U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., S.W.
Washington, DC 20591

March 29, 2022

The Honorable Maria Cantwell
Chair, Committee on Commerce,
Science, and Transportation
United States Senate
Washington, DC 20510

Dear Chair Cantwell:

Enclosed is the Federal Aviation Administration (FAA) report to Congress on the Assessment of Aircraft Data Access and Retrieval Systems, as required by Section 305 of the FAA Reauthorization Act of 2018 (Public Law 115-254).

Section 305 directs the FAA to assess aircraft data access and retrieval systems for Title 14 *Code of Federal Regulations* part 121 air carrier aircraft that operators use in extended overwater operations to (1) determine whether the systems provide improved access and retrieval of aircraft data and cockpit voice recordings in the event of an aircraft accident; and (2) assess the cost-effectiveness of each system. In response to Section 305, this report includes an assessment of the following:

- Underwater Locator Devices;
- Low Frequency-Underwater Locator Devices;
- Automatic Deployable Flight Recorders;
- Emergency Locator Transmitters;
- Triggered Transmission of Flight Data;
- Automatic Distress Tracking; and
- Devices that help protect against disabling flight recorder systems.

In addition, the Appendix of this report responds to questions from Chairman David Price and Ranking Member Mario Diaz-Balart, House of Representatives Committee on Appropriations, Subcommittee on Transportation, Housing and Urban Development, and Related Agencies, concerning aircraft data access and retrieval systems.

The FAA affirms that current U.S. regulations and existing investigative technologies provide effective access and retrieval of aircraft data and cockpit voice recordings in a cost effective manner. In all of the 303 NTSB accident reports that the FAA reviewed in its analysis – covering the period from January 1, 2008 through December 31, 2019 – investigators recovered both the flight data recorder (FDR) and cockpit voice recorder (CVR). This data supports the

conclusion that the current aviation safety structure is effective, and the additional cost of requiring a Low Frequency-Underwater Locator Device (LF-ULD) is not justified.

We have sent identical letters to Chair DeFazio, Ranking Member Wicker, and Ranking Member Graves.

Sincerely,

Steve Dickson
Administrator

Enclosure

U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., S.W.
Washington, DC 20591

March 29, 2022

The Honorable Peter A. DeFazio
Chair, Committee on Transportation
and Infrastructure
House of Representatives
Washington, DC 20515

Dear Chair DeFazio:

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800 Independence Ave., S.W.
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March 29, 2022

The Honorable Roger Wicker
Ranking Member, Committee on Commerce,
Science, and Transportation
United States Senate
Washington, DC 20510

Dear Senator Wicker:

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**Federal Aviation
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800 Independence Ave., S.W.
Washington, DC 20591

March 29, 2022

The Honorable Sam Graves
Ranking Member, Committee on Transportation
and Infrastructure
House of Representatives
Washington, DC 20515

Dear Ranking Member Graves:

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Administrator

Enclosure

FAA
Aviation safety

REPORT TO CONGRESS:

Aircraft Data Access and Retrieval Systems

FAA Reauthorization Act of 2018 (Pub. L. No. 115-254) – Section 305

Executive Summary

The Federal Aviation Administration (FAA) submits this report in accordance with Section 305 of the FAA Reauthorization Act of 2018[1] (the Act). Section 305 requires the FAA to assess aircraft data access and retrieval systems for part 121 air carrier aircraft used in extended overwater operations. This report includes the results of the FAA's assessment of those systems, specifically with regard to the cost-effectiveness of each system and to whether the systems provide improved access to and retrieval of aircraft data and cockpit voice recordings in the event of an aircraft accident.

The FAA reviewed Underwater Locator Devices (ULD), Low Frequency-Underwater Locator Devices (LF-ULD), Automatic Deployable Flight Recorders (ADFR), Emergency Locator Transmitters (ELT), Triggered Transmission of Flight Data (TTFD), and Autonomous Distress Tracking (ADT) to assess whether they improve detection and retrieval of flight data. In addition, the FAA considered potential protections against the disabling of flight recorder systems.

While LF ULDs can be useful, their usefulness has been diminished with the advent of space-based automatic dependent surveillance–broadcast (SBA), which became operational in 2019. SBA now provides four-dimensional (4D) position information (latitude, longitude, altitude, and time) for automatic dependent surveillance–broadcast (ADS B) equipped aircraft nearly everywhere in the world. As of April 2020, Aireon had ADS-B sensors deployed on 66 operational Iridium satellites.

ADS-B position information is accurate. A survey of the 313.041 billion ADS-B reports detected in the United States from April 1, 2020, through March 31, 2021, indicates that 99.9% had a position accuracy of within 0.2 nautical miles (NM) or better, while over 96.7% had position accuracy of within 0.1 NM or better. Commercial operators, air navigation service providers, regulators, and search and rescue organizations can use SBA data, free of charge, to plot the last 15 minutes of a flight.

From January 1, 2008, through December 31, 2019, the NTSB investigated 320 aircraft accidents. For these 320 accidents, 303 brief reports from the NTSB's Aviation Accident and Incident Data System were available for review. In all 303 accidents, investigators recovered the FDR and CVR. This data supports the conclusion that the current aviation safety structure is effective, and the additional cost of requiring an LF-ULD is not justified.

