There's more to it than just maintenance.

BY NEIL RICHARDSON

The challenges faced by today's aviation industry are plenty; many relate to the performance of human beings in complex systems. Appropriate behavior of personnel is key to contributing to systemic safety, but this requires a clear understanding not only of human factors but also of the basic concepts of, and relationships between, airworthiness and maintenance. In a world where noncompliance with rules and standards is still a major issue, how many of these unsafe acts can be attributed to insufficient knowledge of how the system was designed to operate?

Defining 'Airworthiness'

Is there a gap between the maintenance program and the maintenance organization's output — that is, between airworthiness and maintenance? The foundations upon which the concepts of airworthiness are built seem to have been weakened — or to never have been fully established — and there may be a need for the industry to go back to the basics to understand the two concepts.

Problems resulting from misunderstanding the relationships within the approval system vary, but they are numerous, and they exist at all levels within organizations, from the continuing airworthiness organization — for commercial air transport, this is the role of the operator — not supplying the maintenance organization with correct information, to the technical records staff seeing their role as "just a clerk," to the maintenance technician believing that the data limits are only a guide and that a deviation can be justified based upon his or her experience. Such mindsets can result from insufficient awareness of how the system is designed to operate.

National regulations provide clear lines of responsibility for those organizations involved in managing continuing airworthiness and those involved in maintenance, yet the relationship between these requirements often is lost in translation. The operator's continuing airworthiness management organization is responsible for ensuring that a contract is in place between such organizations, and this key document should play a pivotal role in how the maintenance activity is performed. It is common, however, for the contract to focus mainly on commercial — rather than technical — aspects, and in some cases, loss of a contract is used as a bargaining tool or threat, rather than for setting out how each party will contribute to the overall objective of ensuring airworthiness.

Without the correct focus on the basic understanding of the system as a whole, myths and unfounded beliefs will prevail, exacerbated by inappropriate operator behaviors that are not in line with the contract or regulation.

What Is 'Airworthiness'?

The terms "airworthy" and "airworthiness" are used throughout global and national standards; however, none of these standards defines "airworthiness." For this paper, we shall assume the following, developed from a U.K. Ministry of Defence definition:

> *Airworthiness is the ability of an aircraft or other airborne equipment or system to operate without significant hazard to flight and cabin crew, ground crew, passengers, cargo or mail (where relevant) or to the general public and property over which such airborne systems are flown.*

As illustrated, many activities contribute to airworthiness, and the term encompasses more than just maintenance. Certain elements of airworthiness are either accomplished directly or influenced by the performance of maintenance, but in some cases, they lack a connection to the overall airworthiness management system.

The responsibility for ensuring that these elements are accomplished lies with the organization managing airworthiness. Maintenance activities that contribute to airworthiness must be performed by approved maintenance organizations. It must therefore be clear and unambiguous what is required of those organizations — something provided for by the contract.

What Is 'Maintenance'?

This sounds like a simple question, but the objectives of maintenance are varied. For example, scheduled maintenance serves to:

- Confirm the inherent safety and reliability levels of the aircraft (as determined by design);
- Restore safety and reliability to their inherent levels should deterioration occur;
- Obtain information required for redesign in light of discovered system inadequacies; and,
- Accomplish all of this at minimum cost.

The link between the two functions is the maintenance program — a continuing airworthiness requirement, which should reflect the needs of the operator's aircraft, driven by data collected via the reliability program. The maintenance organization performs the required maintenance tasks as determined by the program and contracted by the operator.

That is the concept of the system in a nutshell. Maintenance personnel often believe, however, that they are solely responsible for the airworthiness of the aircraft. This is often reinforced and perpetuated by technical representatives who manage the interface between the operator and the maintenance organization; many of these representatives have a background in maintenance rather than in airworthiness.

Personal Judgments

Experience has shown that many maintenance personnel still believe that it is appropriate to make a judgment — for example, to decide, based on previous experience, not to replace a component

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that is barely out of limits, or, conversely, to replace an item close to limits even though it has had zero degradation since it was last inspected.

The first example may be seen by some as a case of qualified, experienced staff making a judgment based on their maintenance experience, which is what they are paid to do. The second example may raise eyebrows; best practice would, of course, dictate that it be brought to the operator's attention to review the records and decide on a course of action. Given the principles of airworthiness, however, it would be difficult for an inspector within a maintenance organization — who at the time of inspection sees only a snapshot and not the full airworthiness picture — to make an accurate judgment about whether an item would remain serviceable until the next planned inspection. Such a judgment would require knowledge of the specific degradation rate and the failure modes and effects of the item. Having the next due date written on the work card would not be sufficient information from which a judgment could be made. Data such as utilization, operational profile, environmental considerations and wear rates would need to be considered, and this is something that can only be achieved by the organization managing airworthiness. Such data are fed into the maintenance program, and whether an item will remain serviceable until the next check will be determined by the maintenance program.

The inspector's contribution is to inspect at a known interval and to a pre-determined inspection standard, and to compare findings with the

Excessive wear of a jackscrew was blamed for the crash of an Alaska Airlines MD-83 in 2000.

