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Framework for Data Management and Diagnostic System to assist Aircraft System Maintenance

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Abstract: It's been observed that aircraft systems suppliers face huge challenges in maintaining its aircraft system products continuously operating without failures during flight operation. A failure occurrence to any of its aircraft systems, could lead to a significant effort to investigate the issues, financial burden and compromise its competitive advantages. Therefore, there is a need for a system to monitor the performance of the aircraft systems and enable prognostic maintenance which will predict the remaining life of systems and its components, to repair and/or replace the system and avoid operational cost and schedule impacts. This paper describes the basic framework necessary for establishing data management and diagnostic system to assist aircraft system maintenance.

Index Terms **– Aircraft Systems, Prognostic, Maintenance**

I. INTRODUCTION

The intent of this paper is to describe the framework for data management and diagnostic system to assist aircraft system maintenance. The recent trend indicates that the airliners, aircraft manufactures, and aircraft system suppliers faces huge challenges in maintaining the aircraft system operation without failure during flight operation. A failure occurrence could lead to emergency landing, flight diversions and most commonly the failure could prevent dispatch of an aircraft fleet operation. Therefore, there is a need of a framework that could monitor the performance of the aircraft systems and enable prognostic maintenance to repair the fault and avoid cost and schedule impact.

II. OBJECTIVE

Currently, the aircraft systems are sustained based on the traditional periodic maintenances. Accordingly, the parts are replaced or inspected in a timely manner. The downside of this approach is that they may lead to some costly tasks or part replacements when it is not necessary. This is due to not having the means to iteratively assess and estimate the lifetime left in the parts under monitor. This is due to lack of real-time monitoring in the maintenance platform.

The proposed framework will improve the aircraft systems by providing sufficient data required. This will keep the products more efficient and competitive in the market. It helps the airlines, reduces the dispatch delay time, which ultimately leads to a financial gain by reducing the cost of flight cancellations or delays. It will help the product supplier sustain or expands its aerospace market share because the new system would improve and maintain the design of its current aircraft systems. This framework provides an additional operating data necessary for efficient aircraft systems performance analysis, improve the system failure diagnosis, debug, and improve the aircraft system products. Also improve the maintenance operation and system reliability by migrating from periodic to prognostic maintenance.

III. CONCEPT OF OPERATION

To properly develop the proposed system, it is important to identify the context of the system to be operating within. This includes identifying the interfaces for the system and system boundaries. Figure 1 below illustrates these interfaces. The diagram displays the key interfaces and events surrounding the Data Management & Diagnostic System (DMDS) as well as the concept of operation through the perspective of the constituent system's end users. The system boundary includes the physical system modules, the aircraft systems as well as the ground facilities the DMDS interacts with.

The DMDS is comprised of three major modules, including Aircraft System Interface Device (ASID), Data Transmit/Receive Interface (DTRI) installed on aircraft and ground control center, and Data Processing System (DPS). The core airborne system is the ASID, which is integrated as a new subsystem into the aircraft and communicates with the existing aircraft systems. The DTRI installed in the aircraft integrates with the ASID and handles the data communication from ASID module to the DTRI installed on the Ground Control Center (GCC).

ASID can communicate with the Ground Control Center, which as they may indicate, is an aircraft systems operation-monitoring base on the ground. During a flight in case of any failure or detection of a pattern considered as an early diagnosis of a potential failure or possibility of such anomalies, the ASID will immediately establish a connection with the GCC and transfer the data and the report log to the base. Next, the report with the supporting data is provided to the system suppliers functional analysis team for investigating the scenario led to the reported incident. In case the analysis results in validating a potential point of failure in the aircraft systems, the relevant recommendations are generated and passed on to the related aircraft systems overhauls and airline maintenance team.

Regardless of the urgent alert reports generated based on the trend analysis; at the course of each flight operation the ASID will also be continuously collecting the data from the aircraft systems. The data collected will be stored in the ASID module and as soon as the flight cycle ends by landing, the ASID establishes a connection with GCC - the ground facility, and transfer the data collected there. This data will be reviewed and analyzed for prognostic maintenance.

The data gathered this way will be utilized to both develop and improve the baseline as the reference for the aircraft system health monitoring. The findings will be ultimately passed on to the aircraft system design and integration to be considered when revising the design for either immediate corrective action or implementation in the next generation system design iteration.

