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CVR Data Unavailable: A Study of 52 Airline Accidents & Incidents 2014–2022

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ABSTRACT

Concern has grown in recent years over the number of airline accidents and incidents for which investigators were unable to retrieve cockpit voice recorder (CVR) data. In 2018, a National Transportation Safety Board (NTSB) report listed 34 events in which "pertinent CVR data were overwritten" and called for the introduction of CVRs with a 25-hour recording duration. In 2021, the European Union introduced regulations that require new transport aircraft weighing over 27,000 kg to be equipped with 25-hour CVRs. Building on a previous study (Cookson, 2019), this paper presents a protocol for examining safety events for which CVR data were unavailable, and examines 52 safety events that occurred between 2014 and 2022. In a majority of cases, the pertinent CVR data were overwritten because there was no prompt deactivation of the CVR after the safety event and/or a delay in notifying the investigating agency. The paper highlights a lack of standardization in the way that CVR data are presented in accident and incident reports, and a worrying subset of cases with a minimal description of CVR data or no mention at all.

Keywords: Accident investigation, Airline accident, Cockpit voice recorder, Regulations, Safety

INTRODUCTION

On the morning of 7th March, 2016, a KLM Cityhopper regional jet was scheduled to fly from Basel-Mulhouse in eastern France to Amsterdam. Visibility was 10 kilometers when the KLM aircraft entered runway 33 at 10:09:02. A SkyWork Airlines commuter airliner had just started its take-off roll in the opposite direction on the same runway. The SkyWork crew became aware of the KLM jet when they were about 300 meters apart. At 10:09:10, air traffic control radioed, "KLM1986 maintain position, stop". At 10:09:14, the SkyWork crew announced they had taken off, "We are airborne, we are airborne, don't worry". As their aircraft overflew the KLM jet, the SkyWork crew estimated there was at least 10 meters between the two planes.

Fortunately no one was injured or died at Basel Mulhouse, and no aircraft were damaged. It was a serious incident, but it was not a catastrophe. The investigation by the French Bureau Enquêtes-Accidents (BEA) concluded that the KLM crew had incorrectly understood an ATC instruction, and also found that time pressure and distraction in the KLM cockpit may have contributed to the incident. The BEA report states that the investigation was impeded because cockpit voice recorder (CVR) data from the KLM aircraft

were not available. Confusion between the flight crew and maintenance personnel about how to preserve CVR data resulted in the data being overwritten (BEA, 2018).

Cockpit Voice Recorders

The CVR is a device that records speech and sounds on the flight deck while an aircraft's electrical system is switched on. As the CVR records it continually overwrites old data, so that a 2-hour device retains the last two hours of audio information. In the event of a crash, the loss of electrical power means that the CVR is automatically deactivated. Therefore audio information prior to the accident is preserved. For accidents or incidents in which the electrical system continues to function, pilots are required to deactivate the CVR promptly once the aircraft is on the ground by removing circuit breakers so that pertinent audio information is preserved.

The importance of CVR devices for aviation safety is summed up in this extract from a National Transportation Safety Board (NTSB) report:

> "CVRs are among the most valuable tools used for accident investigation. Information such as flight crew verbalizations of intentions and coordination, as well as pilots' awareness of the state of the aircraft and cockpit information, allows investigators to more comprehensively assess accident/incident factors. These factors include flight crews' procedural compliance, distraction, decision-making, workload, fatigue, and situational awareness. Ultimately, CVRs provide unique information with which the NTSB can conduct more thorough investigations to more effectively target safety recommendations." (NTSB, 2018, p. 1)

Aircraft have been hitherto equipped with 30-minute or 2-hour CVRs, or no device at all. The recording duration depends on factors such as the type of flight operations, the number of passenger seats in the aircraft, the number of pilots, and the date of the certificate of airworthiness (CofA). The limited recording duration of CVRs means that audio information of a safety event is vulnerable to being overwritten. This may happen if:

- the remaining flight time after the event exceeds the recording duration;
- the CVR is not promptly deactivated when the aircraft is on the ground after the safety event;
- there is a delay in notifying the investigating agency about the safety event and further flight operations take place in the interim.

CVR Regulations

The Basel-Mulhouse incident was one of many safety events in which investigators were hindered because pertinent CVR data could not be retrieved (AAIB, 2010; BEA, 2012; NTSB, 2018). In response to this problem, accident investigation agencies have repeatedly called for long-duration CVRs to be introduced (AAIS, 2021; NTSB, 2018; TAIC, 2022). Accordingly, the European Union (EU) and the International Civil Aviation Organization (ICAO)

recently introduced new requirements for CVRs. These state that newly-manufactured transport aircraft having a maximum certificated take-off mass (MCTOM) of over 27,000 kg must be equipped with 25-hour CVRs, with 2-hour recorders on smaller aircraft. The European Union regulations relate to aircraft whose CofA is issued on or after 1st January 2021, and the ICAO requirements are from 1st January 2022 (EU, 2015; ICAO, 2018).

