATION AND COLLABORATION WITH RELEVANT STAKEHOLDERS. —In carrying out the EAGLE Initiative, the Administrator shall continue to consult and collaborate, as appropriate, with relevant stakeholders, including—

(A) general aviation aircraft engine, aircraft propulsion, and aircraft airframe manufacturers;

(B) general aviation aircraft users, aircraft owners, aircraft pilots, and aircraft operators;

(C) airports and fixed-base operators;

(D) State, local, and Tribal aviation officials;

(E) representatives of the petroleum industry, including developers, refiners, producers, and distributors of unleaded aviation gasolines; and

(F) air carriers and commercial operators operating under part 135 of title 14, Code of Federal Regulations.

(5) REPORT TO CONGRESS. —

(A) INITIAL REPORT. —Not later than 1 year after the date of enactment of this Act, the Administrator shall submit to the appropriate committees of Congress a report that—

(i) contains an updated strategic plan for maintaining a fleet authorization process for the efficient approval and authorization of eligible piston-engine aircraft and engine models to operate using unleaded aviation gasolines in a manner that ensures safety;

(ii) describes the structure and involvement of all FAA offices that have responsibilities described in paragraph (2); and

(iii) identifies policy initiatives, regulatory initiatives, or legislative initiatives needed to improve and enhance the timely and safe transition to unleaded aviation gasoline for the piston-engine aircraft fleet.

(B) ANNUAL BRIEFING. —Not later than 1 year after the date on which the Administrator submits the initial report under subparagraph (A), and annually thereafter through 2030, the Administrator shall brief the appropriate committees of Congress on activities and progress of the EAGLE Initiative.

(C) SUNSET. —Subparagraph (B) shall cease to be effective after December 31, 2030.

(b) TRANSITION PLAN TO UNLEADED AVIATION GASOLINE. —

(1) IN GENERAL. —In developing the transition plan under subsection (a)(2)(E), the Administrator may, at a minimum, assess the following:

(A) Efforts undertaken by the EAGLE Initiative, including progress toward—

(i) safely eliminating the use of leaded aviation gasoline by piston-engine aircraft by the end of 2030 without adversely affecting the safe and efficient operation of the piston-engine aircraft fleet;

(ii) approving the use of unleaded alternatives to leaded aviation gasoline for use in all piston-engine aircraft types and piston-engine models; and

(iii) facilitating efforts to make approved unleaded aviation gasoline that is approved for use in piston-engine aircraft and engines widely available at airports for purchase and use in the National Plan of Integrated Airport Systems.

(B) The evaluation and development of necessary airport infrastructure, including fuel storage and dispensing facilities, to support the distribution and storage of unleaded aviation gasoline.

(C) The establishment of best practices for piston-engine aircraft owners and operators, airport operators and personnel, aircraft maintenance technicians, and other appropriate personnel for protecting against exposure to lead containment when—

(i) conducting fueling operations;

(ii) disposing of inspected gasoline samples;

(iii) performing aircraft maintenance; and

(iv) conducting engine run-ups.

(D) Efforts to address supply chain and other logistical barriers inhibiting the timely distribution of unleaded aviation gasoline to airports.

(E) Outreach efforts to educate and update piston-engine aircraft owners and operators, airport operators, and other members of the general aviation community on the potential benefits, availability, and safety of unleaded aviation gasoline.

(2) PUBLICATION; GUIDANCE. —Upon completion of developing such transition plan, the Administrator shall—

(A) make the plan available to the public on an appropriate website of the FAA; and

(B) provide guidance supporting the implementation of the transition plan.

(3) COLLABORATION WITH EAGLE INITIATIVE. —In supporting the development of such transition plan and issuing associated guidance pertaining to the implementation of such transition plan, the Administrator shall consult and collaborate with individuals carrying out the EAGLE Initiative.

