Safety and automation

by Adrian Bednarek

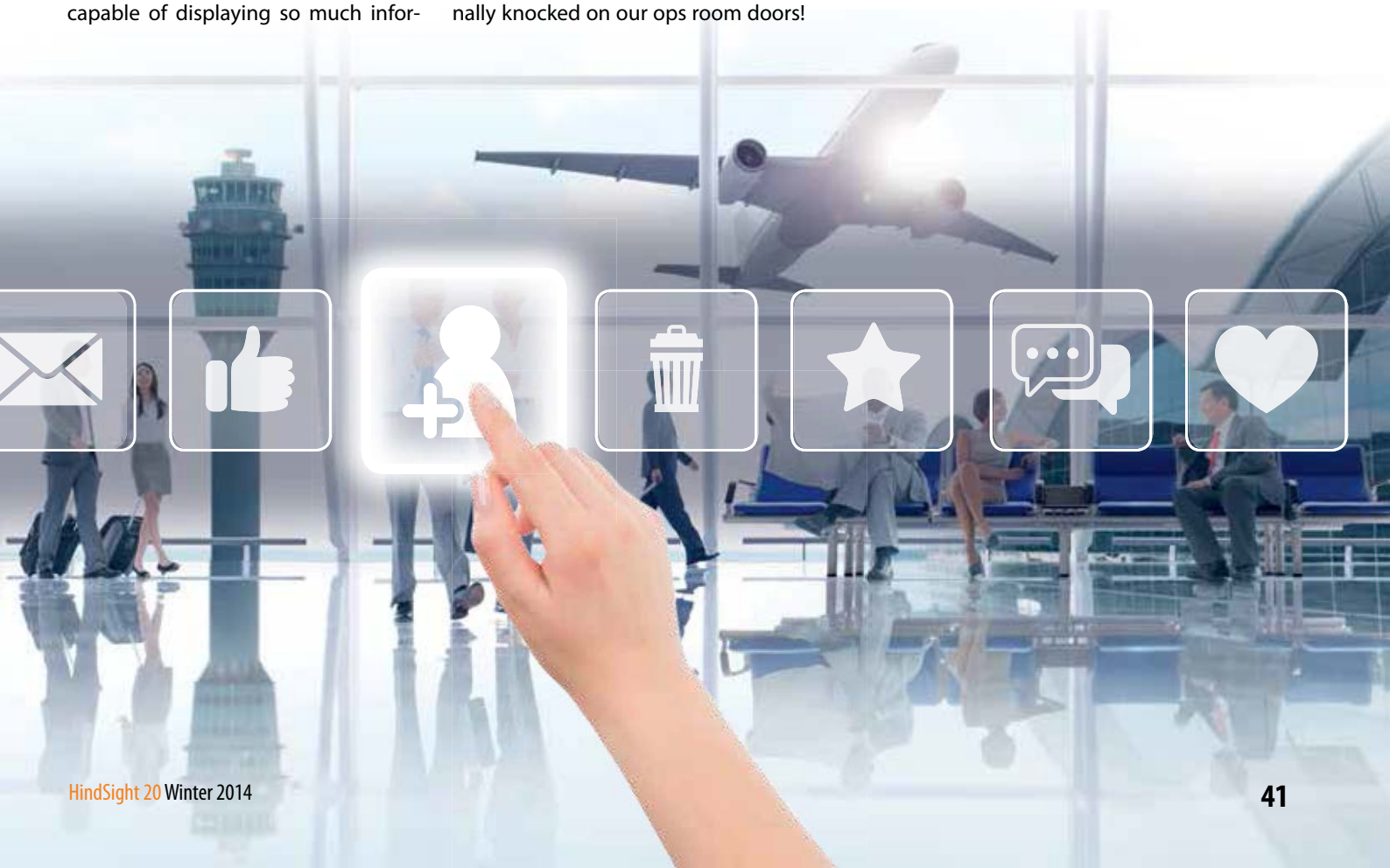
I can remember perfectly my first steps in air traffic control. And no, it is not ancient history... in fact, it is only nine years since I was cleared to use the microphone on my own and talk to pilots for the first time...

Every morning we used to print a new set of strips on A4-sized sheets and then divide them with a paper cutter. The first radar console I ever worked at was made of thick navy blue plastic and filled with tiny red and yellow buttons which glowed in the dark. There wasn't much to look at on the screen - the borders of our sector, final approach tracks, aircraft radar tracks, their mode 3/A codes and mode C altitude readouts. That was all we had and all we needed at that time.