About This Paper

The aims of this paper are twofold: (1) to draw attention to a significant number of safety events for which relevant CVR data could not be retrieved; and (2) to gain a greater understanding of why CVR data were not available for these events. This is an expanded version of a previous study (Cookson, 2019) which looked at 15 accidents and incidents for which CVR data were unavailable. The current study uses a modified methodology to examine 52 safety events.

Regarding terminology, this paper uses the phrase "safety event" as an umbrella term to denote accidents, serious incidents and incidents. The NTSB uses the same phrase (e.g. in NTSB, 2018), while other investigating agencies – such as the TSB in Canada – use the word "occurrence" in a similar way.

Privacy issues, such as concerns that CVR recordings might be leaked or used to monitor pilot performance, are not addressed in this paper.

METHOD

Safety Events

A literature review of official investigation reports and SKYbrary bulletins identified 60 accidents and incidents between 2013 and 2022 for which CVR data were not available. Since the focus of this study is on passenger-carrying civil aviation, 4 cargo flights and 1 repositioning flight were excluded from the analysis because they had no passengers. A further 3 events were excluded because they involved partial loss of pertinent CVR data: high-quality audio channels were overwritten but lower-quality channels preserved data of the events.

The remaining 52 safety events involved airline passenger-carrying flights and occurred between 2014 and 2022. For each event the following data were recorded: date, location, event description, flight phase[1], operator, investigating agency, aircraft type and maximum take-off weight (MTOW).

The events involved 45 airlines and took place in 26 countries in Africa, Asia, Australasia, Europe, North America and South America. The countries that had the most events were France (6 events), the USA (5), Australia (4) and the UK (4). As for the most frequently occurring airlines, Ryanair and KLM were both involved in 4 events, while Emirates and Qantas featured in 3 events.

A range of wide-body, narrow-body and regional planes played a role in the events, with one quarter of the events involving more than one aircraft.

[1]ICAO flight phase definitions were used (ICAO, 2013).

The most featured aircraft were from the Airbus A320 (12 events) and Boeing 737 (11) families of narrow-body jets. The distribution of flight phases was marked, with the most common phases being approach (21 events), en route (13) and take-off (10).

Research Questions

Based on the findings of the previous study (Cookson, 2019), the 52 safety events were coded using the following research questions:

RQ1: What information does the report provide about the CVR?

A. Recording duration
B. Audio quality
C. Reason for CVR data not being available
D. How missing CVR data could have helped the investigation
E. None

RQ2: What was the recording duration of the CVR?

A. 30 minutes
B. 2 hours
C. 25 hours
D. No CVR
E. Unknown

RQ3: Why were CVR data of the safety event not available?

A. Excessive flight time (the remaining flight time after the safety event exceeded the CVR recording duration)
B. No prompt deactivation (the CVR was not promptly deactivated when the aircraft was on the ground after the safety event)
C. Notification delay (there was a delay in notifying the investigating agency about the safety event)
D. Other reason
E. Unknown

RESULTS

Table 1 gives a summary of the results. The following sections provide more details for each research question, illustrated by references to some of the events. Appendix 1 contains a summary of the events that are mentioned.

RQ1: CVR Information in Accident & Incident Reports

The first research question addresses the types of information that investigation reports provide about CVRs. Some reports contain extensive information while others have little or none.

Exactly half of the reports contain information about both the recording duration and the reason for CVR data not being available. Furthermore, 7 of these reports also indicate how the missing CVR data could have helped the investigation. For example, in the case of the previously mentioned Basel-Mulhouse incident (event #12), the report states: "The absence of CVR data at the time of the event did not allow the investigation to determine the extent to which the crew [of the KLM jet] could have been distracted by the presence of a third person in the cockpit." (BEA, 2018, p. 10)

Table 1. Summary of results for RQ1-3.

Research Questions	Number of Events
RQ1: CVR information in report	
A. Recording duration	27
B. Audio quality	1
C. Reason for CVR data not being available	39
D. How missing CVR data could have helped the investigation	15
E. None	9
RQ2: CVR recording duration	
A. 30 minutes	5
B. 2 hours	23
C. 25 hours	0
D. No CVR	0
E. Unknown	24
RQ3: Reason for CVR data not being available[2]	
A. Excessive flight time	8
B. No prompt deactivation	17
C. Notification delay	16
D. Other reason	1
E. Unknown	11

By contrast, other reports provide minimal CVR information. For 9 events, there is no mention of recording duration and the only information is the reason for CVR data not being available. The report of a serious incident in Kathmandu, Nepal, involving a runway excursion after a rejected take-off (event #34) simply states: "CPT [Captain] informs the company that he did not pull out the CB [circuit breaker] after the incident and before he left the aircraft." (AAIB, 2019, p. 6)

The reports for 9 other events provide no CVR information at all. These events include 2 accidents and 4 serious incidents. In one of the accidents a flight attendant was seriously injured when an American Airlines MD-83 encountered turbulence during cruise (event #25). In the other accident a Qantas A330-200 experienced a hydraulic system malfunction, diversion and emergency evacuation in which a passenger was seriously injured (event #47).

