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REAL TIME DATA COLLECTION AND PROCESSING FOR AIRCRAFT MAINTENANCE ENHANCEMENT (REACT)

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***Abstract* – REACT aims to develop an innovative real-time Aircraft/Ground framework to collect, transmit and concentrate aircraft and ground data. This data will be processed to offer maintenance services information for predicting, planning-ahead and supporting aircraft maintenance execution. In the scope of REACT, features of new mobile tools will be also researched with the objective of enhancing the efficiency of maintenance execution.**

***Keywords* – Real-time data transmission; Predictive maintenance; Aircraft Maintenance.**

I. Introduction

In general, all physical assets are becoming more and more complex and aircrafts are not the exception. Nowadays it is necessary to have an easy and friendly access to the condition of physical assets through its monitoring. However, when dealing with disperse physical assets it is necessary to have robust and secure communication systems to access the data. It is even more difficult if such physical assets are not geographically static.

Managing an aircraft fleet, in terms of its maintenance, is a huge challenge since, it is mandatory to guarantee that the aircraft is on condition to complete the next flight without risks, for the equipment itself, but more importantly, to its occupants (high risk sensitive sector).

Typically, a Reliability Centred Maintenance (RCM) process applies when planning maintenance interventions based upon the condition of the equipment, having as main objective the preservation of the equipment's inherent reliability levels. Setting up a repetitive scheduled plan to periodically remove components from an aircraft regardless its condition, can prove to be a burdensome and very expensive process. Failures however, must be avoided to prevent human catastrophes. Thus, the challenge from a maintenance perspective is to secure the highest safety levels of an aircraft, at the minimum possible cost.

In order to extend the length of the complete life cycle of such physical assets and minimise its maintenance costs they can be monitored to optimise the time of their replacement or even their planned maintenance surveys according to their condition. This still is a RCM approach but controlled by Condition-Based Maintenance (CBM).

Every time a fault is detected it should be determined if the aircraft requires immediate maintenance actions or if those actions can be deferred, in accordance with approved applicable rules. The second option points towards a set of further questions:

- For how long is the aircraft able to fly without unacceptable risks?
- Where and when must the aircraft land to be subject to a maintenance intervention?

Aircrafts are on the move all the time. Finding the best moment to ground an aircraft to perform maintenance actions at the best suitable location, is key to minimise costs.

To manage all the information coming from monitored assets a centralised system must collect and process all the data and support maintenance management under an e-Maintenance concept [1].

Today's aircrafts produce a large array of parameters which can be used to infer the state-of-health of some systems or components, so that maintenance actions can be deployed based upon the actual condition of the component rather than waiting for it to fail or relying on accumulated experience.

Current paper addresses the purposes of REACT project that is currently being implemented. REACT aims at develop and integrate technology to:

- Regularly collect, transmit to ground stations and process aircraft data in real-time, in an effective, reliable and affordable way at any given flight stage;
- Predict maintenance needs and reduce the extension of damages on key removed parts;
- Provide maintenance technicians with enhanced mobile access to contextualised documentation, decision-making support methods, and effective communication with other departments and the aircraft.

Unlike the existing systems, some of which are provided as services by aircraft Original Equipment Manufacturers (OEMs) and Maintenance Repair and Overhaul Organisations (MROs), that are currently used by the airlines to support the improvement of resources' maintenance management, the system envisioned in REACT will not be based on failures (reactive maintenance). Instead, REACT will be a CBM system aiming to avoid unpredicted failures by monitoring the condition of physical assets and estimating the probability of degradation ending up in a failure, within a certain period of time (predictive maintenance).

The step of implementing a maintenance methodology that makes extensive use of the condition monitoring of the aircraft has not yet been taken, mainly because current data transmission technologies from aircraft to ground, do not offer a good balance between the performance in the amount of data and affordability for permanent data transmission at any given flight phase and in all regions of the globe. This stage of things doesn't give the aviation authorities enough confidence to support the gradual replacement of the conventional scheduled maintenance by a CBM methodology.