The FAA neither conducted a cost-benefit analysis nor assessed costs the government has expended in searching for downed aircraft, survivors, or location and retrieval of recorders or data. While SAR teams aid accident investigators by providing location information, SAR missions work independently of accident investigation teams and as such will respond regardless of type of aircraft and aircraft data retrieval systems. Each "Analysis and Cost Considerations" section of this report, however, includes the FAA's

[1] Pub. L. No. 115-254

general assessment of the costs of designing and implementing the new capabilities that are the subject of this report.

In this report, the FAA affirms that existing technologies provide effective access to and retrieval of aircraft data and cockpit voice recordings in a cost-effective manner. Additionally, the FAA has created a regulatory framework that is flexible enough to allow aircraft manufacturers, avionics manufacturers, and aircraft operators to invent, design, certify, and install new and novel systems. This regulatory framework also encourages the improvement of current investigative systems and the development of new and novel ways to improve aviation safety.

This report also provides a response to an April 21, 2020, letter from U.S. Representatives David Price and Mario Diaz-Balart to the FAA Administrator requesting information related to this legislative mandate. This response can be found in the Appendix.

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Introduction

The FAA provides this report in response to the legislative requirements established in Section 305 of the Act.

Legislative Mandate

Section 305 of the Act requires:

> *(a) ASSESSMENT.—Not later than 90 days after the date of enactment of this Act, the Administrator shall initiate an assessment of aircraft data access and retrieval systems for part 121 air carrier aircraft that are used in extended overwater operations to—*
>
> > *(1) determine if the systems provide improved access and retrieval of aircraft data and cockpit voice recordings in the event of an aircraft accident; and*
> >
> > *(2) assess the cost-effectiveness of each system assessed.*
>
> *(b) SYSTEMS TO BE EXAMINED.—The systems to be examined under this section shall include, at a minimum—*
>
> > *(1) various methods for improving detection and retrieval of flight data, including—*
> >
> > > *(A) low-frequency underwater locating devices; and*
> > >
> > > *(B) extended battery life for underwater locating devices;*
> >
> > *(2) automatic deployable flight recorders;*
> >
> > *(3) emergency locator transmitters;*
> >
> > *(4) triggered transmission of flight data and other satellite-based solutions;*
> >
> > *(5) distress-mode tracking; and*
> >
> > *(6) protections against disabling flight recorder systems.*
>
> *(c) REPORT.—Not later than one year after the date of initiation of the assessment, the Administrator shall submit to the appropriate committees of Congress a report on the results of the assessment.*
>
> *(d) PART 121 AIR CARRIER DEFINED.—In this section, the term "part 121 air carrier" means an air carrier with authority to conduct operations under part 121 of title 14, Code of Federal Regulations.*

Background

The findings outlined in this report include information on aircraft operated under part 121 that are used in extended overwater operations.[2] In the interest of brevity, this report refers to these aircraft as "aircraft operated under part 121." Based on data in the FAA WEBOPSS database, as of January 14, 2020, 5,240 aircraft meet this definition and form the basis for this review. To support this report, the FAA reviewed several sources, including the *Code of Federal Regulations*, the *Federal Register*, the National

[2] With respect to aircraft other than helicopters, Title 14 of the Code of Federal Regulations (14 CFR) § 1.1 defines extended overwater operations as "an operation over water at a horizontal distance of more than 50 nautical miles from the nearest shoreline."

Transportation Safety Board (NTSB) aviation accident database, the International Civil Aviation Organization (ICAO) databases, FAA databases, and other relevant sources.

Response to Section 305 Requirements

The FAA assessed the six categories of systems listed in Table 1, which provides a comparison of these systems' attributes. For each category, this report includes a description, analysis and cost considerations, and overall assessment.

Table 1 - Data Access and Retrieval Systems for Aircraft Operated Under Part 121

Category	Technology	Aids Search and Rescue (SAR)	Aids Data Recovery	Required by FAA Regulation
1	ULD	No	Yes	Yes [3]
	LF-ULD	No	Yes	No
2	ADFR	If ELT equipped	Yes	No
3	ELT - Fixed Type	Yes	Yes	No
	ELT - Portable Types	Yes	Yes	Yes [4]
4	TTFD	If location data is provided	Yes	No
5	ADT	Yes	Yes	No
6	Protections against disabling flight recorder systems	No	Yes	No

1. Underwater Locator Devices

1.1 Description of ULD and LF-ULD

There are two types of underwater locator devices for aircraft operated under part 121: ULD and LF-ULD. Both types of devices are designed to survive and function in the event of a water landing. They are designed to aid accident investigation teams in finding the wreckage. While these devices are distinct from one another, each is considered an underwater locating device.

Each aircraft operated under part 121 is required to have both a flight data recorder (FDR) and cockpit voice recorder (CVR) that are separate from one another; use of a combined FDR and CVR, otherwise known as a "combi" recorder, alone does not satisfy the requirement to have two recorders mounted in different locations on the aircraft. A ULD must be mounted on or near each of these separately placed recorders.

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[3] 14 CFR §§ 121.344(k) and 121.359(c)(2)(iii).
[4] See 14 CFR § 121.339(b).

