Righting Wrongs

Breaking Down Repeat Problems with Complex Troubleshooting

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Troubleshooting problems is one of the most challenging and rewarding things that an avionics technician can be assigned to do. It is challenging from the respect of adequately bounding the problem, so assure that it is solved correctly the first time and for the lowest possible cost. The rewarding part of the job is getting the problem solved correctly, so that you can move on to the next assignment that awaits you on the task list.

Many troubleshooting efforts are easy to accomplish, since they are simple "broke/fix" problems, or are intuitively obvious. Whether they are as simple as having to perform a TDR to find a break or chafe in a harness, or finding out why a new piece of avionics has decided to go dark due to infant mortality, these troubleshooting "quick fixes" help to make the day go by faster.

Conversely, there are some harder troubleshooting efforts that come up from time to time. These tasks are harder because the answer isn't obvious on the initial review of the symptoms, or that the factors influencing the problem vary with the flight conditions. While these complex tasks are more difficult to troubleshoot, provided that you start with the right mindset and philosophy, your shop and its personnel can be just as effective at solving those problems the first time as you would be in any simple troubleshooting effort. The key is to take the time to put your thoughts together on the problem, which will help you to do the job right.

The Right Start

To get the right start on troubleshooting that is not clear, start by writing down the symptoms. As an example, we'll look at an autopilot installation on a used Cessna 182. The autopilot in question is a popular two-axis version, and has worked in numerous installations. It also has the merit of having a reputation as being troublesome in Cessna 182s, so when you tested the aircraft and found problems following the installation, it wasn't a surprise.

The test pilot reports that the autopilot "porpoises" while in flight, and does not maintain adequate altitude control. Your initial efforts have confirmed that the connections between the autopilot and servos are correct, and that none are intermittent or broken. All connectors and avionics have been verified as seated properly and work fine on the bench, with the autopilot control unit working fine when tested in the shop's aircraft.

Questions

To begin this troubleshooting exercise, we need to ask the test pilot a few questions. The first question we need to ask will help us to establish the flight conditions. This is important, since some problems are influenced by weather, so building a database of information on a recurring problem will eventually help you to connect the dots and have a better chance of finding the cause. The second question is what the test pilot exactly meant by "porpoises"—did he mean that the nose of the aircraft varied by 2 degrees or 10 degrees? Was the altitude being maintained within plus or minus 10 feet or 50 feet?

These questions are intended to help establish the real scope of the problem more than anything. With this scope in hand, you can now put together a list of things to check. Your intent here should be to come up with things that can be examined either in flight or on the ground to look for the problem, whether they are electrical voltages or current readings, or signals between the nav receiver or altitude reference and the autopilot. With the symptoms in hand, you can then put down a list of probable issues, which could range from a faulty servo to excessive control forces to the wrong cable or bridle tension.

This would also be a good time to check in with the manufacturer of the unit, to see if they have any specific experience with a similar problem, and what their suggestions would be. Be sure to inquire if the OEM has heard of other shops with a similar problem, since you might be able to contact them for their solution to the problem. If other installers in your shop have dealt with a similar autopilot installation, take the time to discuss the issue with them, and ask them if they have any suggestions on how you might resolve the problem. This simple search for experience can yield surprising results if you are willing to reach out and ask.

Tracking Complex Problems

We'll assume for the sake of this exercise that your search for information on your autopilot problem turns up nothing that will assist in resolving the issue. Troubleshooting of an autopilot problem that has defied previous troubleshooting or is considered "a problem aircraft" needs more than a few voltmeters. In order to really get your arms around the issue, you need data logging capability to let you see what is going on between the autopilot and the flight controls. With that information in hand, you will be able to better diagnose the problem.

For example, if you were to use a data logger such as a Fluke NetdaQ connected to a laptop computer running Fluke's TrendLink software, you would be able to monitor the electrical signals of the autopilot to the servos and from the nav receiver to the autopilot. In addition to this, through the use of additional troubleshooting inputs such as lanyard potentiometers and LVDTs, you would be able to assemble the input and outputs of the autopilot, and look at them in real time as they are translated to the flight controls. Better yet, this approach would let you troubleshoot in actual flight conditions and compare them to ground traces, to help you more quickly identify where the issue might reside.

Let's look at where this could potentially end up. Your customer reports that their new autopilot is porpoising. By asking the customer some simple questions, you find out that this condition occurs in VFR and IFR conditions, and that the problem makes the plane's altitude wander by plus or minus 50 feet on an average day. In order to see what is going on, you need to monitor the voltage pulses out of the autopilot to the servos, and the control action (i.e., whether the control is moving when the servo tries to move it.) For this, you need two voltage or current transducers of the proper range, a pressure transducer to keep track of altitude, and two lanyard potentiometers to monitor the affected flight controls.

You contact a test equipment rental firm, and rent the required equipment. Connecting the NetdaQ to the data logger takes around two hours of shop time along with the use of a DC to AC inverter, at which point the data logger is belted down in the back seat of the airplane, with the various transducers and potentiometers connected to the wires and flight controls.

To allow for instant viewing of the results, the data logger has been connected to your laptop, which is now sitting on your lap in the passenger seat. With the test pilot flying, the autopilot is engaged, and you can quickly see the problem on the data logger trace shown on the laptop in real time, which is shown in a graphical format using colored traces. In this event, the autopilot is applying corrections, but the aircraft controls are too stiff, so a second or third correction is needed before the controls "break free" and reposition themselves.

