# MODE-SWITCHING IN AIR TRAFFIC CONTROL

In striving for a more efficient, resilient and safe operation, we continuously develop new ATC tools, procedures and airspace. Operational staff are required to switch between new procedures and different technologies, during testing, in the simulator, and with live traffic. In this article, **Zsófi Berkes** and **Miguel Aulet** describe how NATS deals with mode-switching.

## KEY POINTS

- **Mode switching, and mode confusion are not commonly associated with air traffic control, but are increasingly becoming issues of interest.**
- **There are two types of mode-switching: change-related and in-service. Both happen when an operator uses more than one mental model to perform the same task.**
- **There are a number of risks and factors that affect mode-switching.**
- **Mitigations for mode switching include design and changing practice to accommodate effective mode-switching.**

Imagine you are the first officer on a Boeing 737-700. You first flew the 737-500 as a first officer. The pilot in command has left the cockpit and is requesting to return. You confirm on your screen that it is indeed the captain attempting to enter, reach out your left hand and operate the door lock control.

> Mode-switching has been a known issue for some time for pilots with multiple type ratings, but it is not commonly associated with air traffic control. But this is changing.

It's not working, you get frustrated, so you do the obvious thing in this situation: you repeatedly operate the same button, but nothing appears to be happening. What you don't immediately realise is that you have just turned the aircraft upside down and the aircraft will have lost 6,300ft before you recover it. The investigators establish that you operated the rudder trim control instead of the door lock control. They also establish that the rudder trim control of the aircraft you were flying (737-700) was similar to the door lock control of the first aircraft you have flown (737-500) in its positioning, shape, size, and operability. This is thought to have led you to confuse the two switches.

What you have experienced is mode confusion and as you may have guessed, this was a real-life example. The same sort of thing happens in everyday life. You may have had experience of moving from a country where you drive on the right to another where you drive on the left, or vice versa. Or perhaps you have tried to use different key combinations or shortcuts on an unfamiliar computer. When you change modes, the same input (or what looks and feels like the same input) will have different results.

### What is mode-switching?

Mode-switching has been a known issue for some time for pilots with multiple type ratings, but it is not commonly associated with air traffic control. For a long time, the task of a controller was relatively consistent across radar operations, with a radar screen and paper strips setup. But this is changing. In recent years new systems have moved on to electronic strips or trajectory-based (stripless) systems.

At NATS, we refer to mode-switching when an operator uses more than one mental model to perform the same task (with a mental model for each component). This can happen when an operator is required to perform the same or a similar task using different technical systems, operating environments, airspace, procedures, etc., and transitions are required between these.
In recent years, we have been managing an unprecedented rate and scale of change in our business. We have been continuously introducing airspace changes (e.g., systemised airspace) and increasingly automated technology (e.g., our trajectory-based system, iTEC). With these changes, we are creating more frequent mode-switching situations. At Prestwick Centre in Scotland, a number of controllers operate both our electronic flight data (EFD) system with electronic strips on lower level sectors as well as iTEC with medium term conflict detection (MTCD) functionality to control upper airspace. We have identified that switching

between these two systems may lead to mode-switching errors.

We consider two types of mode-switching: change-related and in-service.

- **Change-related mode-switching** takes place as we develop new tools, procedures, or airspace. Controllers operate a new tool (e.g., electronic strips) or new airspace in the simulator, and then afterwards have to plug back in the ops room on live traffic, operating the current tool (e.g., paper strips) or existing airspace.
- **In-service mode-switching** occurs when controllers switch between systems (e.g., electronic flight strip to trajectory-based systems) in live operations. It also happens when controllers switch between sectors or roles (tactical/executive or planning controller, or combined tactical and planner).

There are a number of factors that affect mode-switching performance. One of these is the similarity of technical systems, procedures, airspace, etc.

## So what is the risk and how can we manage it?

One factor is awareness of mode-switching and related errors. For example, we have been in situations where we asked controllers whether they had ever experienced mode-switching issues and their reply was: *"Of course not! The two systems are completely different."* However, when we asked them if they had ever tried to use the mouse in the 'iTEC way' whilst operating the other system, almost everyone said *"yes"*. People regularly make small mistakes and they might not even be aware that some of these are due to mode-switching.

