Investigative Technologies

Aviation Rulemaking Committee

Final Report

[August 29, 2025]

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I. Executive Summary

The Investigative Technologies Aviation Rulemaking Committee (the ARC) represented diverse interests and viewpoints, including those of operators, manufacturers of aircraft and of investigative technologies, labor unions, and industry organizations. The ARC divided into several working groups and subgroups, working collaboratively to develop recommendations with as much consensus as possible.

A list of the ARC's recommendations is below. Details and supporting text for all recommendations are in Section VIII of the report.

HRT1.a	The FAA should harmonize FDR requirements for new airplane model series (application for type certificate) with ICAO Annex 6 Part I Table A8-1, which is based on EUROCAE ED-112A. Because it has not been adopted by ICAO, the FAA should not harmonize to ED-112B.
HRT1.b	Existing type certificated aircraft should not be required to meet new requirements as recommended in HRT1.a or equivalent to ED-112A. Should the FAA decide that existing type certified aircraft be required to meet the requirements of ED-112A (HRT1.a), it should also include an "extensive modification" exception (similar to EASA AMC1.2 CAT.IDE.A.190).

HRT2.a	The FAA should develop rules in compliance with 49 U.S.C 44746 that do not substantially differ from current standards under ICAO GADSS and EU rules for distress tracking and location of end of flight. The rulemaking should: • Consider methods of compliance and certification of solutions congruent to EASA CS-ACNS Issue 4, including ELT(DT), ADFR, and High-Rate Tracker. • Pursue bilateral agreements to establish that GADSS DT installations already approved under EU/EASA would be an Acceptable Means of Compliance (AMC) for 49 U.S.C. 44746(a)(2). The FAA should create guidance material and Acceptable Means of Compliance to support these policies.
HRT2.b	The FAA should establish exclusions from the ICAO GADSS DT requirements for part 121 operators subject to compliance with 49 U.S.C. 44746(a)(2) and that conduct limited operations overwater and within U.S. airspace.
HRT2.c	The FAA should not establish distress tracking requirements for part 135 other than to harmonize with ICAO Annex 6, Part I requirements as applicable to part 135 operations outside the United States.
HRT3	The FAA should align regulation with ICAO Annex 6 by amending 14 CFR parts 121 and 135 to require the installation of Low-Frequency Underwater Locating Devices on all aircraft operating on extended overwater routes by using the approach listed below.

HRT4.a	The FAA should establish requirements to reduce the time needed to recover flight data recordings after an overwater accident. These requirements should be harmonized with the standards and recommended practices of ICAO and those States that have adopted ICAO Annex 6 Part I Chapter 6.3.6.
HRT4.b	The FAA should coordinate with industry to seek amendments to 49 U.S.C. 44746 to align U.S. law with ICAO Annex 6, Part I, Chapter 6.3.6, specifically seeking to limit the applicability to applicants for new type certification under part 25 and to be effective 5 years after the FAA's final rule is published.
HRT4.c	The FAA should require that the flight data parameters to be recorded meet the ranges, accuracies, resolutions, and recording intervals specified in Appendix M of 14 CFR Part 121. This data can be sourced from the flight data recorder (FDR) stream or any other available aircraft source that provides the necessary information.
HRT4.d	The FAA should amend the part 25 airworthiness standards regarding minimum performance requirements for deployable recorders and the integration of the recorder to: • Establish minimum performance requirements for wireless transmission services. • Establish data retention, data access authority, and data privacy protections.

HRT4.e	The FAA should coordinate with industry to seek amendments to 49 U.S.C. 44746 to provide sufficient time to develop the necessary technical standards to support implementation of timely recovery of flight data (TRFD) for newly certified aircraft in a practical and cost-effective manner. Based on its estimation of the time required, the ARC recommends the mandate for TRFD to be no earlier than December 31, 2036.
HRT5.a	The ARC does not support an FAA requirement for class C-AIR or AIRS (Airborne Image Recorders) for part 121 or part 135 operations in the United States.
HRT5.b	The FAA should establish protections for crew privacy, for release of personally identifiable information (PII), and against data misuse as part of any rulemaking or policy that could enable the introduction of CIR.

HRT5.c	The FAA should consider the issues identified with installing image recorders as captured in the United Kingdom Civil Aviation Administration (CAA) CAP 762: The Effectiveness of Image Recorder Systems in Accident Investigations as part of any rulemaking that could mandate CIR in the U.S. fleet. As an example, the ARC asks the FAA to note key areas of concern identified by the UK CAA such as: • The location, specifications, and number of forward-facing cameras required. Research has indicated drawbacks to rearward-facing cameras without a benefit in observing crew behavior. • The perception of having faces and facial expressions recorded as being personally intrusive. Monitoring people while they perform complex tasks has been shown to have a negative effect on their ability to perform those tasks. • While image recording systems gather large amounts of data, any single source of data can be misleading, and its use should be corroborated with all sources of evidence.

HRT5.d	The NTSB, in collaboration with key stakeholders, including FAA, labor, image recorder manufacturers, and aircraft manufacturers, should develop a set of best practices for use and review of CIR recordings. Recommendations on this type of training should be considered from the United Kingdom Civil Aviation Administration (CAA) CAP 762: The Effectiveness of Image Recorder Systems in Accident Investigations study, which noted that image data can be easily misinterpreted, particularly if it is analyzed in isolation. Because image data is also very compelling, it can be difficult to realize that a misinterpretation has occurred. Evidence from image recorders must be corroborated with other sources of data, such as other flight recordings and engineering evidence.
HRT6.a	The FAA should promote and regulate the adoption of systems and processes (e.g., FDM) that enhance the safety of aviation operations conducted under part 135 and § 91.147 in such a manner that systems and processes (e.g., SMS) required under existing provisions can be leveraged.
HRT.6b	The FAA should allow tailoring of FDM programs and systems to fleet size and operational circumstances following the SMS mandate example.
HRT.6c	The FAA should take the type of aircraft into account when defining minimum system performance specifications.
HRT6.d	The FAA should allow the transmission of flight data from an airborne aircraft using public cellphone or mobile satellite services.

HRT6.e	The FAA should consider existing lightweight recorders, such as ED-155 compliant recorders, as satisfying a potential mandate where able.
HRT6.f	The FAA should clarify that an operator establishing a Flight Data Monitoring (FDM) or Flight Operational Quality Assurance (FOQA) program as part of their SMS is establishing the program as a voluntary and additional function that is not required to show compliance with the part 5 SMS requirements.
HRT6.g	The FAA should establish criteria based on the levels of complexity for equipping flight data acquisition hardware to promote the use of FDM programs. By defining the level of complexity or interaction that would require approvals, such as those done by DER/ODA, the process of installing recorders for FDM could be simplified.
HRT7.a	If the FAA adopts ED-112B into TSO-C123d, it should allow TSO-C123c (ED-112A) or later within any revision to regulation and AC 20-186A until after compliance with section 366.
HRT7.b	If the FAA adopts a regulation to retrofit 25-hour CVR, it should consider measures to reduce the impact on operators, design approval holders (DAHs), and OEMs. These measures should include exceptions based on the extensive modifications required to support specifications of the new recorders, consider the remaining useful lifespan of the aircraft, and incorporate realistic compliance dates.
HRT7.c	The FAA should develop guidance materials addressing pass/fail criteria for demonstrating an aircraft CVR system’s audio quality performance.

HRT7.d	The FAA should ensure that any 25-hour CVR retrofit requirement includes sufficient time for operators to comply.
HRT7.e	The FAA should not expand the definition of “covered aircraft” to include covered aircraft under NPRM 2023-2270, which would include turbine-powered aircraft under parts 91, 125, and 135.
HRT8.a	The FAA should consider implementing a flight recorder mandate for all turbine-powered aircraft operated under § 91.147 and part 121, and aircraft originally certificated as turbine-powered operating under part 135, while focusing on reducing installation complexity and ensuring a low barrier to regulatory compliance as well as reducing the potential for over-regulation. For aircraft not covered under the mandate, the ARC recommends FAA promote the adoption of flight recording systems through monetary incentives, tax incentives, and extension of compliance with related mandates.
HRT8.b	The FAA should allow the adoption of flight data transmission and secure and assured, provenance-controlled and impartial cloud-based flight recorder data recording services to be subscribed to as an acceptable means of compliance with a flight recorder mandate.
HRT9	The FAA should permit the use of deployable flight recorders provided that suitable technical means to prevent unintended deployment are implemented. It should modify the language of § 91.15 to reflect this change.

RTR1	The FAA should evaluate if the benefits of expanding the flight recorder requirements of § 135.152 to aircraft with 9 or fewer passenger seats outweigh the costs to operators for compliance.
RTR2	The FAA should simplify the Flight Operational Quality Assurance (FOQA) program structure and guidance and encourage operators to utilize FDM to manage the safety and efficiency of their operations.
RTR3	The FAA should extend part 193 protections to information disclosed pursuant to a mandatory FDM program.
RTR4	The FAA should require cockpit image and audio recorders on all rotorcraft (turbine and reciprocating engines) used in part 135 operations.
RTR5	The FAA should require “impact-resistant” flight recorder systems and cockpit image recorders on newly manufactured and existing turbine-powered rotorcraft in part 135 operation. OEMs should not be required by the FAA to provide the means of installation on existing turbine-powered rotorcraft not equipped with CVR and FDR, allowing the owner/operator flexibility in choosing the most suitable equipment.

RTR6	The FAA should not require existing turbine powered rotorcraft equipped with an FDR and CVR to install a crash-protected CIR system that is compliant with TSO-C176a as broadly stated but should identify a tiered approach to regulatory implementation. The tiered approach should be based on years of certification; certification category (transport, normal, utility, acrobatic, limited, restricted, and provisional); operational segment (14 CFR parts 91, 121, and 135); rotorcraft size; weight; and/or passenger capacity.
RTR7	The FAA should require manufacturers of newly manufactured turbine-powered rotorcraft to install a flight recorder system that records cockpit audio and images with a view of the cockpit environment to include as much of the outside view as possible, designed to mitigate the risk of loss of recorded data as a result of an aircraft incident or accident, while ensuring that such equipment remains operational under diverse environmental conditions.

II. Chairs' Comments

The chairs thank the members of the ARC for their diligence, dedication, and most of all for bringing their extraordinary expertise to bear on the issues that were before us.

We were fortunate to have subject matter experts from a wide range of industry including investigators, associations, researchers, and manufacturers of both aircraft and components. Many have participated in similar rulemaking committees internationally and offered in-depth knowledge of the intention and direction of both the technology and regulatory guidance. Perhaps the largest testimony to the dedication of the ARC members was their ability to put differences aside and come to a consensus in making these recommendations. We are incredibly grateful to the ARC members for the time and dedication they put into these recommendations, which will provide guidance to the FAA for future technologies.

While the ARC had a broad mission, including the early addition of runway safety, there were some particularly prominent issues that bear emphasis.

1) While it was recognized that the Reauthorization Act of 2024 limited the appropriateness of ARC attention to 25-hour cockpit voice recorders (CVR) and the charter was amended, the ARC heard from industry and agreed that regulatory actions the FAA may promulgate should *not* expand beyond the specific safety concern. Although new technologies and expanded capabilities are possible, every operator, regardless of size, should have the latitude to select compliant options that meet the safety mandate of the law, availability of 25-hours of recording. It is recognized that even that bar cannot be met without significant expense for some types of aircraft, and for others it may simply not be achievable at all.
2) Regarding image recording in the cockpit, rulemaking must continue to respect the norms already in place to ensure security and privacy of recordings. These recommendations will apply to regulations in the United States. However, there continue to be examples beyond our borders where flight data recordings are sensationalized and misused. While there is a considerable amount of information to be gained when these recordings are used as intended, the detrimental effects of their misuse must be considered, particularly as these aircraft routinely fly to locations around the world, beyond the protections of our regulations.

With those points made, we further note:

Flight recorders are forensic by nature. They are intended to record parameters allowing investigators to discover factors leading to an accident. The quality of this data and the final report of the investigation are incredibly important to the prevention of future accidents. Worldwide there has been a great deal of discussion on how technological improvements might aid in providing reliable higher quality data, locate an aircraft in distress, and quickly provide relevant parameters to begin an investigation when these events occur in austere locations such as over the ocean.

The original charter tasked the ARC with considering both technological and regulatory modernization as well as considering relevant recommendations from the NTSB. Several high-profile near-miss events triggered a change in the ARC charter to also consider technologies that would help prevent these incidents, improving runway safety. Recognizing the urgent need and potential preventive nature of these systems, the ARC placed a priority on developing immediate recommendations and provided them to the FAA within the first year. While the FAA Reauthorization Act mandated much of the technology the ARC was considering, amendments were made to the ARC charter to address these changes. Since much of the research and recommendation formulation was already underway, this work was included in the final report to offer the FAA context in its new obligation to Congress.

Harmonization was a very important part of the work the ARC undertook. International requirements through ICAO or the European Union were a large part of this and we were fortunate to have many subject matter experts that participated in similar groups for that rulemaking process. The recommendations had to harmonize not only internationally but also with corresponding regulations. Programs such as flight operational quality assurance (FOQA) or, more generally, flight data monitoring, offer the chance to use data from new recorder technology in a more proactive way in a healthy safety management system. However, regulations also need to be revised to protect these recordings to an equivalent level that prevents misuse and protects privacy. There have been examples overseas of non-traditional technology used as flight recorders not being given the proper protections during investigations because they were not specifically designed or designated to be flight data recorders. The data provided from these new technologies can be incredibly beneficial in improving safety but, to be most effective, they also need an equivalent level of protection.

Again, we thank the ARC members and the FAA for the opportunity to provide these recommendations.

III. Background

The Federal Aviation Administration (FAA) established the Investigative Technologies Aviation Rulemaking Committee (ARC) in June 2023 to facilitate collaboration and informed decision-making in the aviation industry concerning investigative technologies.[1] The ARC's principal focus was to develop recommendations to implement and effectively regulate investigative technology systems. The ARC was also charged with developing recommendations to support the FAA's response to numerous National Transportation Safety Board (NTSB) Safety Recommendations regarding cockpit image recorders (CIRs), safety management systems (SMS), and flight data monitoring (FDM).

In September 2023, the FAA amended the ARC's Charter to include cockpit alerting technologies for improved runway safety.[2] This amendment was added due to a number of recent high-profile runway incursion incidents and based on recommendations from the Approach and Landing Go-Around Joint Safety Analysis and Implementation Team as directed by the Commercial Aviation Safety Team.[3]

In December 2024, the FAA amended the ARC's Charter to address several provisions in the FAA Reauthorization Act of 2024 (hereafter referred to as the Reauthorization Act).[4] Specifically, this amendment tasked the ARC with providing recommendations based on section 333 on rotorcraft safety and on 49 U.S.C. 44746 on flight data recovery from overwater operations (added by section 352). It also removed a task from the original Charter asking the ARC to determine whether to retrofit all airplanes required to carry both a cockpit voice recorder

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[1] Investigative Technologies Aviation Rulemaking Committee Charter (June 7, 2023).

[2] Investigative Technologies Aviation Rulemaking Committee Amended Charter (Sept. 21, 2023).

[3] General Distribution ALM JSAIT Final Report.pdf (cast-safety.org).

[4] FAA Reauthorization Act of 2024. Public Law 118-63, 118th Congress, May 16, 2024. 138 Stat. 1025.

(CVR) and a flight data recorder (FDR) with a 25-hour CVR and added a task to provide recommendations based on section 366 of the Reauthorization Act (hereafter referred to as section 366), which introduced a self-implementing mandate for certain aircraft to be retrofitted with a 25-hour CVR.

IV. ARC Charter – Tasks and Objectives

The ARC's objective was to make recommendations to the FAA regarding installation requirements of existing, new, and upgraded investigative technologies that affect applicable airworthiness standards and operating rules. ARC tasks in the charter, as amended Dec. 12, 2024, include:

- Address international harmonization and International Civil Aviation Organization (ICAO) standards (Task 4.a).
- Discuss and develop recommendations to the FAA based on improvements to safety, impact to the flying public, and economic viability (Task 4.b).
- Discuss issues and develop recommendations for maintenance, periodic testing, and validation of investigative technology systems (Task 4.c).
- Discuss issues and develop recommendations based on pending minimum operational performance standards (MOPS) for additional mandatory FDR parameters (Task 4.d).
- Discuss issues and develop recommendations to the FAA related to National Transportation Safety Board (NTSB) recommendations A-13-12, A-13-13, A-15-1, A-15-2, A-15-3, A-15-4, A-15-7, A-15-8, A-16-34, A-16-35, A-20-27, and A-20-28 on:
    - Whether to require newly manufactured and existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with an FDR or CVR and operating under parts 91, 121, or 135 to be equipped with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio and images with a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installed in Technical Standard Order (TSO) TSO-C197 (Task 4.e.i).
    - Whether to require that aircraft used in extended overwater operations under part 121 or part 135, which are required to have a CVR and an FDR, be equipped with a tamper-resistant method to broadcast to a ground station sufficient information to establish the location of an aircraft after the flight has terminated due to a crash within 6 nautical miles of the point of impact in consideration of the mandate in 49 U.S.C. 44746 (Task 4.e.ii).
    - Whether to require aircraft used in extended overwater operations under part 121 or part 135, which are required to have a CVR and FDR, to be equipped with an airframe low frequency underwater locating device that will function for at least 90 days that can be detected by equipment available on military, search and rescue, and salvage assets in consideration of the mandate in 49 U.S.C. 44746 (Task 4.e.iii).

- Whether to require newly manufactured aircraft used in extended overwater operations under parts 121 and 135, which are required to have a CVR and FDR, to be equipped with a means to recover mandatory flight data parameters; the means of recovery should not require underwater retrieval. The data should be captured from a triggering event until the end of the flight and for as long a time period before the triggering event as possible in consideration of the mandate in 49 U.S.C. 44746 (Task 4.e.iv).
- How best to coordinate with other international regulatory authorities and ICAO to harmonize the implementation of requirements specified in A-15-1 and A-15-3 (Task 4.e.v).
- Whether to require newly manufactured and existing aircraft operating under parts 121 and 135, which are required to have a CVR and an FDR, to be equipped with a crash-protected CIR, in compliance with TSO-176a, and to be equipped with an independent power source (Task 4.e.vi).
- Whether to require part 135 operators to install flight data recording devices capable of supporting a flight data monitoring program (Task 4.e.vii).
- Whether to require part 135 operators to establish a structured flight data monitoring program that reviews all available data sources to identify deviations from established norms and procedures and other potential safety issues (Task 4.e.viii).
- Whether to require manufacturers of newly manufactured turbine-powered rotorcraft not equipped with a FDR and CVR, to install a crash-resistant flight recorder system that records cockpit audio and images with a view of the cockpit environment to include as much of the outside view as possible and parametric data per aircraft and system installation, as specified in TSO-C197 (Task 4.e.ix).
- Whether to require manufacturers of newly manufactured turbine-powered rotorcraft equipped with a FDR and CVR to install a crash-protected CIR system compliant with TSO-C176a or equivalent. The CIR should be equipped with an independent power source consistent with that required for CVRs in 14 CFR 29.1457 (Task 4.e.x).
- Whether to require manufacturers of existing turbine-powered rotorcraft not equipped with an FDR or CVR to provide a means to install a crash-resistant flight recorder system that records cockpit audio and images with a view of the cockpit environment to include as much of the outside view as possible and parametric data per aircraft and system installation, as specified in Technical Standard Order C197 (Task 4.e.xi).
- Whether to require existing turbine-powered rotorcraft equipped with an FDR and CVR, to install a crash-protected CIR system that is compliant with TSO-C176a or equivalent. The CIR system should be equipped with an independent power source consistent with that required for CVRs in 14 CFR 29.1457 (Task 4.e.xii).

- Discuss issues and develop a recommendation on whether to allow the use of ADFRs that may currently be contrary to FAA regulations (Task 4.f).

- Discuss and consider alternate approaches for promoting voluntary installations of FDRs, CVRs, and CIRs for aircraft and operations where there may not be a mandatory installation requirement (Task 4.g).
- Develop and recommend to the FAA draft advisory circular language and a strategy, process, and schedule for the implementation of new or revised criteria (Task 4.h).
- Develop and recommend to the FAA updated guidance material, notices, handbooks, and other relevant material for investigative technologies (Task 4.i).
- Develop and recommend to the FAA updated guidance material, notices, handbooks, and other relevant material on how FDRs, CVRs, and CIRs can be integrated into a voluntary or required Safety Management System (SMS) program (Task 4.j).
- Provide recommendations on how to require cockpit alerting technologies designed to reduce runway safety events (Task 4.k).[5]
- Assess and review the need for changes to safety requirements related to FDRs, flight data monitoring, and terrain awareness and warning systems for turbine-powered rotorcraft certificated for six or more passenger seats; and, as appropriate, make recommendations for legislative or regulatory changes to improve safety (Task 4.l).
- For methods for broadcasting within 6 nautical miles, low frequency underwater locating devices, and means to recover mandatory flight data parameters, discuss and develop:
    - Recommendations on whether to apply the requirements regarding flight data recovery in section 49 U.S.C. 44746 to other aircraft in addition to those that meet the definition of “applicable aircraft” in 49 U.S.C. 44746 (Task 4.m.i).
    - Quantitative cost and benefit data for the inclusion of flight data recovery technologies for aircraft that meet the definition of “applicable aircraft” in 49 U.S.C. 44746 and other aircraft under consideration (Task 4.m.ii).
    - A qualitative description of the potential impacts for the inclusion of flight data recovery technologies for aircraft that meet the definition of “applicable aircraft” in 49 U.S.C. 44746 and other aircraft under consideration (Task 4.m.iii).
- Discuss issues and develop the following:
    - Recommendation on whether to expand the retrofit requirement in section 366 to require retrofit of aircraft that are specified in the proposed rule for newly manufactured aircraft and not covered by section 366 (Task 4.n.i).
    - Quantitative cost and benefit data for retrofitting “covered aircraft” as defined in section 366 and other aircraft under consideration (Task 4.n.ii).
    - A qualitative description of the potential impacts for retrofitting “covered aircraft” as defined in section 366 and other aircraft under consideration (Task 4.n.iii).
- For any recommendation to change regulatory requirements, provide qualitative benefit-cost description, quantitative benefit and cost data, and compliance tradeoffs (Task 4.o).

[5] This tasking was addressed in a separate report submitted to the FAA in August 2024.

The ARC made recommendations on the following topics:

- International harmonization and International Civil Aviation Organization (ICAO) standards.
- Improvements to safety, impact on the flying public, and economic viability.
- Maintenance, periodic testing, and validation of investigative technology systems.
- Pending minimum operational performance standards (MOPS) for additional mandatory flight data recorder (FDR) parameters.
- NTSB Safety Recommendations regarding automatic deployable flight recorders (ADFRs), CIRs, and cockpit voice recorders/flight data recorders (CVR/FDR) equipment on aircraft.
- Consideration of specific recording equipment installation for certain aircraft and for specified operations.
- Regulatory amendments, cost-benefit analyses, comprehensive guidance material, and advisory circulars for flight data recovery methods and related investigative technologies.

In developing its recommendations, the ARC addressed some of these taskings in standalone recommendations. It also incorporated content addressing the following taskings throughout its recommendations where relevant:

- Address international harmonization and International Civil Aviation Organization (ICAO) standards (Task 4.a).
- Discuss and develop recommendations to the FAA based on improvements to safety, impact to the flying public, and economic viability (Task 4.b).
- Discuss issues and develop recommendations for maintenance, periodic testing, and validation of investigative technology systems (Task 4.c).
- Discuss and consider alternate approaches for promoting voluntary installations of FDRs, CVRs, and CIRs for aircraft and operations where there may not be a mandatory installation requirement (Task 4.g).
- Develop and recommend to the FAA draft advisory circular language and a strategy, process, and schedule for the implementation of new or revised criteria (Task 4.h).
- Develop and recommend to the FAA updated guidance material, notices, handbooks, and other relevant material for investigative technologies (Task 4.i).
- Develop and recommend to the FAA updated guidance material, notices, handbooks, and other relevant material on how FDRs, CVRs, and CIRs can be integrated into a voluntary or required Safety Management System (SMS) program (Task 4.j).
- For any recommendation to change regulatory requirements, provide qualitative benefit-cost description, quantitative benefit and cost data, and compliance tradeoffs (Task 4.o).

V. Current Regulatory Landscape

FAA operating regulations in 14 CFR parts 91, 121, 125, and 135 address requirements for a number of investigative technologies. Advances in technology have made recorders more diverse than those traditionally addressed in current regulations. Improvements to memory capacity, increases in the number of parameters recorded, the ability to transmit data, and reduction in weight and complexity have driven a need to define specifications and requirements for these devices.

ICAO has added Standards and Recommended Practices (SARPs) addressing how some of these new technologies can be implemented. Likewise, the European Union has changed regulations defining requirements and allowed usage of new recorder technologies to align with ICAO standards.

Recent accidents where the aircraft and recorders were difficult to locate, thereby slowing investigative efforts, have triggered ICAO to amend requirements for locating an aircraft in distress which requires a response by regulators.

In addition, the U.S. Congress added provisions in the Federal Aviation Reauthorization Act of 2024 (P.L. 118-63) addressing rotorcraft safety, flight data from overwater operations, and 25-hour cockpit voice recorders. Section 333 of the Reauthorization Act tasks this Aviation Rulemaking Committee (ARC) with reviewing and assessing the need for changes to safety requirements related to FDR, FDM, and terrain awareness and warning systems for turbine-powered rotorcraft with 6 or more passenger seats. Additionally, 49 U.S.C. 44746(a), added by section 352, directs the FAA to require part 121 aircraft that are required to have a CVR and FDR and used in extended overwater operations to have a means to recover mandatory flight data parameters after an accident without underwater retrieval, a tamper-resistant method to broadcast sufficient information to a ground station to establish flight termination location, and a low-frequency ULD that functions for at least 90 days and can be detected by appropriate equipment within 5 years of enactment. Finally, section 366 requires installation of CVRs with 25-hour duration for existing aircraft within 6 years of enactment.

VI. Challenges

The ARC notes several challenges associated with the acquisition and implementation of recording systems.

A. Rapid Technological Advancement

Aircraft, particularly larger airplanes in airline service, have a long lifespan. The most prolific aircraft models in service today are based on designs that can be 50 years old, with individual aircraft remaining in service for 20 years or more. While the current production variants of these models have been enhanced since the original design, the disparity between the long lifespan of aircraft and the rapid development of electronic components poses challenges in anticipating design and regulatory requirements. New technology can allow recorders to be smaller, track more parameters, retain longer memory, and communicate off the aircraft via a variety of means (cellular, satellite, wi-fi, etc.). This challenges regulators and manufacturers in anticipating the needs of future aircraft designs and appropriate matching of recorder criteria. The impact of using new technology on older aircraft must encompass the implications for existing structure and equipment.

B. Cost

Cost is another major factor affecting both the acquisition of data recording hardware as well as the usability of the data. New hardware can range from $3,000 for a light data recording unit to $60,000 for an ED-112 compliant FDR. These costs do not include aircraft modification and installation into the legacy fleet. Adopting more modern technology to older aircraft can also be much more expensive than replacing an old recorder with a new one. Flight data recorders depend on sensors to collect parameters. While data collection on newer aircraft might be associated with digital components and avionics, older aircraft depend on a network of sensors. New recorders capable of tracking more parameters at higher fidelity would also require expensive upgrades to this network of sensors in older aircraft. Additionally, adopting a flight data monitoring (FDM) program can increase expenses, such as costs associated with software, data readout tools, analysis services, or dedicated employees to manage the program. Although the safety benefits of FDM have been demonstrated to be effective, the cost of a properly run program that follows the current regulatory framework to be afforded the corresponding protections can be a barrier.

C. Regulatory Barriers

Regulations also need to evolve to account for new recorders. ICAO has recently published amendments to Annex 6, which include the acceptance of airborne image recorders, flight crew machine interface recorders, and lightweight recorders. The EUROCAE definitions for flight recorders in ED-112 and for lightweight recorders in ED-155, as referenced by the European Union Aviation Safety Agency (EASA), ICAO, and other civil aviation regulators, continue to evolve and expand in specificity.

The updates to the technical standards and amendments to regulations seek to improve the data available to investigators and increase their use in operation, either through requirements or voluntary adoption.

However, other regulatory barriers exist, particularly with lightweight recorders that may lack regulatory approval for specific aircraft types or approved maintenance programs. Other devices available for voluntary use may meet the specifications of lightweight recorders except for being crash-hardened. Research from the NTSB suggests that standards for accident survivability may not be required for the light aircraft market. Numerous accident reports discuss post-accident data recovery and usability in a high percentage of accidents.

Furthermore, there is a gap in the data protection regulations. ICAO Annex 13 states: “The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability.”[6] As such, the data collected is also offered protection from misuse. ICAO is in the process of addressing these protections in terms of the recordings as opposed to the existing protections by recorders. There are similar discussions on data protection for Annex 19 for data used by safety management systems and flight data monitoring. This gap, both by ICAO and many regulators, in protecting data from non-traditional recorders can also be a barrier to widespread use.

D. Data Usability, Reliability, and Protection

Usability refers to how accessible and interpretable the flight data is. Reliability refers to the levels of data quality and accuracy a recording device provides. Across aircraft types, there are numerous variations of these data aspects. Optimally, data should be easy to access (download or transmit), data should be made interpretable with the help of the OEM or recorder hardware provider, and data quality should be maintained to the highest degree possible. Data should also be protected from misuse. To encourage operators to use flight data to enhance safety initiatives, barriers to corresponding programs should be lowered and data protections should be in place.

E. Disparity in Regulation

While the value of flight recorders and flight data monitoring programs is well understood, different basis in regulation makes harmonization difficult. Both ICAO and the EU offer guidance primarily by type of aircraft and weight whereas the U.S. also factors in the type of operation, for example, by applying 14 CFR parts 121 or 135. While this may not have a large impact on airline operations (14 CFR Part 121) where the needs and benefits can be more obvious, smaller operators (14 CFR Part 135) and aircraft are more heavily impacted. When applying recommendations, consideration must be given to scale. As such, some recommendations seek to encourage installation of recorders instead of requiring it. The intention is to encourage the benefits of installing recorders and benefiting from FDM instead of requiring items that may offer little benefit in overall risk reduction for a burdensome cost.

VII. Working Group Narratives

The ARC established three working groups to address the issues in the Charter:

- Harmonize, Record, and Track,
- Rotorcraft, and
- Runway Safety.

The groups met regularly over several months to more than a year to develop recommendations. The following section outlines the focus areas for the ARC’s work.

[6] ICAO Annex 13, Chapter 3, 3.1.

Between the Harmonize, Record, and Track (HRT) and Rotorcraft working groups, there were areas of overlap on rules relating to part 135 operators and the adoption of FDM programs and mandates for lightweight data recorders (see HRT recommendations HRT6 and HRT8 and Rotorcraft recommendations RTR3, RTR4, and RTR5).

The working groups support FDM and the adoption of flight data recorders. However, the Rotorcraft group does not agree with requiring ED-155 standards and maintains its position on "impact-resistant" TSO-176a for the Rotorcraft group.

A. Harmonize, Record, and Track (HRT)

The HRT group focused on harmonization of U.S. federal regulations with ICAO and foreign civil aviation authority (CAA) regulations and standards to make it easier for operators to maintain aircraft that are properly equipped to operate within another country's airspace based on simply complying with U.S. regulations. The group also considered the various NTSB Safety Recommendations regarding CIR, CVR/FDR, and ADFR equipment installation for certain aircraft and for specified operations.

B. Rotorcraft

The Rotorcraft group focused on CIRs on newly manufactured aircraft and adding flight data recording hardware to support FDM programs. The group explored the feasibility of implementing these policies, and the challenges faced by both OEMs and operators with respect to regulatory, hardware (CIR/FDR devices), and financial concerns. These barriers are particularly significant in the light rotorcraft market, where margins for additional cost, weight, and economics are thin. The group prioritized the development of policies that enable efficient transitions from engineering and development to aircraft installation and use for additional cockpit technologies.

C. Runway Safety

The Runway Safety group focused on providing recommendations for cockpit alerting technologies designed to reduce runway safety events. These technologies alert the flight crew to take corrective actions to avoid adverse outcomes associated with runway/aircraft alignment or runway length. Runway safety is a high priority issue for the FAA, and efforts to progress this work were underway before the ARC was formally established. The ARC members in this group worked tirelessly to complete this tasking on an expedited basis and submitted their recommendations to the FAA in a separate report in August 2024.[7]

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[7] Runway Safety Alerting Subgroup, *Investigative Technologies Aviation Rulemaking Committee Recommendation Report* (Aug. 8, 2024), at https://www.faa.gov/sites/faa.gov/files/Rec-Report_Investigative-Tech-ARC_Airport-Safety-Alerting-Subgroup_08152024.pdf.

VIII. ARC Recommendations – Intent, Rationale, and Approach

A. Harmonize, Record, and Track (HRT)

1. MOPS Standards for Additional Mandatory FDR Parameters[8]

a. New Model Series: Harmonization with ICAO Annex 6 and EUROCAE ED-112A

REC HRT1.a	The FAA should harmonize FDR requirements for new airplane model series (application for type certificate) with ICAO Annex 6 Part I Table A8-1, which is based on EUROCAE ED-112A. Because it has not been adopted by ICAO, the FAA should not harmonize to ED-112B.

INTENT: To increase harmonization and promote incremental safety improvements from additional mandatory FDR parameters for new airplane model series.

RATIONALE: In response to accident investigation agency safety recommendations to address mandatory FDR parameters, EASA submitted a working paper to ICAO in 2015.[9] ICAO adopted the intent of ED-112A mandatory FDR parameters to be recorded November 8, 2018, in Amendment 43 to Annex 6 - *Operation of Aircraft*, Part I - *International Commercial Air Transport* section 3.3.1.1.11 and Table A8-1,[10] with the exception of first officer values for pressure altitude, indicated airspeed or calibrated airspeed, pitch attitude, and roll attitude. This standard is applicable for new airplane model series (e.g. Airbus A390, Boeing 797) of maximum certificated take-off mass of over 5,700 kg for which the application for type certification is submitted after January 1, 2023. This standard does not apply to initial certificate of airworthiness (newly manufactured airplanes for existing airplane model series, e.g. Airbus A350, Boeing 787, Embraer E175), nor is there a recommended practice (recommendation) applicable to newly manufactured airplanes.

The FAA operating regulations in 14 CFR parts 91, 121, 125, and 135 address FDR parameters within appendices and do not refer to separate industry standards. The latest FAA operational requirements[11] are listed below. FAA requirements for mandatory FDR parameters vary by operating regulation:

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[8] *See* Appendix B1 for the full working group report on this topic.

[9] EASA Flight Recorder Working Group, *Upgrading the FDR Parameter Performance Specifications* (Working Paper No. FLIRECSWG/8-WP/4, 2015).

[10] ICAO Annex 6, Operation of Aircraft, Part 1.

[11] *See* 14 CFR Part 91 Appendix E [FAA-2013-0579, 9/3/2013]; 14 CFR Part 121 Appendix M [FAA-2013-0579, 9/3/2013]; 14 CFR Part 125 Appendix E [FAA-2013-0579, 9/3/2013]; and 14 CFR Part 135 Appendix F [FAA-2005-20245, 4/7/2008].

- Section 91.609 requires a flight data recorder for multiengine, turbine-powered airplanes or rotorcraft having a passenger seating configuration of 10 or more.[12]
- Section 121.344 requires digital flight data recorders for turbine-engine powered transport category airplanes.[13]
- Section 125.225 requires a flight data recorder for large airplane operations above 25,000 ft altitude and multiengine turbine powered airplanes.[14]
- Section 135.152 requires a flight data recorder for multiengine, turbine-powered airplanes or rotorcraft having a passenger seating configuration of 10 to 19 seats.[15]

ICAO Annex 6 Part I Table A8-1 includes the following parameters applicable to application for type certification after 1 January 2016 (new airplane models):

- Normal, longitudinal, lateral acceleration at 16 Hz.
- Pilot input and/or control surface position – primary controls at 8 Hz.

It also includes the following parameters applicable to application for type certification after 1 January 2023 (new airplane models):

- Engine fuel metering valve position.
- Cabin pressure altitude.
- Aeroplane computed weight.
- Flight director command.
- Vertical speed.

The FAA has not yet adopted the intent of ICAO Annex 6 Part I Table A8-1 or EUROCAE ED-112A into regulation. The NTSB has not issued safety recommendations for ICAO standards, EUROCAE ED-112A,[16] or EUROCAE ED-112B[17] mandatory FDR parameters. The Reauthorization Act does not include a section relating to additional mandatory FDR parameters.

FAA adoption of EUROCAE ED-112B (2023)[18] mandatory FDR parameter requirements for any applicability (new airplane model series, newly manufactured airplanes, existing airplanes)

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[12] 14 CFR 91.609.

[13] 14 CFR 121.344.

[14] 14 CFR 125.225.

[15] 14 CFR 135.152.

[16] EUROCAE ED-112A *MOPS for Crash Protected Airborne Recorder Systems* (September 2013).

[17] EUROCAE ED-112B *Minimum Operational Performance Standard for Crash Protected Airborne Recorder Systems* (August 2023).

[18] The ARC notes the Charter reference to EUROCAE ED-112B *Minimum Operational Performance Standard for Crash Protected Airborne Recorder Systems* (August 2023) as the "pending" MOPS. This document revision is no longer "pending," having been released in August 2023. ED-112B includes additional mandatory FDR parameters in

would not harmonize with ICAO or any other States/CAAs. FAA has not previously cited EUROCAE documents for mandatory FDR parametric recording requirements. There are also other factors that lean against the adoption of ED-112B, such as:

- Industry has recently revised flight data recording systems for existing airplane models to comply with ED-112A for the European Union and other nations.
- There is no known NTSB safety recommendation referencing ED-112B mandatory FDR parameter requirements for newly manufactured airplanes or new airplane model series.
- Neither ICAO nor any other nation has adopted ED-112B requirements.

EUROCAE ED-112A (2013), on the other hand, has seen significantly more activity regarding harmonization and industry compliance. ED-112A included changes to existing and new mandatory FDR parameter requirements, relative to ED-112 (2003):

- Increase sample rate from:
    - 0.25 (4 Hz) to 0.125 (8 Hz) for longitudinal acceleration, lateral acceleration, primary flight control pilot input for pitch axis, roll axis, and yaw axis.
    - 4 (1/4 Hz) to 1 (1 Hz) for navigation data.
    - 1 (1 Hz) to 0.5 (2 Hz) for yaw or sideslip angle.
    - 1 (1 Hz) to 0.25 (4 Hz) for cockpit flight control input forces.
- Increase resolution from 0.002 to 0.0002 for latitude and longitude.
- Add first officer values for pressure altitude, calibrated/indicated airspeed, pitch attitude, and roll attitude.[19]
- Add engine fuel valve metering position, cabin pressure altitude, aircraft computed weight, flight director command, and vertical speed.

No change would be required to the flight data recording system under adoption of ED-112A if the existing mandatory database software already satisfies ED-112A mandatory FDR parameter requirements, including those added in ED-112A at the required sample rate. However, a change would be required to the flight data recording system (and potentially source systems and

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Table II-A.1 Parameters to Be Recorded – Aeroplanes, relative to the previous revision ED-112A (September 2013). The initial version of ED-112 was released in 2003.

[19] ICAO Annex 6 Part I Table A8-1 does not require first officer values for pressure altitude, calibrated/indicated airspeed, pitch attitude, or roll attitude.

airplane wiring) if the existing mandatory database software does not already satisfy ED-112A mandatory FDR parameter requirements.[20] For example:

- Increasing sample rate for an existing mandatory FDR parameter group may require a revision to the source system if digital data is not provided at a sufficiently high rate to preclude stale data recorded on the FDR. For example, if the data is provided at 1 Hz but the recording requirement is 2 Hz, a revision to the source system would be required to increase the data transmittal rate.

- Adding new mandatory FDR parameter groups may require changes to source system(s) and/or airplane wiring depending on whether the flight data recording system already receives and records the data on the FDR.

Airplane manufacturers have in the past few years developed and certified flight data recording systems for some, but not all, airplane model series currently in production to address EASA, UAE, and UK ED-112A mandatory FDR parameter requirements in Part-CAT AMC1.2 CAT.IDE.A.190[21] with an "extensive modification." The complexity of ED-112A mandatory FDR parameter requirements for newly manufactured airplanes is dependent on the requirements and the airplane design. Airplane model series not recently revised would comply with ED-112 instead. Other airplane model series may not fully comply with ED-112A due to the EASA, UAE, and UK "extensive modification" exception.

<table>
<tr><th>Requirement</th><th>Airplane Design</th><th>Change</th></tr>
<tr><td rowspan="3">ED-112A with "extensive modification"</td><td>ED-112</td><td>Marginally complex</td></tr>
<tr><td>ED-112A with "extensive modification"</td><td>No change required</td></tr>
<tr><td>ED-112A</td><td>No change required</td></tr>
<tr><td rowspan="3">ED-112A</td><td>ED-112</td><td>Complex*</td></tr>
<tr><td>ED-112A with "extensive modification"</td><td>Complex*</td></tr>
<tr><td>ED-112A</td><td>No change required</td></tr>
</table>

**Increased complexity for airplane models that require source system and/or airplane wiring changes to comply with ED-112A mandatory FDR parameter requirements.*

The ARC believes that, as numerous jurisdictions globally have made efforts to harmonize with EUROCAE ED-112A, and industry has already expended considerable resources to comply with it, efforts to harmonize FAA rules with ED-112A would be warranted. However, mandatory FDR

[20] An existing airplane model with a flight data recording system designed to ED-112, which does not meet all ED-112A parameter requirements, is provided as a notional example in the Additional Mandatory FDR Parameters position paper (see Appendix B1).

[21] UK Air Operations Regulation, Part-CAT AMC1.2 CAT.IDE.A.190.

parameter requirements are not well harmonized between ICAO and States at present, so there are a range of options for implementing such harmonization.

FAA adoption of ICAO Annex 6 Part I Table A8-1 (~ED-112A) mandatory FDR parameter requirements could harmonize with ICAO and other States and civil aviation authorities, depending on the applicability.

- FAA adoption of ICAO mandatory FDR parameter requirements for new airplane model series would harmonize with ICAO and other States and civil aviation authorities (China, Hong Kong, Singapore).
- FAA adoption of ICAO mandatory FDR parameter requirements for newly manufactured airplanes **with an "extensive modification"** exception would not harmonize with ICAO but would harmonize with other States and civil aviation authorities (EASA, UAE, UK).
- FAA adoption of ICAO mandatory FDR parameter requirements for newly manufactured airplanes **without an "extensive modification"** exception would not harmonize with ICAO and would only harmonize with India's Directorate General of Civil Aviation (DGCA).
- FAA adoption of ICAO mandatory FDR parameter requirements for existing airplanes (retrofit) would not harmonize with ICAO or any other State or CAA.

The States listed below are not an exhaustive list but rather a sample of the varying implementations.[22]

ICAO standard for new airplane model series

China, Hong Kong, and Singapore have adopted ICAO Annex 6 Part I Table A8-1 (~ED-112A) mandatory FDR parameter requirements into regulation for new airplane model series (application for type certification) after 1 January 2023. As an example, an excerpt from Singapore CAAS Table 1-1 *Parameters to Be Recorded by Crash Protected Flight Data Recorders* shows that specific mandatory FDR parameter groups are identified as applicable only to airplanes with application for type certification after January 1, 2023.[23]

ICAO standard for newly manufactured airplanes

India DGCA has adopted ICAO Annex 6 Part I on mandatory FDR parameter requirements into regulation for new airplane model series and newly manufactured airplanes after January 1, 2023. India DGCA did not provide any consideration for newly manufactured airplanes as

[22] *See* MOPS Standards for Additional Mandatory FDR Parameters position paper in Appendix B1 for more details on each of the three options described.

[23] Singapore CAAS, *Aviation Specifications 2 – Flight Recorders* (December 21, 2018), p. 12.

EASA, UAE, and UK have done (discussed below). India adopted the ICAO SARPs nearly verbatim, and ICAO unfortunately incorrectly included "shall" instead of "should" within the recommendation. This may not have been the intent of India DGCA to adopt the ICAO recommendation into regulation.

EUROCAE ED-112A with "extensive modification" exception

EASA, UAE, and UK have adopted ED-112A mandatory FDR parameter requirements into Part-CAT (Commercial Air Transport) AMC1.2 CAT.IDE.A.190 *Flight Data Recorder* for newly manufactured airplanes (initial certificate of airworthiness) after January 1, 2023. The Acceptable Means of Compliance (AMC) includes an exclusion for new mandatory FDR parameters, which would require "extensive modification" to the airplane systems and equipment, other than the flight data recording system.

The term "extensive modification" is defined as "cannot be achieved without extensive modification to the aeroplane system and equipment other than the flight recording system" in AMC2 CAT.IDE.A.190. This "extensive modification" is limited to newly manufactured airplanes with application for type certification prior to January 1, 2023 (existing airplane model series). The term "extensive modification" is effectively "any change other than the flight data recording system." Thus, if any change other than the flight data recording system were necessary to add new mandatory FDR parameter(s) to an existing airplane model series, then the new mandatory FDR parameter(s) would not be required to be added.

The following figure provides a summary of ICAO and State/CAA regulation.

Figure 1: ICAO and State/CAA Regulation

In general, the complexity increases both with the latest mandatory FDR parameter requirements and with the age of the affected airplanes. Older airplane models had less stringent mandatory FDR parameter requirements at the time of manufacture. Therefore, they would require more effort to bring up to the latest industry standard. Older airplane models tend towards a federated architecture that is more difficult to provide data to the flight data recording system (source system may not output the required data, airplane wiring changes may be required).

The flight data recording system does not itself generate the mandatory FDR parameters, except in the limited case where there are sensors dedicated to the flight data recording system. New mandatory FDR parameters may require the installation of dedicated sensors if not already provided for use by airplane systems. Other airplane systems, many of which are high criticality (e.g. displays), and the engines provide most of the data to the flight data recording system. Not all airplane systems and digital buses are connected to the flight data recording system; therefore, adding new parameter requirements may require changes to airplane wiring. Changes to high-criticality systems (even simply to add data to an existing digital bus) are not trivial, costing hundreds of thousands or millions of dollars to design and certify, including airplane demonstration of proper function. An airplane system may be installed per a supplier's supplemental type certification, requiring coordination and separate certification for revision to a supplier's type design to accommodate additional mandatory FDR parameters.

The ARC recommends harmonization with ICAO and those States/nations that have adopted ICAO Annex 6 Part I Table A8-1 (~ED-112A) for new airplane model series (application for type certification). This would allow the benefits from harmonization while reducing the impact of compliance.

The ARC does not recommend adoption of additional mandatory FDR parameter requirements for existing airplanes (retrofit) due to the very high complexity/impact of modifying out of production airplanes. There is no known NTSB safety recommendation referencing additional (e.g. ICAO or EUROCAE) mandatory FDR parameter requirements for existing airplanes.

APPROACH: To implement ICAO Annex 6 Part I Table A8-1 and ED-112A, operational regulations could be revised as follows, using 14 CFR Part 121 as an example. The ARC recommends adding the blue text:

> 14 CFR 121.344 *Digital flight data recorders for transport category airplanes.*
>
> (a) Except as provided in…a change in installed equipment.
> […]
>
> (91) Standby rudder valve status
>
> (92) Cabin pressure altitude
>
> (93) Airplane computed weight
>
> (94) Flight director command
>
> (95) Vertical speed
>
> […]

(f) For all turbine-engine-powered transport category airplanes manufactured after August 19, 2002—

(1) The parameters listed in paragraphs (a)(1) through (a)(88) of this section must be recorded within the ranges, accuracies, resolutions, and recording intervals specified in Appendix M of this part.

[…]

(x) For all turbine-engine powered transport category airplanes with application for type certification on or after <applicability date> -

(1) The parameters listed in paragraphs (a)(1) through (a)(95) of this section must be recorded within the ranges, accuracies, resolutions, and recording intervals specified in Appendix Q of this part.

A new Appendix Q to part 121 Airplane Flight Recorder Specifications would include the intent of ICAO Annex 6 Part I Table A8-1 for existing and new mandatory FDR parameters.

b. Existing Model Series: Extensive Modification Exceptions

REC HRT1.b	Existing type certificated aircraft should not be required to meet new requirements as recommended in HRT1.a or equivalent to ED-112A. Should the FAA decide that existing type certified aircraft be required to meet the requirements of ED-112A (HRT1.a), it should also include an “extensive modification” exception (similar to EASA AMC1.2 CAT.IDE.A.190).

INTENT: To provide sufficient flexibility for new airplanes from existing model series to comply with the requirements of ICAO Annex 6 Part I Table A8-1 and EUROCAE ED-112A, if desired, while recognizing the high complexity and impact of modifying out-of-production airplanes.

RATIONALE: The complexity of development and certification of additional mandatory FDR parameters vary depending on:

- which mandatory FDR parameter requirements are adopted into regulation (how many parameter groups are revised or added),
- the applicable airplanes (models) subject to the regulation, and
- whether an exception is allowed for new mandatory FDR parameters on existing airplane model series.

The impact of additional mandatory FDR parameter requirements for a new airplane model series is far less than an existing model series, as the new airplane model series can be designed from the start to address the new requirements. It is significantly higher impact to modify existing certified airplane type design than to incorporate into a new not yet certified airplane model series.

The impact of additional mandatory FDR parameter requirements for newly manufactured airplanes (existing model series) is greater than if limited to new airplane model series due to multiple concurrent type design changes required for airplane manufacturers with multiple existing airplane models.

Additional mandatory FDR parameters could impact military commercial derivative aircraft despite these aircraft not being used for commercial air transport.

Multiple concurrent design and certification projects place more strain on design engineering and certification resources.

The following table illustrates the difference in scope for type design changes for newly manufactured airplanes when an “extensive modification” is included and not included for existing airplane model series.

Table 1: Effect of "Extensive Modification" Exception on Additional Mandatory FDR Parameters Required for Newly Manufactured Airplanes

Type design change	**Are mandatory parameters required for newly manufactured airplanes with “extensive modification” exception?**	**Are mandatory parameters required for newly manufactured airplanes?**
Flight data recording system	Yes	Yes
Airplane wiring / network configuration	No	Yes
Source system(s)	No	Yes

Implementing ICAO Annex 6 Part I Table A8-1 and ED-112A with an “extensive modification exception,” like EASA, UAE, and UK, best balances the safety gains from implementation with a desire to address the above compliance challenges for new aircraft from existing model series.

APPROACH: To implement the “extensive modification” exception, operational regulations could be revised as follows with the inclusion of the blue text, using 14 CFR Part 121 as an example:

(x) For all turbine-engine powered transport category airplanes that are manufactured on or after <applicability date> -

(1) The parameters listed in paragraphs (a)(1) through (a)(95) of this section must be recorded within the ranges, accuracies, resolutions, and recording intervals specified in Appendix Q of this Part for airplane model series with application for type certification before <applicability date>, except if modification is required other than the flight data recording system for (a)(43)(92)(93)(94)(95) as noted in Appendix Q of this Part.

(2) The parameters listed in paragraphs (a)(1) through (a)(95) of this section must be recorded within the ranges, accuracies, resolutions, and recording intervals specified in Appendix Q of this Part for airplanes with application for type certification on or after <applicability date>

A new Appendix Q to part 121 Airplane Flight Recorder Specifications would include the intent of ICAO Annex 6 Part I Table A8-1 parameter requirements for existing and new mandatory FDR parameters.

43. Additional Engine Parameters

Remarks: "Where capacity permits, the preferred priority is indicated vibration level, N2, EGT, Fuel Flow, Fuel Cut-off lever position, N3, and engine fuel metering valve position unless engine manufacturer recommends otherwise." [24]

92. Cabin Pressure Altitude

93. Airplane Computed Weight

94. Flight Director Command

95. Vertical Speed

The ARC recommends sufficient time for design and certification related to additional mandatory FDR parameters should the FAA adopt them for newly manufactured airplanes. Specifically, it recommends:

- At least 3 years with "extensive modification" exception.
- At least 5 years without "extensive modification" exception due to the increased complexity of modifying airplane wiring/network configuration and/or source system(s).

[24] Except if modification is required other than the flight data recording system for airplane model series with application for type certification before <applicability date>.

2. Distress Tracking[25]

a. International Harmonization

REC HRT2.a	The FAA should develop rules in compliance with 49 U.S.C. 44746 that do not substantially differ from current standards under ICAO GADSS and EU rules for distress tracking and location of end of flight. The rulemaking should: • Consider methods of compliance and certification of solutions congruent to EASA CS-ACNS Issue 4, including ELT(DT), ADFR, and High-Rate Tracker. • Pursue bilateral agreements to establish that GADSS DT installations already approved under EU/EASA would be an Acceptable Means of Compliance (AMC) for 49 U.S.C. 44746(a)(2). The FAA should create guidance material and Acceptable Means of Compliance to support these policies.

INTENT: To harmonize regulations for tamper-resistant distress tracking methods with ICAO GADSS and EU rules for distress tracking and location of end of flight that meet the requirements of 49 U.S.C. 44746.

RATIONALE: Regarding international harmonization, EU laws based on ICAO SARPs are currently in effect, including mandates for aircraft in distress tracking and locating. The applicable references include:

- ICAO Annex 6 Part 1: 6.18 Location of an Aeroplane in Distress,[26]
- EU Regulation 2022/2203,[27]
- CAT.GEN.MPA.210 Location of an aircraft in distress – Aeroplanes Mandate January 1, 2025,[28] and
- Certificate of Airworthiness issued after January 1, 2024.

Although the EU was the first to adopt the distress tracking SARPs and codify them into law, other civil aviation authorities have also adopted or aligned with the ICAO SARPs (e.g. Canada, South Korea, Singapore, Australia, UAE, Qatar, Brazil). Airlines flying into Europe and other airspaces must comply with the ICAO SARPs and existing EU regulations. Practically speaking,

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[25] *See* Appendix B2 for the full working group report on this topic.

[26] ICAO Annex 6, Operation of Aircraft, Part 1.

[27] *Commission Implementing Regulation (EU) 2022/2203 Amending Regulation (EU) No 965/2012 as Regards the Applicability of the Requirements for Locating an Aircraft in Distress* (November 11, 2022).

[28] UK Air Operations Regulation, CAT.GEN.MPA.210 Location of an aircraft in distress – Aeroplanes.

almost all international air transport flights must comply. Throughout this section, these rules will be referred to as GADSS Distress Tracking (GADSS DT).

The development and implementation of the international regulations has taken almost a decade. However, they are now currently in effect. All major aircraft OEMs were part of the standards and regulatory process, and thus, they were prepared for the mandates. The OEMs have already implemented fully compliant solutions for their airline customers to enable them to fly into the EU and adopting countries. The technology architecture utilized is based on a Distress Tracking Emergency Location Transmitter (ELT(DT)) as described in the ARINC 680 Report.[29]

Given the current state of the aviation industry, it seems obvious to consider FAA rulemaking solutions that do not substantially differ from existing solutions developed for ICAO GADSS Distress Tracking and existing EU rules. However, the ARC tasking and the 49 U.S.C. 44746 mandate are not strictly "distress tracking" and only address the location of the end of flight. There are many other details, differences, and subtleties that will need to be discussed to show a path to existing solutions already implemented. This will not only expedite alignment but also result in the lowest cost approach for the OEMs and operators.

It appears that regulations required by 49 U.S.C. 44746 for location of an aircraft can be closely harmonized with the GADSS DT mandates for most air transport operations. The compliant technology and solutions for compliance with GADSS DT are approved and flying today in international airspace. There are, however, many important requirements outlined in international regulations and standards that are not addressed in the Reauthorization Act, the NTSB A-15-001-008 safety recommendation,[30] or the ARC tasking on location of aircraft. These will have to be addressed when assessing the method of compliance when the FAA installations are approved. There are also a number of other requirements in the GADSS DT requirements that are not addressed in 49 U.S.C. 44746, NTSB A-15-001-008, or the ARC tasking on location of aircraft.

Driving towards harmonization with existing international rules on location of an aircraft after crash will be the most expeditious strategy to meet the requirements of 49 U.S.C. 44746.

Aircraft currently compliant with ICAO GADSS and EU rules for distress tracking and location of end of flight are mainly larger aircraft with international destinations operating under part 121 that have extended operation over water.[31] This would have the lowest impact on the airline industry from a cost and timeframe perspective.

For these aircraft, the timeline required by the Reauthorization Act for equipping them (see Recommendation HRT 2.b) is achievable and underway. A first order assessment of cost would

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[29] *ARINC 680: Aircraft Autonomous Distress Tracking (ADT)* (August 26, 2019).

[30] NTSB Safety Recommendation A-15-001-008 (January 22, 2015).

[31] It should be noted that the ARC tasking and 49 U.S.C. 44746 highlight the need to locate the site of an aircraft crash based on the broadcast (i.e. transmission) of sufficient information. This is very similar to, yet not strictly the same as, existing and now implemented international regulations regarding aircraft distress tracking under GADSS.

be minimal for this approach. The cost concerns focus less on the technology/equipage on aircraft, and more of the cost of additional certifications to show compliance with the new requirements. FAA rules that do not substantially differ from existing ICAO/EU rules and acceptable means of compliance can streamline the process.

APPROACH: The ARC recommends that the FAA rulemaking consider methods of compliance and certification of solutions congruent to EASA CS-ACNS Issue 4.[32] These include ELT(DT), ADFR, and High-Rate Tracker (HRT).

It also recommends that the FAA pursue bilateral agreements to establish that GADSS DT installations approved under EASA would be an acceptable means of compliance to meet 49 U.S.C. 44746(a)(2).

Finally, it recommends that the FAA initiate the creation of guidance material and acceptable means of compliance to support these policies.

[32] EASA Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance (CS-ACNS), Issue 4.

Part 121 Exceptions

REC HRT2.b	The FAA should establish exclusions from the ICAO GADSS DT requirements for part 121 operators subject to compliance with 49 U.S.C. 44746(a)(2) and that conduct limited operations overwater and within U.S. airspace.

INTENT: To ensure that aircraft operating in U.S. airspace under part 121 that do not have to meet the ICAO GADSS DT rules do not face unreasonable burdens regarding compliance with 49 U.S.C. 44746(a)(2).

RATIONALE: Aircraft operating in U.S. airspace under part 121, but which do not have to meet the ICAO GADSS DT rules, will have to comply with 49 U.S.C. 44746(a)(2) for extended operations over water.[33] Generally, these are aircraft that do not fly to international destinations and have extended overwater operations (>50 miles). They are readily tracked by secondary surveillance. These aircraft need to be assessed from a safety benefit point of view. However, it appears this population may be relatively small.

This lesser population of extended overwater operation part 121 (and part 135) aircraft that do not have to meet the international rules on distress tracking are usually smaller aircraft and smaller operators, so the cost impact would be greater. Note that this will impact the production of new aircraft in this subset of operation. The FAA would have to assess the size of this population of aircraft and assess the safety consideration of either inclusion or exclusion in rules relating to 49 U.S.C. 44746. A cost analysis would have to be conducted to better assess the safety risks.