Photos: U.S. National Transportation Safety Board

The lower end of the MD-83's jackscrew assembly was threaded through an acme nut, which was attached to the vertical stabilizer with this gimbal ring.

limits defined in applicable maintenance data, such as the aircraft maintenance manual. The inspection intensity (including the inspection aids that are used) and conditions (lighting, access and cleanliness) will effectively dictate the threshold for reportable defects. These criteria are carefully selected, based on the design criteria, the criticality of each item, and maintenance and operational economics. Inspection staff must not be permitted to deviate from such limits, unless authorized through a company procedure involving the operator.

The fatal Jan. 31, 2000, accident in which an Alaska Airlines McDonnell Douglas MD-83 crashed into the Pacific Ocean off the Southern California coast, killing all 88 passengers and crew, revealed many failings, including failure to consider degradation rates effectively. The U.S. National Transportation Safety Board (NTSB) determined that inadequate maintenance and insufficient lubrication led to excessive wear and catastrophic in-flight failure of the threads of the horizontal stabilizer trim system jackscrew assembly's acme nut.[1]

What was not considered at the time by the maintenance organization was the fact that historic maintenance on the affected item was substandard, and that, in conjunction with other failures (some the fault of the operator), the degradation rate was increasing. The outcome was catastrophic.

Insufficient Knowledge

The world of perceived or real commercial pressure can lead to well-intentioned yet potentially unsafe acts. Yet it remains unanswered how many of these acts are a result of insufficient basic knowledge of "the system." A recently overheard conversation in a restaurant between two maintenance technicians prompted a discussion that began to explore that question. To summarize the debate, one of the technicians was encouraging the other to consider becoming certifying staff.

"I would not know what to look for," said the less experienced technician. The response from his more experienced colleague was alarming: "You soon pick it up. You know what to look for and what you can get away with." The conversation continued, revealing more examples of instances in which maintenance staff made judgments based on personal experience

but clearly well beyond the limits of the applicable maintenance data. In this case, rivets as specified by the drawing were not available, so the certifier decided, while eating dinner, that he would install "alternatives." This behavior begins to move the degradation curve away from what is expected, making future judgments potentially lethal.

Was this being unprofessional? Some would argue yes, but how many other technicians in the organization would have acted in the same manner? Did the maintenance organization fail the technician by not providing the right parts? It would appear from the conversation that this was the case. Would the customer have reacted inappropriately if the technician had behaved assertively and not agreed to certify the task? Recent experience indicates that this is not unheard of. To ask a rhetorical question, to what extent did the operator, the maintenance organization and/or the technician not understand the basic principles of airworthiness?

Many issues that are seen today could be linked to this gap in our knowledge. Further examples:

- Using the classic sign off "SATIS" (satisfactory), which means little to the continuing airworthiness management organization when trying to determine degradation rates — as opposed to recording measured dimensions, tolerances and so forth;
- Considering "greasing" to be a mundane task, rather than one that prevents a failure mode of a possibly critical safety item;
- Providing parts directly to the technician from the operator, bypassing the process — optimally performed by a maintenance organization or repair station — of checking a purchase order and inspecting the parts; and,
- Applying pressure on the maintenance staff to not "look too hard" or "snag" too much.

All of these "minor" transgressions ultimately lead to a change in the degradation rates or the economic basis of the maintenance program. Reliability, based upon analysis of data and maintenance findings, should detect trends, but if defects are being "let go," then the validity of the data is flawed, undermining the trends, and the effectiveness of the overall maintenance program. Quite simply, the system assumes — and is predicated upon — the maintenance organization fulfilling its responsibilities to the contract and to the standard. If the operator requires a different standard to be applied, this must be reflected in its maintenance program, thus putting the responsibility in the right place.

Bring into the equation the organizations that manage lease hand-backs on behalf of the operator, and the need to understand the basics becomes even more evident. A recent event over Clacton, England, involving a Boeing 737 on a post-maintenance check flight appears to highlight this need. During the hydraulic power-off test, which was required because the elevator tabs had been adjusted, the airplane entered an unexpected descent — at one point, the descent rate hit 21,000 fpm. While the final report on the event has yet to be issued, an interim report suggests that the interface between the operator and the maintenance organization, which appears to have been managed by a third party (the lease hand-back organization), could have been handled more effectively. Would a more comprehensive understanding of the principles of the system by personnel and organizations have influenced their behavior and therefore the outcome of the event?

Closing the Gap

Many options appear open to industry; for example, the aircraft maintenance license requirements could be enhanced to include an airworthiness module that explores the approval system, the concepts of airworthiness, the associated responsibilities and how these are achieved. Similarly, degree courses could include the same information. For existing members of industry, maintenance organizations and operators could include such a module in their induction training; certifying staff could receive continuation training or authorization issue/renewal training. Guidance material could be developed to highlight the fact that the technical representative fulfils a continuing airworthiness function and any maintenance bias must be tempered.

It would appear that there is plenty of room for maneuvering by the personnel and organizations involved to bridge the gap between airworthiness and maintenance.

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Note

1. NTSB. Accident report no. DCA-00MA023. Jan. 31, 2000. The accident report was the subject of the February 2003 issue of *Accident Prevention.*