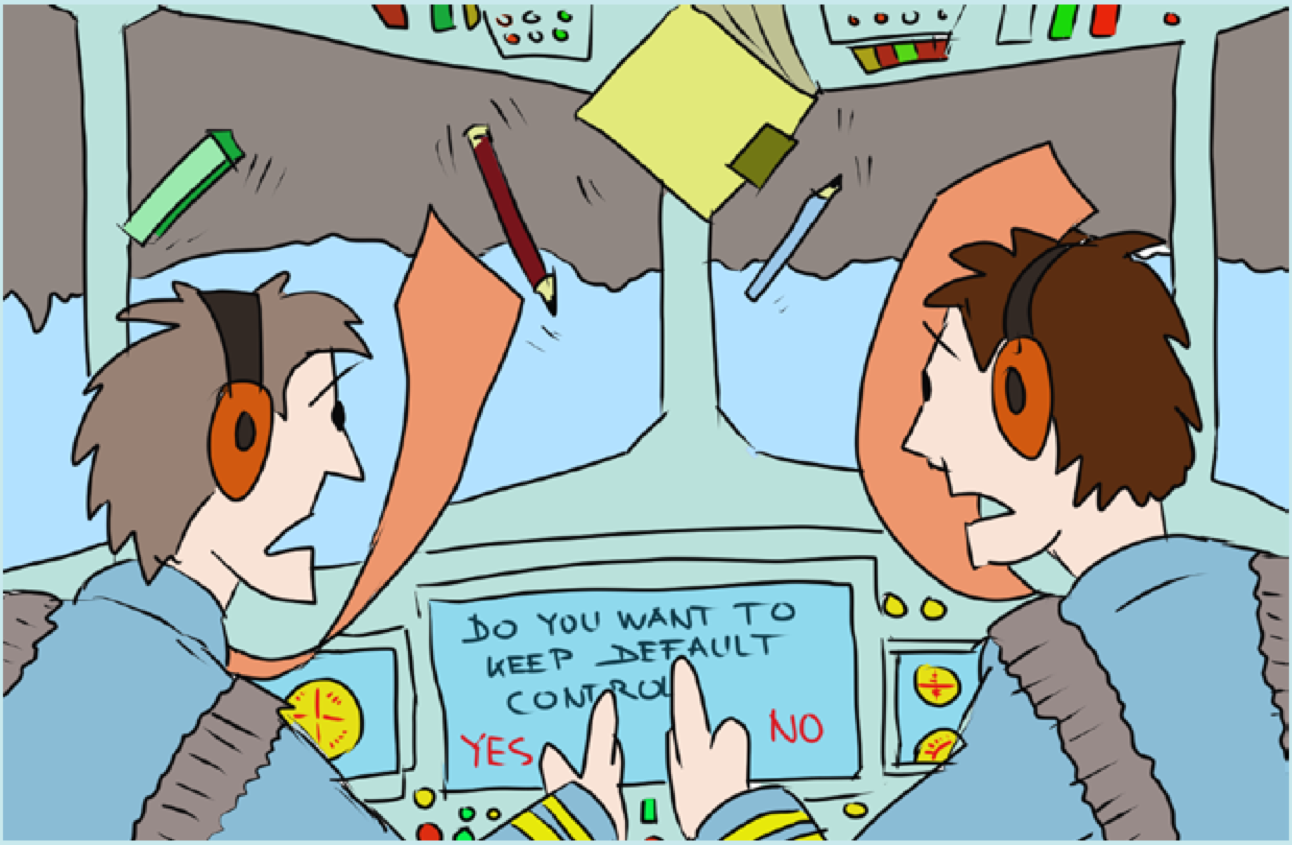
We design systems to be forgiving so that small errors are easy to correct and recover from. A wrong click should be recoverable and shouldn't cause a surge in workload or any other unsafe outcome. But small errors, whether due to mode-switching or something else, can lead to undesirable outcomes.

It's not just mouse clicks that are different between systems. Cognitive tasks and workflows are different too. Our iTEC trajectory-based system presents controllers with predicted conflicts that they have to resolve, whereas on the EFD electronic flight data system, controllers must proactively spot conflictions by scanning strips and radar. Therefore, a controller moving from one system to the other must adapt their mental model.

