Automated System for Tracking and Evaluating Aircraft Structural Damages

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ABSTRACT

Aircraft in service are susceptible to corrosion, fatigue and accidental damages, which can be induced by service loads, environmental conditions or accidental impacts. These structural damages can be detected during a scheduled maintenance or during the aircraft operation (walkaround inspections).

After the damage detection, the Airline Technical Team performs the damage assessment based on aircraft SRM (Structural Repair Manual) instructions. Basically, the information contained in the SRM permits the operators to assess typical damages and restore the structural integrity of the aircraft by means of a simple rework or repair installation.

In order to make easy the information access, to speed up the damage assessment process and to provide damage storage and traceability the iSRM (intelligent Structural Repair Management) system was developed. The iSRM is an automated system that provides electronic evaluation for structural damages that occur during the aircraft life. Also, this web application system provides management and traceability of damages from each aircraft.

Using the system graphic interface trough web, local network and/or local computer, the Airline Technical Team will be able to identify and register all structural damages, including allowable damage, temporary allowable damage, temporary repair and permanent repair. The graphic interface provides to the user three-dimensional lightweight aircraft models, enabling smooth navigation between different aircraft parts and enabling identification of the damaged location on the aircraft.

The management and traceability of the structural damages and repairs enable the Airline Technical Team follow the damage life cycle and enable the manufacturer to identify aircraft field issues such as regions prone to corrosion, fatigue and accidental damages.

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INTRODUCTION

There are several aspects that affect the operating costs and dispatchability of aircrafts. One of these issues is the incidence of structural damages, like corrosion, fatigue and accidental damages, which can be induced by service loads, environmental conditions or accidental impacts. These structural damages can be detected during a scheduled maintenance or during the aircraft operation (walkaround inspections). When the damage is detected through periodic scheduled inspection, usually the maintenance team has enough time to apply the rework or repair procedure recommended by the aircraft manufacturer. On the other hand, when the damage is detected during the aircraft operation, the damage severity will determine if the aircraft is in a condition for safe flight or it shall be promptly removed from operation for repairing.

Seeking the safety improvement and reduction of maintenance cost and human errors, efforts are underway to develop SHM (Structural Health Monitoring) systems [1] capable of inspecting and detecting damages in real time without human interference. Therefore, these new SHM technologies [2] will lead to early detection of damages that usually were identified only through scheduled inspections.

Once the damage is detected during the aircraft operation by means of the conventional inspection methods or through SHM systems, the technical team shall perform a prompt damage assessment, determining the damage severity and avoiding whenever possible the flight delay or cancellation.

The effect of damages and repairs on the structural integrity of aeronautical structures is an aspect that must be evaluated in order to ensure the airworthiness and safe operation of the aircraft [3].

In addition to the static strength, another very important aspect to consider when analysing a damage or repair is the degradation of fatigue life of the structure. Currently, the design damage tolerant philosophy, that uses the fracture mechanics as a method of analysis is adopted to ensure the structural integrity of the aircraft.

After the damage detection, the Airline Technical Team performs the damage assessment based on SRM (Structural Repair Manual) instructions [4]. Basically, the information contained in the SRM permits the operators to assess typical damages and restore the structural integrity of the aircraft by means of a simple rework or repair installation.

SRM - STRUCTURAL REPAIR MANUAL

The SRM contains procedures for damage rework and repair that the airline must perform when a structural damage is detected. These procedures are designed by the manufacturer of the aircraft taking into account the types of structures, types and severity of damage and other information. Through SRM, an airline follows several steps in order to determine the proper disposition for each event, which can be "allowable damage", "fly-by" or "repair".

If the damage is within the limits specified in the SRM document, the airline reworks or/and repairs the aircraft in accordance with SRM instructions.

According to the damage severity, the aircraft may be returned to service without repair. This kind of allowable damage must have no significant effect on the strength or fatigue life of the structure, which must still be capable of fulfilling its design function. Allowable damage may be contingent upon minimal rework, such as blend-out, cleanup or plugging a hole. Depending on its severity, some damages are allowed only for a specific period, called “fly-by period”, in which during a number of flight cycles the aircraft can fly with the damage prior to the repair installation. For more severe typical damage, the SRM contains sufficient information to enable the operator to carry out permissible repairs.

In case of "allowable damage" disposition, some immediate actions to treat the damage that the airline must perform are specified in the SRM. After performing these actions, the aircraft is released for a number of flight cycles, until that the definitive action is done. These immediate and definitive actions are generally reworks on the damaged surface of the structure. After performing the definitive actions, the aircraft is released for operation, and must follow its maintenance plan previously defined.

