SABRINA WOODS

Beware the FRANKENPLANE!

The Hidden Dangers of Layering STCs

Whether you have read Mary Shelley's dark foray into the world of science fiction, or if you are only acquainted with the 1931 Boris Karloff horror classic, the tale of The Modern Prometheus — better known as *Frankenstein* — is as iconic as it is timeless. "It's alive!" Colin Clive as Dr. Frankenstein exclaims in the movie as "the creation" (Karloff) slowly stirs upon the laboratory table. Ecstatic, exuberant, unrepentant and proud, Dr. Frankenstein never really stops to consider the consequences of his actions. Unfortunately it is also the last "feel good" moment in either the text or the picture as it kind of all goes awry from there. What does any of this have to do with general aviation you might ask? Sadly, quite a bit.

The Hidden Risk

"Dangerous? Have you never wanted to do anything that was dangerous? Where should we be if no one tried to find out what lies beyond?" – Dr. Frankenstein (movie)

- A Cessna P210 impacts the ground in an aerodynamic spin. Witnesses observed the airplane in a spin and near-vertical trajectory just prior to impact. Post-accident examination revealed the plane's aerodynamic configuration and weight distribution were significantly modified via several supplemental type certificates (STCs).
- A tailwheel-equipped Cessna 170A touched down in a three-point landing, immediately veered sharp left, exited the runway and careened into a ditch. A review of the logbooks indicated four recent major airframe modifications including STCs for a main landing gear (MLG) reinforcement kit, replacement of MLG components with ones from a Cessna 180, replacement of stock tires, and replacement of a stock tailwheel spring with one from a Cessna L19 *Bird Dog*.
- A Bell UH-1H experienced structural failure in the tail boom while hovering near a cliff

> about 200 feet off the ground. A post-landing examination revealed the left tail boom upper attachment fitting was fractured. Previously, the helicopter had been modified with numerous STCs that included an upgraded engine, installation of the FastFin system, strakes and composite tail rotor blades, as well as an upper skin replacement.

What these incidents all have in common is that like Frankenstein's creation, each aircraft was "pieced" together; upgraded, modified, altered, and overhauled in an attempt to achieve a different level of effectiveness. The only way to "evolve" an aircraft is to modify it and this is the primary reason people pursue either a field approval or in these cases, an STC. This is, inherently, a "good thing." In each of these scenarios the process of applying for and achieving an STC was followed in accordance with FAA regulations.

It is likely that, taken independently, no individual STC posed a threat. However, with the Cessna P210, the *layered* STCs — meaning the installation of an STC on an already modified aircraft — likely altered the airplane's spin susceptibility and recovery capability. A type-club representative of the Cessna 170 mishap stated that due to the differences in landing gear geometry of the two stock plane models from which the parts were taken, the maintenance manual from just one wouldn't be sufficient to guarantee the continued airworthiness of such a mixed configuration. For the Bell UH-1H helicopter, a fitting on the rotorcraft may have been fatigued during one STC initially which was then, in turn, further compromised during a second STC.

These incidents were not the direct result of any one maintenance action that was performed, but rather the result of two or more modifications that together potentially compromised the airworthiness of the aircraft. This makes pinpointing the *exact* moment when things go wrong that much more difficult.

Careful What You Modify

"I am practically industrious — painstaking, a workman to execute with perseverance and labour …" – *Robert Walton, Letter 2 (novel)*

FAA Advisory Circular (AC) 43-210, Appendix 1, Item 9 states;

> *Previous Alterations or Repairs that May be Affected by This Alteration. Look at the aircraft and review its records to determine if there are any modifications, Supplemental Type Certificates (STC), alterations, or repairs that could cause a problem or conflict with the proposed alteration or repair …*

This might be easier said than done. You might assume that the job of determining a "problem or conflict" is typically left to the FAA Aircraft Certification engineers who review and approve STC applications, but in truth there are an infinite number of modification possibilities for which a person might apply. It just isn't feasible for a representative to be able to account for every possible combination. Ultimately it comes down to the person you have commissioned to do the work on the aircraft (the installer), and you (the aircraft owner) to determine the interrelationship among multiple STCs.

This begins with the major alteration and repair application process. Appendix 1, Item 8 of the AC mentioned above, warns that "before completing the alteration or repair to your aircraft, [you must] be aware that after it has been altered or repaired, the aircraft must still meet its certification basis," and then requests documented proof — most typically given in the form of data. This might seem daunting, but your two biggest allies in getting the job done are patience (self-explanatory) and research (read on).

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Before you proceed to purchase an STC, first make sure you are clear about the desired outcome of the modification. Then consider everything the modification will affect within the existing system, even if it is a stock airplane, and *especially* if it has been previously altered. Identify what adding a new system could override in the previous system, what it might overlap with, and what it might complement. This process should be an active dialogue between the installer and the owner, and if the conversation starts to get a bit too "nebulous," that is the time to include a subject matter expert such as a designated engineering representative or the type manufacturer.

