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Remote Black Box

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Abstract- We have often read in the news paper about the black box of an aircraft being vital for analyzing the flight's performance (non performance so to say!) and to understand the reasons for its failure, if any. When an aircraft has crashed, more often than not, an expensive search for the black-box is conducted which at times can be extremely costly and elusive, thus depriving of our ability to understand the causes of the crash. What great value will it be, if we could find a way to store the same flight data (or even better data) in a remote storage other than the in-flight black box and away from the aircraft? At worst at least, equip the black-box to transmit its location that can be detected by a GPS device to precisely identify its location so that costly searches can be avoided. Imagine, if we can also transmit flight data and pictures from inside of an aircraft using the same mechanism. During any hi-jacking or untoward incident, the in-flight happenings can be viewed pictorially by a control room (which, on demand can hook to the remote storage) such that the actors involved could easily be identified. This will immensely help one to frame negotiating positions or mount attempts to retrieve the control of the aircraft. The possibilities of extending its application to other areas are enormous with the availability of such a technology where one can perform online data analysis and views of inside or even outside the aircraft. For example, when an aircraft is in distress, it may be easier to understand what is causing a malfunctioning and be able to even prevent a major catastrophe.

Introduction

Most of the functions such as data transmissions by collector devices or parts, data storage in a black-box and analysis of

data stored in the black-box exist today. It may be only required to do the required changes to locate a black-box replica or peer storage outside of the aircraft at some fixed ground stations and be able to send and receive data to the on-board systems. It is not even necessary to store the black-box anymore inside the aircraft and instead use only the external storage system. However, beyond the black-box storage and analysis as it exists today, additional functionality will need to be extended to cater to the modern day security needs and also to offer other value added services around this core.

Ideally, the features required can be summarized as follows.

1. Flight data of an aircraft in-flight will need to be transmitted to a remote device that will receive, store and acknowledge or ask for re-submission.
2. The flight data transmitted will at least be of what is being recorded today in a black-box. The flight data will be transmitted throughout the duration of the flight from start to end of a journey.
3. The transmission begins and end will be automatically controlled with no manual provision or in the same way as it is being recorded now in the black-box. The idea is that, the transmission will be continuous and complete and interruptions to recordings or non-

recordings, even by mistake are not tolerated.

4. The data transmission, storage and retrieval will be of very high reliability, at least to the same levels offered by the black-box today
5. The remote black box will be allowed to be hooked by the data analysis systems (that may already exist today used for analyzing the current black box). Will need to be treated as same, except for the fact that instead of the in-flight black box it will connect to the remote black box.
6. The remote black box will be allowed to be hooked by a remote online analyzer or a control room system on demand at any time during the flight or after the journey has ended.
7. The connections to the black box from the data analyzers or control room systems through managed subscriptions for security reasons.
8. The control room will be able to analyze and present data online, in addition to providing views of inside or outside the aircrafts through its many cameras installed at vantage points in the aircraft
9. The control room analyzer will be able to point or rotate any camera installed in the aircraft so that the coverage can be focused to the required parts of the aircrafts.
10. The remote store or the analyzer will be able to hook to the black box, by first being able to locate or discover, connect and then retrieve or copy the data in it to a replica. (This means, we can even

forego the physical retrieval of the black-box saving costly retrieval operations.)

11. The analyzer or the control system will be able to transmit the current view of the analysis (what one sees in the control room) to other control centers that are subscribed to it, including in-flight monitors attached to the cockpits)
12. Multiple analyzers from across multiple locations will be able to connect to the remote black box for either pulling raw data or the analyzers for pulling the analyzed views or pictures for its use.
13. The recorded data of the flight will be available for online viewing while the flight is in motion or be available or a static analysis/view up to a specified period after the completion of the flight's journey

High-Level solution or architecture

The following solution components are envisaged.