(4) UNLEADED AVIATION GASOLINE COMMUNICATION MATERIALS. —The Administrator may collaborate with individuals carrying out the EAGLE Initiative to jointly develop and continuously update websites, brochures, and other communication materials associated with such transition plan to clearly convey the availability of unleaded aviation gasoline at airports.

(5) BRIEFING TO CONGRESS. —Not later than 60 days after the publication of such transition plan, the Administrator shall brief the appropriate committees of Congress on such transition plan and any agency efforts or actions pertaining to the implementation of such transition plan.

(6) SAVINGS CLAUSE. —Nothing in this section shall be construed to delay or alter the ongoing work of the EAGLE Initiative established by the Administrator in 2022.

The FAA Reauthorization Act of 2024 (P.L 118-63)
Sec. 770. Grant Assurances.

(a) GENERAL WRITTEN ASSURANCES. —Section 47107(a) of title 49, United States Code, is amended—

(1) in paragraph (20) by striking "and" at the end;

(2) in paragraph (21) by striking the period at the end and inserting "; and"; and

(3) by adding at the end the following:

(22) the airport owner or operator may not restrict or prohibit the sale or self-fueling of any 100-octane low lead aviation gasoline for purchase or use by operators of general aviation aircraft if such aviation gasoline was available at such airport at any time during calendar year 2022, until the earlier of—

(A) December 31, 2030; or

(B) the date on which the airport or any retail fuel seller at such airport makes available an unleaded aviation gasoline that—

(i) has been authorized for use by the Administrator of the Federal Aviation Administration as a replacement for 100-octane low lead aviation gasoline for use in nearly all piston-engine aircraft and engine models; and

(ii) meets either an industry consensus standard or other standard that facilitates the safe use, production, and distribution of such unleaded aviation gasoline, as determined appropriate by the Administrator.

(b) CIVIL PENALTIES FOR GRANT ASSURANCES VIOLATIONS. —Section 46301(a) of title 49, United States Code, is further amended—

(1) in paragraph (1)(A) by inserting "Section 47107(a)(22) (including any assurance made under such section)," after "chapter 451,"; and

(2) by adding at the end the following:

(8) FAILURE TO CONTINUE OFFERING AVIATION FUEL.—Notwithstanding paragraph (1), the maximum civil penalty for a violation of section 47107(a)(22) (including any assurance made under such section) committed by a person, including if the person is an individual or a small business concern, shall be $5,000 for each day that the person is in violation of that section.

The FAA Reauthorization Act Of 2024 (P.L 118-63)
Sec. 771. Aviation Fuel in Alaska.

(a) IN GENERAL. —

(1) PROHIBITION ON RESTRICTION OF FUEL USAGE OR AVAILABILITY. —The Administrator of the Federal Aviation Administration and the Administrator of the Environmental Protection Agency shall not restrict the continued use or availability of 100-octane low lead aviation gasoline in the State of Alaska until the earlier of—

(A) December 31, 2032; or

(B) 6 months after the date on which the Administrator of the Federal Aviation Administration finds that an unleaded aviation fuel is widely commercially available at airports throughout the State of Alaska that—

(i) has been authorized for use by the Administrator of the Federal Aviation Administration as a replacement for 100-octane low lead aviation gasoline; and

(ii) meets either an industry consensus standard or other standard that facilitates and ensures the safe use, production, and distribution of such unleaded aviation fuel.

(2) SAVINGS CLAUSE. —Nothing in this section shall limit the authority of the Administrator of the Federal Aviation Administration or the Administrator of the Environmental Protection Agency to address the endangerment to public health and welfare posed by lead emissions—

(A) in the United States outside of the State of Alaska; or

(B) within the State of Alaska after the date specified in paragraph (1).

(b) GAO REPORT ON TRANSITIONING TO UNLEADED AVIATION FUEL IN THE STATE OF ALASKA. —

(1) EVALUATION. —The Comptroller General of the United States shall conduct an evaluation of the following:

(A) The aircraft, routes, and supply chains in the State of Alaska utilizing leaded aviation gasoline, including identification of remote and rural communities that rely upon leaded aviation gasoline.