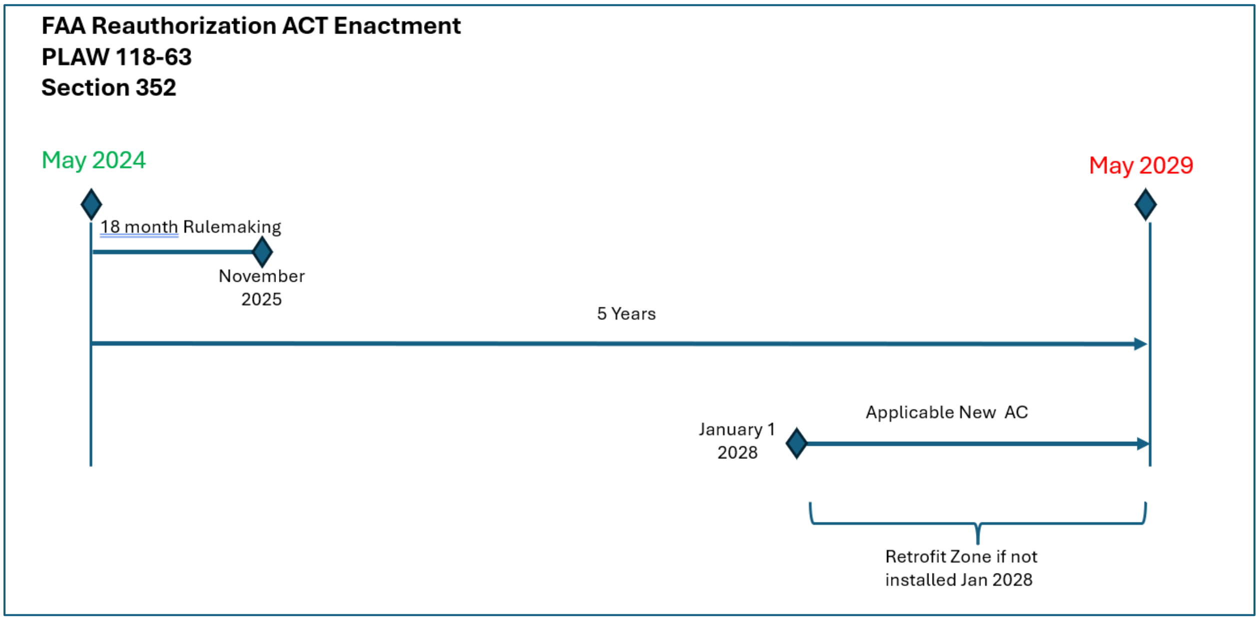
Flights that fly domestically under part 121 and do not engage in extended overwater operations would be exempt from the international GADSS regulations and 49 U.S.C. 44746(a)(2). This applies to domestic airspace along any U.S. oceanic coast or the Great Lakes (<50 miles). These aircraft are readily tracked by primary and secondary surveillance.

Practically speaking, implementing new technology across a fleet of aircraft on a national scale typically will take years. Many examples exist including the ADS-B mandate, which took well over a decade, with years of groundwork prior to the start. The GADSS Distress Tracking mandate took well over a decade to implement and encompassed three extensions of the mandate final data.

[33] 14 CFR Part 1 defines an “Extended over-water operation” generally as, “an operation over water at a horizontal distance of more than 50 nautical miles from the nearest shoreline.” Meanwhile ICAO section 6.5.3 defines “long-range over-water flights” as those “on which the aeroplane may be over water and at more than a distance corresponding to 120 minutes at cruising speed or 400 nm, whichever is lesser, away from land suitable for making an emergency landing.” This report does not take a position on alignment of these definitions.

The current ARC tasking on aircraft location and to comply with 49 U.S.C. 44746(a)(2) will face similar challenges. The timelines for compliance with 49 U.S.C. 44746(a)(2) are shown below. Note, the FAA is required to complete rulemaking by November 2025. The FAA would then prepare publications establishing acceptable means of compliance (AC, MOPS, *et al*), which itself can take years. Even if these existed today, the timeline leaves a little over 2 years for aircraft manufacturers to implement solutions on production aircraft in time for the mandate in January 2028. Production aircraft not meeting this date would have to be retrofit with a compliant solution by the May 2029 deadline for part 121 carriers to be compliant.

Figure 22: Timelines for Compliance With 49 U.S.C. 44746(a)(2)



The mandate leaves only two years for reliable solutions to hit production – an impossible task for new technology. The apparent grace period until May 2029 is a period during which non-compliant production aircraft would have to be retrofit in the field with a compliant solution, resulting in doubling engineering and compliance programs to support forward-fit production and a retrofit program. These timelines support a harmonization strategy with international rules for part 121 aircraft.

APPROACH: The ARC recommends that the FAA assess the size of this population of aircraft and perform a safety assessment for possible exclusion or limited operations overwater. A potential solution may include operational rules to not allow extended overwater operations for this population of aircraft.

b. Part 135 Exclusion

REC HRT2.c	The FAA should not establish distress tracking requirements for part 135 other than to harmonize with ICAO Annex 6, Part I requirements as applicable to part 135 operations outside the United States.

INTENT: To address the ARC tasking to consider part 135 operations.

RATIONALE: Although 49 U.S.C. 44746(a)(2) does not address part 135 operations, the ARC tasking and NTSB recommendations called for consideration of these operations. These aircraft are readily tracked by primary and secondary surveillance.

APPROACH: The ARC recommends that the FAA assess the size of this population of aircraft and perform a safety assessment. With part 135 aircraft being outside of the mandates of 49 U.S.C. 44746, there is ample time for this consideration.

3. Installation of LF-ULD[34]

REC HRT3	The FAA should align regulation with ICAO Annex 6 by amending 14 CFR parts 121 and 135 to require the installation of Low-Frequency Underwater Locating Devices on all aircraft operating on extended overwater routes by using the approach listed below.

INTENT: Install 8.8 kHz Low-Frequency Underwater Locator Devices (LF-ULD) devices on transport category airplanes and retrofit similar installations on airplanes that are used in extended overwater routes.

RATIONALE: Aircraft accidents in deep water (more than 1,000 feet in depth) require significant effort on the part of investigative agencies to locate the wreckage and especially to locate the FDR and CVR. Recent examples of these difficulties contributing to extended search efforts include an Air France A330 accident in the Atlantic Ocean in June 2009 (which was located after a two-year search), and the loss of a Malaysian Airlines B777 in the southern Indian Ocean in March 2014 (which remains missing). Existing regulations in part 25 (namely §§ 25.1457(g)(3)[35] and 25.1459(d)(3)[36]) provide investigators with assistance in locating recorders in the water by requiring the installation of 37.5 kHz High-Frequency Underwater Locator Devices (HF-ULDs) securely attached to each of these two recorders. The performance standards of these HF-ULDs result in a practical maximum detection range of approximately 2 nautical miles or less, when considering the underwater sensors in use by a majority of investigative bodies. Experience has shown that, when searching for an aircraft in water less than 1,000 feet deep, this limits the practical detection range enough that an agency must locate the wreckage to an accuracy of approximately ¾ mile before even being able to identify a useable signal, let alone using that signal to locate where to deploy divers or underwater vehicles to identify wreckage. In water deeper than a few thousand feet, HF-ULD signals may not be detectable at all at the surface. Indeed, both the A330 and B777 accident aircraft included these two HF-ULDs. Deep-water hydrophones were deployed in both cases, but the HF-ULD signals were never identified.

ICAO Annex 6 includes a device that can further help in locating underwater aircraft wreckage, particularly in deeper water. The signals transmitted by an 8.8 kHz LF-ULD penetrate further through water, allowing detectors to identify the signal at ranges approaching 10 nautical miles. After locating the wreckage, the HF-ULDs (which are still installed on the recorders) allow investigators to locate those critical components quickly as well. This can significantly expand the usable range of surface vessels in detecting and locating underwater wreckage and reduce the

[34] *See* Appendix B3 for the full working group report on this topic.

[35] 14 CFR 25.1457(g)(3).

[36] 14 CFR 25.1459(d)(3).

time and cost of performing an underwater search, getting valuable accident data into the hands of investigators (and therefore the industry) even more rapidly. Annex 6 further recommends that the LF-ULD be installed on aircraft engaging in extended overwater flights.[37]

The ARC notes that, in May 2024, the Reauthorization Act amended 49 U.S.C. Section 44746 to require the use of LF-ULDs on part 121 aircraft used in extended overwater operations:

44746 Flight data recovery from overwater operations

a. In General – Not later than 18 months after the date of enactment of this section, the Administrator of the Federal Aviation Administration shall complete a rulemaking proceeding to require that, not later than 5 years after the date of enactment of this section [ARC note: May 16, 2024], all applicable aircraft are –

[….]

   3. Equipped with an airframe low-frequency underwater locating device that functions for at least 90 days and that can be detected by appropriate equipment.

b. Applicable Aircraft Defined – In this section, the term "Applicable Aircraft" means an aircraft manufactured on or after January 1, 2028, that is –

   (1) operated under part 121 of title 14, Code of Federal Regulations;

   (2) required by regulation to have a cockpit voice recorder and a flight data recorder; and

   (3) used in extended overwater operations.

EASA regulation EASA CAT.IDE.A.285 Flight Over Water requires the installation of LF-ULDs on some large aircraft operating on overwater routes, with an exception in place for those that contain equipment related to automated distress tracking.[38]

CAT.IDE.A.285

f. By 1 January 2019 at the latest, aeroplanes with an MCTOM of more than 27,000 kg and with an MOPSC of more than 19 and all aeroplanes with an MCTOM of more than 45,500 kg shall be fitted with a securely attached underwater locating device that operates at a frequency of 8.8 kHz +/- 1 kHz, unless:

[37] 14 CFR Part 1 defines an "Extended over-water operation" generally as, "an operation over water at a horizontal distance of more than 50 nautical miles from the nearest shoreline." Meanwhile ICAO section 6.5.3 defines "long-range over-water flights" as those "on which the aeroplane may be over water and at more than a distance corresponding to 120 minutes at cruising speed or 400 nm, whichever is lesser, away from land suitable for making an emergency landing." This report does not take a position on alignment of these definitions.

[38] EASA CAT.IDE.A.285 Flight Over Water.

1. The aeroplane is operated over routes on which it is at no point a distance of more than 180 NM from the shore; or
2. The aeroplane is equipped with robust and automatic means to accurately determine, following an accident where the aeroplane is severely damaged, the location of the point of end of flight.

Similar LF-ULD requirements are required by Russia, Hong Kong, Singapore, Taiwan, Indonesia, the Republic of Korea, Philippines, Vietnam, the United Arab Emirates, Kuwait, Ethiopia, and Qatar.

While the EASA regulations provide exceptions for airplanes equipped for accurate end-of-flight position finding, the ARC believes that inclusion of LF-ULDs will speed locating of actual wreckage underwater and will speed the recovery of critical perishable evidence in an investigation.

FAA Technical Standard Order TSO-C200a[39] and SAE International Aerospace Standard AS-6254A[40] provide component-level requirements to meet the intent of ICAO Annex 6 and current EASA and other national regulations discussed above. Component manufacturers have developed devices to meet the requirements of TSO-C200a and such devices are installed on newly manufactured aircraft today. Aircraft manufacturers have developed solutions, including retrofit solutions, to perform aircraft-level installations that meet the intent of the annex and the regulations as currently published.

APPROACH: Create a new regulation within 14 CFR Part 121, Subpart K, with language similar to the following:

§ 121.3xx Airframe Underwater Locator Device.

(a) After <date>, no certificate holder may operate an airplane with maximum certificated take-off weight of over 59,525 lbs on routes over water longer than 2 hours at cruising speed or 400 nm, whichever is lesser, without having an approved airframe underwater locating device installed.

(b) The airframe underwater locator device required by paragraph (a) of this section must meet the following application standards:

(1) The airframe underwater locator device must –

(i) meet the standards of TSO-C200a, or later revision,

---

[39] FAA Technical Standard Order TSO-C200a, *Airframe Low Frequency Underwater Locating Device (Acoustic) (Self-Powered)* (May 3, 2016).

[40] SAE International, *Minimum Performance Standard for Low Frequency Underwater Locating Devices (Acoustic) (Self-Powered) AS6254A* (December 12, 2015).

(ii) not be installed in wings or empennage.

Additionally, create a new regulation within 14 CFR Part 135, Subpart C, with language similar to the following:

§ 135.1xx Airframe Underwater Locator Device.

(a) After <date>, no certificate holder may operate an airplane with maximum certificated take-off weight of over 59,525 lbs on routes over water longer than 2 hours at cruising speed or 400 nm, whichever is lesser, without having an approved airframe underwater locating device installed.

(b) The airframe underwater locator device required by paragraph (a) of this section must meet the following application standards:

(1) The airframe underwater locator device must –

(i) meet the standards of TSO-C200a, or later revision,

(ii) not be installed in wings or empennage.

4. New Aircraft Requirements for Timely Recovery of Flight Recorder Data (TRFD)[41]

a. Reduced Data Recovery Time After an Accident

REC HRT4.a	The FAA should establish requirements to reduce the time needed to recover flight data recordings after an overwater accident. These requirements should be harmonized with the standards and recommended practices of ICAO and those States that have adopted ICAO Annex 6 Part I Chapter 6.3.6.

INTENT: To reduce the time to recover the flight data after an accident over water and to harmonize the approach with ICAO.

RATIONALE: Making flight data after an overwater accident[42] available to the accident investigator-in-charge in a way that facilitates quicker access to pertinent information would expedite the overall accident investigation process. It would also allow a quicker identification of possible accident causes, so that there is a better chance of preventing similar accidents in case of systematic technical issues.

Such an approach should be harmonized with international standards laid out in the ICAO annexes. This would enable commonality across all regulators as to airplane configuration and requirements and a common Means of Compliance that allows sufficient time to develop and integrate a robust and safe system into new type certificated aircraft.

APPROACH: To align any upcoming regulation to improve the timely availability of flight data after an accident, the ARC recommends that the FAA adopt rules that do not substantially differ from the ICAO approach defined in ICAO Doc 10165 on timely recovery of flight data.[43]

[41] *See* Appendix B4 for the full working group report on this topic.

[42] 14 CFR Part 1 defines an "Extended over-water operation" generally as, "an operation over water at a horizontal distance of more than 50 nautical miles from the nearest shoreline." Meanwhile ICAO section 6.5.3 defines "long-range over-water flights" as those "on which the aeroplane may be over water and at more than a distance corresponding to 120 minutes at cruising speed or 400 nm, whichever is lesser, away from land suitable for making an emergency landing." This report does not take a position on alignment of these definitions.

[43] ICAO Manual on Global Aeronautical Distress and Safety System (Doc 10165) (2025).

b. Scope of Applicable Aircraft

REC HRT4.b	The FAA should coordinate with industry to seek amendments to 49 U.S.C. 44746 to align U.S. law with ICAO Annex 6, Part I, Chapter 6.3.6, specifically seeking to limit the applicability to applicants for new type certification under part 25 and to be effective 5 years after the FAA's final rule is published.

INTENT: To harmonize the applicability of aircraft types defined in 49 U.S.C. 44746 to those applicable aircraft defined within ICAO Annex 6, Part 1.

RATIONALE: The definition of a 14 CFR Part 25 aircraft offers the closest alignment with the applicability of Annex 6 Part I and Doc 10165.

ICAO SARPs specify airplanes with a Maximum Certificated Takeoff Mass (MCTOM) of 27,000 kg or more and a maximum certified seating capacity exceeding 19 passengers.

APPROACH: To align any upcoming regulation to improve the timely availability of flight data after an accident, the ARC recommends that the FAA adopt rules that do not substantially differ from the ICAO approach defined in ICAO Doc 10165 on timely recovery of flight data.

Current industry planning is primarily focused on the new type certification (TC) approach, meaning readily available solutions are not yet widespread. All potential solutions currently under research are aimed at integration into larger transport category airframes. Smaller aircraft operating under part 121 or part 135 have not fallen systematically within the scope of these efforts due to the absence of a mandate. These smaller aircraft may require dedicated solutions more suitable for their airframe size.

c. Flight Data Parameters to Be Recorded

REC HRT4.c	The FAA should require that the flight data parameters to be recorded meet the ranges, accuracies, resolutions, and recording intervals specified in Appendix M of 14 CFR Part 121. This data can be sourced from the flight data recorder (FDR) stream or any other available aircraft source that provides the necessary information.

INTENT: To clarify the flight data parameters to be recorded, independent of the recording architecture used.

RATIONALE: To ensure a performance-based approach, the ARC concluded that the data characteristics outlined in 14 CFR Part 121 Appendix M[44] represent the minimum required recording performance for parametric flight data. This level of data quality is achievable using any suitable onboard aircraft data source.

APPROACH: 14 CFR Part 121 Appendix M should be the common reference for any kind of mandatory flight data recording device.

[44] 14 CFR Part 121 Appendix M.

d. Integration of Performance Requirements for Flight Data Transmissions and Deployable Recorders Into Part 25 Regulatory Environment

REC HRT4.d	The FAA should amend the part 25 airworthiness standards regarding minimum performance requirements for deployable recorders and the integration of the recorder to: • Establish minimum performance requirements for wireless transmission services. • Establish data retention, data access authority, and data privacy protections.

INTENT: The regulator needs to define the requirements for acceptable means of compliance.

RATIONALE: The ARC identified the necessity of complementing aircraft equipment requirements with associated regulations to ensure the proper integration of such solutions. Furthermore, a regulatory framework is needed to ensure the authenticity, integrity, and consistency of the data. This also includes timely access for an Accident Investigation Authority (AIA) to the data.

Regarding installation aspects, the coming regulation should recognize a deployable recorder in combination with a fixed combination recorder as a suitable means to fulfill the part 25 flight recording requirements.

APPROACH: The ARC recommends that the FAA start corresponding rulemaking activities.

e. Extending Timeline for TRFD Mandate

REC HRT4.e	The FAA should coordinate with industry to seek amendments to 49 U.S.C. 44746 to provide sufficient time to develop the necessary technical standards to support implementation of timely recovery of flight data (TRFD) for newly certified aircraft in a practical and cost-effective manner. Based on its estimation of the time required, the ARC recommends the mandate for TRFD to be no earlier than December 31, 2036.

INTENT: To allow regulators the time to define acceptable means of compliance and related legal requirements, and to allow equipment manufacturers, aircraft integrators, and operators sufficient time to perform due diligence to ensure a safe, robust, and mature implementation

RATIONALE: Based on previous experiences with similar changes, such as TCAS, ADS-B, or distress tracking, the ARC must make assumptions regarding the time for the required rulemaking to take place, the following development of the related systems and the corresponding integration, and the development of the associated maintenance. Training and operational procedures require a similar amount of time to the above-mentioned systems/mandates. This translates into a timeframe of approximately 10 years from the time MASPS/MOPS are published. At this time, MASPS/MOPS are not expected from ICAO Working Group 118 Sub-Group 4 until the fourth quarter of 2026. The Reauthorization Act timeline will drive industry to a one-technology solution (ADFR) to meet the mandate.

APPROACH: The ARC identified two options:

a. Allow more time, in line with the above-stated experiences, for newly manufactured aircraft and their operators to become compliant, or
b. Change the rule’s applicability from newly manufactured aircraft to newly designed aircraft, which would also harmonize with ICAO.

5. CIRs[45]

a. CIR Harmonization

REC HRT5.a	The ARC does not support an FAA requirement for class C-AIR or AIRS (Airborne Image Recorders) for part 121 or part 135 operations in the United States.

INTENT: To harmonize with other investigative authorities regarding CIRs.

RATIONALE: Guidance for FDRs and aircraft data recording systems is provided under ICAO Annex 6, Part I, Section 6.3.1:

> **6.3.1.1** All turbine-engined aeroplanes of a maximum certificated take-off mass of 5,700 kg or less for which the application for type certification is submitted to a Contracting State on or after 1 January 2016 shall be equipped with:
>
> a. An FDR [Flight Data Recorder] which shall record at least the first 16 parameters listed in Table A8-1 of Appendix 8; or
>
> b. A class C AIR [Airborne Image Recorder] or AIRS [Airborne Image Recording System] which shall record at least the flight path and speed parameters displayed to the pilot(s), as defined in 2.2.3 of Appendix 8; or
>
> c. An ADRS [Aircraft Data Recording System] which shall record at least the first 7 parameters listed in Table A8-3 of Appendix 8.

ICAO further defines required inspection intervals for both AIR and AIRS methods that are consistent with current FDR installations, as outlined in ICAO Annex 6, Part I, Appendix 8, section 7.2 "Inspections of Flight Recorder Systems":

> **7.2** FDR systems or ADRS, CVR systems or CARS, and AIR systems or AIRS shall have recording inspection intervals of one year; subject to the approval from the appropriate regulatory authority, this period may be extended to two years provided these systems have demonstrated a high integrity of serviceability and self-monitoring. [...]

The Reauthorization Act does not include a section relating to installation of CIRs.

APPROACH: The ARC does not recommend harmonization with ICAO Annex 6 Part I Section 6.2.1.1 due to the lack of legal protections to protect images from being misused. Public disclosure of CVR audio recordings demonstrates the limitations of the data protection provisions prescribed by ICAO Annex 13. Examples include American Airlines 965, GOL 1907,

[45] *See* Appendix B5 for the full working group report on this topic.

Delta 1187, and Germanwings 9525, where audio recordings were leaked to media and in the public domain. The public's desire for sensational audio and video recordings is a clear risk to the protection of safety data; current regulations offer few protections for the exploitation of accident recordings or video footage.

The ARC supports flight crew machine interface recorder (FCMIR) screen capture technology and additional flight data recorder parameters (in lieu of CIRs). This system supports investigators by recording what is being displayed to the pilots as well as the activation of switches/buttons on the flight deck in accordance with ICAO Annex 6 Part I 6.3.4 and ED-112B on newly built aircraft. Additional flight data recorder parameters on new aircraft types (Airbus A390, Boeing 797, etc.) would provide objective information to flight safety investigators. Examples of additional flight data parameters would include flight management system inputs, higher resolution flight control inputs, etc.

b. Privacy and Data Misuse Concerns

REC HRT5.b	The FAA should establish protections for crew privacy, for release of personally identifiable information (PII), and against data misuse as part of any rulemaking or policy that could enable the introduction of CIR.

INTENT: To protect the privacy of crew members and passengers captured in CIR images and ensure the potential privacy and data misuse effects of this technology are accounted for when making any determination regarding the introduction of new requirements on CIR technology.

RATIONALE: The ARC recognizes the investigative value of CIRs when those recordings supplement several other available data sources to the investigation. Although purpose-built CIRs have not been widely installed in flight decks, there are examples of accident and incident reports where video from a flight deck during the accident sequence proved valuable. The ARC, however, acknowledges there is a lack of regulatory protections and technology to recommend the installation of CIRs at this time.

History has shown that it is extremely difficult to safeguard the privacy of cockpit voice recordings. The same challenge will undoubtedly be true for cockpit image recorders. When cockpit voice recorders were originally installed, it was accompanied by assurances of protection for this safety data. Those guarantees are no longer in place as evidenced by the examples cited above. Given the significant safety data protection related concerns, it is questionable that the costs and protection of the safety data issues outweigh any purported benefits.

This ARC is chartered with the limitation that it can only submit recommendations to the FAA. The FAA has limited authority, which is to regulate operations in the United States and its territories. Many of the carriers affected by the recommendations of this ARC operate outside of the U.S. on a regular basis and thus would be subject to other countries' rules and regulations pertaining to safety data protection in the event of an incident or accident. The FAA must consider how CIRs would be handled for any events outside of the United States. Operators and pilot unions have voiced concerns that not all countries they operate in and out of have a positive safety culture and respect for the protection of this type of safety data. These aircraft will operate in and out of countries with varying degrees of safety cultures, and legal ramifications for aircraft incidents and accidents. This type of video could be easily used to prosecute crew members and operators for any perceived wrongdoing, or it could be released publicly.

The concept of CIRs has also long involved concerns from pilots and aircraft operators, with one of the main concerns being the potential for intrusions on personal privacy of flight deck occupants. Employers, regulators, and other entities that are granted access to flight deck video data may attempt to use this data to pursue punitive or employment actions against flight crews that were not even involved in accidents and incidents. In addition, flight deck video downloaded for any purpose (safety, investigative, or otherwise) runs the risk of being purposely or inadvertently released to the public. Both possibilities would represent grave violations of the just and non-punitive safety culture on which the aviation industry heavily depends.

Public disclosure of CVR audio recordings demonstrates the limitations of the data protection provisions prescribed by ICAO Annex 13. Examples include American Airlines Flight 965, GOL Flight 1907, and Germanwings Flight 9525, where audio recordings were leaked to media and in the public domain. The public's desire for sensational audio and video recordings is a clear risk to the protection of safety data; current regulations offer few protections for the exploitation of accident recordings or video footage.

The United Kingdom's Civil Aviation Authority (CAA) conducted a research project considering the effectiveness of image recorder systems in accident investigations. Researchers involved in the resulting CAA CAP 762 study concluded that image recording systems can provide additional information that would assist in accident investigation. However, according to the report, "the extent of the benefits provided and whether they can be justified in relation to the cost (in both financial and personal privacy terms) will need to be the subject of further research and a carefully prepared regulatory impact assessment."[46]

APPROACH: The ARC recommends that the FAA address these privacy concerns, as described in IX.A. Privacy and Data Misuse, prior to implementing requirements for any CIR technology. The ARC also recommends that the FAA take the potential costs associated with these privacy concerns into account when determining whether to introduce such requirements. Before the FAA implements CIRs, the ARC supports a more cost-effective means of capturing screen data. The ARC also recommends for the FAA to consider FCMIR technology per ICAO Annex 6 Part 1 6.3.4 and ED-112B for newly built aircraft.

If the FAA were to require CIRs to be installed on flight decks, the ARC recommends following some of the CAA CAP 762 recommendations that are still valid today:

- No rear facing cameras.
- No explicitly identifying views of crew members.
- Interpretation of image recorder data must only be performed by those specifically trained in analyzing image recordings.

The ARC also recommends conducting cost-benefit analysis for any new CIR requirements.

The ARC additionally recommends that the FAA consider that the investigators who may be viewing these videos multiple times potentially face trauma, leading to stress and potential post-traumatic stress disorder for the investigator. Consideration should be given to the merits of exposure to these videos and the health of the investigator.

[46] UK Civil Aviation Authority, *CAP 762: The Effectiveness of Image Recorder Systems in Accident Investigations*, ch. 9, p. 1 (November 10, 2006).

The ARC further recommends that the FAA consider how the video, if installed, would be handled for any events outside of the United States.

c. CIR Installation Issues

REC HRT5.c	The FAA should consider the issues identified with installing image recorders as captured in the United Kingdom Civil Aviation Administration (CAA) CAP 762: The Effectiveness of Image Recorder Systems in Accident Investigations as part of any rulemaking that could mandate CIR in the U.S. fleet. As an example, the ARC asks the FAA to note key areas of concern identified by the UK CAA such as: • The location, specifications, and number of forward-facing cameras required. Research has indicated drawbacks to rearward-facing cameras without a benefit in observing crew behavior. • The perception of having faces and facial expressions recorded as being personally intrusive. Monitoring people while they perform complex tasks has been shown to have a negative effect on their ability to perform those tasks. • While image recording systems gather large amounts of data, any single source of data can be misleading and its use should be corroborated with all sources of evidence.

INTENT: To ensure that any CIR requirements take into account issues identified by CAA CAP 762 regarding installation of image recorders on aircraft.

RATIONALE: CAA CAP 762 identified issues associated with installing image recorders on aircraft. One challenge identified was that: "the layout of an aircraft flight deck varies based on several factors, the most significant of which are the aircraft type, the type of variant and the individual modifications made by the operator of the aircraft. The effect of this is that there are many possible flight deck layouts, which makes it very difficult to provide a definitive assessment of where image recorders could be installed on all aircraft being operated."[47]

The same study found that the ability to install image recorder systems on aircraft depends on the following:

- The number of cameras required.
- The available space on the flight deck (i.e. overhead panel).
- The space and weight implications of an additional recorder, or the cost implications of a combined recorder.

Additionally, according to the CAA CAP 762 report, the following issues should be considered:

[47] UK Civil Aviation Authority, Cap 762, at ch. 7, p. 2.

- The cameras will need to be removable to facilitate maintenance but, once in place, they should be fixed to prevent anyone altering their viewing angle.
- A means of demonstrating that the system is functioning correctly (self-monitoring) and that the cameras are recording appropriate images of the flight deck will be required.
- The design will need to address all issues associated with adding a further recording system (plus cameras) to the essential bus.[48]

APPROACH: The FAA should ensure that it takes these issues into account when introducing any CIR requirements.

[48] *Id.* at ch. 7, p. 3.

Cost and Benefits Analysis

A system to record video or images on a flight deck would likely have to consist of more than one camera, possibly five or six cameras. The CIRs will need to comply with crash and fire resistance requirements, and a stabilization function needs to be developed. The CIRs need independent power supplies like the requirements of currently installed CVR and FDR systems. With the current FAA requirement of 25-hour CVRs, CIRs would need to have the same recording duration. Video recordings require considerably more memory for data retention than audio.

When installing cameras on the flight deck, there are several different options as to how and what could be recorded. A standard for video recording would need to be established. There are currently no TSO-176a certified video recorders being manufactured. A CIR system would need to be developed for each individual aircraft flight deck, as the design and layout and mounting locations differ between each aircraft type. Cost impacts are currently unknown regarding the pricing for TSO-C176a certified recorders is going to cost and the amount of downtime needed for retrofitting of aircraft. Additionally, for older aircraft, it is unclear whether an independent power source would be available in the flight deck. Most newer aircraft have independent power sources available in the cockpit, but older aircraft may not. In addition to installation costs (equipment, downtime for the installation, and labor costs), operators would be impacted with additional periodic inspection and maintenance of any newly certificated and installed hardware. Data protection, storage, and encryption costs are unknown at this time, but would be considerable due to the sheer amount of data to be stored. As with most other aircraft parts, CIRs would have to be replaced periodically for maintenance or overhaul reasons. Any subsequent changes to regulations may require overhaul of complex aircraft systems, including aircraft wiring and other hardware.

The installation of CIR systems will increase the aircraft’s weight. Besides the camera itself, the weight of wiring and the crash and fire-resistant housing for the camera will need to be taken into consideration. It is currently not known how much weight is added; this needs to be evaluated and included in the overall cost analysis.

d. Specialized Training Regarding CIR Data

REC HRT5.d	The NTSB, in collaboration with key stakeholders including FAA, labor, image recorder manufacturers, and aircraft manufacturers, should develop a set of best practices for use and review of CIR recordings. Recommendations on this type of training should be considered from the United Kingdom Civil Aviation Administration (CAA) CAP 762: The Effectiveness of Image Recorder Systems in Accident Investigations study, which noted that image data can be easily misinterpreted, particularly if it is analyzed in isolation. Because image data is also very compelling, it can be difficult to realize that a misinterpretation has occurred. Evidence from image recorders must be corroborated with other sources of data, such as other flight recordings and engineering evidence.

INTENT: To ensure that accident investigators and videographers properly analyze and interpret CIR image data.

RATIONALE: The CAA CAP 762 study showed that accident investigators need specialized training on analysis and interpretation of CIR image data. The ARC recognizes that CIR video would be subjective if not reviewed by a well-trained forensic videographer. There are certain issues where video can mislead an investigator who is not trained to view the video footage appropriately. For example, the video cannot tell if the crew are pushing on a rudder pedal or if the rudder pedal is moving on its own and the crewmember's foot is following the pedal. The ARC recommends that industry/labor and the NTSB develop training standards for videographers who would be forensically examining the data.

APPROACH: The ARC recommends that only investigators specifically trained in this discipline provide analysis and interpretation of image data. The training should be jointly developed by accident investigators, pilot associations, and dedicated human factors specialists. Upon completion of this accredited training, investigators will be credentialed to interpret image data.

At a minimum, this recommended training should address the following issues:

- The benefits and disadvantages of image recorders.
- Image recorders cannot be used as a single source of information.
- Limitations of image recorder technology.
- The need for extensive knowledge of flight deck layout.
- The need for extensive knowledge of aircraft systems and operations.
- The need for knowledge of crew background.
- The need for a detailed understanding of human factors analysis.

Quality standards for images would also need to be established, along with a standard for what should be recorded. These standards should explore issues such as what parameters these recorders should capture, how many parameters would be captured, and how to detect smoke in the flight deck.[49]

[49] *Id.*, at ch. 9, p. 2.

6. Systems and Processes Enhancing the Safety of Part 135 Operations[50]

a. Leveraging of Systems and Processes Under Existing Provisions

REC HRT6.a	The FAA should promote and regulate the adoption of systems and processes (e.g., FDM) that enhance the safety of aviation operations conducted under part 135 and § 91.147 in such a manner that systems and processes (e.g., SMS) required under existing provisions can be leveraged.

INTENT: To help prevent accidents and incidents involving part 135 operations through the adoption of flight operational quality assurance (FOQA) programs.

RATIONALE: Following the observation of certain commonalities in accidents occurring in operations under part 135, the NTSB recommended to the FAA in 2016 to consider mandating the implementation of a structured FDM program for such operators, along with the installation of suitable flight recording systems. The NTSB reiterated and further substantiated this recommendation in Special Investigation Report: Safety and Industry Data Improvements for Part 135 Operations, published on July 24, 2024.[51]

Meanwhile, on April 26, 2024, the FAA issued a final rule that updates requirements for safety management systems specified in part 5, while also extending the applicability of part 5 to additional certificate holders.[52] The rule affects commuter and on-demand operators who operate under part 135, commercial air tour operators operating under § 91.147, and certain production certificate holders operating under part 21. However, it stops short of mandating an FDM or flight recording systems for such operators.

The FAA final rule is intended to enhance aviation safety in business and general aviation by mandating the implementation of safety management systems across a broader range of aviation organizations. The rule emphasizes proactive safety management and aligns U.S. regulations with international standards, notably ICAO Annex 19 (Safety Management). The effective date for compliance began on May 28, 2024, with full implementation required within 36 months.

In Report AIR-24-03, the NTSB recommends that business and general aviation operators operating under part 135 establish a structured FDM program and install recording devices capable of supporting it. The implementation of an FDM program is seen as crucial for providing operators with objective data about how flights are conducted, which helps to detect and correct unsafe deviations from standard operating procedures before accidents occur. This

[50] *See* Appendix B6 for the full working group report on this topic.

[51] NTSB Aviation Investigation Report AIR-24-03, *Special Investigation Report: Safety and Industry Data Improvements for Part 135 Operations* (July 24, 2024).

[52] "Safety Management Systems Final Rule," 89 FR 33068, April 26, 2024.

recommendation aims to enhance safety by allowing operators to proactively manage risks based on actual flight data, potentially preventing future accidents. FDM and related FOQA programs, therefore, directly support and are often integrated with safety management systems (SMS).

The FAA received varied feedback from stakeholders on its proposed rule, including support for the expanded applicability of SMS due to its demonstrated contribution to increased aviation safety, but also concerns about the burden on small operators. The FAA amended the requirements based on comments, such as excluding foreign TC holders from certain requirements and providing exceptions for single-pilot operations. Whether to also require part 135 operators to install flight data recording devices capable of supporting a structured flight data monitoring program is therefore tied, *inter alia*, to how closely the government intends to steer compliance with the SMS mandate as specified in part 5.

In the context of an SMS, FDM programs typically serve the purpose of identifying deviations from established norms and procedures. To integrate an FDM program into an SMS is therefore a strategic decision that drives how such programs are set up. It also requires a means to systematically acquire and analyze that data, increasing the barrier to entry in terms of investment and direct and indirect operating expenses.

To assess the benefits and burdens on part 135 operators, it is therefore prudent to understand the basic requirements of integrating an FDM program into an SMS. FDM is a proactive and non-punitive program aimed at improving flight safety through the routine collection and systematic analysis of data recorded during flight operations. For part 135 operators, integrating FDM into an SMS enhances safety by systematically identifying and mitigating many of the factors that the NTSB has identified as primary causes of part 135 accidents.

Integrating an FDM program into an SMS is a strategic approach to enhancing flight safety. It incurs the burdens of systematic data collection, analysis, risk assessment, and continuous improvement processes that align with the proactive safety management principles of an SMS. In return, operators can achieve higher safety performance and foster a robust safety culture.

By fully leveraging a sophisticated FDM, operators can achieve much greater operational safety. This has long-term business benefits, including increased revenue resulting from a better reputation, lower insurance premiums, and higher equipment availability (where paired with a proactive maintenance regime). Additionally, FDM programs can be used to improve overall operational efficiencies, improving performance and lowering operating expenses elsewhere.

However, the expense can be considerable. In particular, operators of older aircraft in remote areas may find that the technical requirements associated with the systematic recording of flight data can result in a cost barrier. This risks of forcing these operators out of business in areas where substantial parts of the infrastructure and local communities often rely on part 135 operations as the sole means of transportation, including access to market for local businesses and receiving supplies.

The burdens of an FDM can be broadly categorized into financial costs, operational challenges, and administrative complexities. Understanding these burdens is essential for legislators considering whether to mandate implementation of an FDM in addition to that of a SMS.[53]

While FDM systems enhance safety and operational efficiency, they also impose substantial burdens on part 135 operators. These burdens include significant financial costs, operational challenges related to data management and system integration, and complex administrative requirements for regulatory compliance and effective safety management. For many operators, particularly smaller ones and those operating older aircraft in remote territories, such as Alaska, these burdens can be a barrier to implementing FDM systems despite their potential benefits. Balancing these burdens with the safety advantages of FDM is critical for legislators to consider when mandating operators to integrate FDM hardware and processes into their SMS.

For smaller operators, the cost of purchasing and installing ED-155 compliant systems could be a significant financial burden. Initial conversations with equipment vendors and Maintenance, Repair, and Overhaul (MRO) providers revealed that equipment costs generally fall between $10,000 and $25,000, depending on complexity, data capacity, and optional configurations. Certification and installation are expected to add a further $10,000 to $50,000, again depending on complexity. Ongoing maintenance adds recurring costs, and the combined costs might not be justifiable for small and medium sized businesses, or private owner/operators, based on the scale of their operations.

APPROACH: The ARC recommends that Congress and the FAA allow systems and processes that enhance the safety of aviation operations conducted under the provisions of part 135 and § 91.147 to integrate with the already existing SMS mandate, as opposed to separate rulemaking and separate systems, to reduce the economic and operational burden associated with their adoption. Recommendations HRT6.b through HRT6.g provide different ways of meeting this goal. Furthermore, the ARC recommends FAA change 14 CFR part 193 to include relevant FDM programs to provide the data protections of FOQA, as outlined in Recommendation RTR3.

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[53] *See* Appendix B6: Systems and Processes Enhancing the Safety of Part 135 Operations for more details on cost-benefit analysis.

b. Tailoring of FDM Programs and Systems

REC HRT6.b	The FAA should allow tailoring of FDM programs and systems to fleet size and operational circumstances following the SMS mandate example.

INTENT: To increase adoption rates and minimize unfair disadvantage to certain operators.

RATIONALE: See Rationale section of Recommendation HRT6.a for discussion of the need for systems and processes that enhance the safety of aviation operations carried out under the provisions of part 135 and § 91.147 to integrate with the already existing SMS mandate, as opposed to separate rulemaking and separate systems, so as to reduce the economic and operational burden associated with their adoption.

Allowing the tailoring of FDM programs and systems to fleet size and operational circumstances would allow for more flexibility in adopting FDM programs that work for a given operator's needs. These programs depend on a reliable means of acquiring accurate flight data. The FAA could specify acceptable means of compliance through specific performance requirements to account for the variability in FDM data acquisition. Older aircraft may only be able to provide limited data sets without significant upgrades while newer aircraft might leverage advanced avionics to provide data. There is also the potential to use flight recorders installed either voluntarily or by mandate as a data source for FDM, such as light weight recorders specified by TSO-C197 based on ED-155 requirements. The number of aircraft or size of the operation may also limit the viability of adopting an FDM.

APPROACH: The FAA should follow the SMS mandate example in allowing the tailoring of FDM programs and systems to fleet size and operational circumstances.

c. Defining Minimum System Performance Specifications

REC HRT6.c	The FAA should take the type of aircraft into account when defining minimum system performance specifications.

INTENT: To protect operators of aircraft that cannot reasonably be upgraded with common data acquisition systems.

RATIONALE: See Rationale section of Recommendation HRT6.a for discussion of the need for systems and processes that enhance the safety of aviation operations carried out under the provisions of part 135 and § 91.147 to integrate with the already existing SMS mandate, as opposed to separate rulemaking and separate systems, so as to reduce the economic and operational burden associated with their adoption.

Providing certain types of aircraft with the flexibility to use data acquisition systems that are feasible for them rather being bound by one-size-fits-all system performance specifications would help reduce the burdens of FDM adoption for older or smaller aircraft.

APPROACH: The FAA should take type of aircraft into account when defining minimum system performance specifications. For example, smaller aircraft may be allowed to fit ED-155A compliant recorders or to use non-standard ultralight recording systems. Aircraft below a certain size and risk category, and older types not fitted with flight data acquisition systems, may be allowed to use mobile or handheld equipment (such as tablets and other smart devices commonly used by pilots as electronic flight bags) to record flight data from an aircraft-independent source (such as built-in GNSS receivers and accelerometers) to record data for the purpose of FDM.

d. Transmission of Flight Data Using Cellphone or Satellite Services

REC HRT6.d	The FAA should allow the transmission of flight data from an airborne aircraft using public cellphone or mobile satellite services.

INTENT: To allow smaller operators with simpler IT systems and older fleets to stand up an improved FDM-backed SMS.

RATIONALE: See Rationale section of Recommendation HRT6.a for discussion of the need for systems and processes that enhance the safety of aviation operations carried out under the provisions of part 135 and § 91.147 to integrate with the already existing SMS mandate, as opposed to separate rulemaking and separate systems, so as to reduce the economic and operational burden associated with their adoption.

By allowing transmission of flight data using cellphone or satellite services, smaller operators that are not capable of implementing the IT infrastructure available to larger organizations for their data recovery and management can subscribe to an online FDM service to meet their compliance needs.

For example, a smart tablet or smartphone can send location, speed, accelerations, audio data, possibly flight data acquired through a USB or Bluetooth interface from a glass cockpit panel, and mission-related data from a flight planning app to a cloud-based (virtual) flight recording service. While less sophisticated than dedicated systems used in part 121 operations, such a simple system may even enable operators of older single-engine piston aircraft to stand up an FDM-backed FOQA and SMS program relatively inexpensively.

APPROACH: The FAA should take appropriate steps to allow the transmission of flight data from an airborne aircraft using public cellphone or mobile satellite services.

e. Existing Lightweight Recorders

REC HRT6.e	The FAA should consider existing lightweight recorders, such as ED-155 compliant recorders, as satisfying a potential mandate where able.

INTENT: To allow smaller operators to comply with a potential mandate using existing technologies.

RATIONALE: See Rationale section of Recommendation HRT6.a for discussion of the need for systems and processes that enhance the safety of aviation operations carried out under the provisions of part 135 and § 91.147 to integrate with the already existing SMS mandate, as opposed to separate rulemaking and separate systems, so as to reduce the economic and operational burden associated with their adoption.

Allowing smaller operators to use existing technologies would reduce costs and efforts associated with compliance under a potential mandate. See also Rationale section for Recommendation HRT8.a.

APPROACH: The FAA should establish policies that allow existing lightweight recorders to satisfy a potential mandate when appropriate.

f. Make FDM Voluntary Addition

REC HRT6.f	The FAA should clarify that an operator establishing a Flight Data Monitoring (FDM) or Flight Operational Quality Assurance (FOQA) program as part of their SMS is establishing the program as a voluntary and additional function that is not required to show compliance with the part 5 SMS requirements.

INTENT: To avoid burdens from an FDM mandate while encouraging operators to use FDM.

RATIONALE: See Rationale section of Recommendation HRT6.a for discussion of the need for systems and processes that enhance the safety of aviation operations carried out under the provisions of part 135 and § 91.147 to integrate with the already existing SMS mandate, as opposed to separate rulemaking and separate systems, so as to reduce the economic and operational burden associated with their adoption.

Given these burdens, offering incentives for compliance would be an effective way to encourage safety gains from widespread FDM use among part 135 operators. These programs are voluntary by nature, proven effective and considered an important part of a robust Safety Management System. The recent mandate of SMS for Part 135 operations should be seen as an opportunity to incorporate FDM from the beginning. Consideration should be given to reducing the scope of traditional FOQA programs found in Part 121 to the appropriate scale of the operation but retaining the protections its voluntary use provides. There is a wide variation in types of Part 135 operations, as such solutions need to be found to accommodate smaller operations choosing to enact FDM. Rotorcraft has faced similar challenges and may offer solutions in ways to reduce the number of people required or simplify the recovery and analysis of data. While not a required component of SMS, an FDM program has proven benefits, its adoption should be voluntary and encouraged.

APPROACH: The FAA should consider incentives for operators to voluntarily include an FDM program as a part of their overall SMS, including tax breaks, extending deadlines, or supporting installations with cash incentives, following the ADS-B equipage example. To help general aviation operators adopt ADS-B out capabilities, the FAA offered up to $500 in financial assistance.

g. Reducing Administrative Burdens

REC HRT6.g	The FAA should establish criteria based on the levels of complexity for equipping flight data acquisition hardware to promote the use of FDM programs. By defining the level of complexity or interaction that would require approvals, such as those done by DER/ODA, the process of installing recorders for FDM could be simplified.

INTENT: To encourage operators to use FDM by simplifying the installation of flight data acquisition units when appropriate.

RATIONALE: See Rationale section of Recommendation HRT6.a for discussion of the need for systems and processes that enhance the safety of aviation operations conducted under the provisions of part 135 and § 91.147 to integrate with the already existing SMS mandate, as opposed to separate rulemaking and separate systems, so as to reduce the economic and operational burden associated with their adoption.

Given the regulatory complexities of installing and maintaining equipment on an aircraft, a set of standards allowing installation of simple units and clarifying when approval should be required by DER/ODA or specific STC would ease the burden on installing FDM recorders. It may not be practical for the manufacturer of a lightweight recorder to attain STCs for all aircraft types. While larger, more complex aircraft may require recorders to interact with intricate sensors or data buses, lightweight recorders on less complex aircraft should be able to be installed with minimal complication. By clarifying criteria as to when DER/ODA approval is required and promoting simple installations of flight data acquisition units, the FAA can help make it easier, more efficient, and less costly to modify aircraft to adopt FDM systems.

APPROACH: The FAA should set criteria allowing the installation of simple flight data acquisition units while clearly define when an installation is complex enough to require DER/ODA analysis.

7. 25-Hour CVRs[54]

a. Revisions to Existing TSO and Advisory Circular

REC HRT7.a	If the FAA adopts ED-112B into TSO-C123d, it should allow TSO-C123c (ED-112A) or later within any revision to regulation and AC 20-186A until after compliance with section 366.

INTENT: To ensure that existing ED-112A cockpit voice recorders can be used to meet the 25-hour CVR mandate.

RATIONALE: Today, TSO C123c[55] and AC 20-186A,[56] along with other guidance materials, specifically reference EUROCAE document ED-112A. The EUROCAE document covers a wide range of flight recorder technology that may be applicable under parts of the Reauthorization Act (section 366 and 49 U.S.C. 44746). Although EUROCAE released ED-112B in August 2023, ICAO has not yet adopted the intent of ED-112B and no cockpit voice recorder has been developed and certified to this industry standard.

APPROACH: If the FAA adopts ED-112B into TSO-C123d, the ARC recommends that any revision to regulation or AC 20-186A allow TSO-C123c or later revision. AC 20-186A allows for "TSO-C123c…or later revision." The ARC recommends against specifying "TSO-C123d or later revision" until after compliance with section 366. This approach is consistent with section 366, which specifies "TSO-C123c, or any later revision," and allows existing cockpit voice recorders to ED-112A along with the next generation cockpit voice recorders to ED-112B to be used to meet the 25-hour CVR mandate.

[54] *See* Appendix B7 for the full working group report on this topic.

[55] FAA Technical Standard Order TSO-C123c, *Cockpit Voice Recorder Equipment*, (December 19, 2013).

[56] *Airworthiness and Operational Approval of Cockpit Voice Recorder Systems*.

b. Reducing Burden of 25-Hour CVR Retrofit Installation

REC HRT7.b	If the FAA adopts a regulation to retrofit 25-hour CVR, it should consider measures to reduce the significant impact on operators, design approval holders (DAHs), and OEMs. These measures should include exceptions based on the extensive modifications required to support specifications of the new recorders, consider the remaining useful lifespan of the aircraft, and incorporate realistic compliance dates.

INTENT: To allow for a desire to introduce a 25-hour CVR retrofit requirement while minimizing extra costs and burdens faced by operators, DAHs, and OEMs.

RATIONALE: With the recent publications of ED-112A and AC 20-186A, certification of retrofit installation of CVR with 25-hour duration may not be as simple as removing the existing CVR with 2-hour duration and replacing it with a new CVR with 25-hour duration. This is particularly the case for airplane models that are out of production or nearing the end of life. Since the April 7, 2008, changes to 14 CFR 121.359 requiring aircraft manufactured before April 7, 2010, to be equipped with 2-hour CVR, there have been changes to battery technology, changes in cockpit safety systems (e.g., O2 masks with smoke goggles), and changes in standards and means of compliance for CVRs and associated installations that older models of aircraft were not certified to. These changes include:

- The use of Non-Rechargeable Lithium Batteries (NRLB) in aircraft must be shown compliant to FAA special conditions starting in 2016.
- The addition of O2 face mask or smoke goggles systems interfacing with the radio communications systems.
- The cancellation of older CVR guidance materials, such as AC 25.1457, and the addition of new minimum operational performance specification (MOPS) for CVRs after the last CVR regulatory mandate in 2008.

These changes can impact the ability of operators with older aircraft to source replacement equipment for obsolete or end of life systems, obtain FAA approved data to install the necessary equipment to meet current MOPS for a CVR installation in a timely manner, and can potential add additional cost burdens beyond the cost of the CVR to be in compliance with section 366.

Below are items of consideration for older aircraft types that may increase the time and cost of retrofitting to a 25-hour CVR.

Additional rationale for this recommendation includes harmonization with international standards, impacts of retrofitting, cost benefit analysis, and other supporting research – each detailed below.

Harmonization With International Standards and Regulations

Numerous State civil aviation agencies[57] are known to have adopted the intent of the ICAO standard for newly manufactured airplanes with certificated maximum takeoff mass of greater than 27,000 kg for CVR with 25-hour duration requirement into regulation, with varying applicability dates.

The 25-hour Cockpit Voice Recorder (CVR) Requirement, New Aircraft Production NPRM (hereafter referred to as NPRM FAA-2023-2270) noted that the proposed 25-hour retrofit change would provide an opportunity to ensure U.S. regulations are consistent in intent with international authorities, leading to less risk for operators facing conflicting requirements. It also noted that forward fitting 25-hour CVRs to comply with the proposed role would likely incur only incremental costs: “Based on the technical standards for CVRs, market research indicates that 25-hour models tend to match the older 2-hour variants in a manner that allows them to be swapped without much difficulty. This compatibility implies that other operational procedures and costs should be similar and not result in notable change.”[58]

The NPRM also stated:

> The NTSB’s Safety Recommendation also included the recommendation to retrofit the current fleet. While retrofitting the current fleet would more expeditiously increase the number of aircraft fitted with the newer 25-hour CVR units and, thereby, the projected benefits to safety, the costs would be significant. Specifically, retrofitting the current fleet would increase by two-thirds the number of aircraft required to install 25-hour CVRs (estimated 29,561 aircraft in the current fleet added to the estimated 43,470 aircraft being built in the next 20 years). Further, the cost to retrofit existing aircraft with 25-hour CVRs would be several times higher than the cost to equip future-built aircraft with a 25-hour CVR instead of a 2-hour model. Assuming no replacement, applying a $25,000 CVR unit cost spread across the estimated 29,651 current fleet would result in roughly $741.28 million (undiscounted) in equipment cost compared to the $195.62 million (undiscounted) in incremental upgrade costs from the proposed rule. Retrofitting current aircraft would also incur additional costs, such as aircraft downtime and labor hours required to replace the CVR unit, which would further increase the total cost. Therefore, in an effort to provide the increased benefit of making more substantive data available to accident investigators while

[57] Bahrain, Belarus, Bermuda, Cayman Islands, Chile, China, Egypt, Ethiopia, European Union, Fiji, Hong Kong, India, Japan, Malaysia, Mexico, Oman, Panama, Qatar, Singapore, South Africa, South Korea, Taiwan, Thailand, Trinidad and Tobago, Turkey, Turkmenistan, Ukraine, United Arab Emirates, United Kingdom, and Vietnam.

[58] “25-Hour Cockpit Voice Recorder (CVR) Requirement, New Aircraft Production,” NPRM, 88 FR 84090, 84095 (Dec. 4, 2023).

maintaining the lowest economic impact on operators, this proposed rule would apply to newly manufactured aircraft only.[59]

NPRM FAA-2023-2270 would require airplane models with maximum certificated takeoff weight of less than 27,000 kg to update CVR to 25-hour duration. Airplane models with maximum certificated takeoff weight of less than 27,000 kg and required to have a CVR by FAA operational regulation would not be expected to have a certified production installation of CVR with 25-hour duration, as no ICAO standard or known State civil aviation agency regulation requires CVR with 25-hour duration for these airplanes at the time of this writing. Thus, design engineering and certification effort would be required for retrofit installation of CVR with 25-hour duration. At a minimum, the following aircraft types flown by regional and cargo carriers would be impacted: ATR42, ATR72, CRJ100/200, ERJ 135/140/145, Q100, and Q300. This represents approximately 348 aircraft operated by 9 airlines. Also, 10 ATR72 not covered under EASA's current 25-hour new aircraft regulation, as well as those of 29 countries, would be impacted by the lack of harmonization between the section 366 requirements and these regulations.

Qualitative Impact of Retrofitting "Covered Aircraft"

Use of NRLB for Underwater Locator Beacons (ULB)

Section 25.1457(g)(3) requires the CVR to have an affixed Underwater Locating Beacon (ULB). The predominant means to power the ULB is via a Non-Rechargeable Lithium Battery (NRLB). NRLBs are subject to lithium battery thermal runaway, which could emit gases and fluids that are toxic or corrosive or present thermal hazards. The FAA released NRLB special conditions in 2017, as the applicable airworthiness regulations did not contain adequate or appropriate safety standards for NRLBs. Examples of FAA NRLB special conditions include 25-632-SC for Boeing model 737-8 and 25-713-SC for Dassault Falcon 2000EX. A safety assessment of the ULB with NRLB is required to ensure that the special conditions are adequately addressed. Additional type design changes may be required to resolve any issues identified in the safety assessment (e.g. if adjacent structure, systems, or wiring are impacted by thermal effects of a lithium battery thermal runaway). Operators can replace the NRLB battery that normally comes with the CVR from the manufacturer with a non-NRLB battery for an additional $250 to $450 per CVR.

MOPS to Demonstrate Adequate CVR Audio Quality

Section 366 requires using a recorder that meets the standards of Technical Standard Order (TSO) TSO–C123c, or any later revision. TSO-C123c, effective date December 19, 2013, provides minimum performance standards (MPS) for original equipment manufacturers (OEM) applying for a TSO authorization for CVR equipment. In section 3 of the TSO, it states that new models of CVR identified on or after the effective date of the TSO must meet EUROCAE

[59] *Id.* at 84092.

document ED-112A, Minimum Operational Performance Specifications for Crash Protected Airborne Recorder Systems. In general, the OEM of CVR equipment must comply with Part I of ED-112A to obtain a TSO for their CVR system. The TSO exempts the OEM from ED-112A requirements regarding equipment installations and post-flight evaluations.

Advisory Circular 20-186 was published in June 2016 and cancelled AC 25.1457-1A. AC 25.1457-1A was the guidance available when regulation 14 CFR 121.359 was amended April 7, 2008, requiring operators to install a 2-hour CVR by 2010. AC 20-186A, published May 6, 2024, is the current revision of the AC as it relates to section 366. Section 1.5 of AC 20-186A recommends that CVRs manufactured after December 19, 2013, meet ED-112A as specified in TSO C123c. AC 25.1457-1A contained no installation guidance on CVR audio quality, whereas AC 20-186A suggests a demonstration of adequate CVR audio quality for all four CVR audio channels per EUROCAE ED-112A. AC 20-186A was released in May 2024 and did not change or revise the requirement to demonstrate aircraft installed performance per ED-112A.

If adequate CVR audio quality cannot be demonstrated with existing cockpit area microphone or audio system, a revision to the cockpit area microphone or audio system may be required. This type design change would be in addition to the installation of a CVR with 25-hour duration, to meet the recommendations of AC 20-186A. In some cases, the necessary type design change may not be limited to a line-replaceable unit (LRU) but also require airplane wiring changes. Cockpit area microphones or audio systems certified before CVR audio quality guidance was available are more likely to require redesign or replacement.

- AC 20-186A in reference to EUROCAE ED-112A I-6.1.4 Quality of Recording suggests that the NTSB be invited by the FAA for CVR audio quality assessments of CVR systems. Should the FAA choose to invite the NTSB, and the NTSB accepts the invitation, then the required time to certify a new CVR system should account for the required FAA and NTSB coordination, the NTSB CVR audio quality assessment, and potential changes to type design which may be required if CVR audio quality is not adequate.
- Other type design changes may be required to address an existing regulatory non-compliance associated with the CVR system. The extent of the type design change would be dependent on the specific regulatory non-compliance but may extend beyond replacement of the CVR and audio system. For aircraft no longer in production, it may be difficult to upgrade audio or other equipment that is no longer in production and may be uneconomical to the OEMs to certify such equipment for such low volume requirements (e.g., MD11, 717, A300).
- Instructions for continued airworthiness require revision to address the new equipment. In particular, the aircraft maintenance manual needs to reflect appropriate download procedures and ground support equipment.

AC 20-186A, when followed in its entirety, is an acceptable means for complying with airworthiness regulations but is not the only means. An applicant may propose alternate means, without type design changes to cockpit area microphone or audio system. Though such a certification plan would not meet the full requirements of EUROCAE ED-112A, it could be considered an incremental safety improvement for the fleet and still provide adequate CVR audio quality for accident investigation purposes. The responsible FAA aircraft certification office would evaluate whether the alternate means could be acceptable.

Guidance material, notices, and handbooks would not necessarily require revision by adoption of a retrofit requirement into regulation. However, additional guidance on the interpretation of audio quality may be warranted. AC 20-186A is applicable to aircraft manufacturers, aircraft operators, MRO organizations, and STC applicants.

At this time, the ARC cannot provide quantitative analysis of the number of aircraft that are impacted by updated MOPS that require demonstration of audio quality. The ARC has identified two groups of aircraft: those aircraft currently in production for which the airframer has FAA approved data for a 25-hour CVR, and out-of-production aircraft where the operator would need an airframer service bulletin or STC to upgrade their aircraft. The ARC has identified that the latter group would have a higher probability of not meeting audio quality guidance and would have a higher cost impact. They include aircraft, such as A300s, 727s, 737 Classics, 747s, 757s, DC-9s, MD-8Xs, MD-9Xs, MD-1Xs, and other similar aircraft types. The aircraft listed have TCs that date prior to the last CVR regulation and publication of ED-112 and TSO C123 and may not have audio equipment that meet demonstrated audio quality. Additionally, OEMs no longer manufacture equipment for these models and there may be difficulties in procuring suitable replacement components that would meet required audio quality.

Interpretation of 25-Hour Retrofit Compliance Between Various Guidance Documents

Due to the incorporation of ICAO’s guidance of requiring a 25-hour CVR for aircraft built after January 1, 2022, by multiple Civil Aviation Authorities, aircraft manufacturers have incorporated a 25-hour CVR for in-production aircraft or have offered a 25-hour CVR as an option. To have commonality between aircraft delivered before the January 1, 2022, date, some operators have sought STCs to retrofit older aircraft with a 25-hour CVR. In researching the requirements for audio quality in section 3.2.1.2 of Appendix B7 on 25-Hour CVRs, the ARC found that there were varying approaches between airframers, CVR OEMs, and STC holders on developing approved data for installing a 25-hour CVR. Some groups used guidance from AC 20-186A for installation certification where audio quality was taken into consideration, while other groups sought an alternate means of compliance based on the existing regulations requiring that a TSO C123c 2-hour CVR would be swapped out with a TSO C123c 25-hour CVR.

For certain aircraft models, the Illustrated Parts Catalog (IPC) allows for aircraft that were delivered with a 2-hour CVR to be replaced with a 25-hour CVR, provided that certain audio units were upgraded at the same time. The interchangeability data is one way forward in that, once an operator removes the 2-hour CVR and older audio unit with the 25-hour CVR and newer audio unit, it cannot go back to the originally delivered equipment. As discussed below, the upgrade of the audio unit can dramatically increase the cost of retrofitting the CVR for operators who use the airframer's approved data. Other operators, to avoid such cost, may seek approved data that only requires a box swap of the 25-hour CVR without any upgrades to the audio equipment. With the introduction of section 366 requiring that all 14 CFR 121 aircraft be retrofitted with a TSO C123c 25-hour CVR, are the two methods of certifying a 25-hour CVR prior to the law equivalent and does each meet the intended level of safety implied by the law?

