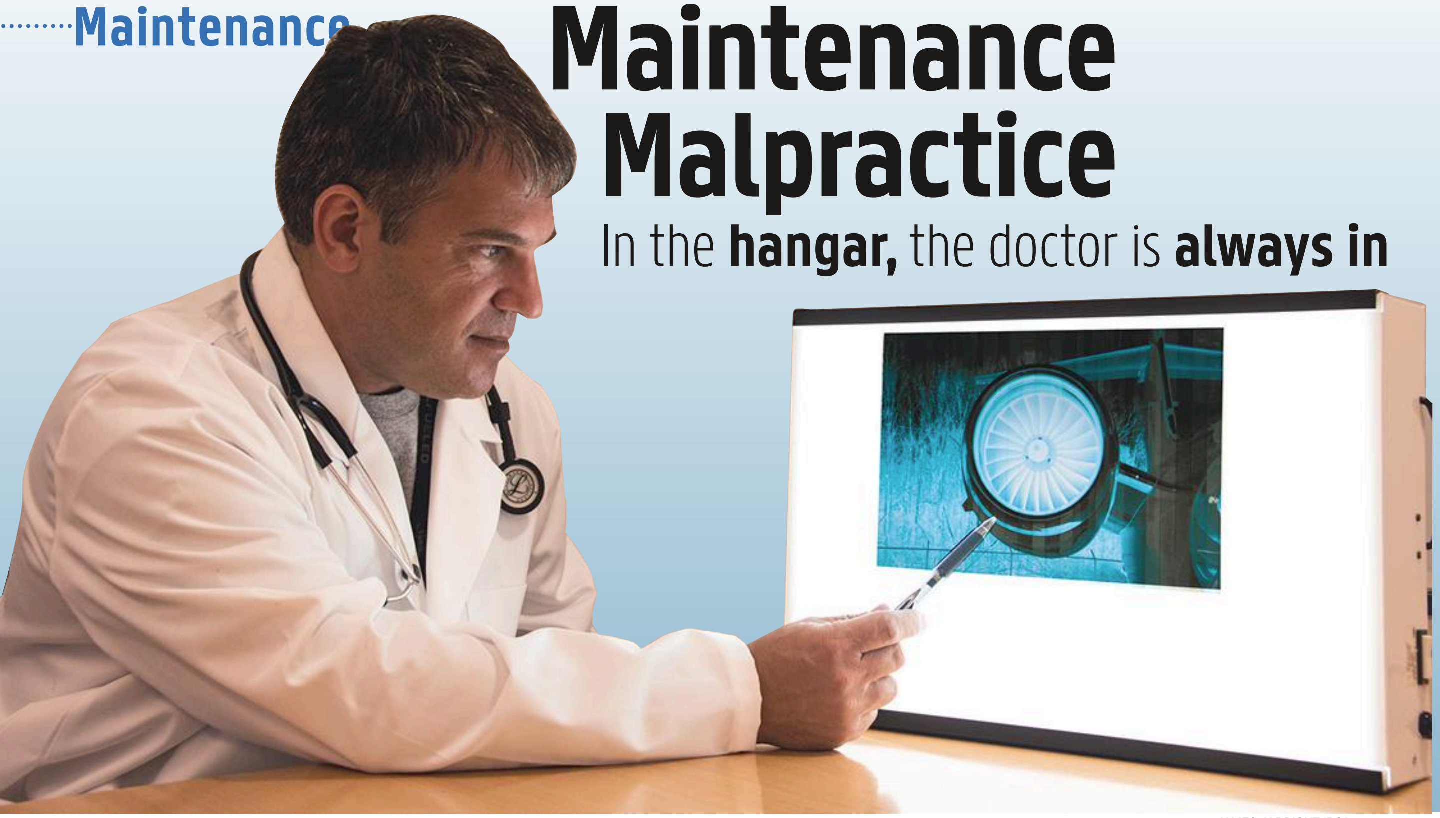
Maintenance Malpractice

In the **hangar,** the doctor is **always in**



JAMES ALBRIGHT/BCA

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It seems all airplane technicians have a bit of "shade tree mechanic" in their DNA, and that's a good thing. The ability to quickly diagnose a problem and come up with a solution is a valuable skill, even when you earn your living working on multimillion-dollar aircraft.

