Nose up, nose down

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When maintainers re-installed trim switches on three Metros IIs the wrong way there were unforeseen consequences, write Pete Cowood and Mike Nendick.

ON THREE OCCASIONS over the past few years maintenance engineers working on Dornier Fairchild Metro aircraft control yokes incorrectly installed trim switches.

In each case, when the pilot trimmed for pitch on the first flight after maintenance, the aircraft was physically trimmed in the opposite direction. Nose-up trim selection caused nose-down movement. Fortunately no-one was injured.

How could such a mistake be made? Did the maintainers cross-connect switch wiring? Did they simply get it wrong and install the switches upside down, or was there more to it than that?

Cockpit trim controls in the Metro consist of:

- a switch on each control yoke
- a paddle switch to select either left or right yoke switch
- a separate auxiliary switch on the centre console
- a gauge on the instrument panel.

Each control yoke switch system is made up of two independent switches, the first providing power to the actuator and the second grounding one of the two directional windings in the actuator.

Trim switches at each yoke are mounted on the left-hand arm and fitted vertically in the arm's rear face.

At the horizontal stabiliser, the position transmitter for the indicator is mounted on the airframe. A lever connects the indicator to the leading edge of the stabiliser. The cockpit gauge is therefore a physical representation of whether the stabiliser is trimmed for nose up or nose down. This means that for a given stabiliser movement, the gauge represents the effect on the aircraft rather than whether the stabiliser is moving up or down.

When the aircraft maintenance manual test procedures refer to "Pushing switch UP moves horizontal stabiliser toward Nose Down direction", they are referring to a physical action at the switch with the resulting indication.

The circumstances of each reported occurrence differ slightly. In one case, both yoke switches were fitted upside down; in another, one switch was fitted upside down; and in the third case two wires were cross-connected. All involved maintenance of the roll axis bearing in the control yokes.

Checks: But why were these errors not picked up during required checks? In each incident the pitch trim system should have been checked at least four times (functional, independent, pre-flight and taxi checks) involving four people – two LAMEs and two pilots.

The checks are specified in the Civil Aviation Regulations, manufacturer's aircraft maintenance manual and aircraft flight manual. They are designed to provide defences against errors.

At disconnection of the switches, a functional check, to be carried out after their reconnection, should be called up in the worksheets. The switches are:

- pitch trim
- press to transmit
- interphone press to talk
- autopilot disconnect.

An independent check prescribed under CAR 42G also is required. The maintenance manual reference includes "action related to indication": when the gauge shows nose up, the stabiliser is moved down. The wording in the maintenance manual relates to airframe effect, not horizontal stabiliser movement, although this is not made clear.

The flight manual requires pilots to do a pre-flight check of the stability augmentation system (SAS). This includes moving the pitch trim from neutral to outside the take-off band and then back to neutral. Since it is impossible to see the horizontal stabiliser from the cockpit, the pilots should have used the indicator gauge to monitor the stabiliser trim position. It is possible that they didn't monitor the gauge.

Some pilots check trim movement by listening for the warning sound of the sonalert, which comes on when horizontal stabiliser position moves outside green band limits. The problem is that the warning sound indicates movement, not direction. If the pilots were relying on the warning sound, without a visual check, they would not have known that the horizontal trim was moving the wrong way.

The next check is during the taxi, when the flight manual for Metros requires each pilot to check their pitch trim switch and the auxiliary control for correct operation.

Again, this requires monitoring of the indicator gauge. The wording in the flight manual is clear, referring to airframe effect, not horizontal stabiliser movement.

The maintenance manual does not refer to any pitch trim test as part of the switch installation procedure. However, LAMEs should be aware that all systems disturbed during maintenance require functional checks before release of the aircraft to service. LAMEs should also be able to specify which checks are required.

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Note: Service difficulty reports are used in part by CASA to monitor safety trends in maintenance in order to take appropriate action when problems are identified.

To submit a defect report call 131 757 (local call cost) and ask for the service difficulty reports section; fax 02 6217 1920; email sdr@casa.gov.au; or mail your report to: Service Difficulty Reports Section, Civil Aviation Safety Authority, Defect Report, GPO Box 2005, Canberra,

Key causes of maintenance error

TO PREVENT THESE KINDS OF incidents, we need to know why they happened. To understand some of the human factors involved we can ask four key questions:

The task: What was the task to be performed? This seems an obvious question, but you need to be clear about how people see the nature of the job – this will uncover any confusion or miscommunication that might have occurred. In these examples, the task might have been to perform maintenance on the yoke bearing. Disturbance of the trim control is a consequence of this task and is not a primary consideration. Any investigation would look at whether maintenance and flight crews used local unapproved procedures or shortcuts that penetrated the defences against error put into place by approved procedures.

Goals: What were the goals of the people involved? The job happens in a context. For example, there might be time pressure to move onto the next task, and this might encourage short cuts.

Knowledge: What did the people involved know about the situation? For example, did they realise that it is possible to install the switches upside down? Did they know the indicator gauge reflects airframe effect, not horizontal stabiliser movement? Was the maintenance manual sufficiently clear? It would also be useful to examine the methods of communication between the maintenance engineers and flight crews to ensure that flight crews are adequately briefed on maintenance carried on control systems.

Attention: What were those involved paying attention to? Concentration and focus are critical. We need to know, for example, whether the maintainers and pilots were distracted, whether they were interrupted or whether they were thinking about the next job? The flight crew might have been unaware that maintenance affecting the trim control had occurred. If they did know, would this make them pay greater attention to the associated taxi check? The difficulty of working in the confined space of the cockpit might also have affected the concentration of the maintenance engineers .

These issues are not solely related to this aircraft's design or operation, although the problem has been reported to CASA more often on the Metro. The questions posed above are relevant to a wide selection of maintenance activities, aircraft types and organisations. They offer an opportunity for you to examine your local environment for similar error-provoking conditions with the potential to cause an in-flight incident or accident.

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Research findings: Recent research indicates that three key problem areas lie behind many maintenance errors.

Alan Hobbs, of the NASA Ames Research Centre at Moffett Field, California, discovered that more than 50 per cent of errors related to memory problems, deviation from procedures and unfamiliar situations.

The memory errors relate to what Hobbs calls memory for intentions or prospective memory – remembering something you have to do, like removing tools, replacing caps and reconnecting wires.

The problem is that prospective memory seems to deteriorate markedly with age, a finding that could have implications for older maintenance workers.

In a study of job performance of European aircraft maintainers, researchers at Trinity College, Dublin found that 34 per cent said that their most recent task was done in a way that did not comply with formal procedures (see *Flight Safety Australia*, May-June 2004).

A survey of Australian airline maintenance specialists showed that 30 per cent of LAMEs reported that they had decided not to perform a functional check or engine run. As the Metro trim switch story reveals, the omission of a functional check at the completion of maintenance removes an important defence against error.

Some 30 per cent also reported that they had signed off on a task before it was completed. And 90 per cent admitted having done a task without the correct tools or equipment.

Other studies have shown that unfamiliar situations can contribute to error because mental demands are higher when you are unsure of how to proceed. The danger here is that you go for a trial-and-error approach because you don't know the tricks and traps associated with the task.

Management has ultimate responsibility. Some key areas managers need to be wary of include:

- the increased likelihood of error during night maintenance
- communication problems between separate commercial entities, such as those conducting operations and those doing maintenance
- the impact of management decisions on the shop floor.