The intent of the audio quality requirement is to ensure that recorded audio of cockpit conversations is intelligible by an AIA and that pertinent sounds and background noises are recorded and can be heard. For aircraft that have a path to upgrade their CVRs via IPC data, operators can do so today. It can be argued, technically and logically, that the audio quality of an aircraft delivered on December 30, 2021, (i.e. 2-hour CVR) will not be different from an aircraft delivered on January 2, 2022 (i.e. 25-hour CVR required). It could also be argued that, if the sound quality of CVR audio recordings on an out-of-production aircraft is found to be sufficient during a CVR check maintenance task, it would seem logical that the audio quality would be the same when a 25-hour CVR is installed. As NPRM 2023-2270 states in the summary of impact section: "Based on the technical standards for CVRs, market research indicates that 25-hour models tend to match the older 2-hour variants in a manner that allows them to be swapped without much difficulty. This compatibility implies that other operational procedures and costs should be similar and not result in notable change."[60] At a high level, the ARC contemplated whether those involved in the NTSB Safety Recommendations, FAA authors of the NPRM, and those involved in writing section 366 assumed that retrofitting aircraft would require only a box swap. Because audio quality requirements are buried within ED-112 I-6.1.4 and section 2.4 of the AC, the validation of audio quality may have been overlooked or not considered in the approved data, nor the additional time and cost required to upgrade the CVR if the audio quality is unsatisfactory.

The conclusion is that there may not be uniformity in approved data for updating a 2-hour CVR with a 25-hour CVR. Between ICAO's January 1, 2022, requirement for new production aircraft to have a 25-hour CVR and the publication of section 366, there is some approved data for the installation of a 25-hour CVR on various aircraft types where no test for audio quality was required and other approved data requiring audio upgrades for the same aircraft type. In complying with the retrofit portion of the Reauthorization Act, operators may pay 5 times the cost of the CVR depending on what approved data they use. One could say that the upgrading of audio systems along with a 25-hour CVR provides the highest increases in safety, but it could be argued that updating the CVR duration without also updating the audio system provides an incremental safety improvement beyond the current equipage. In developing regulations to comply with U.S. law, the FAA should provide guidance material with additional information for

[60] 88 FR 84090 at 84095.

ACOs, operators, and DAHs on required data for CVR approval and whether existing approved data may need to be amended for use.

Cost and Benefits Analysis

The ARC concurs with the FAA's evaluation in NPRM FAA-2023-2270 that retrofitting existing aircraft would incur additional costs compared to newly manufactured airplanes due to the additional engineering and certification effort. Based on the above factors, NPRM FAA-2023-2270's estimate of $25,000 for the "CVR unit cost" per existing airplane underestimates the costs that an operator could incur per fleet or per aircraft to meet ED-112A MOPS. The cost estimate in the NPRM:

1. Does not align with current costs of a new CVR, which can range from $25,000-$45,000[61]depending on the selected vendor.
2. Does not factor in the current costs of a new cockpit area microphone and/or audio system (e.g., a new Audio Management Unit (AMU) has a list price of up to $200,000, new microphones are approximately $500/mic) and installation kits to meet AC 20-186A or ED-112A. If an operator were to use the airframer's Illustrated Parts Catalog (IPC) notes or service bulletin or use the newer deliveries as a baseline for retrofitting older aircraft, then there is additional cost for the audio equipment and related NRE for certification. To avoid those AMU costs, the operator must provide documentation (e.g., analysis) that the AMU used for a 2-hour CVR meets audio quality when used with a 25-hour CVR.
3. Does not consider the significant non-recurring (spread across multiple airplanes) costs and time of design engineering and certification effort ($50,000+ per operator for a given model), CVR ground support equipment, and CVR shop test equipment. Non-recurring costs are expected to include significant design engineering and certification effort, any necessary safety assessments, additional type design changes, and time to obtain FAA approved data.
4. Does not consider the recurring (each airplane) costs of aircraft downtime and labor hours to replace the CVR, cockpit area microphone and audio system, and wiring as necessary. An aircraft may need to be taken out of service for an extensive update such as replacing audio wiring to address electromagnetic interference issues, depending on the result of the CVR audio quality assessment. Recurring costs include aircraft downtime and labor hours. Additional "kit" cost includes not only the CVR but also cockpit area microphone, audio system, and airplane wiring, as necessary. Recurring equipment costs (i.e. spare units) are expected to include not only the CVR but also additional equipment (cockpit area microphone, audio system) which may be required for the CVR system to have adequate CVR audio quality per AC 20-186A and ED-112A.

[61] The cost will vary depending on the number of units sold, the cost of chip sets and delivery times to meet schedules, and the relationship between the OEM and operator with contractual price breaks.

In addition to the impact on the operator, there is an impact to avionics OEMs. The number of equipment manufacturers who produce CVRs and audio system equipment is limited. These OEMs may have production capacity to support newly manufactured airplanes (~2,000 airplanes per year). These equipment manufacturers may require significant time to add production capacity to provide over 20,370 LRUs for newly manufactured airplanes and U.S retrofit requirements (est. 10,950[62] new A/C U.S. and foreign operators, 7,568[63] U.S. operator retrofit A/C, and 10% spares). In discussions with OEMs, it was calculated that, depending upon quantities of LRUs required, it could take from 9 months to over a year to increase manufacturing to include retrofit aircraft in addition to current production projections for new aircraft. In that estimate, the OEM must consider production bottlenecks (e.g., number of ATE cells and burn in chambers) and increase resources to meet production quotas, supply chain issues, and subcomponent part obsolescence. To the later point, OEMs may have already purchased final buys of subcomponents that have been identified as end of life for older models of LRUs. Increasing production may impact the OEM's ability to supply piece parts to support the remaining life of the product.

Benefit Analysis of U.S. Operator Cost and NTSB Benefit to Retrofit All U.S. Aircraft in Operation

In response to the Reauthorization Act, the FAA has requested that the ARC discuss and develop a benefit analysis for retrofitting "covered aircraft" defined in section 366.

The retrofit of existing aircraft with a 25-hour CVR, as documented in the NTSB's safety recommendations, were meant to provide the NTSB with more data from incidents and accidents to make recommendations to improve safety, but the desire for more data does not necessarily equate to an increase in safety when considering the cost and impact of such regulations on operators, STC holders, airframers, and OEMs. In Section III. Discussion of the Proposal for NPRM FAA-2023-2270 of Appendix B7, Table 1 list safety events, up to 2018, where pertinent CVR data was overwritten or lost.[64] The section also provided details of three more recent incidents not included in the table, for a sample of 20 events. These events were noted in the NPRM that, "…numerous accidents and incidents have occurred where the CVR data was overwritten and, had it been available, would have positively contributed to NTSB investigations."[65] The contribution to an NTSB investigation does not necessarily lead to improvements in safety or are all NTSB recommendations made into regulation by the FAA. It is therefore difficult to put a dollar amount on incremental safety benefits, as these future benefits

[62] Antoine Fafard, "Commercial Fleet 10-Year Forecast Shows Airbus Taking Prominence," *Aviation Week Network*, October 21, 2024 (21,900 new commercial deliveries between 2025 – 2024. Average delivery/yr = 2,190. 10,950 aircraft estimated to be delivered between 2025 – 2030).

[63] *See* Appendix A and details below.

[64] *See* Appendix B7.

[65] 88 FR 84090 at 84093.

would be cost avoidance versus cost savings. Therefore, this analysis is purely clinical for the use of the FAA to support their rulemaking process.

Based on the NTSB's database, from January 1, 2010, to September 27, 2024, 523 accidents/incidents related to 14 CFR 121 operations have occurred in the U.S. At the time of the dataset, 40 events were in work with only a preliminary report or no report at the time of analysis. In the 14 years, the NTSB has made 20 safety recommendations[66] based on these 523 events. This represents 3% of all events spanning 165 months. Nine events were documented as accidents, with 4 events having 7 fatalities and 4 events having 12 serious injuries, with 2 of the 4 events documented with the previous events with fatalities. There were 4 events having 152 minor injuries with 2 events documented with fatalities. In 2 of the events, the aircraft was destroyed. All others were classified as substantial damage to the aircraft. Eleven events were classified as incidents with no fatalities or injuries. Three events had minor ground damage to aircraft. Four of the 20 events were related to the movement of aircraft either on the active area or separation between aircraft taking off and landing. One event listed in the 20 incidents in the database was included in NPRM FAA-2023-2270.

Excluding those accidents where there was a loss of an aircraft and the last two hours of CVR data would be recorded, nothing indicates that, had the NTSB had the recordings for those incidents where the CVR was overwritten, any safety recommendation would be issued. In the most recent examples provided in the NPRM, where a major accident could have occurred, the flight crews enacted their training and overcame adverse conditions to avoid loss of life and loss of aircraft.

The ARC recognizes that, as aircraft become more efficient and can fly longer distances, there is value in having longer duration CVRs. This value comes from understanding, in total, how well the flight crew used their crew resource management (CRM) training, the interpretation of communications with ATC, and the overall communications between crew members leading up to the accident or incident. From an historical perspective, as an example, having additional CVR data from United Flight 173 on December 28, 1978, and Avionica Flight 052 on January 25, 1990, could have provided additional information that may have enhanced or created additional safety recommendations on CRM and communications if more information was available beyond the 30 minutes of the CVRs at that time. However, in many cases, the additional information may only be valuable to the operator involved for making improvements in crew training, changes to operations manuals, or additions of new flight crew bulletins and not to the industry at large.

Unfortunately, human error cannot entirely be eliminated, even with longer duration recorders. Though having a full data set of information after an incident is important, the incremental safety improvements to the operator would most likely not provide an equivalent ROI for the expense

[66] This number is established by filtering on "HasSafetyRec" = TRUE from the downloaded NTSB database.

for retrofitting current aircraft, especially when as many as 4,323 aircraft could be permanently parked within the next 6 to 10 years and 21,900 new aircraft with a 25-hour CVR would be manufactured in that same period.

Analysis of Recommendations on Expansion of "Covered Aircraft" to Include Aircraft Specified in NPRM 2023-2270

Due to the Reauthorization Act, the FAA has requested that the ARC make recommendations on whether to expand the retrofit requirement in section 366 to aircraft beyond those that operate under 14 CFR 121. The ARC assumes that this would include aircraft specified in the NTSB's safety recommendations and discussed in sections of NPRM 2023-2270, specifically aircraft operating under 14 CFR 91.609, 14 CFR 121.359, 14 CFR 125.227, and 14 CFR 135.151. The FAA estimated that the original NTSB recommendation that all aircraft under these parts be retrofitted with a 25-hour CVR would increase the number of covered aircraft to approximately 29,561 aircraft. The NTSB estimated the number of aircraft as 13,500.

The impact of adding these additional aircraft to the current regulation would have a substantial impact on the overall cost of a 25-hour CVR upgrade, the supply chain for sub-components, and LRUs required to comply with the regulation. The FAA's number of 29,500 aircraft amounts to 32,450 CVRs, including spares, amounting to a cost of $1.1 billion for U.S. operators. If the NTSB number of 13,500 aircraft is used, that amounts to 14,850 units at $35,000, or $520 million, for 14 CFR 91, 121, 125, and 135 operators. Based on the impact and potential costs to 14 CFR 121 carriers discussed earlier in this recommendation, and the FAA's own analysis documented in NPRM 2023-2270, the ARC does not recommend that the regulation to be created by the FAA include additional aircraft beyond that identified in section 366.

Analysis of Reducing the Number of "Covered Aircraft" to Exclude Certain Older Aircraft

NTSB safety recommendation A-18-031, from which most of section 366 is derived, did not offer any consideration for age (remaining lifespan) of existing aircraft. The typical lifespan for narrow-body aircraft is 25-30 years and for wide-body aircraft is 30-40 years or more, not accounting for economic considerations, fuel efficiency, maintenance costs, and regulatory requirements. The return on investment for the incremental safety benefit of installing a CVR with 25-hour duration would be less for older airplanes with a shorter remaining lifespan, while the impact and costs to certify a retrofit installation on older airplanes is expected to be much higher than newer, currently in production airplanes. If the rule applies only to aircraft with 10 years or more of useful life from the time of compliance (i.e. currently 2030), this will reduce the number of impacted planes from 7,568 to 4,345 aircraft, or a 42.6% reduction of aircraft. Though the cost is still substantial, this reduces the impact on the supply chain.

Over the past several years, aviation news articles have reported on how several U.S. operators have invested heavily in fleet modernization and network transformations. In addition, Airbus and Boeing have had difficulties delivering replacement aircraft to operators for various reasons.

These factors should be considered when factoring in the cost of proposed rulemaking for retrofitting a 25-hour CVR. In one case, one operator has committed to replacing over 155 older 737 NG aircraft with newer aircraft models, while another U.S. operator has plans to replace approximately 270 757s and 767s with newer aircraft models. These orders were placed 3 to 5 years ago, and due to the COVID pandemic, supply chain, and manufacturing issues, deliveries have been delayed, impacting these two operators significantly. The estimated cost to retrofit soon-to-be-retired aircraft, including 10% spares, represents a $16.3 million dollar investment for aircraft that are intended to be retired as new aircraft are delivered with a 25-hour CVR.

The ARC acknowledges that the FAA, as a department under the Executive Branch of the U.S. government, must execute section 366 as written and approved. Based on the ARC's cost benefit analysis and the FAA's own analysis as part of NPRM FAA-2023-2270, the ARC believes that there is an undue cost burden for operators who operate out-of-production aircraft or have already placed orders for newer aircraft to replace older aircraft, but have to keep these older aircraft in revenue service while waiting for new aircraft deliveries. The ARC recommends that the FAA share this information with Congress and where possible, request amending the existing statute to grant the FAA authority to provide limited or targeted exceptions for covered aircraft operators or including this authority in the 2028 FAA Reauthorization Act.

APPROACH: The ARC recommends that the FAA implement a process for operators to submit a letter to the FAA requesting either an exception or an extension of compliance dates based on remaining aircraft life span, upgrading audio systems due to poor audio quality, or an FAA-approved hardship.

Aircraft Life Span

With today's fuel consumption, noise abatement, and environmental concerns, many aircraft are reaching the end of their useful life. Based on historical data, the ARC estimates that the average, useful life span of an aircraft is 30 years for all aircraft types. The ARC believes that it may be feasible to except aircraft with 10 years or less of remaining life from the requirement to install a 25-hr CVR by May 16, 2030. This would exclude from the requirement aircraft manufactured in or before 2000, which would include certain numbers of Airbus (A300, A320, A330, A340); Boeing (717, 737NG and 737 Classics, 747, 757, 767, 777, MD11); and regional aircraft (e.g., Bombardier and Embraer). Below is an example of how 14 CFR 121.359 could be amended with such exceptions for retrofit aircraft if Congress were to grant the FAA the authority to provide an accommodation for some aircraft against the retrofit requirement.

> 14 CFR 121.359 Cockpit Voice Recorder
>
> (l) By May 16, 2030, all turbine engine-powered airplanes subject to this section that are manufactured after May 17, 2000, must have a cockpit voice recorder installed that also—

(1) Meets the requirements of § 23.1457(d)(6) or § 25.1457(d)(6) of this chapter, as applicable.

(2) Retains at least the last 25 hours of recorded information using a recorder that meets the standards of TSO-C123c, or later revision.

(3) Is operated continuously from the use of the checklist before the flight to completion of the final checklist at the end of the flight.

(4) If transport category, meets the requirements in § 25.1457(a)(3), (a)(4), and (a)(5) of this chapter.

U.S. Operator Application for Exception Due to Poor Audio Quality or an FAA-Approved Hardship

Based on the ARC's analysis, operators may have difficulty meeting the audio quality requirement in ED-112B. If this occurs, the cost to upgrade audio equipment could exceed the cost of a 25-hour CVR and control panel. Additionally, the time required to approve new audio equipment may make it difficult for operators to have compliant aircraft by the May 16, 2030, deadline. Many operators have already committed capital and resources to the purchase of newer aircraft to replace older aircraft. These newer aircraft will have 25-hour CVR. However, due to many factors, the aircraft deliveries have been delayed causing operators to continue flying older aircraft longer than envisioned in their fleet plans. Using EASA Regulation (EU) 29/2009 as an example, the 25-hour regulation could allow operators to communicate with the FAA on reasons for being granted an exception from the rule or reasons for requesting an extension to the compliance date. The FAA could then look at each individual case, decide whether a hardship exists, and either grant the request or provide additional guidance to the operator to help comply with the regulation in a timely fashion. The ARC believes that this is the best alternative that addresses the issues regarding the impact of retrofitting covered aircraft. Below is an example of how 14 CFR 121.359 could be amended with such exceptions for retrofit aircraft:

14 CFR 121.359 Cockpit Voice Recorder

(l) By May 16, 2030, all turbine engine-powered airplanes subject to this section must have a cockpit voice recorder installed that also—

(1) Meets the requirements of § 23.1457(d)(6) or § 25.1457(d)(6) of this chapter, as applicable;

(2) Retains at least the last 25 hours of recorded information using a recorder that meets the standards of TSO-C123c, or later revision; and

(3) Is operated continuously from the use of the checklist before the flight to completion of the final checklist at the end of the flight.

(4) If transport category, meets the requirements in § 25.1457(a)(3), (a)(4), and (a)(5) of this chapter.

(5) For aircraft that meet the criteria below, if circumstances prevent compliance with the requirements of this regulation, the certificate holder must communicate to the FAA by May 16, 2027, detailed information justifying the need for granting an exception to the aircraft type:

(i) Aircraft type is no longer in production and the procurement of parts to meet audio quality requirements is difficult to obtain or certify.

(ii) Aircraft type reaching the end of useful life and will be retired from service within 5 years after the compliance date.

NOTE: It is the responsibility of secondary operators who may purchase excepted aircraft from the previous owner to ensure that they comply with the 25-hour CVR regulation.

c. FAA Guidance Material for Determining Qualitative and Quantitative Demonstration of Audio Quality Performance

REC HRT7.c	The FAA should develop guidance materials addressing pass/fail criteria for demonstrating an aircraft CVR system's audio quality performance.

INTENT: To bring uniformity to approved data for ACOs, ODAs, DERs, and operators and reduce the level of uncertainty as it relates to compliance times and additional certification work that may be required.

RATIONALE: Based on the ICAO recommendation that aircraft manufactured after January 1, 2022, be equipped with a 25-hour CVR and the documentation (e.g., TSO C123c, ED-112, AC 20-186A) that has been created or updated since the last regulatory mandate to upgrade the CVR from a 30-minute CVR to a 2-hour CVR, operators of older aircraft or out-of-production aircraft have demonstrated interest in FAA guidance materials that would address pass/fail criteria for demonstrating an aircraft CVR system's audio quality performance. Though ED-112A provides guidance material for pass/fail criteria, the guidance was designed for a generic timeline for building and certifying a flight recorder on an aircraft. Given the law's existing timelines for a 25-hour CVR, performing the flight testing; contracting test labs; scheduling lab results with FAA, DER, and NTSB resources; and making the necessary aircraft design changes will be challenging for operators, FAA ACOs, NTSB representatives, and DERs. If there are no deadline extensions or aircraft exceptions, there must be uniform, fast-track guidance material for all parties to use to certify a 25-hour CVR along with any additional equipment to meet audio quality performance.

APPROACH: FAA guidance material should address the following:

1. Based on the applicability of ED-112A Section 1-A.1 Note 3, operators may have their own equipment or contracts with playback centers for maintenance purposes that may not meet all the requirements in ED-112A (e.g., 1-A.2.2) for the DER's certification. The FAA should provide a list of multichannel audio replay and analysis software applications that can be used and a list of replay centers acceptable to the administrator.
2. In cases where the manufacturer has aircraft IPC data to replace a 2-hour CVR with a 25-hour CVR with an upgrade of the AMU, what level of audio quality equivalency must a DER show to obtain a fast-track STC that does not require the upgrading of the AMU?
3. Considerations on how operators should address unsatisfactory audio quality performance for aircraft and audio components that are out of production. Consideration should include the cost, lead time, and testing required to find suitable replacement of audio components.

By providing this material, the FAA can reduce the level of uncertainty as it relates to compliance times and additional certification work that may be required.

d. Deadline for 25-Hour CVR Retrofit Requirement

REC HRT7.d	The FAA should ensure that any 25-hour CVR retrofit requirement includes sufficient time for operators to comply.

INTENT: To allow sufficient time for the following aspects related to retrofit of CVRs with 25-hour duration:

- Industry certification of new CVR systems, associated audio systems, and other required type design changes that may be applicable for out-of-production models.
- FAA and NTSB coordination for CVR audio quality assessment of new CVR systems, as included in EUROCAE ED-112A.
- Equipment manufacturers of CVRs with 25-hour duration, cockpit area microphones, ULBs, and audio systems to increase production capacity for sufficient quantities of LRUs for U.S. and international newly manufactured airplanes and U.S. retrofit requirements. Any of the options for exception mentioned in Recommendation HRT7.b would lessen the supply chain impact.

RATIONALE: Prior to the enactment of the Reauthorization Act, the ARC spent several months discussing and developing recommendations on whether to require the retrofitting of all CVRs on all airplanes required to carry both a CVR and FDR with a CVR capable of 25 hours of recording capability. This was a task from amendment 1 of the Investigative Technology ARC Charter. Though this item is no longer a part of amendment 2 of the Investigative Technology ARC Charter, the ARC believes that its findings are relevant for consideration in developing a regulation that will comply with section 366.

The ARC believes that the 6-year timeframe from May 16, 2024, is insufficient for operators to obtain the necessary FAA approved data, OEMs to manufacture the appropriate number of 25-hour CVRs, LRUs to obtain required FAA approved data, and insufficient time for operators to install equipment beyond a box swap of a CVR for the 7,179 retrofit aircraft the ARC believes may be most at risk.

APPROACH: The ARC recommends sufficient time for the following aspects related to retrofit of CVRs with 25-hour duration be provided by amending the statute or Congress granting the FAA the authority for limited or targeted exceptions for covered aircraft operators, including by:

- Allowing time for industry to certify new CVR systems, associated audio systems, and other required design changes that may be applicable for out-of-production models.
- Allowing time for the FAA and NTSB coordination for CVR audio quality assessment of new CVR systems, as included in EUROCAE ED-112A.
- Allowing time for the equipment manufacturers of CVRs with 25-hour duration, cockpit area microphones, ULBs, and audio systems to increase production capacity for enough

LRUs for newly manufactured U.S. and international airplanes and U.S. retrofit requirements. Any of the exception recommendations mentioned in Recommendation HRT7.b would lessen the supply chain impact.

If the FAA has the authority to grant compliance extension through 121 operator request under section 366, the ARC recommends that compliance date extension of 3 additional years (e.g., May 16, 2033) should be sufficient to allow OEMs to ramp up production and allow TC/STC applicants, the NTSB, and the FAA time to create, test, analyze, and approve data package submittals.

e. Expanding the Retrofit Requirement to Include Aircraft Specified in NPRM 2023-2270 and Not Covered by Section 366

REC HRT7.e	The FAA should not expand the definition of "covered aircraft" to include covered aircraft under NPRM 2023-2270, which would include turbine-powered aircraft under parts 91, 125, and 135.

INTENT: To avoid additional strain on CVR and AMU manufacturers, replay centers, DERs, and ODA and additional cost to industry.

RATIONALE: The ARC recognizes the benefit that a 25-hr CVR provides accident investigators over a 2-hour CVR. Section 366 is applicable to 14 CFR 121 aircraft only and it constrains the industry to those covered operators in having to meet the aggressive 6-year timeline in the law. Congress specifically excluded from covered aircraft, including from the retrofit provision, aircraft not operated in part 121 (i.e., there is no statutory basis for 25-hour CVR requirements outside part 121). Some of the non-part 121 aircraft will, however, be equipped with 25-hour recorders by way of the ICAO Annex 6, Part I, provision.

Given the uncertainties of the effect of failing audio quality for certain aircraft types, adding approximately three times the number of "covered" aircraft would complicate compliance with the regulation because of the demands on the supply chain and obtaining approved data to meet the compliance time.

APPROACH: The ARC recommends against the FAA expanding the 25-hour retrofit mandate beyond the "covered aircraft" defined in section 366.

8. Reducing Burdens of Recorder Mandate for Light Aircraft Operations[67]

a. Flight Recorder Mandate for Turbine-Powered Aircraft

REC HRT8.a	The FAA should consider implementing a flight recorder mandate for all turbine-powered aircraft operated under § 91.147 and part 121, and aircraft originally certificated as turbine-powered operating under part 135, while focusing on reducing installation complexity and ensuring a low barrier to regulatory compliance as well as reducing the potential for over-regulation. For aircraft not covered under the mandate, the ARC recommends FAA promote the adoption of flight recording systems through monetary incentives, tax incentives, and extension of compliance with related mandates.

INTENT: To ensure an effective flight recorder mandate for light aircraft operations that increases the success rate of accident and incident investigations with a view to prevent future occurrences, but that does not lead to unnecessary burdens on operators.

RATIONALE: Crash-protected cockpit voice recorders (CVRs) and flight data recorders (FDRs) have proven invaluable in determining accident causes and aiding in developing corrective measures. However, while part 121 (scheduled commercial flights) mandates these recorders for large airplanes, § 91.147 (under a letter of authorization) and part 135 (commercial, on-demand operations) do not, creating a gap in data available for many accident investigations involving smaller commercial and general aviation aircraft.

Historically, smaller aircraft and those operated on-demand have had lower recorder requirements due to presumed operational differences, lower overall risk, lower passenger capacities, and concerns over the FAA's ability to justify expanded equipage in a regulatory cost-benefit analysis, additional costs and the weight of installing such system recorders on certain aircraft, and the availability of appropriate recording equipment – especially prior to the development of EUROCAE ED-155. That said, accidents in these sectors can still result in significant fatalities, requiring complex investigations where crash-protected recorders or equivalent data recovery means could offer critical insights. This is especially true for turbine powered aircraft with sufficient performance to demand pilot training and operational requirements closer to large commercial aircraft. The lack of flight data has been identified by, among others, the NTSB as one of the contributing factors in part 91 and part 135 accident rates remaining relatively constant. In many cases where flight data is unavailable, accident investigations result in the NTSB being unable to determine a probable cause due to the lack of parametric evidence. [NTSB-A-13-12 and A13-13[68]]

The NTSB and other aviation safety bodies have therefore increasingly advocated for equipping smaller aircraft with recorders, noting that safety improvements should not be limited by the

[67] *See* Appendix B8 for the full working group report on this topic.

[68] NTSB Safety Recommendation A-13-12, A-13-13 (May 6, 2013).

operational category, size of the aircraft, or type of operation. Advances in lightweight, cost-effective recorder technology and the increasing availability of in-flight connectivity systems for light aircraft have reduced the feasibility barrier, allowing even smaller aircraft to be equipped without significant impact on performance or economics of operations.

Expanding the existing mandate for either crash-protected recorders or other forms of data recovery (for example, through data transmission systems) under parts 91 and 135, along with smaller aircraft operating under part 121 and not currently required to carry recorders, would align safety standards more closely with those of large transport airplanes in scheduled operations, potentially helping to reduce accident rates for part 91 and part 135 operations to levels currently achieved only in part 121 operations.

The assessment also needs to account for improvements to safety resulting from the integration of SMS and flight data monitoring (FDM) frameworks. The ARC notes that part 5 was expanded in applicability to part 135 operations as well as certain air tours performed for revenue under part 91. Additionally, the FAA has moved forward with establishing requirements for flight data monitoring for some segments of the on-demand part 135 industry, such as rotorcraft air ambulance operations.

The ARC also notes that the U.S. regulatory system for recording equipment is not fully in compliance with the most recent amendment to the ICAO Standards and Recommended Practices (SARPs) for equipage. The FAA may—at a minimum—review and determine alignment of the U.S. regulations for smaller aircraft with the ICAO SARPs.

APPROACH: The ARC recommends the FAA draft performance-based rules instead of blanket equipment mandates, with an overall risk reduction being the highest priority and design driver. Considering this, flight data monitoring programs and online flight data transmission solutions offer better support for a proactive safety culture, and a better fit with the SMS mandate already in place, than purely forensic solutions.

The TSO C197 (ED-155) standard and compliant recorders were developed with the objective of realizing the balance of lightweight design, and cost-effectiveness for smaller aircraft. These systems cover a broad range of configurations, with voice-only recorders typically being more economical, while combined recorders offer enhanced data monitoring and analysis capabilities. The focus of any proposed rule should expand the existing mandate for flight recorder equipage for turbine aircraft operating in part 91 or part 135. Newly established rules and mandates should also consider reducing installation complexity and ensuring a low barrier to regulatory compliance for light aircraft operations.

The FAA should consider combining the benefits of enhanced crash survivability and investigation support realized from requiring a TSO C197 compliant system with the proactive safety and operational advantages of an FDM-based solution, as regulating both independently would likely overburden smaller operators. It is therefore desirable to allow flight recording compliance for systems that also support FDM and SMS requirements, such as wireless data recovery and off-board flight data analysis systems. Moreover, the FAA should consider establishing a voluntary adoption program incentivizing the installation of crash protected storage solutions that support FDM and SMS functions. The ARC notes that the FAA incentivized early ADS-B equipage to help realize the January 1, 2020, mandate for equipage.

b. Adoption of Flight Data Transmission and Cloud-Based Data Recording Services

REC HRT8.b	The FAA should allow the adoption of flight data transmission and secure and assured, provenance-controlled and impartial cloud-based flight recorder data recording services to be subscribed to as an acceptable means of compliance with a flight recorder mandate.

INTENT: To allow aircraft unable to economically accommodate fixed installations of crash protected recorders to also become compliant with a flight recorder mandate.

RATIONALE: See Rationale section of Recommendation HRT8.a for discussion of the benefits from a flight recorder mandate for turbine operators and the need to balance them with reducing installation complexity, ensuring a low barrier to regulatory compliance, and reducing the potential for over-regulation.

Allowing flight data transmission and cloud-based flight data recording services would lower the cost and barrier to entry for compliance with a flight recorder mandate for turbine-powered aircraft compared to equipment contained on the aircraft.

APPROACH: The FAA should take steps to allow the adoption of flight data transmission and cloud-based flight data recorder services to be subscribed to as an acceptable means of compliance. It should ensure that cloud-based services are secure, assured, provenance-controlled, and impartial. The steps include the definition of acceptable means of compliance and the related rulemaking to pass these into law.

9. Use of ADFRs That May Currently Be Contrary to FAA Regulations[69]

REC HRT9	The FAA should permit the use of deployable flight recorders provided that suitable technical means to prevent unintended deployment are implemented. It should modify the language of § 91.15 to reflect this change.

INTENT: To minimize the risk of injury to persons or damage to property on the ground resulting from the unintended release of an automatic deployable flight recorder (ADFR), and to clarify the allowance and terms of acceptance within 14 CFR 91.15.[70]

RATIONALE: Application of existing technologies and standards can achieve an adequate safety level meeting the intent of § 91.15 to protect third parties on the ground. The capabilities of a deployable recorder with an integrated emergency locator transmitter (ELT) would allow the timely recovery not only of the mandatory flight parameters but also the cockpit voice and datalink recordings. Furthermore, an integrated ELT with position transmission would be an additional means for locating the point of end of flight.

APPROACH: Section 91.15 of the FAA's regulations prohibits the dropping of objects that create a hazard to persons or property from civil aircraft in flight, except if reasonable precautions are taken to avoid injury or damage. The ARC believes the purpose of § 91.15 is to prevent intentional dropping of objects from an airplane. Any part falling off the airplane may also be subject to concern, including those falling off unintentionally, e.g., because they are not properly secured or checked before flight.

The ARC believes that existing international standards, regulations, and guidance exist to address the risk of unintentional deployment of parts, and particularly for a deployable recorder, define reasonable precautions to avoid injury or damage to persons or property. Generally, FAA draft policy PS-ANM-25-23 (Risk to Persons on the Ground from Objects Falling off Transport Category Airplanes) and EASA CM-21.A-A-001 (Parts Detached from Aeroplanes)[71] address people safety on ground due to unintentionally falling objects. Additionally, EUROCAE standard ED-112A/B includes dedicated design precautions for development and integration of deployable recorders, including the following:

- Providing that deployable recorders should not be allowed to be deployed by manual action from crew (EUROCAE ED-112A/B 3-1.7g).
- Addressing quantitative safety targets to prevent unintentional deployment (EUROCAE ED-112A/B 3-1.5.1).

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[69] *See* Appendix B9 for the full working group report on this topic.

[70] 14 CFR 91.15.

[71] EASA CM-21.A-A-001 (Parts Detached from Aeroplanes).

The ARC believes this material provides acceptable methods to assess the appropriate design measures preventing people on the ground being severely injured when hit by parts falling off an airplane due to unintended parts deployment, which adequately addresses the need for reasonable precautions expressed in § 91.15, provided SAE ARP4761(A) on design methods for the safety assessment process is also applicable.[72]

The ARC recommends that the FAA clarifies that § 91.15 permits use of ADFRs that comply with its conditions. The ARC recommends excluding ADFR technology from 14 CFR 91.15 coverage. Alternatively, the ARC recommends amending 14 CFR 91.15 with verbiage outlined in CS.25.1457(d)(7)[73] and the corresponding AMC 25.1457 Section 8.[74]

Furthermore, the ARC recommends the FAA initiate rulemaking activities regarding the integration of minimum performance requirements for deployable recorders into the part 25 regulatory environment. Refer to Recommendation HRT4.d.

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[72] SAE International, *Guidelines for Conducting the Safety Assessment Process on Civil Aircraft, Systems, and Equipment ARP4761A* (December 20, 2023).

[73] EASA CS.25.1457(d)(7).

[74] EASA AMC 25.1457 Section 8.

B. Rotorcraft

1. Flight Data Recording Devices for Part 135 Operators

REC RTR1	The FAA should evaluate if the benefits of expanding the flight recorder requirements of § 135.152 to aircraft with 9 or fewer passenger seats outweigh the costs to operators for compliance.

INTENT: To identify potential safety hazards, develop risk mitigation measures via continuous monitoring of flight data, enhance safety, and prevent accidents by making regulatory data an open source of information that is readily available to the operator for FDM analysis while avoiding significant burden on smaller aircraft.

RATIONALE: Analyzing recorded flight data allows operators to detect trends and patterns that may indicate risks or safety issues and implement corrective actions to prevent accidents and incidents.[75] By tracking parameters, such as altitude, airspeed, engine performance, and flight maneuvers, operators can evaluate crew performance and identify deviations from desired behavior. Detecting unusual trends early on allows for targeted interventions to address operational risks.

Risk mitigation is a key benefit of FDM programs. Instead of waiting for accidents or incidents to occur, operators can use flight data analysis to identify potential hazards before they escalate, significantly improving aviation safety. Moreover, the investigative value of FDM data is critical to determining the cause of accidents when they do occur, benefiting both passengers and crew members.[76]

FDM is a vital component of SMS. It empowers operators to make data-driven decisions that improve operational practices. FDM also offers other benefits,[77] such as:

- Engine monitoring;
- Improved fuel consumption;
- Reduction in unnecessary maintenance and repairs; and
- Evidence of aircraft and crew performance for training, reporting requirements, or verification purposes.

A critical aspect of equipment requirements is the definition of required parametric data and commercial availability. Basic parametric data, such as altitude, airspeed, GPS location, and engine performance, are generally available from various sources in modern aircraft, though operator access may be limited. Legacy aircraft may require significant and costly modifications to comply with new regulations. These modifications may prove economically unfeasible for

[75] https://www.asias.faa.gov/apex/f?p=100:1

[76] https://www.cast-safety.org/pdf/General%20Distribution%20ALM%20JSAIT%20Final%20Report.pdf.

[77] https://www.ntsb.gov/Advocacy/mwl/Pages/mwl-21-22/mwl-as-02.aspx.

small operators unless alternative means of compliance, such as rebates or exceptions, become available.

Another important consideration is the availability of the recorded data to the operator. Proprietary and encoded data sources may prevent operators from accessing parametric data in a meaningful manner. Required data should be scaled to the operator based on fleet size and type of operations. Consideration must be given to the ability of the operator to analyze collected data, given its resources. Small operators flying aircraft with 9 or fewer passenger seats will not have the personnel or technological capabilities of a large, multi-aircraft entity. Flight data recording equipment should be scaled to allow for reasonable data collection to support an FDM program without introducing undue financial strain on the operator.

APPROACH: The ARC believes the FAA should recommend, but not require, FDM programs for all part 135 operators. The programs should be appropriately scaled to the size of the operation and designed to proactively monitor and collect data over the entirety of the operations. FDM programs should be nonpunitive in nature, and the data should be used only to identify safety trends and develop corrective and preventive actions. The ARC believes this recommendation is consistent with the NTSB recommendations regarding FDM programs. The ARC further recommends protecting all FDM data from disclosure in accordance with part 193.

2. FDM Requirement for Part 135

REC RTR2	The FAA should simplify the Flight Operational Quality Assurance (FOQA) program structure and guidance and encourage operators to utilize FDM to manage the safety and efficiency of their operations.

INTENT: To encourage operators to utilize FDM as one of many tools to manage the safety and efficiency of their operations by significantly simplifying the FOQA program structure and guidance.

RATIONALE: Requiring all part 135 operators to employ an FDM program may result in operators directing limited resources to processes that would not best impact safety. An SMS is intended to be designed in a manner appropriate to the operator. FDM is a metric that is best used within an SMS. Some operators may be more effective in reducing risk and identifying hazards through other means. Requiring all operators to use FDM may result in lost opportunities to be most effective.

The FAA should instead encourage the use of FDM by broadening the appeal of participation in a voluntary FOQA program. Some operators intentionally avoid FDM due to perceived regulatory and liability risk without FOQA protections. They also choose not to pursue an FAA-approved FOQA program due to an approval process that is arduous, time- and resource-consuming, and arguably unnecessarily complex. Removal of administrative and bureaucratic barriers to FOQA program implementation will result in more operators considering this method of safety assurance.

APPROACH: The FAA should redesign the FOQA process, including 8900.1 guidance and Advisory Circular 120-82, to drastically simplify program implementation and operations. The 2020 redesign of the Aviation Safety Action Program guidance and implementation process should be a model for redesigning FOQA. This should include creating a tool like the Automated Memorandum of Understanding (MOU) Generator to generate an Implementation & Operations (I&O) Plan for FAA review and approval. Another potential solution would be to require a Declaration of Compliance similar to part 5 requirements. The FAA should limit the content of the I&O Plan to only the most essential items with opportunities to leverage existing SMS features to support the program rather than creating duplicative documentation and processes. The agency should also integrate Certificate Management Team approval and ongoing monitoring into SMS surveillance. This approach would allow operators to leverage existing tools, effectively use resources, and avoid new administrative burdens that discourage operators from participating in this valuable approach to safety management.

3. Part 193 Protections to Support FDM Programs

REC RTR3	The FAA should extend part 193 protections to information disclosed pursuant to a mandatory FDM program.

INTENT: To protect FDM data from disclosure and incentivize data sharing in support of safety initiatives.

RATIONALE: Part 193 describes when and how the FAA protects voluntarily submitted safety and security information from disclosure.[78] The protection is necessary to avoid a chilling effect on data sharing that could hinder the FAA's ability to fulfill its safety mission. Under the current regulations, only information that has been *voluntarily* submitted is eligible to receive part 193 protection. Information that is *required* to be submitted (or otherwise discovered by the FAA) does not receive part 193 protection.

While the ARC supports mandatory FDM programs for part 135 operators and a requirement to share FDM data with the FAA, the ARC also believes that FDM data should be protected from disclosure under part 193. In the ARC's view, FDM data should still be considered "voluntarily" submitted (i.e., protected under part 193), even if FDM programs are mandatory. This approach will ensure that FDM data is used for its highest purpose, which is to avoid future accidents and improve the safety of the NAS.

The part 193 protections are designed to incentivize sharing data with the government in support of safety initiatives like the FAA's Aviation Safety Information Analysis and Sharing (ASIAS) Program. The ASIAS Program has been effective in assessing data across a broad spectrum of operations to identify emerging risks. The ARC acknowledges the success of programs like ASIAS, ASAP, and FOQA, but reiterates its concerns about FAA access to recordings of an operator's day-to-day activity, which would include hundreds of thousands of hours of flight data. The ARC also notes that part 193, which pre-dates ASIAS, was specifically enacted to protect certificate holders from the FAA's use of safety information in enforcement actions. ASIAS may work well now, but many operators remain reluctant to record or share data for fear that it will be used for enforcement. Indeed, the ARC is aware of certain operators refusing to record data due to liability concerns, even when they have the capability, equipment, and resources to do so. In many respects, being able to record and not doing so out of fear of enforcement is worse than not having the capability at all.

APPROACH: The FAA should specify that FDM programs are established under part 193, and as such, none of the information shared with the FAA can be used in any enforcement proceeding or released pursuant to a FOIA request. The "Part 193 specification" is necessary to comply with newly issued DOT requirements[79] that agencies must specify which regulation a program is created under in order to receive the protections afforded to voluntarily submitted data.

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[78] 14 CFR 193.1.

[79] 14 CFR Part 5.

Currently, only those programs recognized by DOT qualify for protection (e.g., ASAP, FOQA, NASA reporting program for mechanics). Thus, the FAA should be unequivocal in declaring that it fully intends for FDM programs to have part 193 protection.

4. CIR/CVR Requirement for All Rotorcraft in Part 135 Operations

REC RTR4	The FAA should require cockpit image and audio recorders on all rotorcraft (turbine and reciprocating engines) used in part 135 operations.

INTENT: To ensure that all rotorcraft[80] used in part 135 operations have equipment that captures cockpit audio and images.

RATIONALE: The NTSB has long advocated for CIRs to improve aviation safety and assist with rotorcraft accident investigations. The ARC supports these recommendations, as CIRs will allow crew actions to be evaluated regularly and will help prevent crashes.[81]

APPROACH: The ARC intends for every part 135 rotorcraft operator to reap the benefits of CIR. To that end, the ARC strongly recommends CIRs that are affordable and practical, with data platforms that are accessible to the user without the need for special decoding software, and that are robust enough to survive aircraft impact. Each of these characteristics are discussed in turn below.

<u>Affordable, Practical, and Accessible</u>
The ARC considers FDM data accessibility to be a key imperative of its recommendations. Operators must be able to access their own FDM data without having to first decrypt it with vendor software. In many cases, operators are required to pay for more than one software service. Some STC solutions exist for the "dual service" problem, but they involve retrofits, licenses, and data labels. The ARC recommends an ARINC 787/767 standard with decodable labels (non-proprietary standard), so there is no need to pay a vendor to read the data. The Genesis system that provides the data labels, 429 outputs, and decoder instructions in the installation manual is also an option (Garmin GDL90 is similar). Operators should have the ability to capture and decode data without encryption. This ability should be portable across all systems and performance based rather than prescriptive and based on a standard (e.g., ARINC 767).

<u>Robust</u>
The ARC considered whether CIR requirements should include a crash-hardened standard in accordance with ED-155. The ARC noted the importance of having devices that could withstand the impact of an accident but considered the ED-155 standard to be too onerous for many operators to meet, and ultimately, inconsistent with the goal of making CIRs affordable. Instead, the ARC believes that the device should meet <u>***a***</u> standard (e.g., ANSZ), but not necessarily an ED-155 standard. To that end, the ARC recommends that CIRs be impact resistant and meet the durability standards prescribed in DO-160 - Environmental Conditions and Test Procedures for

[80] The ARC intends for this recommendation to be applicable only to rotorcraft.

[81] Install Crash-Resistant Recorders and Establish Flight Data Monitoring Programs (ntsb.gov).

Airborne Equipment.[82] An impact-resistant standard ensures that the costs and certification timelines are not too burdensome. It also allows operators to use low cost/low tech devices, like GoPros with ScanDisk SD cards, which are also very lightweight. The ARC considers this approach to strike the appropriate balance between ensuring that CIRs are adequately durable and resilient and incorporating standards that are not overly burdensome, and that the equipment currently meets in many cases.

[82] See also AC 21-16G - RTCA Document DO-160 versions D, E, and F - Environmental Conditions and Test Procedures for Airborne Equipment.

5. CIR/CVR for Newly Manufactured Turbine-Powered Rotorcraft in Part 135 Operations

REC RTR5	The FAA should require "impact-resistant" flight recorder systems and cockpit image recorders on newly manufactured and existing turbine-powered rotorcraft in part 135 operation. OEMs should not be required by the FAA to provide the means of installation on existing turbine-powered rotorcraft not equipped with CVR and FDR, allowing the owner/operator flexibility in choosing the most suitable equipment.

INTENT: To incorporate a crash-resistant flight recorder system and cockpit image recorder on turbine-powered, non-experimental, non-restricted category rotorcraft operating under part 135 while maintaining owner/operator flexibility regarding the type of FDR/CVR/CIR installed on their rotorcraft, thereby enhancing the safety of rotorcraft operations and facilitating the investigation of accidents and incidents involving rotorcraft.

RATIONALE: Rotorcraft with turbine engines present more complexity and higher demands in operation compared to their piston-engine counterparts. They frequently undertake critical missions like emergency medical services, police work, and over-water operations. This leads to a greater chance of occurrences that could involve human factors, including pilot error, fatigue, inattention, or stress. CIR equipment can provide valuable information on the cockpit environment, crew actions, and flight instrument indications, which can help identify the causes and contributing factors of rotorcraft accidents and incidents. The ARC agrees that part 135 owner/operators of existing turbine-powered rotorcraft that are not equipped with an FDR or a CVR should install an impact-resistant flight recorder system. However, the ARC does not agree that the rotorcraft OEM should be required to provide the means to install it.

<u>Impact-Resistant Flight Data Recorder Systems</u>
The ARC's recommendation does not require turbine rotorcraft operating under part 135 with less than 9 passengers to require crash resistant flight data recorder. Review of NTSB data has found numerous examples of flight data recording devices that have survived the accident sequence and are able to provide information related to flight performance for investigation purposes. The burden to require traditional crash resistant standards will be unfeasible for many part 135 operators as the hardware does not exist for some types of light turbine rotorcraft or will be problematic in terms of weight and cost. The ARC has adopted the term "impact resistant" to describe the capabilities of the device. Impact-resistant devices should focus on durability and reliability but will not be required to meet fire or burn survivability standards.

<u>Cockpit Image Recorders</u>
CIR equipment can also serve as a deterrent for non-compliance with regulations and procedures, and as a tool for training and performance evaluation of rotorcraft pilots. CIR technology can document visual and audio specifics not captured by traditional recording devices such as FDRs or CVRs. This additional information can enhance the recorded data, offering a more detailed and accurate account of what transpired in the cockpit and of crew actions.

The ARC agrees with and supports wider adoption and use of data recorders and image recorders across the rotorcraft industry. Crash-survivable data, both parametric and image/video, would assist investigators with various types of accidents where the causal factors are speculative. However, the policy, as written, is not feasible to implement. The ARC recommends a more targeted approach in requiring flight data recording options, specifically:

- Newly manufactured rotorcraft only: The ARC recommends OEM requirements for crash-resistant flight recorder systems for newly manufactured rotorcraft. In its research, the ARC found numerous operators experiencing significant challenges in attempting to find or create the proper STCs to match the recording requirements to older airframes.
- Flight recorders are usually supplied by third-party vendors, independent of the rotorcraft OEM. The recorders vary widely in cost, size, weight, and functionality, offering owner/operators a range of equipment options to choose from based on their operational needs. If the OEM is required to provide the means of installation, it would severely limit the owner/operators' choice of equipment, as they would be restricted to the equipment chosen by the OEM, rather than the full range of equipment available for their aircraft type. Moreover, in most cases, the third-party vendor already holds an STC that includes the means of installation, making it unnecessary and burdensome for the OEM to provide it.
- Part 135 operators with a fleet size of 25 or more: Part 91 operators should not be required to install crash-resistant flight recorders, as general aviation compliance with this requirement will be challenging. Part 121 operators should not be required to comply, as the ARC considers the current part 121 regulations to provide the necessary data recording requirements without the need to install additional equipment. For part 135 operators, the ARC recommends requiring data recorders when the operator has a fleet size of 25 or more turbine-powered rotorcraft.
- Crash-Resistant Flight Recorder System: The ARC does not believe that ED-112 or ED-155 approved recorders are necessary for the light turbine rotorcraft market. This performance standard will present a challenge in adoption and operational feasibility. Across the market, there are few crash-resistant hardware options available for the light aircraft market. Additionally, considerations of weight and cost will prevent widespread adoption. In this case, the ARC recommends promoting the term "impact resistant" as an alternative. NTSB data supports that data recorders may not need to be fully crash resistant to survive most accidents. Reducing the standard of crash resistance will likely net higher numbers of recorders across part 135 operators; however, some accident sequences with post-crash fires or submerged wreckage may not yield data. The ARC believes this tradeoff is favorable for more widespread investigative technologies and is opting for an impact-resistant standard.

APPROACH: The ARC recommends that the FAA require part 135 owner/operators of turbine-powered rotorcraft to install a crash-resistant flight recorder system. The ARC further recommends that the agency allow owner/operators to choose the flight recorder most suitable for the operation, provided that it meets the recording specifications prescribed in TSO-C197 (not including the survivability qualifications). While the ARC believes that regulations requiring recording systems are necessary, it does not recommend that the systems meet the TSO-C197 standard. It is the ARC's view that TSO-C197, which invokes ED-155, drives unnecessary costs and weight to the recorder system. This concept also applies to TSO-C176a, which invokes ED-112A. The ARC further recommends that the CIRs include the ability to capture parametric data. OEMs should not be required to provide the means of installation as this would essentially allow the OEM to dictate to the owner/operator which recorder they could use, which could create conflicts. The ARC notes that the FAA will need to revise regulations in 14 CFR parts 27 and 29 to implement these recommendations. It will also need to update related advisory circulars and guidance material outlining proper installation, usage, and constraints of CIR systems. These updates must address integration, compatibility, and maintenance concerns with rotorcraft operations. Manufacturers should be given 2 years from the date of the rule's implementation to comply and equip new turbine rotorcraft.

6. Existing CVR/FDR Upgrade Requirement to CIR per TSO-C176a

REC RTR6	The FAA should not require existing turbine powered rotorcraft equipped with an FDR and CVR to install a crash-protected CIR system that is compliant with TSO-C176a as broadly stated but should identify a tiered approach to regulatory implementation. The tiered approach should be based on years of certification; certification category (transport, normal, utility, acrobatic, limited, restricted, and provisional); operational segment (14 CFR parts 91, 121, and 135); rotorcraft size; weight; and/or passenger capacity.

INTENT: To implement a tiered approach to incorporating CVR/FDR upgrades on existing turbine-powered rotorcraft equipped with an FDR and a CVR installed.

The CIR system should be equipped with an independent power source consistent with that required for CVRs in 14 CFR 29.1457 (A-20-30) by creating a tiered approach that will prevent overly burdening the manufacturers, owners, and operators while remaining aligned with the FAA's commitment to the recovery of flight data for the improvement of aviation safety.

RATIONALE: The stated tasks of the amended Investigative Technologies ARC Charter centers around the FAA's commitment to the recovery of flight data (whether in flight data or information collected after an incident or accident), international harmonization between the FAA and the ICAO standards, overall improvements to safety, impact to the flying public, and economic viability of regulatory change. To this end, regulatory recommendations should encourage manufactures, owners, and operators to understand the benefits of the industry-wide recovery of flight data to improve the economic viability of their own organizations, rather than another onerous hurdle to overcome. Regulatory recommendations should therefore be minimal and outcome based, encouraging innovation to provide new solutions to achieve the stated goal of capturing the highest amount of actionable data.

APPROACH: "Crash-protected" should be precisely defined in accordance with ED-112a, which defines the minimum specification to be met for all aircraft required to carry flight recorders. TSO-C176a references ED-112a as well as stating that the functionality requirements of TSO-C176a store the data in a "crash-protected memory." Therefore, "crash-protected cockpit image recording system" and "crash-protected memory" need to be individually defined.

Crash-protected flight recorders should be precisely and consistently identified throughout the regulatory material in accordance with ICAO Annex 6 Operation of Aircraft, 6.3 Flight recorders as follows:

- A flight data recorder (FDR),
- A cockpit voice recorder (CVR),
- An airborne image recorder (AIR),

- A data link recorder (DLR).

Lightweight flight recorders should be precisely defined in accordance with ED-155, which defines the minimum specification to be met for aircraft required to carry lightweight flight recording systems.

Lightweight flight recorders should be precisely and consistently identified throughout the regulatory material in accordance with ICAO Annex 6 Operation of Aircraft, 6.3 Flight recorders as follows:

- An aircraft data recording system (ADRS),
- A cockpit audio recording system (CARS),
- An airborne image recording system (AIRS),
- A data link recording system (DLRS).

Detailed requirements of each flight recorder system should be consistent with ICAO Annex 6 Operation of Aircraft, Appendix 8 Flight Recorders.

Applicability of aircraft affected by the tiered regulation should be defined by addressing year of certification, certification category (transport, normal, utility, acrobatic, limited, restricted, and provisional), operational segment (14 CFR parts 91, 121, and 135), rotorcraft size, weight, and/or passenger capacity. Examples of this approach are below.

<u>Example 1: Lightweight Flight Recorder Systems.</u>

All rotorcraft of a maximum take-off mass over (applicable weight) up to and including (applicable weight) for which the application for certification of Normal, Transport, or Utility Category was submitted on or after (applicable date) and operated under 14 CFR parts 91 or 135, shall be equipped with a lightweight flight recorder system (selected systems as appropriate from list defined above) that shall record the information as defined in [the FAA equivalent of Appendix 8 of ICAO Annex 6 Operations of Aircraft Operations].

<u>Example 2: Crash-Protected Flight Recorder Systems.</u>

All rotorcraft of a maximum take-off mass over (applicable weight greater than example one) up to and including (applicable weight greater than Example 1) for which the application for certification of Normal or Transport Category was submitted on or after (applicable date) and operated under 14 CFR part 135, shall be equipped with a crash-protected flight recorder system (selected systems as appropriate from list defined above) that shall record the information as defined in [the FAA equivalent of Appendix 8 of ICAO Annex 6 Operations of Aircraft Operations].

7. Manufacturer Requirement for CIRs per TSO-C197; New Rotorcraft Without FDR/CVR

REC RTR7	The FAA should require manufacturers of newly manufactured turbine-powered rotorcraft to install a flight recorder system that records cockpit audio and images with a view of the cockpit environment to include as much of the outside view as possible, designed to mitigate the risk of loss of recorded data as a result of an aircraft incident or accident, while ensuring that such equipment remains operational under diverse environmental conditions.

INTENT: To require manufacturers of newly manufactured turbine-powered rotorcraft to install a crash-resistant flight recorder system designed to mitigate the risk of loss of recorded data because of an aircraft incident or accident, while ensuring that such equipment remains operational under diverse environmental conditions. While audio and image recordings should meet the specifications of ED-155 as required by TSC-C197, the determination of crash survivability should be appropriate to the size and operation of the rotorcraft. (A-20-27)

RATIONALE: In the NTSB's recommendation (A-20-28), five exemplar rotorcraft accidents are cited to demonstrate the need for crash-resistant CIRs. However, the NTSB fails to differentiate between accidents where no CIR or other data recording device was installed and those where a recorder was installed but failed to survive the accident. The existence of a flight data recorder or CIR was not mentioned in any of the five accident final reports. Additionally, in at least one of those five accidents, data was retrievable from a system that was not crash resistant. The extensive certification program for crash-resistant and crash-protected recorders as specified in EUROCAE ED-112 and required by TSO-C176a substantially increases cost and has the potential to additionally increase weight while providing an unproven benefit with respect to the survivability of such a system involved in a rotorcraft accident. Similarly, the requirement for software developed to a level consistent with the failure condition of "Minor," as is required in TSO-C176a, would not accurately affect the impact that the failure of a CIR would have on the safety of an individual flight. For that reason, a failure condition of "No Effect" would be more suitable.

TSO-C197 specifies audio and video recording, data-link, and data recording. In addition, TSO-C197 specifies requirements for crash survivability as set forth in EUROCAE ED-155. Requiring manufacturers to certify a CIR with audio to TSO-C197 places a large burden on the smaller aircraft due to cost, complexity, and certification basis required to install such equipment. Research on past accident events (NTSB Carol Database) has shown that data/image recovery from devices after an accident that do not meet the requirements of TSO-C197 (often meeting DO-160) have an approximate 85% success rate. The requirement should be at a level that encourages manufacturers (and customers) to adopt and install recording equipment due to simplicity, weight savings, and low cost for smaller aircraft. By specifying TSO-C197, this is not feasible for smaller aircraft. The goal should be a method that penetrates most of the market with a tiered approach to make the implementation more attractive to more manufacturers while recognizing that a more robust, comprehensive solution is necessary at the higher end of the market. Requiring all manufacturers of newly manufactured turbine-powered rotorcraft to employ a CIR with audio meeting TSO-C197 may result in manufacturers significantly increasing the cost for all customers while only capturing a safety impact for a small segment of the overall market. Rotorcraft operate in diverse environments, and for that reason, the FAA should retain the environmental qualifications requirements outlined in RTCA/DO-160G. Taking a more nuanced, and somewhat relaxed, approach to the certification requirements of this highly valuable piece of safety equipment ensures that the industry sees the most benefit possible while acknowledging the potentially significant cost and operational burdens associated with existing crash-resistant CIR technologies. A CIR with audio should be implemented in a manner appropriate to the intended aircraft operation and/or size. Requiring all manufacturers to implement the same expensive solution may result in lost opportunities. However, it is important to implement more robust solutions for manufacturers of larger turbine-powered rotorcraft with more occupants.

APPROACH: The FAA should require manufacturers of newly manufactured turbine-powered rotorcraft to install a flight recorder that records cockpit audio and images with a view of the cockpit environment that includes as much of the outside view as possible. The design should mitigate the risk of loss of recorded data due to an aircraft incident or accident and be equipped with an independent power source consistent with that required for CVRs in 14 CFR 29.1457. Equipment and certification requirements should be based on rotorcraft categories under certain operational rules and size. The following is recommended:

Newly Manufactured Turbine Powered Rotorcraft		
Operation	**Number of Seats**	**CIR Requirements**
Part 91	Less than 10 seats	Any type of audio/image recorder (No hardware cert requirements) Image Rate: 1 Hz min
	10 to 19 seats	Audio/image recorder meeting DO-160 hardware cert Image Rate: 4 Hz min
	20 or more seats	Audio/image recorder meeting TSO-C197
Part 135	Less than 10 seats	Any type of audio/image recorder (No hardware cert requirements) Image Rate: 2 Hz min
	10 to 19 seats	Audio/image recorder meeting DO-160 hardware cert

		Image Rate: 4 Hz min
	20 or more seats	Audio/image recorder meeting TSO-C197
Part 121	All	Audio/image recorder meeting TSO-C197

This approach would allow the vast majority of manufacturers (if not all) to utilize existing low-cost and lightweight products with simplified architectures for those smaller, low-cost rotorcraft and avoid burdens that discourage manufacturers (and subsequent customers) from installing valuable investigative equipment.

IX. Other Issues

A. Privacy and Data Misuse[83]

The ARC believes there are deficiencies in current FAA regulations (parts 13 and 193), international harmonization and ICAO standards, and other guidance as it relates to the use of recorded data and the protection of personal information.

The ARC acknowledges that the FAA did not specifically request a review of the regulatory environment concerning privacy and data misuse. However, the ARC elected to present the following information because concerns about privacy and data misuse are relevant to many of the other technologies that the ARC was asked to consider.

The ARC is concerned about the misuse of information and many interrelated issues, such as privacy concerns, criminalization of incidents and accidents, punitive actions against pilots by employers, media exposure, and other unintended consequences that could jeopardize a positive reporting culture and negatively impact aviation safety. The potential misuse of data and information increases as new investigative technologies are implemented throughout the aviation system. Concern about the potential misuse of information is applicable to several different technologies, including:

- Cockpit Voice Recorders.
- Flight Data Recorders.
- Cockpit Image Recorders.
- Data Link Recorders (DLRs) and messages.
- Automatic Deployable Flight Recorders.

The ARC submits the following additional recommendations to the FAA with the goal of improving the just and non-punitive safety culture on which investigations rely:

- Work with the NTSB to strengthen the privacy regulations in 49 CFR parts 831 and 837, with the aim of protecting personally identifiable information (PII) of flight crewmembers involved in incidents and accidents, including identifying information captured in audio, image, and digital form.
- Strengthen privacy considerations in 14 CFR parts 13, 193, and others, as required, with the aim of protecting PII of flight crewmembers involved in FAA-led safety investigations, including identifying information captured in audio, image, and digital form.
- Create new regulations in 14 CFR parts 13, 193, 121, and 135 that limit the use of flight deck audio, image, and data recordings in enforcement investigations.
- Change Title 49 Chapter 11 c.2 to only release CVR/CIR summaries to the public, not the actual transcript, as well as only summaries of any interview transcripts.