ULD begin transmitting within four hours after immersion in water. The ULD broadcasts at 37.5 kilohertz (kHz) and requires specialized detection equipment that may take days to deploy to a crash site. The underwater detectable range of a ULD is 1.0 to 1.9 nautical miles (NM), depending on environmental conditions. This report refers to such ULDs as short-range ULDs.

The LF-ULD operates at 8.8 kHz and is mounted to the airframe. LF-ULDs also begin transmitting within four hours after immersion in water. The underwater detectable range of a LF-ULD is 7.0 to 12.0 NM. Sonar equipment that United States Coast Guard and naval vessels, submarines, and sonar buoys often use can detect LF-ULDs. Accident investigation teams searching for wreckage frequently benefit from such equipment. The purpose of the LF-ULD is to aid investigation authorities in finding the aircraft wreckage site, which can be detected if the sonar receiver is within 7 to 12 NM of the device.

Once the wreckage site is located, accident investigation teams search the area for the short-range ULD to locate the FDR, CVR, or combi in the wreckage.

When the FAA first mandated ULDs[5], Technical Standard Order (TSO) TSO-C121, Underwater Locating Devices (Acoustic) (Self Powered) and TSO-C121a required each ULD to have a battery that would allow the ULD to operate for a minimum of 30 days. Under the most recent change to TSO-C121b published in February 2012, the ULD and its battery must operate for at least 90 days. The publication of TSO-C121b also rescinded TSO-C121 and TSO-C121a, ensuring that new units would not be manufactured in accordance with the outdated standards. Because compliance with the applicable TSO requires ULD batteries to be replaced every five to seven years, attrition has resulted in most ULDs containing batteries that operate for 90 days.

1.2 Analysis and Cost Considerations of ULD and LF-ULD

The FAA requires ULDs on aircraft that operate under part 121; LF-ULDs are not required. While LF-ULDs can be useful, their usefulness has been diminished with the advent of space-based automatic dependent surveillance–broadcast (SBA), which became operational in 2019. Managed by the U.S.-based company Aireon, SBA now provides four-dimensional (4D) position information (latitude, longitude, altitude, and time) for automatic dependent surveillance–broadcast (ADS-B) equipped aircraft nearly everywhere in the world. As of April 2020, Aireon had ADS-B sensors deployed on 66 operational Iridium satellites.[6] SBA is able to provide aircraft position information to an air navigation service provider within two seconds of receiving a transmitted message.[7]

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[5] The requirements for underwater locating devices are codified at §§ 25.1459(d)(3), 121.343(k) and 121.344(k) for flight data recorders and at §§ 25.1457(g)(3) and 121.359(c)(2)(iii) for cockpit voice recorders.

[6] Aireon, Iridium Constellation (last visited Mar. 3, 2021), *available at* https://aireon.com/resources/overview-materials/iridium-constellation/.

[7] Soe Han Tha, “McLean Company Aireon Now Providing Real-Time Space-Based Airline Tracking,” Washington Business Journal (Apr. 3, 2019), *available at* https://aireon.com/tag/washington-business-journal/.

ADS-B position information is accurate. A survey of the 313.041 billion ADS-B reports detected in the United States from April 1, 2020, through March 31, 2021, indicates that 99.9% had a position accuracy of within 0.2 NM or better, while over 96.7% had position accuracy of within 0.1 NM or better.

Using SBA every second to track aircraft position within 200 miles of the United States using ground-based systems and every two to eight seconds anywhere else in the world mitigates the need for an LF-ULD. SBA provides precise tracking and trajectory data for all ADS-B-equipped aircraft all the way to the surface (land or water). Commercial operators, air navigation service providers, regulators, and search and rescue organizations can use SBA data, including latitude, longitude, altitude, and time, free of charge, to plot the last 15 minutes of a flight.[8]

1.3 Assessment of ULD and LF-ULD

When used in conjunction with other investigative and surveillance technologies such as ADS-B and SBA, ULDs provide a cost-effective and improved means to retrieve aircraft flight data and cockpit voice recorders from aircraft operated under part 121. LF-ULDs are useful in providing access to and retrieval of aircraft flight data and cockpit voice recordings, but the FAA has not concluded that installation of them is cost beneficial. From January 1, 2008, through December 31, 2019, the NTSB investigated 320 aircraft accidents. For these 320 accidents, 303 brief reports from the NTSB's Aviation Accident and Incident Data System were available for review. In all 303 accidents, investigators recovered the FDR and CVR[9]. This data supports the conclusion that the current aviation safety structure is effective, and the additional cost of requiring an LF-ULD is not justified.

2. Automatic Deployable Flight Recorders (ADFR)

2.1 Description of ADFR

An ADFR is a device that detaches from an aircraft and contains either an FDR, a CVR, or a combi. A manufacturer can design an ADFR to detach if it senses deformation of the aircraft, shortly before impacting the ground or when submerged in water. An ADFR also can be designed to include an ELT to help locate survivors at the accident site and a distress-tracking capability, which broadcasts position information if it senses a distress condition before an aircraft crashes.