- a. Flight Data Transmitter
- b. Remote Data Storage
- c. Black-Box locator and data retriever
- d. Remote black-box Data Connector
- e. Data Analyzer
- f. In-flight data collector device manager
- g. Analysis Data Subscription Manager
- h. Distribute analysis views to Subscribers
- i. Cockpit special communicator

Flight data transmitter

This component is similar to the existing component that collects data and transmits

to the internal black-box today. The only difference being, that it sends the data to a remote receiver and recorder, Instead of sending the data to the local black-box, Additionally, this component will have capability to double send and resend in case of acknowledgement failures. The transmission will be enabled to begin automatically when the flight sets in to motion and to end when the flight comes to a halt or when engines are switched-off. The identification, authentication, and authorization of the receiver to be transmitted to, will need to be configurable and based on strict security standards.

Open Issue: The ability to communicate to a device on the ground in a non-stop fashion under all circumstances regardless of the aircraft's altitude will need to be determined.

Remote data storage

The remote data storage is both a hardware and software component that will receive (part of communication with the aircraft) the transmitted data, validate and ask for resending valid data (and check locally from the double send received), store and send the acknowledgement of the receipt status. The acknowledgement will be appropriately processed by the sender to ensure that no data packets are missed by the receiver.

In-flight black box locator and data retriever

The current black-box will need to be made to transmit its location via signals that can be detected by the locator. The locator then hooks on to the in-flight black-box and remotely retrieves all the data and creates a replica of it, as long as the in-flight black box is live and not destroyed or dead. This avoids the necessity to physically retrieve the in-flight black box.

Remote black box data connector

This component is an interface component that enables the connection to the remote black box and the data analyzer system. This is isolated to a separate connector component in order to provide a standard interfacing protocol, standard data model for send and receive between the 2 systems, ideally, even if the individual systems are made by multiple different vendors.

Data analyzer

Analyzer with most functionality needed exists today that handles the in-flight black-box. Where new enhancements are to be added are only in providing views of pictures from the in-flight cameras and controlling these devices from the analysis room remotely. However, we will summarize below, the functionality to be built in this component.

This component will be able to connect to the remote black-box (via the data connector) based on demand or need basis. The need basis can vary from connecting to the remote black-box from the start of the journey or when the recording begins for a specific journey or anytime during its flight or anytime after the flight ends (up to a period defined as per data retention policy). This again can be managed by a separate subscriptions manager (a sub component) that manages the connection type and connection demands of the analyzer to the remote black box.

Once the black-box is connected, the analyzer will have options to perform multiple analyses just like a security control room or a CCTV room where the monitoring and analysis of an aircraft in motion or an aircraft that was in motion can

be performed. This component will also have the ability to play forward or backward (second by second or minute by minute) right from the starting of a journey to its completion or at any point during or after the flight has ended.

In-flight data collector device manager

The in-flight data collecting devices can be specialized devices that collect the required data from the various flight parts or systems or even as simple as cameras installed at various locations of the aircraft.

It will also have the ability to project the pictures received from the various cameras installed at vantage points inside and outside of the aircraft and also to adjust the position, angle and the focus of the shoot.

Analysis data subscription manager

This component handles the registration, security and connection of the various analysis systems from across the world to the analyzer. The subscribers and their subscriptions are managed to allow on demand views/hooks to the analyzer system and its outputs. (This is a pull type subscription where they can hook to the system and receive either the raw data feed for their own storage, analysis, interpretations and the analyzers outputs (after analysis) or simply the pictures from the cameras.

Distribute analysis views to subscribers

This is more of a push-type technology where the analyzer pushes various outputs and views to the registered subscribers. The

push type can be activated on demand or in a passive way for the subscribers to store or online viewing.

Cockpit special communicator

This component interacts with the monitor installed in the cockpit to present inside and outside view of the aircraft, while in-motion or even some of the online outputs and views based on the analysis of the transmitted data.

Commercial viability or a business case

Does a business case exist to embark on such a massive development effort? Surely, I think. Assuming that there are 10K flights a day being operated across the globe and a subscription charge of say \$1000 per journey and at a market share of 10%, we have the subscriptions of $10K * 365 * 1000 * 10\%$, year revenue.

Conclusions

While I know that it is economically viable to invest in such a system, the engineering feasibility of designing and producing a system of this scale, size and highly fault in tolerant environments are to be determined. More so, if some of the aircraft manufacturers or airline operators are already planning such a system, which I suspect very much though, as even in the last month newspapers, I read about plane crashes and its black-boxes being searched in a deep ravine or in deep sea.