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[83] *See* Appendix B10 for the full working group report on this topic.

During the ARC's research, it discovered that there is no NTSB guidance concerning the procedure to return a CVR, FDR, DFDR, etc. to the operator. The ARC recommends that the NTSB create and publish guidance that stipulates this procedure. The ARC recommends that the NTSB erase all data from the unit/system before it is returned to the operator/owner. Because of the sensitivity of recordings, it is possible that the return organization for the recorder unit is not the same organization that receives the original recording medium. In such cases, it would be necessary to return only the physical device minus the erased medium to this return organization.

X. List of Acronyms

Acronyms	
ADFR	Automatic Deployable Flight Recorder
AIA	Airworthiness Investigation Authority
AIR	Airborne Image Recorder
AIRS	Airborne Image Recording System
ASAP	Aviation Safety Action Program
ASIAS	Aviation Safety Information Analysis and Sharing
AMC	Acceptable Means of Compliance
AMU	Audio Management Unit
CAA	Civil Aviation Authority
CIR	Cockpit Image Recorder
CVR	Cockpit Voice Recorder
DAH	Design Approval Holder
DFDR	Digital Flight Data Recorder
DSP	Datalink Service Provider
EASA	European Union Aviation Safety Agency
ELT	Emergency Locator Transmitter
FAA	Federal Aviation Administration
FDM	Flight Data Monitoring
FDR	Flight Data Recorder
FOQA	Flight Operational Quality Assurance
GADSS	Global Aeronautical Distress & Safety System
HF-ULD	High-Frequency Underwater Locator Devices
ICAO	International Civil Aviation Organization
LF-ULD	Low-Frequency Underwater Locator Devices
LRU	Line-Replaceable Unit
MOPS	Minimum Operational Performance Standards
MRO	Maintenance, Repair, and Overhaul
NRLB	Non-Rechargeable Lithium Battery
NTSB	National Transportation Safety Board
OEM	Original Equipment Manufacturer
PII	Personally Identifiable Information
SARPs	Standards and Recommended Practices
SMS	Safety Management System
STC	Supplemental Type Certificate
TRFD	Timely Recovery of Flight Data
ULB	Underwater Locating Beacon

Appendix A – ARC Members/Participants

FAA & Industry Co-Chairs	**Organization**
Charisse Green	FAA
Robert Ireland	Airlines for America
Jeff Mee	Air Line Pilots Association
Members	**Organization**
Lauren Beyer	Cargo Air
Robert Burke	Airbus
Doug Carr	National Business Aviation Association
Jens Hennig	General Aviation Manufacturers Association
Chris Hill	Vertical Aviation International
Murray Huling	Aircraft Owners and Pilots Association
Chad Kirk	AIA Aerospace
George Paul	National Air Carrier Association
Kipp Lau	Coalition of Airline Pilots Associations
Ric Peri	Aircraft Electronics Association
Erik Strickland	Regional Airline Association
Casey York	Boeing
HRT Subgroup Participants	**Organization**
Thomas Pack (Chair)	TJPack Consulting, LLC
Andrew Averna	JetBlue
Tanya Boisseranc	Boeing
Robert Burke	Airbus
Kara Charles	Boeing
Pina Desai	Acron Aviation
Robert Fujimoto	Hawaiian
Russ Gossman	UPS

Hannes Griebel	CGI
Mitch Hanson	Coalition of Airline Pilots Associations
Chris Heck	Air Line Pilots Association
Kevin Heffernan	Delta
Kira Hein	Boeing
Jens Hennig	GAMA
Jacob Hillery	JetBlue
Jennifer Holder	Boeing
Chad Kirk	AIA
Sven Knoop	Airbus
Matt Langridge	Gulfstream
Kipp Lau	Coalition of Airline Pilots Associations
Ted McFann	FedEx
Greg Moran	Boeing
Jeff Perin	Air Line Pilots Association
Justin Pinkerton	Air Line Pilots Association
Chris Sidor	Air Line Pilots Association
Erik Strickland	RAA
Robert Swanson	FedEx
Luke Tschacher	Boeing
Blake Van den Heuvel	Leonardo DRS
Peter Walther	Airbus
Brighton Wang	Hawaiian
Mike Wickboldt	Air Line Pilots Association
Casey York	Boeing
Jacob Zeiger	Boeing
Rotorcraft Subgroup Participants	**Organization**
Jeff Currin (Chair)	Brazos Safety
Seth Buttner	Airbus

Brandon Carpenter	Metro Aviation
Jay Eller	Honeywell
Chris Hill	Vertical Aviation
Jose Jaramillo	Chevron
Alan Love	Bell Flight
Brody Paine	LifeFlight Network
Dan Shapiro	Sikorsky
David Shear	Robinson
Chad VerBerkmoes	Air Methods Corp.
Observers and Contractors	**Organization**
Joe Sedor	NTSB
Becca Fribush	The Regulatory Group, Inc.
Puja Sardana	The Regulatory Group, Inc.

Appendix B – HRT Position Papers

The following draft position papers written by the HRT group participants regarding different charter taskings are included to present a full picture of the HRT group's thought processes and key concerns in their own words, as well as further background on each of the areas discussed. They are presented exactly as written and do not represent the position of the full ARC.

B1: MOPS Standards for Additional Mandatory FDR Parameters

The following draft position papers written by the HRT group participants regarding different charter taskings are included to present a full picture of the HRT group's thought processes and key concerns in their own words, as well as further background on each of the areas discussed. They are presented exactly as written and do not represent the position of the full ARC.

INTRODUCTION:

The Federal Aviation Administration (FAA) has established an Investigative Technologies Aviation Rulemaking Committee (ARC) to seek recommendations on the best ways of recovering aircraft flight data. This position paper will address the topic of pending minimum operation performance standards (MOPS) for additional mandatory (required by regulation) Flight Data Recorder (FDR) parameters. This position paper contains some information with which the FAA is already aware for the familiarity of subgroup members.

This position paper addresses the following charter item for large airplanes:

> d. Discuss issues and develop recommendations based on pending minimum operational performance standards (MOPS) for additional mandatory FDR parameters.

BACKGROUND:

It is understood that the FAA is referring to EUROCAE ED-112B *Minimum Operational Performance Standard for Crash Protected Airborne Recorder Systems* (August 2023) as the "pending" MOPS, although this document revision is no longer "pending" having been released in August, 2023. ED112B includes additional mandatory Flight Data Recorder (FDR parameters in Table II-A.1 Parameters to be Recorded – Aeroplanes), relative to the previous revision ED-112A (September 2013). The initial version of ED-112 was released in 2003. The FAA has not previously cited EUROCAE documents for mandatory FDR parametric recording requirements.

In response to accident investigation agency safety recommendations to address mandatory FDR parameters, the European Union (EU) European Aviation Safety Agency (EASA) submitted a working paper to the United Nations (UN) International Civil Aviation Organization (ICAO) in 2015. ICAO adopted the intent of ED-112A mandatory FDR parameters to be recorded 8 November 2018 in Amendment 43 to Annex 6 - *Operation of Aircraft,* Part I - *International Commercial Air Transport* section 3.3.1.1.11 and Table A8-1, with the exception of first officer values for pressure altitude, indicated airspeed or calibrated airspeed, pitch attitude, and roll attitude. This standard is applicable for new airplane model series (e.g. Airbus A390, Boeing 797) of maximum certificated take-off mass of over 5,700kg for which the application for type certification is submitted after 1 January 2023. This standard does not apply to initial certificate of airworthiness (newly manufactured airplanes for existing airplane model series, e.g. Airbus A350, Boeing 787, Embraer E175), nor is there a recommended practice (recommendation) applicable to newly manufactured airplanes.

FAA operating regulations in 14 CFR parts 91, 121, 125, and 135 address FDR parameters within appendices and do not refer to separate industry standards. The latest FAA operational requirements are listed below.

- 14 CFR part 91 appendix E [FAA-2013-0579, 9/3/2013]
- 14 CFR part 121 appendix M [FAA-2013-0579, 9/3/2013]
- 14 CFR part 125 appendix E [FAA-2013-0579, 9/3/2013]
- 14 CFR part 135 appendix F [FAA-2005-20245, 4/7/2008]

FAA requirements for mandatory FDR parameters vary by operating regulation.

- 14 CFR part 91 *General Operating and Flight Rules* subpart G *Additional Equipment and Operating Requirements for Large and Transport Category Aircraft* includes 91.609 *Flight data recorders and cockpit voice recorders* which requires a flight data recorder for multiengine, turbine-powered airplane or rotorcraft having a passenger seating configuration of 10 or more.
- 14 CFR part 121 *Operating Requirements: Domestic, Flag, and Supplemental Operations* includes 121.344 *Digital flight data recorders for transport category airplanes* for turbine-engine powered transport category airplanes
- 14 CFR part 125 *Certification and Operations: Aircraft Having a Seating Capacity of 20 or More Passengers or a Maximum Payload Capacity of 6,000 Pounds or More; and Rules Governing Persons on Board Such Aircraft* includes 125.225 *Flight data recorders* requiring a flight data recorder for large airplane over 25,000ft. altitude and multiengine turbine powered airplanes.
- 14 CFR part 135 *Operating Requirements: Commuter and on Demand Operations and Rules Governing Persons on Board Such Aircraft* includes 135.152 *Flight data recorders* which requires a flight data recorder for multiengine, turbine-powered airplane or rotorcraft having a passenger seating configuration of 10 to 19.

The FAA has not yet adopted the intent of ICAO Annex 6 Part I Table A8-1 (~ED-112A) into regulation.

The NTSB has not issued any safety recommendations for ICAO standard, EUROCAE ED-112A or EUROCAE ED-112B mandatory FDR parameters.

House Resolution (HR) 3935 FAA Reauthorization Act of 2024 (May 16, 2024) does not include any section relating to additional mandatory FDR parameters.

Harmonization

Mandatory FDR parameter requirements are not well harmonized between ICAO and states/nations at present. The states/nations listed within this position paper are not an exhaustive list but rather a sample of the varying implementations.

ICAO standard for new airplane model series

China, Hong Kong and Singapore have adopted ICAO Annex 6 Part I Table A8-1 (~ED-112A) mandatory FDR parameter requirements into regulation for new airplane model series (application for type certification) after 1 January 2023. As an example, an excerpt from Singapore CAAS Table 1-1 *Parameters to be recorded by Crash Protected Flight Data Recorders* shows that specific mandatory FDR parameter groups are identified as applicable only to airplanes with application for type certification after 1 January 2023.

Serial number	*Parameter*	*Applicability*	*Measurement range*	*Maximum sampling and recording interval (seconds)*	*Accuracy limits (sensor input compared to FDR read-out)*	*Recording resolution*
35*	Additional engine parameters (EPR, N_1, indicated vibration level, N_2, EGT, fuel flow, fuel cut-off lever position, N_3, engine fuel metering valve position)	Engine fuel metering valve position: Application for type certification is submitted to a Contracting State on or after 1 January 2023	As installed	Each engine each second	As installed	2% of full range

79*	Cabin pressure altitude	Application for type certification submitted to a Contracting State on or after 1 January 2023	As installed (0 ft to 40 000 ft recommended)	1	As installed	100 ft
80*	Aeroplane computed weight	Application for type certification submitted to a Contracting State on or after 1 January 2023	As installed	64	As installed	1% of full range
81*	Flight director command	Application for type certification submitted to a Contracting State on or after 1 January 2023	Full range	1	± 2%	0.5°
82*	Vertical speed	Application for type certification submitted to a Contracting State on or after 1 January 2023	As installed	0.25	As installed (32 ft/min recommended)	16 ft/min

ICAO standard for newly manufactured airplanes

India DGCA has adopted ICAO Annex 6 Part I mandatory FDR parameter requirements into regulation for new airplane model series and newly manufactured airplanes after 1 January 2023. India DGCA did not provide any consideration for newly manufactured airplanes, as EASA, UAE, UK have done (discussed below). India adopted the ICAO SARPs nearly verbatim, and ICAO unfortunately incorrectly included "shall" instead of "should" within the recommendation. This may not have been the intent of India DGCA to adopt the ICAO recommendation into regulation.

4.1.11 All aeroplanes of a maximum certificated take-off mass of over 5 700 kg for which the application for type certification is submitted on or after 1st January, 2023 shall be equipped with an FDR capable of recording at least the 82 parameters listed in Table-1 of Appendix-I.

4.1.12 All aeroplanes of a maximum certificated take-off mass of over 5700 kg for which the individual certificate of airworthiness is first issued on or after 1st January, 2023 shall be equipped with an FDR capable of recording at least the 82 parameters listed in Table-1 of Appendix-I.

The applicable ICAO Annex 6 part I SARPs are summarized below, with the incorrect "shall" instead of "should" within a recommendation highlighted in red font.

6.3.1.1.11 all airplanes > 5,700kg with application for type certification after 1 January 2023 shall record at least the 82 parameters in Table A8-1 of Appendix 8.

6.3.1.1.12 **Recommendation** all airplanes > 5,700kg with application for type certification after 1 January 2023 shall record at least the 82 parameters in Table A8-1 of Appendix 8.

EUROCAE ED-112A with 'extensive modification' exception

EASA, UAE and UK have adopted ED-112A mandatory FDR parameter requirements into part-CAT (Commercial Air Transport) AMC1.2 CAT.IDE.A.190 *Flight Data Recorder* for newly manufactured airplanes (initial certificate of airworthiness) after 1 January 2023. The Acceptable Means of Compliance (AMC) includes an exclusion for new mandatory FDR parameters, which would require 'extensive modification' to the airplane systems & equipment, other than the flight data recording system. This 'extensive modification' is limited to newly manufactured airplanes with application for type certification prior to 1 January 2023 (existing airplane model series). The term 'extensive modification' is effectively "any change other than the flight data recording system." Thus, if any change other than the flight data recording system were necessary to add new mandatory FDR parameter(s) to an existing airplane model series, then the new mandatory FDR parameter(s) would not be required to be added.

As an example, if a change was required to the display system and/or airplane wiring to provide new parameter data to the flight data recording system, it would not be required for newly manufactured airplanes for existing airplane model series (with initial application for type certification submitted prior to 1 January 2023). Such a change would be required for any new airplane model series with application for type certificate after 1 January 2023, however.

	Newly manufactured airplanes after 1 January 2023	
	Type certification submitted prior to 1 January 2023	**Type certification submitted on or after 1 January 2023**
AMC1.2 CAT.IDE.A.190 FDR parameter requirements	Not all mandatory FDR parameters required, if 'extensive modification' required for ED-112A parameters	All mandatory FDR parameters required (no 'extensive modification' exclusion)

An excerpt of the AMC is provided below for the new ED-112A parameters.

AMC1.2 CAT.IDE.A.190 Flight data recorder

ED Decision 2021/005/R

OPERATIONAL PERFORMANCE REQUIREMENTS FOR AEROPLANES FIRST ISSUED WITH AN INDIVIDUAL CofA ON OR AFTER 1 JANUARY 2023

(b) The FDR should, with reference to a timescale, record:

(1) the list of parameters in Table 1 below;

(2) the additional parameters listed in Table 2 below, when the information data source for the parameter is used by aeroplane systems or is available on the instrument panel for use by the flight crew to operate the aeroplane; and

(c) The parameters to be recorded should meet the performance specifications (range, sampling intervals, accuracy limits and resolution in read-out) as defined in the relevant tables of EUROCAE Document 112A, or any later equivalent standard produced by EUROCAE.

Table 1: FDR — All aeroplanes

No*	**Parameter**
2	Pressure altitude (including altitude values displayed on each flight crew member’s primary flight display, unless the aeroplane is type certified before 1 January 2023 and recording the values displayed at the captain position or the first officer position would require extensive modification)
3	Indicated airspeed or calibrated airspeed (including values of indicated airspeed or calibrated airspeed displayed on each flight crew member’s primary flight display, unless the aeroplane is type certified before 1 January 2023 and recording the values displayed at the captain position or the first officer position would require extensive modification)
6	Pitch attitude — pitch attitude values displayed on each flight crew member’s primary flight display should be recorded, unless the aeroplane is type certified before 1 January 2023 and recording the values displayed at the captain position or the first officer position would require extensive modification.
7	Roll attitude — roll attitude values displayed on each flight crew member’s primary flight display should be recorded, unless the aeroplane is type certified before 1 January 2023 and recording the values displayed at the captain position or the first officer position would require extensive modification.

*The number in the left-hand column reflect the serial number depicted in EUROCAE Document 112A.

Table 2: FDR — Aeroplanes for which the data source for the parameter is either used by the aeroplane systems or is available on the instrument panel for use by the flight crew to operate the aeroplane

No*	**Parameter**
No*	**Parameter**
35 35i	Additional engine parameters (if not already recorded in parameter 9 of Table 1, and if the aeroplane is equipped with a suitable data source) Engine fuel metering valve position (or equivalent parameter from the system that directly controls the flow of fuel into the engine) – for aeroplanes type certified before 1 January 2023, to be recorded only if this does not require extensive modification.
79	Cabin pressure altitude – for aeroplanes type certified before 1 January 2023, to be recorded only if this does not require extensive modification
80	Aeroplane computed weight – for aeroplanes type certified before 1 January 2023, to be recorded only if this does not require extensive modification
81 81a 81b 81c 81d	Flight director command: Left flight director pitch command – for aeroplanes type certified before 1 January 2023, to be recorded only if this does not require extensive modification Left flight director roll command – for aeroplanes type certified before 1 January 2023, to be recorded only if this does not require extensive modification Right flight director pitch command – for aeroplanes type certified before 1 January 2023, to be recorded only if this does not require extensive modification Right flight director roll command – for aeroplanes type certified before 1 January 2023, to be recorded only if this does not require extensive modification
82	Vertical speed – for aeroplanes type certified before 1 January 2023, to be recorded only if this does not require extensive modification

*The number in the left-hand column reflect the serial number depicted in EUROCAE Document 112A.

The term ‘extensive modification’ is defined as “cannot be achieved without extensive modification to the aeroplane system and equipment other than the flight recording system” in AMC2 CAT.IDE.A.190.

The following figure provides a summary of the ICAO and state/nation regulation:

EUROCAE ED-112B

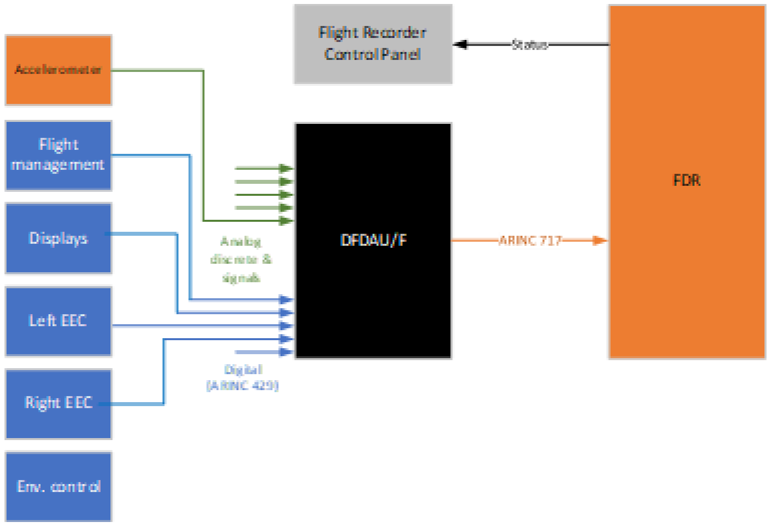
ICAO has not yet considered adoption of ED-112B mandatory FDR parameters into a standard or recommended practice.

No state/nation is known to have adopted the intent of ED-112B mandatory FDR parameters into regulation.

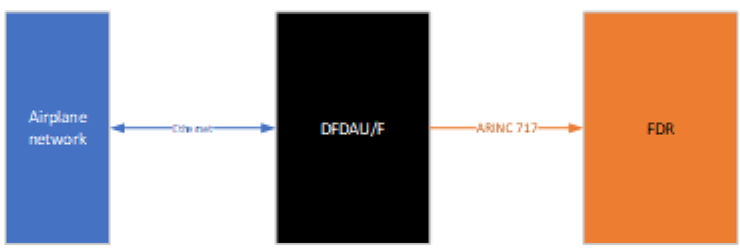
Impact

The flight data recording system is at minimum comprised of a digital flight data acquisition function and flight data recorder, which provides the crash protected memory module to enable recovery of flight data in the event of an accident. The digital flight data acquisition function may be a separate line replaceable unit (e.g. digital flight data acquisition unit), a function within integrated modular avionics, or integrated within the flight data recorder itself. A dedicated flight deck control panel may be used for test and status indication.

Flight data parameters are provided to the digital flight data acquisition function/unit typically via a combination of analog sensors, some of which may be dedicated to the flight data recording system, and digital data (e.g. ARINC 429) from source systems (a system that provides data to the flight data recording system, e.g. flight management function, displays, electronic engine controller, etc.). The digital flight data acquisition function/unit samples analog and digital inputs to provide a subset of received data to the flight data recorder via digital bus (e.g. ARINC 717). The flight data recorder receives the data from the digital flight data acquisition function/unit and stores it within crash-protected memory.



Source system data is provided via Ethernet networks on newer airplane models, negating the need for dedicated wiring for analog and digital sources. An airplane network configuration change may then be required to provide new parametric data to the digital flight data acquisition function/unit, instead of an airplane wiring change for older airplane models.



The flight data recording function is typically configured via an airplane loadable software database which identifies the input of each mandatory FDR parameter and location within the mandatory FDR data frame (e.g. ARINC 717) stored in FDR crash protected memory.

The digital flight data acquisition function/unit is able to acquire and send parameter data to the flight data recorder only for what is provided to it by source systems. That is to say, if a source system is not connected to the digital flight data acquisition function/unit, an airplane wiring or airplane network configuration change may be required to add mandatory FDR parameters for this new source system. Alternatively, if a source system is connected to the digital flight data acquisition function/unit via a digital bus or Ethernet network, but the new mandatory FDR parameters are not present then the source system would require revision to include additional data on the existing digital bus or Ethernet network. Most source systems have a higher design assurance level than the flight data recording system developed and certified to design assurance level D (minor hazard classification). Thus, the impact to revise source systems (and airplane network) to address flight data recording parameters can be significant with regard to technical complexity, resources and schedule.

ANALYSIS:

The following provides the subgroup's analysis of the harmonization and impact of additional mandatory FDR parameters

Harmonization

EUROCAE ED-112B

FAA adoption of EUROCAE ED-112B (2023) mandatory FDR parameter requirements for any applicability (new airplane model series, newly manufactured airplanes, existing airplanes) would not harmonize with ICAO nor any other state/nation civil aviation agency.

- ICAO has not adopted a standard or recommend practice for ED-112B mandatory FDR parameters.
- No state/nation civil aviation agency is known to have adopted a regulation for ED-112B mandatory FDR parameters.

ICAO standard for new airplane model series

FAA adoption of ICAO Annex 6 Part I Table A8-1 (~ED-112A) mandatory FDR parameter requirements could harmonize with ICAO and other state/nation civil aviation agencies, depending on the applicability.

- FAA adoption of ICAO mandatory FDR parameter requirements for new airplane model series would harmonize with ICAO and other state/nation civil aviation agencies (China, Hong Kong, Singapore).
- FAA adoption of ICAO mandatory FDR parameter requirements for newly manufactured airplanes with an 'extensive modification' exception would not harmonize with ICAO, but would harmonize with other state/nation civil aviation agencies (EASA, UAE, UK).
- FAA adoption of ICAO mandatory FDR parameter requirements for newly manufactured airplanes without an 'extensive modification' exception would not harmonize with ICAO, and would harmonize with only India DGCA.
- FAA adoption of ICAO mandatory FDR parameter requirements for existing airplanes (retrofit) would not harmonize with ICAO nor any other state/nation civil aviation agency.

Impact

The complexity of development and certification of additional mandatory FDR parameters varies depending on

- which mandatory FDR parameter requirements are adopted into regulation (how many parameter groups are revised or added),
- the applicable airplanes (models) subject to the regulation, and
- whether an exception is allowed for new mandatory FDR parameters on existing airplane model series.

In general, the complexity increases both with a) the latest mandatory FDR parameter requirements and b) the age of the affected airplanes. Older airplane models had less stringent mandatory FDR parameter requirements at the time of manufacture therefore would require more effort to bring up to the latest industry standard. Older airplane models tend towards a federated architecture which is more difficult to provide data to the flight data recording system (source system may not output the required data, airplane wiring changes may be required).

The flight data recording system does not itself generate the mandatory FDR parameters, except in the limited case where there are sensors dedicated to the flight data recording system. New mandatory FDR parameters may require the installation of dedicated sensors if not already provided for use by airplane systems. Other airplane systems, many of which are high-criticality (e.g. displays), and the engines provide the majority of the data to the flight data recording system. Not all airplane systems and digital buses are connected to the flight data recording system; therefore, adding new parameter requirements may require changes to airplane wiring. Changes to high-criticality systems (even simply to add data to an existing digital bus) are not trivial, costing hundreds of thousands or millions of dollars to design & certify, including airplane demonstration of proper function. An airplane system may be installed per a supplier's supplemental type certification, requiring coordination and separate certification for revision to a supplier's type design to accommodate additional mandatory FDR parameters.

The impact of additional mandatory FDR parameter requirements for a new airplane model series is far less than an existing model series, as the new airplane model series can be designed from the start to address the new requirements. That is to say, it is significantly higher impact to modify existing certified airplane type design than to incorporate into a new not yet certified airplane model series.

The impact of additional mandatory FDR parameter requirements for newly manufactured airplanes (existing model series) is greater than if limited to new airplane model series, due to multiple concurrent type design changes required for airplane manufacturers with multiple existing airplane models.

Additional mandatory FDR parameters could impact military commercial derivative aircraft, despite these aircraft not being used for commercial air transport.

Multiple concurrent design and certification projects place more strain on design engineering and certification resources.

EUROCAE ED-112A (2013) additional mandatory FDR parameters

EUROCAE ED-112A (2013) included changes to existing and new mandatory FDR parameter requirements, relative to ED-112 (2003):

- increase sample rate from
  - 0.25 (4Hz) to 0.125 (8Hz) for longitudinal acceleration, lateral acceleration, primary flight control pilot input for pitch axis, roll axis & yaw axis,
  - 4 (1/4Hz) to 1 (1Hz) for navigation data,
  - 1 (1Hz) to 0.5 (2Hz) for yaw or sideslip angle,
  - 1 (1Hz) to 0.25 (4Hz) for cockpit flight control input forces,
- reduce resolution from 0.002 to 0.0002 for latitude and longitude,
- add first officer values for pressure altitude, calibrated/indicated airspeed, pitch attitude, roll attitude,*
- add engine fuel valve metering position, cabin pressure altitude, aircraft computed weight, flight director command and vertical speed

**ICAO Annex 6 Part I Table A8-1 does not require first officer values for pressure altitude, calibrated/indicated airspeed, pitch attitude, roll attitude.*

No change would be required to the flight data recording system if the existing mandatory database software already satisfies ED-112A mandatory FDR parameter requirements, including those added in ED-112A at the required sample rate.

A change would be required to the flight data recording system and potentially source systems & airplane wiring if the existing mandatory database software does not already satisfy ED-112A mandatory FDR parameter requirements.

- Increasing sample rate for an existing mandatory FDR parameter group may require a revision to the source system if digital data is not provided at a sufficiently high rate to preclude stale data recorded on the FDR. For example if the data is provided at 1Hz but the recording requirement is 2Hz, a revision would be required to the source system to increase the data transmittal rate.

- Adding new mandatory FDR parameter groups may require changes to source system(s) and/or airplane wiring depending on whether the flight data recording system already receives and records the data on the FDR.

An existing airplane model with a flight data recording system designed to ED-112, which does not meet all ED-112A parameter requirements, is provided as a notional example.

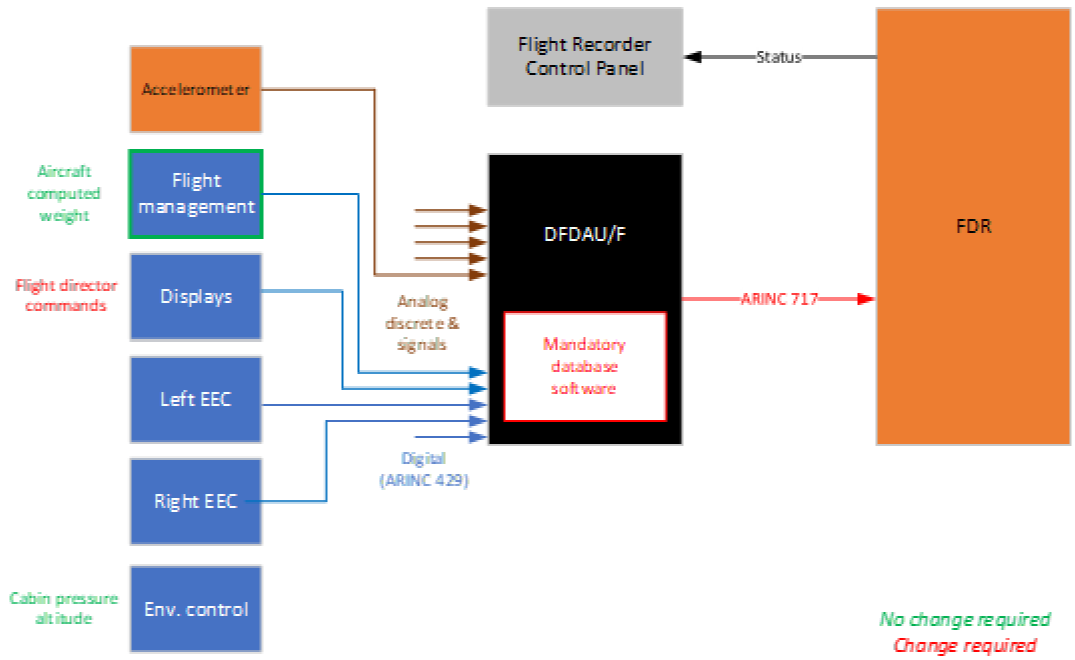
1. The flight management system receives **cabin pressure altitude**, but requires modification to provide to the digital flight data acquisition function/unit on the existing digital bus.
2. The display system generates **flight director commands** and provides to the flight data recording system, but the digital flight data acquisition function/unit does not acquire this data within the mandatory database software.

The impact to source systems and the flight data recording system for an existing model is dependent on applicability of the regulation mandating ED-112A mandatory FDR parameter requirements. The following discussion addresses a non-networked airplane as an example, but similar concepts regarding additional type design changes beyond the flight data recording system apply to a networked airplane (instead of airplane wiring changes, a networked airplane may require changes to the network configuration).

- Regulation applies only to new airplane model series: the existing airplane model is not impacted thus no change required to displays or flight data recording systems.
- Regulation applies to newly manufactured airplanes with ‘extensive modification’ exclusion for existing airplane model series: the existing airplane model would be affected, but only for changes required to the digital flight data acquisition function/unit mandatory database software.

    1. **Aircraft computed weight** requires a change to the flight management system to include the data on an existing digital bus, thus would not be applicable.
    2. **Flight director commands** require a change only to the flight data recording system, so would be applicable.
    3. **Environmental control system** has cabin pressure altitude on an existing digital bus, but requires an airplane wiring change to connect to the digital flight data acquisition function/unit.

    The digital flight data acquisition function/unit mandatory database software is revised to acquire flight director commands from displays system to provide to the flight data recorder.



- Regulation applies to newly manufactured airplanes: the existing airplane model would be affected, with changes required to the flight data recording system, source systems and airplane wiring as necessary.
    1. **Aircraft computed weight** requires a change to the flight management system to include the data on an existing digital bus.
    2. **Flight director commands** require a change only to the flight data recording system.
    3. **Environmental control system** requires an airplane wiring change to connect the digital bus to the flight data recording system.

The flight management system is revised to include cabin pressure altitude on the digital bus provided to the digital flight data acquisition function/unit.

The airplane wiring is revised to connect the environmental control system digital bus to the digital flight data acquisition function/unit.

The mandatory database software is revised to acquire cabin pressure altitude from the flight management system, flight director commands from displays system, and cabin pressure altitude from environmental control system to provide to the flight data recorder.

Airplane manufacturers have in the past few years developed and certified flight data recording systems for some, but not all , airplane model series currently in production to address EASA, UAE and UK ED-112A mandatory FDR parameter requirements in part-CAT AMC1.2 CAT.IDE.A.190 with an ‘extensive modification’.

Complexity of ED-112A mandatory FDR parameter requirements for newly manufactured airplanes is dependent on requirement and the airplane design. Airplane model series not recently revised would comply with ED-112. Other airplane model series may not fully comply with ED-112A due to EASA, UAE and UK ‘extensive modification’ exception.

Requirement	**Airplane Design**	**Change**
ED-112A with ‘extensive modification’	ED-112	Marginally complex
	ED-112A with ‘extensive modification’	No change required
	ED-112A	No change required
ED-112A	ED-112	Complex*
	ED-112A with ‘extensive modification’	Complex*
	ED-112A	No change required

**Increased complexity for airplane models which require source system and/or airplane wiring changes to comply with ED-112A mandatory FDR parameter requirements.*

EUROCAE ED-112B (2023) additional mandatory FDR parameters

EUROCAE ED-112B (2023) added significantly more mandatory FDR parameter requirements, relative to ED-112A (2013) and ED-112 (2003):

- increase sample rate from

- o 2 (1/2Hz) to 1 (1Hz) for flaps (trailing edge flap position & cockpit control selection),
- o 1 (1Hz) to 0.5 (2Hz) for vertical beam deviation (ILS/GPS/GLS glide path, MLS elevation, IRNAV/I/AN vertical deviation), horizontal beam deviation (ILS/GPS/GLS localizer, MLS azimuth, IRNAV/I/AN lateral deviation),
- o 4 (1/4Hz) to 0.5 (2Hz) for landing gear (landing gear position & gear selector position),
- o 4 (1/4Hz) to 1 (1Hz) for ice detection, de-icing and/or anti-icing systems selection,

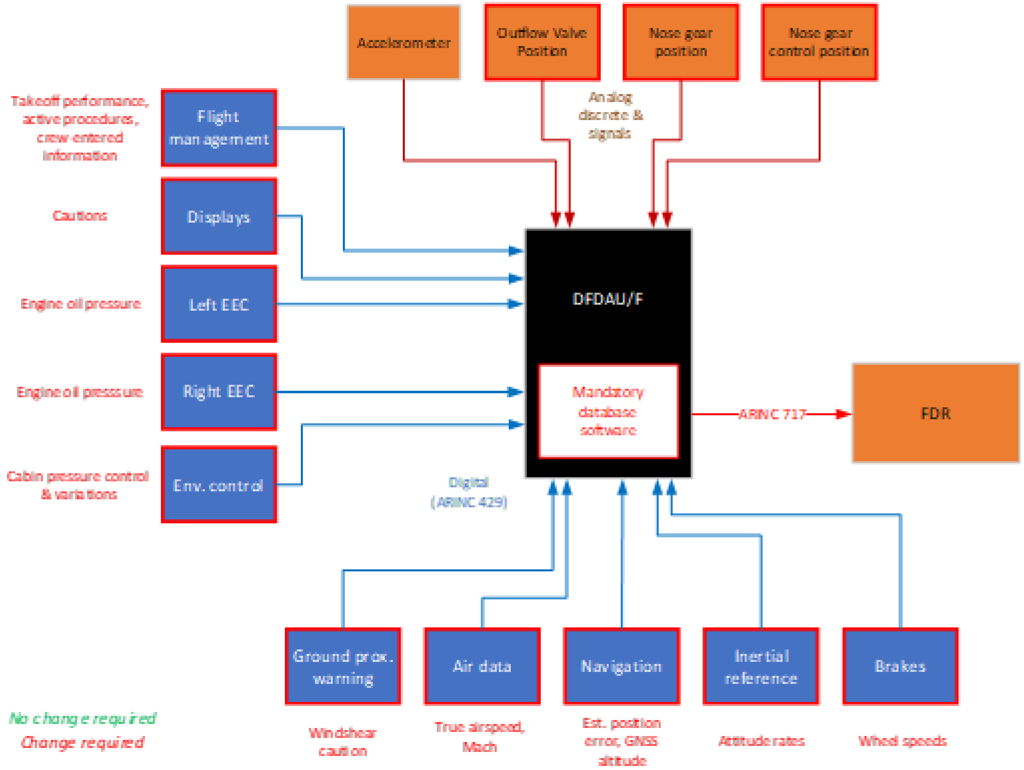
- add cautions presented to the flight crew on a multi-function engine/alerts electronic display and for windshear,
- add estimated position error, GNSS altitude, engine parameters (engine oil pressure, blade angle, condition lever position), cabin pressure control & variations (cabin altitude rate, outflow valve position, cabin pressurization control – selected mode), nose wheel steering (nose wheel steering angle, nose wheel steering control position), aircraft track, true airspeed/Mach number, takeoff performance parameters (V_r, V_1, V_2, selected take-off modes or values), designation of active procedures (selected SID route, selected STAR route, next active waypoint, selected landing runway), attitude rates (pitch, roll, yaw), wheel speed (measured wheels), crew-entered information used for performance, control and engine calculations.

Adoption of ED-112B mandatory FDR parameter requirements for newly manufactured airplanes would be highly complex, particularly if an exception is not provided that only the flight data recording system need be revised, due to the large number of new mandatory FDR parameter groups anticipated to require changes to source systems, airplane wiring and new sensors. The impact would be higher for airplane model series which received initial type certification in the 20th century which use more federated systems and analog sensors & discretes.

- Increasing sample rate for an existing mandatory FDR parameter group may require a revision to the source system if digital data is not provided at a sufficiently high rate to preclude stale data recorded on the FDR.
- Added windshear cautions could potentially require revision to the ground proximity warning system and airplane wiring to provide the windshear cautions to the flight data recording system.
- Adding cautions from the multi-function engine/alerts electronic display is not trivial due to the large number of cautions (estimated to be between 100 and 250) and the anticipated need to revise the display/alerting system to provide caution data to the flight data

recording system. Due to the large number of alerts, a new digital bus (new airplane wiring) may be required. Although new warnings are added rarely, it is not unusual for new cautions to be added to the alerting system. Each time a caution is added, the digital flight data function/unit mandatory database software could require revision.

- Adding additional navigation data could potentially require revision to the navigation system to provide the new parameters for estimated position error & GNSS altitude to the flight data recording system.
- Adding additional engine parameters could potentially require revision to the electronic engine controllers to provide the new parameters for engine oil pressure, etc. to the flight data recording system.
- Adding cabin pressure control parameters could potentially require revision to the environmental control system and new airplane wiring to provide new data to the flight data recording system. The new outflow valve position parameter may require a new sensor to measure the valve position, analog to digital conversion and a digital bus to provide measured position to the flight data recording system.
- True airspeed and Mach could require revision to the air data or display system and new airplane wiring to provide data to the flight data recording system.
- Adding nose wheel steering angle and control position may require new sensors on the nose gear itself and nose gear controls within the flight deck, analog to digital conversion and airplane wiring, such that the data could be provided to the flight data recording system. Other source systems which currently use nose gear data but do not currently provide to the flight data recording system could be impacted.
- Attitude rates could potentially require revision to the inertial reference system and new airplane wiring to provide data to the flight data recording system.
- Wheel speeds could potential require revision to source system and new airplane wiring to provide data to the flight data recording system.
- Takeoff performance, designation of active procedure and crew-enter information used for performance control & engine calculations could potentially require revision to the flight management system and new airplane wiring to provide data to the flight data recording system.



RECOMMENDATIONS:

This subgroup supports the incremental safety improvements of additional mandatory FDR parameters, and recommends the FAA consider the following:

1. Adoption of EUROCAE ED-112B (2023) mandatory FDR parameter requirements is not recommended at this time as

    - neither ICAO nor any other nation has adopted ED-112B requirements,
    - industry has recently expended considerable resources to develop and certify revised flight data recording systems for existing airplane models to comply with ED-112A (with 'extensive modification') for the European Union, UAE and UK, and
    - there is no known NTSB safety recommendation referencing ED-112B mandatory FDR parameter requirements for newly manufactured airplanes or new airplane model series.

2. Harmonization is recommended with ICAO and those states/nations that have adopted ICAO Annex 6 Part I Table A8-1 (~ED-112A) for new airplane model series (application for type certification). There is no known NTSB safety recommendation referencing ED-112A or ICAO mandatory FDR parameter requirements for newly manufactured airplanes or new airplane model series.

Operational regulation could be revised as follows, using 14 CFR part 121 as an example:

14 CFR 121.344 *Digital flight data recorders for transport category airplanes.*

(a) Except as provided in…a change in installed equipment.

(91) Standby rudder valve status

(92) Cabin pressure altitude

(93) Airplane computed weight

(94) Flight director command

(95) Vertical speed

(f) For all turbine-engine-powered transport category airplanes manufactured after August 19, 2002—

(1) The parameters listed in paragraphs (a)(1) through (a)(88) of this section must be recorded within the ranges, accuracies, resolutions, and recording intervals specified in appendix M to this part.

(x) For all turbine-engine powered transport category airplanes with application for type certification on or after <applicability date> -

(1) The parameters listed in paragraphs (a)(1) through (a)(95) of this section must be recorded within the ranges, accuracies, resolutions, and recording intervals specified in appendix Q to this part.

A new Appendix Q to Part 121 Airplane Flight Recorder Specifications would include the intent of ICAO Annex 6 Part I Table A8-1 for existing and new mandatory FDR parameters.

3. If the FAA elects to adopt ICAO Annex 6 Part I Table A8-1 (~ED-112A) requirements for newly manufactured airplanes, it is recommended to include an ‘extensive modification’ exclusion for existing airplane model series (similar to EASA AMC1.2 CAT.IDE.A.190). It is not recommended to adopt ICAO Annex 6 part I Table A8-1 requirement for newly manufactured airplanes without an ‘extensive modification’ exception for new mandatory FDR parameters.

The following table illustrates the difference in scope for type design changes for newly manufactured airplanes when an ‘extensive modification’ is included and not included for existing airplane model series.

Type design change	**Newly manufactured airplanes with 'extensive modification' exception**	**Newly manufactured airplanes**
Flight data recording system	Yes	Yes
Airplane wiring / network configuration	No	Yes
Source system(s)	No	Yes

The subgroup recommends sufficient time for design and certification related to additional mandatory FDR parameters, should the FAA adopt for newly manufactured airplanes

- at least three (3) years with 'extensive modification' exception
- at least five (5) years without 'extensive modification' exception due to the increased complexity of modifying airplane wiring / network configuration and/or source system(s).

Operational regulation could be revised as follows, using 14 CFR part 121 as an example:

(x) For all turbine-engine powered transport category airplanes that are manufactured on or after <applicability date> -

(1) The parameters listed in paragraphs (a)(1) through (a)(95) of this section must be recorded within the ranges, accuracies, resolutions, and recording intervals specified in appendix Q to this part for airplane model series with application for type certification before <applicability date>, except if modification is required other than the flight data recording system for (a)(43)(92)(93)(94)(95) as noted in appendix Q to this part.)(2) The parameters listed in paragraphs (a)(1) through (a)(95) of this section must be recorded within the ranges, accuracies, resolutions, and recording intervals specified in appendix Q to this part for airplanes with application for type certification on or after <applicability date>)A new Appendix Q to Part 121 Airplane Flight Recorder Specifications would include the intent of ICAO Annex 6 Part I Table A8-1 parameter requirements for existing and new mandatory FDR parameters.) 43. Additional Engine Parameters Remarks "Where capacity permits, the preferred priority is indicated vibration level, N2, EGT, Fuel Flow, Fuel Cut-off lever position, N3, and engine fuel metering valve position[20] unless engine manufacturer recommends otherwise.")92. Cabin Pressure Altitude[20])93. Airplane Computed Weight[20])94. Flight Director Command[20])95. Vertical Speed[20]) [20]Except if modification is required other than the flight data recording system for airplane model series with application for type certification before <applicability date>.))Adoption of any additional mandatory FDR parameter requirements for existing

airplanes (retrofit) is not recommended due to the very high complexity / impact of modifying out of production airplanes. There is no known NTSB safety recommendation referencing additional (e.g. ICAO or EUROCAE) mandatory FDR parameter requirements for existing airplanes.))**REFERENCE:**

1. ICAO Annex 6 *Operation of Aircraft* Part I *International Commercial Air Transport - Aeroplanes*
2. EUROCAE ED-112, *Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems*, March 2003
3. EUROCAE ED-112A, *Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems*, September 2013
4. EUROCAE ED-112B, *Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems*, August, 2023

B2: Distress Tracking

The following draft position papers written by the HRT group participants regarding different charter taskings are included to present a full picture of the HRT group's thought processes and key concerns in their own words, as well as further background on each of the areas discussed. They are presented exactly as written and do not represent the position of the full ARC.

Proposed Rule Making To Require Part 121 & 135 Aircraft with a tamper-resistant method to broadcast to a ground station sufficient information to establish the location of an aircraft after the flight has terminated due to a crash within six (6) Nautical Miles of the point of impact.

Introduction

The Federal Aviation Administration (FAA) created a charter to establish the Investigative Technologies Aviation Rulemaking Committee (ARC) June 6, 2023. Two subsequent revisions updated the ARC Charter. The ARC will provide a forum for the United States aviation community to discuss, prioritize, and provide recommendations to the FAA concerning requirements on the installation of existing, new, and upgraded investigative technologies that affect applicable airworthiness standards and operating rules.

The purpose of this paper is to address one objective outlined in the charter which establishes the location of an aircraft after the flight has terminated due to a crash within six (6) Nautical Miles of the point of impact. This is applicable to extended overwater operations of applicable Part 121/135 Aircraft.

Per the Investigative Technologies ARC Charter(s):

Effective Date: 6/7/2023 Amendment #1: 9/21/2023

4 e) ii. Whether to require that aircraft used in extended overwater operations under Part 121 or Part 135, which are required to have a CVR and a FDR, be equipped with a tamper-resistant method to broadcast to a ground station sufficient information to establish the location of an aircraft after the flight has terminated due to a crash within six (6) Nautical Miles of the point of impact.

Amendment #2: 12/12/2024 [BOLD highlights changes]

4 e) ii. Whether to require that aircraft used in extended overwater operations under Part 121 or Part 135, which are required to have a CVR and a FDR, be equipped with a tamper-resistant method to broadcast to a ground station sufficient information to establish the location of an aircraft after the flight has terminated due to a crash within six (6) Nautical Miles of the point of impact ***in consideration of the mandate in section 352 of the Act .(A-15-1)***

4 m) In addition to tasks 4.e.ii, 4.e.iii, and 4.e.iv of this charter, discuss and develop the following:

i. ***Recommendations on whether to apply the requirements regarding flight data recovery in section 352 of the Act to other aircraft in addition to those that meet the definition of "applicable aircraft" in Section 352.***

ii. ***Quantitative cost and benefit data for the inclusion of flight data recovery technologies for aircraft that meet the definition of "applicable aircraft" in section 352 and other aircraft under consideration.***

iii. **A qualitative description of the potential impacts for the inclusion of flight data recovery technologies for aircraft that meet the definition of "applicable aircraft" in section 352 and other aircraft under consideration.**

It should be noted that the ARC Tasking and the FAA Re-Authorization Act (PLAW 118-63 Section 352) highlight the need to locate the site of an aircraft crash based on the broadcast (i.e. transmission) of sufficient information. This is very similar, yet not strictly the same, as existing and now implemented international regulations regarding aircraft Distress Tracking under the Global Aeronautical Safety System. This paper will reference, compare, and contrast these internation regulations and offer recommendations of harmonization.

This position paper will review current avionics systems that can achieve this objective, barriers that may make implementation of this objective into Federal regulations difficult or cost prohibitive to the OEMs and airlines, and a set of recommendations based on the sub-committee's findings for the FAA to consider as part of their rule making proceedings.

Applicable References

This section introduces the applicable references to address the tasking of the ARC charter. Both national (USA) and international regulations and standards are cited to develop harmonized recommendations. The discussion, analysis, and recommendations of this paper will refer to this section.

NTSB Safety Recommendation a-15-001-008 [2015]

The NTSB issued Safety Recommendation a-15-001-008 in January 2015 re-iterating that recovering the recorders (FDR, CVR) is an investigative priority at the crash site. Then recent events prior to 2015 highlighted that recovering flight data can be costly and difficult when an accident occurs in a remote area, outside of radar coverage. Cited in the Safety Recommendation is the example, the 2009 Air France 447 crash in the mid-Atlantic which resulted in not finding the FDR/CVR for almost 2 years after the accident. Also included is the 2014 disappearance of Malaysian Airline 370, which was never found despite extensive search efforts. The Safety Recommendation A15-01 pertinent to the ARC Charter is cited on Page 11.

Require that all aircraft used in extended overwater operations and operating under Title 14 Code of Federal Regulations (1) Part 121 or (2) Part 135 that are required to have a cockpit voice recorder and a flight data recorder, be equipped with a tamper-resistant method to broadcast to a ground station sufficient information to establish the location where an aircraft terminates flight as the result of an accident within 6 nautical miles of the point of impact. (A-15-1)

[…..]

Concurrent with the implementation of Safety Recommendations A-15-1 and A-15-3, coordinate with other international regulatory authorities and the International Civil Aviation Organization to harmonize the implementation of the requirements outlined in Safety Recommendations A-15-1 and A-15-3. (A-15-4)

FAA Reauthorization Act of 2024 - PUBLIC LAW 118–63

SEC. 352. FLIGHT DATA RECOVERY FROM OVERWATER OPERATIONS.

(a) FLIGHT DATA RECOVERY FROM OVERWATER OPERATIONS.— Chapter 447 of title 49, United States Code, is further amended by adding at the end the following:

§ 44746. Flight data recovery from overwater operations

(a) IN GENERAL.—Not later than 18 months after the date of enactment of this section, the Administrator of the Federal Aviation Administration shall complete a rulemaking proceeding to require that, not later than 5 years after the date of enactment of this section, all applicable aircraft are—

(1) fitted with a means, in the event of an accident, to recover mandatory flight data parameters in a manner that does not require the underwater retrieval of the cockpit voice recorder or flight data recorder;

(2) equipped with a tamper-resistant method to broadcast sufficient information to a ground station to establish the location where an applicable aircraft terminates flight as the result of such an event; and

(3) equipped with an airframe low-frequency underwater locating device that functions for at least 90 days and that can be detected by appropriate equipment.

(b) APPLICABLE AIRCRAFT DEFINED.—In this section, the term 'applicable aircraft' means an aircraft manufactured on or after January 1, 2028, that is—

(1) operated under part 121 of title 14, Code of Federal Regulations;

(2) required by regulation to have a cockpit voice recorder and a flight data recorder; and

(3) used in extended overwater operations.".

(b) CLERICAL AMENDMENT.—The analysis for chapter 447 of title 49, United States Code, is further amended by adding at the end the following:

"44746. Flight data recovery from overwater operations.".

As defined in 14 CFR 1.1, Extended over-water operation means—

(1) With respect to aircraft other than rotorcraft, an operation over water at a horizontal distance of more than 50 nautical miles from the nearest shoreline; and

(2) With respect to rotorcraft, an operation over water at a horizontal distance of more than 50 nautical miles from the nearest shoreline and more than 50 nautical miles from an off-shore heliport structure.

ICAO Annex 6 Part 1 – International Commercial Air Transport

The ICAO Annex 6 Part 1 Amnd 48 outlines the Specifications and Recommended Practices (SARPs) for Commercial Air Transport. There are three main sections cited: 6.18, Appendix 9, and Attachment H which are primarily concerned with the Global Aeronautical Distress & Safety System (GADSS). These SARPs represent the primary reference for GADSS which national authorities then construct laws and regulations. Note that the implementation deadlines were extended from January 2021 to January 2025. This is outlined in the EU/EASA section with the pertinent regulations.

6.18 LOCATION OF AN AEROPLANE IN DISTRESS

6.18.1 As of 1 January 2025, all aeroplanes of a maximum certificated take-off mass of over 27 000 kg for which the individual certificate of airworthiness is first issued on or after 1 January 2024, shall autonomously transmit information from which a position can be determined by the operator at least once every minute, when in distress, in accordance with ***Appendix 9****.*

6.18.2 Recommendation.— All aeroplanes of a maximum certificated take-off mass of over 5 700 kg for which the individual certificate of airworthiness is first issued on or after 1 January 2023, should autonomously transmit information from which a position can be determined at least once every minute, when in distress, in accordance with ***Appendix 9****.*

6.18.3 The operator shall make position information of a flight in distress available to the appropriate organizations, as established by the State of the Operator.

Annex 6 Part 1 – Appendix 9

1. PURPOSE AND SCOPE : Location of an aeroplane in distress aims at establishing, to a reasonable extent, the location of an accident site within a 6 NM radius.

2. OPERATION

2.1 An aeroplane in distress shall automatically activate the transmission of information from which its position can be determined by the operator and the position information shall contain a time stamp. It shall also be possible for this transmission to be activated manually. The system used for the autonomous transmission of position information shall be capable of transmitting that information in the event of aircraft electrical power loss, at least for the expected duration of the entire flight.

Note.— Guidance on the location of an aeroplane in distress is provided in ***Attachment H****.*

2.2 An aircraft is in a distress condition when it is in a state that, if the aircraft behaviour event is left uncorrected, can result in an accident. Autonomous transmission of position information shall be active when an aircraft is in a distress condition. This will provide a high probability of locating an accident site to within a 6 NM radius. The operator shall be alerted when an aircraft is in a distress condition with an acceptable low rate of false alerts. In case of a triggered transmission system, initial transmission of position information shall commence immediately or no later than five seconds after the detection of the activation event.

Note 1.— Aircraft behaviour events can include, but are not limited to, unusual attitudes, unusual speed conditions, collision with terrain and total loss of thrust/propulsion on all engines and ground proximity warnings.

Note 2.— A distress alert can be triggered using criteria that may vary as a result of aircraft position and phase of flight. Further guidance regarding in-flight event detection and triggering criteria may be found in the EUROCAE ED-237, Minimum Aviation System Performance Specification (MASPS) for Criteria to Detect In-Flight Aircraft Distress Events to Trigger Transmission of Flight Information.

2.3 When an aircraft operator or an air traffic service unit (ATSU) has reason to believe that an aircraft is in distress, coordination shall be established between the ATSU and the aircraft operator.

2.4 The State of the Operator shall identify the organizations that will require the position information of an aircraft in an emergency phase. These shall include, as a minimum:

a) air traffic service unit(s) (ATSU); and

b) SAR rescue coordination centre(s) (RCC) and sub-centres.

2.5 When autonomous transmission of position information has been activated, it shall only be able to be deactivated using the same mechanism that activated it.

2.6 The accuracy of position information shall, as a minimum, meet the position accuracy requirements established for ELTs.

Annex 6 Part 1 – Attachment H

2. CLARIFICATION OF PURPOSE OF EQUIPMENT

2.1 Information from which a position can be determined: Information from an aircraft system which either is active, or, when automatically or manually activated, can provide position information which includes a time stamp. This is a performance-based requirement which is not system-specific and may also bring operational benefits

2.2 Emergency locator transmitter (ELT): The current generation of ELTs were designed to provide the position of impact for a survivable accident. The next generation of ELTs may have the capability to activate a transmission in flight when any of the conditions detailed in EUROCAE ED-237, Minimum Aviation System Performance Specification (MASPS) for Criteria to Detect In-Flight Aircraft Distress Events to Trigger Transmission of Flight Information are met. When an ELT sinks below the surface of water, its signal is not detectable.

2.3 Automatic deployable flight recorder (ADFR): The purpose of an ADFR is to have flight recorder data available soon after an accident, in particular for accidents over water. The integrated ELT provides for both locating the accident site for accident investigation and search and rescue purposes. Being floatable, it will assist in locating the accident site by providing an ELT signal when the wreckage sinks below the surface of the water. It also ensures redundancy for one ELT.

2.4 Underwater locator device (ULD): A ULD operating at a frequency of 8.8 kHz is attached to the airframe to locate aeroplane wreckage below the surface of water when an ELT signal is not possible to detect. The ULDs operating at 37.5 kHz are attached to the flight recorders and are used for locating the flight recorders under water.

Other pertinent ICAO GADSS documents are listed below. They capture the origins and intent of GADSS and provides some guidance for national authorities to determine Methods of Compliance to the SARPs.

ICAO Concept of Operation, Global Aeronautical Distress & Safety System (GADSS) Version 6.0, (2017)

ICAO Doc 10165 - Manual on Global Aeronautical Distress and Safety System (GADSS) (First Ed. 2025)

Location of an Aircraft in Distress Repository (LADR), Functional Specification, Version 3.1, (2019)

EU / EASA

The EU was first to codify the ICAO GADSS SARPs into Law. These included Normal Tracking, Distress Tracking, Location of End of Flight, and Underwater Locating Devices. EASA conducted a series of workshops with regulators and industry to seek input on implementing the ICAO GADSS SARPs.

Introduced in 2015 as an amendment to EU 2012/965 Air Operations Regulations, EU Regulation 2015/2338 deals with the Location of an Aircraft in Distress (CAT.GEN.MPA.210) with a target implementation date of January 2021.

<u>EU Regulation 2015/2338</u>

CAT.GEN.MPA.210 Location of an aircraft in distress — Aeroplanes: The following aeroplanes shall be equipped with robust and automatic means to accurately determine, following an accident where the aeroplane is severely damaged, the location of the point of end of flight

(1) all aeroplanes with an MCTOM of more than 27 000 kg, with an MOPSC of more than 19 and first issued with an individual CofA on or after 1 January 2021; and

(2) all aeroplanes with an MCTOM of more than 45 500 kg and first issued with an individual CofA on or after 1 January 2021.'.

By 2019, it was apparent that meeting the requirements of regulations were going to take much longer, and the mandate date moved to January 2023.

<u>EU Regulation 2019/1384</u>

CAT.GEN.MPA.210 Location of an aircraft in distress — Aeroplanes : The following aeroplanes shall be equipped with robust and automatic means to accurately determine, following an accident during which the aeroplane is severely damaged, the location of the point of end of flight:

(1) all aeroplanes with an MCTOM of more than 27 000 kg, with an MOPSC of more than 19 and first issued with an individual CofA on or after 1 January 2023; and

(2) all aeroplanes with an MCTOM of more than 45 500 kg and first issued with an individual CofA on or after 1 January 2023.

In March 2022, the International Coordination Council of Aerospace Industry Associations (ICCAIA), on behalf of all aircraft manufacturers concerned, requested that ICAO postpone the applicability of Standard 6.18.1. At the same time, Airbus requested EASA to postpone the applicability of point CAT.GEN.MPA.210.

EASA initiated a Notice of Public amendment (NPA_2022-104) and worked with industry and ICAO on the issues.

The COVID-19 pandemic affected the planned delivery in 2022 of 700–1000 aeroplanes with an MCTOM of more than 27 000 kg, which had been designed and manufactured without the equipment needed to comply with point CAT.GEN.MPA.210 and Standard 6.18.1.

Furthermore, the International COSPAS/SARSAT Programme has been facing some delays in setting up the communication infrastructure that is necessary to process and transmit ELT(DT) signals to the SAR points of contact of States.

As a result of this, the ICAO Council approved an extension and essentially set the equipage installation deadline to 1 January 2024, with 1 January 2025 as the new applicability date. EASA Opinion No 05/2022 proposed to amend CAT.GEN.MPA.210 to align its applicability dates with the new applicability dates adopted for ICAO Standard 6.18.1.

EU Regulation 2022/2203

CAT.GEN.MPA.210 Location of an aircraft in distress – Aeroplanes

As of 1 January 2025, the following aeroplanes shall be equipped with robust and automatic means to accurately determine, following an accident during which the aeroplane is severely damaged, the location of the point of end of flight:

(a) all aeroplanes with an MCTOM of more than 27 000kg, with a MOPSC of more than 19, and first issued with an individual CofA on or after 1 January 2024; and

(b) all aeroplanes with a MCTOM of more than 45 500kg and first issued with an individual CofA on or after 1 January 2024.’