From here, the troubleshooting effort changes from an autopilot connection and electronics issue, and becomes a hunt for the mechanical problem that is causing the stickiness in the flight controls. It is important to note that the problem has moved away from the shop's performance in the autopilot installation, and has moved to the aircraft's performance where it belongs. Better yet, after you download the data from the TrendLink software, you will be able to print out the NetdaQ traces and show your customer exactly what is going on with the plane and the autopilot, breaking the cycle of "Your installation is the problem, and you need to make it right!"

Other problems are less obvious, and even using data loggers may not yield as much help as asking the pilot some questions will. We'll look at a customer with a Cessna 340, which was certified for flight in Known Icing conditions, and had an excellent autopilot and flight director on board. The problem in this case was the Flight Director horizon, which had failed on the customer once, and who has now returned to your shop with a second failure of his freshly overhauled unit.

When the Flight Director originally failed, your shop removed it and bench tested it to confirm it was dead, and then sent it to the vendor for troubleshooting and repair. However, when it arrived at the vendor, the unit erected and worked properly with no problems found. Due to the AOG nature of the failure, the manufacturer elected to replace the unit with a remanufactured Flight Director.

Your shop appropriately installed the unit per the approved installation manual, and returned the plane to service, only to fail again some weeks later while in flight. The customer in this case was noticeably distraught with having to bring his plane in twice for the same problem, and wanted to know what you and your shop was going to do to make things right.

Once again, we go to the complex troubleshooting approach, and determine the flight conditions in question. The customer finds it easy to relate his

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intense frustration, as both times the Flight Director failed were in hard Instrument conditions, with icing and low visibility. Since you know that good troubleshooting requires diligence, you refer to your shop notes from the previous problem, to look for clues to help you with the latest event.

To try to identify the factors that are causing the failure, you ask the pilot about the airplane in question, including what kind of ice protection he has on board, to which the pilot replies he has a hot plate which was recently replaced. You inquire further and find out that the plane was in icing conditions at the time of the failures, and that the hot plate was in use both times the instrument has failed.

You know as an avionics professional that a hot plate draws a lot of power, and generates a substantial electromagnetic field around the wires that supply it, so you want to take a look at it. When you inspect the wire routing, you find the power and ground connections for the hot plate run straight up the firewall behind the Flight Director, which is so long that it is nearly up against the wires. From this point, you recognize that the power consumption and large magnetic field are most likely magnetizing the bearings in the Flight Director, causing it to fail in flight.

This also explains why the unit worked when it reached the manufacturer after it was removed by shop and verified to be non-functional. Even well-packed, the motion of shipping can be sufficient to disrupt the magnetic field. With this explanation in hand, you can now approach the customer with options on how to remediate the problem, which includes the installation of a shorter Flight Director, or the replacement of the Flight Director with a standard gyro horizon.

Symptom Based Troubleshooting and Brainstorming

For challenging avionics issues, taking the time to identify and write down the symptoms, and then brainstorm all the things that could cause such a symptom. The difficult part of this task is having sufficient knowledge to encompass all the variables that would be in play for a typical symptom. However, most shops have at least 20 to 100 person-years of experience on hand, so getting some or all the shop personnel together for a brainstorming session may be more efficient and effective than having a lone individual, no matter how bright they might be, take a try at the same task.

Brainstorming should be an open process, with people free to throw out ideas and be free from criticism. At times, this may seem counter-productive, since it will produce a good number of false leads. However, these leads can be quickly supported or refuted once the troubleshooting process begins in earnest, and by encouraging such ideas, the remaining technicians are more likely to contribute.

Once the causes to the symptoms are assembled, it is time to build a table to help you in sorting out how to support or refute each cause. For example one technician might suggest that the component was misbehaving due to inadequate voltage. This can be refuted through a check of the input voltage in flight. Another might think that the ground was inadequate, which can be supported or refuted with a VOM check.

The most important part of this task comes in the *validation of the answers*. This is important since with the knowledge of most technicians, they may base answers on their experience, and in doing so, miss the opportunity to identify the problem. By forcing physical checks to validate answers instead of going on assumptions, your shop will be more likely to find problems the first time. Conversely, assuming that something works is one way to extend the troubleshooting process, since the shop will lose time when it starts over from square one, and tries to bring the problem to resolution.

There are some simple tips that will help your troubleshooting go better. In general terms, by keeping good notes on all troubleshooting, writing down the symptoms of complex problems, taking advantage of operating experience from the shop and the equipment manufacturer, and taking nothing for granted, your shop will be able to be more effective at troubleshooting difficult problems.

There will be rare circumstances where complex systems are not functioning as expected; connecting up recording test equipment such as a Fluke NetdaQ can help your shop to further delve into the issue, to better identify the scope of the problem. Such test equipment is typically available for rent from a variety of reputable firms, some of which you may already do business with when you purchase test equipment for your shop. Due to the rapid advance of technology and the infrequent use, in our experience rental is the best way to go with such equipment.

While this approach would seem to cost slightly more, in the long run, your shop will be rewarded with troubleshooting efforts that provide successful results with increased frequency the first time out. The translation of this effort will be in satisfied, loyal customers who are more likely to return to your business with the knowledge that you were able to capably handle their problems, and more satisfied shop personnel who grow stronger in the knowledge that they can conquer the most difficult problems. ❑