However, not all of an auto mechanic's tricks should be employed in an airplane hangar. The temptation to improvise and cobble together fixes out of scrap bits and baling wire, for example, should be resisted. In fact, there should be no comparison at all between an airplane technician and Good ol' Joe, the flivver magician.

Once a person earns an Airframe and Powerplant (A&P) license, a better career comparison would be to a surgeon. An A&P requires extensive classroom and practical training. Like the surgeon, the A&P must continue his or her education and treat every "patient" as if lives are at stake. Yes, the patient is an airplane, but lives of those within are definitely at risk.

With either profession, mistakes due to personal shortcomings can be labeled a form of malpractice. No A&P begins a maintenance task with the thought of sabotaging an airplane. And yet we continue to have mishap after mishap in which a botched repair or wrongly installed part are found to be a factor, though rarely does cause seem directly related to effect.

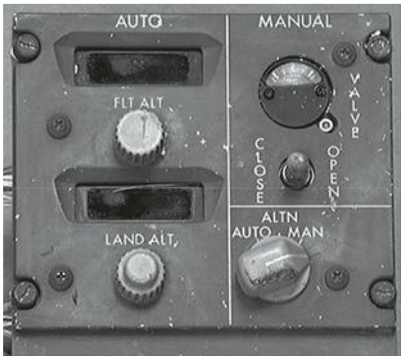
Some mechanics do complete tasks for which they are not properly trained. Some show up for work without adequate rest but manage the day's work without incident. Others take shortcuts here and there, because they think they know better than the airplane's manufacturer. And there are those who "turn wrenches" and then assume another role, inspecting and approving their own work. They get away with all that . . . until they don't.

It is time every aircraft mechanic, and all who manage and employ them, take another look at these issues with an eye toward elevating the A&P license to the status of their medical peers. Consider it an M.D. in aircraft maintenance.

Issue One: Training

We take it for granted that a medical doctor's education continues beyond medical school. Even those who don't specialize must stay abreast of recent discoveries and innovations. Pilots are also expected to have a broad range of knowledge to be considered truly prepared for flight. Why should we allow an aircraft technician's education to stop upon the award of an A&P license?

For example, a competent A&P can change the wheel brakes on just about any aircraft given the right manuals and tools. But it takes an A&P with a firm understanding of carbon-fiber-reinforced carbon (carbon-carbon) chemistry to spot the cause of some types of brake damage. Both can accomplish the task, but the mechanic with the intellectual curiosity to study harder can be a lifesaver. Just about every facet of aircraft mechanics can benefit from this extra step of training, while a lack thereof can result in a form of maintenance malpractice that can be deadly.



Boeing 737 pressurization panel, from Hellenic Republic Air Accident Investigation & Aviation Safety Board Aircraft Accident Report, Helios Airways Flight HCY522

On Aug. 13, 2005, a Helios Airways Boeing 737 crew complained about a leaking service door seal. That evening a mechanic found no defects on the door seal and performed a pressurization check by applying maximum pressurization until the safety valve opened at 8.25 lb. per square inch (psi). He reasoned that if the cabin could take maximum pressure, it had to be OK.

The correct procedure would have been to bring the cabin to 4.0 psi and time the pressurization loss to 2.5 psi. Since the mechanic was simply operating on his own without the benefit of the step-by-step Boeing procedure, he left the pressurization controller in the "manual" mode, leaving the aircraft's outflow valves partially open.

The next day Helios Flight 522 departed Larnaca Airport (LCLK), Cyprus, bound for Athens-Eleftherios Venizelos International Airport (LGAV), Greece. It never arrived. The flight crew missed the improperly set pressurization controller switch and made several critical mistakes that led them to climbing to altitude unpressurized. Everyone on board passed out and the aircraft flew on autopilot until it ran out of fuel and crashed. Of course, the mechanic's mistake alone did not cause the deaths of all 121 people on board, but it was a factor. If he had a better understanding of the complexities of aircraft pressurization and human physiology, he might have been less cavalier about applying his own system check. He would have then been more likely to open the book to the Boeing procedure and more methodical about following each step along the way.