(B) The estimated costs and benefits of transitioning aircraft and the supply chain in the State of Alaska to aviation fuel that meets the requirements described in clauses (i) and (ii) of Section 47107(a)(22)(B) of title 49, United States Code, as added by Section 770, including direct costs of new aircraft and equipment and indirect costs, including transportation from refineries to markets, foreign imports, and changes in leaded aviation gasoline prices as a result of reduced supply.

(C) The programs of the Environmental Protection Agency, the Federal Aviation Administration, and other government agencies that can be utilized to assist individuals, communities, industries, and the State of Alaska with the costs described in subparagraph (B).

(D) A reasonable time frame to permit any limitation on 100-octane low-lead aviation gasoline in the State of Alaska.

(E) Other logistical considerations associated with the transition described in subparagraph (B).

(2) REPORT. —Not later than 3 years after the date of enactment of this section, the Comptroller General shall submit a report containing the results of the evaluation conducted under paragraph (1) to—

(A) the Committee on Commerce, Science, and Transportation of the Senate;

(B) the Committee on Environment and Public Works of the Senate;

(C) the Committee on Transportation and Infrastructure of the House of Representatives; and

(D) the Committee on Energy and Commerce of the House of Representatives.

42 U.S. Code § 7571. Establishment of Standards

(a) Study; proposed standards; hearings; issuance of regulations

(1) Within 90 days after December 31, 1970, the Administrator shall commence a study and investigation of emissions of air pollutants from aircraft 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)

(A) 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.

(B)

(i) The Administrator shall consult with the Administrator of the Federal Aviation Administration on aircraft engine emission standards.

(ii) The Administrator shall not change the aircraft engine emission standards if such change would significantly increase noise and adversely affect safety.

(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 regulations with such modifications as he deems appropriate. Such regulations may be revised from time to time.

(b) Effective date of regulations

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, considering the cost of compliance within such period.

(c) Regulations which create hazards to aircraft safety

Any regulations in effect under this section on August 7, 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. Code § 7572 - Enforcement Of Standards

(a)Regulations to ensure compliance with standards

The Secretary of Transportation, after consultation with the Administrator, shall prescribe regulations to insure compliance with all standards prescribed under Section 7571 of this title 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 part A of subtitle VII of title 49 or the Department of Transportation Act. Such Secretary shall ensure that all necessary inspections are accomplished, and [1] 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)Notice and appeal rights

In any action to amend, modify, suspend, or revoke a certificate in which violation of an emission standard prescribed under Section 7571 of this title 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 part A of subtitle VII of title 49 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.

49 U.S. Code § 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.

APPENDIX G: GUIDANCE MATERIAL AND STANDARD PRACTICES

AMERICAN PETROLEUM INSTITUTE (API)	
DOC NO.	**DESCRIPTION**
API 652	Linings of Aboveground Petroleum Storage Tank Bottoms
API 653	Tank Inspection, Repair, Alteration
API 1543	Documentation, Monitoring and Laboratory Testing of Aviation Fuel During Shipment from Refinery to Airport - Recommended Practice
API/IP 1595	Design, Construction, Operation, Maintenance and Inspection of Aviation Pre-Airfield Storage Terminals - Recommended Practice
API 1543	Documentation, Monitoring and Laboratory Testing of Aviation Fuel During Shipment from Refinery to Airport
API 2610	Design, Construction, Operation, Maintenance, and Inspection of Terminal & Tank Facilities
API 2003RP	Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents

ASTM INTERNATIONAL	
DOC NO.	**DESCRIPTION**
ASTM MNL 1	Significance of Tests for Petroleum Products
ASTM MNL 5	Aviation Fuel Quality Control Procedures
ASTM D7826	Standard Guide for Evaluation of New Aviation Gasolines and New Aviation Gasoline Additives