A potential risk could arise when the controller goes from a more automated to a less automated system. Here's an example of what could happen: John has just unplugged from iTEC where the system provided conflict detection. He now plugs in on EFD. It's been a couple of days since he last controlled on EFD. For a few seconds, he sits there waiting for an alert to pop up telling him about a conflict. Suddenly, he realises that he is on EFD and it's him who needs to do the conflict detection as automated conflict detection support tools are not available. Nothing bad happened. He caught it in time. But he was annoyed at himself.

To understand the mode-switching risk, we start with highlighting the differences between the two systems and examining the worst-case scenario when switching in either direction. This helps us understand if there are any risks. If we identify a hazard, we can conduct a formal risk assessment.

Our aim is to agree on a course of action to manage any risk. We frequently create checklists that highlight the differences in human-machine interfaces (HMIs), procedures, or functionality. These aim to help the controller get into the ▸▸




right mental model before plugging in. Other mitigations we have put in place include limiting the amount of switching and introducing mandatory breaks between switches. Our aim is to limit the exposure to mode-switching errors, but we always try to introduce tailored solutions that we continuously update. We also do not want to hinder the operation by imposing unnecessary constraints.

## What affects our mode-switching performance?

There are a number of factors that affect mode-switching performance. One of these is the similarity of technical systems, procedures, airspace, etc. Having just spent a day on the simulator testing a small change in procedure for a specific sector, a controller may forget to switch to the current one when they plug back in during live operation on the same sector.

A potential risk could arise when the controller goes from a more automated to a less automated system.

Currency and recency play a role as well. If a controller has spent the majority of the previous week or month working on only one of the systems and then has to control on the other one, they may report that they feel 'rusty' on the other system, and we find that mode-switching errors tend to increase. Then there's fatigue; a fatigued person is more likely to make mistakes. Various other factors – controller competency, experience, current task load, type of sector, traffic complexity – can affect our ability to cope with mode-switching. It's not always clear cut when and why mode-switching errors happen.

## Mode-switching in ATC – final considerations

Whenever mode-switching is required, one key focus is awareness and changing practice. We teach controllers about mode-switching so they can incorporate techniques to minimise related errors – for example by getting into the right mind-set when taking over a sector using a different system. And, similar to unsafe procedures being reported and improved or eliminated, mode-switching issues can be reported through our reporting system.

In the same way that our ATC manuals don't prescribe for every eventuality, we cannot predict or design out every issue that operational staff may encounter. So we need collaboration between controllers and everyone else involved in designing for safety to gain insight and develop effective mitigations.

### Reference

Japan Transport Safety Board (September 25, 2014). AI2014-4. Aircraft serious incident investigation report. Boeing 737-700, Ja16an. Nosedive from upset (LOC-I) at an altitude of 41,000 ft, approx. 69nm east of Kushimoto, Wakayama Prefecture, Japan around 22:49 JST, September 6, 2011. Available at: http://www.mlit.go.jp/jtsb/eng-air_report/JA16AN.pdf

**Table 1: Examples of mode switching errors and mitigations**

| Example of mode-switching error | Possible mitigation(s) |
|---|---|
| The same mouse is used for all the systems, but the buttons perform different actions.<br>*"I clicked right button on an aircraft expecting a vector line and instead a menu appeared."*<br>*"I inadvertently changed the range while trying to rotate a label."* | System design allows for quick/ easy recovery of errors<br>*"I clicked the menu away and remembered to use the middle button to get the vector line."* |
| *"I went from plugging in with the 'automated' system to the 'manual' one... I found myself waiting for a system prompt to show a conflict, to then realise I had to actively spot them."* | Consult aide-memoire prior to plugging in; training. |
| *"I spent half of my shift testing the new procedure in the simulator. . . When I plugged in to control live traffic I mistakenly used the procedure I had been testing... and had an embarrassing phone conversation apologising to the approach controller."* | Introduce a break before switching. |
| *"Lately I have been using the new kit a lot and it's been weeks since I used the old equipment. . . I have asked for a support controller as an extra pair of eyes for a few minutes because I wasn't confident I was up to speed."* | Raise awareness and create a culture where controllers recognise the issues and feel comfortable making this call. |
| *"I had to go from a 'low-level' sector with a small range where lateral separation is about 3cm on the screen, to a 'high-level' sector where the same separation is about 2cm. . . I got worried I may have lost separation between two aircraft on parallel headings when I actually had 8nm between them (when I only needed 5nm)."* | Consult aide-memoire prior to plugging in; training. |

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