CS-ACNS Issue 4.0

CS-ACNS = Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance

In 2020, the EASA Notice of Proposed Amendment (NPA 2020-03) facilitated the implementation of CAT.GEN.MPA.210 ‘Location of an aircraft in distress — Aeroplanes’ of Annex IV (Part-CAT) to Regulation (EU) No 965/2012 (the ‘Air OPS Regulation’). The NPA proposed to amend the certification specifications (CSs), acceptable means of compliance (AMC), and guidance material (GM) to support the implementation of CAT.GEN.MPA.210.

The amendment updated changes included in EASA document CS-ACNS Issue 4, specifically in Sub Part E, Section 3 – Location of an Aircraft in Distress. Three main categories of solutions are discussed, with AMC and GM discussions.

Automatic deployable flight recorder (ADFR) : An ADFR is composed of a recorder in a deployable package, a deployment system, and sensors in the aircraft. The deployable package floats and contains an ELT that facilitates locating the ADFR.

Distress tracking ELT (ELT(DT)) : An ELT(DT) is a specific type of ELT that relies on an 'automatic triggering function'. That function monitors aircraft parameters and automatically triggers the ELT when it detects conditions that are likely to result in an accident during which the aircraft is severely damaged. The ELT(DT) is currently being implemented in at least 5 Part 121 and 135 aircraft.

High-rate tracking (HRT) : HRT relies on an airborne system that frequently transmits signals that enable locating the aircraft in case of an accident. (An Iridium based transmitter is an example). Like ELTs, a 121.5MHz homer transmitter would be required.

Industry Specifications

RTCA DO-204B – MOPS for ELTs – Outlines new requirements for ELTs which can be autonomously triggered in flight.

EUROCAE ED-237 : MASPS for Criteria to Detect In-Flight Aircraft Distress Events to Trigger Transmission of Flight Information

ARINC Report 680 – Aircraft Autonomous Distress Tracking

The report describes the technical requirements, architectural options, and recommended interface standards to support an Autonomous Distress Tracking (ADT) System intended to meet global regulatory requirements (GADSS) for locating aircraft in distress situations. A decomposition of international requirements is outlines. Current technology architectures which could realistically be implemented are described. The solutions categories are ADS-B (terrestrial and space), ELT(DT), ADFR, SATCOMM (Iridium and Inmarsat), and Hybrid Combinations. Interface architectures to the aircraft avionics and Autonomous Distress Trigger functionality are discussed.

Discussion Topics:

This section analyses the ARC tasking for objective 4 (e) ii, for locating an aircraft within 6 nm after a crash in consideration of PLAW 118-63 section 352(a)(a)(2).

4 e) ii. Whether to require that aircraft used in extended overwater operations under Part 121 or Part 135, which are required to have a CVR and a FDR, be equipped with a tamper-resistant method to broadcast to a ground station sufficient information to establish the location of an aircraft after the flight has terminated due to a crash within six (6) Nautical Miles of the point of impact ***in consideration of the mandate in section 352 of the Act .(A-15-1)***

Also covered are issues of international harmonization, technology, operational use cases, and applicable aircraft. These are outlined in Table 1 below with discussion following.

Table 1 – Comparison of Regulations on Location of Aircraft Crash Site

	ARC HRT Tasking	FAA Re-Authorization Act PLAW 118-63	ICAO SARP	EU Regulation 2022/2203
	Recommendation 4 (e) ii	**Section 352 a) 2)**	**Annex 6 Part 1 6.18** **Location of Airplane in Distress** **Appendix 9; Attachment H**	**CAT.GEN.MPA.210** **Location of an Aircraft in Distress** **CS-ACNS Issue 4.0**
Applicable Aircraft	Part 121 or 135 Operations	Part 121 Operations	MCTOM of more than 27 000 kg	MCTOM of more than 27 000 kg with MOPSC of more than 19
	Extended Overwater Operations (EOW 50nm) Required to have a CVR and a FDR	Extended Overwater Operations (EOW 50nm) Required to have a CVR and a FDR		MCTOM of more than 45000 kg
Mandate	Not Specified	May 2024 + 5Y = May 2029 Mfg on or after January 1, 2028	January 1 2025 CfOA issued after January 1, 2024	January 1 2025 CfOA issued after January 1, 2024
Operational Requirement	Location of Point of Impact < 6nm Broadcast sufficient Information Tamper resistant	Location of flight termination Broadcast sufficient Information Tamper resistant	Location of accident site < 6nm radius Autonomous Tranmission < 1minute Manual activation permitted. Time stamped position Transmission with Power Loss Specifies distress conditions	Location of End of Flight< 6nm automatically Determin Specifies distress conditions
Acceptable Means of Compliance			ELT(DT), ADFR, ULD	ELT(DT), ADFR, HRT 121.5MHz Homer Class 0 or 1 (-55C or -40C) GNSS Receiver Survivable Crash

Harmonization:

Regarding international harmonization, EU laws based on ICAO SARPs are currently in effect, including mandates for aircraft in distress tracking and locating. The applicable references are outlined in this paper summarized in Table 1 and in the ensuing discussion below.

- ICAO Annex 6 Part 1: 6.18 LOCATION OF AN AEROPLANE IN DISTRESS
- EU Regulation 2022/2203
  - CAT.GEN.MPA.210 Location of an aircraft in distress – Aeroplanes
- Mandate
  - January 1 2025
  - CfOA issued after January 1, 2024

Although the EU was the first to adopt the distress tracking SARPS and codify them into law, other national aviation authorities have also adopted or aligned with the ICAO SARPs [e.g. Canada, S. Korea, Singapore, Australia, UAE, Qatar, Brazil, …among others]. Airlines flying into Europe and other airspaces must comply with the ICAO SARPs and existing EU regulations Practically speaking, almost all international air transport flights must comply. Throughout this section, these rules will be referred to as GADSS Distress Tracking, or GADSS DT.

The development and implementation of the international regulations has taken years (almost a decade), however they are now currently in effect. All major Aircraft Manufacturers (OEMs) were part of the standards and regulatory process, and thus they were prepared for the mandates. The OEMs have already implemented fully compliant solutions for their Airline Customers to enable them to fly into the EU and adopting countries. The technology architecture utilized is based on a Distress Tracking Emergency Location Transmitter [ELT(DT)] as described in the ARINC 680 Report. As indicated previously, an ADFR provides the location of end of flight and is considered a compliant option under EASA CS-ACNS Issue 4.

Given the current state of the aviation industry, it seems obvious to consider and align FAA rulemaking with existing solutions developed for ICAO GADSS Distress Tracking and existing EU rules for Location of End of an Aircraft in Distress. Note, however, that the ARC tasking and the PLAW 118-63 Section 352 regulations, are not strictly "distress tracking" and only addresses the location of the end of flight. There are many other details, differences, and subtleties which will need to be discussed in the ensuing sections to show a path to existing solutions already implemented. This will not only expedite compliance but also result in the lowest cost approach for the OEMs and operators.

Applicable Aircraft

In the US aviation regulations are typically organized around the Certification of Aircraft (part 23, 25, 27 *et al*), Airspace Restrictions (91,101, 07, *et al*) , or the Operation of the Aircraft (part 121,135,137 *et al*).

The ARC Tasking and the PLAW 118-63 Section 352(a)(a)(2) deal with the Aircraft Operation. Part 121 and 135 for the ARC Tasking and Part 121 for the PLAW 118-63 352. The applicability is stated for extended overwater operations. In addition, both are restricted to aircraft which already have carriage requirements for and a Flight Data Recorder and a Cockpit Voice Recorder.

In the EU and EASA, there is a similar organizational structure, however, there are cases in which specify Mass Take Off Weight (MTOW) and Maximum Operational Passenger Seating Configuration (MOPSC) This is the case for GADSS Distress tracking and EASA rules. The applicable aircraft are MTOW > 27000kg and MOPSC > 19. Aircraft with MTOW > 45000kg are also covered regardless of MOPSC.

Reconciling this difference between the US and EU should not be a problem. Applicable aircraft currently operating under the GADSS DT mandate for the most part cover most Part 121 operations today in the US Airspace. There are a narrow category of smaller regional airliners that are light enough to be under 27,000 kg MTOW but still have sufficient passenger capacity to require operation under Part 121. Such aircraft may include the small aircraft many of which will come under Part 135 including commuter operations. The following table is a cursory survey of these aircraft [Source : ChatGPT for illustrational purposes only].

Aircraft	**MTOW (kg)**	**Seats**	**CVR Required?**	**FDR Required?**	**Part 121 Use (U.S.)**	**Part 135 Use Possible?**
Embraer EMB-120	~11,995	~30	✅ Yes	✅ Yes	Rare / Mostly retired	✅ Yes (commuter ops)
Dash 8-100 / -200	~15,650	~37	✅ Yes	✅ Yes	Limited use (e.g. Alaska)	✅ Yes (some in Alaska)
Dash 8-300	~19,505	~50	✅ Yes	✅ Yes	Limited use	✅ Yes (less common)

ATR 42-500	~16,400	~48	✅ Yes	✅ Yes	Rare in U.S.	✅ Yes
BAe Jetstream 41	~10,886	~29	✅ Yes	✅ Yes	Very limited use	✅ Yes
Embraer ERJ-145	~24,000	~50	✅ Yes	✅ Yes	✅ Still in use (Envoy, JSX)	⚠️ Rare (mainly 121 due to size and complexity)
Bombardier CRJ-200	~24,040	~50	✅ Yes	✅ Yes	✅ Still in use (SkyWest)	⚠️ Very rare (mostly 121)

Table 2 – Aircraft NOT applicable to GADSS DT; Possibly for PLAW 118-63 352(a)(a)(2)

In summary, for the aviation industry to comply with PLAW 118-63 Section 352 (a)(a)(2) the following points must be considered.

- Aircraft currently compliant to ICAO GADSS and EU Rules for Distress Tracking and Location of End of Flight will comply to Section 352. These are mainly larger aircraft with international destinations operating under Part 121 and have extended operation over water.
- Aircraft operating in US Airspace under Part 121, but do not have to meet the GADSS DT, will have to comply with PLAW 118-63 Section 352 (a)(a)(2) for extended operations over water. This is a smaller set of aircraft upon which the impact would have to be further assessed.
- Flights which fly domestically under Part 121 and do not engage in extended overwater operations would be exempt from the international regulations and PLAW 118-63 Section 352 (a)(a)(2).

Although PLAW 118-63 Section 352 (a)(a)(2) does not address Part 135 operations, the ARC Tasking and NTSB Recommendations called for consideration of this. From the applicability table, this becomes an even smaller set of aircraft, especially if they have extended operations overwater. The FAA would have to carefully assess the safety benefit for this limited population of aircraft.

Operational Requirements

It appears at this point that the PLAW 118-63 Section 352(a)(a)(2) for location of an aircraft can be closely harmonized with the GADSS DT mandates for most air transport operations. The compliant technology and solutions for compliance to GADSS DT are approved and flying today in international airspace. There are, however, many important requirements outlined in international regulations and standards, which are not addressed in US PLAW 118-63, the NTSB a-15-001-008 safety recommendation, or the ARC Tasking on location of aircraft.

These are worth some discussion and will have to be addressed when assessing the Method of Compliance when the FAA installations are approved. They are organized below based on major topics and some reference back to Table 1.

- Location of the Aircraft
    - FAA PLAW-118-63 Section 352(a)(a)(2)
        - To find where aircraft terminates flight…no accuracy specified.
        - Sufficient Information broadcast to a "ground station"
        - Does this mean inflight transmission is mandatory?
            - Post Crash transmission could reach a ground station
            - Satellite Relay or Direct Terrestrial Transmission
            - Transmission occurs after the crash for ADFR and ELT(AD)
    - NTSB a-15-001-008
        - …broadcast to a ground station sufficient information to establish the location where an aircraft terminates flight as the result of an accident within 6 nautical miles of the point of impact
    - ARC Tasking
        - the location of an aircraft after the flight has terminated due to a crash within six (6) Nautical Miles of the point of impact
    - ICAO GADSS DT
        - Inflight transmission of Location once a minute during distress
        - Referenced as 6nm in ICAO Annex 6 Part 1 Appendix 9
        - 6nm ~ 1 minute @ 360knots.

- Discussion
    - A FAA Recommendation of 6 nm location will allow compliance via a GADSS DT Solution or an EASA Certified ADFR.
    - The Issue of Transmission during flight needs to be clarified. It seems logical that transmission would occur prior to flight termination, such as is required in GADSS DT. There are, however, solutions which would meet PLAW 118-63 352(a)(a)(2) which do not require inflight transmission (ELT(AF), ADFR).

- Tamper Resistant:
    - FAA PLAW-118-63 Section 352(a)(a)(2) - Includes "tamper resistant"
    - NTSB a-15-001-008 - Includes "tamper resistant"
    - ARC Tasking: - Includes "tamper resistant"
    - ICAO GADSS DT
        - Specifically, does NOT include "tamper resistant"
        - Early versions did include "tamper resistant" or "not accessible in flight", however, these were not included in the subsequent versions.

- Discussion
    - There does not appear to be a formal definition of "tamper resistant in CFR 14. There are uses of the phrase when outlining some equipment regulations.
        - 14 CFR § 121.343(a)(3) – *Flight Data Recorders - "Each flight data recorder system required by this section must be installed in a manner to ensure that it is protected from damage and is tamper-resistant."*
        - This is largely to preserve data for accident investigation.
- Consideration of Defining "Tamper Resistant"
    - FAA Methods of Compliance will need to be established
    - By Whom, When or Where
    - On the ground, during flight,
    - Accessible by maintenance, pilots, passengers…..
    - Indication of tampering: to cockpit, maintenance, etc.,
    - Interval of inspections
    - Tampering by means of cyber-attack? Cyber Security?

- Autonomous Operation:
  - FAA PLAW-118-63 Section 352(a)(a)(2) -
    - Does not specify how the broadcast of data is initiated.
    - Is it during flight or post crash on the ground?
    - It could be manually by the pilot or autonomously.
  - NTSB a-15-001-008
    - Does not specify how transmission of data is initiated.
  - ARC Tasking:
    - Does not specify how the broadcast of data is initiated.
  - ICAO GADSS DT
    - Requires that transmission of location data occurs autonomously
    - Term “autonomous” and “automatics” are both cited in the SARPs
    - Upon detection of a distress condition in flight (ie Distress Trigger)
    - Manual initiation of distress transmission may also be included.
    - Only the method of activation can deactivate transmission.

  - Discussion
    - Unlike the ICAO rules, there is no requirement in the PLAW 118-63, NTSB a-15-001-008, or ARC Tasking that states that transmission of location data needs to be an autonomous operation triggered by a distress in flight.
    - This GADSS DT solutions flying today are autonomous and would comply with PLAW 118063 352(a)(a)(2).
    - ADFR solutions automatically broadcast the location of end of flight post-crash and would also comply with PLAW 118063 352(a)(a)(2).
    - However, without a requirement for autonomous transmission triggered upon distress in flight, an Acceptable Means of Compliance in the USA could encompass may technology or operational solutions. For example,
      - In the USA, it could be that the pilot manually initiates the transmission.

        - This is permissible today….The pilot may turn on the ELT when the aircraft is in distress and prior to crash.
        - Since location accuracy is not specified in the PLAW 118-63, any transmission which gets close is acceptable.
        - It is not, however, mandated that a pilot take an action to turn on an ELT in flight, since controlling the aircraft and preventing a catastrophe is a priority.
    - There needs to be clarification on this by the FAA.   Not so much for GADSS DT compliant solutions, but for other domestic implementations.

Other Issues

- There are several other requirements in the GADSS DT requirements which are not addressed in PLAW 118-63(a)(a)(2), the NTSB a-15-001-008 safety recommendation, or the ARC Tasking on location of aircraft
- False Alarm Rate
    - Unlike the ICAO and EASA rules, there is no requirement in the proposed US regulations which state a tolerable false alarm rate.
    - GADSS DT acceptable false alarm rate is 1 per 100,000 flight hour
    - This is categorized as a 1E-05 Major Failure condition
    - ADFR minimum acceptable false alarm rate specified in EUROCAE ED-112A, is Hazardous (10E-7) per ARP4761A and AC to 25.1309.
    - The solutions are forced into a DAL C Implementation.
- Power Source
    - GADSS DT requires a certain degree of independent power (not from the aircraft power).
    - The US proposed requirements do not address power sources.
    - An acceptable implementation in the US could use Aircraft Power for the duration of broadcast.

- Duration of Transmission Operation
    - Not specified in the US proposed regulations.

- The BEA established a data base which showed a high percentage of aircraft crashes occur within 5 minutes after the detection of a distress.
- GADSS DT Compliance Solutions
  - ELT(DT) –370 minutes @406Mhz (ETOPS of A350)
  - ELT(DT) with crash survivability: 24hr @406Mhz; 48hr @121.5MHz
  - ADFDR – 24hr @406Mhz; 150hrs @121.5MHz

- Homing Signal
  - Not specified in the US proposed regulations.
  - Under EASA Regulations, the CS-ACNS Issue 4 requires a homing signal.
  - In case of a survivable accident, a 121.5-MHz homing signal is automatically transmitted after reaching the point of end of flight.
  - The 121.5-MHz homing signal is transmitted for at least 48 hours or until the aircraft is submersed.
  - Both an ADFR and ELT(DT) with crash survivability meet the EASA homing regulations.

Cost Benefit Considerations

In line with the ARC InvTech Charter, the following guidance was requested to be addressed regarding "flight data recovery" for applicable aircraft in Section 352. Being that this issue paper addresses Location of an Aircraft After Crash, the discussion will focus on applicable aircraft and timeline issues. It will be shown that driving towards harmonization with existing international rules on Location of an Aircraft After Crash will be the most expeditious strategy to meet compliance to PLAW 118-63 Section 352. This will drive the final recommendations of this position paper.

4 m) In addition to tasks 4.e.ii, 4.e.iii, and 4.e.iv of this charter, discuss and develop the following:

i. *Recommendations on whether to apply the requirements regarding flight data recovery in section 352 of the Act to other aircraft in addition to those that meet the definition of "applicable aircraft" in Section 352.*

ii. *Quantitative cost and benefit data for the inclusion of flight data recovery technologies for aircraft that meet the definition of "applicable aircraft" in section 352 and other aircraft under consideration.*

iii. A qualitative description of the potential impacts for the inclusion of flight data recovery technologies for aircraft that meet the definition of “applicable aircraft” in section 352 and other aircraft under consideration.

Applicable Aircraft:

The applicable aircraft targeted by PLAW 118-63 Section 352(a)(a)(2) has been briefly addressed in the previous Discussion Section of this paper. This section will continue the discussion at the risk of being repetitive. It’s important to note that the overriding premise of this section is not to include other aircraft in the PLAW 118-63 Section 352 as suggested in the ARC Charter. Instead, the emphasis will be on Part 121 aircraft which already must comply with international GADSS Distress Tracking mandates. Aircraft outside of these requirements need to be assessed from a safety benefit point of very, however, it appears that population may be relatively small.

Consider the following positions:

- Aircraft currently compliant with ICAO GADSS and EU Rules for Distress Tracking and Location of End of Flight will comply to Section 352(a)(a)(2).
  - These are mainly larger aircraft with international destinations operating under Part 121 and have extended operation over water.
  - It is recommended that the FAA draft guidance material or reciprocity policies to establish that GADSS DT installations approved under EU/EASA would be an Acceptable Means of Compliance to meet PLAW 118-63 Section 352(a)(a)(2).
- Aircraft operating in US Airspace under Part 121, but do not have to meet the GADSS DT, will have to comply with PLAW 118-63 Section 352 (a)(a)(2) for extended operations over water.
  - Basically, these are aircraft which do not fly to international destinations and have extended overwater operations (>50 miles).
  - It is recommended that the FAA assess the safety impact to the industry for this smaller population of aircraft.
  - These aircraft are readily tracked by secondary surveillance
  - A potential solution may include operational rules to not allow extended overwater operations for this population of aircraft (<50 miles).
- Flights which fly domestically under Part 121 and do NOT engage in extended overwater operations would be exempt from the international GADSS regulations and PLAW 118-63 Section 352 (a)(a)(2).

- This applies to domestic airspace along any US oceanic coast or the Great Lakes (<50 miles).
- These aircraft are readily tracked by primary and secondary surveillance.

- Although PLAW 118-63 Section 352 (a)(a)(2) does not address Part 135 operations, the ARC Tasking and NTSB Recommendations called for consideration of this.
  - These aircraft are readily tracked by primary and secondary surveillance.
  - It is recommended that the FAA assess the safety impact to the industry for this smaller population of aircraft.
  - With Part 135 being outside of the mandates of PLAW 118-63 Section 352, there is ample time for this consideration.

Quantitative Cost and Benefit

The discussion proposed guidance for the Applicable Aircraft was important to set the boundary conditions for the Quantitative Costs of the industry complying to PLAW 118-63 Section 352(a)(a)(2).

Applicable Part 121 aircraft flying under existing ICAO and EU/EASA GADSS DT rules, the timeline outlined in PLAW 118-63 Section 352 is achievable and underway. It is recommended that the FAA draft guidance material or reciprocity policies to establish that GADSS DT installations approved under EU/EASA would be an Acceptable Means of Compliance to meet PLAW 118-63 Section 352(a)(a)(2).

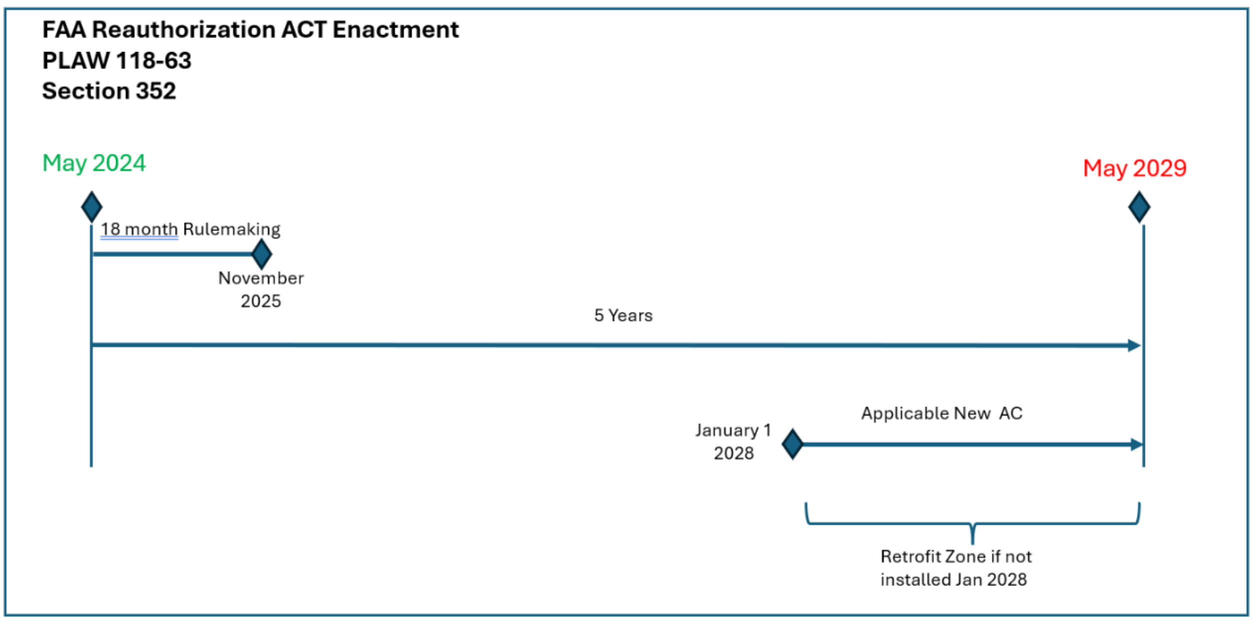
A first order assessment of cost would be minimal for this approach. The cost is less an issue with the technology/equipage on aircraft, and more of the cost of additional certifications to show compliance with PLAW 118-63 Section 352. This is where FAA rulings which encompass existing ICAO/EU rules and acceptable means of compliance can streamline the process.

As pointed out in the appliable aircraft discussion, there is a lesser population of extended overwater operation Part 121 (and Part 135) aircraft which do not have to meet the international rules on Distress Tracking. These are usually smaller aircraft and smaller operators so the cost impact would be greater. Note that this will impact the production of new aircraft in this subset of operation. The FAA would have to assess the size of this population of aircraft and assess the safety consideration of either inclusion or exclusion in rules relating to PLAW 118-63 Section 352. A cost analysis would have to be conducted to better assess the safety risks.

Qualitative Description of the Potential Impacts

Practically speaking, implementing new technology across a fleet of aircraft on a national scale typically will take years. Many examples exist including the ADS-B mandate which took well over a decade, with years of groundwork prior to the start.

The GADSS Distress Tracking mandate took well over a decade to implement and encompassed three extensions of the mandate final data. For the current ARC Tasking on aircraft location and to comply with PLAW 118-63 Section 352(a)(a)(2), will face similar challenges. The timelines for compliance with PLAW 118-63 Section 352(a)(a)(2) are shown below. Note the already the FAA is required to complete rulemaking by November 2025. This would then have to be followed by publications to establish acceptable means of compliance (AC, MOPS, *et al*) which in itself can take years. Even if these existed today, this leaves little over 2 years for aircraft manufacturers to implement solutions on production aircraft in time for the mandate in January 2028. Production aircraft not meeting this date would have to be retro-fit with a compliant solution by the May 2029 deadline for Part 121 carriers to be compliant.



It can be seen that the mandate per PLAW 118-63 Section 352 leaves only two years for reliable solutions to hit production. Clearly, an impossible task for new technology. The apparent grace period until May 2029 is a zone of time in which non-compliant production aircraft would have to be retro-fit in the field with a compliant solution. This is not a viable strategy, resulting in doubling engineering and compliance programs to support forward-fit production and a retrofit program. These timelines support a harmonization strategy with international rules for Part 121 aircraft.

Summary:

This paper addressed the ARC Innovative Technology Charter regarding the Location of an Aircraft Crash [4(e)(ii)]. It included presentation and discussion of recommendations and existing international rules including:

- NTSB Safety Recommendation a-15-001-008 [2015]
- FAA Reauthorization Act of 2024 - PUBLIC LAW 118–63 [352]
- ICAO Annex 6 Part 1: 6.18 Location of an Aeroplane in Distress
- EU Regulation 2022/2203: CAT.GEN.MPA.210 Location of an Aircraft in Distress

Issues of international harmonization, technology, operational use cases, and applicable aircraft were discussed in depth. In addition, implementation timelines were discussed.

The NTSB recommendations, ARC InvTech Tasking, and FAA Reauthorization Act all aimed to address the issue covered by the ICAO Distress Tracking mandates with the aim of establishing, to a reasonable extent, the location of an accident site within a 6 NM radius.. These mandates are now in force, and aircraft (mostly Part 121) currently operate internationally under these rules. Under the current US mandate timelines (May 2029), a harmonization approach will be strongly recommended.

The applicable aircraft sets are similar. The acceptable means of compliance are internationally defined already. Some international requirements go above and beyond the US rules and recommendations (autonomy, false alarm rates, transmission rates, etc), however, those solutions are congruent with compliance to US rules.

Recommendations:

Recommendation 1: International Harmonization

Aircraft currently compliant with ICAO GADSS and EU Rules for Distress Tracking and Location of End of Flight will comply to Section 352(a)(a)(2). These are mainly larger aircraft with international destinations operating under Part 121 and have extended operation over water. This would have the lowest impact on the airline industry from a cost and timeframe perspective.

- It is **recommended** that the FAA Ruling consider methods of compliance and certification of solutions congruent to the EASA CS-ACNS Issue 4. These include ELT(DT), ADFR, and High-Rate Tracker (HRT).

- It is **recommended** that the FAA Ruling include reciprocity policies to establish that GADSS DT installations already approved under EU/EASA would be an Acceptable Means of Compliance to meet PLAW 118-63 Section 352(a)(a)(2).
- It is **recommended** that FAA initiate the creation of Guidance Material and Acceptable Means of Compliance to support these policies.

Recommendation 2: Part 121 Exceptions

Aircraft operating in US Airspace under Part 121, but do not have to meet the ICAO GADSS DT rules, will have to comply with PLAW 118-63 Section 352 (a)(a)(2) for extended operations over water.

- It is **recommended** that the FAA assess the population size of this population of aircraft and perform a safety assessment for possible exclusion or limited operations overwater.

Recommendation 3: Part 135 Exclusion

Although PLAW 118-63 Section 352 (a)(a)(2) does not address Part 135 operations, the ARC Tasking and NTSB Recommendations called for consideration of this. These aircraft are readily tracked by primary and secondary surveillance.

- It is **recommended** that the FAA assess the population size of this population of aircraft and perform a safety assessment.
    - With Part 135 aircraft being outside of the mandates of PLAW 118-63 Section 352, there is ample time for this consideration

B3: Installation of LF-LUD

The following draft position papers written by the HRT group participants regarding different charter taskings are included to present a full picture of the HRT group's thought processes and key concerns in their own words, as well as further background on each of the areas discussed. They are presented exactly as written and do not represent the position of the full ARC.

REC1	**The FAA should align regulation with that of ICAO by amending 14 CFR Part 121 and 135 to require the installation of Low-Frequency Underwater Locating Devices on all aircraft with a maximum takeoff weight greater than 59,525 lbs operating on extended overwater routes.**

INTENT: Install 8.8 kHz Low-Frequency Underwater Locator Devices (LF-ULD) devices on transport category airplanes and retrofit similar installations on airplanes that are used in extended overwater routes.

RATIONALE: Aircraft accidents in deep water (more than 1,000 feet in depth) require significant effort on the part of investigative agencies to locate the wreckage and especially to locate the Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR). Recent examples of these difficulties contributing to extended search efforts include an Air France A330 accident in the Atlantic Ocean in June 2009 (which was located after a two-year search), and the loss of a Malaysian Airlines B777 in the southern Indian Ocean in March 2014 (which remains missing). Existing regulations in 14 CFR Part 25 [namely 25.1457(g)(3) and 25.1459(d)(3)] provide investigators with assistance in locating recorders in the water by requiring the installation of 37.5 kHz High-Frequency Underwater Locator Devices (HF-ULDs), securely attached to each of these two recorders. The performance standards of these HF-ULDs results in a practical maximum detection range of approximately 2 nautical miles or less, when considering the underwater sensors in use by a majority of investigative bodies. Experience has shown that when searching for an aircraft in water less than 1,000 feet deep, this limits the practical detection range enough that an agency must locate the wreckage to an accuracy of approximately ¾ mile before even being able to identify a useable signal, let alone using that signal to locate where to deploy divers or underwater vehicles to identify wreckage. In water deeper than a few thousand feet, HF-ULD signals may not be detectable at all at the surface. Indeed, both the A330 and B777 accident aircraft included these two HF-ULDs. Deep-water hydrophones were deployed in both cases but the HF-ULD signals were never identified.

ICAO Annex 6 includes a device that can further help in locating underwater aircraft wreckage, particularly in deeper water. The signals transmitted by an 8.8 kHz, LF-ULD penetrate further through water, allowing detectors to identify the signal at ranges approaching 10 nautical miles. After locating the wreckage, the HF-ULDs (which are still installed on the recorders) allow investigators to locate those critical components quickly as well. This can significantly expand the useable range of surface vessels in detecting and locating underwater wreckage and cut down on the time and cost of performing an underwater search, getting valuable accident data into the hands of investigators (and therefore the industry) even more rapidly. Annex 6 further recommends that the LF-ULD be installed on aircraft engaging in extended over-water flights.[1]

The ARC notes that in May 2024, FAA Reauthorization Bill H.R. 3935 amended 49 USC Section 44746 to require the use of low-frequency Underwater Locator Devices on part 121 aircraft used in extended overwater operations:

44746 Flight data recovery from overwater operations

a. In General – Not later than 18 months after the date of enactment of this section, the Administrator of the Federal Aviation Administration shall complete a rulemaking proceeding to require that, not later than 5 years after the date of enactment of this section [ARC note: 16 May, 2024], all applicable aircraft are –

   3. Equipped with an airframe low-frequency underwater locating device that functions for at least 90 days and that can be detected by appropriate equipment

b. Applicable Aircraft Defined – In this section, the term “Applicable Aircraft” means an aircraft manufactured on or after January 1, 2028 that is –

   1. Operated under Part 121 of title 14, Code of Federal Regulations;

   2. Required by regulation to have a cockpit voice recorder and a flight data recorder; and

   3. Used in extended over-water operations.

EASA regulation EASA CAT.IDE.A.285 Flight Over Water requires the installation of LF-ULDs on some large aircraft operating on overwater routes, with an exception in place for those that contain equipment related to automated distress tracking:

CAT.IDE.A.285

f. By 1 January 2019 at the latest, aeroplanes with an MCTOM of more than 27,000 kg and with an MOPSC of more than 19 and all aeroplanes with an MCTOM of more than 45,500 kg shall be fitted with a securely attached underwater locating device that operates at a frequency of 8.8 kHz +/- 1 kHz, unless:

   1. The aeroplane is operated over routes on which it is at no point a distance of more than 180 NM from the shore; or

2. The aeroplane is equipped with robust and automatic means to accurately determine, following an accident where the aeroplane is severely damaged, the location of the point of end of flight.

Similar LF-ULD requirements are required by Russia, Hong Kong, Singapore, Taiwan, Indonesia, the Republic of Korea, Philippines, Vietnam, the United Arab Emirates, Kuwait, Ethiopia, and Qatar.

While the EASA regulations provide exceptions for airplanes equipped for accurate end-of-flight position finding, the ARC believes that inclusion of LF-ULDs will speed locating of actual wreckage underwater, and will speed the recovery of critical perishable evidence in an investigation.

FAA Technical Standard Order TSO-C200a and SAE International Aerospace Standard AS-6254A provide component-level requirements to meet the intent of ICAO Annex 6 and current EASA and other national regulations discussed above. Component manufacturers have developed devices to meet the requirements of TSO-C200a and such devices are installed on newly manufactured aircraft today. Aircraft manufacturers have developed solutions, including retrofit solutions, to perform aircraft-level installations that meet the intent of the Annex and the regulations as currently published.

APPROACH: Create a new regulation within 14 CFR Part 25, Subpart K, with language similar to the following:

§ 121.3xx Airframe Underwater Locator Device.

(a) After <date> no certificate holder may operate an airplane with maximum certificated take-off weight of over 59,525 lbs. on routes over water longer than 2 hours at cruising speed or 400nm, whichever is lesser, without having an approved airframe underwater locating device installed.

(b) The airframe underwater locator device required by paragraph (a) of this section must meet the following application standards:

(1) The airframe underwater locator device must –

(i) meets the standards of TSO-C200a, or later revision,

(ii) not be installed in wings or empennage.

Additionally, create a new regulation within 14 CFR Part 135, Subpart C, with language similar to the following:

§ 135.1xx Airframe Underwater Locator Device.

(a) After <date> no certificate holder may operate an airplane with maximum certificated take-off weight of over 59,525 lbs. on routes over water longer than 2 hours at cruising speed or 400nm, whichever is lesser, without having an approved airframe underwater locating device installed.

(b) The airframe underwater locator device required by paragraph (a) of this section must meet the following application standards:

(1) The airframe underwater locator device must –

(i) meets the standards of TSO-C200a, or later revision,

(ii) not be installed in wings or empennage.

B4: New Aircraft Requirements for Timely Recovery of Flight Recorder Data

The following draft position papers written by the HRT group participants regarding different charter taskings are included to present a full picture of the HRT group's thought processes and key concerns in their own words, as well as further background on each of the areas discussed. They are presented exactly as written and do not represent the position of the full ARC.

PROPOSED RULE MAKING TO REQUIRE PART 121 & 135 AIRCRAFT BE FITTED WITH MEANS TO R

1. INTRODUCTION

The Federal Aviation Administration (FAA) created a charter to establish the Investigative Technologies Aviation Rulemaking Committee (ARC) June 6, 2023. One investigative technology of interest is the recovery of mandatory flight data parameters without requiring underwater retrieval. This position paper will review current avionics systems that can achieve this objective, barriers that may make implementation of this objective into Federal regulations difficult or cost prohibitive to the airlines, and a set of recommendations based on the sub-committee's findings for the FAA to consider as part of their rule making proceedings.

Per the Investigative Technologies ARC Charter, Task 4.e.iv, this position paper provides recommendations to the FAA on "Whether to require newly manufactured aircraft used in extended overwater operations under Part 121 and Part 135, which are required to have a Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR), to be equipped with a means to recover mandatory flight data parameters; the means of recovery should not require underwater retrieval. The data should be captured from a triggering event until the end of the flight and for as long a time period before the triggering event as possible in consideration of the mandate in section 352 of the Act.(A-15-3)".

The following items shall be discussed and developed:

A qualitative description of the potential impacts for the inclusion of flight data recovery technologies for aircraft that meet the definition of "applicable aircraft" in section 352 and other aircraft under consideration.

Quantitative cost and benefit data for the inclusion of flight data recovery technologies for aircraft that meet the definition of "applicable aircraft" in section 352 and other aircraft under consideration.

Recommendations on whether to apply the requirements regarding flight data recovery in section 352 of the Act to other aircraft in addition to those that meet the definition of "applicable aircraft" in Section 352.

References:

Reference	Document
1.1.1	Public Law 118-63: 2024 FAA Reauthorization Act
1.1.2	NTSB Safety Recommendation, January 22, 2015
1.1.3	NTSB/FAA Recommendation Report Correspondence Rec# A-15-003
1.1.4	49 CFR Part 830 Notification and Reporting of Aircraft Accidents or Incidents and Overdue Aircraft, and Preservation of Aircraft Wreckage, Mail, Cargo, and Records
1.1.5	14 CFR Part 121.344 Digital flight data recorders for transport category airplanes [Amdt 121-251]
1.1.6	14 CFR Part 121.359 Cockpit Voice Recorders [Amdt 121-387]
1.1.7	International Standards and Recommended Practices Annex 6 to the Convention on International Civil Aviation – Operating of Aircraft, Part 1 – International Commercial Air Transports – Aeroplanes, 12 Edition, July 2022
1.1.8	ICAO Global Aeronautical Distress and Safety System (GADSS) Concept Version 6.0
1.1.9	Doc 10165 – Manual on Global Aeronautical Distress and Safety System (GADSS), 1st Edition, 2025
1.1.10	Doc 10054 – Manual on Location of Aircraft in Distress and Flight Recorder Data Recovery, 1st Edition, 2019 (For Reference Only)
1.1.11	EASA Certification Specification CS-25.1459 Flight Data Recorders [Amdt 25/23] and AMC 25.1459
1.1.12	EASA Research Project EASA.2020.C43 Quick Recovery of Flight Recorder Data (wireless transmission)
1.1.13	ARINC 681 Timely Recovery of Flight Data (TRFD)
1.1.14	EUROCAE ED-112B Change 1 Minimum Operational Performance Standard for Crash Protected Airborne Recorder Systems
1.1.15	EUROCAE ED-62B Change 1 Minimum Operational Performance Standard for Aircraft Emergency Locator Transmitters 406MHz

1.1.1. Public Law 118-63 – 2024 FAA Reauthorization Act

The United States Government passed into law, on 16MAY2024, the FAA Reauthorization Act of 2024. Section 352 of the law amends Chapter 447 of title 49 of the U.S. code to include Flight Data Recovery from Overwater Operations. The rule states:

SEC. 352. FLIGHT DATA RECOVERY FROM OVERWATER OPERATIONS.

(a) FLIGHT DATA RECOVERY FROM OVERWATER OPERATIONS.—

Chapter 447 of title 49, United States Code, is further amended by adding at the end the following:

"§ 44746. Flight data recovery from overwater operations

‘‘(a) IN GENERAL.—Not later than 18 months after the date of enactment of this section, the Administrator of the Federal Aviation Administration shall complete a rulemaking proceeding to require that, not later than 5 years after the date of enactment of this section, all applicable aircraft are—

‘‘(1) fitted with a means, in the event of an accident, to recover mandatory flight data parameters in a manner that does not require the underwater retrieval of the cockpit voice recorder or flight data recorder;

‘‘(2) equipped with a tamper-resistant method to broadcast sufficient information to a ground station to establish the location where an applicable aircraft terminates flight as the result of such an event; and

‘‘(3) equipped with an airframe low-frequency underwater locating device that functions for at least 90 days and that can be detected by appropriate equipment.

‘‘(b) APPLICABLE AIRCRAFT DEFINED.—In this section, the term ‘applicable aircraft’ means an aircraft manufactured on or after January 1, 2028, that is—

‘‘(1) operated under part 121 of title 14, Code of Federal Regulations;

‘‘(2) required by regulation to have a cockpit voice recorder and a flight data recorder; and

‘‘(3) used in extended overwater operations.’’.

(b) CLERICAL AMENDMENT.—The analysis for chapter 447 of title 49, United States Code, is further amended by adding at the end the following:

‘‘44746. Flight data recovery from overwater operations.’’.

1.1.2. NTSB Safety Recommendation, January 22, 2015

The ARC task originated from the January 22, 2015, National Transportation Safety Board (NTSB) release of Safety Recommendation A-15-1 through 8 to the FAA based on its Emerging Flight Data and Locator Technology Forum held on October 7, 2014. The recommendations were based, in part, on the difficulties in finding the flight recorders from Air France Flight 447 and not finding the flight recorders of Malaysia Airlines Flight 370. The forum identified 1.) The need for improved technologies to locate aircraft wreckage and flight recorders following an accident in a remote location or over water; 2.) The need for timely recovery of critical flight data following an accident in a remote location or over water as safety issues. Recommendation A-15-3 states:

Require that all newly manufactured aircraft used in extended overwater operations and operating under Title 14 Code of Federal Regulations (Part 121 or (2) Part 135 that are required to have a cockpit voice recorder and a flight data recorder, be equipped with a means to recover, at a minimum, mandatory flight data parameter; the means of recovery should not require underwater retrieval. Data should be captured from a triggering event until the end of the flight and for as long a time period before the triggering event as possible. (A 15 3)

On the forum topic of "Supplemental Methods to Recover Flight Data", the NTSB summarized that technology advances over the past several years have yielded alternate means to provide some degree of recorded flight data redundancy without the delays associated with a difficult underwater recovery.

Two potential technologies cited: a) deployable recorders that can be used to recover flight data without the delay of a long and expensive underwater recovery; and, b) triggered flight data transmission of critical flight data when triggering parameters deviate from their normal operating envelope.

Automatic Deployable Flight Recorders (ADFR) combine traditional FDR and CVR functions into one unit and are capable of providing the same level of flight data. They are designed to separate from the aircraft upon fuselage structural deformation or when submersed in water. They are designed to float indefinitely on the surface. These units are equipped with Emergency Locator Transmitters (ELTs) that operate on the 406 MHz and 121.5 megahertz (MHz) frequencies respectively for location and recovery.

Triggered flight data transmission involves monitoring preselected aircraft parameters and triggering satellite transmission of critical flight data when the parameters deviate from their normal operating envelope.

The forum believed that these two technological advances over the past several years have yielded alternate means to provide some degree of recorded flight data redundancy without the delays associated with a difficult underwater recovery.

1.1.3. NTSB/FAA Recommendation Report Correspondence Rec# A-15-003

This document provides dialogue from 01/2015 – 11/2023 on the intent and issues associated with the "rapid" recovery of flight data and the efforts. The document captures the framework in which the NTSB and FAA have been working on the issue, from which various industry organizations have been developing the various capabilities to meet the GADSS concept.

1.1.4. 49 CFR Part 830 Notification and Reporting of Aircraft Accidents or Incidents and Overdue Aircraft, and Preservation of Aircraft Wreckage, Mail, Cargo, and Records

With respect to flight data recordings, 49 CFR Part 830 creates the legal framework that ensures the availability and integrity of flight data recorder data following reportable aviation events, thus providing a fundamental prerequisite for the NTSB's safety investigations.

1.1.5. 14 CFR Part 121.344 Digital flight data recorders for transport category airplanes

The regulation 14 CFR Part 121.344 defines the flight data recording requirements for part 121 operations. This regulation (and its associated Appendix M to Part 121) defines the minimum flight data parameter set that must be recorded.

1.1.6. 14 CFR Part 121.359 Cockpit Voice Recorders

The regulation 14 CFR Part 121.359 defines the cockpit voice recording requirements for part 121 operations. This regulation (and its associated 23.1457 or 25.1457 regulations) defines the minimum data that must be recorded.

1.1.7. International Standards and Recommended Practices Annex 6 to the Convention on International Civil Aviation – Operating of Aircraft, Part 1 – International Commercial Air Transports – Aeroplanes, 12 Edition, July 2022

This publication introduced SARPS for distress tracking and timely recovery of flight recorder data (TRFD), and ELT's to support the recovery of flight recorder data in remote locations or over water and introduces the concept of recovering flight data in a timely manner, originally with applicability for aircraft with an application for type certification submitted on/after Jan 1, 2021.

Section 6.3.6 Flight recorder data recovery states the following:

6.3.6.1 All aeroplanes of a maximum certificated take-off mass of over 27 000 kg and authorized to carry more than nineteen passengers for which the application for type certification is submitted to a Contracting State on or after 1 January 2021, shall be equipped with a means approved by the State of the Operator, to recover flight recorder data and make it available in a timely manner.

6.3.6.2 In approving the means to make flight recorder data available in a timely manner, the State of the Operator shall take into account the following:

the capabilities of the operator;

overall capability of the aeroplane and its systems as certified by the State of Design;

the reliability of the means to recover the appropriate CVR channels and appropriate FDR data; and

specific mitigation measures.

It should be noted that in ICAO the term Flight Recorder Data Recovery is not limited to mandatory flight recorder data parameters, but also includes cockpit voice recorder and data link recorder data.

1.1.8. ICAO Global Aeronautical Distress and Safety System (GADSS) Concept Version 6.0

Version 6.0 published 07/06/2017 is the latest version of the document that specifies the high-level requirements of a set of systems and procedures to ensure the timely detection of an aircraft in distress, ensure the timely and accurate location of end of flight for an aircraft in distress, enable efficient and effective search and rescue operations, and ensure the timely retrieval of flight recorder data.

1.1.9. Doc 10165 – Manual on Global Aeronautical Distress and Safety System (GADSS), 1st Edition, 2025

This manual provides guidance and information on the implementation and operation of the GADSS and is intended to facilitate the uniform application of SARPs contained in Annex 6 – Operation of Aircraft, Part I – International Commercial Air Transport – Aeroplanes and provisions in the Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS, Doc 8168).

This guidance is targeted to aircraft operators, air traffic service units (ATSUs), rescue coordination centres (RCCs), SAR services and accident investigation authorities (AIAs) along with the States responsible for the oversight of these services. This manual details the key characteristics of the GADSS functions including aircraft tracking, location of an aircraft in distress, post flight localization (PFL) and flight recorder data recovery (FRDR).

1.1.10. Doc 10054 – Manual on Location of Aircraft in Distress and Flight Recorder Data Recovery, 1st Edition, 2019

NOTE: This document has been superseded by Doc. 10165 and is referenced here because various documents in this table reference this document.

ICAO Doc 10054 was developed to provide guidance in support of Standards and Recommended Practices (SARPs) introduced into Annex 6, Part I regarding Flight Recorder Data Recovery and the Location of an Aircraft in Distress. The document released in 2019, provides high level guidance for States and operators to support compliance with ICAO Standards and Recommended Practices (SARPs) for implementation of GADSS technology, which is inclusive of the recovery of flight recorder data. This document provides a level of standards and requirements, intent of the standards, definition, and descriptive wording regarding State and operator requirements, operator's capability, and aircraft systems. The manual represents a possible method of complying with ICAO's recommendations but not the only methods. The ICAO document discusses two methods of flight recorder recovery, automatic deployable flight recorders (ADFR) and recovery of flight recorder data through aircraft transmissions.

One point of difference between the ARC's tasks and ICAO documentation is that the ARC task, as defined by both NTSB recommendations and U.S. Law, is that the NTSB recommendation stresses the timely recovery of mandatory flight data whereas ICAO documentation is specific, to specifies the timely recovery of flight recorder data more generally and make it available in a timely manner.

According to the definitions in Chapter 1 of Annex 6 Part I, the term ‘flight recorder’ designates ‘any type of recorder installed in the aeroplane for the purpose of complementing accident/incident investigation’. In addition, a general note in section 6.3 of Annex 6 Part I ‘Flight recorders’ indicates that ‘Crash protected flight recorders comprise one or more of the following systems: a flight data recorder (FDR), a cockpit voice recorder (CVR), an airborne image recorder (AIR) and/or a data link recorder (DLR). Image and data link information may be recorded on either the CVR or the FDR.

1.1.11. European Union Aviation Safety Agency Certification Specification CS-25.1459 and AMC 25.1459

As part of CS25 Amdt 23 and following amendments the EASA specifies installation and performance requirement for deployable flight recorders if installed in lieu of a fixed installed flight data recorder. This includes safety objectives concerning inadvertent deployment. Transmission of flight data for accident investigation purposes is not covered by current CS 25 standards.

1.1.12. EASA Research Project EASA.2020.C43 Quick Recovery of Flight Recorder Data (wireless transmission)

On May 31, 2021, EASA published a research project paper EASA.2020.C43 on the Quick Recovery of Flight Recorder Data (wireless transmission) that provide a detailed study of the possible methods available, the types of processes required, and the implementation challenges for the timely recovery of flight recorder data by wireless means.

The study concluded that there are no principle showstoppers to using transmission of flight recorder data as acceptable means of compliance with GADSS tracking and flight recorder data recovery provisions, so long as certain requirements regarding the immutability, provenance, security, assurance, and data access controls are met.

1.1.13. ARINC 681

The purpose of ARINC Report 681 is to provide a basis for developing standards for implementing the ICAO TRFD SARP. This report draws requirements from several ICAO documents and other standards bodies that are related to GADSS, TRFD, and distress tracking and other standards.

This document describes the technical requirements and architectural options for the Timely Recovery of Flight Data (TRFD) in commercial aircraft. It describes the two TRFD architectures in the context of a common architectural framework and identifies requirements. This report also discusses implementation recommendations from an airplane-level perspective.

Section 3 of the document presents the results of studies of potential TRFD architectures which could be used to meet the requirements of a TRFD system. It also discusses additional issues which should be considered when developing a TRFD system. The results and insights developed in this section are intended to support the TRFD standards development.

The two architectures analyzed in this section include:

Transmission of Flight Data (TFD)

Automatically Deployable Flight Data Recorder (ADFR)

Section 3.1 presents a framework that provides a common perspective in terms of a common set of functions and terminology to apply to the two candidate architectures. This section also provides a notional mapping of the requirements developed in Section 2.5 to the common functional components.

Section 3.2 follows with an analysis of the TFD architecture and how this solution satisfies the requirements identified in Section 2.0.

Section 3.3 follows with an analysis of the ADFR architecture and how this solution satisfies the requirements identified in Section 2.0.

Like ICAO Doc 10054 and ICAO Doc 10165, ARNIC Report 681, has several references to ICAO SARPS, including Doc 10054 that defines timely recovery of flight data to include recovery of the appropriate CVR channels and appropriate FDR data.

1.1.14. EUROCAE ED-112B

EUROCAE ED-112B Change 1 was released in December 2024 and provides minimum operating performance standards for crash protected flight recorders.

Section 3 provides standards and guidance for automatic deployable flight recorders, and

Section 6 provides standards and guidelines for transmission of flight recorder data (TFRD).

Section 3 – Automatic Deployable Flight Recorders (ADFR):

Section 3 details the additional requirements and exceptions that are specific to deployable recorders. The requirements specified in this section shall be met in addition to the requirements of Sections 1 and 2, together with Sections 4 and 5 as applicable, and the appropriate recorder specific parts.

Para 3-1.2 Use of Deployable Recorders, summarizes the purpose of an ADFR

“to have flight recorder data available soon after an accident, in particular for accidents over water.

The integrated ELT provides for locating the accident site for both search and rescue and timely recovery of flight data purposes.

Being floatable, it will assist in locating the accident site by providing ELT signals when the wreckage sinks below the surface of the water.

For aircraft equipped with two combination recorders, it is expected that an ADFR may be one of the combination recorders.

It is expected that the ADFR provide all the recording functions required for the aircraft for which it is installed.

Para 3-1.8.2, Radio Location Beacon, specifies the specific ELT requirements:

shall be equipped with a Class 1 dual frequency 406 MHz and 121.5 MHz ELT compliant with the requirements of ED-62B instead of the underwater locator beacon and its attachment as specified in paragraph 2-1.16.4.

The ELT shall be attached to the deployable recorder such that the aerodynamic properties of the recorder are not adversely affected and the risk of damage to, or separation of, the locating device is minimized.

In addition to meeting the endurance requirements specified by ED-62B, the 121.5MHz radio shall operate for an additional 102 hours for a total minimum operational duration of 150 hours, under the conditions specified in paragraph 3.8.6 of ED-62B for a class 1 ELT. For the operational duration in exceedance of ED-62B (between 48 hours and 150 hours of operation), the minimum Equivalent Isotropic Radiated Power (EIRP) for the 121.5MHz radio shall be 5mW.

3-3.2 Test Procedures, specify the various tests applicable to an ADFR. There are a number of tests that specifically applicable to the ELT in the ADFR.

3-3.2.1 Impact Shock: The ELT is to be validated when subjected to an impact shock of 152 ft/sec. This is double the impact shock for a deployable ELT,

3-3.2.3 Static Crush: The deployable recorder is subjected to a static crush of 2,000 lbs. applied continuously for a test period of five (5) minutes.

3-3.2.8 Seaworthiness

The intention of this test is to demonstrate that the ADFR is able to remain buoyant and provide a detectable distress signal after deployment.

Transmission of the ELT frequencies shall then be demonstrated… confirming reception of the alert signals using the Aliveness test per ED-62B Section 4.3.1. paragraphs a), c), and h).

Section 6 – Transmission Of Flight Recorder Data (TFRD):

Section 6 details the additional requirements and exceptions that are specific to Transmission of Flight Recorder Data (TFRD) systems. The requirements specified in this section shall be met in addition to the requirements of Sections 1 and 2, together with Sections 3, 4 and 5 as applicable, and the appropriate recording application specific parts except as noted.

Para 6-1.1.1, Use of TFRD Systems, states, “the purpose of a TFRD system is to aid in the timely recovery of flight recorder data, which can include accident data from aircraft that are lost in deep water, mountainous terrain or in areas difficult to reach.”

It is expected that a TFRD be supplemental to the mandated physical onboard recorder system(s).

6-1.1.3 TFRD Classes, summarizes the two classes of TFRD Systems

Class	Recording System Purpose
T	TFRD systems designed to transmit flight recorder data in the event a pre-determined triggering condition is met (triggered transmission of flight recorder data)
C	TFRD systems designed to continuously transmit flight recorder data in near real-time

- Class T TFRD systems store flight recorder data to a memory buffer and, when triggered by an onboard event, instead transmit the data set in near real time as defined in this Section. Additionally, buffered historical data recorded prior to the trigger event should be transmitted to the largest extent possible without compromising the transmission of the real time data.
- Class C TFRD systems transmit flight recorder data in near real time as defined in this Section.

1.1.15. EUROCAE ED-62B

EUROCAE ED-62B Change 1 was released in June 2020 and provides minimum operating performance standards and guidelines for emergency locator transmitter. Section 2.9.4 describes ELT automatic deployable as part of an automatic deployable flight recorder.

ED-62B was the first ELT document to specifically set test requirements for an ELT in an Automatic Deployable Flight Recorder (ADFR) and a Distress Tracking ELT.

The update to EUROCAE ED-62B was used to incorporate additional environmental and crash tests for:

an ELT in an ADFR (more stringent that for an Automatic Deployable ELT (ELT(AD))

and

a Distress Tracking ELT (ELT-DT).

In reference to EUROCAE ED-62B Group A Tests, an ELT in an ADFR is mandated to pass four (4) additional tests to that of a Distress Tracking ELT:

Lightning Induced Transient Susceptibility

Lightning Direct Effects

Icing

Water Sensor

An ADFR, designed to be installed in an external location on the aircraft, in a more hostile environment, is required to pass the additional test to ensure it remains operational to reliably deploy and activate it ELT during a crash event.

In reference to EUROCAE ED-62B, Group B Tests, an ELT in an ADFR is mandated to pass seven (7) additional tests to that of a Distress Tracking ELT:

Fluids Susceptibility

Fungus Resistance

Sand and Dust

Impact (projection test)

Fire

Post Crash Immersion

Buoyancy

An ADFR, meeting the requirements of ED-112B for flight recorders, is required to pass the additional ED-62B crash safety tests is designed to survive the crash event and continue to transmit its 406 and 121.5 Distress/Homing frequencies post the crash event for the purpose of Post Flight Localization (PLF), and after to provide Post Crash Homing in support of Search and Rescue.

ED-62B in Para 4.1.1. ELT(AD) in ADFR, states that an ELT AD embedded in ADFR is also required to meet the requirements of ED-112A 36 section 3, in particular the sequence of test § 3-1.8.1.a. III or ED-155 section 3, in 37 particular the sequence of tests described in § 2-1.14.3.

2. DISCUSSION

As part of the Investigative Technology ARC, a subgroup was formed to address recommendations to the FAA for:

Whether to require newly manufactured aircraft used in extended overwater operations under part 121 and part 135, which are required to have a CVR and FDR, to be equipped with a means to recover mandatory flight data parameters; the means of recovery should not require underwater retrieval. The data should be captured from a triggering event until the end of the flight and for as long a time period before the triggering event as possible in consideration of the mandate in section 352 of the Act.

The subgroup reviewed specifications, manuals, and reports related to the initial ICAO specification in Annex 6 Part I for the timely recovery of flight recorder data. These documents were outlined in section 1.3, ARINC Industries Activity specifications in section 1.4, and European Union Aviation Safety Agency studies in section 1.5. Currently, there are two technologies that members of the aviation industry have been working on for over a decade that have the highest likelihood of meeting the requirements of Public Law 118-63, Section 352 – deployable aircraft recorders and the use of satellite communication systems to stream the parametric data set compliant with the 14CFR Part 121 Appendix M. The subgroup is comprised of subject matter experts spanning airframers, OEM's, operators, and aviation specialists familiar with one or both technologies. This report will provide qualitative descriptions of the technologies, the impact for inclusion of these technologies for "applicable aircraft" cited in the Act, a rough order of magnitude cost of such technologies, and the benefits of these technologies.

2.1 Assumptions

Due to the various organizations who have studied and produced reports and guidance material on this subject, the intent and interpretation of the products of these groups, and the actual wording of section 352 of the Act, the subgroup has reviewed the material and established a set of assumptions and definitions that bound the problem space to the tasks required by the FAA due to the Act.

The subgroup's recommendations are based on the following assumptions:

The NTSB's recommendations to the FAA does not include the word "timely" but that recovery of flight recorder data would not require underwater recovery. The subgroup assumes that the NTSB would prefer recovery of flight recorder data in a timely manner.

The NTSB's recommendations to the FAA states that aircraft should be equipped to "…recover mandatory flight data parameters…" The subgroup interprets this to mean that a recommendation for regulation would require a solution to recover at a minimum the mandated flight data parameters from the DFDR. CVR, DLR, and AIR's recordings are not required to comply with section 352 of the Act as part of a recommended solution.

The subgroup interprets the term “mandatory flight data parameters” as meaning those parameters as listed with the appropriate accuracy, resolution, and frequency defined in 14 CFR 121.344 or 14 CFR 135.152.

If those parameters meet the accuracy, resolution, and frequency the required data set may come from the Flight Data recorder map stream or stream or any other available aircraft source providing them.

For accidents and incidents occurring during extended overwater operations, the NTSB will work with Search and Rescue (SAR) operators to recover the physical aircraft and fixed flight recorders regardless of an aircraft’s ability to provide flight recorder data in real-time or near real-time, or to deploy a memory module designed for extended floatation.

2.2 Harmonization between US Law and ICAO Standards and Practices

In 2017, ICAO released version 6.0 of the GADSS concept. GADSS highlighted four functions: aircraft tracking, location of aircraft in distress, post flight localization, and flight recorder data recovery. Section 352 of the Law reads almost verbatim to the NTSB's language in A-15-1 through A-15-3. They basically require 14 CFR 121 operators to equip their aircraft with a means of post-flight localization and the recovery of mandatory flight data parameters (i.e 14 CFR 121.344 Appendix M parameters required by a DFDR). As shown in the table below, the language of the Law does not harmonize with the GADSS concept and in particular, does not harmonize well with section 3.6.3 of ICAO Annex 6. This leads OEM's and operators with multiple interpretations between the US Law and ICAO standards and recommended practices.

