Dr. Robert Baron is the President and Chief Consultant of The Aviation Consulting Group. He performs extensive work in his core specializations of Human Factors (HF), Safety Management Systems (SMS), Crew Resource Management (CRM), and Line Operations Safety Audit (LOSA). He consults with, and provides training to, hundreds of aviation organizations on a worldwide basis.

Failure to Follow Procedures

In 2007 an American Airlines MD-82 experienced an in-flight engine fire requiring a turnback and emergency landing in St. Louis. The NTSB investigation revealed that a component in the manual start mechanism of the engine was damaged when a mechanic used an unapproved tool to initiate the start of the #1 (left) engine while the aircraft was parked at the gate at STL. The deformed mechanism led to a sequence of events that resulted in the engine fire, to which the flight crew was alerted shortly after take-off. Fortunately there were no injuries or fatalities.

In 2003 an Air Midwest Beech 1900D experienced a loss of control on takeoff from Charlotte-Douglas International Airport. The NTSB investigation revealed that overloading and an aft CG combined with incorrect rigging of the elevator were causal to the accident. The incorrect rigging was attributable to an AMT skipping steps in the full rigging procedure because he deemed the steps “unnecessary.” A functional check was not conducted, nor was it required, at the time of the accident. In this case all occupants (2 crew and 19 passengers) received fatal injuries.

These are but a few examples of the significance of the problem; deviations from approved procedures continue to be a leading cause of maintenance-related aircraft accidents. These unfortunate accidents are largely symptomatic of deeper, underlying problems in the aircraft maintenance domain. While it might be easy to fault each accountable AMT for “pulling the trigger” on these accidents, there are usually other antecedent variables that come into play long

before the final active error. For instance, deviations may stem from factors such as time pressure, stress, fatigue or lack of resources. These factors typically do not occur in isolation but are linked together and may increase the likelihood of skipped steps, signoffs without verification, or continuing a job without the correct tools or equipment.

Ambiguous or confusing maintenance documentation may also contribute to procedural deviations. In 2003 a Colgan Air Beech 1900D, with just the pilots aboard, crashed shortly after takeoff due to a reversal of the elevator trim system. Although there were a number of links in the causal chain, one of those links included a pictorial error in the aircraft maintenance manual. Specifically, the elevator trim drum graphic was incorrectly depicted, which if followed, would cause a reversal of the action of the elevator manual trim system. That is exactly what happened. Compounding matters further, a functional check, which would have detected the error, was not accomplished.

To date, some studies have been conducted in the area of maintenance documentation. For instance, NASA researcher Barbara Kanki and her colleagues found that procedural errors, which are defined as any information-related error involving documents, have been implicated in 44% to 73% of maintenance errors. The three most problematic areas identified were inspection and verification issues (34%), incompleteness of the documents (27%), and incorrectness of the documents (22%). Similarly, in a study of 458 ASRS reports submitted by AMT's, Kanki and her colleagues found that the most frequently cited maintenance document deficiencies were missing information (48%), incorrect information (19%), difficult to interpret (19%), and conflicting information (19%). Another study by Wichita State University researcher Bonnie Rogers and her colleagues investigated Publication Change Requests (PCR's) by AMT's on the types of errors found in aircraft maintenance manuals published by four manufacturers. Results

showed that the majority of PCR's related to procedures found in Flight Controls, Landing Gear, and Powerplant systems. The highest percentage of PCRs involved Procedural Errors (42.5%) followed by Language (29.9%), Technical (16.5%), Graphic (8.1%), and Effectivity (n/a). Common procedural errors were categorized as Step(s), Ordering, Alternate method, Check/Test/Inspection, Caution/Warning. Language errors included typographical errors (Typos), grammatical errors (Grammar), a need for clarification of the information (Clarity), and inaccurate information within a step (Incorrect).

