SECURE GROUND-BASED REMOTE RECORDING AND ARCHIVING OF AIRCRAFT "BLACK BOX" DATA USING RASPBERRY PI.

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***Abstract:** Aircraft accident investigation center analysis specifies that data captured and recorded in the flight data recorder and cockpit voice recorder, which are often referred to as the "black boxes" of aircraft is the key among the sources of information. It is observed that in some accidents, this flight data may be lost entirely or partially damaged and largely unusable. The aircraft flight data recorders record the flight data..This paper discusses the technical framework and examines the feasibility for a system that transmits flight data from an aircraft to a ground recording station in real time using Wi-Fi. This paper discusses an approach of transmitting FDR data to the nearest earth station simultaneously when it is stored in onboard FDR. Transmission of data takes place by switching the wireless network. This approach will point out the root cause for the crash instantly without any delay in searching the FDR. The major focus will be upon the requirements for security and assurance of the information flow, so that the confidentiality, integrity and authenticity of the data are ensured.*

Keyword-Aircraft, Black box, FDR, GPS, Cockpit Voice recorder

I. INTRODUCTION

Air transport is a vast international industry and the requirements of air transport of both goods and passengers is to grow up even supplementary because of its high speed, rapid services, & infrastructure asset. Even though air transports are at hike, it is one of the unsafe forms of transport, because of slight accidents may put an extensive loss to the goods, passengers, and the crew. Probabilities of accidents are greater in contrast to other modes of transport; Airways have no assurance and reliability. It is highly exaggerated by weather change; in addition it cannot function in unpleasant weather. There remains an opportunity for a flight crash [1]. In such a condition flight data recorder is a priceless tool for air crash investigators to access the root cause for the flight crash. When a flight crash occurs over the ocean However finding a FDR under the ocean surface becomes a complicated task.

In 1956 the Defence Science and Technology Organizations, Aeronautical Research Laboratories in Australia Dr. David Warren designed the first prototype coupled FDR / CVR for explicit port-crash examination purpose in airplane accidents. On June 1, 2009, Air France Flight 447 crashed into the Atlantic Ocean, route to Paris from Rio de Janeiro. All the passengers and crew members perished and most of the aircraft disappeared. Even after investigating the Airbus A330-200 disaster have never found the jetliner's FDRs in the deep ocean waters. Limited messages were only received from the aircraft during the emergency via conventional communication systems. It was not enough information for ground assistance, nor did they clarify the cause of the emergency. As a result, investigators do not know the cause for all the recently occurring accidents and missing planes. So, it's time to move on to new technology to overcome this critical problem in the aviation field [2].

In the proposed system, instead of keeping all those flight related data in onboard FDR, it's feasible to transmit that data to the earth station Simultaneously it also get stored in FDR [3]. This will give us an efficient way of finding the root cause for the problem instantly without any delay and provides the secure journey of passengers from terrorist attacks and hijacking of flights. This is done through criminal detection in the proposed system. Ground-based monitoring system would aggregate data in just this way. Investigators could thus examine information from a crashed aircraft for symptomatic patterns, to infer more precisely what had happened to it [4].

Sensors are equipped at various parts of the flight and wired throughout the plane. When the sensor detects that any function of the plane is turned on or off, changes in flight condition such as temperature, pressure, air speed at that height are measured by sensors and send it to FDAU (Flight Data Acquisition Unit). This unit digitizes the received data and sends it to FDR in a timely fashion for storage. When a flight crash occurs those data's are precious to find out the root cause for the crash. More than a hundred of crash FDR gave distressing fine points about the crash [5].