Function	ICAO GADSS Concept	Section 352 of Public Law 118-63
Aircraft Tracking	4-dimensional position (4D – latitude, longitude, altitude and time) at a reporting interval of 15 minutes or less	N/A
Location of Aircraft in Distress	Identify the location of an aircraft in distress with the aim of establishing, to a reasonable extent, the location of an accident site within a 6 NM radius	Equipped with a tamper-resistant method to broadcast sufficient information to a ground station to establish the location where an applicable aircraft terminates flight as the result of such an event
Post Flight Localization	To assist the localization of the wreckage and recovery of flight recorder data after an accident, the post flight localization and recovery function specifies a number of requirements for, ELTs, ULDs and flight recorders	Equipped with an airframe low-frequency underwater locating device that functions for at least 90 days and that can be detected by appropriate equipment.
Flight Data Recovery	Recover the flight recorder data and make it available in a timely manner. This includes FDR and CVR data and other recorders installed for the purpose of complimenting accident/incident investigation. (6.3.6)	in the event of an accident, to recover mandatory flight data parameters in a manner that does not require the underwater retrieval of the cockpit voice recorder or flight data recorder

In amendment #2 of the Investigative Technology ARC, section 4.e.v. was modified to discuss issues and develop recommendations on, "How best to coordinate with other international regulatory authorities and ICAO to harmonize the implementation of requirements…" for a means of recovering mandatory flight data parameters that do not require underwater retrieval. ICAO has issued recommendation 6.3.6 for the timely recovery of flight data and published a manual, Doc 10165, as a means of approving systems for the location of aircraft in distress and flight recorder data recovery. It needs to be highlighted that the ICAO mandate on Flight Recorder Data Recovery is aiming for the development of new aircraft types for which the type certification process started on or after January 1st, 2021. Airframers and OEM's have been using GADSS guidance materials as a framework for their investment in technology that would meet the timely recovery of flight recorder data. Based on reference document 1.13, the FAA was working with ICAO and other organizations to better leverage technology to improve safety from which the Investigative Technology ARC was created. In the last communication document, on 11/8/2023, the NTSB was concerned that the FAA would not issue rule making regarding the TRFD. Section 352 of the Law creates issues with the idea of TRFD in that it requires only a subset of the GADSS concept but the time frame for compliance gives insufficient time for airframers to implement a system that would meet section 6.3.6 of ICAO Annex 6.

2.3 Potential Technology Solutions

Automatic Deployable Flight Recorders (ADFR)

ICAO Annex 6, Part 1 defines an Automatic Deployable Flight Recorder (ADFR), as follows: "Automatic deployable flight recorder (ADFR). A combination flight recorder installed on the aircraft which is capable of automatically deploying from the aircraft."

The purpose of an ADFR is defined by ICAO in Annex 6 Part 1: Attachment K, 2. Clarification of Purpose of Equipment:

"2.3 Automatic deployable flight recorder (ADFR): The purpose of an ADFR is to have flight recorder data available soon after an accident, in particular for accidents over water. The integrated ELT provides for both locating the accident site for accident investigation and search and rescue purposes. Being floatable, it will assist in locating the accident site by providing an ELT signal when the wreckage sinks below the surface of the water. It also ensures redundancy for one ELT." Being an ED-112A / ED-62B certified flight data recorder, an ADFR can be installed as one of the required recorders in a dual combination CVR/FDR recorder system. ED-112A and its references to ED-62B or later revisions, includes MOPS for an ADFR.

EASA CS 25 Amdt 27, references: CS 25.1457 Cockpit voice recorders, CS 25.1459 Flight data recorders, and AMC 25.1457, Section 8, provide details on the accepted means of compliance for deployable Cockpit Voice Recorders (applicable also to deployable FDR & DLR by reference).

Transmission of Flight Recorder Data (TFRD)

In the context of this document, TFRD is a means of using onboard aircraft system(s) to transmit flight recorder data to a cloud storage facility for the purposes of an accident investigation. The system is not an additional flight recorder but a system that interfaces with a data acquisition unit or directly with the flight recorders and some form of airborne connectivity. The data can be streamed in real-time throughout the flight or based on a triggered event where the most recent data is transmitted followed by historical data from the flight.

Full GADSS TFRD Solution

This technology is intended to be a ground up system that aligns with industry manuals and recommendations associated with the GADSS concept, and its intended function is to provide data for an AIA. The intended function includes the necessary ground infrastructure that has the level of data security, data integrity, and appropriate levels of authentication required for the purpose of an accident investigation. At this time, Minimum Aviation System Performance Standards and related Minimum Operational Performance Specifications are still being developed. Currently ED-112B has general design specifications for TFRD and ARINC Report 681 has an architectural framework for TFRD.

Solution(s) That Meet Intent of Section 352 of the Law

Today there are systems installed onboard aircraft (i.e. AID, IFC, and DFDAU) that are capable of transmitting parametric flight data during flight. However, their intended function is to provide flight data to the operator and 3rd party vendors to improve safety and reliability of the air carrier's operations, e.g. in the frame of a Safety Managment System or for maintenance purposes. Even though these systems being in the position to provide valuable data to support an incident or accident investigation these installations are not designed to ensure reliable transmission of the data under abnormal operating conditions likely to be encountered when the aircraft is entering a distress condition. In many cases, the communications link used for this function has been installed specifically for use by passengers or cockpit communications for safety and operational services. Though there are ARINC specifications and TSO's for individual LRU's that make up the streaming system, guidance materials and MOPS that dictate how data is streamed off the aircraft, or common standards to ensure the integrity of the data stored on ground, are still in development.

For more detailed discussions on the technologies mentioned, reference documents listed in sections 1.1.9 and 1.1.10 – 1.1.14.

3. Analysis

3.1 Qualitative Impact of Flight Data Recovery Technologies

3.1.1 Readiness of Technology (Airframer/OEM Considerations)

3.1.1. Readiness of ADFR Technology

Automatic Deployable Flight Recorders (ADFRs) and Automatic Deployable Emergency Locator Transmitters (ELT(AD)s) have been operated for over 50-years on fixed and rotary wing aircraft, supporting difficult operational roles including offshore oil exploration, search and rescue, polar, and military missions.

The FAA granted a TSO for a rotary-wing deployable flight recorder in 1999. There is one OEM who has designed and manufactured an ADFR and has a partnership with a major US OEM who manufactures and sells various aircraft flight recorder systems for transport category aircraft. At least one 14 CFR 25 aircraft manufacturer has made announcements about its plans to install ADFRs on its long-range aircraft models. As of this writing, the development process for this OEM is in progress. There are military versions of certain transport category aircraft examples of deployable recorders and emergency locator transmitters that have been qualified as ‘dual-use’ on fixed-wing transport aircraft (e.g. B707, B727, B737, Dassault HU-25, Lockheed L-188). It should be noted that some examples of such recorders may have capabilities or design factors that meet specific military missions above and beyond the requirements of ED-112A. It is believed that the application of ADFR on commercial aircraft imposes new aircraft level requirements (like expressed in CS25.1457(d)(7) and corresponding AMC material).

The installation design of an ADFR system has several elements that must be considered in light of ED-112A and FAA regulations for newly manufactured aircraft versus retrofit aircraft. Today, in summary, 14 CFR 25.1459 and 14 CFR 25.1457 state that the DFDR and CVR must be in a separate container from the other recorder and must be located as far aft as practicable. Should a dual-combination CVR/FDR recorder system be installed, then each combination recorder must comply with combined CVR/DFDR requirements. In such an installation, it is allowable for one combi-CVR/FDR (Master CVR) to be located near the cockpit and the second combi-CVR/FDR (Master FDR) must be installed in the aft section of the aircraft. An ADFR can be installed as the second combi-CVR/FDR (Master FDR) recorder. Each Combi-recorder is designed to record multiple aircraft data types (ex. DFDR, CVR, DLR, CIR). Generally, airframers can use both methods, separate containers or combi recorder, for installation of required recorders on production aircraft.

Despite the availability of the industry standard MOPS: EUROCAE ED-112A / ED-112B and ED-62B, corresponding US regulations regarding equipment aircraft installation of deployable recorders are not yet available and need to be developed. For recovery and investigations no new tools or equipment would be required. Policies and controls governing the investigation and recovery of the data from fixed recorders, in place to ensure that the data is secure and cannot be tampered with, are applicable to deployable recorders.

3.1.1.2. Readiness of GADSS Transmission of Flight Recorder Data (TFRD)Technology

ED-112B Section 6, provides general design specifications for the transmission of flight recorded data. Doc 10165 and ARINC Report 681 provide guidance for TFRD technology and are written with the assumption that the primary function of the system is for TFDR and that any other uses will have lower priority to the TFDR function. There are industry groups who are currently working on various MOPS and performance specifications for systems that will meet the GADSS concept. These include aircraft system (ex. Virtual recorders) and ground systems that would handle the aircraft data. The subgroup believes that there are no specific systems certified to ED-112B, section 6 or perform the TRFD as documented in Doc 10165 for TFRD technologies. There are OEM's who specialize in the various aspects of acquiring, processing, offloading, and performance of post flight analysis who have existing LRU's that may already meet many of the GADSS concept requirements for TRFD.[84] These OEM's may be working with airframers to develop a full-up TRFD solution. The group estimates that MOPS for the TFRD will be available by the end of 2026 and that the required ground-based infrastructure would be up and running within the same timeframe.

3.1.1.3. Readiness of Other TFRD Technology

Today, a large portion of aircraft operated by 14 CFR 121 operators have some form of satellite-based IFC/IFE equipment. This equipment allows passengers the ability to perform office tasks, like email and web browsing and the streaming of media content. There are multiple 14 CFR 121 operators who employ an AID connected to the IFC system or have IFC systems that can act as an AID that can collect parametric data. Most flight and cabin crews use of an IFEC is for PED's (ex. EFB's and crew tablet devices) with specific applications that can be used to facilitate improved operation of the aircraft and flight. The committee is aware that some operators are currently using IFC technology to offload parametric data, while in air. As of this writing, their 3rd party flight data analysis firm who are improving their systems to allow processing of real-time data to make it available to users prior to the end of the flight. Using technology available today, with modifications to software in the IFEC system, potential H/W modifications, and additional aircraft wiring, IFEC systems can be used to offload parametric flight data. Data collected by the operator can be made available to AIA's. However, these system capabilities are based on the assumption that the aircraft will successfully complete its flight and is not necessarily designed to capture data during the premature termination of flight. The equipment used is designed and certified for their intended purpose (i.e. AID or passenger entertainment) based on OEM specifications or certain ARINC standards. They are not designed to meet

[84] *The avionics options to comply with GADSS*, Aircraft Commerce, Issue No. 127, December 2019/January 2020

ICAO's GADSS concept or ED-112B specifications. Additionally, industry experts have concluded that a TFRD system used for AIA investigations must be able to transmit parametric flight data to a secure (i.e. both physical and cyber) ground storage facility. The subgroup is aware of the efforts of industry working groups in developing MOPS and standards for virtual flight recorders and IT/Business consulting services firms who are working with operators on the secure storage of flight data. Today, it is typical for IFEC and cellular Quick Access Recorder (cQAR) communications to occur between the aircraft and DSP, and from the DSP to the operator. The operator then can elect to send the raw data to other 3rd parties. The subgroup is aware of at least one existing automated, ground storage/communications system for flight recorders in the final stages of operational preparation, including the process of enabling access for Accident Investigation Authorities particularly the NTSB.

3.1.2 Affected Aircraft and Section 352 Timelines

Section 352 of the Law requires that the FAA issue regulation within 18 months of enactment of the section (17NOV2025) to complete rule making proceedings to require that no later than 5 years after the date of enactment of this section (17MAY2029), all applicable aircraft will be fitted with a means to recover mandatory flight data without requiring underwater recovery. Applicable aircraft include those that are manufactured on or after 01JAN2028 and:

- Operated under 14 CFR 121
- Required to have a CVR and an FDR; and
- Used in extended overwater operations

Applicable aircraft include, but not limited to, the following aircraft families:

- Airbus A220
- Airbus A32X neo
- Airbus A330 neo
- Airbus A350
- Boeing 737 MAX
- Boeing 777X
- Boeing 787
- Embraer E2

Using information from the internet, on average, it takes airframers 2.5 – 3[85] months to manufacture an airplane provided that there are no external factors (ex. Supply chain issue, natural disasters, etc.). Additionally, the materials required for the aircraft being produced should be on dock 45 to 60 days before the aircraft assembly starts. To assemble an aircraft on a specific date requires 5 months' lead time for all completed parts to be on hand for installation. This does not include the lead time for parts and sub-assemblies to be built and shipped to the assembly site. Based on 2025 delivery estimates for Boeing and Airbus and adding 20% to capture Embraer and other builders along with market changes between now and 2028, the subgroup estimates that approximately 2000[86] aircraft would be delivered in 18 month period between 01JAN2028 to 01JUN2029.

Figure 3, below, graphically shows the timeline for expected compliance to section 352 of the Law.

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[85] https://travelupdate.com/how-long-does-it-take-to-build-a-commercial-aircraft/

[86] Assumes additional regulatory agencies will adopt the mandate with third country operator obligations as has occurred on similar mandates in recent history (ex. Distress Tracking) resulting in near 100% incorporation for each aircraft OEM.

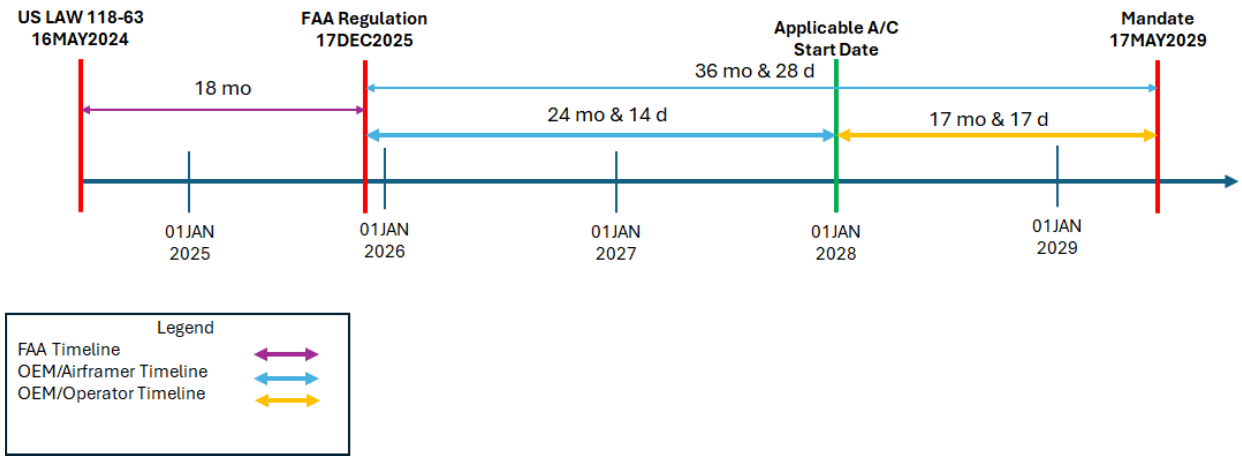

Figure 3 – P.L. 118-63, Section 352 Timeline

The Law gives the FAA eighteen months to create rule making. Until an NPRM is published OEM's and airframers have insufficient engineering requirements to make design decisions on what to design the intended systems to. This gives OEM and Airframers approximately 24 months to design, build, test, get FAA approvals for equipment, Part Manufacturing Authority (PMA), and changes to the aircraft's type design. This provides parts OEM's approximately 12 months to deliver parts for aircraft that will complete manufacturing on or after 17MAY2029. Due to 01JAN2028 applicability date, the airframer and OEM's must develop FAA approved data and parts necessary for operators to retrofit applicable aircraft delivered in the seventeen months prior to the 2029 mandate.

The law specifies a timeline which is significantly more ambitious than comparable mandate introductions in the past. Based on previous experiences with similar changes, such as TCAS, ADS B or Distress Tracking, we must assume that the required rulemaking to take place, the following development of the related systems and the corresponding integration, and the development of the associated maintenance, training and operational procedures require a similar amount of time to the above-mentioned systems / mandates. This translates into a timeframe of approximately 10 years.

3.1.3. Additional Uses of Technology – Assessment of additional technology benefit

The Automatic Deployable Flight Recorder (ADFR), certified to ED-112A, is a complementary solution to provide an alternative method to recover the entire 25-hours of regulated flight recorder data following an accident. The ADFRs ability to deploy and separate from the aircraft is beneficial for over-water and remote location events. The additional benefit of an ADFR is its ability to provide 150 hours of post-crash ELT homing (121.5 MHz) to optimize SAR operations focused on rescuing survivors. The subgroup believes that an AFDR being a Combined-CVR/FDR and meeting the requirements of ED-112A/B can replace one of the installed recorders specified in 14 CFR 121 when configured as a dual-combined recorder installation. For the purposes of the Law, the AFDR would be installed in lieu of one of the fixed combination recorders.

A Transmission of Flight Recorder Data (TFRD) system, depending upon how it is implemented, can provide additional usage to the operator if it is designed to continuously transmit flight data parameters in near real-time. During normal operations the data, in association with a 3rd party data processing and analysis tools, can be used for a FOQA or MOQA program. As data is streamed in, the analysis tool is programmed to look for exceedance or identify data that is a precursor to failure of a component and can provide notifications of an occurrence. For a FOQA program, safety analysis can see trends earlier and can preemptively incorporate training or flight crew bulletins to alert pilots of issues. For MOQA, along with aircraft health monitoring and condition monitoring reports, a maintenance coordination center (MOC) can plan in advance of the aircraft's arrival for the time and place for preventative maintenance. This helps maintain high reliability of the aircraft, helps in trouble shooting, and reduce delays due to unplanned maintenance. Additionally, the connectivity can provide flight crews with other tools that allow them to fly the aircraft more efficiently and provide additional situational awareness, and with proper cyber security measures in place can provide passenger revenue as well. If the operator cannot use a FDS system for anything other than the intent of the Law, then it has a negative impact on the operation of the aircraft by the additional cost for the connectivity, and fuel and performance penalties due to the extra weight of the system and the aerodynamic drag of additional antennas mounted on the fuselage.

3.1.4. Tradeoffs of Technologies

Both technologies can be used to comply with P.L. 118-63, section 352 for obtaining aircraft flight data parameters without requiring underwater recovery and positive and negative factors for choosing which technology to use to comply with the law. AFDR's when compared with TFDR technology is simple and straight forward in that under normal operations an operator only needs to comply with the aircraft OEM's ICA's for maintenance of the system as with any other installed recorders. The AFDR does not require any additional equipment or processes for an AIA to recover and access the data on the recorder. Data on an ADFR will be accessible after SAR assets located and recovered the recorder and download, and decoding the data stored on the ADFR memory module has been done. It is anticipated that the AFDR being programmable to expand its data-set in response to future regulatory requirements, will have a life-expectancy of 25+ years.

A TFDR has the advantage that the data is immediately accessible to AIA's without requiring the recovery of the system or determining the location of the aircraft, but after data authenticity has been assessed and confirmed. Additionally, the system can have expanded usage for the operator beyond the AIA's requirement. However, the implementation of such a system is believed to require several subsystems and require TCP/IP technology to work successfully. Due to vulnerabilities of internet technology, the system must have strong cyber security protections in place on the aircraft and ground systems. There must be a means to authenticate the data to the aircraft and methods to validate that the data has not been tampered with.

3.2. Quantitative Cost and Benefit Data

At this time, there is not an available solution that meets the requirements of section 352 of the Act that the subgroup can derive reasonable actual costs to operators for enactment of the law.

However, the group acknowledges the importance of evaluating the costs and benefits of the potential Timely Recovery of Flight Data (TRFD) technologies previously discussed.

<u>Benefits of Timely Availability of Flight Data</u>

Providing flight data soon after an accident significantly enhances aviation safety. The prompt availability of this data allows investigators to quickly determine precise and immediate corrective actions, helping to restore and maintain the highest levels of aviation safety. This, in turn, minimizes the potential impact on operations. Given that safety is the paramount value in the aviation industry, the group will not conduct a further benefit analysis.

<u>Scope of Cost Assessment</u>eThe cost assessment will focus solely on the cost of the technology itself, excluding expenses related to accessing the flight data, which is deemed to be part of an accident investigation activity.eFor Automatic Deployable Flight Recorder (ADFR): Costs associated with recorder search and retrieval by Search and Rescue (SAR) teams will not be assessed. These costs can vary significantly based on factors like weather and accident location. Similarly, cost for ELT-AD signal transmission are not part of the cost assessment. It is also to be noted, that the (SAR) communication infrastructure is in place today.eFor Transmission of Flight Recorder Data (TFRD): The cost assessment will not include costs related to data retention, continuous updates to data centers, or server maintenance, security, or software. This is due to the wide range of potential cost elements and the likelihood of reusing existing infrastructure, including security measures.e**3.2.1. Estimated Cost for ADFR Solution**eAn Automatic Deployable Flight Recorder would be deeply integrated into the aircraft's system and structural environment. Hence, to assess the estimated cost for an ADFR, some assumptions need to be made:eRetrofit Costs: Retrofit costs will vary significantly due to the highly variable nature of integration into existing airframes based on the original type certification timeframe, aircraft communication technology, extent of available provisions and a number of additional installation variables. The analysis assumes that the affected aircraft has the necessary minimum provisions already installed and its configuration has been designed with the needed modification for deployable recorder in mind.eFunctional Maintenance Parity: There are no differences in functional maintenance, MMEL (Master Minimum Equipment List), or certified maintenance reviews between a classical flight recorder and an ADFR. This implies that the ongoing operational maintenance costs for the recording function itself are comparable and therefore may double, given the ADRF is likely to be installed in addition to existing recorders in many installations.eIntegration Drives Cost: The physical integration of the ADFR into the aircraft's structure (e.g., vertical tail plane vs. fuselage) is a primary driver of cost, impacting both:eIntegration Costs: The complexity of installation, structural modifications, and associated labor.eEquipment Costs: Potential variations in the ADFR unit itself due to differing form

factors, ruggedization requirements, or specialized interfaces based on its location.eSafety and Qualification Impact: The integration location and method will influence:eDesign Assurance Level (DAL): Higher DALs may be required for components integrated into critical structural areas, leading to more rigorous design, testing, and documentation, thus increasing cost.

- Qualification Level: The level of certification and qualification testing required will vary depending on the integration, directly influencing development and testing costs.

Potential Design for an ADFR (under consideration of ED-112A/B, CS-25, CM-21 and derived design needs):

Based on the aforementioned MOPS, certification specifications, and the need for deep integration, a potential design for an ADFR is assumed to consist of:

- a deployable unit which includes a data acquisition part, the storage medium, a self-monitoring function, an ELT-AD with its associated battery pack, ELT 121.5/406MHz and GNSS antenna, a locking device and a retention mechanism
- a cradle/tray carrying the ADFR including adjustment means
- a release unit bearing means to deploy the ADFR in case of significant airframe deformation or when immersed in water

Classical flight recorders equipment range in costs between $25,000 and $45,000 based on today's available pricing for several recorder suppliers. One may conclude, as a very rough estimate, a pricing for an ADFR system will be in the range of 4 to 6 times the price of a single classical flight recorder. This rough estimation is also based on:

- the different functional elements which exist similarly on the aircraft like, ELT AF/DT, antennas or slide cradles
- the increased environmental qualification level (DO160) when compared to classical recorders due to exposure to the aircrafts outside (i.e. lightning effects, (de-)icing etc)
- an assumption that existing legacy equipment is cost optimized over decades while the ADFR is all new for commercial application
- the use of modern light-weight composites to cope with the weight constraints for parts on the aircraft's outside and the resulting loads

For similar reasons and due to the significant variability in physical and electrical integration of an ADFR retrofit solution, associated labor hours and retrofit duration required for installation on each of the potential 2000 aircraft within the retrofit window, retrofit costs (excluding system equipment) may be in excess of $50,000-$80,000 per aircraft. This estimate could vary significantly based on the level of provisions the OEM is able to incorporate prior to delivery of each aircraft. In a very rough estimate, one can consider a 5–10-day aircraft downtime[87] for retrofit activities. To avoid additional loss of profit due to that downtime, a retrofit would be deemed doable only during a heavy maintenance check (C or D), which creates additional constraints for the retrofit time window.

These estimates are in addition to recurring costs to install in production and maintain equipment (and spares) for all affected aircraft.

While deployable recorder system is addressed in existing MOPS (like ED-112A/B, ED-62B, etc.) there is no certification specification issued by the FAA. Hence, the ultimate cost of Automatic Deployable Flight Recorder equipage, retrofit and its associated interconnections is difficult to assess. The above estimate also presents the result of an analysis based on today's existing foreign regulations. The real costs may consequently differ significantly. Market volume, technology upgrades, and other factors will influence the pricing.

3.2.2. Estimated Cost for TFRD Solution

Today, there are two main radio bands used for satellite data communication: L-band and Ka/Ku band. Cockpit and safety links that run on L-band, which is more resilient to weather related signal attenuation effects, remain an order of magnitude more expensive than the broadband pipes used for passenger Wi-Fi. Safety and high-reliability / high-availability networks underpinning the ground networks of these satcom services drive the price. About $3–$6 / MB on Inmarsat SwiftBroadband or Iridium Certus is still typical. Ka/Ku packages from ViaSat, Jet ConneX (Inmarsat GX, now also ViaSat), Starlink or FlexExec are available between $0.07 and $0.20 / MB when bought in 10–50 GB blocks – and can fall effectively to zero on today's "unlimited" plans that cap costs at $8 k–$14 k per aircraft per month. Data rates follow the same pattern: L-band tops out at ~700 kbps, whereas Ka/Ku services routinely deliver 15–250 Mbps to the cabin, with Starlink and ViaSat now advertising >100 Mbps and performance similar to fibre-optic cables.

Recent developments in the management of multi-bearer networks, where a service may automatically choose the best available network ("hyperconnectivity") promise higher reliability at an overall lower cost.

Below is a business-level estimate of how much data the flight recorders record, the bandwidth required to stream them live, and what that would cost on today's typical aeronautical satellite data plans.

Key points

[87] available sources identify the cost of aircraft downtime at approximately $10,000 per hour, which includes factors such as loss of revenue, replacements, scheduling, organization, etc.

- Flight-data is tiny by modern networking standards: the statutory 88-parameter data set produces only ~1 kbit/s, or 0.46 MB per flight-hour. Even a “full” recorder running at 2048 words/s is still <12 MB/h.
- Cockpit voice is more dat. Six audio channels sampled at telephone quality (8 kHz, 12-bit) need ~0.6 Mbit/s, i.e. 260 MB/h uncompressed.
- On L-band (Iridium Certus or Inmarsat SwiftBroadband) that voice stream would cost hundreds of dollars per hour; on modern Ka/Ku packages (ViaSat, Jet ConneX) the same traffic is well under $25/h, and effectively free on Starlink’s flat-rate plan.
- Streaming the minimum Part 121 Appendix M data set costs very little by comparison, at <$0.10/h on Ka/Ku and ~$2/h on L-band, opening the door to real-time FDR mirroring.

This analysis assumes that the line-fit L- and Ka/Ku-band satcom systems installed on large transport aircraft will meet the performance criteria necessary for an acceptable means of compliance with the forthcoming TRFD regulation; therefore, no separate communication subsystem is deemed to be required.   If that is not the case, additional retrofit costs in excess of ~$250k/aircraft may be required to install necessary equipment and interfaces, such as L- and Ka/Ku-band satcom systems or similar.

In the absence of approved MOPS, or any equivalent end-to-end standards governing data authenticity, integrity and security, the ultimate cost of streaming flight-recorder data is likely to vary. Normal market factors such as technology upgrades, the rapid growth of satellite communication networks, increased reliance on software, increasing standard equipage of both L and Ka/Ku band satcom systems on new airplanes, and economies of scale in both data and hardware will continue to influence pricing.

For similar reasons and due to the significant variability in physical and electrical integration of an TFRD retrofit solution, associated labor hours and retrofit duration required for installation on each of the potential 2000 aircraft within the retrofit window, retrofit costs (excluding system equipment) may be in excess of $10-50k/aircraft, Again, this estimate could vary significantly based on the level of provisions the OEM is able to incorporate prior to delivery of each aircraft. These estimates are in addition to recurring costs to install in line-fit and maintain equipment and spares on all affected aircraft.

The table below summarizes the quantitative cost analysis for timely recovery of flight data systems in retrofit.

Technology	ROM Equipment Cost / Airplane	ROM Retrofit (Labor/Installation kit) Cost/Airplane	Estimated Duration for retrofit	Total Cost / Airplane (excluding Downtime)	Total cost of retrofit for affected aircraft (~2000)
ADFR	$140-210k	$50-80k	5-10 days	$190-290k	$380-580M
TFRD	$50-250k	$10-50k	1-6 days	$60-300k	$120-600M

Non-recurring engineering cost and recurring installation cost during aircraft production will be significant and are assumed to be part of the airframe manufacturer's pricing policy.

4. Recommendations

NOTE: Due to the framework given by the 2024 Reauthorization Act, the FAA is limited on what they can do with regards to affected aircraft and timelines. When the Investigative Technology ARC makes recommendations asking for exemptions or accommodations from US Law, it is assumed that in Congressional Committee hearings that the FAA will use the information provided by this committee to advocate for changes in the law.

The group believes that such means to more timely retrieve flight recordings after an accident will benefit overall aviation safety. This needs to be ensured at an international level with common performance standards based on available ICAO Standards and Recommended Practices (SARPs).

Based on the investigated potential solutions the group has the following recommendations with regards to recovery of mandatory flight data without requiring underwater retrieval:

REC 1	The FAA shall establish requirements to reduce the time needed to recover flight data recordings after an overwater accident. These requirements should be harmonized with the standards and recommended practices of ICAO and those States that have adopted ICAO Annex 6 Part I Chapter 6.3.6.

<u>Summary of Rationale:</u>

The group believes that such means to more timely retrieve flight recordings after an accident will benefit overall aviation safety. This needs to be ensured at an international level with common performance standards based on available ICAO Standards and Recommended Practices (SARPs).

Expedited access to flight data post-accident is crucial for aviation safety. Prompt data availability enables investigators to more swiftly identify root causes and contributing factors, accelerating the implementation of effective countermeasures. This rapid analysis helps determine whether an accident resulted from technical issues, operational errors, or a combination of both. Consequently, targeted safety measures can be applied much sooner, significantly reducing the time required to restore safety standards. This efficiency also addresses public expectations for quick and accurate findings, along with immediate corrective actions.

REC 2	The scope of applicable aircraft should align with the initial aircraft population identified in ICAO Annex 6, Part I, Chapter 6.3.6. We recommend mandating this recovery means for newly designed Part 25 airplanes type-certificated on or after [5 years after enactment of the regulation].

Summary of Rationale:

Current industry planning is primarily focused on the new type certification (TC) approach, meaning readily available solutions are not yet widespread.

All potential solutions currently under research are aimed at integration into larger transport category airframes. Smaller aircraft operating under Part 121 or Part 135 have not been systematically within the scope of these efforts due to the absence of a mandate. These smaller aircraft may require dedicated solutions more suitable for their airframe size.

The current landscape of newly manufactured aircraft often leads to an excess of diverse technological configurations, resulting in a multitude of architecturally distinct solutions within the same aircraft family. This can be inefficient and resource-intensive, also at the approver level. However, applying solutions directly to newly certified Part 25 aircraft offers a more effective approach. This method prioritizes the development of optimal and technically sound solutions, eliminating the need for redundant, architecturally varied systems for a single aircraft family. Furthermore, performance limitations inherent in existing architectural designs will not constrain the development of solutions for these newly certified aircraft. This approach is expected to significantly reduce the overall number of solutions required compared to the current, less streamlined process for newly manufactured aircraft.

REC 3	The flight data parameters to be recorded shall meet the ranges, accuracies, resolutions, and recording intervals specified in Appendix M of 14 CFR Part 121. This data can be sourced from the flight data recorder (FDR) stream or any other available aircraft source that provides the necessary information.

Summary of Rationale:

To ensure a performance-based approach, the working group concluded that the data characteristics outlined in Appendix M of 14 CFR Part 121 represent the minimum required recording performance for parametric flight data. This level of data quality is achievable using any suitable onboard aircraft data source.

It is recognized that the parameters identified in Appendix M of part 121 sufficiently meet the needs for thorough accident and incident investigation.

Modern aircraft widely utilize integrated networks, making a vast array of flight data, including mandatory flight recorder parameters, readily available. Even aircraft without advanced networks like AFDX often feature multiple data sinks (e.g., cQAR, vDAR) that access the same data as those concentrated in Flight Data Acquisition Units (FDAU) or directly at the recorder (e.g., Enhanced Airborne Flight Recorder EAFR). This data frequently surpasses Flight Data Recorder (FDR) quality in terms of resolution and refresh rates.

Therefore, we recommend sourcing mandatory flight data for TFRD from any available aircraft network or data sink, provided the data meets the performance standards outlined in Appendix M of Part 121.

Applying international standards for data format and coding will seamlessly enable investigators and authorities to independently access and assess this critical information.

REC 4	The FAA should initiate rulemaking activities regarding the integration of minimum performance requirements for deployable recorders into the Part 25 regulatory environment, as well as establishing regulations concerning the minimum performance requirements for wireless transmission services. This should also include regulations and guidance regarding data retention, access authority, and ensuring the protection and privacy of the data.

Summary of Rationale:

The group identified the necessity of complementing aircraft equipage requirements with associated regulations to ensure the proper integration of such solutions. Furthermore, a regulatory framework is needed to ensure the authenticity, integrity, and consistency of the data. This also includes timely access for an Airworthiness Investigation Authority (AIA) to the data if it is not stored on the recorder.

The widespread adoption of wireless data transmission in aviation, from commercial purposes to cockpit communications, presents significant governance challenges. The critical nature of this data, particularly for accident and incident investigations, necessitates a robust framework for its management. Current transmission technologies, while commercially available, lack established governance standards to ensure data authentication, guaranteed consistency, tamper-resistant transmission, appropriate retention, and accessible usability. A national approach to this issue is insufficient given the global scope of the aviation industry; therefore, international collaboration among states and authorities is essential to develop and implement comprehensive data governance protocols. Additionally, regarding ADFR installation aspects, the coming regulation should recognize a deployable recorder in combination with a fixed combination recorder as a suitable means to fulfil the part 25 flight recording requirements.

REC 5	The timeline for introducing the mandate for TRFD should be extended to allow sufficient time for the creation of the pertinent regulations, followed by the industry systems integration of equipment on aircraft by the industry, including the necessary activities to ensure a stable entry into service.

Summary of Rationale:

Based on previous experiences with similar changes, such as TCAS, ADS B, or Distress Tracking, we must assume that the time for the required rulemaking to take place, development of the TRFD systems, airplane integration, development of associated maintenance, training development and operational procedure development will require a similar amount of time to the above-mentioned systems/mandates. This translates into a timeframe of approximately 10 years from the time performance standards are published. At this time MASPS/MOPS are not expected from ICAO Working Group 118 Sub-Group 4 until 4Q 2026. Despite the availability of MOPS for ADFR, the timeline currently stated in the Reauthorization Act is deemed insufficient for full development, integration and industrialization of an ADFR technology.

B5: CIRs

The following draft position papers written by the HRT group participants regarding different charter taskings are included to present a full picture of the HRT group's thought processes and key concerns in their own words, as well as further background on each of the areas discussed. They are presented exactly as written and do not represent the position of the full ARC.

Cockpit Image Recorders (CIRs)

1.0 INTRODUCTION:

The Federal Aviation Administration (FAA) has established an Investigative Technologies Aviation Rulemaking Committee (ARC) to seek recommendations on the best ways of recovering aircraft flight data. This position paper will address the topic of installing Cockpit Image Recorders (CIR) on newly manufactured aircraft and retrofitting existing aircraft that are required to carry a CVR and FDR.

This position paper addresses the following Charter items:

1. International harmonization and International Civil Aviation Organization (ICAO) standards.
2. Discuss and develop recommendations to the FAA based on improvements to safety, impact to the flying public, and economic viability.
3. Discuss issues and develop recommendations for maintenance, periodic testing, and validation of investigative technology systems.
4. For the following National Transportation Safety Board (NTSB) Safety Recommendations, discuss issues and develop recommendations to the FAA on:

a. Whether to require newly manufactured and existing aircraft operating under Part 121 and 135, which are required to have a CVR and an FDR, to be equipped with a crash-protected CIR, in compliance with TSO-176a, and to be equipped with an independent power source (A-15-7 and A-15-8).

2.0 BACKGROUND:

The NTSB made recommendations A-15-7 and A-15-8 to the FAA, recommending that existing (for recommendation A-15-7) and newly manufactured (for recommendation A-15-8) aircraft operated under FAR Part 121 or 135 be equipped with a crash-protected cockpit image recording system compliant with TSO-C176a. NTSB final reports in accidents and incidents that contributed to these recommendations indicated a possible need for the provision of Cockpit image recording (CIR).

Require that all existing aircraft operated under Title 14 Code of Federal Regulations (CFR)_ Part 121 or 135 and currently required to have a cockpit voice recorder and a flight data recorder be retrofitted with a crash – protected cockpit image recording system compliant with Technical Standard Order TSO - C176a, "Cockpit Image Recorder Equipment," TSO-C176a or equivalent. The cockpit image recorder should be equipped with an independent power source consistent with that required for cockpit voice recorders in 14 CFR 25. 1457. (A-15-7) (See section 2.7)

Require that all newly manufactured aircraft operated under Title 14 Code of Federal Regulations (CFR) Part 121 or 135 and required to have a cockpit voice recorder and a flight data recorder also be equipped with a crash – protected cockpit image recording system compliant with Technical Standard Order TSO - C176a, "Cockpit Image Recorder Equipment," or equivalent. The cockpit image recorder should be equipped with an independent power source consistent with that required for cockpit voice recorders in 14CFR25.1457. (A-15-8) (Supersedes Safety Recommendation A-00-31)

Although purpose-built CIRs have not been widely installed in flight decks, there are examples in historical accident and incident reports where video from a flight deck during the accident sequence proved valuable.

Referenced Accidents:

Atlas flight 3591, a Boeing 767 cargo flight, crashed into Trinity Bay on February 23, 2019. NTSB concluded that an inadvertent activation of the takeoff/go around (TO/GO) autopilot mode was causal to the accident. While the FDR recorded autopilot modes, the TO/GA activation button is not a specifically recorded parameter. NTSB stated in their final report (AAR 20/02) that available CIR data would have had a positive impact in the investigation to confirm the TO/GA activation.

Air Niugini flight 73, a Boeing 737-800 landed short of the runway at Chuuk International airport on September 28, 2018. In this accident, a company mechanic occupying the flight deck jumpseat used his personal cell phone during the flight to record the approach, capturing views of the flight deck forward panels and portions of the view out the window. The availability of the recording aided the investigation of Accident Investigation Commission (AIC) of Papua New Guinea.

An Indonesian MD-83 utilized a voluntarily installed CIR and encountered an engine exceedance during a flight. FDR data indicated that the autothrottle had switched off near the time of the exceedance, and the investigation considered focus areas on erroneous airplane behaviors that could have contributed to the event. Video data showed that the crew had moved the thrust levers forward just prior to the event, causing the autothrottle disconnect and subsequent engine exceedance.

CAA CAP 762 was a study done to investigate the effectiveness of image recorders in a accident investigation. The study found that, “While flight deck image recording systems may be able to provide additional information, flight crews have expressed the concern that these systems would constitute a significant invasion of their privacy. As a result of this concern, the pilot associations require assurance that the benefits to accident investigation of the provision of such equipment would justify the potential invasion of privacy.”

3.0 PROTECTION OF SAFETY DATA CONCERNS:

This ARC is chartered with the limitation that it can only submit recommendations to the FAA. The FAA has limited authority, which is to regulate operations in the United States and its territories. Many of the carriers affected by the recommendations of this ARC operate outside of the US on a regular basis and thus would be subject to that country's rules and regulations pertaining to safety data protection, in the event of an incident or accident. Considerations must be given as to how CIR’s would be handled for any events outside of the United States. Operators and pilot unions have voiced concerns that not all countries they operate in and out of have a positive safety culture and respect for the protection of this type of safety data . These aircraft will operate in and out of countries with varying degrees of safety cultures and legal ramifications for aircraft incidents and accidents. This type of video could be easily used to prosecute crew members and operators for any perceived wrongdoing or it could be released publicly.

The concept of CIRs has also long involved concerns from pilots and aircraft operators. Employers, regulators, and other entities that may be granted access to flight deck video data may attempt to use this data to pursue punitive or employment related actions against flight crews that were not even involved in an accident or incident. In addition, flight deck video that was downloaded for any purpose (safety investigative or otherwise) runs the risk of being purposely or inadvertently released to the public. Both of these possibilities would represent grave violations of the positive and non-punitive safety culture that the aviation industry heavily depends on.

Until the misuse of recorded data and information has been prevented through enhanced global regulations protecting the privacy of aviation professionals, airline pilot unions (Air Line Pilots Association, Allied Pilots Association, Coalition of Airline Pilots Association, Independent Pilots Association, Southwest Airlines Pilots Association, Teamsters, International Federation of Airline Pilots Association, etc.) in the United States and throughout the world will be opposed to new investigative technologies in airliners.

Recent examples of leaked audio recordings from accident investigations to the media does not provide assurance to the industry that current regulations would prevent identifiable images of flight crewmembers from being broadcast in the public domain; this would affect safety and could have a devastating effect on families of victims following a fatal accident and would be a clear breach of the protection of safety data.

In a recent case (Sept. 2018), Air Niugini Flight 73 – a Boeing 737-800 – crashed short of the runway at Chuuk International Airport (FSM) and came to rest in the Chuuk Lagoon. An engineer seated in the flight deck jumpseat filmed the approach on his personal cell phone. After the accident, the engineer shared the video images of the crash sequence with investigators. Images of the crash were made public through the final reports and portions of the video are publicly available through YouTube https://youtu.be/DnpdDMPulLc?si=fFnZ8haBnLJprgzJ. Even after the New Guinea investigation authority edited the video for length, identifiable features of each pilot remained in the final product.

4.0 HARMONIZATION:

ICAO Annex 6, Part I, section 6.3.1 Flight data recorders and aircraft data recording systems provides guidance on recording available data in a flight deck:

6.3.1.1 All turbine-engined aeroplanes of a maximum certificated take-off mass of 5,700 kg or less for which the application for type certification is submitted to a Contracting State on or after 1 January 2016 shall be equipped with:

a. An FDR [Flight Data Recorder] which shall record at least the first 16 parameters listed in Table A8-1 of Appendix 8; or

b. A class C AIR [Airborne Image Recorder] or AIRS [Airborne Image Recording System] which shall record at least the flight path and speed parameters displayed to the pilot(s), as defined in 2.2.3 of Appendix 8; or

c. An ADRS [Aircraft Data Recording System] which shall record at least the first 7 parameters listed in Table A8-3 of Appendix 8.

ICAO further defines required inspection intervals for both AIR and AIRS methods that are consistent with current FDR installations, as outlined in ICAO Annex 6, Part I, Appendix 8, section 7.2 “Inspections of Flight Recorder Systems”:

7.2 FDR systems or ADRS, CVR systems or CARS, and AIR systems or AIRS shall have recording inspection intervals of one year; subject to the approval from the appropriate regulatory authority, this period may be extended to two years provided these systems have demonstrated a high integrity of serviceability and self-monitoring. [...]

The FAA Reauthorization Act of 2024 (May 16, 2024) did not include any section relating to installation of Cockpit Image Recorders (CIR)

5.0 Cost Analysis:

Part of the ARC tasking is to provide cost benefit analysis for CIR’s.

A system to record video or images on a flight deck would likely have to consist of more than one camera, possibly 5-6 cameras. The CIRs will need to comply with crash and fire resistance requirements and a stabilization function needs to be developed. The CIRs need independent power supplies like the requirements of currently installed CVR and FDR systems. With the current FAA requirement of 25-hour CVRs, CIRs may need to have the same recording duration. Video recordings in comparison to audio require a considerably larger amount of memory for data retention.

The installation of cameras on the flight deck has several different options as to how and what to be recorded. A standard for video recording would need to be established. At the current time there are no TSO-176a certified video recorders being manufactured. A CIR system would need to be developed for each individual aircraft flight deck as the design and layout and mounting locations differ between each aircraft type. Cost impact of video recorders installation is currently unknown as to how much a TSO-C176a certified recorder is going to cost and how much down time for the aircraft for retrofitting to already built aircraft. Additionally, for older aircraft the availability of an independent power source in the flight deck is questionable. Most newer aircraft have independent power sources available in the flight deck, but older aircraft may not. In addition to installation costs (equipment, downtime for the installation and labor costs), operators would be impacted with additional periodic inspection and maintenance of any newly certificated and installed hardware. Data protection, storage and encryption costs are unknown at this time, but would be considerable due to the sheer amount of data to be stored. As with most other aircraft parts, CIRs would have to be replaced periodically for maintenance or overhaul reasons. Any subsequent changes to regulations may require overhaul of complex aircraft systems, including ship's wiring and other hardware.

The installation of CIR systems will increase aircraft weight. Besides the camera itself, the weight of wiring and the crash and fire-resistant housing for the camera(s) will need to be taken into consideration. It is currently not known how much weight is added; this needs to be evaluated and included in the overall cost analysis.

6.0 IMPACT ANALYSIS:

CAA CAP 762 identified issues associated with installing image recorders on aircraft. One challenge identified was that "the layout of an aircraft flight deck varies based on several factors, the most significant of which are the aircraft type, the type of variant and the individual modifications made by the operator of the aircraft. The effect of this is that there are many possible flight deck layouts, which makes it very difficult to provide a definitive assessment of where image recorders could be installed on all aircraft being operated."

The same study found that the ability to install image recorder systems on aircraft is dependent on the following:

a. The number of cameras required.

b. The available space on the flight deck (i.e. overhead panel); and

c. The space and weight implications of an additional recorder, or the cost implications of a combined recorder.

Additionally, according to the CAA CAP 762 report, the following issues should be considered:

a. The cameras will need to be removable to facilitate maintenance but, once in place, should be fixed to prevent anyone altering their viewing angle.

b. A means of demonstrating that the system is functioning correctly (self-monitoring), and that the cameras are recording appropriate images of the flight deck will be required; and

c. The design will need to address all issues associated with adding a further recording system (plus cameras) to the essential bus.

Furthermore, the study showed specialized training was needed for accident investigators since recorded images can be misleading.

It is recommended that only investigators specifically trained in this discipline provide analysis and interpretation of image data.

The training should be jointly developed by accident investigators, pilot associations, and dedicated human factors specialists. Upon completion of this accredited training, investigators would be credentialed to interpret image data.

At a minimum, this recommended training should address the following issues:

a. The benefits and disadvantages of image recorders.

b. Image recorders cannot be used as a single source of information.

c. Limitations of image recorder technology.

d. The need for extensive knowledge of flight deck layout.

e. The need for extensive knowledge of aircraft systems and operations.

f. The need for knowledge of crew background; and

g. The need for detailed understanding of human factors analysis.

Quality standards of images would need to be established. A standard of what should be recorded needs to be developed. What parameters should these recorders capture? How many parameters would be captured? How to detect smoke in flight deck (See CAA CAP 762 study for reference)?

A study would need to be done to determine the ability of cameras to provide quality images in varying lighting configurations low light, night and bright daylight. Furthermore, many flight deck switches and handles are typically not illuminated and therefore would make it extremely hard to exactly determine their position in nighttime conditions.

Additionally, image stabilization will need to be studied. Timing synchronization standards would need to be developed to synchronize FDR and CVR data. Recording length would need to be determined. There is no reason to record the entire flight.

CIR recorders need to only capture critical phases of flight such as takeoff to 10,000 feet and approach phase below 10,000 feet to after landing rollout, or a reasoning for capturing more data would need to be justified.

Many current aircraft are equipped with Heads-Up-displays (HUD), it should be evaluated how and if this information needs to be recorded.

Should CIRs have lithium batteries installed, a risk analysis should be conducted mitigations be developed to minimize the hazardous impact of these batteries.

Maintenance considerations:

- Installation
- Development of consensus industry standards
- Calibration of camera angles
- Recuring maintenance checks for quality
- Replacement of defective parts
- MEL development for defective parts of the CIR system

7.0 RECOMMENDATIONS:

The ARC sees the investigative value of Cockpit Image Recorders (CIRs), when those recordings supplement several other available data sources to the investigation. The ARC does, however, acknowledge there is a significant lack of a suitable global regulatory protection framework, as well as technology to recommend the installation of CIR's.

The concept of CIRs has long involved concerns with protection of safety data from pilots and aircraft operators. Employers, regulators, and other entities that are granted access to flight deck video data may attempt to use this data to pursue punitive or employment related actions against flight crews that were not even involved in accidents and incidents. In addition, flight deck video downloaded for any purpose (safety investigative or otherwise) runs the risk of being purposely or inadvertently released to the public. Both possibilities would represent grave violations of the just and non-punitive safety culture that the aviation industry heavily depends on. The ARC recommends that the FAA address these concerns, as described in a separate Position Paper on Privacy and Data Misuse.

The ARC recommends the consideration of how the video, if installed, would be handled for any events outside of the United States. Operators and labor unions have voiced a concern that not all nations they operate in and out of have a positive safety culture and respect for the privacy of the crew members. These aircraft will operate around the world in and out of countries with varying degrees of safety cultures, video could be easily used to prosecute crew members and operators for any perceived wrongdoing.

The ARC also recognizes that CIR video would be subjective if not reviewed by a well-trained forensic videographer. There are certain issues video can mislead an investigator if not trained to view the video footage appropriately, an example is that the video cannot tell if the crew are pushing on a rudder pedal or if the rudder pedal is moving on its own and the crew members foot is following the pedal. The ARC recommends training standards be developed by industry/labor and the NTSB for videographers who would be forensically examining the data.

Another recommendation of the ARC is to consider the investigators who may be viewing these videos multiple times, to the traumatic end. This exposure to traumatic experience can and will cause stress in the investigator, like listening to a CVR, but you have video images that will be replayed. This exposure can lead to PTSD in the investigator. Consideration should be given to the merits of exposure to these videos and the health of the investigator.

If the FAA were to legislate CIR's to be installed on flight decks, the ARC recommends following some of the CAA CAP 762 recommendations that are still valid today:

- No Rear Facing Cameras
- No Explicitly Identifying Views of crew members
- Interpretation of Image Recorder Data must only be Performed by those Specifically trained in Analyzing Image Recordings

Researchers involved in the CAA CAP 762 concluded that image recording systems can provide additional information that would assist in accident investigation.

However, according to the report, "the extent of the benefits provided and whether they can be justified in relation to the cost (in both financial and personal privacy terms) will need to be the subject of further research and a carefully prepared regulatory impact assessment."

REFERENCE:

TSO-176a

NTSB A-15-7 & A-15-8

CAA CAP 762 study

ICAO A39-WP/307

The release of video by investigative authorities, Air Nugini flight 73.
https://youtu.be/DnpdDMPulLc?si=fFnZ8haBnLJprgzJ

GAO digital surveillance – stakeholder perspective Aug 28, 2024. GAO-24-107639

Leaked CVR audio from DAL flight 1141 August 31, 1988
https://youtu.be/Z4luBUXR1cY?si=deXk0D90ccR_7Yrs

B6: Systems and Processes Enhancing the Safety of Part 135 Operations

The following draft position papers written by the HRT group participants regarding different charter taskings are included to present a full picture of the HRT group's thought processes and key concerns in their own words, as well as further background on each of the areas discussed. They are presented exactly as written and do not represent the position of the full ARC.

Proposed Rule Making To Require Part 135 operators to install flight data recording devices and establish a structured flight data monitoring program.

Scope

This position paper will provide recommendations to the FAA on whether to require Part 135 operators to install flight data recording devices capable of supporting a flight data monitoring program (A-16-34), and whether to require Part 135 operators to establish a structured flight data monitoring program that reviews all available data sources to identify deviations from established norms and procedures and other potential safety issues (A-16-35) in response to ARC tasking 4. e. vii. and viii.

Background

Following the observation of certain commonalities in accidents occurring in operations under 14 CFR Part 135, the National Transportation Safety Board (NTSB) recommended to the FAA in 2016 to consider mandating the implementation of a structured flight data monitoring (FDM) program for such operators, along with the installation of suitable flight recording systems. The NTSB reiterated and further substantiated this recommendation in Special Investigation Report AIR-24-03 published on July 24, 2024. The important role of operators using FDM was also identified in the NTSB's Most Wanted List (MWL)[1] seeking operators to "Establish Flight Data Monitoring Programs"

Additionally, on April 26, 2024, the FAA issued a final rule[2] that updates requirements for safety management systems specified in 14 CFR Part 5, while also extending the applicability of Part 5 to additional certificate holders certificated under 14 CFR Part 119. The rule affects commuter and on-demand operators under 14 CFR Part 135, commercial air tour operators operating under 14 CFR Part 91.147, and certain production certificate holders operating under 14 CFR Part 21. The final rule mandates SMS for these operators, but does not mandate FDM or flight recording systems for such operators.

This position paper explores whether FAA should require a structured FDM and, if so, how this might best be accomplished in response to the tasking provided to the ARC

Because the applicability of Part 5 was expanded to Part 135 operators, any additional FDM mandate for such operators will also require them to integrate the FDM program into their already mandated SMS strategy. It is therefore necessary to gain a basic understanding of the changes to 14 CFR Part 5 and the wider SMS mandate , along with the economic and operational impact an additional FDM mandate might impart on the affected operators.

SMS Mandate key points relevant to this position paper

The 2024 amended SMS is intended to enhance aviation safety in on-demand and commuter Part 135 operations as well as air tours by mandating the implementation of an SMS program across these operators. The rule emphasizes proactive safety management and aligns U.S. regulations with international standards, notably ICAO Annex 19 (Safety Management). The effective date of the rule is May 28, 2024, with full implementation required within 36 months in 2027 New applicants for relevant certificates must have an SMS in place by the time of certification. The 2024 rule also expanded the applicability of SMS to Part 21 certificate holders as directed in the Aircraft Certification, Safety, and Accountability Act (ACSAA) of 2020 (P.L.. 116-260) to organizations that hold both a production and type certificate under Part 21.

The objective of the rule is to improve aviation safety by requiring the implementation of an SMS that identifies safety hazards, assesses and manages risks, and ensures the effectiveness of safety risk controls.

1. **Regulation:**

- **Organizations subject to Part 5 must establish an** SMS that include that basic framework of a safety policy, safety risk management, safety assurance, and safety promotion. The operators SMS must integrate into the organization's operations and emphasize managing safety with the same priority as other critical areas. This typically necessitates the integration of structured flight operations quality assurance (FOQA) and flight data monitoring (FDM) programs to identify and evaluate deviations from nominal operations as specified in standard operating procedures (SOP).
- The rule allows for scalability to accommodate different sizes and complexities of organizations. The FAA also provides specific provisions exempt certain single-pilot operators from certain SMS requirements.

2. **NTSB Recommendations relevant to this position paper**

In its report AIR-24-03, the NTSB recommends that business and general aviation operators under 14 CFR Part 135 establish a structured Flight Data Monitoring (FDM) program and install recording devices capable of supporting it. While the FAA did not task the ARC with responding to this recommendation, the ARC sees this NTSB recommendation as important to inform its evaluation of FDM based on other direction provided by the FAA. The implementation of an FDM program is seen as crucial for providing operators with objective data about how flights are conducted, helping to detect and correct unsafe deviations from standard operating procedures before accidents occur. This recommendation aims to enhance safety by allowing operators to proactively manage risks based on actual flight data, potentially preventing future accidents. FDM and related FOQA programs therefore directly support, and are often integrated with, safety management systems.

Basic Considerations

The FAA received varied feedback from stakeholders, including support for the expanded applicability of SMS due to its demonstrated contribution to increased aviation safety, but also concerns about the burden on small operators.

Adjustments were made based on comments, such as excluding foreign TC holders from certain requirements and providing exceptions for single-pilot operations.

The ARC sees the FAA's ability to require Part 135 operators to install flight data recording devices capable of supporting a structured flight data monitoring program is therefore tied, inter alia, to how closely the government intends to steer compliance with the SMS mandate as specified in 14 CFR Part 5. Specifically, in the context of an SMS, FDM programs typically serve the purpose of identifying deviations from established norms and procedures. To integrate an FDM program into an SMS is therefore a strategic decision that drives how such programs are set up. It also requires a means to systematically acquire and analyze that data, increasing the barrier to entry in terms of investment and direct and indirect operating expenses.

To assess the benefits and burdens on Part 135 operators, it is therefore prudent to understand the basic requirements of integrating an FDM program into an SMS.

Integration of a Flight Data Monitoring Program into a Safety Management System for Aircraft Operators under 14 CFR Part 135

FDM is a proactive and non-punitive program aimed at improving flight safety through the routine collection and systematic analysis of data recorded during flight operations. For operators under 14 CFR Part 135, integrating FDM into a SMS enhances safety by systematically identifying and mitigating many of the factors that the NTSB has identified as primary causes of Part 135 accidents.

While there is no single way of integrating an FDM into an SMS, it is worth considering the following items to assess the costs and operational implications:

1. **Objectives:**

- Define the goals of the FDM program within the SMS framework, focusing on identifying and managing potential risks, and preventing accidents by proactively using this information as part of the SMS' safety assurance processes.

2. **Data Collection:**

- Equip aircraft with the necessary flight data recording devices. Ensure that data collection methods comply with regulatory requirements (including aviation and non-aviation specific regulations such as data protection) and capture relevant parameters, such as aircraft state vectors and system performance parameters.

3. **Data Analysis:**

- Develop processes for systematic data retrieval, analysis, and review. Automated systems can be used to detect deviations from standard operating procedures and identify trends that could indicate emerging safety issues.
- Provide software tools that allow for data analysis and visualization to better understand and interpret flight data.

4. **Risk Identification and Assessment:**

- Integrate FDM data into the SMS's Safety Risk Management component. Use the data to identify hazards and assess the risks associated with them.
- Compare data against predefined safety performance indicators and thresholds to identify areas of concern.

5. **Safety Assurance:**

- Develop mechanisms within the SMS to ensure the continuous monitoring of the FDM data as part of the verification of safety performance.
- Implement periodic reviews and audits of the FDM program to ensure its alignment with safety objectives and evolving regulatory requirements.

6. **Safety Promotion:**

- Include findings from FDM analyses in regular training programs to improve pilot awareness, and to inform the creation of educational materials to address identified safety issues.
- Promote a safety culture that encourages the reporting of hazards and participation in the FDM program without fear of punitive action.

7. **Confidential Reporting System:**

- Establish a confidential reporting system within the SMS to encourage pilots and crew to report safety concerns observed in FDM data. Ensure that the system protects the identity of involved crew members and focuses on safety improvement rather than blame.

8. **Management Review and Feedback:**

- Regularly present FDM findings to senior management as part of a systematic safety and operational review. Ensure that management reviews the data, provides feedback, and supports necessary changes to policies, procedures, and training programs.
- Establish a feedback loop where insights from FDM are used to make informed decisions about operational changes and safety improvements.

Integrating a FDM program into a SMS is a strategic approach to enhancing flight safety. The implementation of the FDM program incurs the burdens of systematic data collection, analysis, risk assessment, and continuous improvement processes that align with the proactive safety management principles of an SMS. In return, operators can achieve higher safety performance and foster a robust safety culture.

Cost / Benefit Analysis

By fully leveraging a sophisticated FDM, operators can achieve much greater operational safety. This has long-term business benefits, including increased revenue resulting from a better reputation, lower insurance premiums, and higher equipment availability (where paired with a proactive maintenance regime). Additionally, FDM programs can be used to improve overall operational efficiencies, improving performance and lowering operating expenses elsewhere.

The expense of implementing an FDM program can be considerable. Especially operators of older aircraft in remote areas will find that the technical requirements associated with the systematic recording of flight data can result in a cost barrier. The FAA mandating operators to have an FDM may force operators out of business. The FAA should specifically consider the implications on air service if an FDM mandate is viewed as placing a risk at reducing the availability of operators that support remote and local communities that rely on Part 135 operations as the sole means of transportation, including access to market for local businesses and receiving supplies. It should that operators in the U.S. remote region of Alaska have embraced SMS. As an example, the Alaska Air Carrier Association – the primary stakeholder group that supports the operators that serve these remote communities -- provide SMS training to its operators. The AACA, however, has also advocated about its member concerns[3] about the cost of SMS programs.

