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How to cope with more and more data

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How to cope with more and more data

Problem area

The last decade saw a large increase in the growth of air traffic. To stay competitive, airlines will want to continuously reduce inspection and maintenance to a minimum to allow for fast turnaround times and keep their aircraft safely flying for as long as possible before maintenance is necessary. Both Boeing and Airbus have large backlogs for the 787 and A350, indicating a continued growth of air traffic. If these rates are maintained, it can be expected that operators will have higher demands on the inspection and monitoring of their aircraft to reduce turnaround times. One likely aspect is that systems will be developed that allow for more efficient inspection and monitoring. Most likely operators would want increasingly to have monitoring carried out during flight to save time on the ground. Many structural health monitoring and related systems are being developed which probably will be implemented in the future.

The amount of data generated by monitoring and inspection systems is therefore likely to grow. One important question is how to evaluate and manage this growing amount of data to be able to take a decision in an efficient way: can an aircraft continue to fly safely or should be kept on the ground for additional inspection or maintenance.

Description of work

With the expected increase in the amount of available data, questions on decision making based on the data, reliability of the systems which generate the data, data processing and the necessity of having so much data is discussed.

Results and conclusions

Continuous monitoring by (SHM) systems will generate an increasing amount of data. This data has to be efficiently processed with attention to the relevant

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operating conditions, but also on the validity of the data, as vital decisions will be based on the data.

A "Big Data" approach may reveal possible relationships and dependencies previously not accounted for in more traditional data evaluation and in aerospace lead to a more conservative design approach, but it could also help in understanding the consequences of currently used design approaches.

Currently, there is still much development in the area of SHM and related disciplines and many questions are asked. SHM offers a possibility for increased efficiency by improving reliability, safety and reducing costs, as well as a potential change in design philosophy leading to optimized structural efficiency. The potential for improvement is large, and research into this area should yield greater efficiency for aircraft structures in the long term.

Applicability

This subject discussed in this report can be used in the definition of an approach how to tackle the increasing amount of data that will be generated in the future by structural health monitoring and related systems.

GENERAL NOTE

This report is based on a keynote presentation held at the 3rd International Conference on Advances in Structural Health Management and Composite Structures ASHMCS, Jeonju, Republic of Korea, August 23-25, 2016.

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HOW TO COPE WITH MORE AND MORE DATA?

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ABSTRACT

The last decade saw a large increase in the growth of air traffic. To stay competitive, airlines will want to continuously reduce inspection and maintenance to a minimum to allow for fast turnaround times and keep their aircraft safely flying for as long as possible before maintenance is necessary. Both Boeing and Airbus have large backlogs for the 787 and A350, indicating a continued growth of air traffic. If these rates are maintained, it can be expected that operators will have higher demands on the inspection and monitoring of their aircraft to reduce turnaround times. One likely aspect is that systems will be developed that allow for more efficient inspection and monitoring. Most likely operators would want increasingly to have monitoring carried out during flight to save time on the ground. Many structural health monitoring and related systems are being developed which probably will be implemented in the future.

The amount of data generated by monitoring and inspection systems is therefore likely to grow. One important question is how to evaluate and manage this growing amount of data to be able to take a decision in an efficient way: can an aircraft continue to fly safely or should be kept on the ground for additional inspection or maintenance.

With the expected increase in the amount of available data, questions on decision making based on the data, reliability of the systems which generate the data, data processing and the necessity of having so much data will be discussed.

Keywords: Data management, Evaluation, Monitoring, Decision making

1. INTRODUCTION

Over the next 20 years, Boeing is forecasting a need for over 39,600 aircraft and expects the number of aircraft in service to double [1] and air traffic is expected to double in the next 15 years [2]. This growth rate obviously depends on various social and economic factors, but it may be assumed that the amount of air traffic will increase significantly in the future.

With an increase in air traffic, operators will not only be expanding their fleet, but will also look into methods to increase the efficiency of their fleet.

In order to maintain structural integrity and hence ensure safety, inspections into the state of aircraft structures are still mainly carried out at scheduled intervals or when an unexpected occurrence, such as impact with ground vehicles, takes place.