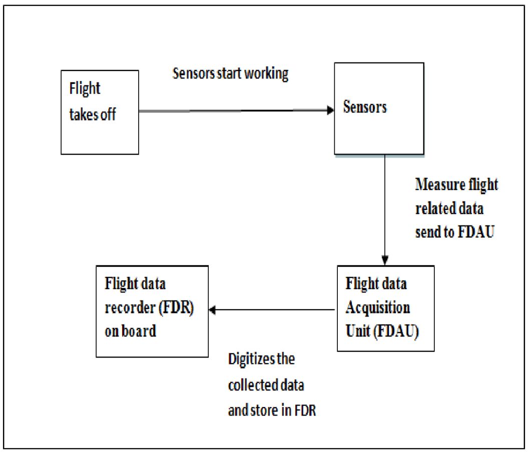

Fig 1: Data Acquisition in FDR onboard

II. PROPOSED SYSTEM

BLOCK DIAGRAM:

Flight Data Recorder

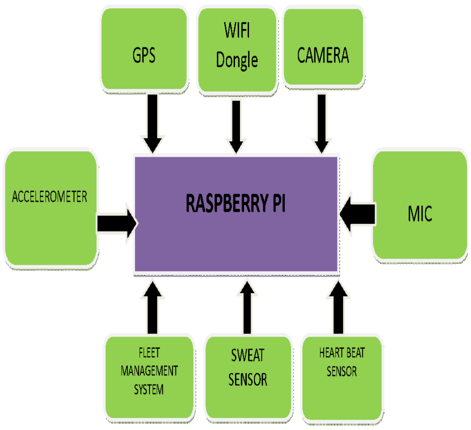

Fig 2: Flight data recorder

Ground Station

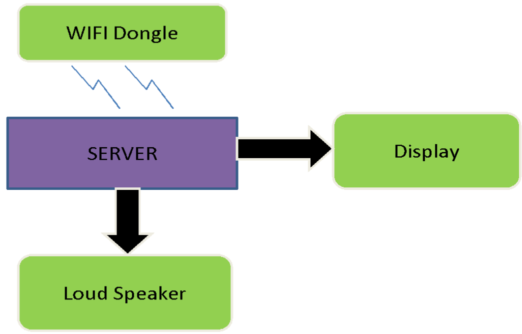

Fig 3: Overview of Proposed system

a) *Temperature Sensor*

Temperature is the most often measured environmental quantity. Many electronic components get damaged by exposure to high temperature and low temperatures. Several temperature sensing equipment are widely used. Depending on the required temperature range, linearity, accuracy, cost, features, and ease of designing the necessary support circuitry also varies according to applications.

b) *Pressure Sensor*

Superior pressure sensing is the main requirement for highly efficient A/C loop systems. It enables reduced fuel consumption and improved emissions. Advantages of automotive Pressure Sensor are low-cost, lightweight solution for accurate and robust pressure sensing such as engine load management and compressor protection.

c) *Heart Beat Sensor*

This sensor monitors the heart rate of a pilot in real time or records the heart rate for later study. If some abnormality in the heart rate of a pilot is found then the ground station provides a warning based on emergency healthcare of the pilot.

d) *Sweat Sensor*

The sweat sensor used to track the pilot's health according to his level of perspiration. If the pilot is undergoing any stress due to some unconditional happening in the plane then he might get sweat which will be more than his actual sweating level. The authorised people thus conclude the dangerous situation of flight and take further actions to safeguard the life of passengers in the plane [6].

e) ***Global Positioning System [GPS]***

GPS is used to get the location of flight in the ground station server.GPS, to predict whether the aircraft's current flight path could put it in conflict with obstacles such as mountains or high towers. The GPS information is given to the ground station in the form of longitudinal and latitudinal values. This Information used to give warnings to the flight controlling ground stations [7].

f) ***Accelerometer***

Accelerometer gives the direction of the plane and towards which it is heading and it gives the rate of change of the velocity of an object. A triple-axis accelerometer with digital I2C interfacing is used. Accelerometer gives the X, Y and Z values of acceleration of flight and thus provides any unconditional vibration that leads to an accident.

g) Mic and Camera

The microphones which are used in the cockpit area of the plane that records the conversation between the pilot and co-pilot and also between pilot and the ground station control server. The recorded audio provides the information during any unnatural occurrence in the plane. These recorded audio is retrieved at the server along with all noise in the cockpit area.

A pi cam is placed at the entrance door of the plane, which captures the images of passengers, crew members and all those who enter into the plane. And these captured images are then compared with the predefined images of people with criminal background in order to detect the presence of any criminals [8].