COORDINATING RESEARCH COUNCIL (CRC)	
DOC NO.	**DESCRIPTION**
None	CRC Handbook of Aviation Fuel Properties

ENERGY INSTITUTE (EI)	
DOC NO.	**DESCRIPTION**
EI 1529	Aviation Fueling Hose and Hose Assemblies
EI 1530	Quality Assurance Requirements for the Manufacture Storage and Distribution of Aviation Fuel to Airports
EI 1540	Design, Construction, Operation and Maintenance of Aviation Fueling Facilities - Recommended Practice
EI 1541	Performance Requirements for Protective Coating Systems Used in Aviation Fuel Storage Tanks and Piping
EI 1542	Identification Markings for Aviation Fuel Distribution Facilities, Airport Storage and Mobile Fueling Equipment
EI 1550	Handbook on Equipment Used for Maintenance and Delivery of Clean Aviation Fuel
EI 1581	Specifications and Qualification Procedures for Aviation Jet Fuel Filter/Separators
EI 1582	Specification for Similarity for API/IP 1581 Aviation Jet Fuel Filter/Separators
EI 1583	Laboratory Tests and Minimum Performance Levels for Aviation Fuel Filter Monitors
EI 1587	Single Stool Filtration Systems for Low Flow Rate Applications
EI 1588	Water Barrier Filter
EI 1590	Specifications and Qualification Procedures for Aviation Fuel Microfilters
EI 1592	Bulk Water Detector
EI 1597	Procedures for Overwing Fueling to Ensure Delivery of the Correct Fuel Grade to an Aircraft RP)
EI 1598	Quantitative Water Sensor
EI 1599	Dirt Defense Filter

FEDERAL AVIATION ADMINISTRATION (FAA)	
DOC NO.	**DESCRIPTION**
AC20-122A	Anti-Misfuelling Devices: Their Availability and Use
AC 150	Aircraft Fuel Storage, Handling, and Dispensing on Airports
FAA Advisory Circular AC 150/5230-4B	"Aircraft Fuel Storage, Handling, Training, and Dispensing on Airports." The FAA uses the standards contained in the most recent edition of National Fire Prevention Association (NFP) 407, Standards for Aircraft Fuel Servicing.
INTERNATIONAL FIRE CODE (IFC)	
DOC NO.	**DESCRIPTION**
ICC IFC-2018	International Fire Code
JOINT INSPECTION GROUP (JIG)	
DOC NO.	**DESCRIPTION**
JIG 1	Guidelines for Aviation Fuel Quality Control and Operating Procedures for Joint Into-Plane Fuelling Services
JIG 4	Guidelines for Aviation Fuel Quality Control and Operating Procedures for Smaller Airports
NATIONAL AIR TRANSPORTATION ASSOCIATION (NATA)	
DOC NO.	**DESCRIPTION**
Manual	Refueling and Quality Control Procedures for Airport Service and Support Operations
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
DOC NO.	**DESCRIPTION**
NFPA 30	Flammable and Combustible Liquids Code
NFPA 77	Recommended Practice on Static Electricity
NFPA 385	Standard for Tank Vehicles for Flammable and Combustible Liquids
NFPA 407	Standard for Aircraft Fuel Servicing
SOCIETY AUTOMOTIVE ENGINEERS (SAE)	
DOC NO.	**DESCRIPTION**
SAE ARP 5818	Recommended Practice - Design and Operation of Aircraft Refueling Tanker Vehicles
U.S. DEPARTMENT OF THE INTERIOR	
DOC NO.	**DESCRIPTION**
None	Aviation Fuel Handling Handbook