The burdens of an FDM can be broadly categorized into financial costs, operational challenges, and administrative complexities. Understanding these burdens is essential for legislators considering a mandate for the implementation of an FDM in addition to that of a SMS.

Financial Costs:

1. **Initial Investment:**

- Acquiring and installing flight data recording devices can be costly, especially for operators of older aircraft that do not already have modern avionics systems. Operators must purchase hardware, which can vary significantly depending on the aircraft type and the sophistication of the system.
- In addition to the direct investment cost incurred by the data acquisition systems, upgrading older aircraft to accommodate FDM systems may involve further (and often substantial) modifications and related certification processes.

2. **Ongoing Expenses:**

- Maintenance and calibration of data acquisition equipment require continuous investment to ensure reliability and accuracy.
- Data storage and management involve recurring costs, particularly for operators with large fleets generating larger amounts of data.
- The systematic analysis of that data, along with its integration into the relevant SMS processes, requires additional staff (and potentially licenses and subscriptions).

3. **Software and Analysis Tools:**

- Purchasing and maintaining software tools for data analysis and visualization adds to the financial burden. These tools are necessary for processing and interpreting the collected data.
- Training staff to use these tools effectively may also involve additional costs.

Operational Challenges:

1. **Data Management:**

- Collecting, storing, and managing large volumes of flight data requires robust data handling procedures to ensure data integrity and security.
- Ensuring compliance with data protection regulations adds another layer of complexity to data management, up to and including dedicated data protection officers and related staff for larger fleets.

2. **Integration with Existing Systems:**

- Integrating FDM with current operational and safety management systems can be complex. Ensuring compatibility and seamless data flow requires technical expertise and may involve extensive system modifications.

3. **Human Resources:**

- Hiring or training personnel to manage and analyze FDM data represents a considerable resource allocation challenge. Smaller operators may struggle to justify the expense of dedicated staff for FDM activities, and there may not be enough qualified applicants in the current labor market.
- It is acceptable for smaller operators to outsource some of the functions of an FDM program (CAP 739).

Administrative Complexities:

1. **Regulatory Compliance:**

- Meeting regulatory requirements for FDM implementation and operation involves significant administrative effort. Operators must navigate complex regulatory landscapes and ensure ongoing compliance.
- Preparing for and undergoing audits and inspections by aviation authorities requires meticulous documentation and record-keeping.

2. **Reporting and Communication:**

- Developing and maintaining effective reporting systems to communicate FDM findings within the organization is an administrative burden. Operators must ensure that relevant safety information is accurately and promptly disseminated to appropriate personnel.
- Establishing a non-punitive reporting culture, as required for SMS integration, necessitates clear policies around data access and cyber security.

3. **Data Analysis and Action:**

- The process of analyzing FDM data, identifying safety issues, and implementing corrective actions requires a structured and systematic approach. This can be particularly challenging for smaller operators with limited resources.
- Ensuring that FDM insights lead to tangible safety improvements involves ongoing monitoring, review, and adaptation of safety practices.

Conclusion

While FDM systems enhance safety and operational efficiency, they also impose substantial burdens on Part 135 operators. These burdens include significant financial costs, operational challenges related to data management and system integration, and complex administrative requirements for regulatory compliance and effective safety management. For many operators, particularly smaller ones and those operating older aircraft in remote territories such as Alaska, these burdens can be a barrier to implementing FDM systems despite their potential benefits.

Balancing these burdens with the safety advantages of FDM is critical for legislators to consider when mandating operators to integrate FDM hardware and processes into their SMS.

Recommendations

Based on this analysis, the ARC recommends the FAA:

1. To increase adoption rates and to minimize unfairly disadvantaging certain operators, a possible FDM mandate should be tailored to the fleet size and operational circumstances following the SMS mandate example.

1. The FAA should not mandate FDM programs on on aircraft that cannot reasonably be upgraded with common data acquisition systems.

2. The FAA should make it clear as part of any mandate for FDM on operators that the use of lightweight data recorder, such as those compliant with ED-155, would be permitted to support FDM and other data monitoring programs since these systems are in wide use today in voluntary programs (i.e., the introduction of a mandate should not constrain the permissible equipage). Allow time for integration of FDM into SMS. For example, give operators additional time to design SMS with FDM in mind from the ground up, rather than punishing operators that have already started on the SMS mandate compliance with the additional burden of now having to modify that system, which in itself can be an additional cost.

1. Consider making FDM a voluntary addition but offer incentives for operators opting to comply. For example, by extending deadlines or supporting installs with cash incentives, following the ADS-B equipage example.

B7: 25-Hour CVRs

The following draft position papers written by the HRT group participants regarding different charter taskings are included to present a full picture of the HRT group's thought processes and key concerns in their own words, as well as further background on each of the areas discussed. They are presented exactly as written and do not represent the position of the full ARC.

Section 366 25-Hour Cockpit Voice Recorder

1. Introduction

The Federal Aviation Administration (FAA) has established an Investigative Technologies Aviation Rulemaking Committee (ARC) to seek recommendations on the best ways of recovering aircraft flight data. This position paper will discuss issues and develop recommendations, qualitative descriptions, and quantitative cost and benefits related to section 366 of Public Law 118-63 25-Hour Cockpit Voice Recorder (CVR) as well as the new FAA tasking in which the agency seeks the ARC's recommendations in response to NTSB recommendations that are broader in scope than the statute.

This position paper addresses the following charter items from section 4 of the Investigative Technologies ARC Charter, Amendment 2, date 12DEC2024:

n. Discuss issues and develop the following:

i. Recommendation on whether to expand the retrofit requirement in section 366 of the Act to require retrofit of aircraft that are specified in the proposed rule for newly manufactured aircraft and not covered by section 366.

ii. Quantitative cost and benefit data for retrofitting "covered aircraft" as defined in section 366 and other aircraft under consideration.

iii. A qualitative description of the potential impacts for retrofitting "covered aircraft" as defined in section 366 and other aircraft under consideration.

2. Background

The International Civil Aviation Organization (ICAO) adopted the 2-hour duration CVR standard 09MAR2001 in Amendment 26 to Annex 6 - Operation of Aircraft, Part I - International Commercial Air Transport.

This standard for all new aircraft of maximum certificated takeoff mass of over 5,700kg for which the initial certificate of airworthiness was issued (newly manufactured airplanes) after 01JAN2003. State civil aviation agencies then adopted the CVR with 2-hour duration into regulation, including the FAA in 14 CFR parts 91, 121, 125, and 135.

FAA operating regulations in 14 CFR parts 91, 121, 125, and 135 address CVR duration which is presently at 2 hours. The regulations were last amended for this aspect in 2008 in Notice of

Proposed Rulemaking (NPRM) FAA-2005-20245 to address NTSB safety recommendation A-96-171.

The following existing regulations establish the requirements for flight and cockpit voice recorder equipage:

- 91.609 Flight data recorders and cockpit voice recorders [91-300 07APR2008)
- 121.359 Cockpit Voice Recorder [121-338 07APR2008]
- 125.227 Cockpit voice recorders [125-54 07APR2008]
- 135.151 Cockpit voice recorders [135-113 07APR2008]

14 CFR part 25 airworthiness standards do not address CVR duration.

In response to accident investigation agency safety recommendations to address a lack of access to relevant CVR audio, the European Union Aviation Safety Agency (EASA) adopted a requirement for CVRs with 25-hour duration for newly manufactured commercial aircraft with a Maximum Certificated Takeoff Mass (MCTOM) of 27,000 kg in September 2016 with an implementation date of 01JAN2021. The purpose of this extended recording duration is to provide investigators with more audio to aid in accident investigations and improve aviation safety, as there were numerous cases where the 2-hour duration was viewed to be insufficient, or was overwritten before the CVR audio could be downloaded. The applicability of EASA's Pa was later amended to 01JAN2022 due to the effects of the COVID pandemic. EASA's mandate is for new aeroplanes only and currently not applicable to retrofit.

EASA proposed a working paper to the ICAO flight recorder panel which resulted in ICAO adoption of the 25-hour duration cockpit voice recording standard in March 2016 in Amendment 40 to Annex 6 - Operation of Aircraft, Part I - International Commercial Air Transport. This standard requires that all new aircraft of maximum certificated takeoff mass of over 27,000kg for which the initial certificate of airworthiness was issued after 01JAN2021, have a CVR capable of recording at least 25 hours of audio. ICAO did not adopt a standard nor recommended practice for retrofit of CVR with 25-hour duration. The newly manufactured airplane standard applicability was later amended to 01JAN2022, due to the impacts of the COVID pandemic. ICAO established a Targeted Exemption (TE) mechanism to accommodate supplier and equipage challenges encountered.[1]

National Transportation Safety Board (NTSB) safety recommendations address the need to install CVRs with a minimum 25-hour recording capability (duration) on all newly manufactured airplanes and retrofits on existing aircraft required to have both CVR and FDR. These recommendations are derived from the NTSB's experiences with investigations that lacked access to relevant CVR audio.

- A-18-030 Require all newly manufactured airplanes that must have a cockpit voice recorder (CVR) be fitted with a CVR capable of recording the last 25 hours of audio.
- A-18-031 By January 1, 2024, require retrofit of all cockpit voice recorders (CVR) on all airplanes required to carry both a CVR and a flight data recorder with a CVR capable of recording the last 25 hours of audio.

FAA Reauthorization Act of 2024 (P.L. 118-63), 16MAY2024, section 366 requires aircraft manufactured after 16MAY2025, to have installed a CVR with 25-hour duration. Additionally, within 6 years (16MAY2030) of enactment of the law covered aircraft are required to have a CVR with 25-hour duration installed. Congress specifically and with intent limited covered aircraft to aircraft operated under part 121 of title 14, Coder of Federal Regulations, and aircraft with 30 or more passenger seats.

SEC. 366. 25-HOUR COCKPIT VOICE RECORDER.

(a) IN GENERAL.—

(1) COCKPIT VOICE RECORDER FOR NEWLY MANUFACTURED AIRCRAFT.—A covered operator may not operate a covered aircraft manufactured later than the date that is 1 year after the date of enactment of this Act unless such aircraft has a cockpit voice recorder installed that retains the last 25 hours of recorded information using a recorder that meets the standards of Technical Standard Order TSO–C123c, or any later revision.

(2) COCKPIT VOICE RECORDER FOR COVERED AIRCRAFT.— Not later than 6 years after the date of enactment of this Act, a covered operator may not operate a covered aircraft unless such aircraft has a cockpit voice recorder installed that retains the last 25 hours of recorded information using a recorder that meets the standards of Technical Standard Order TSO–C123c, or any later revision.

(b) PROHIBITED USE.—The Administrator or any covered operator may not use a cockpit voice recorder recording for a certificate action, civil penalty, or disciplinary proceedings against a flight crewmember.

(c) RULEMAKING.—Not later than 3 years after the date of enactment of this Act, the Administrator shall—

(1) issue a final rule to update applicable regulations, as necessary, to conform to the requirements of subsection (a)(2); and

(2) issue a rule to update applicable regulations, as necessary, to ensure, to the greatest extent practicable, that any data from a cockpit voice recorder—

(A) is protected from unlawful or unauthorized disclosure to the public;

(B) is used exclusively by a Federal agency or a foreign accident investigative agency for a criminal investigation, aircraft accident, or aircraft incident investigation; and

(C) is not deliberately erased or tampered with following a National Transportation Safety Board reportable event under part 830 of title 49, Code of Federal Regulations, for which civil and criminal penalties may be assessed in accordance with section 1155 of title 49, United States Code, and section 32 of title 18, United States Code.

(d) SAVINGS CLAUSE.—Nothing in this section shall be construed as rescoping, constraining, or otherwise mandating delays to FAA actions in the notice of proposed rulemaking titled "25–Hour Cockpit Voice Recorder (CVR) Requirements, New Aircraft Production", issued on December 4, 2023 (88 Fed. Reg. 84090).

(e) RULE OF CONSTRUCTION.—Nothing in this section shall be construed to affect—

(1) the confidentiality of recording and transcripts under section 1114(c) of title 49, United States Code;

(2) the ban on recording for civil penalty or certificate under section 121.359(h) of title 14, Code of Federal Regulations; or

(3) the prohibition against use of data from flight operational quality assurance programs for enforcement purposes under section 13.401 of title 14, Code of Federal Regulations.

(f) DEFINITIONS.—In this section:

(1) COVERED AIRCRAFT.—The term "covered aircraft" means—

(A) an aircraft operated by an air carrier under part 121 of title 14, Code of Federal Regulations; or

(B) a transport category aircraft designed for operations by an air carrier or foreign air carrier type-certificated with a passenger seating capacity of 30 or more or an all-cargo or combi derivative of such an aircraft.

*(2) COVERED OPERATOR.—The term "covered operator" means the operator of a covered aircraft.*FAA requirements for aircraft required to carry both a CVR and FDR vary by operating regulation:

- 14 CFR part 91 *General Operating and Flight Rules* requirement to have both CVR and FDR: multi-engine, turbine-powered large and transport category airplane having a passenger seating configuration of 10 or more.
- 14 CFR part 121 *Operating Requirements: Domestic, Flag, and Supplemental Operations* requirement to have both CVR and FDR: turbine-engine-powered transport category airplanes.

- 14 CFR part 125 *Certification and Operations: Aircraft Having a Seating Capacity of 20 or More Passengers or a Maximum Payload Capacity of 6,000 Pounds or More; and Rules Governing Persons on Board Such Aircraft* requirements for both CVR and FDR: turbine-engine-powered transport category airplane.
- 14 CFR part 135 *Operating Requirements: Commuter and on Demand Operations and Rules Governing Persons on Board Such Aircraft* requirements for both CVR and FDR: multi-engine, turbine-engine powered airplane or rotorcraft having a passenger seating configuration of 10 to 30 seats.

3. Potential Impact for Retrofitting "covered aircraft" with a 25-Hour CVR

1. Background

With the recent publications of ED112B, and AC 20-168A, certification of retrofit installation of CVR with 25-hour duration may not be as simple as removing the existing CVR with 2-hour duration and replacing it with a new CVR with 25-hour duration. This is particularly the case for airplane models that are out of production or nearing the end of life. Since the 07APR2008 changes to 14 CFR 121.359 requiring aircraft manufactured before 07APR2010 to be equipped with 2-hour CVR, there have been changes to battery technology, changes in cockpit safety systems (ex. O2 masks with smoke goggles), and changes in standards and means of compliance for CVR's and associated installations that older models of aircraft were not certified to. These changes include:

- The use of Non-Rechargeable Lithium Batteries (NRLB) in aircraft must be shown compliant to FAA special conditions starting in 2016.
- The addition of O2 face mask or smoke goggles systems interfacing withthe radio communications systems.
- The cancellation of older CVR guidance materials such as AC 25.1457 and the addition of new minimum operational performance specification (MOPS) for CVR's after the last CVR regulatory mandate in 2008.

These changes can impact the ability of operators with older aircraft to source replacement equipment for obsolete or end of life systems, obtain FAA approved data to install the necessary equipment to meet current MOPS for a CVR installation in a timely manner, and can potential add additional cost burdens beyond the cost of the CVR to be in compliance with Section 366 of the Act.

2. Analysis

Below are items of consideration for older aircraft types that may increase the time and cost of retrofitting to a 25-hour CVR.

1. Harmonization with International Standards and Regulation

Section 366(a)(1) of the Law harmonizes with ICAO standards and regulations adopted by many countries to require a 25-hour CVR for newly manufactured aircraft. Section 366(a)(2) does not harmonize with published international standards and regulations.

The following state civil aviation agencies are known to have adopted the intent of the ICAO standard for newly manufactured airplanes with certificated maximum takeoff mass of greater than 27,000kg for CVR with 25 hour duration requirement into regulation, with varying applicability dates: Bahrain, Belarus, Bermuda, Cayman Islands, Chile, China, Egypt, Ethiopia, European Union, Fiji, Hong Kong, India, Japan, Malaysia, Mexico, Oman, Panama, Qatar, Singapore, South Africa, South Korea, Taiwan, Thailand, Trinidad and Tobago, Turkey, Turkmenistan, Ukraine, United Arab Emirates, United Kingdom, and Vietnam.

NPRM FAA-2023-2270 discussed harmonization of CVR requirements with ICAO and EASA: "With both EASA and ICAO amending their CVR rules to require 25 hours of audio recording time, this proposed change also presents an opportunity to ensure U.S. regulations are consistent in intent with international authorities. This should lead to a reduction of risk for some operators who would otherwise face conflicting requirements and the cumbersome task of ascertaining guidance for the appropriate authorities in an attempt to satisfy differing regulations."

NPRM FAA-2023-2270 included an impact assessment for CVR with 25-hour duration for both newly manufactured airplanes and existing airplanes (retrofit):

"The FAA does not anticipate other costs besides the incremental costs of forward fitting 25-hour capable CVRs to comply with the proposed rule. Based on the technical standards for CVRs, market research indicates that 25-hour models tend to match the older 2-hour variants in a manner that allows them to be swapped without much difficulty. This compatibility implies that other operational procedures and costs should be similar and not result in notable change. The FAA invites comments on the expected costs for this proposed rule."

The NTSB's Safety Recommendation also included the recommendation to retrofit the current fleet. While retrofitting the current fleet would more expeditiously increase the number of aircraft fitted with the newer 25-hour CVR units and, thereby, the projected benefits to safety, the costs would be significant. Specifically, retrofitting the current fleet would increase by two-thirds the number of aircraft required to install 25-hour CVRs (estimated 29,561 aircraft in the current fleet added to the estimated 43,470 aircraft being built in the next 20 years). Further, the cost to retrofit existing aircraft with 25-hour CVRs would be several times higher than the cost to equip future-built aircraft with a 25-hour CVR instead of a 2-hour model. Assuming no replacement, applying a $25,000 CVR unit cost spread across the estimated 29,651 current fleet would result in roughly $741.28 million (undiscounted) in equipment cost compared to the $195.62 million (undiscounted) in incremental upgrade costs from the proposed rule. Retrofitting current aircraft would also incur additional costs, such as aircraft downtime and labor hours required to replace the CVR unit, which would further increase the total cost. Therefore, in an effort to provide the increased benefit of making more substantive data available to accident investigators while maintaining the lowest economic impact on operators, this proposed rule would apply to newly manufactured aircraft only."

NPRM FAA-2023-2270 would require airplane models with maximum certificated takeoff weight of less than 27,000kg to update CVR to 25-hour duration. Airplane models with maximum certificated takeoff weight of less than 27,000kg and required to have a CVR by FAA operational regulation would not be expected to have a certified production installation of CVR with 25-hour duration, as no ICAO standard nor known state civil aviation agency regulation requires CVR with 25-hour duration for these airplanes at the time of this writing. Thus, design engineering and certification effort would be required for retrofit installation of CVR with 25-hour duration. At a minimum, the following aircraft types flown by regional and cargo carriers would be impacted: ATR42, ATR72, CRJ100/200, ERJ 135/140/145, Q100, Q300. This represents approximately 348 aircraft operated by 9 airlines. Also 10 ATR72 are not covered under EASA's and 29 countries current 25-hour new aircraft regulation and would be impacted by the lack of harmonization between section 366 of the Law and CAA regulations of 29 countries plus the EU.

2. Qualitative Impact of Retrofitting "covered aircraft"

1. *Use of NRLB for Underwater Locator Beacons (ULB)*

The CVR is required to have an affixed Underwater Locating Beacon (ULB) by 14 CFR 25.1457(g)(3). The predominant means to power the ULB is via a Non-Rechargeable Lithium Battery (NRLB). NRLB are subject to lithium battery thermal runaway, which could emit gases & fluids that are toxic or corrosive and/or present thermal hazards. The FAA released NRLB special conditions in 2017 as the applicable airworthiness regulations did not contain adequate or appropriate safety standards for NRLB. Example FAA NRLB special conditions include, but are not limited to, 25-632-SC for Boeing model 737-8 and 25-713-SC for Dassault Falcon 2000EX. A safety assessment of the ULB with NRLB is required to ensure that the special conditions are adequately addressed. Additional type design changes may be required to resolve any issues identified in the safety assessment (e.g. if adjacent structure, systems or wiring are impacted by thermal effects of a lithium battery thermal runaway). To avoid these special conditions an operator may choose to replace the NRLB battery commonly delivered with the ULB with a lithium free battery at an additional cost of $250 to $350 per CVR.

2. *MOPS to Demonstrate Adequate CVR Audio Quality*

Section 366, section (a)(1) and (2) of the Act requires using a recorder that meets the standards of Technical Standard Order (TSO) TSO–C123c, or any later revision. TSO-C123c, effective date 19DEC2013, provides minimum performance standards (MPS) for original equipment manufacturers (OEM) applying for a TSO authorization for CVR equipment. In section 3 of the

TSO, it states that new models of CVR identified on or after the effective date of the TSO must meet the European Organization for Civil Aviation Equipment (EUROCAE) document ED-112A, Minimum Operational Performance Specifications for Crash Protected Airborne Recorder Systems. In general, the OEM of CVR equipment must comply with Part I of ED112A to obtain a TSO for their CVR system. The TSO exempts the OEM from ED112A requirements regarding equipment installations and post flight evaluations. It should be noted that TSO-C123c does not provide a statement that later versions of ED-112 can be used. TSO-C123c is out of date in that EUROCAE ED-112B supersedes ED-112A as of August 2023.

Advisory Circular 20-186 was published in June 2016 and cancelled AC 25.1457-1A. AC 25.1457-1A was the guidance materials available when regulation 14 CFR 121.359 was amended 7APR2008, requiring operators to install a 2-hour CVR by 2010. AC 20-168A, published 6MAY2024, is the current revision of the AC as it relates to section 366 of the Law. Section 1.5 of AC 20-168A requires CVR manufactured after 19DEC2013 to meet ED112A as specified in TSO C123c. In comparison between AC 20-168A and AC 25.1457-1A, AC 25.1457-1A contained no installation guidance on CVR audio quality. Whereas AC 20-168A requires a demonstration of adequate CVR audio quality for all four CVR audio channels per EUROCAE ED-112A.

2.4 Demonstrate Performance. The applicant must demonstrate the CVR system performs as intended per ED-112A Chapters 2-5 and I-6. Use ED-112A Annex I-A for postflight evaluation of the flight test recordings.

Demonstrating adequate airplane installation performance involves verifying:

- the required audio inputs are connected to the CVR system and
- recorded levels and audio quality of each audio channel are acceptable.

The following are to be considered for evaluation of recorded levels and audio quality:

- full recording dynamic range is used without excessive clipping of peak signals,
- adequate signal to noise ratio for each audio channel,
- audio levels are reasonably balanced between the audio channels and
- audio channels are free from electrical interference and effects of vibration.

AC 20-168A was released in May 2024 and did not change or revise the requirement to demonstrate aircraft installed performance per ED-112A.

If adequate CVR audio quality cannot be demonstrated with existing cockpit area microphone and/or audio system, then a revision to the cockpit area microphone and/or audio system may be required. This type design change would be in addition to the installation of a CVR with 25-hour duration, to meet the requirements of AC 20-168A. In some cases, the necessary type design change may not be limited to an LRU but also require airplane wiring changes. Cockpit area microphones and/or audio systems certified before CVR audio quality guidance was available are more likely to require redesign or replacement.

o AC 20-168A in reference to EUROCAE ED-112A I-6.1.4 Quality of Recording may limit the number of replay centers available to perform the audio quality analysis, if the replay center cannot meet all of the requirements specified in Annex I-A Section 1-A.1. Should the FAA determine that a operator's facility or replay facility used by a DAH or operator is not acceptable, then the required time to certify a new CVR system should account for the time required for the operator or DAH to find, contract, and schedule testing with a replay center acceptable to the administrator. The certification time must also consider any potential changes to type design which may be required if CVR audio quality is not adequate within the six year period of the law.

o Other type design changes may be required to address an existing regulatory non-compliance associated with the CVR system. The extent of the type design change would be dependent on the specific regulatory non-compliance but may extend beyond replacement of the CVR and audio system. For aircraft no longer in production, it may be difficult to upgrade audio or other equipment that is no longer in production and may be uneconomical to the OEMs to certify such equipment for such low volume requirements (ex. MD11, 717, A300).

o Instructions for continued airworthiness require revision to address the new equipment, in particular aircraft maintenance manual needs to reflect appropriate download procedures and ground support equipment.

AC 20-168A when followed in its entirety is an acceptable means for complying with airworthiness regulations but is not the only means. An applicant may propose alternate means, without type design changes to cockpit area microphone and/or audio system. Though such a certification plan would not meet the full requirements of EUROCAE ED-112A, it could be considered an incremental safety improvement for the fleet and still provide adequate CVR audio quality for accident investigation purposes. The responsible FAA aircraft certification office would evaluate whether the alternate means could be acceptable.

Guidance material, notices, handbooks would not necessarily require revision by adoption of a retrofit requirement into regulation. However, additional guidance on the interpretation of audio quality may be warranted. AC 20-168A is applicable to aircraft manufacturers, aircraft operators, MRO organizations and STC applicants.

At this time, the committee cannot provide accurate quantitative analysis of the number of aircraft that are impacted by updated MOPS that require demonstration of audio quality. The committee has identified two groups of aircraft. Those aircraft currently in production for which the airframer has FAA approved data for a 25-hour CVR, and out of production aircraft where the operator would need an airframer service bulletin or STC to upgrade their aircraft. The committee has identified the latter group would have a higher probability of not meeting audio quality guidance and would have a higher cost impact. They include aircraft such as A300's, 727's, 737 Classics, 747's, 757's, DC-9's, MD-8X's, MD-9X, MD-1X's, and other similar aircraft types. The aircraft listed have TC's that date prior to the last CVR regulation and publication of ED-112 and TSO C123 and may not have audio equipment that meet demonstrated audio quality. Additionally, OEM's no longer manufacture equipment for these models and there maybe difficulties in procuring suitable replacement components that would meet required audio quality.

3. Interpretation of 25-Hour Retrofit Compliance Between Various Guidance Documents

Due to the incorporation of ICAO's guidance of requiring a 25-hour CVR for aircraft built after 01JAN2022 by multiple Civil Aviation Authorities, aircraft manufacturers have incorporated a 25-hour CVR for in production aircraft or have offered a 25-hour CVR as an option. To have commonality between aircraft delivered before the 01JAN2022 date, some operators have sought STCs to retrofit older aircraft with a 25-hour CVR. In researching the requirements for Audio Quality in section 3.2.1.2, the committee found that there were varying approaches between airframers, CVR OEM's, and STC holders on developing approved data for installing a 25-hour CVR. Some groups used the guidance of AC 20-168A for installation certification where audio quality was taken into consideration, while other groups sought an alternate means of compliance based on the existing regulations requiring that a TSO C123c 2-hour CVR would be swapped out with a TSO C123c 25-hour CVR. For certain aircraft models, the Illustrated Parts Catalog (IPC) allows for aircraft that were delivered with a 2-hour CVR to be replaced with a 25-hour CVR provided that certain audio units were upgraded at the same time. The interchangeability data is one way forward in that once you remove the 2-hour CVR and older audio unit with the 25-hour CVR and newer audio unit, you cannot go back to the originally delivered equipment. As will be shown in section 3.2.3, the upgrade of the audio unit can dramatically increase the cost of retrofitting the CVR for operators who use the airframers approved data. Other operators, to avoid such cost, may seek approved data that only requires a box swap of the 25-hour CVR without any upgrades to the audio equipment. With the introduction of section 366 of the Law, requiring that all 14 CFR 121 aircraft be retrofitted with a TSO C123c 25-hour CVR, are the two methods of certifying a 25-hour CVR prior to the law equivalent and does each meet the intended level of safety implied by the law?

The intent of the audio quality requirement is to ensure that recorded audio of cockpit conversations is intelligible by an AIA and that pertinent sounds and background noises are recorded and can be heard. For aircraft that have a path to upgrade their CVR's via IPC data, operators can do so today. It can be argued technically and logically that the audio quality of an aircraft delivered on 30DEC2021 (i.e. 2-hour CVR) will not be different from an aircraft delivered on 02JAN2022 (i.e. 25-hour CVR required). It could also be argued that if the sound quality of CVR audio recordings on an out of production aircraft is found to be sufficient during a CVR check maintenance task, it would seem logical that the quality of the audio would be the same, or better, when a 25-hour CVR is installed. As NPRM 2023-2270 states in the summary of impact section of the NPRM," Based on the technical standards for CVRs, market research indicates that 25-hour models tend to match the older 2-hour variants in a manner that allows them to be swapped without much difficulty. This compatibility implies that other operational procedures and costs should be similar and not result in notable change." At a high level, the committee contemplated if those involved in the NTSB Safety Recommendations, FAA authors of the NPRM, and those involved in writing section 366 of the law assumed that retrofitting aircraft would require only a box swap. Since audio quality requirements are buried within ED112 I-6.1.4 and the advisory circular section 2.4, the validation of audio quality may have been overlooked or not considered in the approved data, not the additional time and cost required to upgrade the CVR if the audio quality is unsatisfactory.

The conclusion from the committee is that there may not be uniformity in approved data for updating a 2-hour CVR with a 25-hour CVR. Between ICAO's 01JAN2022 requirement for new production aircraft to have a 25-hour CVR and the publication of section 366 of the Law, there exist approved data for the installation of a 25-hour CVR on various aircraft types where no test for audio quality was required and other approved data requiring audio upgrades for the same aircraft type. In complying with the retrofit portion of the law, operators may pay 5 times the cost of the CVR depending upon what approved data they use. One could say that the upgrading of audio systems along with a 25-hour CVR provides the highest increases in safety, but it could be argued that updating the CVR duration without also updating the audio system provides an incremental safety improvement beyond the current equipage. In developing regulations to comply with US Law, the FAA may want to provide guidance material to provide additional information to ACO's, operators, DAHs on a uniformed approach to required data for CVR approval.

3. Quantitative Cost and Benefits

The committee concurs with the FAA's evaluation in NPRM FAA-2023-2270, that retrofitting existing aircraft would incur additional costs compared to newly manufactured airplanes due to the additional engineering and certification effort. Based on the above factors, NPRM FAA-2023-2270's estimate of $25,000 for the "CVR unit cost" per existing airplane is an underestimation of the costs that an operator could incur per fleet or per aircraft to meet ED-112A MOPS. The NPRM cost:

1. does not align with current costs of a new CVR, which can range from $25,000-$45,000, depending on the selected vendor,

2. does not factor in the current costs of a new cockpit area microphone and/or audio system (ex. A new Audio Management Unit (AMU) list price of up to $200K, new microphones are approximately $500/mic) and installation kits to meet AC 20-168A or ED112A,

3. does not consider the significant non-recurring (spread across multiple airplanes) costs and time of design engineering and certification effort ($50,000+ per operator for a given model), CVR ground support equipment, and CVR shop test equipment.

4. does not consider the recurring (each airplane) costs of aircraft downtime and labor hours to replace the CVR, cockpit area microphone and audio system, and wiring as necessary. An aircraft may need to be taken out of service for an extensive update such as replacing audio wiring to address electromagnetic interference issues, depending on the result of the CVR audio quality assessment.

Due to the current 25-hour CVR forecast for new aircraft, supply chain issues with chip manufacturers and inflationary costs, the price of a CVR is going up from the average cost of $25,000 noted in NPRM FAA-2023-2270. The cost will vary depending on the number of units sold, the cost of chip sets and delivery times to meet schedules, and the relationship between the OEM and operator with contractual price breaks.

There are several aircraft types with original type certificates dating back to the 1980s and 1990s (ex. 767 and A320) that are still in production today. In certain cases, the airframer has cut into production a 25-hour CVR and has certified an upgraded AMU as well. This has been done to ensure that the quality of audio recordings meets ED112A. If the operator where to use the airframers Illustrated Parts Catalog (IPC) notes, service bulletin, or use the newer deliveries as a baseline for retrofitting older aircraft, then there is additional cost for the audio equipment and related NRE for certification. To avoid those AMU cost the operator must provide documentation (ex. Analysis) that the AMU used for a 2-hour CVR meets audio quality when used with a 25-hour CVR.

Non-recurring costs are expected to include significant design engineering and certification effort, particularly for older out of production airplanes. A safety assessment is required for each CVR STC to ensure that the effects of non-rechargeable lithium battery thermal runaway pose no safety risk (e.g. thermal effects to nearby structure, systems and wiring) and for EMI between the CVR and AMU and other aircraft equipment. Additional type design changes may be required (e.g. to relocate nearby wiring) depending on the result of the safety analysis. This requires additional down time of an aircraft to perform STC testing. For just a CVR replacement, an STC project takes approximately 6 to 9 months to generate the certification document package and the ACO approvals to proceed to show compliance testing. The data collection for a simple CVR STC "show compliance" activity can take 1 to 2 days, and the data submittal and FAA approval takes approximately 45 days. For just a CVR replacement, an STC project can take 10 to 12 months. As part of the initial data package submittals, the ACO may elect for a representative of the NTSB to be present for testing or reject the data from an audio playback center. If the audio recording does not meet ED112A, as stated in the advisory circular, then additional engineering time is required to identify the necessary LRU's, update the certification plan, wait for approvals before additional testing can be performed. The more complex the modification becomes, the longer the aircraft remains out of service, especially if any wiring changes are involved. The committee estimates that obtaining FAA approved data will vary between nine months to up to two years, with the most likely time frame being 12 to 18 months to obtain approved data. This estimate takes into account ODA and non-ODA 3rd party STC houses, project workloads for DER, FAA, and NTSB, and time for operators to get the necessary designated representatives under contract if they do not have in-house DER's and DAR's.

Recurring costs include aircraft downtime and labor hours. Additional "kit" cost includes not only the CVR but also cockpit area microphone, audio system and airplane wiring, as necessary. Recurring equipment costs (i.e. spare units) are expected to include not only the CVR but also additional equipment (cockpit area microphone, audio system) which may be required for the CVR system to have adequate CVR audio quality per AC 20-168A and ED-112A.

In addition to the impact on the operator, there is an impact to avionics OEM's. The number of equipment manufacturers who produce CVR's and audio system equipment is limited. These OEM may have production capacity to support newly manufactured airplanes (~2,000 airplanes per year). These equipment manufacturers may require significant time to add production capacity to provide over 20,370 LRUs for newly manufactured airplanes and U.S. retrofit requirements, (est. 10,950[2] new A/C US & Foreign operators, 7,568[3] US operator retrofit A/C, and 10% spares). In discussions with OEM's, it was calculated that depending upon quantities of LRU's required, that it could take between nine months to over a year to increase manufacturing to include retrofit aircraft in addition to current production projections for new aircraft. In that estimate, the OEM must consider production bottlenecks (ex. # of ATE cells and burn in chambers), increase resources to meet production quotas, supply chain issues, and subcomponent part obsolescence. To the later point, OEM's may have already purchased final buys of subcomponents that have been identified as end of life for older models of LRU's. Increasing production may impact the OEM's ability to supply piece parts to support the remaining life of the product.

1. *Cost Analysis*

Referencing Section III. Discussion of the Proposal for NPRM FAA-2023-2270, the FAA's analysis covers an estimated cost of $748M based on a requirement to retrofit 29,500 aircraft. The NTSB believes that the number of retrofit aircraft would be 13,500, which would be $338M.   Due to P.L. 118 - 63, the FAA has requested that the committee provide data or develop a cost benefit analysis for "covered aircraft" defined in section 366 of the law. The committee used publicly available data to estimate 1.) the number of 14 CFR 25 aircraft produced from 1991 to September of 2024; 2.) the number of 14 CFR 121 category aircraft in operation around the world and with US operators; 3.) the number of 14 CFR 25 aircraft since 2021 that were delivered with 25-hour CVR's.

The following assumptions were made regarding the committee's cost benefit analysis:

- Newly manufactured airplanes with maximum certificated takeoff weight less than 27,000kg delivered to U.S. operators since 2021 would not be expected to have CVR with 25-hour duration, since no state civil agency so requires.
- Only a subset of newly manufactured airplanes with maximum certificated takeoff weight greater than 27,000kg delivered to U.S. operators since approximately 2021 may include CVR with 25-hour duration, as the FAA has no regulation to date. US Operator wide body aircraft delivered after 2021 would have a 25-hour CVR, but narrow body aircraft would not necessarily have a 25-hour CVR because it is currently an option for operation within the United States. Business jets that are required to have the 25-hour recorder, per ICAO, have 25-hour recorder available as an option and operators are taking delivery of aircraft compliant with the ICAO standard.
- The committee performed a fleet review of over 42+ U.S. operators including Major 121 carriers, Regional Operators, and Major Cargo Carriers to determine the number of active aircraft.
- The committee assumes that US operators will need a minimum of 10% of total CVR's for spares. The committee acknowledges that due to MEL requirements operators may opt for more than 10% based on their operating network.
- NRE Cost – First applicant of fleet type would pay a higher cost of $50,000 to obtain FAA approved data. Operators after the initial STC would pay a lower cost of $15,000 to amend the DAH's STC. The committee excluded any STC cost for operators of older aircraft still in production (ex. 767-300) for which approved data already exists and is available via IPC data or interchangeability documents from airframers who have already cut-in a 25-hour CVR for that model.
- The committee assumes that parked aircraft will not come back into revenue service and are excluded from this analysis.
- Pricing of LRU's & Services: Average list price[4] of

o 25-hr CVR @$35,000

o Audio Management Unit (AMU) @$161,514

o 4 x Microphones@$2000

- Labor Rate & Time[5]

o Hourly mean wage $46.38/hr[6]

- o LRU Box Swap = 1 hr[7] x 1 AMT required
- o Wire removal, re-termination, new wire installation – grand average = 6:36 minutes x 1 AMT
- o Wire harness/Equipment Installation – time varies based on #harness segments, length of a segment, common wire routing, accessibility to aircraft zones: ROM
  - A/C Access (removal of equipment, panels, etc.) – 1 Day x 2 AMT's
  - Laying of wiring harnesses (assume new audio wiring between cockpit to tail section of aircraft – 3 days x 2 AMT's min
  - Termination of wiring – 1 day x 2 AMT's
  - Installation of equipment – 1 hr./LRU x 1 AMT's
  - A/C Access restoration – 1 Day x 2 AMT's

Since 1991, approximately 35,000 aircraft have been delivered by Airbus, Boeing, Bombardier, Embraer, and other manufacturers or aircraft used by airlines worldwide. As of the fall of 2024, approximately 31,016 aircraft of these aircraft are in operation globally with major airlines, regional airlines, and cargo airlines. Additionally, over 14,000 business jets have been delivered since 1991, many of which exceed the 27,000 kg threshold.

Based on 42+ US airlines, there are approximately 7,698 aircraft currently in revenue service, which represents 25% of the total number of revenue aircraft in service. Approximately 3,178 aircraft have been produced after the ICAO standard and EASA's rulemaking in 2021 requiring new aircraft to have a 25 hr. CVR installed. The committee assumes that 795 aircraft (25%) of these new aircraft went to US operators, comprising 665 narrow body aircraft (ex. 737 MAX & A320NEO), and 130 wide body aircraft (ex. 787 and A350). Based on stated assumptions that new narrow body aircraft were not delivered with 25-hour CVR's, the total number of US registered 14 CFR 121 aircraft effective by the NTSB recommendation is 7,568 aircraft.

NOTE: For the following discussion, reference Appendix A.

1. **NRE COST**: Based on the review of US operator aircraft, the committee believes that the following aircraft types would require an STC or airframer SB: 717, 737NG's or older, 747-400, 757, MD11, A300, A320 family (including CEO), A330-200/300, CRJ's, ERJ's, and ATR's. This impacts a total of 39+ operators per various aircraft types. In most cases, major carriers are included more than once in this count, due to their mixed fleet of aircraft. The NRE cost charged by DAH for the STC alone, amounts to a minimum of $1.4M. The following older aircraft types, currently in production, are assumed to have airframer approved data and would not require an STC: Airbus A220, A320NEO, A330NEO, A350; Boeing 767, 747-8, 777, 787, 737 MAX 8's & 9's.

2. **CVR COST**: The cost of a CVR, as noted previously, will range between $25K and $45K. This price will vary depending upon the OEM, the relationship the OEM has with the operator, the number of units being sold, and the number of aircraft systems the OEM supplies to the operator beyond a CVR. Currently, there are two major CVR manufacturers who control a large segment of the CVR market, and approximately three other OEM's who are making inroads into the CVR market. Based on public data, the committee estimates that in the next six years, a minimum of 2,620 CVR's for new aircraft deliveries and an additional 262 spares are required for US operators. Extrapolating that number for global new deliveries, OEM's have planned to make a minimum of 3,842 CVR's. If a retrofit regulation is enacted, an additional minimum of 7,889 units will need to be manufactured for a total of 11,731 units in the next six years. To retrofit 7,172 aircraft, US operators must purchase $276M in CVR's.

NOTE: The LRU cost above is only for a single CVR. The analysis does not take into account aircraft certified with two Digital Voice Data Recorder (DVDR) which can perform both the DFDR and CVR functions. The ERJ 175 is an example of an aircraft TC'd with two LRU's in the FWD and AFT portions of the fuselage. The cost excludes changes to the CVR control panel and area microphone.

The modification would take 1 hour and a minimum of 1 AMT to accomplish the maintenance task. Based on the total number of covered aircraft, the labor cost is roughly estimated as being $332,637.

3. AMU Cost: The committee acknowledges that at this time, there is insufficient data to know if existing audio management equipment on older aircraft would meet the requirements of AC 20-168A and ED-112A for audio quality. Based on operator and airframer information for older aircraft still in production, there are cases where a new AMU is cut into production with a 25-hour CVR cut in. The cost of an AMU can vary between $101K to $200K (OEM list prices). This price will vary depending upon the OEM, the relationship the OEM has with the operator, the number of AMU's being purchased, and the number of aircraft systems the OEM supplies to the operator beyond the AMU. The committee, based on the information available, believes that at least 8 families of aircraft making up 4,162 aircraft may require upgrades to audio management systems. Assuming 10% spares, operators would purchase 4,578 units. This number of AMU's is in addition to units being produced for new aircraft deliveries by the respective OEM's. The estimated total cost is $739M. The modification would take 1 hour and a minimum of 1 AMT to accomplish the maintenance task. Based on the total number of covered aircraft, the labor cost is roughly estimated as being $332,637.

4. **Microphone Costs**: The committee acknowledges that at this time, there is insufficient data to know if existing audio control panels (ex. 757) and Captain's, F/O's, and observer audio channel microphones on older aircraft would meet the requirements of AC 20-168A and ED-112A for audio quality. Many out of production aircraft (ex. 757) use the ACP to route audio to the CVR versus collectively through an AMU. The committee, based on information available, believes that at least 8 families of aircraft, making up 2,218 aircraft may require microphone upgrades and possible upgrades to the audio control panel (ACP). ACP's can run from $10K to $50K and there may be 3 or more units installed. For 3 ACP @ average of $30K, could cost an operator $90K/aircraft. Due to the variation of the number of ACP's used between operators and within fleet types, the committee opted to exclude a worse case cost. Excluding ACP cost, the estimated total cost for microphones is $4.5M. Labor cost is not included in this estimate because of the variability of scope of work.

Based on the committees' analysis, the worst-case cost to retrofit 7,568 operational 14 CFR 121 operator aircraft with a 25-hr CVR with full compliance with ED112A and AC 20-168A could be as high as $905M for US operators. This number does not account for 14 CFR 91, 125, or 135 operators.

2. *Benefit Analysis of US Operator Cost and NTSB Benefit to Retrofit all US Aircraft in Operation*

In response to P.L.118-63, the FAA has requested that the committee discuss and develop a benefits analysis for retrofitting "covered aircraft" defined in section 366 of the FAA reauthorization act of 2024.

The retrofit of existing aircraft with a 25-hour CVR, as documented in the NTSB's safety recommendations were meant to provide the NTSB with more data from incidents and accidents to make recommendations to improve safety, but the desire for more data does not necessarily equate to an increase in safety when considering the cost and impact of such regulations on operators, STC holders, airframers, and OEM's. In section III. Discussion of the Proposal for NPRM FAA-2023-2270, table 1 list safety events, up to 2018, where pertinent CVR data was overwritten or lost. The section also provided details of three more recent incidents not included in the table, for a sample of 20 events. These events were noted in the NPRM that, "…numerous accidents and incidents have occurred where the CVR data was overwritten and, had it been available, would have positively contributed to NTSB investigations." The contribution to an NTSB investigation does not necessarily lead to improvements in safety or are all NTSB recommendations made into regulation by the FAA. It is therefore difficult to put a dollar amount on incremental safety benefits, as these future benefits would be a cost avoidance versus cost savings. Therefore, this analysis is purely clinical for the use of the FAA to support their rulemaking process.

Based on the NTSB's database, from 01JAN2010 to 27SEP2024, there have been 523 accidents/incidents related to 14 CFR 121 operations that have occurred in the US. At the time of the dataset, 40 events were in work with only a preliminary report or no report at the time of analysis. In the fourteen years, the NTSB has made 20 safety recommendations[8] based on these 523 events. This represents 3% of all events spanning 165 months. 9 events were documented as accidents with 4 events having 7 fatalities. 4 events having 12 serious injuries with 2 of the 4 events documented with the previous events with fatalities. There were 4 events having 152 minor injuries with 2 events documented as part of the group with fatalities. In two of the events the aircraft was destroyed. All others were classified as substantial damage to the aircraft. 11 events were classified as incidents with no fatalities or injuries. Three events had minor damage to aircraft. Four of the 20 events were related to the movement of aircraft either on the active area on the ground or separation between aircraft taking off and landing. One event listed in the 20 incidents in the database was included in NPRM FAA-2023-2270.

Excluding those accidents where there was a loss of an aircraft and the last two hours of CVR data would be recorded, there is nothing that indicates that had the NTSB had the recordings for those incidents where the CVR was overwritten that any safety recommendation would be issued. In the most recent examples provided in the NPRM, where a major accident could have occurred, the flight crews enacted their training and overcame adverse conditions to avoid loss of life and loss of aircraft.

It is recognized that as aircraft become more efficient and can fly longer distances, there is value in having longer duration CVR's. This value comes from understanding, in total, how well the flight crew used their crew resource management (CRM) training, the interpretation of communications with ATC, and the overall communications between crew members leading up to the accident or incident. From an historical perspective, as an example, having additional CVR data from United Flight 173 on 28DEC1978 and Avionica Flight 052 on 25JAN1990 could have provided additional information that may have enhanced or created additional safety recommendations on CRM and communications if more information was available beyond the 30 minutes of the CVR's at that time. However, in many cases, the additional information may only be valuable to the operator involved for making improvements in crew training, changes to operations manuals, or additions of new flight crew bulletins and not to the industry at large.

Unfortunately, human error cannot entirely be eliminated, even with longer duration recorders. Though having a full data set of information after an incident is important, the incremental safety improvements to the operator would most likely not provide an equivalent ROI for the expense for retrofitting current aircraft, especially when as many as 4,323 aircraft could be permanently parked within the next 6 to 10 years and 21,900 new aircraft with a 25-hour CVR would be manufactured in that same period.

4. Analysis of Recommendations on Expansion of "Covered Aircraft" to Include Aircraft Specified in NPRM 2023-2270

The committee was asked to provide a recommendation on whether to expand the retrofit requirement in section 366 of the Act to require retrofit of aircraft that are specified in the proposed rule for newly manufactured aircraft and not covered by section 366. NPRM 2023-2270 provides verbiage for the proposed amendments to 14 CFR 91.609, 14 CFR 121.359, 14 CFR 125.227, and 14 CFR 135.151. The verbiage generally states that aircraft subject to the section that are manufactured after the effective date of the rule would have a 25-hour CVR that meets TSO-C123c. The applicability of the proposed amendment would include all newly manufactured aircraft under that section without sub-conditions such as the number of seats, type of operations, or maximum payload. Covered aircraft in section 366 of P.L. 118-63 are divided into two groups, aircraft operated under part 121 and transport category aircraft designed for operations by an air carrier or foreign air carrier type certificated with passenger seating capacity of 30 or more seats, all-cargo, or combi derivatives. Additionally, “covered operator” means an operator of a covered aircraft. Based on the second group of covered aircraft in section 366 of the Law, the committee believes that the Law covers a certain number of aircraft currently operated under part 135 . The committee interprets the expansion of covered aircraft to include aircraft operated by air carriers (Part 135) with less than 30 passenger seats and aircraft operated under parts 91 and 125 based on the Discussion of the Proposal in the NPRM.

The NPRM, Discussion of the Proposal, addresses the original NTSB recommendation that all aircraft under these parts be retrofitted with a 25-hour CVR. The FAA estimated that it would increase the number of covered aircraft to approximately 29,561 aircraft. The NTSB estimated the number of aircraft as 13,500. Reviewing the Air Operator FAR Search in the FAA’s aeronautical Data and Products, many aircraft operated by 14 CFR 125 and 14 CFR 135 have a higher probability of needing some form of upgrade to audio equipment. Using the FAA’s Excel file “Title 14 Code of Federal Regulations (14 CFR) Part 135 Operators and Aircraft”[9], and filtering out rotorcraft, traditional business jets (ex. Cessna CE-206), and other small aircraft, there were 216 aircraft[10] which may qualify as being built under 14 CFR 25 in revenue service with twenty-one 4 CFR 135 operators. The committee was unable to find similar list for 14 CFR 91 and 125 operations. The impact of adding these additional aircraft to the current regulation would increase the overall cost of a 25-hour CVR upgrade, and add further stress to the supply chain for sub-components and LRU’s required to comply with the regulation. Using the FAA’s number of 29,500 aircraft, that amounts to 32,450 CVR’s , including spares, amounting to a cost of $1.1B for US operators. If the NTSB number of 13,500 aircraft is used, that amounts to 14,850 units @ $35K or $520M for 14 CFR 91, 121, 125, and 135 operators. Based on the impact and potential costs to 14 CFR 121 carriers discussed in section 3.2.2 and 3.2.3, and the FAA’s own analysis documented in NPRM 2023-2270, the sub-group does not recommend that new regulation include additional aircraft beyond that identified in section 366 of P.L. 118-63.

5. Analysis of Reducing the Number of “Covered Aircraft” to Exclude Certain Older Aircraft

Prior to the enactment of Section 366 of P.L. 118-63, the committee spent several months discussing and developing recommendations on whether to require the retrofitting of all CVRs on all airplanes required to carry both a CVR and FDR with a CVR capable of 25 hours of recording capability. This was a task from amendment 1 of the Investigative Technology Arc Charter. Though this item is no longer a part of amendment 2 of the Investigative Technology Arc Charter, the committee believes that our findings are relevant for consideration in developing a regulation that will comply with section 366 of the Law.

NTSB safety recommendation A-18-031, from which most of section 366 of the Law is derived, did not offer any consideration for age (remaining lifespan) of existing aircraft. The typical lifespan for narrow-body aircraft is 25-30 years and for wide-body aircraft is 30-40 years or more. The life span can be reduced for economic considerations, fuel efficiency, maintenance costs, and regulatory requirements. The return on investment for the incremental safety benefit of installing a CVR with 25-hour duration would be less for older airplanes with a shorter remaining lifespan, while the impact and costs to certify a retrofit installation on older airplanes is expected to be much higher than newer, currently in production airplanes (Reference Section 3.2.2 and 3.2.3). If the rule applies only to aircraft with ten plus years or more of useful life from the time of compliance (i.e. currently 2030), this will reduce the number of impacted planes from 7,568 to 4,345 aircraft or a 42.6% reduction of aircraft. Though the cost is still substantial, this does reduce the impact on the supply chain.

Over the past several years, aviation news articles have reported on how several US operators have invested heavily (i.e. aircraft purchases and hiring of additional pilots and attendants) on fleet modernization and network transformations. Currently, the two major airframers (Airbus and Boeing) have had difficulties delivering replacement aircraft to operators for various reasons. These factors should be considered when factoring in the cost of proposed rulemaking for retrofitting a 25-hour CVR. In one case, one operator has committed to replacing over 155 older 737 NG aircraft with newer aircraft models, while another US operator has plans to replace approximately 270 757's and 767's with newer aircraft models. These orders were placed three to five years ago, and due to the COVID pandemic, supply chain, and manufacturing issues, deliveries have been delayed. These delays have impacted these two operators significantly. The estimated cost to retrofit soon to be retired aircraft, including 10% spares, represents a $16.3M dollar investment for aircraft that are intended to be retired as new aircraft are delivered with a 25-hour CVR. This represents just two operators, but many other operators have similar issues.

Based on our analysis, the committee recommends that the FAA shares this information with Congress and where possible, request amending the existing statute or include in the 2028 FAA Reauthorization Act to grant the FAA authority to provide limited or targeted exemptions for covered aircraft operators.

4. Recommendations

1. Revisions to Existing TSO and Advisory Circular

REC HRT7.a	The FAA should refrain from updating TSO C123c and/or AC 20-168A until after compliance with section 366 of the law and should use specified language indicating that the latest revision to EUROCAE ED-112 applies if it must update regulations or documentation to reference revised guidance materials within the next 5 years.

Today, TSO C123c and AC 20-168A, along with other CAA guidance materials specifically reference EUROCAE document ED112A. The EUROCAE document covers a wide range of flight recorder technology that may be applicable under parts of P.L. 118-63 (sections 352 and 366). ED112A has been superseded by ED112B per the FOREWARD section, 2nd statement in the document. As the FAA continues to work with various international bodies to harmonize aviation regulations, there are various efforts to revise existing documents to reference the latest materials. The committee recommends that any FAA effort to update TSO C123c and/or AC 20-168A not occur until after compliance to Section 366 of the Law. If the FAA must update regulations or documentation to reference revised guidance materials within the next 5 years, then the committee recommends language as in the following example "…must meet the MPS qualification and documentation requirements in European Organization for Civil Aviation Equipment (EUROCAE) document ED-112A, Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems, dated September 2013, or later revision."

2. Reduce Burden of 25-Hour CVR Retrofit Installation

REC HRT7.b	If the FAA adopts a retrofit installation regulation for 25-hour CVR, it should consider measures to reduce the significant impact operators, design approval holders (DAHs), and OEMs would face.

1. Expansion of Covered Aircraft to Include 14 CFR 91, 14 CFR 125, and 14 CFR 135

Section 366 of P.L. 118-63 is applicable to aircraft operated under Part 121 and a certain number of transport category aircraft designed for operations by an air carrier or foreign air carrier TC'd with passenger seating capacity of 30 or more or all-cargo or combi derivatives that may operate under Part 135 and it constrains the industry to those covered operators in having to meet the aggressive 6-year timeline in the law. Congress specifically excluded from covered aircraft in the retrofit provision aircraft operated not in Part 121 (i.e., there is no statutory basis for 25-hour CVR requirements outside Part 121) or which have less than 30 seats. Some of the non-Part 121 aircraft will, however, be equipped with 25-hour recorders by way of the ICAO Annex 6, Part I, provision.

The committee recognizes the benefit that a 25-hr CVR provides accident investigators over a 2-hour CVR. Given the uncertainties of the effect of failing audio quality for certain aircraft types, adding approximately three times the number of “covered” aircraft would complicate compliance with the regulation because of the demands on the supply chain and obtaining approved data to meet the compliance time. The Committee recommends against the FAA expanding the 25-hour retrofit mandate beyond the “covered aircraft” defined in section 366. The FAA should adjudicate comments to NPRM 24-08 as it relates to aircraft outside the scope of part 121 covered aircraft, including input provided by industry about the FAA complying with the ICAO SARPs for 25-hour CVR in any amendments to the regulation (e.g., any update to 14 CFR 91.609)

2. FAA Guidance Material for Determining Qualitative and Quantitative Demonstration of Audio Quality Performance

Based on ICAO recommendation that aircraft manufactured after 01JAN2022 be equipped with a 25-hour CVR and the documentation (ex. TSO C123c, ED112, AC 20-168A) that has been created or updated since the last regulatory mandate to upgrade the CVR from a 30-minute CVR to a 2-hour CVR, operators of older aircraft or out of production aircraft would like FAA guidance materials that would address an aircraft CVR systems pass or fail criteria for demonstrating audio quality performance. ED112A provides guidance for evaluating audio quality. The guidance was designed for a generic timeline for building and certifying a flight recorder on an aircraft or for operator maintenance checks. The committee has concerns about the availability of resources and facilities for performing audio quality checks, given the Laws existing timelines for a 25-hour CVR. If there are no deadline extensions or aircraft exemptions, the FAA should consider creating uniformed, fast track guidance material for certifying a 25-hour CVR. FAA guidance material (ex. A memo) should address the following:

1. Based on the applicability of ED 112A Section 1-A.1 Note 3. Operators may have their own equipment or contracts with playback centers for maintenance purposes that may not meet all of the requirements in ED112A (ex. 1-A.2.2) for the DER’s certification. The FAA should provide a list of multichannel audio replay and analysis software applications that can be used and a list of replay centers acceptable to the administrator.

2. In cases where the manufacturer has aircraft IPC data to replace a 2-hour CVR with a 25-hour CVR with an upgrade of the AMU, what level of audio quality equivalency must a DER show to obtain a fast track STC that does not require the upgrading of the AMU.

3. Considerations on how operators should address unsatisfactory audio quality performance for aircraft and audio components that are out of production. Consideration should include the cost, lead time, and testing required to find suitable replacement of audio components.

By providing this material the FAA can reduce the level of uncertainty as it relates to compliance times and additional certification work that may be required.

3. Consideration of Exemptions in Proposed FAA Regulation

The committee acknowledges that the FAA, as a department under the Executive Branch of the US government, must execute P.L. 118-63, Section 366 as written and approved. Based on the sub-groups cost benefit analysis and the FAA's own analysis as part of NPRM FAA-2023-2270, the committee believes that there is an undue cost burden for operators who operate out-of-production aircraft and/or have already placed orders for newer aircraft to replace older aircraft, but have to keep these older aircraft in revenue service while waiting for new aircraft deliveries. The committee requests that the FAA seek Congressional consideration for some form of exemption that could reduce the cost burden to operators. The intent of this recommendations is to reduce the number of aircraft required to have a 25-hour CVR, reduce the cost and scheduling impact to manufacturers the required number of 25-hour CVR's and any associated audio equipment as discussed in section 3.3, and reduce the cost to US operators. If this recommendation was accepted by the FAA, operators would submit a letter to the FAA requesting either an exemption or extension of compliance dates based on remaining aircraft life span, upgrading audio systems due to poor audio quality, or what the committee classifies as exemptions due to an FAA approved hardship.

1. *Aircraft Useful Life*

With today's fuel consumption, noise abatement, and environmental concerns many aircraft are reaching the end of their useful life. Based on historical data, the committee estimates that the average, useful life span of an aircraft is 30 years for all aircraft types. The committee believes that it may be feasible to exempt aircraft with 10 years or less of remaining life from requiring the installation of a 25-Hr CVR by the due date of 16MAY2030. This would exempt aircraft manufactured on or before 2000 which would include certain numbers of Airbus (A300, A320, A330, A340), Boeing (717, 737NG and 737 Classics, 747, 757, 767, 777, MD11), and regional aircraft (ex. Bombardier and Embraer). Below is an example of how 14 CFR 121.359 could be amended with such exemptions for retrofit aircraft were the FAA to be granted the authority by Congress in statute to provide an accommodation for some aircraft against the retrofit requirement

14 CFR 121.359 Cockpit Voice Recorder

(l) By May 16, 2030, all turbine engine-powered airplanes subject to this section that are manufactured after May 17, 2000, must have a cockpit voice recorder installed that also—

(1) Meets the requirements of § 23.1457(d)(6) or § 25.1457(d)(6) of this chapter, as applicable;

(2) Retains at least the last 25 hours of recorded information using a recorder that meets the standards of TSO-C123c, or later revision; and

(3) Is operated continuously from the use of the checklist before the flight to completion of the final checklist at the end of the flight.

(4) If transport category, meets the requirements in § 25.1457(a)(3), (a)(4), and (a)(5) of this chapter.

