The History and Use of Flight Data Recorders

Student's Name:

Professor's Name:

Institution:

Date:

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The Flight Data Recorder – commonly known as "the Black Box" – is often one of the few identifiable items found in the wreckage of an airplane crash. Flight Data Recorder (FDR) has existed for decades; however, the technology utilized to record flight data has evolved over time from relatively primitive devices to contemporary recording systems with the most advanced digital technology. For many years, aircraft carried a single "Black Box," though, more recently two separate devices are used: the FDR and the Flight Voice Recorder (FVR). The "Black Box" nickname for Flight Data Recorders is a misnomer: FDRs and FVRs are typically painted bright orange or bright red, to improve visibility in the aftermath of a crash (L3.com, 2011).

A 1953 plane crash in India spurred the development of the first FDR. David Warren, a researcher from Australia, was investigating the site of that 1953 crash and found himself frustrated by the lack of available information. Warren's frustration prompted him to develop a series of FDR prototypes over the next few years; by the end of the 1950s, FDRs were in widespread use. In 1960, the United States Federal Aviation Administration (FAA) made FDRs mandatory on all U.S. commercial aircraft (Suddath, 2009).

The original technology used in FDRs was quite primitive by current standards – and even by the standards of the 1950s. Utilizing a system hardly more advanced than Thomas Edison's wax cylinders, as the first FDRs contained strips of thin foil. A needle scratched grooves into these strips in real-time, encoding very basic aircraft data: e.g., altitude, speed (both forward speed and the speed of vertical movements), the direction in which it was traveling, and the current time (L3.com, 2011). Despite the simplicity of the early FDR technology, the

nickname “Black Box” caught on; this was not a reference to the color of the FDR, but to its mysterious and unseen contents (Suddath, 2009). The earliest FDRs were usually installed in the landing-gear wells, connected to the aircraft’s primary controls and instrumentation. After several crashes, FDRs still were damaged, despite, aircraft manufacturers relocated them to the rear of most aircraft where damage was less likely (Phillips, 1997).

There were some efforts to create FDRs before Warren produced his prototypes but most failed because the “box” itself – the casing that housed the recording device – simply could not physically withstand significant crashes. The casing was critical because the best recording technology in the world was useless if it was not salvageable after a crash. Most aircraft make use of current or recent technology in their FDRs, but there are some older aircraft that still prefer the original “foil strip” FDRs.

FDRs were further hampered in their earliest days because the basic information they recorded was of limited usefulness. Despite these limitations, some FDRs were only capable of recording such basic information as recently as 1987 (Suddath, 2009). By the mid-1960s, FDRs with tape-recording systems began to replace the first-generation FDRs. These newer systems recorded to magnetic tape information such as conversations among crew members and between aircraft teams and air traffic controllers. Known as Cockpit Voice Recorders (CVRs), these devices could record speech and other audio for the last thirty minutes up to crash. The technology used for these new CVRs was adapted for use in FDRs as well; with the arrival of the magnetic-tape FDRs, more flight information could be recorded (L3.com, 2011). Along with the main parameters captured by first-generation FDRs, they could now record a range of information about the mechanical operation of the aircraft, including the position of wing flaps,

the functionality of landing gear, and the condition of the engines at the time of a crash (Suddath, 2009).

Tape-based FDRs remained the norm until the 1990s when they were supplanted by Solid-State Flight Data Recorders (SSFDRs). SSFDRs utilize digital circuitry instead of the moving parts in tape-based systems. Data are encoded in the circuitry and, in the event of a crash, these data are less likely to be compromised and more easily recovered than data recorded to tape (L3.com). Along with advances in the recording capabilities of FDRs came improvements in the design of their external shells. Casings are now more resistant to fire, air, and water pressure, and can sustain greater impacts. The growth of the recording technology allowed investigators to access data almost immediately, and CVRs could record greater lengths, expanding from 30 minutes to 120 minutes by the mid-1990s (Suddath, 2009).

