

BY CAROL E. GILES

# The **ABC**s of Aviation Maintenance Manuals





Paper manuals are giving way to digital formats, but accuracy, balance and clarity still are essential.

If I close my eyes and think back real hard, I can remember when I was a newly certificated aviation maintenance technician (AMT).

Armed with my airframe and powerplant certificate issued by the U.S. Federal Aviation Administration (FAA), I hired on at a regional carrier in Alaska. If this article were a movie, a flashback would show my first day on the job and me standing on the hangar floor, clueless, with no training on company procedures, no knowledge about the operator's general operations manual. Still, I had a task: Clean the engine fuel nozzles and check them for spray patterns.

"Roger that," I thought as I located the company's technical manuals. They were spread across a workbench, looking like a giant cross-wise Rolodex. I flipped through the dog-eared pages to find the section on fuel nozzles. Check. I completed the task; I was ready for the next one.

That was then. Today, with the aviation industry's heightened level of safety awareness, tremendous focus on mitigating risk and safety management, greater knowledge of maintenance human factors, as well as much improved practices and procedures, writing the movie scene for an AMT's first day would be vastly different. Further, there have been dramatic advancements in aviation maintenance manuals (AMMs) — from technical manuals to company manuals.

Manuals formerly printed are now largely in digital formats and can be stored in the cloud, accessed through a company portal, often loaded on a personal computer or tablet with revisions pushed to the device. While many tasks involve accessing multiple sources, such as airworthiness directives and service bulletins, as well as manuals, thanks to digital technology, the days of AMTs needing to search through six-plus pounds (or kilos) of paper are becoming a thing of the past. Who knows? With the advent of new electronic devices, pretty soon there may be an app that displays technical manual information on an AMT's wrist.

Since that day cleaning engine nozzles, I have thought about manuals and procedures from several perspectives — first as an AMT on

the hangar floor, next as an FAA airworthiness aviation safety inspector overseeing air carriers and repair stations, then as an FAA executive developing and reviewing regulations and policy, and now as an aviation consultant with exposure to operators and repair stations around the world.

All that I have seen underscores the importance of AMMs to aviation safety and efficiency, and the paramount importance of the "ABCs" of maintenance manuals — their accuracy, balance and clarity.

AMMs must be accurate, balanced and clear. The consequences of poor technical and operations manuals can be costly — in lives, in operational efficiencies, in time and equipment, and in loss of reputations. To be sure, inadequate manuals can also get operators and maintenance and repair organizations into trouble with the regulator.

Estimates vary, but according to the U.S. National Transportation Safety Board (NTSB), approximately 60 Federal Aviation Regulations Part 121 accidents between 1990 and 2011 involved maintenance as a cause or factor. According to the International Air Transport Association's *Safety Report 2013*,<sup>1</sup> between 2009 and 2013, maintenance events accounted for an average of 10 percent of threats that led to 432 aircraft accidents worldwide.

One accident in particular highlights the importance of AMMs. On Jan. 8, 2003, a Raytheon (Beechcraft) 1900 crashed on takeoff at Charlotte Douglas International Airport in Charlotte, North Carolina, U.S. The crash killed two crewmembers and all 19 passengers. The NTSB<sup>2</sup> determined the accident's probable cause was loss of pitch control during takeoff and said that "the loss of pitch control resulted from the incorrect rigging of the elevator control system." The investigation found that an AMT did not follow procedures and bypassed steps in the rigging procedure.

Not following procedures, but instead aligning with workplace norms — expected but unwritten ways of doing things — is one of the "The Dirty Dozen,"<sup>3</sup> the 12 human factors



elements that contribute to maintenance errors identified in the 1990s by Transport Canada. There can be any number of reasons for not following procedures. William B. Johnson, FAA chief scientist and technical advisor, maintenance human factors, says, “All too often, there is insufficient root cause analysis to determine why there was a failure to follow procedures.”

Most cases that involve manuals and maintenance errors stem from the lack of one or more of the ABCs. Sections of a manual may not be accurate; the manual may not be balanced with sufficient information or have too much information; or the manual (or portions of it) may not be clear, or may be so incomprehensible as to be unusable.

### Accuracy

Accuracy, of course, is the first priority in writing manuals. A well-known instance of a manual inaccuracy was revealed in the NTSB’s investigation of the Aug. 26, 2003, Colgan Air Flight 9446 crash into water near Yarmouth, Massachusetts. The investigation found that the illustration of the forward elevator trim tab cable drum was reversed in the Beech 1900D AMM.<sup>4</sup> The mechanic completed the task by following the illustration, and that led to a reversal in the action of the elevator trim system, and the crash. The two pilots perished. Raytheon quickly revised its manual.

The accuracy of the information contained in AMMs is extremely important and can limit maintenance errors. A study<sup>5</sup> by U.S. National Aeronautics and Space Administration (NASA) researcher Barbara Kanki and her colleagues found that procedural errors, defined as any information-related errors involving documents, were implicated in 44 to 73 percent of maintenance errors, with incomplete and incorrect documents having the highest ranking.

Accuracy, to an organization, also means making the manual your own by customizing generic content. I tell operators that the old saying “write what you do and do what you write” is spot-on when it comes to manuals. Many operators purchase off-the-shelf manuals and make half-hearted attempts to make them their own. I have seen

published manuals that still contain lines that say “Insert Company Name.” Ownership of processes that go into an operator’s manual is a must. Further, the processes must be a custom fit.

Accuracy must be carefully watched when translating information from a manufacturer’s maintenance manual to a task card or other technical maintenance instructions. Here’s a cautionary tale: A repair station was transcribing maintenance tasks from an engine maintenance manual to its standard operating procedures in the repair station manual. The engine manual, which itself was confusing, required an additional step in an inspection process.

