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Science For Peace: Small Discoveries, Big Changes

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Introduction

The Black Box Flight Recorder is a simple concept that has revolutionised safety in the aviation industry. The Black Box records both flight data and cockpit audio. When an accident or incident occurs, the Black Box's data can be recovered to determine the probable cause.

Despite being a simple invention, its data has assisted accident and incident investigators to potentially prevent countless air crashes. The information it has recorded has helped calm multiple international crises and improved public confidence in safety in the aviation industry. It has provided an authoritative voice which can be universally accepted across international and cultural boundaries.

Although being known as a 'Black' Box, these devices are painted 'international orange' in order to assist recovery parties in locating them in aircraft wreckage.

The first modern flight recorder was invented in 1954 by Australian scientist Dr David Warren (*Figure 1*) (National Museum of Australia, 2024). After helping investigate several aircraft which mysteriously disintegrated mid-air, he conceived a device that could continuously record flight information which could then be recovered after a crash.

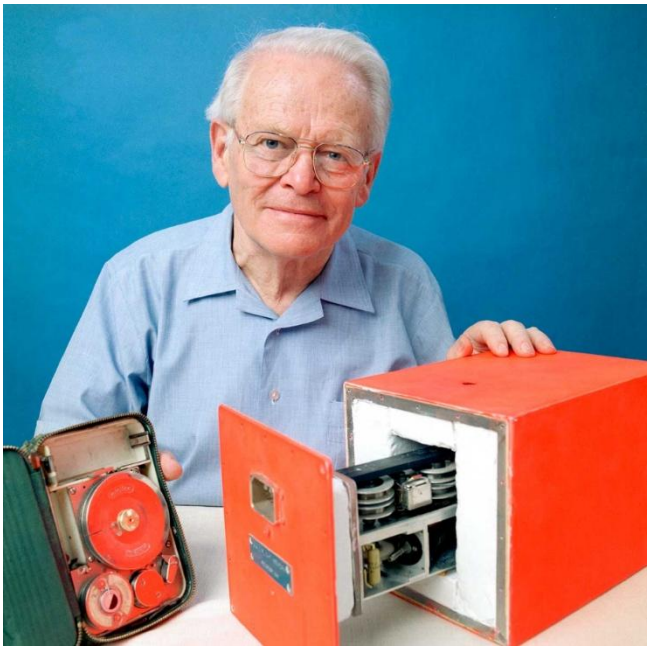

Figure 1: Dr David Warren in 2004 with the first prototype flight data recorder (National Muesum of Australia, 2024).

By 1967, most countries around the world made Black Box devices mandatory in aircraft (Stefan, 2022).

How the Black Box Works

The modern Black Box consists of two separate recording devices, the Flight Data Recorder (FDR), and the Cockpit Voice Recorder (CVR).

As the name suggests, the FDR obtains and records information about the flight. The raw data is first obtained by sensors placed all over the aircraft. An onboard Air Data Computer (ADC) receives the raw data and calculates important information (e.g. altitude, airspeed, heading) before sending the information to the Flight Data Acquisition Unit (FDAU). The FDAU then converts the information into electronic signals before it is stored in the FDR.

The CVR is a machine that records audio coming from the cockpit. These include conversations from the pilots, alarms, and radio transmissions.

The earliest analog CVRs were based on the German dictaphone, the *Minifon*, which at the time was an engineering marvel. The CVR's design was simple. By utilising magnetised wire it would continuously record the last 30 minutes of audio. It worked by pulling a thin steel wire across a recording head which magnetised each point of the wire differently depending on the polarity and intensity of the surrounding audio. Later, wire recordings were replaced with magnetic tape which used a similar concept to magnetise layers of chemicals.

Unfortunately, these analog devices could get damaged quite easily despite being contained in crash proof boxes. In the 1980s, the solution for this problem was to digitise the audio and store it in a solid-state memory board (ebray.net, n.d.).

Examples of Global Influence

Before the invention of the Black Box, accident and incident investigators could only piece together what happened through eyewitness reports and by examining the crash scene. This process could not always pinpoint the cause of an error, which could lead to more crashes if no changes were implemented. The Black Box Flight Recorder records crucial information which can help investigators ensure that similar events never happen again.

There have been multiple scenarios where the recorded information disproved initial beliefs about the cause of an accident which threatened peace in the local instance. The following are some examples.

1961 Ndola Transair Sweden Douglas DC-6 Crash

In the early hours of 18 September 1961, a Douglas DC-6 crashed in Northern Rhodesia (modern day Zambia) killing all onboard. This included the UN

Secretary-General Dag Hammarskjöld who was en route to negotiate a ceasefire regarding the Congo Crisis. Many nations believed that this was an assassination by either the United States of America or the Soviet Union, both of which were nations who could profit from the destabilisation of east Africa (Lynch, 2016). International tensions began to threaten the authority of the United Nations. Without the United Nations acting as a neutral body, the world would lose its impartial negotiator. However, the audio recordings from the CVR led Rhodesian investigators to attribute the crash to pilot error (Mishra, 2024). This led to the calming of global tensions keeping the fragile peace between the Cold War superpowers.