Visual inspection and conventional non-destructive testing (NDT) methods, such as ultrasonic, X-ray, thermography and eddy current inspection can be used for the detection of damage in structures. However, these NDT methods can be labour-intensive and time-consuming, especially for large-scale structures and still very often allowing only “off-line”, local inspection of the structure using dedicated equipment. [3]

It is clear that an inspection method that continuously registers the state of a structure would offer improved reliability and safety if it enables to clearly define the integrity or “health” of a structure in more or less real-time. Action can be taken based on the status or condition of the structure, potentially saving cost by skipping unnecessary inspection and increasing maintenance intervals. Structural health monitoring (SHM), combines advanced sensor technology with intelligent algorithms to interrogate the structural ‘health’ condition. Different from NDT, the real-time and on-line damage detection via in-situ sensors can be achieved in SHM. The potential benefits of SHM include improving reliability, safety and reducing lifecycle costs.[3]

Currently, especially for composite structures, a conservative design approach is taken, as there is uncertainty over the failure mechanisms and damage tolerance behaviour. In case SHM systems can be developed that allow for a more detailed and accurate monitoring of a structure, a different design philosophy may employed. E.g. if a more reliable detection of impact damage can be achieved, weight can be saved by taking a less conservative approach.[4]

2. DISCUSSION

A large number of SHM systems is being currently developed which can continuously monitor the state of a structure. Due to the increasing availability of inexpensive sensors, systems will generate a large amount of data which has to be processed and evaluated in an efficient way. Filtering methods to separate events that are related to damage occurrence from normal operating conditions must be developed further. As operating conditions can vary, this must be accounted for using knowledge about operating conditions or by statistically validated measurements.

Another aspect is the evaluation of the validity of the data obtained. How can one be certain that the data generated is representative and not due to a sensor error? Human insight may still be necessary to determine if a result is, e.g., due to a sensor that came loose or an actual event during operation. Ageing of sensors can be an issue: how does e.g. an embedded fibre optic sensor behave after 20 years in service?

Material models need to be extended to deal with the complexity which is introduced when failure criteria are applied on structural level instead of coupon level. In this way, sensor results measuring complex 3D stress states in the structure can be properly evaluated.

The increasing amount of data becoming available may raise questions. If the data available cannot be properly evaluated due to its sheer size, will it perhaps raise more doubt? Using a “Big Data” approach, it may be possible to reveal relationships and dependencies previously not accounted for in more traditional data evaluation. For an aerospace structure, this could perhaps lead to a more conservative approach in design e.g. when a possible failure is predicted based on a Big Data approach, even though in actual practice such a failure may have never occurred. However, a Big data approach can also lead to a better understanding and quantification of the current design approaches by identifying details previously not noticed.

At a certain moment, sufficient data will be available to take a decision. This brings the question on how a decision will be made: in an automated way, e.g. based on a pre-established threshold, or will an human intervention always be necessary? Ideally, this decision should be taken automatically. However, there may be circumstances an automated system does not account for which a human would be flexible enough to evaluate the exception and take appropriate action.

For a decision to be taken automatically, it is necessary to be certain that when an action is taken, that this is based on the right grounds. Do the systems used provide the right data at the right accuracy? How is it

ensured that the signal from the sensor is reliable? How are malfunctions handled? How does the systems react to undefined situations? These are vital questions.
For land based structures such as bridges or buildings, an inadequate decision will probably have smaller direct consequences than that of an airborne system or other transportation systems such as trains or automobiles. Automated systems need an extensive amount of testing and validation and there will can always be a situation that was not foreseen which can lead to catastrophic situations, e.g. as occurred with a car with automated driving options [5].

As stated before, SHM has the potential to improve reliability, safety and reduce lifecycle costs. However, aircraft operators will require from new SHM systems at least the same performance as currently available systems and methods at an equivalent level of safety or better.
They will also probably prefer systems that do not increase workload for technical personnel, although it is likely that more trained maintenance staff will be necessary as complexity of systems increases [6].

Cost benefits when implementing new SHM systems should be considerable, as a large effort is necessary to have a new monitoring system qualified and certified for use in aircraft [7]. One estimate is that up to 20% of current maintenance and inspection cost can be saved by integrated on-line systems [6]. However, several disciplines (NDT, structures, avionics) are involved in the development of SHM systems and a large amount of effort is still required to have SHM techniques as well-established technologies.

3. CONCLUSION

Continuous monitoring by SHM systems will generate an increasing amount of data. This data has to be efficiently processed with attention to the relevant operating conditions, but also on the validity of the data, as vital decisions will be based on the data.

A “Big Data” approach may reveal possible relationships and dependencies previously not accounted for in more traditional data evaluation and in aerospace lead to a more conservative design approach, but it could also help in understanding the consequences of currently used design approaches.

Currently, there is still much development in the area of SHM and related disciplines and many questions are asked. SHM offers a possibility for increased efficiency by improving reliability, safety and reducing costs, as well as a potential change in design philosophy leading to optimized structural efficiency. The potential for improvement is large, and research into this area should yield greater efficiency for aircraft structures in the long term.

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