If an aircraft crashes in water, an ADFR is designed to detach from the aircraft and float to the surface. An ADFR floating on the water's surface transmitting position information is easier and cheaper to recover than one submerged with wreckage in deep water. Accident investigators also can use transmitted position data from the ADFR to assist in locating wreckage that has settled to the bottom of the ocean.

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[8] AireonALERT, *available at* https://aireonalert.com/faq.html.
[9] Based on a review of the 303 NTSB accident reports that were available from January 1, 2008 - December 31, 2019

2.2 Analysis and Cost Considerations of ADFR

ADFR systems are a new means to provide access to and retrieval of aircraft data and cockpit voice recordings on aircraft operated under part 121. While the FAA expects this equipment to be successful, the FAA has not evaluated the reliability of deployable recording devices. The FAA has, however, evaluated the reliability of fixed devices (FDRs and CVRs).

Unlike fixed recorders, an ADFR includes a deployment mechanism that must be designed to prevent accidental or unintentional deployment. Under 14 CFR § 91.15, no pilot in command of a civil aircraft may allow any object to be dropped from that aircraft in flight in a manner that creates a hazard to persons or property. Section 91.15 states, however, that it does not prohibit the dropping of any object if reasonable precautions exist to avoid injury or damage to persons or property. As such, the FAA expects the probability of an unintended ADFR deployment to be very low. An ADFR also would need to meet many FDR and CVR standards to ensure it would survive a crash if it did not deploy as intended.

Similar to fixed recorder systems, ADFRs require maintenance, including periodic inspections and battery replacement. Additional expenses might exist for periodic maintenance and testing of the deployment system or its replacement.

An ADFR does not replace the function that other recorders installed on the aircraft serve. Each required recorder must be recovered for accident investigation teams to have all data related to the accident in the event one of the recorders is damaged, or the data on one of the recorders is corrupted. Investigators also recover the fixed recorders to ensure sensitive crash information is not left for salvage by unauthorized entities. Additionally, accident investigators recover as much accident wreckage as possible to inform their investigation.

The availability of robust primary and secondary radar systems and their precise tracking capability limits the need for an ADFR for flights within the United States. Furthermore, for aircraft that are required to use ADS-B, the advent of SBA diminishes the need for an ADFR. To date, no aircraft manufacturer has requested that the FAA certify an ADFR device.

2.3 Assessment of ADFR

The FAA acknowledges that ADFR systems could provide improved access to and retrieval of aircraft data and cockpit voice recordings systems on aircraft used for operations under part 121, but notes that significant effort and cost will exist for ensuring ADFRs meet the safety and performance standards of fixed recorders as well as deployable features. While manufacturers have accomplished many developments, more work would need to occur to ensure ADFRs are as reliable as fixed recorders and are safe to use. In the alternative, ADS-B systems provide increased position accuracy of crashed aircraft, mitigating the need for a deployable device. Finally, as discussed earlier, the installation of an ADFR would not fulfill all the functions of fixed recorders.

3. Electronic Locator Transmitters (ELT)

3.1 Description of ELT

An ELT is a device that search and rescue (SAR) teams use to find survivors and the aircraft accident site. The device is designed to transmit a radio signal between 406.0 and 406.1 MHz that a constellation of satellites can detect anywhere in the world. An international organization known as Cospas-Sarsat manages the satellite constellation, infrastructure, and supporting standards.

Updates to Cospas-Sarsat standards now enable an ELT device to transmit GPS position information as well. While Cospas-Sarsat can determine the position of a non-GPS equipped ELT using multilateration, GPS information has proven useful for improving the determination of the location of a transmitting ELT.

Aircraft contain two main types of ELTs. The first type, automatic fixed, is mounted to the airframe. This type of ELT can be activated manually but is designed to work automatically when it detects an excess of normal g-force, such as when an aircraft crashes.[10] ELTs might be activated unintentionally by a hard landing or not activated if the airplane crashes but makes a soft landing, which is a landing that does not exceed the g-force threshold of the ELT sensor. The second type of ELT is a survival type, which is portable rather than being hard-mounted to an aircraft. Such ELTs are stowed in the aircraft or attached to a life raft and are intended to aid aircraft accident survivors who have moved out of an aircraft and into a raft or moved away from the wreckage for safety.

When activated, an ELT also transmits a 121.5 MHz signal to help SAR teams determine the signal location. Because aircraft this report addresses currently are required to carry survival type emergency locator transmitters, this report considered requiring fixed ELTs on such aircraft.

3.2 Analysis and Cost Considerations of ELT

In a water landing, a fixed ELT system must be designed to survive the initial impact and to begin transmitting before water shorts out the ELT system or before the antenna is submerged because the signal cannot transmit past the surface of the water. An ELT likely will continue to function after crashing in water, however, if it is part of a protected ADFR, as discussed above.

To determine whether fixed ELTs are effective on large commercial aircraft for the purpose of accessing or retrieving aircraft flight data or cockpit voice recordings, the FAA reviewed 303 accident reports in the NTSB accident database involving U.S. aircraft that operated under part 121 from January 1, 2008, through December 31, 2019. None of

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[10] According to EUROCAE Minimum Operational Performance Standard For Aircraft Emergency Locator Transmitters 406 MHz, December, 2018, Section 4.5.8, g-forces required to trigger an ELT are +1 g forward, -1 g aft, +2 g's left -2 g's right, +3 g's up or -3 g's down.

these accident reports indicated an ELT aided in locating a crash.[11] This data indicates the cost to purchase, install, and maintain a fixed ELT is not justified.