The hardware is presented for audio and image identification including the testing of sensors. To avoid the hacking of data by the intruders, encryption is done while the data is read in flight data recorders. At the receiver, the embedded audio data is extracted and played for getting additional information from cockpit area of flight. In case of criminal detection in the proposed system the images of all passengers and crew members are taken at the entrance of the flight, and these captured images are compared with the predefined images of criminal lists. And if the images match then it will display as a criminal detected else it will display as criminal not detected [9].

III. PROBLEM ANALYSIS

In-case when black box settled under ocean debris of more than 14,000 feet, ultrasonic ping emitted by ULB cannot be captured [10]. In such a case it's very complicated to find the black box. Once the black box is vanished, various factors are considered:

- Time taken to find the black box. It may take several days or months.
- Even black box is found, time taken to retrieve data from the damaged box may take time.
- Black box lost beyond all chances of recovery, total data gets lost.
- No one can pinpoint the root cause for the crash, to take steps to prevent similar failure in future.

a) Controller-pilot communication

Controller-Pilot Data-Link Communication (CPDLC) enables the exchange of text messages between controller and pilot. CPDLC complements traditional voice communications too. The maximum flight level for commercial passenger airliners is 41,000 feet (12.5 km) above sea level. Altitude above ground depends on how high the ground is. The maximum flight level for a passenger's jet is about 3.6 km higher than the highest point on the ground. Conversation takes place through VHF (Very high frequency (30MHz to 300MHz)) bands for line-of-sight or HF (High frequency (3 to 30 MHz)) band for long-distance communication.

Air Traffic Control radar facilities presently have both primary and secondary radar.

1) Primary radar works on the principle of bouncing high-powered microwave pulses off objects and detecting the reflected echo. Primary radar has lots of limitations. It works best with large all-metal aircraft, not so well on small, composite aircraft, and not at all with some of the new technology. It doesn't report about its altitude.

2) Secondary radar is used to overcome the limitations of primary radar, which depends on a transponder in the aircraft and respond to interrogations received from the ground station. Transponder sends back identification code or altitude information Depending on the type of interrogation received. The major demerit is when particular controllers of all pilots are tuned to the same frequency. This increases the chance that one pilot will accidentally override another, thus requiring the transmission to be repeated [11]. Once the number of flights being controlled reaches a saturation point, the controller will not be able to handle any further aircraft. The solution to this problem is by dividing a saturated air traffic sector into smaller units, each has its own controller and each uses a different voice channel communication [12].

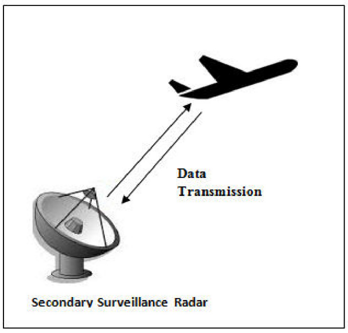

Fig 4: Secondary Radar Data Transmission

b) Aviation Frequency

Aviation frequency varies from 118.0 and 136.975 MHz for communication.
1) 121.5 is the emergency frequency. If there is some sort of emergency, the pilot will transmit it.
2) 122.750 is the frequency for general aviation air to air communications.
3) 123.025 is the frequency for helicopters air to air communications.
4) 123.450 MHz is the unofficial frequency for air to air communication

c) Modes of Transponder

Various modes of transponders like A, C, S and Ident are used in aviation field for operating in different modes:
1) Mode A equipment transmits an identifying code only.
2) Mode C equipment enables the ATC to see aircraft altitude or flight level.
3) Mode S equipment has altitude capability and moreover permits data exchange. Mode C or S equipment is a mandatory requirement for a much busy area of controlled airspace. Transponder has an Indent facility which causes the aircraft radar response to stand out when the pilot operates the Indent switch in the cockpit. This should only be operated upon ATC request [13].
Communication link between ground station and aircraft are laid out now-a-days to prevent collisions, still the reason behind the crash could not be known till the black box was located. Technology grows in every field but till now there is no replacement for the black box yet today. Yet the reason behind the crash has been known only after the black box found after several months [14].