Based on the above data, it is clear that maintenance documentation may in and of itself be part of the overall problem in terms of procedural deviations. However, these documentation deficiencies should not be viewed as a shift of blame from the AMT to the manufacturer. AMT's are still doing some things "their own way" even when the documentation is considered effective and comprehensible. A major reason for this may include shortcutting to save time on perceived "unimportant steps." Other reasons may include complacency and norms. These are factors that can be somewhat easier to mitigate at the person level as compared to organizational factors such as pressure, fatigue and lack of resources, which can require a paradigmatic shift in the overall safety culture of a company.

Countermeasures

Person Level

Procedural deviations is such a hot topic right now that the FAASTeam (www.faasafety.gov) has introduced a new online course to specifically address the topic. Entitled, "Failure to Follow Procedures-Inspection," the course highlights the consequences of failing to follow procedures with specific emphasis and best practices presented in the areas of installation, inspection, and

maintenance. The course is case based, free of charge and is an excellent starting point for AMT's who want to increase their awareness of this important topic.

Additionally, AMT's should maintain an awareness of the consequences of intentional procedural deviations and violations. Keep in mind that some of the biggest problem areas are skipping steps, signoffs without verification, or continuing a job without the correct tools or equipment. Also, I would be remiss if I did not make special mention of the consequential effects of skipping a required functional/operational check. Not only is this step a required component of many tasks but it is also, in many cases, the last chance to trap any errors that may have occurred in the job completion process. I estimate that at least half of all maintenance-related accidents occurred with a corresponding omission of a functional/operational check. Think about this the next time you decide to skip this check in the interest of time. Those extra few minutes could save you your job, an aircraft and even a few lives.

Organization Level

When speaking of the organization, we will consider this to be employees acting in upper and middle level management positions. Although you may feel that, due to your distal relationship to the front line, your decisions and actions may not be consequential in an accident chain, think again. Some of the most vivid aviation accidents have been propagated by flawed management decisions, sometimes referred to as latent errors. If you want a good example just go back to the Challenger space shuttle launch in 1986. The unpropitious decision to launch was influenced by a social psychological phenomenon known as groupthink. Yes, even NASA can make bad decisions. And those are the same types of flawed decisions that can occur at your maintenance facility.

Thus, management also needs to be very cognizant of its influences on the front line. You are

the company leaders that may create that pressure, fatigue and lack of resources. This may happen with, and sometimes without, your own awareness. Step back for a moment and rethink to yourself what the possible outcome might be if you continue to pressure your AMT's with inappropriate deadlines. Think about the typical compounding effects of fatigue. Or how about those resources that you keep holding off on providing because, even though your staff has been complaining about them, you think that a reactive approach will be cheaper in the long run. How do you think these things will affect your line personnel? It will typically lead them to procedural deviations and violations. Also, keep in mind that simple exhortations such as "make sure you always do a functional check" will not be effective. Organizations need to emphasize to their AMT's, in an ongoing and holistic manner, the critical importance of following approved procedures.

Manufacturer Level

As mentioned previously, evidence has been found to indicate that there are a number of problems with manufacturers' written procedures. Until documentation issues such as missing information, incorrect information, difficulty in interpretation, and conflicting information are resolved, it will be difficult to sell the idea of following approved procedures to AMT's on a far-reaching basis. Thus I implore manufacturers and AMT's to work together on this issue. AMT's should continue to identify and provide PCR's to manufacturers and manufacturers should realize that their documentation can be a significant contributor to procedural deviations. You should step back and realize that many of the tasks in your maintenance manual have been written by engineers who may have never actually performed the procedure on the real aircraft. The end result is a procedure that is unrealistically transferable to a practical working environment. This in turn could account for an AMT making up his or her own way of

performing the task.

In summary, I hope that this article helps to create an awareness of one of the most problematic areas in aircraft maintenance today. As with many other human performance issues, procedural deviations usually do not occur in isolation but instead are a confluence of various factors. These factors include the person, the organization and the manufacturer. No doubt, a healthy safety culture will help to curtail some of these deviations.