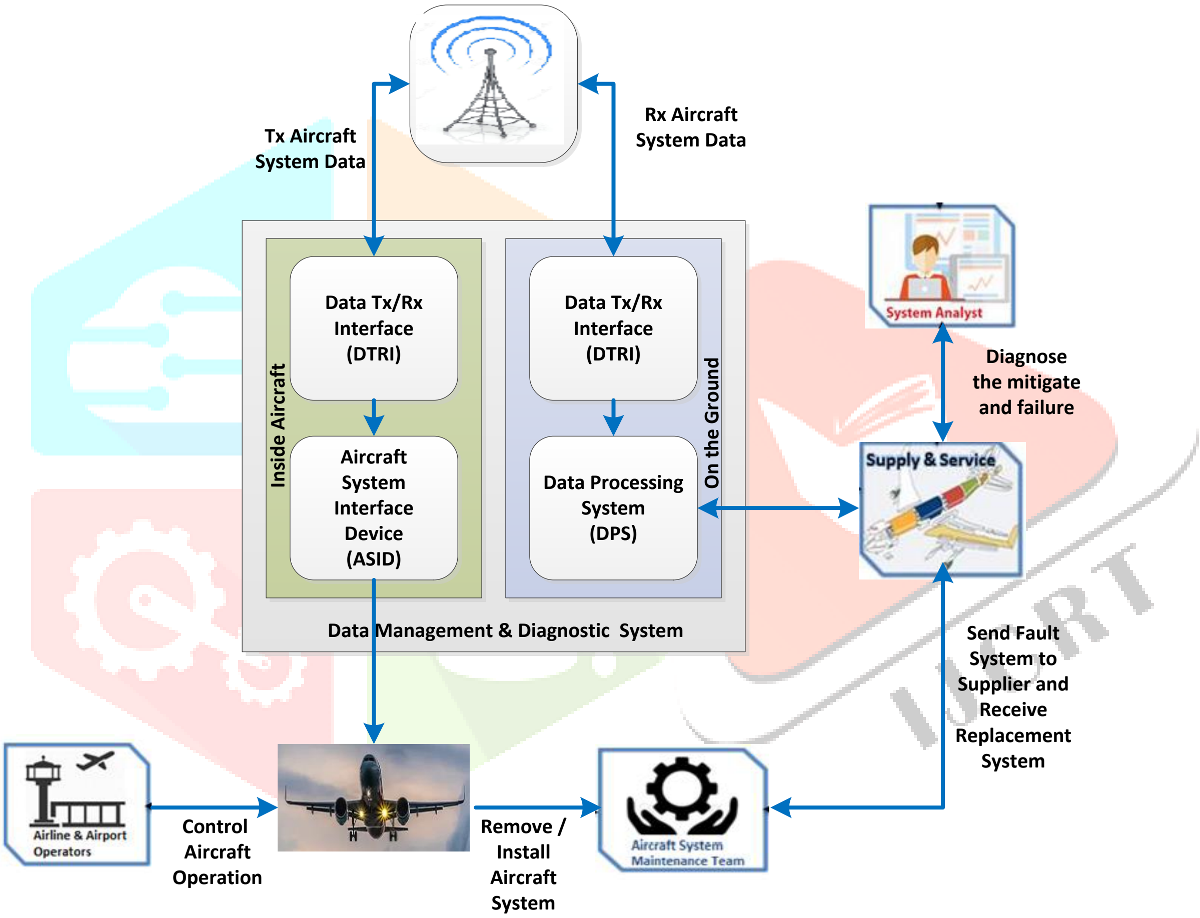

Fig. 1: Framework for Data Management and Diagnostic System

IV. DMDS OPERATIONAL VIEW

The main objective of the DMDS is to capture and communicate to the ground if any faults occur to the aircraft systems while in flight. This will allow to make real-time decisions to diagnose the fault and mitigate it. Also, the DMDS system will capture the operational and health data of aircraft systems during flight operation. Then the data will be processed and predict the failure of the system allowing maintenance to be perfomed during the scheduled maintenance check before the system loses flight performance.

From the operational concept perspective, the user can access the reports and records generated from the Ground Control System, allowing them to make proper planning and decision-making of maintenance activities, system diagnostics and prognostic health management.

The ASID can receive the data transmitted from the aircraft system through existing avionics communication medium. The existing aircraft system may have avionics communication medium (e.g Ethernet, WI-FI, AFDX/ARINC664 [1], ARINC 429 [2], ARINC 834[3]). A trade analysis can be conducted to identify effective communication medium to be used.

The figure 2 below provides a graphical depiction of the DMDS system architecture, and the major components and its operations involved.