IV. PROPOSED SYSTEM

Instead of storing flight related data on the FDR onboard, it is feasible to transmit that flight related data to the earth station simultaneously when it is stored in FDR. Data collected using FDR depends on whether the plane is in the takeoff, landing, or cruising stage [15].

V. METHODOLOGY

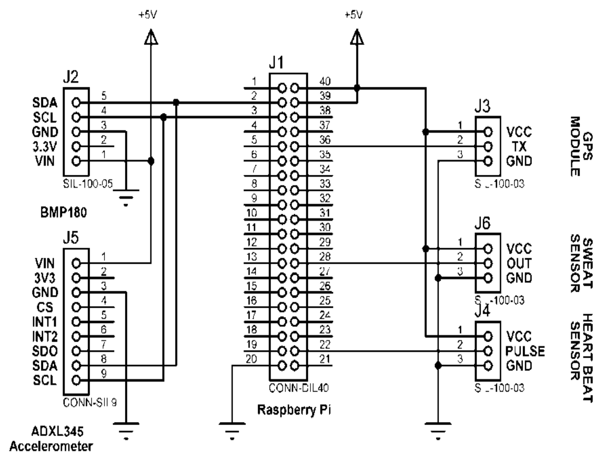

Fig 5: Circuit Diagram

Communication requirements for transmitting FDR data to ground stations continuously have been figured. The plane could transmit the operational data to the earth station straight away where possible, when flying high or over ocean, it could resort to transmit data through satellite network. When flight would be in a landscape area, it would transmit data to the nearest earth station by calculating the shortest distance using the shortest-path algorithm, but when it is cruising in ocean area it switches to satellite network for data transfer. Satellite-borne bandwidth is a limited resource, to economize the bandwidth, only Operational data from FDR are transmitted to earth station [16] whereas cockpit voice recording would go into an onboard recorder as of today. As a backup the current black box technology might continue.

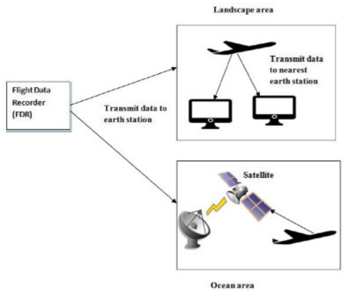

Fig 6: Overview of Proposed system

Most of the aircraft sends some of the information to ground stations. The data, which comes at regular intervals, specify the flight path and airspeed, as well as information that crews need to service the plane during lands. This system mostly uses VHF frequency-shift keying. The message now sent to ground station generally contains 220 bytes at a time [17].

One of the major problems is to get around the lack of a uniform communication medium. To stay in touch with every aircraft, our proposed system would have to switch among all these communication channels. When an aircraft flying over land at low altitude can access VHF, and when flying high or over water can access satellite communication. The amount of data transmitted may be varying according to the status of the flight. More data needs to be transmitted during takeoff and landing, when several parameters change rapidly, than during cruising [18]. Whenever the ground-based system notices something unusual, it requests additional data to clear things up. Another trick is to hold back some data whenever bandwidth is tight, transmit only the parameters that show significant deviation from previous sampling. Later transmit the hold back data when bandwidth becomes available again.

VI. EXPERIMENTAL ANALYSIS

Various factors improve by transmitting FDR data to earth stations:

a) Time

FDR stores all flight data. Once the FDR is vanished, time required to find the black box may take several days or months. Even if the FDR is found, the time taken to reveal the data from that damaged box may take time. In real time data transmission there would be no dependence on FDR data, because copies of the data can be sent to earth stations according to the bandwidth availability.

b) Data Loss

FDR of the aircraft was lost during the crash, the entire data gets lost. In such a case there is no way to get a single junk of data. In real time transmission, some data was lost, not the entire data because of tight bandwidth. Once the bandwidth available the data could be retransmitted.

c) Root Cause

Once the FDR was lost, nobody could come out with the reason behind the crash. Root cause for the crash has been found only after the FDR was located, until the reason for the crash becomes a mystery.