When dealing with surface or structure changes, an FAA engineer reviewing the paperwork will want to consider whether the change affects the structure, creates fatigue points, increases loads, or changes aerodynamics. For powerplant modifications, he or she will want to know how it will affect power output, change fuel consumption, or affect speed controls. For avionics or electrical component STCs, you can be sure that aspects such as how the "boxes" integrate with one another and how much electrical power the system consumes will be scrutinized. Some key "catch-all" questions to consider are whether the change(s) alter gross weight, center of gravity, stability, or control. Any one (or more) of these categories could compromise the airworthiness of your aircraft should the STCs not be compatible.

To start identifying your needs, a great idea is to ask if the STC holder can give you some insight on what to expect of a post-modified aircraft, how they came to the decisions they reached — what ideas worked, and what didn't (and *why*). Next, ask your local FSDO representatives what they have been seeing out in the field as they might have more experience dealing with different types of modified aircraft. Lastly, seeking the advice of an experienced flight test pilot could also be very beneficial in determining interrelationship operability. This information, in conjunction with all the technical data you need for the individual STC itself, should get you on the right path to success.

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Getting Testy

"Forgive me, but I am forced to take unusual precautions." – Dr. Frankenstein (movie)

"[N]ever performed fatigue analysis;" "[no one] evaluated the individual or combined effects of the STC changes…;" "… not properly analyzed…;" and "… was not test flown/taxied for adverse effects… ." These are the common statements lifted from various mishap and post-incident reports in which multiple modifications were found to be suspect. Inspectors, investigators, and engineers involved in these cases believe that most of the design flaws and issues that presented at the onset of the mishaps could have been detected beforehand.

One example to illustrate this point — the P-51D *Galloping Ghost* mishap at the National Championship Air Races in Reno, Nev. — is also probably the most widely known in recent history. On September 16, 2011, after zooming through the air at speeds upwards of 440 knots, the P-51D suddenly rolled left and experienced a high-G pitch up. A few seconds later the left elevator trim tab departed the aircraft, rendering it uncontrollable and resulting in a crash into a seating area adjacent to the runway.

Investigation revealed that the former military aircraft

> *… [H]ad undergone many structural and flight control modifications that were undocumented and for which no flight testing or analysis had been performed to assess their effects on the airplane's structural strength, performance, or flight characteristics.*

The combined effects of the maintenance actions unfortunately rendered tragic results.

Obviously it is highly desirable to avoid such outcomes. So once you have decided on a course of action and launched the maintenance, the next step is to test, evaluate, record, and test again. Which brings us back to that test pilot mentioned earlier. This individual has been specially educated, trained, and credentialed to iron out the kinks and identify potential issues in new and modified aircraft — so why not use one to your advantage? If working with a test pilot just isn't feasible, then the next best bet is to put your newly modified aircraft through the paces, slowly, during a series of small test flights and preferably with a high-time pilot in the right seat (left is good too!).

When testing your modifications, remember that the primary goal is to ensure your aircraft is airworthy and safe to operate within its operational envelope. Another important goal is to make sure *you* know how to handle the new modifications prior to having to do it "for real." Once this has been established, all of the flight test operational and performance data needs to go into the aircraft's flight manual for future reference.

It's Alive! (now document it)

Sound recordkeeping is a critical part of owning and operating an aircraft and, at least theoretically, every decision you make is going to be based upon your historical data. This collection includes maintenance records, pilot operating handbooks, and logbooks. They should be carefully annotated so that you have a good solid ground to work from when the next big project comes along. Common documentation errors include inadequate descriptions of the work that has been performed, listing the wrong references, and incorrect life-limit annotations — all of which can prove to be costly when trying to establish a workable baseline.

Epilogue

"I will pioneer a new way, explore unknown powers, and unfold to the world the deepest mysteries of creation." – Dr. Frankenstein, Chapter 3 (novel)

As an owner/operator, one of the greatest joys is tinkering on, upgrading, refurbishing, or modifying your aircraft. I, for one, am all for it. New ideas and innovations help to extend the life and repurpose our existing general aviation fleet, while the latest and greatest technologies reflect in the new models coming off the assembly line. Absolutely, you should want to be a part of it. All that we ask is that you go about it the right way and in the best interest of safety, so that you and your "creation" can be around for many, many more happy flying years.

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For More Information

Designated Engineer Representative comprehensive list:
http://go.usa.gov/Kk55

Special Airworthiness Information Bulletin CE-12-37, STC Modification Airworthiness Interrelationship Effects can be found here:
http://go.usa.gov/KWWP

FAA AC 43-210, Standardized Procedures for Requesting Field Approval of Data, Major Alterations, and Repairs can be found here:
43-210: http://1.usa.gov/1jwmD8E