Table 15 – Guidance Materials and Standard Practices

APPENDIX H: EARLY FAA RESEARCH ACTIVITIES RELATED TO UNLEADED FUELS

REPORT ID NUMBER	TITLE	PUBLICATION YEAR
DOT/FAA/CT-93/65	*Unleaded AVGAS Program Interim Report*	*1994*
DOT/FAA/AR-99/70	*Evaluation of Reciprocating Aircraft Engines with Unleaded Fuels*	*1999*
DOT/FAA/AR-04/25	*Full-Scale Engine Knock Tests of 30 Unleaded, High-Octane Blends*	*2004*
DOT/FAA/AR-06/27	*Spark Ignition Aircraft Engine Tests of Ethyl Tertiary Butyl Ether*	*2006*
DOT/FAA/AR-TN07/5	*High-Octane and Mid-Octane Detonation Performance of Leaded and Unleaded Fuels in Naturally Aspirated, Piston, Spark Ignition Aircraft Engines*	*2007*
DOT/FAA/AR-08/40	*Full-Scale Engine Detonation Tests of 47 Unleaded, High-Octane Blends*	*2008*
DOT/FAA/AR-08/53	*Full-Scale Engine Detonation and Power Performance Evaluation of Swift Enterprises 702 Fuel*	*2009*
DOT/FAA/AR-10/13	*Full-Scale Engine Endurance Test of Swift Enterprises UL102 Fuel*	*2010*
DOT/FAA/AR-TN11/22	*Aviation Fuels Research Reciprocating Engine Aircraft Fleet Fuel Distribution Report*	*2011*
DOT/FAA/TC-12/31	*Lead Deposit Effects on Unleaded Aviation Fuel Antiknock Performance*	*2012*
DOT/FAA/TC-14/10	*Anti-Knock Performance of Reduced Lead Aviation Gasoline in a Full-Scale Engine*	*2014*
DOT/FAA/TC-14/11	*General Aviation Engine Fleet Assessment for Octane Requirement*	*2014*
DOT/FAA/TC-14/51	*Anti-Knock and Power Performance Evaluation of Swift Fuels 100SF Fuel Blended with Commercial 100 Low-Lead Aviation Gasoline in a Full-Scale Engine*	*2015*
DOT/FAA/TC-14/21	*Anti-Knock Performance of Unleaded 94 Aviation Gasoline in High-Octane Demand Full-Scale Engines*	*2015*

Table 16 – Reports of early FAA research activities related to UL fuels

APPENDIX I: OUTREACH AND COORDINATION WITH GOVERNMENT ENTITIES (LOCAL, STATE, TRIBAL, INTERNATIONAL)

Throughout the transition to unleaded AvGas, FAA aims to provide consistent and comprehensive information about the unleaded AvGas transition to all interested or impacted local, state, Tribal, and international government entities. This communication is in the interest of safety and transparency, and FAA anticipates it will strengthen government-to-government relationships.

Past and scheduled future FAA informational briefs on unleaded AvGas at various aviation events. Some examples include the following:

- 2023
  - Tribal Aviation Symposium
  - National Tribal and Indigenous Climate Conference
  - AirVenture at Oshkosh, WI
  - Periodic EAGLE Stakeholder meetings
- 2024
  - Tribal Aviation Symposium
  - National Transportation in Indian Country Conference
  - Tribal Consultation Committee Meeting
  - AirVenture at Oshkosh, WI
  - Periodic EAGLE Stakeholder meetings
- 2025
  - Alaska Air Carriers Association Annual Conference
  - Federal Aviation Administration Safety Team (FAASTeam) educational outreach
  - AirVenture at Oshkosh, WI
  - Periodic EAGLE Stakeholder meetings
  - National Transportation in Indian Country Conference
- 2026
  - NASAO Washington Conference
  - Alaska Air Carriers Association Annual Conference
  - AirVenture at Oshkosh, WI
  - Periodic EAGLE Stakeholder meetings
  - CRC Alexandria, VA
  - ASTM Chicago, IL

As evident throughout this transition plan, continued education, guidance, and communications will be essential throughout all phases of the transition to ensure the safe and orderly replacement of leaded avgas.

Federal Aviation
Administration