The novel concept which underpins REACT is to propose an upgrade of the legacy aircraft architecture in terms of data collection, concentration and transmission by integrating reliable and affordable technology. The solution envisioned in REACT will enable a continuous transmission of large amount of data from aircraft to ground stations, supported by its processing, to assess the condition of selected components. As such, timely insights will be provided to the relevant maintenance departments which will support a pre-emptive schedule of maintenance actions and effectively mitigate unplanned downtime of the aircraft.

The enhancement of the maintenance value chain will be fully completed by developing new applications for mobile tools targeted to maintenance technicians, featuring a more intuitive access to information that will allow efficiency gains, shorter turnaround times, better knowledge of the actual aircraft's health condition and fewer operational disruptions.

The remaining of the paper is organised as follows:

- Chapter II presents the concept and approach of REACT system;
- Chapter III presents the REACT architecture;
- The final chapter presents the conclusions.

II. Concept and Approach

In order to carry out the proof of concept, REACT envisages that for some selected systems and components, a standard sampling of observable parameters will be defined to describe the expected behaviour of a system when in normal operation. Conditions are created in the aircraft to collect all the necessary data to observe the performance of the established parameters at any flight phase, taking the maximum advantage of the existing aircraft systems.

Whenever the parameters show significant deviation from the previous sampling, data is sent in real-time to a ground station. The ground station records the output of the aircraft's sensors and electronics, processes the transferred information and determines the aircraft's systems that are in risk of failure.

Based on collected data, the centralised system in the ground station, through the use of big data technologies, will analyse the fault conditions and propose a set of tasks and a time frame to those scheduling the maintenance. This will allow the maintenance planners to accommodate those tasks in the regular scheduled inspections of the aircraft, without jeopardising the aircraft's availability. There are several published results from CBM approaches that can be transposed to the aviation world, like in [2] where a solution for wind generators is presented, that accesses monitoring measurements data online and processes these data in real-time using prediction models to prevent failures. In [3] a Hidden Markov Model (HMM) is applied on diesel engines to estimate their condition. The advantage of HMM is that it is a memoryless model.

Trying to find the best compromise between the next aircraft's missions, available resources and skills and the most suitable destination to perform maintenance works, the maintenance planners will distribute the tasks among the appropriate technicians who receive it through a mobile device.

In their mobile device technicians will have access to:

- Assigned job cards;
- Contextualised documentation;
- Bidirectional communication with other departments and the aircraft;
- Selected procedures in augmented and virtual reality.

Apart from the capacity of REACT to transmit aircraft's condition details, even during a flight when deviations pointing to faults are detected, also an interface for on-ground works will be available. Thus, if an anomaly is detected by the technicians, when performing maintenance in the aircraft, they have just to use a mobile device to describe the fault they are facing. Then, an expert system will analyse the report and suggest maintenance procedures to solve the anomaly. If no immediate action is required, the centralised system keeps the information introduced by the technician for later planning of appropriate actions.

Augmented Reality is a powerful technology tested on several projects, some of them in the aviation sector in which the final assembly cabling routes are superimposed in real-time on a video sequence of the aircraft fuselage to avoid mistakes [4] using a tablet or even by projecting on components instructions to complete a task [5]. The major constraint of using augmented reality in industrial environments is to identify the targets without the use of artificial markers; a possible workaround solution could be the use of texture-based techniques, which implementation is however also problematic due to light changes sensibility. A useful edge-based approach that uses CAD model details to detect and track objects in the scene, tends to be more reliable on such environments because the object's contours are not significantly affected by light changes, [6].

Conventional paper-based instructions are becoming inadequate, mainly when changes are applied. Digital instructions tend to be easily accessed, are easier to update and such updates may be available to all maintenance infrastructure in real-time. This has been verified during the assembly of the Airbus A400M [5] reaching significant time savings on creating, consulting and maintaining up to date digital working orders. This problematic is not new; in 2001 a paper has been presented about a project that attempted to replace paper-based documentation by augmented reality instructions on maintenance of nuclear power plants, [7]. There is also a report from 2012 that addresses the expected benefits and what must a mobile device contain, to support military aircraft maintenance management at Saab Aeronautics, [8].

