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NONDESTRUCTIVE INSPECTION PERSPECTIVES

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SUMMARY

This paper presents ideas for consideration by those concerned with commercial aircraft nondestructive inspection (NDI). The perspective is that of an individual with a background in military aircraft NDI, and important differences are indicated between the commercial NDI and military NDI activities. In particular, it is significantly more expensive to implement some new NDI technology, and therefore, in-depth cost-benefit studies for commercial users are recommended.

INTRODUCTION

Nondestructive tests have greatly improved in their ability to reliably reveal hazardous defects in aircraft structures. In addition, new testing modalities have become available to our arsenal of NDI methods. However, no test is clearly so self-sufficient that it can be relied upon by itself, even for a single type of defect. Sensitivities (probability of detection for critically significant defects) and specificities (probability that a diagnosis is correct) are functions of equipment, procedure and personnel reliability which cannot be assumed to approach 100%. Moreover, there is a great diversity of defect types and geometric configurations. Therefore, use of a single method for a single type of defect (such as stress corrosion cracking or exfoliation corrosion) is only of moderate value. Conversely, for principle structural elements and other important components of those aircraft at highest risk, the use of a full spectrum of complementary nondestructive inspection methods should be of high value. The objective in this paper is to address improving NDI technology for commercial aircraft, and to ask if the military NDI full spectrum approach contains lessons worthy of in-depth consideration by the commercial aircraft sector.

NEW NDI TECHNOLOGY RESULTS

Sacramento Air Logistics Center (SM-ALC) is one of five U. S. Air Force maintenance centers. The U.S. Navy also operates its own aircraft maintenance depots. At SM-ALC, the responsibilities of the NDI division include the inspections of:

1. intact aircraft brought in for spot checks of critical items (Analytical Condition Inspection);

2. intact aircraft and/or detached components of aircraft brought in for major maintenance, typically at four or five year intervals (Programmed Depot Maintenance);

3. components used to supply replacement parts for depot or field maintenance (MISTR).

In the past decade, at least sixteen major advances in NDI technology have been carefully evaluated for possible implementation at SM-ALC (Table 1). The studies involve complex subjects such as advanced computer engineering, laser physics and nuclear science. The goal was to provide cost-benefit comparisons of the options available by teams independent of equipment vendors. Technologies evaluated and found not to be required for implementation at SM-ALC at this time, include: laser holography, shearography, infrared thermography, x-ray backscatter, x-ray computed tomography, dual energy x-ray, neutron backscatter, and a transportable neutron radiography system tested in cooperation with the U.S. Navy. The fact that no follow-up action is planned at SM-ALC on these technologies at this time should not be interpreted to mean there will be no further interest.

The technology upgrades of most significance that have been implemented are as follows:

Advanced Eddy Current Technologies. Eddy current is recognized at SM-ALC as an extremely powerful and versatile technology and a continuous effort is made to utilize the most advanced technology. Computer signal processing is playing an increasingly important role in this field. The range of eddy current technologies implemented includes impedance type testers for surface and subsurface crack detection, phase/amplitude type testers for corrosion cracks, thickness indication, and fastener and bolt hole inspections. In addition to our extensive microprocessor controlled eddy current equipment inventory, we have auxiliary probes and transducers valued at over $150,000. We use commercially available equipment, we manufacture some equipment to meet our specific needs, and we keep abreast of computer software developments in eddy current technology taking place elsewhere, such as the current Air Force sponsored work being pioneered by Northrop.

Advanced Ultrasonic Techniques. In 1982, we introduced into service a twelve axis robotically controlled water squirter ultrasonic scan system which is used primarily in through transmission mode for locating disbonds in detached components. The unit interfaces with five different computers.

Microfocus Real-Time X-ray. Because microfocus x-ray technology provides a geometric magnification of the image on the detecting screen the resolution limitations of electronic imaging become acceptable. Two such real-time x-ray systems were put into service at McClellan Air Force Base about 1985 and computer-based image analysis has produced standard routines which minimize variations between individual radiographers.