RQ2: CVR Recording Duration

The second research question concerns the recording duration of the CVR devices involved in the safety events. As indicated in Table 1, either a 30-minute or 2-hour CVR featured in 28 events. The recording duration is unknown for the other 24 events because the reports did not include this information. The 5 events with a 30-minute CVR featured aircraft ranging in size from a DHC-8-100 regional turboprop to a Boeing B747-300 wide-body jet that was manufactured in the 1980s. One of the events involved

[2]One event (#3) was coded as B and C because the report stated both reasons. For the other events only one reason is stated in the reports, but it is reasonable to assume there was no prompt CVR deactivation *and* a notification delay in multiple cases.

a runway incursion, take-off without ATC clearance and rejected take-off by an Air Georgian CRJ-200 regional jet in Toronto, Canada (event #42). The jet subsequently completed its scheduled flight to Columbus, Ohio, even though the report states that under FAA and ICAO regulations it should have been equipped with a 2-hour CVR for this international flight to the USA (TSB, 2021).

A range of aircraft were also involved in the 23 events that featured a 2-hour CVR: 9 regional aircraft, 9 narrow-body jets, 11 wide-body jets and 1 helicopter. One of the events was the fuel exhaustion crash of an Avro 146-RJ85 in Antioquia, Colombia (event #21). This accident was widely reported because the aircraft was carrying Brazil's Chapecoense football squad and there were 71 fatalities. The investigation found that the CVR stopped recording during the flight, 1 hour 45 minutes *before* the crash. The report states: "It was not possible to determine the reasons why the recorder stopped working early" (GRIAA, 2017, p. 40).

RQ3: Reasons for CVR Data Not Being Available

The third research question concerns the reason why CVR data of the safety events were not available to investigators. Table 1 shows that in 8 cases the remaining flight time after the safety event exceeded the CVR recording duration. In 5 of these cases, a wide-body jet experienced a safety event during the en route phase. For instance, an Emirates Airbus A380 encountered severe turbulence about 13 hours into a flight from Auckland to Dubai, which left 1 person seriously injured (event #40). The aircraft had a 2-hour CVR, and the audio record of the event was overwritten as the flight continued to its destination.

In 32 events, CVR data were not available because the device was not promptly deactivated when the aircraft was on the ground after the safety event and/or there was a delay in notifying the investigating agency. Half of these events involved low cost carriers (9 events), regional airlines (5) or charter airlines (2). After the events, 3 of the airlines filed for bankruptcy: Air Georgian, Darwin Airline and VLM Airlines. In the VLM Airlines incident, a Fokker 50 regional turboprop experienced a near mid-air collision with a private plane near Friedrichshafen, Germany (event #13). The Fokker 50 commander wanted to preserve the CVR for a possible investigation but was overruled by a member of the airline's technical division. The report states: "As a consequence, the recordings of the conversations between the flight crew members as well as the sounds emitted by the TCAS [traffic collision avoidance system] on the flight deck were not available, resulting in the loss of a detailed evidence base" (STSB, 2018, p. 24).

Table 1 includes 1 event coded as "Other reason". This was an ATR72 turboprop aircraft that experienced a landing gear failure and diversion during approach at Nelson, New Zealand (event #27). After landing the circuit breakers were removed in order to preserve the CVR data. However, maintenance personnel then reset the circuit breakers and reapplied power to the aircraft, resulting in some of the pertinent data being overwritten (TAIC, 2019).

Finally, for 11 events the reason that CVR data were not available is unknown. These events include 4 accidents and 4 serious incidents. In one of the accidents, a Delta Air Lines Airbus A330-300 experienced an engine fire and diversion shortly after taking off from Atlanta, USA (event #33). The airplane landed back at Atlanta about 26 minutes after take-off, but the pertinent CVR data were overwritten. The accident report simply states: "Unfortunately, the Cockpit Voice Recorder (CVR) was overwritten after the event and any discussion between crew members about the engine fire was unrecoverable" (NTSB, 2022, p.1). The event was coded as "Unknown" because the accident report gives no reason for data being unavailable. However, the NTSB online investigation docket includes a short CVR report which suggests that the CVR was powered up again for more than 2 hours when the aircraft was on the ground after the event.