3.3 Assessment of ELT

The FAA concludes that fixed ELTs add additional expenses for operators but do not improve access to or retrieval of aircraft flight data or cockpit voice recordings on aircraft operated under part 121.

4. Triggered Transmission of Flight Data (TTFD)

4.1 Description of TTFD

The purpose of TTFD is to provide improved access and retrieval of aircraft data and cockpit voice recordings by transmitting information from aircraft FDR and CVR recordings to the ground before an aircraft crashes. Providing this data could be invaluable if the aircraft is lost at sea and the flight recorders are never found.

There are two modes of operation for the transmission of flight data:

- *Triggered* – upon detecting a distress condition, an aircraft begins transmitting real-time data, as well as data from up to 25 hours prior to the distress condition, to a secure server on the ground via satellites.
- *Continuous* – flight data is transmitted continuously, in real-time, to a secure server on the ground via satellites, even when the aircraft is not in a distress condition.

Data transmitted to the ground can include FDR recordings, CVR recordings, data link information (such as Controller Pilot Data Link Communications), and other information an operator chooses to transmit.

As defined by ICAO, an aircraft is in a distress condition when it is in a state that, if the aircraft behavior event is left uncorrected, can result in an accident.[12] The minimum distress conditions that can trigger the transmission of data are:

- Unusual attitude: excessive roll, pitch, or yaw and their corresponding rates of change
- Unusual speed: excessive vertical speed, stall condition, low airspeed, over-speed, or other speed conditions
- Collision with terrain: including a high rate of closure to terrain or inappropriate altitude for the current position
- Total loss of thrust or propulsion on all engines.

The minimum conditions that define when a distress condition exists are deliberately broad in nature and intended to allow the aircraft manufacturer to determine specific situations that would constitute a distress condition.

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[11] This review also included aircraft operated under part 129.
[12] ICAO Annex 6 Part I, Appendix 9 section 2.2. (Tenth Edition, July 2016)

The speed at which data can be transmitted and the amount of data that can be transmitted from aircraft has increased in recent years. As an example, the SwiftBroadband system marketed by Inmarsat is able to transmit as much as 432 kilobits per second (kbps) per channel, and an aircraft may have several channels installed. The Iridium Certus Broadband satellite network can provide speeds from 176 kbps to 1.4 megabits per second from the aircraft to the ground.

An estimated seven kbps would be required to stream FDR data, while Cockpit Area Microphone data would require 64 kbps. Three channels of flightcrew audio are estimated to require an additional 48 kbps and data link messages would require 0.2 kbps for an estimated total of 119.2≅ kbps.[13] In the event of a distress condition, a triggered system would stream real-time data, and any remaining bandwidth would be used to send data stored in memory prior to detection of the distress condition.

Operators that seek to transmit flight recorder data using these systems need to consider the security of the information when broadcast and when handled by a communications link provider and while stored on the ground. Any information broadcast to a satellite would need to be encrypted because it also is broadcast to anyone able to see the aircraft. Aircraft operators sending data over satellite communications networks should understand how potentially sensitive data is managed, processed, and provided to the receiving repository. Data stored on a server on the ground would need to be safeguarded from being released to unauthorized persons and from being altered or corrupted. Security of CVR data is of particular importance because the recording may contain sensitive information such as the last sounds of the aircraft and the voices of crewmembers.

4.2 Analysis and Cost Considerations of TTFD

The ability to stream limited amounts of FDR and CVR data is possible via a relatively new technology that is expanding as data download speeds increase and the cost of these services decreases. Triggered or continuously transmitting flight data systems potentially provide improved access to and retrieval of aircraft information on aircraft operated under part 121. This technology offers a means to augment current fixed FDR and CVR systems by providing alternative access to flight data and cockpit voice data.

Several factors affect the ability of an aircraft to stream flight recorder data to a secure server on the ground. Table 2 lists examples of these factors.

Table 2: Examples of Factors That Impact Flight Recorder Data Availability

Factors Related to the Aircraft	Factors External to the Aircraft
• Volume of the data.	• Radio frequency of the satellite link used (i.e. moisture in the air might

[13] Data based on estimates in Table 22 of ARINC DRAFT Report 681 (July 2020), *available at* https://www.aviation-ia.com/products/draft-5-arinc-project-paper-681.

• Speed at which the data is generated and processed. • Type of data bus used on the aircraft.[14]	adversely affect some types of satellite links). • Ability of the satellite link to remain connected while the aircraft maneuvers.

The actual time available to transmit data to the ground is another factor worthy of consideration when reviewing download speeds. In a worst-case scenario, an aircraft could break up in flight, leaving the equipment intact and powered only long enough to transmit a few seconds or less of data. Other factors such as the aircraft antenna in relation to the satellite constellation will affect the system's ability to reliably lock on, track, and transmit data from the aircraft to a ground station. These types of systems are relatively new and show promise in transmitting FDR and CVR data off of aircraft; however, they are not as reliable as fixed recorders. As such, while these systems show promise, they will not be considered as a replacement to a fixed recorder system until they can be shown to be at least as reliable.