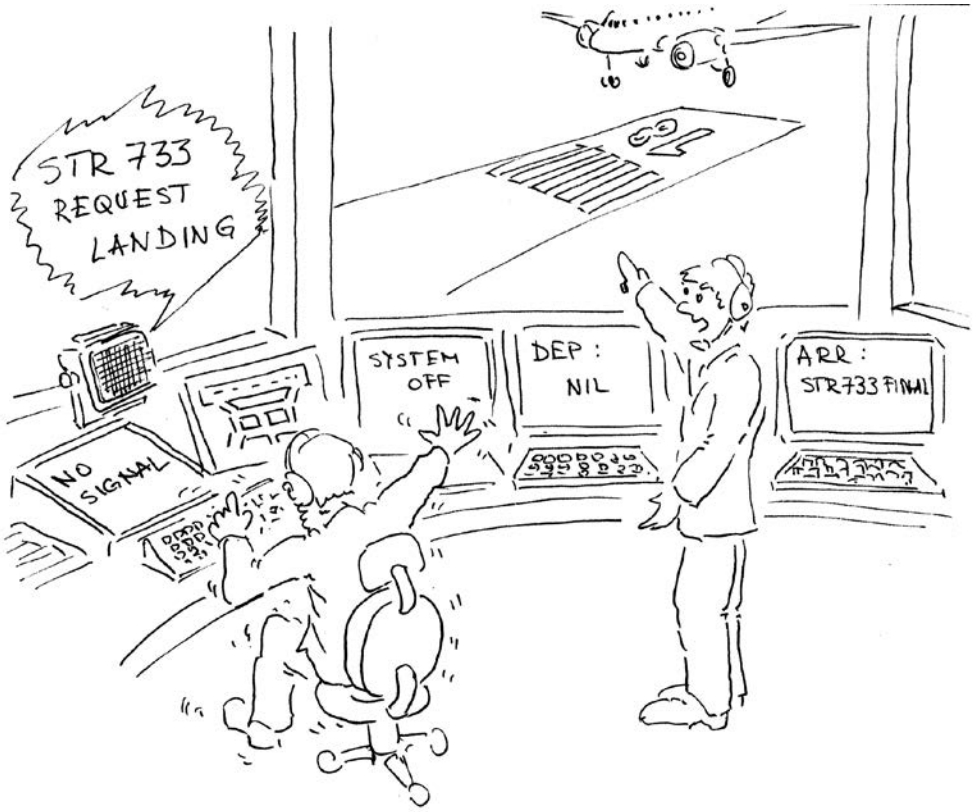
Less than ten years have passed and everything has changed. Today, I sit in front of a high resolution radar screen, capable of displaying so much information that I am unable to read it all at once: Active areas and zones, meteorological data, main roads, rivers, cities, SIDs and STARs, flight plan tables, taxiing queues, mode S data, planned trajectories, velocity vectors etc. All clearances given to pilots are immediately visible on adjacent sectors' screens. Safety net servers monitor all available data to alert me before separation violations or airspace infringements occur. I can honestly say that my job has become more pleasant and less stressful.

The technology which has already stormed into aircraft flight decks has finally knocked on our ops room doors! And it has completely changed the way our work is done. Which makes me wonder if we are aware of the risk automation is introducing to our everyday routine? Are we able to recognise the threats and avoid the traps which computerised ATM systems set? Do we understand what is going on inside those systems?

On the evening of 29 September 2006 a Boeing 737 on a scheduled flight from Manaus to Rio via Brasilia collided with an opposite-direction Embraer Legacy 600 which was on the first leg of a delivery flight to the USA ▸▸



Safety and automation (cont'd)



Tell him to go around and hold! I have to initialize the ASMGCS, RIMCAS, alerts and all...
But George, the RWY is clear and it's the last flight of the day...

flying from São José dos Campos to Manaus. The accident occurred in VMC with both aircraft in level flight at FL370 over the Brasilian rainforest and took the lives of all 154 people on board of the 737. It occurred half an hour after ACC controllers had lost both radio contact with the Embraer and its transponder readouts. As the investigation revealed, the latter was probably the result of inadvertent selection of the transponder to standby by the pilots. Their aircraft then continued its flight at the initially assigned level of FL370 in the absence of an ATC instruction to descend to FL360 at the point specified in the filed Flight Plan. And what was clearly not appreciated by the military air traffic controllers involved once the mode C replies from the Embraer had ceased was that their ATC system had reverted to flight plan data. As a result, successive ACC sectors were provided with information that the Embraer (only intermittently visible as an unstable primary track) was actually flying at FL360. As always, it was not the sole cause of this tragedy but it was certainly a crucial factor.

I would risk making the statement that this accident could have then – and still can today – happen anywhere else in the world.

How many surprises is your ATM system hiding from you? Do we fully understand the equipment we work with? I suspect that no one knows the full extent of all the algorithms which together create the logic of computer systems we use. Even their creators are unable to foresee all the scenarios which their systems could face in the future. Am I exaggerating?