Ailment: Aircraft mechanics do not always get type-specific training and yet can be authorized to work on systems for which they do not have a complete understanding.

Prescription: A truly professional aircraft technician never stops learning and is always seeking to understand the "why" behind every task. That education should encompass all aspects of flight, not just the mechanized or systems portion.

NTSB

Eurocopter AS350 nut and split pin on fore/aft servo input rod

Issue Two: Fatigue

Even the best surgeon's skill in an operating room can be compromised by fatigue, which is why they, like pilots, are expected to be well rested before duty. Moreover, commercial pilots have limits on the number of days of duty as well as the hours flown during specific time spans. But what about limits for aircraft mechanics?

They can always take a break whenever they feel tired, so no problem, right? Yet, a technician who serves as an airplane's only mechanic is often expected to be "on call" and show up whenever the airplane breaks. We tell the mechanic to take frequent rest breaks and to call it quits when tired. But the impact of fatigue on performance is not always evident in the moment.

The margin for maintenance error tends to narrow when a helicopter is involved. And when that margin is exceeded, the results can be deadly, as was the case with N37SH. On a beautiful afternoon in early December 2011, the Eurocopter AS350 lifted off from Las Vegas McCarran International Airport on a twilight tour of the Hoover Dam and the Vegas strip. Just minutes from the dam, the aircraft experienced a sudden climb and turn, followed by a rapid descent, and then crashed into a ravine, killing the pilot and all four passengers.

It was the fourth flight since the helicopter underwent maintenance the previous day. A mechanic had replaced the fore/aft servo, which sends pilot control inputs to the main rotor. The servo rod is secured with a bolt, washer and nyloc (self-locking) slotted nut. A split (cotter) pin is used to prevent the nut from backing off. When reassembling the parts, the mechanic reused the same nut. It appears he misjudged the nut's locking capability and forgot or improperly attached the cotter pin. A quality assurance inspector missed the errors and signed the aircraft off as airworthy. After the fourth flight the nut backed off, the servo rod detached, and the helicopter became uncontrollable.

Since the mechanic had accomplished this task many times, as had the inspector, how could they have made such serious mistakes? A look at their duty times provided the needed clues. While both reported close to normal total sleep hours in the previous days, both had changed from midday to early morning work shifts. Furthermore, by the time the inspector completed the inspection, he had been on duty for 14 hr. Research shows that adjusting for changes to an early morning shift, known as phase advance, takes longer than doing so when moving from a day to a night shift, or phase delay. Inconsistency in work shift has been shown to be a factor associated with the development of fatigue.

Ailment: Tired mechanics, like pilots, make mistakes. Muscle memory helps when completing routine tasks, but when fatigued, steps can get skipped. Our eyes tend to see what they want to see and only an alert brain can correct these "oversights." A mechanic is no less susceptible to these quirks of human nature than are pilots. And yet there are no regulatory rest and duty limits for mechanics.

WIKIPEDIA

American Airlines Flight 191 moments after takeoff.

Prescription: Organizations should voluntarily institute rest and duty time limits for mechanics, similar to those used for pilots.

Issue Three: Shortcuts

Most hospitals today have instituted medical versions of Crew Resource Management (CRM) to prevent procedural shortcuts and improvisation. Pilots tend to be checklist-oriented because the effects of missing important steps can be disastrous. Mechanics, on the other hand, are often rewarded for saving time and money for thinking — and venturing — outside the box.

When replacing a spark plug on a late-model sports car, for example, a shade tree mechanic can often find a faster way than the manual suggests. The consequences of such an action are limited to a car that won't start or might need a second tune up sooner than expected. The stakes are much higher when the vehicle in question is an aircraft. Shortcuts are possible, of course. But the manufacturer should at least get a vote. But sometimes the aircraft operator can conspire with the FAA for a shortcut outside design considerations, thereby denying that vote.