Satellite-based communications providers have indicated they will not charge operators to download flight recorder data if the data is sent following a triggering event. While the cost for satellite communications has decreased, costs exist with purchasing and maintaining the TTFD equipment that must be certified and installed. Many aircraft operated under part 121 have the equipment and satellite subscriptions, but a TTFD system that would 1) link recorder data (such as that found in an FDR or CVR) to the Satellite Communication (SATCOM) system, and 2) monitor the aircraft for triggering events (if it is a triggered system) still would need to be developed, tested, certified, and installed. Operators that seek to transmit data to a server on the ground when a triggering event occurs likely would need a separate, standalone system, as FDR and CVR are designed only to receive and store data, not transmit it. As such, operators would encounter a cost for the design, testing, and installation of TTFD systems on aircraft operated under part 121. The FAA does not have standards for any such systems but is working with its international partners to develop them.

Having data gathered and stored on a server on the ground does not diminish the importance of recovering all recording devices installed on the aircraft and ensuring that accident investigation teams have all data related to the accident in the event a recorder is damaged, or the data is found to be unavailable. Investigators also should recover recorders to ensure that no unauthorized entity obtains sensitive accident information. It also is likely that electronically transmitted data may not reach the ground and could be lost due to unusual aircraft attitudes, in-flight breakups, or loss of power.

The goal of the timely recovery of flight data is to deliver accident data to investigators in a quick, accurate, secure, and efficient manner. The FAA is working to write procedures that certificate holders operating under part 121 (and third-party contractors responsible

[14] An aircraft data bus is a digital communications system in which avionics line replaceable units (LRU) or subsystems may transmit and receive data.

for gathering, storing, and securing data) can follow to ensure accident data is available to investigators in a quick and secure manner.

Triggered and continuous transmission of flight data may complement fixed FDR and CVR systems and provide accident investigation teams with recorder data in a timely manner. The cost-effectiveness of these TTFD systems will depend on several factors (noted in Table 2), including those related to each particular aircraft, such as the type of data bus used or whether the system is continuous or a triggered type. The effectiveness of TTFD systems also depends on factors external to the aircraft, such as the transmission frequency (which is affected by moisture in the air) or the ability of a satellite to maintain a signal lock as the aircraft experiences routine or emergency movement or maneuvers.

The FAA does not prohibit TTFD if used in addition to current FDR and CVR systems as long as it does not interfere with the safe operation of the aircraft or the requirements to record and protect the data.

4.3 Assessment of TTFD

The FAA affirms that triggered transmission or the continuous transmission of flight data provides improved access to the flight recorder and cockpit voice data. The Appendix provides additional discussion of TTFD.

Satellite-based solutions used as a supplement to current fixed FDR or CVR could become another valuable tool for accident investigators, allowing them to begin determining the cause of an accident while the fixed recorders are being recovered.

A satellite subscription is required for TTFD, and the use of satellite solutions could incur additional costs. Additionally, a system would need to be added to stream flight data to the SATCOM link and, in the case of triggered systems, detect distress events. TTFD's cost-effectiveness is questionable, as the retrieval of every FDR and CVR was successful in the accidents reviewed.

5. Autonomous Distress Tracking (ADT)

5.1 Description of ADT

ADT sometimes referred to as distress tracking or DT, is part of a large ICAO initiative known as the global aeronautical distress safety system (GADSS). The GADSS concept was developed to harmonize aircraft tracking throughout the world and covers normal aircraft tracking, distress tracking, and post-flight localization and recovery information management and procedures. The purpose of ADT is to have aircraft manually or autonomously broadcast aircraft position prior to an accident in order to aid SAR and accident investigation teams in locating a crash site.

As the ADT system would need to operate for the duration of the flight even if the aircraft lost all power, the FAA determined the ADT would require a battery. Because a battery is a fire risk, the cost of the ADT system and the fire risk associated with the ADT battery must be weighed against the risk that the ADS-B system might fail.

5.2 Analysis and Cost Considerations of ADT

Any new system will have design, certification, installation, and continuing airworthiness costs. The FAA has determined that within the United States, systems and procedures such as ADS-B and SBA serve the same purpose as ADT without burdening part 121 operators with the additional requirements or related expenses associated with ADT. The benefits of ADS-B and SBA are discussed in detail in section 1.2 above.

5.3 Assessment of ADT

ADT systems could provide improved access to and retrieval of aircraft data and cockpit voice recordings systems on aircraft operated under part 121. However, current systems used under applicable U.S. regulations, when used in conjunction with other investigative technologies and surveillance systems, provide a cost-effective means to retrieve FDR and CVR data without the additional burden of equipment and maintenance that ADT would require. The Appendix includes further discussion of ADT.

6. Protections Against Disabling Flight Recorder Systems

6.1 Description of Protections Against Disabling Flight Recorder Systems

There are two ways to protect a recorder system from being manually disabled in flight: 1) isolating the system so it cannot be accessed, and 2) removing the option to turn the device off.