CONCLUSION

This study makes two contributions to the literature of aviation safety. Firstly, it has identified 52 safety events involving passenger-carrying flights during the period 2014–2022 for which CVR data were not available. These events included 10 accidents and 25 serious incidents. They occurred worldwide, and were not limited to any particular countries or airlines. It is possible that the actual number of such events was considerably greater as the literature review was not exhaustive. Secondly, the paper presents a protocol for analysing safety events for which CVR were unavailable. This protocol is designed to probe: (1) the information provided about CVRs in investigation reports; (2) the recording duration of CVRs involved in the events; and (3) the reasons why CVR data could not be retrieved.

Pertinent CVR data were not available in 8 of the cases because the remaining flight time exceeded the recording duration (e.g. event #40). These cases involved 6 wide-body jets, 1 narrow-body jet and 1 regional turboprop. If the aircraft had hypothetically been subject to the new CVR requirements, 7 would have carried 25-hour CVRs and the regional airliner would have had a 2-hour CVR (because its MTOW was less than 27,000 kg). In each case the recording duration would have been sufficient to retain data of the safety event *if* the CVR was promptly deactivated when the aircraft was on the ground.

CVR data were not available for a majority (32) of the cases because there was no prompt deactivation of the device and/or there was a delay in notifying the investigating agency. If the new requirements had been in force, they may have been effective in cases where the CVR was removed before the aircraft made further flights. For example, a 25-hour device would probably have retained data from the runway excursion and rejected take-off in Kathmandu (event #34). In other cases the new requirements would not have made any difference. After a near mid-air collision near Friedrichshafen, the VLM Airlines Fokker 50 continued to make flights without the CVR being secured (event #13); neither a 2-hour nor a 25-hour device would have retained data for this event. In many cases there is not enough information to judge the effectiveness of the new requirements.

In summary, long-duration CVRs are likely to reduce the number of cases of data being lost due to excessive flight time. However, they will probably have limited impact on the larger number of cases featuring no prompt deactivation and/or notification delay. This includes cases such as the Basel-Mulhouse runway incursion described at the start of the paper (event #12). It is difficult to predict the impact of the new requirements because of the lack of standardization in the way that reports present CVR information, and the significant number of reports with minimal information. In 9 cases there is no CVR information, even though such data would have been valuable to investigators if available. For instance, in the case of the American Airlines MD-83 that encountered turbulence, CVR data may have included cabin announcements about turbulence and seatbelts (event #25). For the Qantas A330-200 that experienced a hydraulic system malfunction and diversion, CVR data could have resolved the conflicting accounts of the captain and customer service manager about the emergency evacuation (event #47).

By learning from past accidents and incidents, it is possible to prevent future tragedies. Investigation reports play a vital role in the process, providing an invaluable record of safety lessons that have been learned. In order to improve the quality of this record, it is strongly recommended that future reports include the following CVR metadata:

1. Duration – the start time, end time and length of the CVR recording;
2. Quality – an assessment of the quality of the audio recording (see the rating scale in NTSB, 2016);
3. Missing data – details of any data pertinent to the investigation that were not retained by the CVR and the reason for data not being retained.

APPENDIX 1

Table 2 below has key information about safety events referred to in this paper.

Table 2. Information for safety events cited in the paper.

Event	Date	Location	Event Description	RQ1	RQ2	RQ3
#3	29 Jan 2015	Dordogne, France	Incident: EGPWS alert & missed approach	CD	E	BC
#12	7 Mar 2016	Basel-Mulhouse, France	Serious incident: runway incursion	ACD	B	B
#13	21 Apr 2016	Near Friedrichshafen, Germany	Serious incident: near mid-air collision	CD	E	B
#21	29 Nov 2016	La Union, Antioquia, Colombia	Accident: fuel exhaustion crash during approach	AD	B	E
#25	9 Mar 2017	Dallas-Fort Worth, USA	Accident: turbulence during cruise	E	E	E
#27	9 Apr 2017	Nelson, NZ	Incident: landing gear failure & diversion	ABC	B	D

Continued

Table 2. Continued.

Event	Date	Location	Event Description	RQ1	RQ2	RQ3
#33	18 Apr 2018	Atlanta, USA	Accident: engine fire & diversion	D	B	E
#34	19 Apr 2018	Kathmandu, Nepal	Serious incident: runway excursion after rejected take-off	C	E	B
#40	10 Jul 2019	Bay of Bengal, India	Accident: severe turbulence during cruise	AC	B	A
#42	9 Aug 2019	Toronto, Canada	Occurrence: runway incursion, take-off without ATC clearance & rejected take-off	ACD	A	B
#47	15 Dec 2019	Near Sydney, Australia	Accident: hydraulic system malfunction, diversion & emergency evacuation	E	E	E

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[3]There are two typos in the paper: the date of event #5 in Table 1 should be "29 April 2014"; and the answer to RQ2 for event #14 in Table 3 should be "No".

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