American Airlines Flight 191 fell prey to a company instituted maintenance shortcut in 1979. The McDonnell-Douglas DC-10's left engine broke loose during takeoff from Chicago-O'Hare International Airport (KORD), Illinois. The departing engine severed several hydraulic lines and caused two sets of spoilers on that wing to retract. The aircraft rolled into its dead engine and never recovered.

Those were the flight events, but they did not initiate the accident. That began two years earlier when the carrier came up with a quicker way to comply with a Service Bulletin to the engine pylons. As it turned out, an operator could save over 200 man-hours if using a forklift and keeping the engine attached to the pylon. This was contrary to the manufacturer's recommended procedure to treat the engine and pylon in two separate steps.

The airline asked the manufacturer for the center of gravity of the engine and pylon combination so as to determine where to position supports. The airframer supplied the requested data but also issued an objection: "Douglas would not encourage this procedure due to the element of risk involved in the remating of the combined engine and pylon assembly to the wing attach points."

The airline disagreed, saying its procedure was actually better because it required fewer hydraulic and other lines to be disconnected. So, it used a forklift to lower and lift the engine and pylon as a single unit. However, doing so placed undue stress on pylon components. A flange in the pylon developed a crack and eventually failed. As stated in the NTSB's accident report, the procedure "was within American Airlines' authority, and approval or review was neither sought nor required from the manufacturer or the FAA."

Ailment: Mechanics and aircraft operators can often discover shortcuts that appear to save time and money and can even be thought to improve safety. But without the manufacturer's full involvement, these unproven procedures could have unintended and unwelcome consequences.

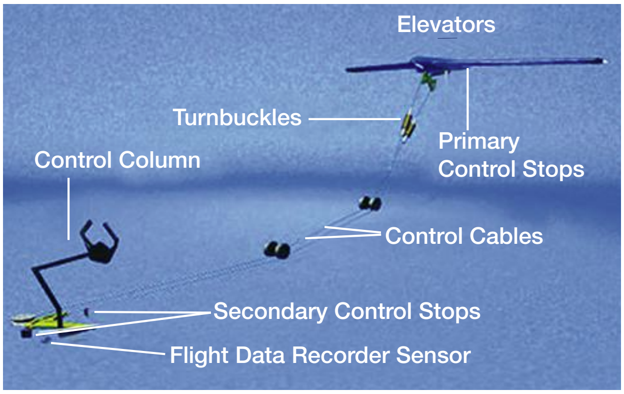
Prescription: Shortcuts should be considered carefully and vetted with the manufacturer and other experts. Going through this process can unearth consequences you may not have considered.

Issue Four: Quality Assurance

Stories of medical malpractice once were commonplace and medical instruments left in bodies and wrong limb amputations made for sensational headlines. Since then the medical profession has adopted multiple layers of quality assurance to prevent such gross errors. Transport category pilots tend to have a built-in quality assurance partner occupying the opposite seat. But what about QA for an aircraft mechanic?

Mechanics are often tasked to work alone and perform their own inspections to ensure the tasks were completed correctly. The results of their efforts may never see a true quality assurance check until a failure requires it.

NTSB DRAWING



Beech 1900D pitch control system (NTSB drawing)

In January 2003, a Beech 1900D operated as Air Midwest Flight 5481 was destroyed during takeoff because the elevator was improperly rigged. The quality assurance inspector of the repair had been filling two additional roles as the airplane's mechanic and an instructor to two student mechanics. He allowed his students to adjust the elevator cable tension while skipping several vital steps in the procedure. The students failed to evenly adjust the two cable turnbuckles, leaving the nose-up turnbuckle almost fully compressed and the nose-down unit almost fully extended. The inspector failed to properly check the resulting elevator travel, which would have revealed the elevator's nose-down authority was severely restricted.

The next day's trip had the airplane loaded with a center of gravity beyond aft limits. Combined with the limited nose-down elevator authority, the airplane departed controlled flight seconds after lifting off the runway. Both pilots and all 19 passengers were killed.

Ailment: Mechanics are often tasked with inspecting their own work, even on critical items in which mistakes can leave the airplane non-airworthy.