Most flight recorder systems are on a circuit that has an accessible Circuit Breaker (CB) in the cockpit. The purpose of the CB is to disable any system on the circuit, including the flight recording systems. CBs are required to prevent further damage to a device, should it short out internally. The flightcrew can pull the CB manually or, if the CB senses an electrical surge, the CB automatically disconnects electrical power to the system. CBs also electrically isolate systems to prevent a short from causing an electrical fire that could damage other parts of the aircraft.

The FAA researched the feasibility of moving flight recorder system CBs to a location less accessible to the flightcrew and found that NTSB-recommended design changes would not provide a quantifiable safety benefit that would justify a new design standard.[15]

6.2 Analysis and Cost Considerations for Protections Against Disabling Flight Recorder Systems

Improving protections that prevent flightcrews from disabling flight recorder systems during flight could improve access to and retrieval of aircraft data and cockpit voice recordings systems of aircraft operated under part 121. However, removing a flightcrew's ability to disconnect some systems could hamper the crew's ability to prevent or inhibit a fire or other electrical issue in one of the recording systems. The

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[15] See FAA response dated February 15, 2017 to NTSB Recommendations A-15-05 and A-15-06. The NTSB issued these safety recommendations as a result of the Emerging Flight Data and Locator Technology Forum on October 7, 2014.

need to protect and save flight data by removing access to the CB must be weighed against the risk of harm to passengers, flightcrew, and aircraft. Any redesign of a circuit system will incur additional design and certification costs.

In a review of all NTSB accident reports from January 1, 2008, through December 31, 2019, the FAA did not find any case where flightcrew tampered with or turned off flight recorder circuit breakers.

6.3 Assessment of Protections Against Disabling Flight Recorder Systems

Removing flightcrew access from certain functions affecting flight recorder systems might improve access to and retrieval of aircraft data and cockpit voice recordings systems of aircraft operated under part 121. However, the FAA cannot justify requiring certificate holders that conduct operations under part 121 to modify their aircraft when it has not identified a tangible safety benefit and when no reports exist regarding flightcrew tampering with recorder circuit breakers.

Conclusion

This report fulfills the requirements of Section 305 of the Act. The FAA has completed its assessments of ULD, LF-ULD, ADFR, ELT, TTFD, and ADT as they relate to possible improved detection of location and retrieval of flight data. The FAA also considered options to help protect against disabling flight recorder systems. Additionally, the FAA examined other aspects of data access and retrieval after receiving a request for further information from U.S. Representatives David Price and Mario Diaz-Balart; the Appendix of this report provides information in furtherance of the FAA's response to that request.

The FAA continues to engage with industry to improve aviation safety. Industry continues to develop new technologies that show promise in improving access to and retrieval of aircraft data and cockpit voice recordings from aircraft involved in accidents. The FAA concludes that existing investigative technologies provide effective access to and retrieval of aircraft data and cockpit voice recordings in a cost-effective manner.

Appendix – Response to Congressional Request for Information

This Appendix includes information the Federal Aviation Administration (FAA) agreed to provide in response to an April 21, 2020, letter from U.S. Representatives David Price and Mario Diaz-Balart. While some of the following information is beyond the scope of the legislative mandate in Section 305 of the FAA Reauthorization Act of 2018 (Pub. L. No. 115-254), the FAA provides this information pursuant to its correspondence with Representatives Price and Diaz-Balart.

1) ***Status of the FAA's actions to implement the International Civil Aviation Organization (ICAO) requirement for a second backup Flight Data Recorder (FDR)/Cockpit Voice Recorder (CVR) capability.***

FAA Response

At this time, the FAA is not considering revising its regulations concerning FDRs and CVRs to align them with ICAO Annex 6 Part I section 6.3.5.5.2. The FAA analyzed 320 aircraft accidents that the U.S National Transportation Safety Board (NTSB) investigated from January 1, 2008, through December 31, 2019. For these 320 accidents, 303 brief reports from the NTSB's Aviation Accident and Incident Data System were available for review. In all 303 accidents with brief reports, investigators recovered the FDR and CVR. This data supports the conclusion that the current recorder installation requirements in the United States are effective. As a result of the safety analysis, the FAA does not plan to update its regulations to adhere to the ICAO standard and has filed a difference with ICAO.

2) ***Status of the FAA's actions to address NTSB Recommendations A-15-01 and A-15-03.***

FAA Response

A-15-01[16]*:* The FAA is working with ICAO and our international partners to better define Global Aviation Distress and Safety System (GADSS) by defining the specifications for the Location of an Aircraft in Distress Repository (LADR). The FAA, acting as the secretary is helping to write an ICAO Document describing a means to show compliance with GADSS. The FAA has begun research to determine the quality and effectiveness of Space Based ADS-B (SBA) to meet the intent of the ICAO distress-tracking requirement. The results of this research will inform the FAA if and how this technology can be leveraged to improve safety through the use of existing systems to better pinpoint the location of a crash. An application for rulemaking to update the rules related to the GADSS was submitted for FY 2020 but was not chosen due to competing priorities. The application has been resubmitted for consideration in FY21. The FAA will inform

[16] NTSB Recommendation A-15-01 recommends that manufacturers install a tamper resistant system that would assist in determining the location of where a flight terminates.

the NTSB if rulemaking is approved to consider mandating GADSS compliant technologies in the US.