2. US Operator Application for Exemption

Based on the committee’s analysis, there may be difficulty for operators to meet the audio quality requirement in ED112B. If this occurs, the cost to upgrade audio equipment could exceed the cost of a 25-hour CVR and control panel. Additionally, the time required to approve new audio equipment may make it difficult for operators to have compliant aircraft by the 16MAY2030, deadline. Many operators have already committed capital and resources to the purchase of newer aircraft to replace older aircraft. These newer aircraft will have 25-hour CVR. However, due to many factors, the aircraft deliveries have been delayed causing operators to continue flying older aircraft longer than envisioned in their fleet plans.   Using EASA Regulation (EU) 29/2009 as an example, the 25-hour regulation could allow operators to communicate with the FAA on reasons for being granted an exemption from the rule or reasons for requesting an extension to the compliance date. The FAA could then look at each induvial case and decide whether a hardship exists and either grant the request or provide additional guidance to the operator to help meet the regulation in a timely fashion. The committee believes that this is the best alternative, that addresses the issues highlighted in section 3.0.   Below is an example of how 14 CFR 121.359 could be amended with such exceptions for retrofit aircraft:

14 CFR 121.359 Cockpit Voice Recorder

(l) By May 16, 2030, all turbine engine-powered airplanes subject to this section must have a cockpit voice recorder installed that also—

(1) Meets the requirements of § 23.1457(d)(6) or § 25.1457(d)(6) of this chapter, as applicable;

(2) Retains at least the last 25 hours of recorded information using a recorder that meets the standards of TSO-C123c, or later revision; and

(3) Is operated continuously from the use of the checklist before the flight to completion of the final checklist at the end of the flight.

(4) If transport category, meets the requirements in § 25.1457(a)(3), (a)(4), and (a)(5) of this chapter.

(5) When particular circumstances, based on the criteria in paragraph I, prevent aircraft of specific types from complying with the requirements of this Regulation, the operator concerned shall communicate to the FAA by May 16, 2027 at the latest, detailed information justifying the need for granting exemption to the aircraft type.

(i) The criteria referred to in paragraph (5) shall be the following:

(a) aircraft type is no longer in production and the procurement of parts to meet audio quality requirements is difficult to obtain or certify

(b) aircraft type reaching the end of useful life and will be retired from service within five years after compliance dates

NOTE: It is the responsibility of secondary operators who may purchase exempted aircraft from the previous owner to ensure that they comply with the 25-hour CVR regulation.

4. Consideration of Extension of Compliance Time

Prior to the enactment of P.L. 118-63, the committee spent several months discussing and developing recommendations on whether to require the retrofitting of all CVRs on all airplanes required to carry both a CVR and FDR with a CVR capable of 25 hours of recording capability. This was a task from amendment 1 of the Investigative Technology ARC Charter. Though this item is no longer a part of amendment 2 of the Investigative Technology ARC Charter, the committee believes that our findings are relevant for consideration in developing a regulation that will comply with section 366 of the Law.

The committee believes that the six year time frame from 16May2024 is insufficient for operators to obtain the necessary FAA approved data, OEM's to manufacturer the appropriate number of 25-hour CVR's and any additional LRU's required to obtain FAA approved data, and sufficient time for operators to install equipment beyond a box swap of a CVR for the 7,179 retrofit aircraft the committee believes may be most at risk.

The committee recommends sufficient time for the following aspects related to retrofit of CVRs with 25-hour duration be provided by amending the statute or Congress granting the FAA the authority for limited or targeted exemptions for covered aircraft operators, including by:

1. Allow time for the industry to certify new CVR systems, associated audio systems and other required design changes which may be applicable for out-of-production models.

2. Allow time for the FAA and NTSB coordination for CVR audio quality assessment of new CVR systems, as included in EUROCAE ED-112A.

3. Allow time for the equipment manufacturers of CVRs with 25-hour duration, cockpit area microphones, ULBs and audio systems to increase production capacity for enough LRUs for newly manufactured U.S. & international airplanes and U.S. retrofit requirements. Any of the exemption recommendations mentioned in section 4.3 would lessen the supply chain impact.

If the FAA has the authority to grant compliance extension through 121 operator request under section 366 of the Law, the committee recommends that compliance date extension of three additional years (ex. 16MAY2033) should be sufficient to allow OEM's to ramp up production and allow TC/STC applicants, the NTSB, and the FAA time to create, test, analyze, and approve data package submittals.

B8: Reducing Burdens of Recorder Mandate for Light Aircraft Operations

The following draft position papers written by the HRT group participants regarding different charter taskings are included to present a full picture of the HRT group's thought processes and key concerns in their own words, as well as further background on each of the areas discussed. They are presented exactly as written and do not represent the position of the full ARC.

ARC Response about all turbine powered aircraft operated under Part 91, Part 121, and Part 135, being required to carry crash-protected flight recorders

Scope

This position paper will provide recommendations to the FAA on whether to require all turbine powered aircraft operated under 14 CFR Part 91, Part 121, and Part 135 to carry crash-protected flight data recorders and cockpit voice recorders.

Background

Crash-protected cockpit voice recorders (CVRs) and flight data recorders (FDRs) have proven invaluable in determining accident causes and aiding in developing corrective measures. However, while 14 CFR Part 121 (scheduled commercial flights) mandates these recorders for large airplanes, 14 CFR Part 91 (general aviation) and Part 135 (commercial, on-demand operations) do not, creating a gap in data available for many accident investigations involving smaller commercial and general aviation aircraft.

Historically, smaller aircraft and those operated on-demand have had different recorder requirements due to presumed operational differences, lower passenger capacities, the FAA's ability to justify expanded equipage in a regulatory cost-benefit analysis, the weight of installing recorders on certain aircraft, and the availabilty of appropriate recording equipment – especially prior to the development of EUROCAE ED-155. That said, accidents in these sectors can still result in significant fatalities, requiring complex investigations where crash-protected recorders could offer critical insights. This is especially true for turbine powered aircraft with sufficient performance to demand pilot training and operational requirements closer to large commercial aircraft. The lack of flight data has been noted by—among other the U.S. National Transportation Safety Board (NTSB)--as one of the contributing factors in Part 91 and Part 135 to some accident investigations not resulting in the NTSB being able to determine a probable cause.

The NTSB and other aviation safety bodies have therefore increasingly advocated for equipping smaller aircraft with recorders, noting that safety improvements should not be limited by the the size of the aircraft or type of operation. Advances in lightweight, cost-effective recorder technology have reduced the feasibility barrier, allowing even smaller aircraft to be equipped without significant impact on performance or cost of equipage.

Expanding the existing mandate for crash-protected recorders under Parts 91 and 135, along with smaller aircraft operating under Part 121 and not currently required to carry recorders, would align safety standards more closely with those of scheduled operations, potentially helping to reduce accident rates for Part 91 and Part 135 operations to levels currently achieved only in Part 121 operations.

The InvTech ARC was tasked with assess whether "to require newly manufactured and existing turbine-powered nonexperimental, non-restricted category aircraft that are not equipped with a FDR or CVR and operating under Parts 91, 121 or 135 to be equipped with a crash-resistant recorder"[1] . The interesting enhancing aviation safety through increased availability of recorded digital and voice data with the ultimately result in contributing to aviation safety improvements has been tasked by the FAA to this ARC to assess against the economic, operational, and other impacts. sIncreasing recorder equipage within the fleet needs to take into account improvements to safety resulting from the integration of Safety Management System (SMS) and Flight Data Monitoring (FDM) program use of the recorded data witin Part 135 operations, as outlined in the related position paper. The ARC notes that Part 5 was expanded in applicability to Part 135 operations as well as certain air tours. Additionally, the FAA has moved forward with establishing requirements for flight data monitoring for some segments of the on-demand Part 135 industry, such as rotorcraft air ambulance [2]operations.

The ARC also notes that the U.S. regulatory system for recording equipment is not fully in compliance with the most recent amendment to the International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPS) for equipage. The FAA may—at a minimum—review and determine alignment of the U.S. regulations for smaller aircraft with the ICAO SARPS.

Advantages of Flight Recorders for Light Aircraft

A standard for light weight flight recorders suitable for light turbine aircraft exists in EUROCAE ED155. The ARC therefore determined to conduct its analysis based on ED155 compliant recording systems presently available in the market. To remain commercially neutral, the ARC will not mention product names or specifications but base its analysis on the general characteristics and the industry standard document

Below is a summary of the six key reasons why turbine-powered aircraft, not currently mandated to carry any flight recording system under 14 CFR Part 91, Part 121, or Part 135, should consider installing an ED-155 compliant recording system:

Enhanced Safety and Accident Investigation

An ED-155 compliant recording system provides essential flight data and cockpit voice recordings that can significantly aid in understanding the causes of incidents or accidents. This information assits investigative authorities in their work to pinpoint contributing factors accurately, leading to improved safety investigations and may prevent similar occurrences in the future. Some vendors offer compatible digital cockpit instrumentation for older aircraft that do not have a native data capture system, providing an upgrade path for many legacy airframe types currently in operation.

2. **Proactive Risk Management**
   Installing flight recorders allows operators to monitor key flight parameters proactively. With modern systems capable of capturing and analyzing trends in operational data, airlines and operators can identify and address potential safety issues or risks before they escalate, contributing to overall flight safety and operational efficiency. This particular benefit is discussed in greater detail in our analysis of whether to require flight data recording systems and flight data management (FDM) programs in Part 135 operations. For example, the recently published Safet Management System (SMS) mandate for Part 135 and certain Part 91 operators can be supported by FDM program through a structured and systematic Flight Operations Quality Assurance (FOQA) program. FDM programs, in turn, require a capability to record and offload data from an aircraft, something nearly all ED155 compliant systems support.
   Many ED-155 compliant recording systems also support interfaces for quick access data retrieval, therefore supporting all three functions (flight data recording, FDM, and crash protected storage).

3. **Regulatory Anticipation and Compliance Readiness**
   While current regulations may not require flight recorders for all turbine-powered aircraft, related regulatory requirements are either in place or on the horizon. ED-155 compliant recording systems available on the market today can support some or all of those as well.

   Installing an ED-155 compliant system positions operators to meet current, upcoming, and potential future mandates with minimal disruption or equipment expenses, likely saving time and costs in retrofitting if such new regulations are implemented.

4. **Operational and Maintenance Benefits**
   ED-155 compliant recorders can capture data that helps in monitoring aircraft health and performance. This capability allows for predictive maintenance, reducing unscheduled downtime, enhancing reliability, and optimizing maintenance cycles. Operators can realize long-term cost savings through improved asset management, while satisfying recently published and potential future requirements (see also 3).

5. **Improved Insurance and Liability Management**
   Initial conversations with insurers revealed that having flight recorders in place may offer liability protection and potentially lower insurance premiums if certain criteria are met, notably a reasonable expectation of a reduced accident risk. In case of an accident or incident, recorded data provides definitive proof of compliance (or lack thereof) with operating procedures, helping mitigate legal risks and disputes.

The same mechanism also incentivizes safer behaviors, as observed in other industries (notably automotive and rail). Therefore, aircraft carrying a crash-protected flight recorder are less likely to be involved in a serious incident or accident.

6. **Public Trust and Passenger Confidence**
   Demonstrating a commitment to the highest safety standards can enhance an operator's reputation and build trust with passengers, stakeholders, and regulators. Installing modern recording systems shows a proactive dedication to safety, which can positively impact the operator's brand and market positioning. This observation leads us to conclude that voluntary adoption of flight recorders for revenue generating operations (i.e., 14 CFR Part 119 certificated operators, or operators operating with an LOA under 14 CFR Part 91 para. 147) could be incentivized without necessarily relying on statutory legal provisions.

These reasons demonstrate the importance of ED-155 compliant recorders to aviation in general, not just for regulatory alignment, but as a proactive measure towards improving operational safety, efficiency, and risk management.

Currently, a number of manufacturers of turbine airplane, rotorcraft, and piston aircraft are equipping new aircraft with data recording capabilities, including to the the ED-155 standard. Operators have also equipped based on specific mandates issued by the FAA, such as air ambulance operations[3]. There is also some limited adoption of flight recorders on aircraft that are not required by international standards or regulations to have an installed recorder. It is therefore necessary to understand the challenges to the installation of such systems.

Challenges

Looking into the challenges faced by the adoption of flight recorders for light aircraft, we identified six key reasons. The FAA advancing a proposed expanded regulatory requirement for all or some turbine-powered aircraft under 14 CFR Part 91, Part 121, or Part 135 to install crash-protected recording systems must be expected to face the following contentions:

1. **Cost Implications for Small Operators**
   For smaller operators, especially those in Part 91 or small Part 135 operations, the cost of purchasing and installing ED-155 compliant systems could be a significant financial burden. Initial conversations with equipment vendors and MRO providers revealed that equipment costs generally fall between $10,000 and $25,000, depending on complexity, data capacity, and optional configurations. Certification and installation must be expected to add a further $10,000 to $50,000, again depending on complexity. Ongoing maintenance adds recurring costs, and the combined costs might not be justifiable for small and medium sized businesses, or private owner/operators, based on the scale of their operations.

2. **Limited Safety Benefits for Low-Risk Operations**
   In many cases, operators under Part 91 engage in low-risk operations, such as short flights with minimal exposure to complex airspace or adverse weather. For these operators, the safety benefits of recording systems may not be substantial enough to justify the costs or regulatory burden, as their operations may already pose relatively low risks.

3. **Technical and Practical Limitations**
   Mandating the installation of recording systems in older or legacy aircraft can be technically challenging due to their design, aircraft architecture, existing avionics configurations, and the availability of the input data in a digital format to record. Retrofitting older aircraft to accommodate modern recording systems may require substantial modifications, which could be impractical and impact the aircraft's certification.

4. **Administrative and Regulatory Complexity**
   Imposing a regulatory requirement would involve creating new compliance frameworks, standards, and oversight mechanisms. This could increase administrative complexity for both regulators and operators, potentially leading to a lengthy and complicated implementation process with increased paperwork and record-keeping requirements.

5. **Privacy Concerns for Private and Small Commercial Operators**
   Part 91 operators, especially , private aircraft owners, may have concerns about privacy and data security. Recording systems capture audio and flight data that could be perceived as an invasion of privacy or as subject to misuse if not handled with strict confidentiality protocols.

6. **Potential for Over-Regulation**
   Some operators and industry professionals argue that introducing mandatory flight recorders for all turbine-powered aircraft could lead to over-regulation in aviation. Operators already comply with a wide range of safety requirements, and imposing additional mandates could be seen as excessive, particularly if existing safety data doesn’t demonstrate a clear need for mandatory flight recording systems in all cases.
   This is especially true if a flight recording and FDM mandate was to be passed (see related position paper on flight data acquisition and FDM in Part 135 operations).

These reasons highlight the challenges and potential downsides of imposing a blanket regulatory requirement for crash-protected (i.e., ED-155 compliant) recording systems across all turbine-powered aircraft operations. Instead, a risk-based, voluntary, or targeted approach could be more appropriate in addressing safety needs without introducing excessive regulatory burden.

Relation to Flight Data Acquisition, Transmission, and FDM Solutions

An ED-155 compliant flight recording solution and a flight data collection and transmission system (such as those used for Flight Data Management, or FDM) already offer distinct approaches to enhancing safety and operational oversight in light aircraft. **ED-155 recorders** are crash-survivable, capturing both cockpit voice and essential flight data. Their primary advantage is their durability and the ability to provide critical evidence during accident investigations. However, these systems can be relatively costly to purchase, install, and maintain, especially for operators of light aircraft that are not mandated to carry recorders. In contrast, **flight data collection and transmission systems** focus on capturing key flight parameters in real-time and transmitting them to ground stations for proactive analysis. This approach supports predictive maintenance and safety trend monitoring but lacks the resilience of crash-survivable memory. The key advantage of FDM is the immediate availability of data and insights, promoting a proactive safety culture and tying in with the recently published SMS mandate. The downside, however, is the reliance on constant data transmission, which may not be feasible in all operations.

Recommendations

1. Prefer performance-based rules over blanket equipage mandates, with an overall risk reduction being the highest priority and design driver. Considering this, flight data monitoring programs and online flight data transmission solutions offer better support for a proactive safety culture, and a better fit with the SMS mandate already in place, than purely forensic solutions.

2. The ED-155 standard and compliant recorders were developed with the objective of realizing the balance of lightweight design, and cost-effectiveness for smaller aircraft. These systems cover a broad range of configurations, with voice-only recorders typically being more economical, while combined recorders offer enhanced data monitoring and analysis capabilities. The focus of any proposed rule expanding thee existing mandate for flight recorder equipage for turbine aircraft operating in Part 91 or Part 135 must consider reducing installation complexity and ensuring a low barrier to regulatory compliance for light aircraft operations.

3. FAA should in any rulemaking weigh the benefits of enhanced crash survivability and investigation support realized from requiring an ED-155 system against the proactive safety and operational advantages of an FDM-based solution, as legislating both independently would likely overburden smaller operators. The FAA should consider establishing a voluntary adoption program and incentivizing the installation of crash protected storage solutions. The ARC does not that the FAA did incentive early ADS-Bequipage to help realize the January 1, 2020 mandate for equipage. aForthcoming regulation should take overall risk and operational scenarios into account, allowing for scalability with key parameters. For example, aircraft age and technical capabilities

should be taken into account, so as to ensure older aircraft aren't faced with uneconomical installation requirements.

4. Furthermore, compatibility with the existing SMS mandate and a combination with potential flight data acquisition systems for FDM (as outlined in the position paper on flight data and FDM for Part 135 operators) should be considered, encouraging and incentivizing the addition of a crash protected memory, rather than mandating this separately.

B9: Use of ADFRs That May Currently Be Contrary to FAA Regulations

The following draft position papers written by the HRT group participants regarding different charter taskings are included to present a full picture of the HRT group's thought processes and key concerns in their own words, as well as further background on each of the areas discussed. They are presented exactly as written and do not represent the position of the full ARC.

Discuss issues and develop a recommendation on whether to allow the use Of ADFRs that may currently be contrary to FAA regulations

The authors believe that it would be beneficial to consider a deployable flight data recorder as an alternative means to ensure the timely recovery of flight data without a need for underwater recovery operations.
The capabilities of a deployable recorder with an integrated ELT would not only allow the timely recovery of the mandatory flight parameters but also the cockpit voice and datalink recordings. Furthermore, an integrated ELT with position transmission would be an additional means for locating the point of end of flight.

With regards to 14CFR 91.15:

§ 91.15 Dropping objects. https://www.ecfr.gov/current/title-14/section-91.15

No pilot in command of a civil aircraft may allow any object to be dropped from that aircraft in flight that creates a hazard to persons or property. However, this section does not prohibit the dropping of any object if reasonable precautions are taken to avoid injury or damage to persons or property.

Author's interpretation: 14 CFR Subchapter F part A 91 relates to people and behavior when operating an aircraft. It is believed that the purpose of §91.15 is meant to prevent intentional dropping of objects from an aeroplane. It could be considered that any part falling off the aeroplane (also unintentionally, e.g. because not properly secured or not checked being fixed before flight) may also be subject of concern.

We believe that existing international standards, regulations and guidance exist to address the risk of unintentional deployment of parts, and in particular for a deployable recorder, defining reasonable precautions to avoid injury or damage to persons or property

Generally, FAA draft policy PS-ANM-25-23 (Risk to Persons on the Ground from Objects Falling off Transport Category Airplanes) and EASA CM-21.A-A-001 (Parts Detached from Aeroplanes) address people safety on ground due to unintentionally falling objects.

Additionally, Eurocae standard ED-112A/B includes dedicated design precautions for development and integration of a deployable recorder:

- shall not be allowed to be deployed by manual action from crew (Eurocae ED-112A/B 3-1.7g)
- addressing quantitative safety targets to prevent unintentional deployment (Eurocae ED-112A/B 3-1.5.1)

We believe that this material provides acceptable methods to assess the appropriate design measures preventing people on the ground being severely injured when hit by parts falling off an aeroplane due to unintended parts deployment. This is believed to adequately address the need for reasonable precautions expressed in 14 CFR Subchapter F §91.15.

The above still requires applicability of SAE ARP4761(A) on design methods for the safety assessment process.

As the deployable recorder meets the intent of objectives of this ARC and adequate safety level can be achieved by existing technologies and standards, we kindly ask the sub-group to amend the position paper accordingly.

B10: Privacy and Data Misuse

Introduction:

The Federal Aviation Administration (FAA) has established an Investigative Technologies Aviation Rulemaking Committee (ARC) to seek recommendations from the aviation community on various technologies to improve the collection and recovery of flight data, flightdeck voice and images, and more precise methods to track and locate aircraft in distress.

This position paper will address industry concerns on the misuse of data and information and many interrelated issues such as privacy concerns, criminalization of incidents and accidents, punitive actions against pilots by employers, media exposure and other unintended consequences that could jeopardize a positive reporting culture and negatively impact aviation safety.

The potential for the misuse of data and information increases as new investigative technologies are implemented throughout the aviation system. This paper is applicable to several different technologies including:

a. Cockpit Voice Recorders (CVRs)

b. Flight Data Recorders (FDRs)

c. Cockpit Image Recorders (CIRs)

d. Data Link Recorders (DLRs) and messages

e. Automatic Deployable Flight Recorders (AFDRs)

This paper will address deficiencies in current FAA regulations (CFR 49 Chapter 11 and CFR 13, 193), international harmonization and International Civil Aviation Organization (ICAO) standards and other guidance as it relates to the use of recorded data and the protection of personal information.

Background:

Public disclosure of CVR audio recordings demonstrates the limitations of the data protection provisions of ICAO Annex 13. Examples include American Airlines flight 965, GOL flight 1907 and Germanwings flight 9525 where audio recordings were leaked to media and on the public domain. The public desire for sensational audio and video recordings is a clear risk to the privacy of a pilot; current regulations offer few protections for the exploitation of accident recordings or video footage.

Outside of the United States, there has been an increase in legal actions against flight crewmembers and other aviation workers (Fig. 1) that has effectively criminalized aviation incidents and accidents. Often “dual investigations” are initiated following an incident or accident; one for the purpose of improving safety, the other to prove criminal intent and subsequent prosecution. This too is contrary to the provisions of ICAO Annex 13.

Since 1956, there have been 57 documented cases of prosecution against aviation professionals worldwide. These cases involved many different aviation professionals including pilots, air traffic controllers, maintenance technicians, airline and air traffic managers, manufacturer representatives, and third-party vendors. Penalties in these cases vary and result in either prison sentences, monetary damages, or probation. (Mateou and Mateou), 2010, *Flying in the Face of Criminalization)*

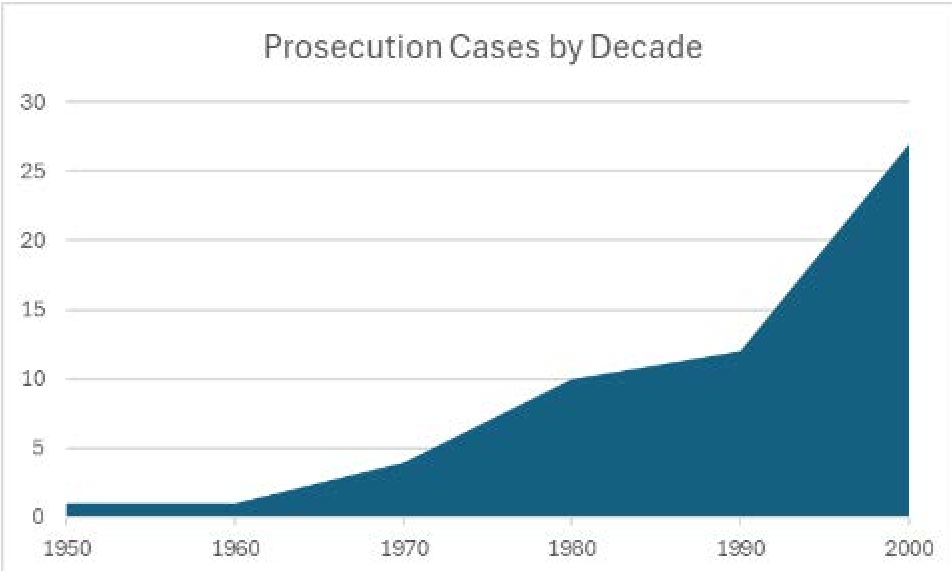

Fig. 1 Prosecution cases of aviation professionals by decade

The Flight Safety Foundation (FSF) has taken note of this uptick in criminal investigations and recognizes the negative impact on safety by stating, “This can have a chilling effect on the flow of crucial safety information and a long-term adverse impact on safety. Holding controllers, pilots, and aviation maintenance technicians criminally liable for honest mistakes ultimately threatens the safety of the traveling public.”

Proposed and current regulations in the United States address the use of aircraft data and information following an aircraft accident. ICAO clearly states in Annex 13 (*Aircraft Accident, and Incident Investigation)* that the sole objective of an aircraft accident or incident investigation is the prevention of future accidents and incidents. It is not the purpose of an investigation to apportion blame or liability.

Recent rulemaking activities (2024 FAA Reauthorization Act Sec. 366) provided new language to the use of data collected from CVRs:

The rulemaking must ensure that data from the CVRs is protected from unlawful or unauthorized disclosure to the public, is used exclusively by a federal agency or a foreign accident investigative body for a criminal investigation, aircraft accident, or aircraft incident investigation, and is not deliberately erased or tampered with following a NTSB reportable event for which civil and criminal penalties may be assessed. Section prohibits data from CVRs from being used by the FAA or a covered operator for a certificate action, civil penalty, or disciplinary proceedings against flight crew members.

United States Code

Congressional lawmaking provides guidance to the National Transportation Safety Board regarding the protection of personal data through 49 USC 1114 (Disclosure, availability, and use of information):

a. GENERAL. —
    1. Except as provided in subsections (b), (c), (d), and (f) of this section, a copy of a record, information, or investigation submitted or received by the National Transportation Safety Board, or a member or employee of the Board, shall be made available to the public on identifiable request and at reasonable cost. This subsection does not require the release of information described by section 552(b) of title 5 or protected from disclosure by another law of the United States.
    2. The Board shall deposit in the Treasury amounts received under paragraph (1) to be credited to the appropriation of the Board as offsetting collections.
b. TRADE SECRETS. —
    1. The Board may disclose information related to a trade secret referred to in section 1905 of title 18 only—
        a. to another department, agency, or instrumentality of the United States Government when requested for official use;
        b. to a committee of Congress having jurisdiction over the subject matter to which the information is related, when requested by that committee;
        c. in a judicial proceeding under a court order that preserves the confidentiality of the information without impairing the proceeding; and
        d. to the public to protect health and safety after giving notice to any interested person to whom the information is related and an opportunity for that person to comment in writing, or orally in closed session, on the proposed disclosure, if the delay resulting from notice and opportunity for comment would not be detrimental to health and safety.
    2. Information disclosed under paragraph (1) of this subsection may be disclosed only in a way designed to preserve its confidentiality.
    3. PROTECTION OF VOLUNTARY SUBMISSION OF INFORMATION.— Notwithstanding any other provision of law, neither the Board, nor any agency

receiving information from the Board, shall disclose voluntarily provided safety-related information if that information is not related to the exercise of the Board's accident or incident investigation authority under this chapter and if the Board finds that the disclosure of the information would inhibit the voluntary provision of that type of information.

c. **COCKPIT RECORDINGS AND TRANSCRIPTS. —**

1. CONFIDENTIALITY OF RECORDINGS. —Except as provided in paragraph (2), the Board may not disclose publicly any part of a cockpit voice or video recorder recording or transcript of oral communications by and between flight crew members and ground stations related to an accident or incident investigated by the Board.
2. EXCEPTION. —Subject to subsections (b) and (g), the Board shall make public any part of a transcript (Summary), any written depiction of visual information obtained from a video recorder, or any still image obtained from a video recorder the Board decides is relevant to the accident or incident—
    a. if the Board holds a public hearing on the accident or incident, at the time of the hearing; or
    b. if the Board does not hold a public hearing, at the time a majority of the other factual reports on the accident or incident are placed in the public docket.
3. REFERENCES TO INFORMATION IN MAKING SAFETY RECOMMENDATIONS. —This subsection does not prevent the Board from referring at any time to cockpit voice or video recorder in- formation in making safety recommendations.

d. SURFACE VEHICLE RECORDINGS AND TRANSCRIPTS. —

1. CONFIDENTIALITY OF RECORDINGS.—Except as provided in paragraph (2), the Board may not disclose publicly any part of a surface vehicle voice or video recorder recording or transcript of oral communications by or among drivers, train employees, or other operating employees responsible for the movement and direction of the vehicle or vessel, or between such operating employees and company communication centers, related to an accident investigated by the Board.
2. EXCEPTION. —Subject to subsections (b) and (g), the Board shall make public any part of a transcript, any written depiction of visual information obtained from a video recorder, or any still image obtained from a video recorder the Board decides is relevant to the accident—

a. if the Board holds a public hearing on the accident, at the time of the hearing; or (B) if the Board does not hold a public hearing, at the time a majority of the other factual reports on the accident are placed in the public docket.

3. REFERENCES TO INFORMATION IN MAKING SAFETY RECOMMENDATIONS. —This subsection does not prevent the Board from referring at any time to voice or video recorder information in making safety recommendations.

e. FOREIGN INVESTIGATIONS. —

1. IN GENERAL. —Notwithstanding any other provision of law, neither the Board, nor any agency receiving information from the Board, shall disclose records or information relating to its participation in foreign aircraft accident investigations; except that—

a. the Board shall release records pertaining to such an investigation when the country conducting the investigation issues its final report or 2 years following the date of the accident, whichever occurs first; and

b. the Board may disclose records and information when authorized to do so by the country conducting the investigation.

2. SAFETY RECOMMENDATIONS. —Nothing in this subsection shall restrict the Board at any time from referring to foreign accident investigation information in making safety recommendations.

f. PRIVACY PROTECTIONS. —Before making public any still image obtained from a video recorder under subsection (c)(2) or subsection (d)(2), the Board shall take such action as appropriate to protect from public disclosure any information that readily identifies an individual, including a decedent.

NTSB Regulations and Procedures

The United States Code is rolled into NTSB rulemaking in 49 CFR Part 801, Public Availability of Information. This confirms that disclosure of information is limited when an individual’s privacy is at risk:

801.56 Unwarranted invasion of personal privacy

Pursuant to 5 USC 552(b)(6), any personal, medical, or similar file is exempt from public disclosure if its disclosure would harm the individual concerned or would be a clearly unwarranted invasion of the individual’s personal privacy.

The NTSB’s guidance for responding to legal proceedings (49 CFR Part 837) also refers to this regulation when determining which records should be produced in legal proceedings.

Sensitivity of personal data is also contained in the NTSB Major Investigations Manual, in Section 3, CVR Recording Disclosure and Access:

3.1 CVR recordings and transcripts contain highly sensitive material, and premature or unauthorized release of information by Safety Board employees is grounds for disciplinary action. All Safety Board staff and Members who obtain information concerning the contents of a CVR recording or written transcript, regardless of reason or source, are bound by Federal CVR nondisclosure laws (refer to 49 USC 1114 – Disclosure, availability, and use of information)

FAA Regulations

Current federal regulations for the FAA (14 CFR 121.359(h)) similarly specify that information obtained from the CVR recording is to be used for investigative purposes only.

14 CFR 121.359 Cockpit Voice Recorders

(h) In the event of an accident or occurrence requiring immediate notification of the National Transportation Safety Board under 49 CFR part 830 of its regulations, which results in the termination of the flight, the certificate holder shall keep the recorded information for at least 60 days or, if requested by the Administrator or the Board, for a longer period. Information obtained from the record is used to assist in determining the cause of accidents or occurrences in connection with investigations under 49 CFR part 830. The Administrator does not use the record in any civil penalty or certificate action.

This same paragraph is repeated in 14 CFR § 91.609 – Flight data recorders and cockpit voice recorders regarding other operations not covered by 14 CFR Part 121.

Harmonization:

ICAO provides guidance to operators, and States of operators, regarding privacy concerns in ICAO Annex 6, Part I, Chapter 3:

3.3.4 States shall not allow the use of recordings or transcripts of CVR, CARS, Class A AIR and Class A AIRS for purposes other than the investigation of an accident or incident as per Annex 13, except where recordings or transcripts are:

a. related to a safety-related event identified in the context of a safety management system; are restricted to the relevant portions of a de-identified transcript of the recording; and are subject to the protections accorded by Annex 19;
b. Sought for use in criminal proceedings not related to an event involving an accident or incident investigation and are subject to the protections accorded by Annex 19; or

c. Used for inspections of flight recorder systems as provided in Section 7 of Appendix 8.

3.3.5 States shall not allow the use of recordings or transcripts of FDR, ADRS, as well as Class B and Class C AIR and AIRS for purposes other than the investigation of an accident or incident as per Annex 13, except where the recordings or transcripts are subject to the protections accorded by Annex 19 and are:

a. Used by the operator for airworthiness or maintenance purposes;
b. Used by the operator in the operation of a flight data analysis programme required in this Annex;
c. Sought for use in proceedings not related to an event involving an accident or incident investigation;
d. De-identified; or
e. Disclosed under secure procedures

This guidance is further referenced in ICAO's Safety Management Annex 19, Appendix 3, Section 6, Protection of recorded data:

6.1 States shall, through national laws and regulations, provide specific measures of protection regarding the confidentiality and access by the public to ambient workplace recordings.

6.2 States shall, through national laws and regulations, treat ambient workplace recordings required by national laws and regulations as privileged protected data subject to the principles of protection and exception as provided for in this appendix.

Specific to accident and incident investigations, ICAO Annex 13, paragraph 5.12 provisions concerning the protection of accident and incident investigation records, which state as follows:

5.12 The State conducting the investigation of an accident or incident shall not make the following records available for purposes other than accident or incident investigation, unless the competent authority designated by that State determines, in accordance with national laws and subject to Appendix 2 and 5.12.5, that their disclosure or use outweighs the likely adverse domestic and international impact such action may have on that or any future investigations:

a. cockpit voice recordings and airborne image recordings and any transcripts from such recordings; and
b. records in the custody or control of the accident investigation authority

The sub-paragraph then goes on listing these records.

EU Regulations

European Union (EU) Regulation (EU) 996 – 2010, Article 14 *Protection of sensitive safety information* is applicable to all its member states:

1. The following records shall not be made available or used for purposes other than safety investigation:

a. all statements taken from persons by the safety investigation authority in the course of the safety investigation;

b. records revealing the identity of persons who have given evidence in the context of the safety investigation; EN L 295/44 Official Journal of the European Union 12.11.2010

c. information collected by the safety investigation authority, which is of a particularly sensitive and personal nature, including information concerning the health of individuals;

d. material subsequently produced during the course of the investigation such as notes, drafts, opinions written by the investigators, opinions expressed in the analysis of information, including flight recorder information;

e. information and evidence provided by investigators from other Member States or third countries in accordance with the international standards and recommended practices, where so requested by their safety investigation authority;

f. drafts of preliminary or final reports or interim statements;

g. cockpit voice and image recordings and their transcripts, as well as voice recordings inside air traffic control units, ensuring also that information not relevant to the safety investigation, particularly information with a bearing on personal privacy, shall be appropriately protected, without prejudice to paragraph 3.

2. The following records shall not be made available or used for purposes other than safety investigation, or other purposes aiming at the improvement of aviation safety:

a. all communications between persons having been involved in the operation of the aircraft;

b. written or electronic recordings and transcriptions of recordings from air traffic control units, including reports and results made for internal purposes;

c. covering letters for the transmission of safety recommendations from the safety investigation authority to the addressee, where so requested by the safety investigation authority issuing the recommendation;

d. occurrence reports filed under Directive 2003/42/EC.

e. Flight data recorder recordings shall not be made available or used for purposes other than those of the safety investigation, airworthiness or maintenance purposes, except when such records are de-identified or disclosed under secure procedures. 3.

Notwithstanding paragraphs 1 and 2, the administration of justice or the authority competent to decide on the disclosure of records according to national law may decide that the benefits of the disclosure of the records referred to in paragraphs 1 and 2 for any other purposes permitted by law outweigh the adverse domestic and international impact that such action may have on that or any future safety investigation. Member States may decide to limit the cases in which such a decision of disclosure may be taken, while respecting the legal acts of the Union.

3. The communication of records referred to in paragraphs 1 and 2 to another Member State for purposes other than safety investigation and, in addition as regards paragraph 2, for purposes other than those aiming at the improvement of aviation safety may be granted insofar as the national law of the communicating Member State permits. Processing or disclosure of records received through such communication by the authorities of the receiving Member State shall be permitted solely after prior consultation of the communicating Member State and subject to the national law of the receiving Member State. Only the data strictly necessary for the purposes referred to in paragraph 3 may be disclosed.

EASA report (Research Project EASA. 2020.C43) on Quick Recovery of Flight Recorder Data (wireless transmission) – Report D7 "*Scenario-based study of legal aspects*" addresses EU's General Data Protection Regulation (GDPR) and the protection of personal data:

5.1.2 Personal Data

In EU law, the protection of personal data is recognized as a fundamental right embodied in Article 16 of the Treaty on the Functioning of the EU and Article 8 of the Charter of Fundamental Rights of the EU. The GDPR guarantees a high level of protection. It has been described as the *"toughest privacy and security law in the world"*

As already explained (see 4.1.2) the GDPR's extraterritorial scope advocates for the application of its principles to all Flight Recorder Data.

However, it is worth mentioning Convention 108 of the Council of Europe "for the Protection of Individuals with regard to Automatic Processing of Personal Data" (1981) as the first internationally legally binding act dealing with data protection, ratified by the 47 Council of Europe Member States including for instance the Russian Federation. A modernized version of the Convention will enter into force on 11 October 2023 with a level of protection similar to the GDPR.

Many countries, on the other hand, do not recognize a general right to personal data protection, including major nations such as the USA. The question of the compatibility between US and EU laws 17 as well as between Chinese and EU laws 18 is not settled.

As was seen in section 4.1.2, the definition of “personal data” in the GDPR is very broad as it relates to both identified and identifiable natural persons (‘data subjects’). The identification of a natural person can therefore be made from a single data or from the crossing of a set of data. According to that definition, even technical data such as some of the FDR parameters can be regarded as personal if their crossing with other data allows to identify the actions or behavior of a crew member for instance.

The principles relating to the processing of personal data are outlined in article 5 of the GDPR. Among them, transparency, purpose limitation, data minimization, storage limitation, integrity and confidentiality.

As for the data subjects’ privacy rights, the list includes the right to be informed, the right of access and to obtain a copy, the right to rectification, to erasure and to restrict processing.

Some of these rights may not be exercised fully when an accident or serious incident occurs as ICAO Annex 13 [Ref 8] limits the availability and disclosure of recorded data, but article 23 of the GDPR allows to restrict the scope of these obligations and rights by adopting a law “when such a restriction respects the essence of the fundamental rights and freedoms and is a necessary and proportionate measure in a democratic society to safeguard : (…)

(c) public security

(h) a monitoring, inspection or regulatory function connected, even occasionally, to the exercise of official authority in the cases referred to in points (a) to (e), which includes public security (the “official authority" may be AIAs).

This restriction applies when an accident or serious incident occurred, and an AIA is investigating.

If an accident or serious incident did not occur, the question of the protection of the collected data remains.

Solution #1 therefore raises more concerns in respect of compliance with the GDPR than does solution #2. In solution #1, data, including personal data, are acquired, transported and stored systematically, regardless of their potential relevance for an AIA investigation; indeed, an overwhelming majority of flights are performed without accidents or serious incidents, which could lead to the conclusion that in that vast majority of cases, the collection of personal data will not be lawful.

This, however, would be an erroneous conclusion. As rare as they may be, instances when flight recorders cannot be physically recovered have been determined to be sufficient reason to mandate quick recovery of data through other means. If solution #1 were to be pursued, its primary purpose would remain to allow for the investigation of accidents and serious incidents and thereby ensure aviation safety.

Robust encryption (see paragraph 5.1.3) and limited time of storage policies (see paragraph 5.4.3) should however be very strictly implemented.

Finally, regarding non personal data, EU Regulation 2018/1807 on a framework for the free flow of non-personal data in the European Union requires that it should be available for competent authorities (article 5); and, mirroring the public security exception for personal data (see above), it prohibits data localization requirements “unless they are justified on grounds of public security in compliance with the principle of proportionality” (article 4(1)).

Analysis

Court ruling on privacy for U.S. citizens: In a 1965 case (Griswold v. Connecticut) the court ruled that US citizens have a constitutional right to privacy in all their affairs, including at work. The court found that the Constitution creates a "zone of privacy" when the penumbras of the First, Third, Fourth, Fifth, and Ninth Amendments are taken together. Privacy could be enforced through encryption of CVR and CIR recordings.

Impact:

Until the misuse of recorded data and information has been prevented through enhanced regulations protecting the privacy of aviation professionals, airline pilot unions (Airline Pilots Association, Allied Pilots Association, Coalition of Airline Pilots Association, Independent Pilots Association, International Federation of Airline Pilots Association, etc.) in the United States and throughout the world will be opposed to new investigative technologies in airliners. These technologies include:

a. Cockpit Image Recorders (CIRs)

b. Data Link Recorders (DLRs) and messages

c. Automatic Deployable Flight Recorders (AFDRs)

d. Streaming of flight data

<u>Cockpit Image Recorders</u> (CIR) [*Alternatively known as Airborne Image Recorders*]

CIRs have been recommended by the NTSB and other accident investigation authorities as a tool to enhance accident investigations. FDRs and CVRs have long been used effectively to investigate aviation accidents and incidents. Labor unions support expanding the capability of FDRs to support investigations.

Recent examples of leaked audio recordings from accident investigations to the media does not provide assurance to the professional airline pilot community that current regulations would prevent identifiable images of flight crewmembers from being broadcast in the public domain; this would affect safety and could have a devastating effect on families of victims following a fatal accident.

In a recent case (Sept. 2018), Air Niugini Flight 73 – a Boeing 737-800 – crashed short of the runway at Chuuk International Airport (FSM) and came to rest in the Chuuk Lagoon. An engineer seated in the cockpit jumpseat filmed the approach on his personal cell phone. After the accident, the engineer shared the video images of the crash sequence with investigators. Images of the crash were made public through the final reports and portions of the video are publicly available through YouTube without any attempt to obscure identifiable features of each pilot.

Streaming of flight recorder data

Currently, there are two solutions proposed in the Investigative Technologies ARC to quickly recover flight data: AFDRs and wireless data streaming.

AFDRs are currently being used on a limited basis and include protection features that are equivalent to existing methods of data recovery. Data streaming – or wireless streaming of flight recorder data – raises concerns about protecting the data against misuse or alteration.

Streaming flight data and storing it in extra-territorial clouds is a risk to data privacy and protection. Cybersecurity is a major concern for corporations, governments, and individuals. Aviation regulations must be amended to account for major advances in data streaming and storage technologies to protect the integrity of flight safety investigations (data manipulation and corruption) and account for data and privacy concerns of individuals and organizations.

Protection of cockpit recordings (introduction of new discussion from IFALPA)

NTSB and ICAO have established provisions for the protection of "cockpit voice recordings and airborne image recorders/video recordings and transcripts from those recordings. However, in the case of ICAO there are no definitions of "cockpit voice recordings" and "airborne image recordings," which leaves it to individual states to determine which recordings fall under these provisions.

This has created disparities throughout the world regarding what types of recordings are protected. Most associate cockpit voice and airborne image recordings as those made by installed CVRs and AIRs/CIRs (as defined in ICAO Document 9756 Manual of Aircraft Accident and Incident Investigation).

Other technologies such as tablets, mobile phones and cameras also have the capability to record images, voice and other data. Many of these devices can survive a high-energy impact such as an aircraft accident. Often the data and information from these devices are used during accident investigations.

Currently, there are no international standards to protect the recordings made on the flight deck by these mobile devices. ICAO Annex 13 (5.12.1) includes a recommendation by stating "States should determine whether any other records obtained or generated by the accident investigation authority, as a part of an accident or incident investigation, need to be protected in the same way as the records listed in 5.12." Many regulations are ambiguous and do not address recordings or images on the flight deck captured by devices such as personal mobile phones or cameras; without updated regulations this information could be released to the public without any restrictions.

Deidentified accident reporting

ICAO Annex 13 (5.12.3) cautions that "the names of the persons involved in the accident or incident shall not be disclosed to the public by the accident investigation authority."

Similarly, the European Union states through Regulation EU 996 article 16 that "The report shall protect the anonymity of any individual involved in the accident or serious incident."

Publicly identifying individuals directly involved with an occurrence can harm future investigations and result in detrimental consequences. Current FAA regulations (CFR 49 Chapter 11) do not prohibit the release of personal identifiable information.

Releasing the personal identifiable information of pilots involved in serious incidents or accidents can have negative consequences that relate to psychological safety (PTSD), physical safety (vengeful personal attacks), and criminal or civil liabilities (lawsuits).

Recommendations:

The ARC understands that a review of the regulatory environment around privacy and data misuse was not specifically requested of the rulemaking committee. However, the ARC submits the following additional recommendations to the FAA with the goal of improving the Just and non-punitive safety culture on which investigations rely:

1. Work with the National Transportation Safety Board (NTSB) to strengthen the privacy regulations in 49 CFR Part 831 and 837, with the aim of protecting personally identifiable information (PII) of flight crewmembers involved in incidents and accidents, including identifying information captured in audio, image, and digital form.

2. Strengthen privacy considerations in 14 CFR Parts 13, 193, and others as required, with the aim of protecting personally identifiable information (PII) of flight crewmembers involved in FAA-led safety investigations, including identifying information captured in audio, image, and digital form.

3. Create new regulations in 14 CFR Part 13, 193, 121, and 135 that limit the use of flight deck audio, image, and data recordings in enforcement investigations.

4. Change Title 49 Chapter 11 c.2 only release CVR/CIR summaries to the public not the actual transcript, also only summaries of any interview transcripts.

5. Change applicable regulation (Ref. Document?) to change NTSB procedure to return recorders (i.e. CVR, DFDR, CIR, etc.) unit to operator (or return organization) with erased medium. Because of the sensitivity of recordings, it is possible that the return organization for the recorder unit is not the same organization that shall receive the original recording medium. (To only return the physical device minus or erased medium).

Supplemental information:

1. NTSB accident investigation handbook – information related to CVR and audio recordings.

15. Release of the Recorder and Audio Recording

15.1. The IIC shall supply the CVR specialist with the recorder’s return organization and address. Ordinarily with minor accidents and incidents, the owner/operator at the time of the accident or incident is the rightful return organization. However, there are instances when the rightful return organization is less apparent, such as when the insurance company has control of the wreckage, or there are fractional owners, or if the aircraft is leased. If there is uncertainty regarding the proper return organization, the IIC and CVR specialist shall contact the General Counsel, who can resolve any issues regarding who shall receive the CVR and original CVR recording.

15.2. Because of the sensitivity of CVR recordings, it is possible that the return organization for the CVR unit (the recorder box) is not the same organization that shall receive the original CVR recording medium.

15.3. For tape-based CVRs, the CVR unit—minus the recording original tape—may be returned to the owner (or authorized recipient) as soon as the CVR specialist determines that there are no issues related to its operation. The original tape recording is returned to the authorized recipient only after the investigation is complete and the transcript has been released to the public.

15.4. Typically with a solid-state recorder and recording, the actual recorder and its memory cannot be easily separated. Therefore, the entire CVR is considered "The Original Recording" and appropriate security measures and protection must be observed.

15.5. For solid-state recorders, the CVR, with its solid-state memory, shall not be released until the investigation is completed or otherwise authorized by the Directors of the Offices of Research and Engineering and Aviation Safety on a case-by-case basis.

15.6. Prior to returning an original CVR recording medium, the CVR specialist must obtain specific permission from the Directors of the Offices of Research and Engineering and Aviation Safety. The CVR specialist shall notify the IIC of its return.

15.7. Copies of the CVR recording shall not be released to the owner, or any other party without the approval of the Directors of the Offices of Research and Engineering and Aviation Safety.

Appendix C – ARC Member Voting Responses and Ballots

The ARC believes this report fulfills the tasks in the mission of the Charter. The recommendations contained in this report were robustly debated and every voting member of the ARC voted on the report electronically prior to submission to the FAA.

Members were permitted to concur as written, concur with comment/exception, or not concur. All submissions are included in this report.

The ARC completed its deliberations and report drafting on August 21, 2025. Voting ballots were distributed to the voting ARC members on August 21, 2025. The tallies are as follows:

11 – Concur as Written
3 – Concur with Comment/Exception
0 – Non-Concur
0 – Ballot Not Submitted

Members	Organization	Vote
Chad Kirk	AIA Aerospace	Concur as written
Jeff Mee	Air Line Pilots Association	Concur with comment/exception
Robert Burke	Airbus	Concur as written
Ric Peri	Aircraft Electronics Association	Concur as written
Murray Huling	Aircraft Owners and Pilots Association	Concur as written
Robert Ireland	Airlines for America	Concur as written
Casey York	Boeing	Concur as written
Lauren Beyer	Cargo Air	Concur as written
Kipp Lau	Coalition of Airline Pilots Associations	Concur with comment/exception
Jens Hennig	General Aviation Manufacturers Association	Concur as written
George Paul	National Air Carrier Association	Concur as written
Doug Carr	National Business Aviation Association	Concur as written
Erik Strickland	Regional Airline Association	Concur with comment/exception
Chris Hill	Vertical Aviation International	Concur as written

Investigative Technologies Aviation
Rulemaking Committee

ARC Member Ballot

1. Your Name *

Chad Kirk

2. What member organization are you representing? *

Aerospace Industries Association

3. Statement of Concurrence/ Non-Concurrence: *

- (selected) I concur with the report as written.
- I concur with the report with comment or exception.
- No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

4. If concurring with comment or exception, please provide comment or exception in the text box below. You may submit a separate paper on company/organization letterhead to becca.fribush@reg-group.com if additional space is required (may not exceed 2 pages in length).

5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Chad E. Kirk

Investigative Technologies Aviation Rulemaking Committee

ARC Member Ballot

1. Your Name *

Jeffrey Mee

2. What member organization are you representing? *

ALPA

3. Statement of Concurrence/ Non-Concurrence: *

- ○ I concur with the report as written.
- ● I concur with the report with comment or exception.
- ○ No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

4. If concurring with comment or exception, please provide comment or exception in the text box below. You may submit a separate paper on company/organization letterhead to becca.fribush@reg-group.com if additional space is required (may not exceed 2 pages in length).

Comments provided via email.

5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Jeffrey Mee

AIR LINE PILOTS ASSOCIATION, INTERNATIONAL
7950 Jones Branch Drive, Suite 400S | McLean, VA 22102 | 703-689-2270 | 888-FLY-ALPA

August 29, 2025

Subject: Investigative Technologies Aviation Rulemaking Committee (ARC)

IN SUPPORT WITH EXCEPTION AND COMMENTS

Dear Sir or Madam:

The Air Line Pilots Association (ALPA), representing the safety interests of more than 80,000 professional airline pilots flying for 43 airlines in the United States and Canada, has reviewed the ARC final report.

The Investigative Technologies ARC was tasked by the FAA to review and provide comments to a variety of taskings, including recorders and flightdeck technologies. While ALPA agrees with the intent and majority of the extensive report, there are subject areas which ALPA does not agree with in the report.

<u>ALPA does not support the installation of Cockpit Image Recorders (CIR)</u>

Cameras in the flight deck can be misleading and compelling, meaning that it is difficult to realize when information is misinterpreted.

There is no reliable way to protect the image recordings from misuse, particularly outside of the United States. Previous instances of leaked recordings of the Cockpit Voice Recorder (CVR) underscore that. There are still significant reports of criminalization of accidents around the globe where CVR recordings are used in court proceedings. The objective of accident investigation is to prevent further occurrences, not to attribute blame. The use of these recordings for any other reason erodes trust in our safety systems. The sensational nature of these images places them in high demand and risk being released to the public and misinterpretation of events.

While CIRs *may* give some indication of flight crew workload and stress, they are not wide-ranging and only show physical manifestations which may be attributed to stress. Considerable training and investigative research by other means would be required to determine flight crew workload and stress. Money could be better spent on modern digital avionics which provide means of tracking a greater number of flight deck parameters and displays. (FCMIR). Furthermore, research has shown that there is a negative effect on performance and decision-making when people know they are being recorded and evaluated.

<u>Data Protections must be ensured</u>

ALPA supports the use of innovative technologies for flight recorders; however, the data must be protected and only used as intended. Measures must be in place to ensure that flight data is used for accident investigation or non-punitive, aggregate flight data monitoring programs only. The misuse of data jeopardizes the safety benefits earned through these programs by establishing years of trust.

ALPA provided opposing comments to the FAA NPRM requiring 25-hour CVRs for newly manufactured aircraft, citing similar data protection concerns.

Technologies that stream data from the aircraft must consider the infrastructure required with its corresponding costs, data protection, and security issues. Where the data will be stored, who has access, and how it can be validated for accuracy are all important aspects of any system to be evaluated beyond the engineering ability to stream data. Such solutions have not been developed, tested, or certified. Any technology transmitting data, particularly using cellular data or satellite data transfers must be evaluated for interference, ensuring the absolute protection of data, and consider future demands on bandwidth.

ALPA supports Flight Data Monitoring and Safety Management Systems

Flight Operational Quality Assurance (FOQA) or more broadly Flight Data Monitoring (FDM) has been proven to be a proactive safety measure. ALPA is in support of its promotion and integration into Safety Management Systems (SMS) provided the data protections and non-punitive aspects of FOQA are maintained.

ALPA appreciates the opportunity to participate in the ARC and comment.

Sincerely,

Captain Jeff Mee
Chair, Accident Analysis and Prevention
Air Line Pilots Association, International

Investigative Technologies Aviation
Rulemaking Committee

ARC Member Ballot

1. Your Name *

Robert Burke

2. What member organization are you representing? *

Airbus

3. Statement of Concurrence/ Non-Concurrence: *

- (●) I concur with the report as written.
- ( ) I concur with the report with comment or exception.
- ( ) No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

4. If concurring with comment or exception, please provide comment or exception in the text box below. You may submit a separate paper on company/organization letterhead to becca.fribush@reg-group.com if additional space is required (may not exceed 2 pages in length).

5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Robert H Burke

Investigative Technologies Aviation
Rulemaking Committee

ARC Member Ballot

1. Your Name *

Ric Peri

2. What member organization are you representing? *

Aircraft Electronics Association

3. Statement of Concurrence/ Non-Concurrence: *

- (●) I concur with the report as written.
- ( ) I concur with the report with comment or exception.
- ( ) No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

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5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Richard Peri

Investigative Technologies Aviation Rulemaking Committee

ARC Member Ballot

1. Your Name *

Murray Huling

2. What member organization are you representing? *

AOPA

3. Statement of Concurrence/ Non-Concurrence: *

- (selected) I concur with the report as written.
- I concur with the report with comment or exception.
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5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Murray D. Huling

Investigative Technologies Aviation
Rulemaking Committee

ARC Member Ballot

1. Your Name *

Robert Ireland

2. What member organization are you representing? *

Airlines for America

3. Statement of Concurrence/ Non-Concurrence: *

- (selected) I concur with the report as written.
- ( ) I concur with the report with comment or exception.
- ( ) No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

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5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Robert Ireland

Investigative Technologies Aviation
Rulemaking Committee

ARC Member Ballot

1. Your Name *

Casey York

2. What member organization are you representing? *

The Boeing Company

3. Statement of Concurrence/ Non-Concurrence: *

- (selected) I concur with the report as written.
- I concur with the report with comment or exception.
- No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

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5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Casey York

Investigative Technologies Aviation
Rulemaking Committee

ARC Member Ballot

1. Your Name *

Lauren Beyer

2. What member organization are you representing? *

Cargo Airline Association

3. Statement of Concurrence/ Non-Concurrence: *

- (selected) I concur with the report as written.
- I concur with the report with comment or exception.
- No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

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5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Lauren Beyer

Investigative Technologies Aviation
Rulemaking Committee

ARC Member Ballot

1. Your Name *

Stuart "Kipp" Lau

2. What member organization are you representing? *

Coalition of Airline Pilots Association (CAPA)

3. Statement of Concurrence/ Non-Concurrence: *

- ○ I concur with the report as written.
- ● I concur with the report with comment or exception.
- ○ No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

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The Coalition of Airline Pilots Association (CAPA) representing over 30,000 professional airline pilots across passenger and all-cargo pilot unions in the United States was honored to have the opportunity to participate in the Federal Aviation Administration's Investigative Technologies Aviation Rulemaking Committee (ARC).

Following nearly two years of participating in the ARC process, CAPA formally agrees with the recommendations in the Investigative Technologies ARC final report with the following caveats (comments):

Acknowledging the advancement and growth of the safety culture in the aviation industry over the past two decades, CAPA does not support the FAA advancing a regulatory requirement for the installation of Cockpit Image Recorders/Airborne Image Recorders (CIR/AIR) as a regulatory mandate for Part 121 or Part 135 operators in the United States.

Furthermore, CAPA does support strengthening data protection regulations and the protection of personal identifiable information for all pilots operating in the United States and around the world.

5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Stuart Lau

Investigative Technologies Aviation
Rulemaking Committee

ARC Member Ballot

1. Your Name *

Jens Hennig

2. What member organization are you representing? *

General Aviation Manufacturers Association

3. Statement of Concurrence/ Non-Concurrence: *

- (●) I concur with the report as written.
- ( ) I concur with the report with comment or exception.
- ( ) No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

4. If concurring with comment or exception, please provide comment or exception in the text box below. You may submit a separate paper on company/organization letterhead to becca.fribush@reg-group.com if additional space is required (may not exceed 2 pages in length).

5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Jens C Hennig

Investigative Technologies Aviation
Rulemaking Committee

ARC Member Ballot

1. Your Name *

George paul

2. What member organization are you representing? *

National Air Carrier Assc (NACA)

3. Statement of Concurrence/ Non-Concurrence: *

- (selected) I concur with the report as written.
- ( ) I concur with the report with comment or exception.
- ( ) No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

4. If concurring with comment or exception, please provide comment or exception in the text box below. You may submit a separate paper on company/organization letterhead to becca.fribush@reg-group.com if additional space is required (may not exceed 2 pages in length).

5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

George Raymond Paul

Investigative Technologies Aviation
Rulemaking Committee

ARC Member Ballot

1. Your Name *

Doug Carr

2. What member organization are you representing? *

NBAA

3. Statement of Concurrence/ Non-Concurrence: *

- (●) I concur with the report as written.
- ( ) I concur with the report with comment or exception.
- ( ) No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

4. If concurring with comment or exception, please provide comment or exception in the text box below. You may submit a separate paper on company/organization letterhead to becca.fribush@reg-group.com if additional space is required (may not exceed 2 pages in length).

5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Douglas Carr

Investigative Technologies Aviation
Rulemaking Committee

ARC Member Ballot

1. Your Name *

Erik Strickland

2. What member organization are you representing? *

Regional Airline Association

3. Statement of Concurrence/ Non-Concurrence: *

- ○ I concur with the report as written.
- ● I concur with the report with comment or exception.
- ○ No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

4. If concurring with comment or exception, please provide comment or exception in the text box below. You may submit a separate paper on company/organization letterhead to becca.fribush@reg-group.com if additional space is required (may not exceed 2 pages in length).

Throughout this report, there are highlights to how important it is to take in the unique characteristics of each fleet when it comes to implementing changes to avionics and technology. The US fleet is not homogenous, and each operation has unique requirements.

As an example, it's important to highlight language from Recommendation HRT 7.b related to retrofit requirements of 25-hour CVRs. Not every airframe is the same and the costs of a retrofit are drastically different than the costs associated with a forward fit option. The requirement necessitates more than just an equipment swap and has the potential to require rewiring and the installation of additional technology in the cockpit.

It is important to modernize and update when possible, but the true cost and benefits of these changes need to be taken into account.

5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Erik Strickland

Investigative Technologies Aviation
Rulemaking Committee

ARC Member Ballot

1. Your Name *

Chris Hill

2. What member organization are you representing? *

Vertical Aviation International

3. Statement of Concurrence/ Non-Concurrence: *

- [x] I concur with the report as written.
- [ ] I concur with the report with comment or exception.
- [ ] No, I do not concur with the report **(Letter of Dissent must be provided - must be on company letterhead and may not exceed 2 pages in length)**

4. If concurring with comment or exception, please provide comment or exception in the text box below. You may submit a separate paper on company/organization letterhead to becca.fribush@reg-group.com if additional space is required (may not exceed 2 pages in length).

5. As a voting member and full participant of the Investigative Technologies Aviation Rulemaking Committee, I hereby acknowledge that I have reviewed the Final Report and recommendations. My response is recorded on this ballot. Below is my virtual signature. (Please type your full name) *

Christopher B. Hill