Those publications attest the validation of the mobile interface of REACT. However some other constraints must be overcome such as the communication between REACT and the remaining maintenance management systems, namely the proprietary systems.

In REACT the centralised system will preserve data from several aircrafts, over many flights and years, and mine this information with sophisticated algorithms to identify the signs of recurring problems for long-term maintenance needs anticipation. This feature may become an important resource to estimate accurately the behaviour of aircraft's physical assets in the future.

In the project, real life airline operational oriented demonstrations will be defined with the aim of verifying compliance with the objectives. The implementation of the solutions will be evaluated within operational context making use of an end-user's maintenance infrastructure to measure the expected impact in the aviation industry, specifically in what concerns the reduction of maintenance costs and operational disruptions. In Fig. 1, REACT's general concept is illustrated.

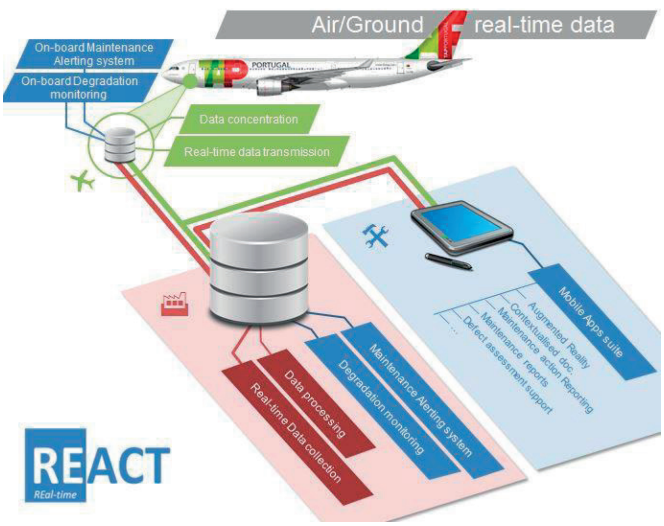

Fig. 1. REACT's concept

III. Architecture

REACT comprehends tree main sub-systems: the ground platform, which is the central core; the on-board monitoring system; and the mobile devices. The global architecture is presented in Fig. 2.

The Aircraft/Ground maintenance platform is based on the integration of mature aircraft and ground technological bricks to host the real-time maintenance functions within aircraft legacy architecture:

- Aircraft infrastructure segment: Integrated within the aircraft "open world", it would offer a flexible but secured environment to communicate with the legacy "Aircraft Control Domain" (ACD i.e. Avionics world). It would acquire and concentrate aircraft, maintenance and operational data such as Aircraft Condition Monitoring System/Virtual Quick Access Recorder (ACMS/VQAR), maintenance reports, eLogbook database, etc. and transmit them in real-time, and when appropriate, by making use of available avionics, cabin or open world (i.e. Wi-Fi, 3/4G) connectivity.
- Ground infrastructure segment: This would collect the overall real-time fleet and ground data such as information provided by the Maintenance Information System (MIS) and distribute it to other maintenance functions.

This platform is the backbone to support the aircraft maintenance operations and to host the maintenance functions using the centralised database:

- Maintenance anticipation: It would be a real-time degradation monitoring function split into aircraft segment to provide a quick degradation pattern and ground segment.
- Maintenance preparation: It would be a maintenance alerting system to warn the Maintenance and Engineering (M&E) back office, or the field operator directly, about degradation of monitored parameters and failures.
- Maintenance execution: It would be an application suite belonging to an on-field maintenance technician to support maintenance execution tasks such as degradation and failure analysis and recovery, maintenance actions reporting, etc.

IV. Conclusions

The transmission of data from aircraft to ground in real-time, once the aircraft is airborne, is a burdensome and expensive process with significant limitations. Currently, some reports are transmitted from aircraft to ground when the aircraft is flying. These reports are only transmitted under very specific trigger conditions and are set to minimise transmission costs and make the minimum use of satellite bandwidths.

Aircraft produce plenty of parameters which can be used to infer the state-of-health of some systems or components. Also, due to the lack of effective data processing tools for aircraft maintenance, non-mandatory recorded aircraft data currently produced is often lost or not used by the maintenance services on a systematic and regular basis.