A-15-03[17]: The FAA is working with our international partners to better define Timely Recovery of Flight Data, (TRFD), and how this data can be securely collected, stored, and provided to accident investigation authorities. Information gathered as a member of the ARINC AEEC GAT working group will form the basis for a Minimum Operational Performance Specification, (MOPS), in EUROCAE Document ED-112B. The results of this research will inform the FAA how this technology can be leveraged to improve safety.

The FAA reviewed every accident in the NTSB database from Jan 01, 2008 - Dec 31, 2019. This review found that in every case the recorder was recovered. Based on this assessment, the FAA cannot provide an economic justification requiring operators install a third recording mechanism and considers this recommendation closed. While the FAA considers this recommendation closed, it will continue to work to improve the value of technologies surrounding TRFD. The FAA is working with our international partners to refine the requirements of TRFD systems (both deployable recorders as well as those that transmit safety data off aircraft via a satellite link). Furthermore, the FAA will be publishing an Advisory Circular to aid operators wishing to install TRFD systems once the MOPS for these systems have been defined in EUROCAE Document ED-112.

3) An assessment of how alternative technologies, such as those referenced in Section 305 and others, can complement traditional fixed flight data and cockpit voice recorders that are required on commercial part 121 air carriers to a) maximize the ability to identify the location of a downed aircraft, b) achieve more timely recovery of survivors, and c) ensure that at least one set of flight data and cockpit voice recording data will be recovered without underwater retrieval.

FAA Response

Technologies that aid in locating downed aircraft and accident survivors, and that aid in recovering flight data, have improved over the last ten years. The FAA has continued to be involved in the development of these technologies.

Distress tracking systems can better pinpoint the location of a downed aircraft. Use of such systems also improves rescue times for survivors and positively affects the timely recovery of flight data.

Automatic dependent surveillance–broadcast (ADS-B) and surveillance–broadcast (SBA) complement current aviation safety systems by using data that already exists and does not require new equipment or hardware. ADS-B and SBA provide end-of-flight locations with an accuracy of better than 0.2 miles nearly 99.9% of the time and an accuracy of 0.1 miles 96.7% of the time,

[17] NTSB Recommendation A-15-03 recommends that all newly manufactured aircraft operated under part 121 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 parameters and the means of recovery should not require underwater retrieval. Furthermore, the recommendation states that the data from a triggering event until the end of the flight, and for as long a time period as possible before the triggering event, should be captured.

anywhere in the world. This precise location information also aids accident investigation teams in finding survivors and recovering FDRs and CVRs.

Precise position data from the ADS-B system is also useful in the event an Emergency Locator Transmitter fails to operate after an accident.

In addition to the technologies mentioned above, the FAA also has improved options for the recovery of flight data by part 121 carriers in several ways, including through Automatic Deployable Flight Recorders (ADFR) and TTFD. The FAA has participated in developing Standards and Recommended Practices at ICAO for ADFR and TTFD and is currently working with our international partners to update the internationally recognized Minimum Operational Performance Specifications (MOPS) for ADFRs and TTFD in EUROCAE document ED-112B.

4) ***Updates that can be made to the Federal Aviation Regulations to encourage and ease the voluntary installation of complementary safety technologies that can work together with traditional fixed black boxes to meet the NTSB's recommendations to improve the timely localization of survivors and the recovery of FDR/CVR data without underwater recovery.***

FAA Response

The FAA does not currently have rulemaking projects concerning aircraft data access and retrieval systems. To support the installation and use of these new and novel systems, the FAA is participating in the following activities:

- ICAO efforts to draft documents outlining global aeronautical distress safety system (GADSS) concepts that include aircraft tracking, autonomous distress tracking, post-flight localization, and recovery and GADSS information management and procedures[18].
- EUROCAE Working Group 118 to update the EUROCAE document ED-112, which will improve the standards for FDRs, CVRs, and ADFRs, and will add standards for TTFD and Flight Crew - Machine Interface Recorder systems. The FAA expects this MOPS to form the basis for a new Technical Standard Order in the United States, which will apply to equipment manufacturers as they demonstrate that these systems meet a minimum performance specification.

5) ***If a cost-benefit analysis is conducted, it is requested that the report include all costs expended by government assets (both civilian and military) in the search for a downed aircraft, survivors, and the location and full retrieval of the flight data recorder and cockpit voice recorder data.***

FAA Response

The FAA neither conducted a cost-benefit analysis nor assessed costs the government has expended in searching for downed aircraft, survivors, or location and retrieval of recorders or data. While SAR teams aid accident investigators by providing location information, SAR missions work independently of accident

[18] Global Aeronautical Distress & Safety System- Concept of Operations, Version 6.0 (July 6, 2017) *available at* https://www.icao.int/safety/globaltracking/Documents/GADSS.

investigation teams and as such will respond regardless of type of aircraft and aircraft data retrieval systems. Each “Analysis and Cost Considerations” section of this report, however, includes the FAA’s general assessment of the costs of designing and implementing the new capabilities that are the subject of this report.