Contemporary FDRs that record a wider array of data can be used for more than just investigating crashes. By constantly monitoring nearly every data-point during a flight, investigators can learn not just went wrong in a crash, but what went right during safe, otherwise-uneventful flights (Suddath, 2009). This new wealth of information helps pilots fly more safely and engineers build better aircraft.

The existence and use of FDRs are well-known to the general public. Many crashes generate a significant amount of media coverage, and the search for the "Black Box" is often as closely monitored by journalists as it is by investigators (Suddath, 2009). Aircraft that crash at sea can pose a serious challenge to locating and recovering the FDR, as can crashes in remote or rugged terrain. Prompted by the challenges rescue and recovery teams often face, FDR designers began installing radio beacons inside the devices to make them easier to locate (L3.com).

The existence of this radio beacon does not always ensure locating the FDR after a crash. The signal from the typical FDR beacon is designed to broadcast for approximately thirty days; after that time, the signal weakens before disappearing completely. In some instances, the radio beacon has helped to recover FDRs fairly quickly, both on land and at sea. In other instances, the radio beacon fails before the FDR can be recovered. In 1987, South African Airlines Flight 747 crashed at sea on a flight between Taiwan and Johannesburg, South Africa. Over a year had passed before investigators located the FDR. Of the several dozen commercial aircraft that have crashed at sea since the advent of FDRs, only one remained missing as of 2009 (Suddath, 2009).

A 2009 article in TIME Magazine recounts some infamous aircraft incidents during which the FDR captured compelling information. In 1990, a pilot aboard a British Airways flight was nearly pulled out through a broken windshield but survived because a flight attendant and co-pilot pulled him back in by his legs and torso. In 1994, an Aeroflot pilot had his two children in the cockpit and allowed each of them to take a turn at the controls. After the 12-year-old girl had a turn, her brother took over. His voice can be clearly heard on the CVR as he asks his father for permission to turn right shortly before the plane slammed into a mountainous region of Siberia (Suddath, 2009).

As the TIME article's author rightly notes, perhaps the most infamous recordings ever recovered from a CVR is that of United Flight 93 on September 11, 2001. The plane had been taken over by a team of hijackers, and on the CVR the voices of the hijackers can be heard as they issue commands to the passengers. Soon after the voices of several passengers can be heard as they enter the cockpit and overwhelm the hijackers. Moments later, the plane crashed into an unpopulated field in Pennsylvania (Suddath, 2009). Investigators later announced that the

hijacked aircraft was intended for the Washington, D.C. where the hijackers intended to crash the plane into the Capitol building in the same manner as two other planes struck the World Trade Center earlier that morning. The public would learn later that some passengers had been in touch with family and loved ones before they rushed the hijackers; they were aware of the attacks on the World Trade Center and sacrificed themselves to spare more lives on the ground.

As FDR technology has advanced, the required number and type of data points has expanded as well. Periodic adjustments and updates are issued by the FAA to ensure that aircraft are using the most up-to-date technology. (Anon., 2011). With very few exceptions, nearly all "turbine-powered" aircraft are required to carry a Flight Data Recorder onboard (Phillips, 1997). Where once FDRs recorded a mere five data points, today's FDRs record nearly a hundred simultaneous sets of information. In addition to the basic bits of information, such as speed and altitude, FDRs now record everything from the hydraulic fluid levels in the wing flaps to dozens of measurements of engine function, to the thickness of ice forming on the wings (faa.gov). Not all data points are needed for (or even available on) all types of aircraft, but the chances are quite good that if it flies, it has a Flight Data Recorder.

While the technology found in FDRs has come a long way in the last half-decade, the basic principles that spurred their creation remain the same: those responsible for designing and flying aircraft, as well as those responsible for investigating aircraft catastrophes, constantly seek as much useful information about their flights as possible. For anyone who has ever flown or ever will, the invention of the Flight Data Recorder remains invaluable. With these devices, we do not just learn what contributed to or caused a crash; we often discover ways in which such tragedies can be avoided in the future.

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