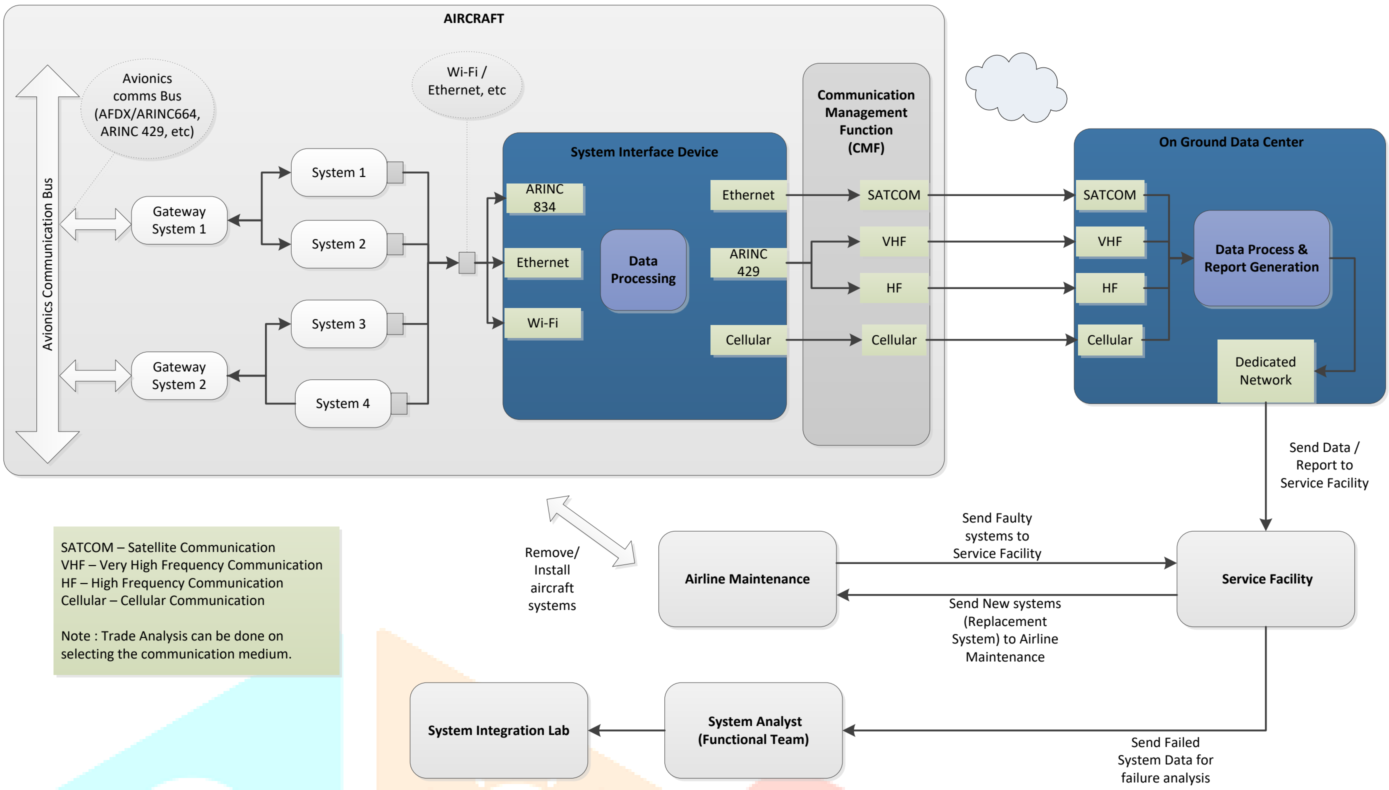

Fig. 2: DMDS System Architecture

The ASID, as the master subsystem, will be the core driver by operating in two major modes. In the default operational mode, initially it will be establishing a connection with the all the aircraft systems and in case no fault occurred, it will start the main task for the default operational mode by receiving, storing, and real-time analyzing the data.

The second operational state is triggered when the data analysis performed by the ASID is led to detecting a fault, anomaly, or any pattern, which may be interpreted initially as a red flag. In such cases, the ASID will transit to the second operational state, which includes the tasks for generating a report with supported data, then establishing an immediate communication with the OGDC to alert on the findings in real time. The ASID will wait to receive the acknowledgement signal from the OGDC, which verifies the successful communication.

V. DMDS DATA PROCESSING

DMDS data processor processes all incoming data from the different aircraft systems. The DMDS system can transfer all data to storage unit to transfer to OGDC at the end of each flight cycle. This DMDS unit also perfoms data analysis to see any sign of abnormal behavior or faulty condition in any of the aircraft system. If the DMDS system sees any signs of a fault condition it will immediately transfer data to the OGDC. DMDS processor identifies the data type, and the airline companies decide what communication channels to use for different types of a data. Most airlines select SATCOM for faulty system data and cellular for normal data transfer.

VI. DMDS BENEFITS

The ultimate purpose of the DMDS is to reassure the system of interest will be continuously delivering its goals to achieve its mission through its life cycle. Regarding the DMDS, the proposed system's mission is to provide real-time aircraft systems fault detection management, which is communicated promptly, and to provide prognostics maintenance, which is done by continuously analyzing the collected data. Accomplishing the system's mission will contribute toward meeting the following improvement needs:

- Aircraft systems maintenance efficiency
- Aircraft systems reliability
- Reduce rate of turn-backs for the aircraft systems
- Improve flight operations performance
- Reduce Flight operations downtime
- Frequency of flight cancellation, delays, and diversions

VII. CONCLUSION

In this paper the framework for data management and diagnostic System to assist smart aircraft system maintenance is described from the perspective of end user. The DMDS framework explains an approach to collect data from safety critical aircraft systems continuously and alert the aircraft system supplier in the event of failure and enable them to identify and mitigate the failure efficiently. The internal data of the safety critical system are then analyzed to observe the health of the system and provide information to enable the prognostic maintenance or repair of the fault system.

VIII. REFERENCES

[1] https://en.wikipedia.org/wiki/Avionics_Full-Duplex_Switched_Etherne
[2] https://en.wikipedia.org/wiki/ARINC_429
[3] https://en.everybodywiki.com/ARINC_834