In case of "fly-by" disposition, as well as in the previous case, some immediate actions to treat the damage that the airline must perform are specified in the SRM. After performing these actions, the aircraft is released for a number of flight cycles, until that the structural repair is applied. This period is called "fly-by period". These immediate actions are generally reworks on the damaged surface of the structure, on the other hand, to carry out a repair the damaged region of the structure must be removed, and recomposed through the application of a structural repair specified in SRM. After performing the repair, the aircraft is released for operation, and must follow its maintenance plan previously defined, and an inspection plan for the repair performed.

In case of "repair" disposition, the aircraft can not fly while the damage is not completely removed and the structure repaired. The SRM presents to the airline some applicable repair options to each structure and damage size. Usually, are provided options for temporary and permanent repairs. If the airline chooses a temporary repair, although a more simplified procedure, after a certain number of flight cycles, a permanent repair must be applied. After carrying out a permanent repair, the aircraft is released for operation, and must follow its maintenance plan previously defined, and an inspection plan for the repair performed.

On the other hand, when the damage is not within the limits specified in the SRM or not covered by manual, the damage shall be evaluated by the aircraft manufacturer. Return to Service Technical Team performs the damage assessment based on structural analysis and engineering judgement and a specific rework or repair design will be developed or evaluated. Finally, the airline reworks or/and repairs the aircraft in accordance with manufacturer instructions.

There are some issues in the process presented above, such as the long time spent by the airline technical team consulting the SRM and assessing the damage based on its instructions. Besides that, due to human factors, mistakes can occur during this activity resulting in an incorrect damage disposition.

Therefore, a computerized and automated system specially developed in order to characterize and assess typical structural damages and repairs based on SRM data should reduce the operation costs and produce safety benefits.

RESULTS

The iSRM (intelligent Structural Repair Management) proof of concept is a web application system able to provide to its user, the electronic disposition of structural damages based on the information currently presented in the SRM. The system also provides management and traceability of damages from each aircraft and makes easy the characterization of these, which is performed through the system graphic interface which has visualization capabilities of 3D models.

Using the system graphic interface through Web, Local Network and/or Local Computer, the Airline Technical Team will be able to identify and register all structural damages, including "allowable damage", "fly-by" and "repair". The graphic interface provides to the user a three-dimensional aircraft model (3D digital mock-up), enabling smooth navigation between different aircraft parts and enabling identification of the damaged location on the aircraft.

The management and traceability of the structural damages and repairs enable manufacturer to identify aircraft field issues such as regions prone to corrosion, fatigue and accidental damages.

First of all, the damage is detected by means of the conventional inspection methods including visual and/or NDI (Non-Destructive Inspection, such as Eddy Current, X-Ray, Die Penetrant, Ultrasound, etc.).

Using the system graphic interface, the Airline Technical Team defines the aircraft damaged structure (figure 1) and characterizes the detected damage (figure 2) supplying damage information such as dimensions, damage type, location, affected areas, etc.

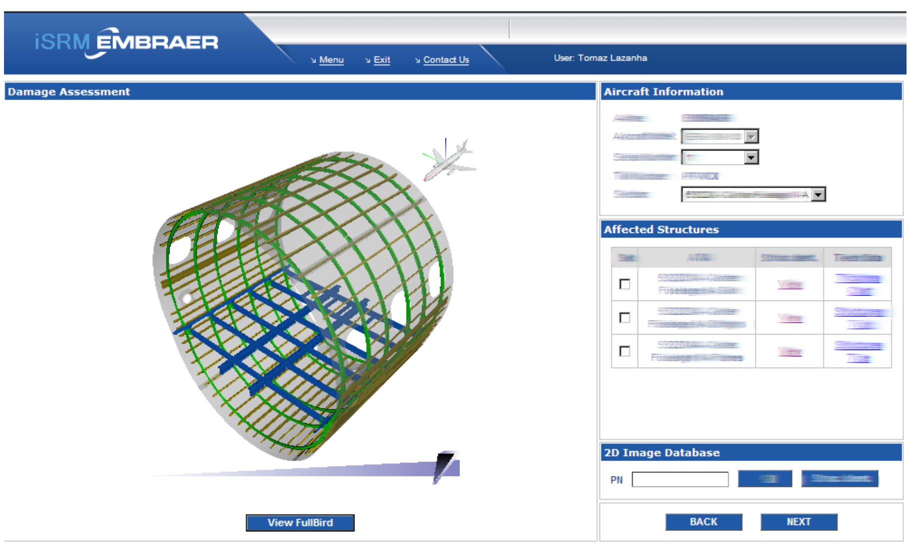

Figure 1. Graphic interface for definition of damaged structure.