The step said that if the component was out of limits and didn’t pass the first level of measurements, but was still repairable and could be re-measured, then the component could be put back into the engine. The repair station’s quality engineer, who was responsible for transcribing the engine maintenance manual steps into the repair station’s standard operating procedures, left out this part of the instructions, which led to improper repairs.

As you would expect, the consequences of this mistake were huge, forcing recalls and self-disclosures. Both operators and maintenance providers should have a robust quality assurance department to review the results of revising manuals from the original equipment manufacturers (OEMs) as well as their own revisions to task cards and engineering orders. Systems must be in place to ensure manual procedures are checked and cross-checked for accuracy.

### Balance

Having a “right-sized” or balanced AMM also is imperative. But, how little is too little, and how much is too much? It is essential for manual writers to capture what is important to complete an operation or task, and yet not overburden the user with too much information.

In reviewing Aviation Safety Reporting System (ASRS) reports submitted by AMTs, NASA’s Kanki and her colleagues found that the most frequently cited deficiency in maintenance documents was missing information.<sup>6</sup>



# Balance

The other extreme of too little information is what I call the “Band-Aid syndrome.” Many AMTs have used general operation manuals or operator maintenance manuals that appeared to grow beyond control. Every time a problem or issue arose, information was added to the manual to address it. These oversized manuals grew from what likely started as a good set of operating procedures, but as the operation expanded or as errors increased and events occurred, the manual became a collection of reactionary “fix-its” or Band-Aids.

What should really take place after an error or event is a reasoned risk analysis of how and why it occurred, determination of the shortcomings, and identification of what, if anything, should be revised in the manual to complement a systemic corrective action. The revision may result in a downsizing of the manual and the elimination of confusing or contradictory information.

The same principle of balance — not too much but not too little — can be applied to an operator’s quality department when generating task cards. I have witnessed occasions when maintenance errors occurred, and the answer from the quality department was to build a non-routine task card to make sure the error didn’t occur again — or to at least reduce the risk. Yet that adds to the work package and can, in some cases, induce another set of errors.

It could be that, after a thorough risk analysis, a non-routine task or a revision to the manual may be the answer or part of a bigger corrective action that can include training and other changes. The point is to take a balanced approach when it comes to developing operating and maintenance manuals, always keeping in mind that too much of a good thing may just be too much.

## Clarity

When an operator or a manufacturer develops manuals and procedures, considerable attention is required to ensure the information and instructions are not misleading or confusing. “Difficult to interpret” was also cited as a leading problem in the ASRS report research by Kanki and her colleagues.

Manuals must be clear and concise. Much research has been done in this area, notably by Colin G. Drury, lead author of a paper titled “Writing Aviation Maintenance Procedures That People Can/Will Follow.”<sup>7</sup> This 2013 publication follows the Documentation Design Aid developed in the 1990s that provided a template and assistance to manual writers.

Clarity in manual and technical documentation is both a major challenge and a top priority. Further, manuals should be designed and written through a process that considers the execution phase of the task or procedure. The same goes for the workflow that makes up procedures, another target-rich environment for maintenance errors. If a task card or an engineering order has a confusing workflow or step-sequencing that does not make sense to the AMT, the likelihood of an error in executing that task or procedure is greater.

Of course, it is human nature to look for more efficient methods to do work. There are mistakes that arise all too often from the tendency to revise existing procedures to make them more efficient or to flow more smoothly at the flight line or on the hangar floor. Additionally, there may be a desire to avoid involving the quality department on the revision. These are not necessarily intentional errors but they are insidious, since AMTs may not realize they are actually revising a procedure. By repeatedly performing the same task or procedure over time, it is easy to incorporate shortcuts, combine tasks or accomplish tasks out of order, because it makes the job easier or (seemingly) more efficient.

Years ago, on an inspection walkthrough of the hangar of my assigned air carrier, I saw a technician get an engineering order and task card from “upstairs” engineering management, and before he was through with the job, he revised the task’s workflow without going back up to engineering to get the procedures revised.

When I asked him what he was doing, he said, “Well, you can’t get this part off without taking this other part off first.” It was only when

I “suggested” that he take it back to engineering to get it revised that he understood both the regulatory and safety implications.

When an operator or a manufacturer develops manuals and procedures, a considerable amount of attention is required to ensure that misleading and confusing information and instructions are eliminated. Developing and revising AMMs, as noted, requires coordination of multiple expert resources within an organization. Engineers, technical writers and technical and customer support all must integrate their respective information and data to provide the necessary information for a well-written manual. This also means establishing controls, such as document checklists and review boards consisting of the right technical disciplines. Once the manual is published and in use, a customer-feedback program and methods to validate and track the feedback are essential to keep the contents up-to-date, clear and usable.

AMTs must have a way to report problems up the chain of command to the operator and then from the operator to the OEM. FAA’s Johnson says these systems are not as mature as they should be. It is essential for maintenance personnel at all levels to be encouraged to properly report a problem whenever there is one.

At that hangar in Alaska years ago, I used an open-end wrench to remove the engine fuel nozzles for cleaning. I was proud of my tools, and over the years, I collected quite a few. What I didn’t know then, but know only too well now, is that the most important safety tool — next to my training, expertise and experience — was right there on the workbench — the AMM. Manuals are vital tools to assure aviation safety and efficiency, so we must make sure they are as accurate, balanced and clear as possible.

Finally, as essential as the proper execution of prescribed procedures — which means using the manual — is doing so every time. And, if something is wrong, incomplete or unclear, do not do your own fix or workaround; take it to the quality department or engineering or the person responsible for the process. ➔

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## Notes

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