Reverse Geometry X-ray. Instead of the normal point source and planar detector, this technology uses a planar source which is swept by the electron beam near the object, and a single point digital detector at a distance on the far side of the object. Because the point detector does not receive scattered x-rays the system offers exceptional signal to noise ratios. Images displayed on a video screen can be given a three dimensional effect by use of a second detector and the use of polarized glasses.

Film Digitization System. Equipment is being implemented that will digitize the data from standard 14" x 17" x-ray film, permit electronic image processing, and provide archival storage on optical discs. This is a step towards reduction in film archiving problems and towards an eventual Inspection Data Interpretation System (IDIS) that will provide a network for a comparative interpretation of formatted images from all complementary NDI systems.

Intact Aircraft X-ray. This system consists of a shielded bay in which aircraft up to about 78 feet wing span can be scanned radiographically using a programmable overhead gantry positioner. A yoke system holds the x-ray source - either 160 Kv microfocus or standard focus 320 Kv - on one side of the aircraft panel, and the real-time x-ray imaging device on the opposite side.

Intact Aircraft Neutron Radiography. The neutron inspection bay is adjacent to the x-ray bay, and is similar in size and mode of operation. However, in this case, the radiation source is a californium-252 isotopic source of neutrons. There are, in fact, two similar sources, one used with the overhead gantry robot for electronic imaging of flight control panels and the other used for a ground based positioner to perform film radiography of underside fuselage panels.

One advantage of the intact aircraft x-ray and n-ray systems is that they can inspect aircraft with minimal out-of-service time (i.e., spot checks or Analytical Condition Inspections on aircraft not required to undergo major overhaul). A typical scan can be completed in a total of four days, two days in the x-ray and two days in n-ray.

The systems entered operation in 1990 and performance equals or exceeds the design criteria. The first ten aircraft showed over 240 incidents of hidden moisture or honeycomb corrosion; critical information that was not indicated by other means.

Detached Component High Resolution Neutron Radiography. The Stationary Neutron Radiography System (SNRS), which has a small nuclear reactor as a neutron source, is designed to perform high resolution electronic or film imaging at a high throughput rate on detached components. There are four bays which can be used simultaneously. Three of them are equipped with robotic positioners and real-time neutron imaging equipment for parts up to a 37 foot long wing, and the fourth bay is available for inspection of pyrotechnic devices, hydraulics or turbine blades.

This system entered operation in mid-1991 and performance equals or exceeds expectations.

DISCUSSION

A question is whether experience being gained in the application of new NDI technology for aging military aircraft deserves in-depth evaluation for possible application to commercial aircraft?

Certainly the history of NDI technology development teaches us to be looking for new advances. At SM-ALC in 1940, we had only x-ray and magnetic particles. Eddy current was introduced in 1963, and the first ultrasonics was in 1967. The technology changes currently underway will be neither the first nor the last.

The motivations for improved NDI at SM-ALC include: (1) extension of aircraft life, (2) reduction of risk of in-flight mishap, and (3) an improved database for engineering activities. These are motivations that may be also of interest to the commercial aircraft sector, but specific cost benefit analyses would be necessary before conclusions could be reached.

TABLE 1

NEW METHODS EVALUATED 1980 - 1990

WITHOUT FOLLOW-UP PLANS	SELECTED FOR IMPLEMENTATION
Holography	Eddy Current - Computer Advances
Shearography	Ultrasonics - Computer Advances
Thermography	X-ray Microfocus - Real-Time
X-ray Backscatter	X-ray - Reverse Geometry
X-ray Computed Tomography	X-ray - Film Digitization
X-ray Dual Energy	X-ray - Intact Aircraft
X-ray Backscatter	N-ray - Intact Aircraft
N-ray Transportable	N-ray - High Resolution - RT