REACT aims at proposing an effective, reliable and affordable solution for making permanent aircraft-ground data transmission in real-time possible. This aircraft-ground data link can be triggered based on the deviation of selected health parameters from normal behaviour or whenever demanded either by the flight crew or by the ground maintenance services, at any flight phase and over any region of the globe.

Innovative data transmission technologies will use artificial intelligence capabilities to make smart decisions on

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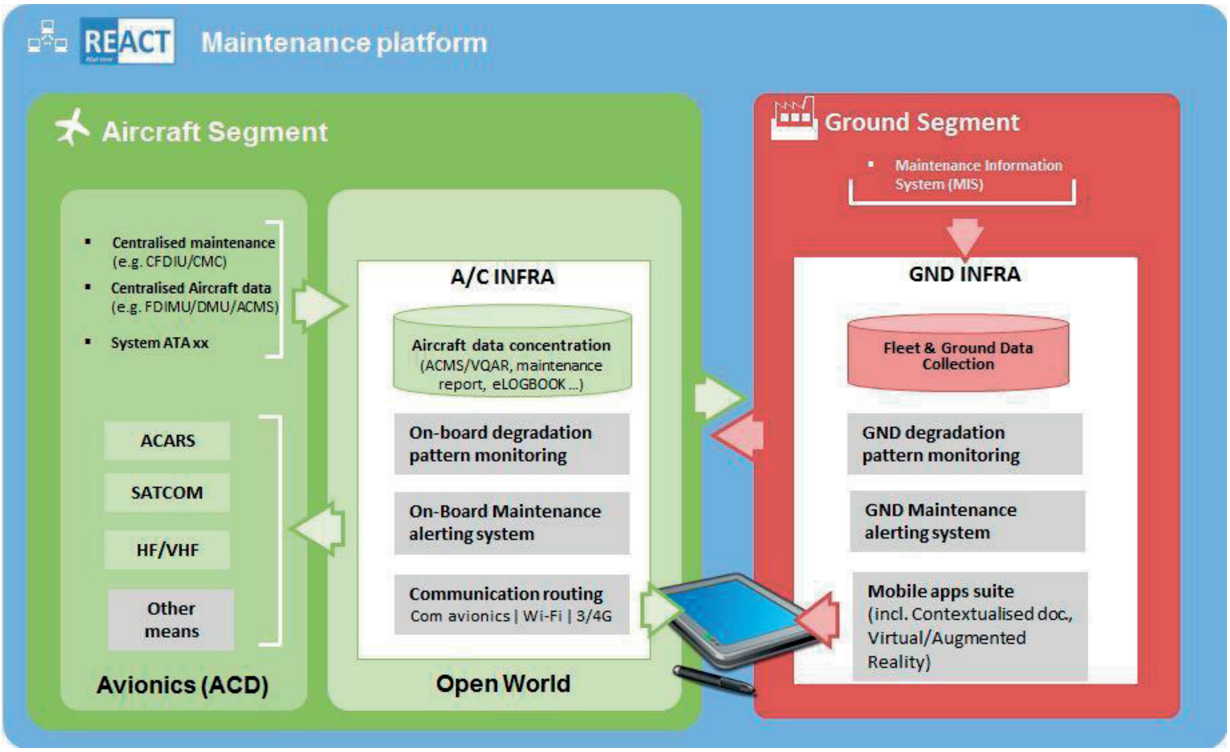

Fig. 2. REACT's generic architecture

data to be transmitted either in real-time or via gate link. This, together with the cutting-edge architecture proposed by REACT, represents a great leap beyond the state-of-the-art.

Through the extensive use of big data technologies, abnormal performance output data of selected aircraft systems and components will be recorded, processed and turned into maintenance relevant information to set up appropriate maintenance actions.

This will not only allow a better management of the maintenance resources, but also a better management of the manpower and airline's resources, like the aircrafts, the maintenance facilities and the spare components needed in the inventory to help preventing operational disruptions due to maintenance.

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