Fig 7: Overview of Proposed system

VII. RESULT

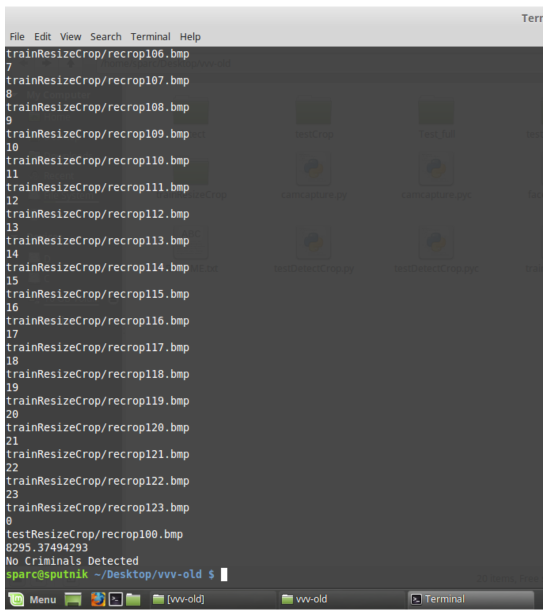

Fig 8: Overview of Proposed system

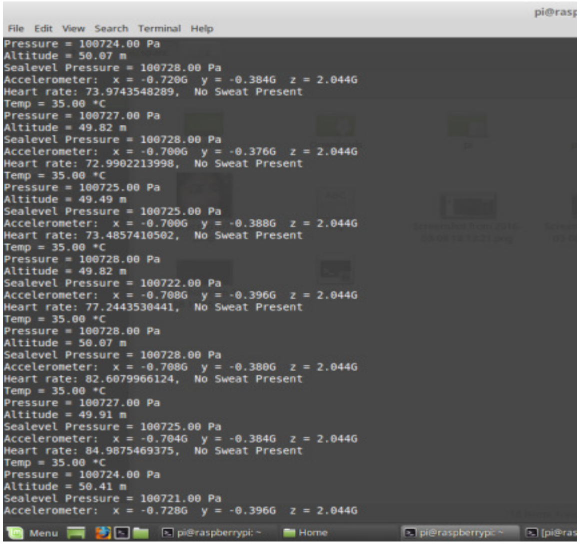

Fig 9: Overview of Proposed system

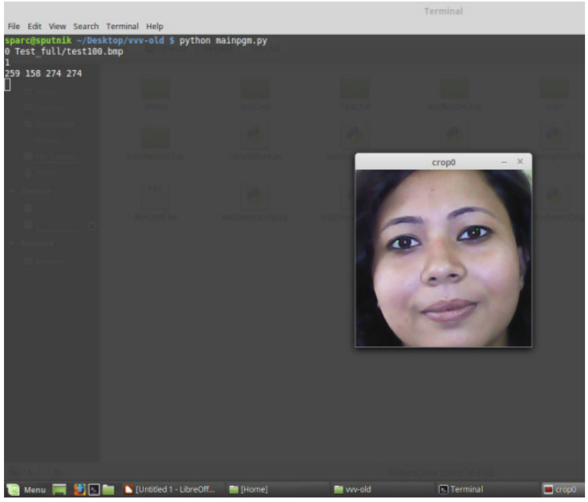

Fig 10: Overview of Proposed system

VIII. CONCLUSION

In the prevailing manner of storing operational data in onboard FDR gives reason about the cause for the crash in many cases. FDR has no use when flight is on air, yet it serves as precious data after a crash. Although when flight gets crashed over-water it's complicated to find the black box underwater and it is difficult to find the root cause. In our proposed system this complication could be overcome by transmitting flight operational data to the earth station instantly. So it helps to know the root cause for the crash immediately without any delay. As a future work security has been planned to provide for protected transmission of flight data to earth station. The data collected from several flights can be interrelated and data-mined to erect scenarios that could escort to perilous incidents in future. Such analyses can be utilized by the intellectual software agents to notice potentially unsafe circumstances in real-time and provide early warning to the pilot.

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