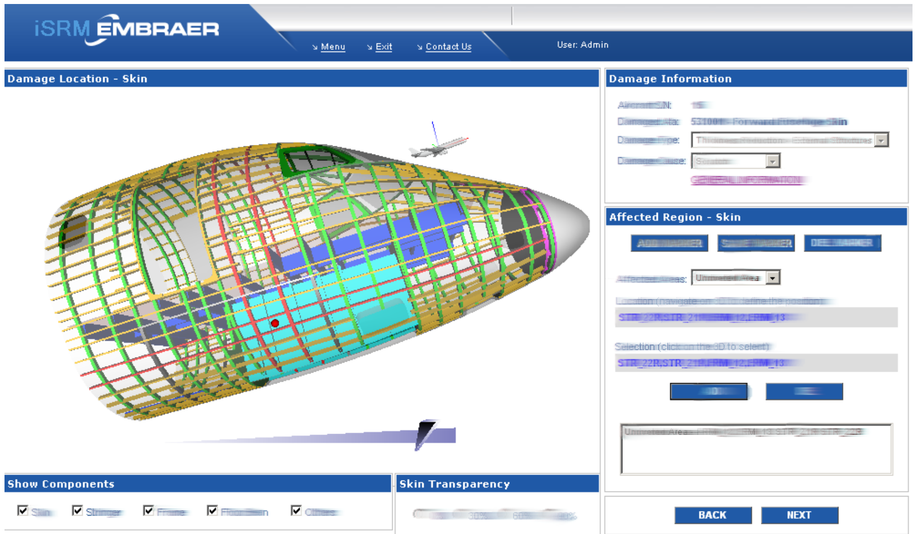

Figure 2. Graphic interface for damage characterization.

The system will assess the damage based on the damage information supplied by the user and suggest an appropriated damage disposition. This analysis shall result in an "allowable damage", "fly-by", "repair" or "contact manufacturer for specific disposition".

The damage disposition will be provided based on the already issued SRM. The system will compare the damage information supplied by the user with the limits specified in the SRM. Since the assessment will be made automatically by the system without human interference, the mistakes that nowadays can occur during SRM consultation and during damage assessment based on its instructions will be eliminated.

Besides the rework or repair procedure, the system provides, when applicable, the number of flight cycles allowed before the repair installation and the new inspection intervals for the repair location. Additionally, the system identifies when a particular damage is outside the SRM analysis rules and, therefore, should be sent to the customer support department of the manufacturer.

The process automation, besides the costs reduction, prevent human errors arising from misinterpretation of the conventional SRM.

Through the graphic interface (figure 3), it is possible to manage records and damage data that occurred in each aircraft of the fleet and thus assist in the identification of the regions most susceptible to damage from corrosion, accidental impacts and material fatigue. Reports can be generated (figure 4) with the damage location represented over the aircraft pictures.

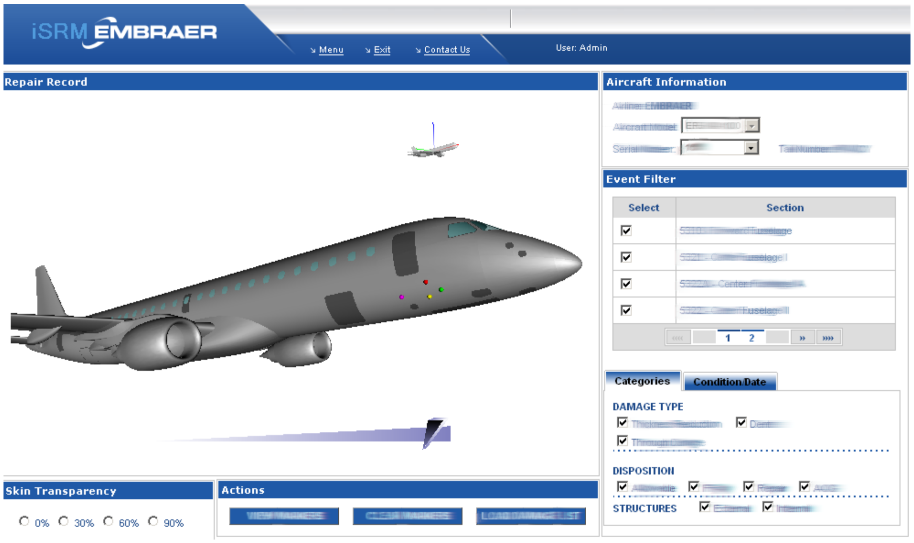

Figure 3. Graphic interface for research and management of structural damages and repairs.

Figure 4. Graphic interface for report generation.

CONCLUSIONS

The iSRM proof of concept has demonstrated the technique feasibility of developing a future system based on this prototype. Through the tests running on the system, and the simulating of the damage occurrence, it was shown many potential benefits, among which we highlight:

- Automated and faster assessment of damage occurred during the aircraft life;
- Mapping of structural damages and repairs for each aircraft of the airline fleet;

- Possibility of increasing the aircraft residual value, due to the repair and allowable damage traceability;
- Assistance in the review aging process of the fleet;
- Elimination of possible misinterpretation of the SRM.

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