American Airlines Flight 587

On 12 November 2001, American Airlines Flight 587 crashed into a residential area of New York City killing 265 people. As this occurred soon after the 9/11 terrorist attacks, initial fears led to the belief that this was another terrorist attack. These fears were intensified when an Al-Qaeda follower informed Canadian officials that the crash of Flight 587 was the result of a shoe bombing conducted by Al-Qaeda. Investigators managed to prove with information from the FDR, that the first officer's actions led to the crash (tailstrike.com, n.d.). This finding calmed the public's fears about future terrorist attacks and helped restore its trust in the aviation industry.

Polish Air Force 101

On 10 April 2010, a Polish Air Force aircraft crashed near the Russian city of Smolensk killing all 96 people onboard. The victims included the President of Poland and high-ranking military officials. This immediately sparked concerns that the aircraft had been shot down by Russian forces. The Black Box's data helped both Russian and Polish investigators determine that the cause of the crash was due to increased stress on the pilots. VIPs in the aircraft pressured the pilots to land despite unsafe conditions (tailstrike.com, n.d.).

Limitations of the Black Box

A limitation of this device is the fact it must be retrieved for its data to be used. There are cases when the Black Box was never found (e.g. Malaysian Airlines Flight 370 which disappeared on 8 March 2014 (Falcus, 2026)). When the Black Box's information is not available to investigators, conspiracy theories tend to replace data which creates misinformation as the public demands answers. Currently, underwater locator beacons (ULB) which activate upon contact with water are attached to these recording

devices. However, the ULB does not guarantee recovery due to its battery only lasting for at least 30 days and that its range is limited (skybrary.aero, n.d.).

Another limitation is the devices' data capacity. Presently, the FDR and the CVR can only accumulate a certain amount of information before having to record over existing data. In 2021, in response to this matter, the International Civil Aviation Organisation (ICAO) has mandated that all CVRs must be able to contain a minimum of 25 hours of data (skybrary.aero, n.d.).

The storage unit can also be damaged after crashes, potentially destroying crucial information within (e.g. in 2025 the FDR of Angara Airlines Flight 2311 was destroyed by a post-crash fire (Mak-iac.org, 2025)). This is despite rigorous engineering standards and tests.

All of these limitations can inhibit the outcome of investigations, which could potentially result in investigators misidentifying or being unable to determine the cause of an accident.

Future Applications

A solution to the previous mentioned limitations could be a 'digital' Black Box.

Companies like Honeywell are already in the process of creating devices capable of livestreaming flight data to ground centres essentially creating a 'digital' Black Box (*Figure 2*). The livestreaming process would work by sending the flight data to either a satellite (which would in turn transmit the information to a data centre), or directly to a data centre. This would provide instantaneous information about an aircraft's flight which could then be stored for an indefinitely to be accessed at any time.

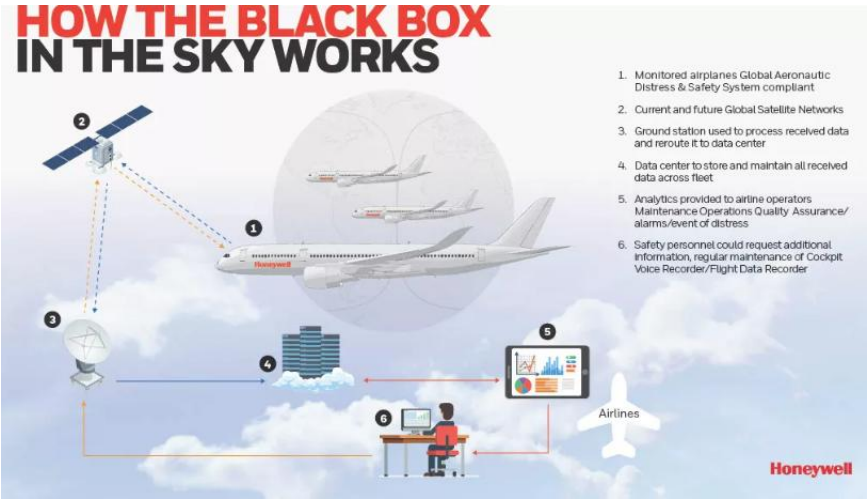

Figure 2: How Honeywell's 'digital' Black Box would work (Honeywell.com, 2021)

However, legal and ethical problems could arise as a result of a 'digital' recorder. These would include data ownership, privacy concerns, and international regulations.

The question of who would own the data would come into play. Would it be the airline, the manufacturer of the aircraft, or a regulatory body like a national investigator? If a nation which is involved in an accident or incident could control the data, could it be able to influence the outcome of any investigations? This may affect peace between nations. It could also create a perception that the investigators' findings might be manipulated, thus breaking the public's trust in any outcomes of investigations.

Pilots could also feel at risk if everything that they mention in the cockpit is recorded and stored indefinitely.

An international body like ICAO may have to change its regulations if a 'digital' Black Box was used.

Conclusion

This simple concept and invention, the Black Box Flight Recorder, has assisted investigators to solve countless aviation accidents and incidents.

The information it records has repeatedly influenced global political events by disproving initial false assumptions and by improving the public's perception of safety in the aviation industry. The public knows that no matter how or where an accident took place, the Black Box has no prejudices, it only provides the information recorded.

Future versions of the Black Box might threaten the peace it has created in the world. If the recorded information from flights is sent to a data centre, external parties could then potentially control and manipulate the data. The public's belief that the Black Box has no biases would then be undermined, affecting peace around the world as there would be little trust in any investigations.

(**Word Count:** 1446)

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