Prescription: Mechanics should request oversight from any available resource when completing critical tasks. They can develop cooperative networks with local mechanics. Even a mechanic without type-specific training can be used to compare maintenance manual descriptions and drawings against the completed work. A second set of eyes may bring to light something otherwise overlooked. The aircraft's pilot can also provide a second set of eyes.

Steps to Avoid Maintenance Malpractice

The common thread among many of the events cited is the motivation of the mechanic, the organization or both to get the job done more efficiently. Completing a repair or inspection more quickly frees the technician for the next task and saves the company money. Getting the airplane back in service sooner than expected has cascading benefits. But this motivation can lead to unsafe shortcuts and missed opportunities for proper quality assurance.

Another common theme in many maintenance-related mishaps derives from a shortage of resources, usually manpower. Organizations too often push mechanics harder than flight crews because they can; there are no regulatory limits on pre-duty rest or duty day duration. Tired mechanics, like everyone else, make mistakes.

In the most critical cases, the first opportunity for a quality assurance check is during the next flight. We obviously shouldn't be performing an operational check in flight when it could be done with the airplane safely chocked on the ground. From accident statistics it seems most of us are doing this right, or perhaps most of us have been lucky. In either case, we need to self assess our maintenance programs to either pat ourselves on the back or give a needed heading correction.

(1) Check staffing levels. If our mechanics are routinely putting in more than 8 hr. each workday, we might have a problem. Other indications of understaffing can include elevated divorce rates, drug or alcohol abuse, and frequent hospitalization among the maintainers.

(2) Establish pre-duty rest and duty time for maintenance personnel that take into account factors such as start time, workload, shift changes, circadian rhythms, adequate rest time and other factors shown to affect alertness. The FAA recently released Draft Advisory Circular 120-MFRM, "Maintainer Fatigue Risk Management," that provides an excellent starting point.

(3) Evaluate and employ maintenance training programs. These should be varied to incorporate other aviation-related subjects. Consider private pilot flight lessons for your mechanics, for example. An understanding of the mechanics of flight will help better prepare a technician to keep your airplane flying.

JAMES ALBRIGHT/BCA

Gulfstream mechanic John Rockwell working on his G450 with mechanic Mark Paul providing quality assurance

(4) Institute "suitability of task" rules. There are certain maintenance functions that should never be attempted by a single mechanic, such as replacing a landing gear strut on a large aircraft. (It is just too dangerous.) There are some tasks that are beyond a field mechanic's expertise, such as replacing components inside an engine electronic control. (It is just too intricate.) And there are other tasks that while not risky or complicated, require tooling and lots of help to accomplish safely.

(5) Ban undocumented shortcuts. It is true that not all maintenance manuals are clearly written with enough detail to specify each step of a job. But inventing a new process on the fly is a recipe for missing something critical. Shortcuts should be considered away from the airplane and documented. The manufacturer should be consulted. A good shortcut may find a home in the next maintenance manual revision.

(6) Implement "Work Cards" for maintenance procedures. A checklist-like work card can serve to compensate for some shortcomings in training, can keep a fatigued mechanic on task, and can minimize the temptation to take short-cuts. A quality assurance inspector should have a separate work card for the same reasons. As the NTSB recommended in its accident report on Eurocopter N37SH: "Using work cards that clearly delineate the steps to be performed and critical areas to be inspected to support both the maintenance and inspection tasks is one way to mitigate inadvertent errors of omission in the performance and verification of maintenance tasks, especially tasks involving critical flight controls."

(7) Consider real quality assurance. Failure-critical tasks should not be signed off as airworthy without a second set of eyes. Even something as routine as a tire change can have disastrous consequences if completed incorrectly. Mechanics should develop networks where another A&P can quickly inspect a repair and informally agree everything is in order. At the very least, the work should be explained and shown to the captain of the next flight.

During normal day-to-day operations the aircraft mechanic may be an unsung hero. (When nothing bad happens, the mechanic has been successful.) Think of the hangar as an operating room, the aircraft as the patient and the A&P as the surgeon specializing in aircraft maintenance. To prevent a case of malpractice, the maintenance team needs the proper rest, knowledge, operating tools and procedural discipline to perform at the doctoral level. **BCA**