Maybe. But I suggest that you try to honestly answer these questions:

- How well do you know the computer system you use?
- How often are you surprised by its behaviour?
- Are you able to convince yourself that you fully understand its logic?
- Can you always use all of its functions in a timely manner?

I remember one day few years ago, shortly after a new ATM system had been introduced at our unit, when it turned out that even the simplest situations might cause us trouble. In this case, two controllers were dealing with the aeroplane which was flying without a transponder. Thanks to our new software, the controllers' assistant had been able to correlate the aircraft primary track with its flight plan, which was supposed to be a great help in such scenario. But in reality it quickly became obvious that the effects of this rarely used function were not clear to everyone involved - it was very hard to distinguish a pseudo-track created in this way from a real-time track based on transponder information. You can imagine what the crew members were thinking when two ATCOs kept asking them to double-check their transponder settings when they didn't have one on board!

Of course, as long as my state-of-the-art computer system is working the way I want it to, I need no longer worry about loads of simple things. It is more relaxed, my actions are more efficient and the system as a whole is safer for sure. Problems arise only when the computer itself becomes the object I am focussing on. Unsuccessful flight plan update, unusual route modification, setting the required ATC sector sequence, displaying or hiding another layer of information, moving an electronic flight strip to a place

it doesn't want to be moved to... All those actions require our attention and they very often make us forget about what is really important - the aircraft tracks on the screen or the aircraft themselves outside the Tower windows. Many incidents and accidents have taken place when the pilots forgot that their priority was actually to fly the aeroplane. Now air traffic controllers are facing a similar challenge.

Focusing on the tool instead of the job being done is not the only problem with automated systems. Many researchers have pointed out that we ought to expect a number of others, for example:

- **Breakdowns in mode awareness and the resulting automation surprises.** We have already seen in the examples above that our automated ATC systems, with their continuously increasing autonomy, are capable of putting us in a difficult position. The number of functions and available automation modes is getting bigger all the time. It is clear to everybody that we will continue to find ourselves surprised by their behaviour.

- **Knowledge demands and the need for new approaches to training.** Most of our current training programs don't cover the complexity of the whole system and instead provide us with just a simple set of tips and tricks to make the system work under routine conditions. But to fully anticipate effects of our actions, we need to understand the complex input-output relationships going on 'inside the box'.

- **Complacency and trust in automation.** Our computer systems work fine for most of the time and we have learnt to trust them. But are we really prepared for what is going to happen after a total or even partial failure of the automated system we use?

About two years ago my colleagues and I were ourselves faced with a failure. It was a summer afternoon and it was busy when we received a phone call that our ACC flight plan database had failed. We were still able to get all the aircraft safely to their destinations but it was not possible to assign any new SSR codes and ACC management decided that new flights could not be accepted into the airspace.

We were determined to find a way to get the aircraft waiting to take off in our TMA safely airborne as soon as possible. It took us nearly half an hour to come up with arrangements which could be substituted for the usual procedures. All departing traffic would be kept at lower flight levels to stay clear of our FIR's ACC sectors and was re-routed to adjacent FIRs and TMAs. All coordination was done verbally and was necessary on an individual aircraft basis since the routing on their filed flight plans had become irrelevant.. We were also given a few transponder codes which we could use but there were not really enough and we had to make sure that none of them were used more than once every 30 minutes. Again, a piece of paper, a pen and a clock played a vital part in air traffic control! It was completely safe but very far from being efficient.

That day made me aware of how many actions are required just to make a simple flight from A to B happen. It reminded me how many phone calls would have to be made simply to get the proper transponder code and coordinate a higher level for a departing aeroplane without automation. Many, many actions including a lot of phone calls which would together represent multiple reasons why my attention might easily be drawn away from the blips on my radar screen.

Looking back at that afternoon I also realised that someday a similar failure may affect the safety of aircraft in the air. Just imagine the potential effects of losing a flight plan database in a split second. Do your local procedures clearly state what should you do under such circumstances? How many times in your career have you had an opportunity to practice how to deal with such a failure? Does your refresher training address this issue?

All of those problems are inherent elements of such complicated systems where thousands of gigabytes of data is being pushed through countless servers and where several people make decisions based on the presentation of that data. No technological advancement, nor even the most generous investment, will set us free from those threats – continuous development will quickly introduce new challenges.

The only thing we can do is to prepare ourselves by learning how the automated systems work as a whole, what logic they are following and by practicing what to do when they stop working. By making such preparations we should be ready with the proper response and, if necessary, be able to start working the way which nine years ago was considered an everyday routine.

Adrian Bednarek
works in Krakow, Poland as an air traffic controller and a safety manager, focusing on safety culture and practical drift in organizations. He has university degrees in safety engineering and aviation.