HindSight 16

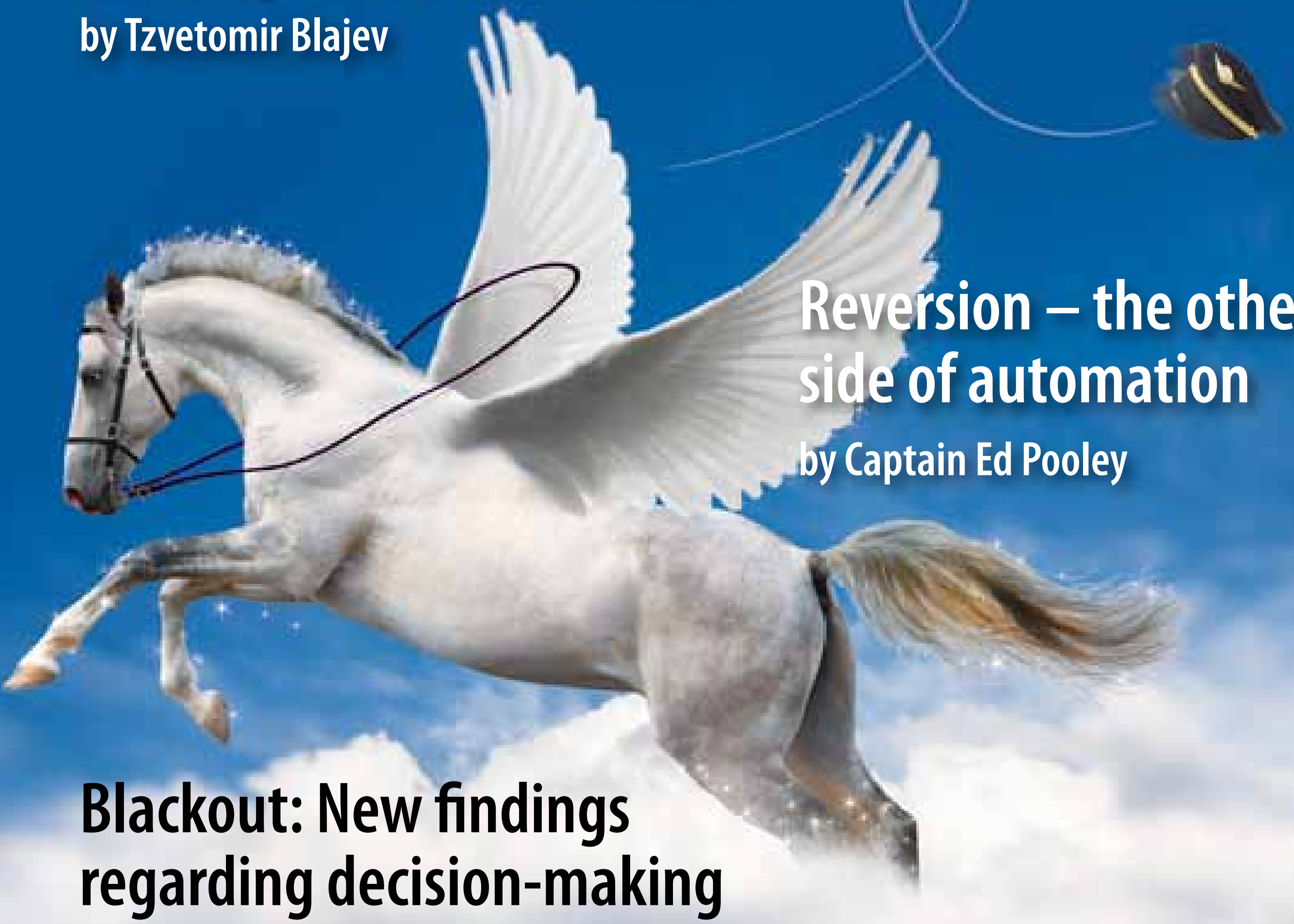
The ability or opportunity to understand and judge an event or experience after it has occured

EUROCONTROL

Understanding (modern) aircraft performance

The average weight of one elephant and four ants...

by Tzvetomir Blajev



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Winter 2012

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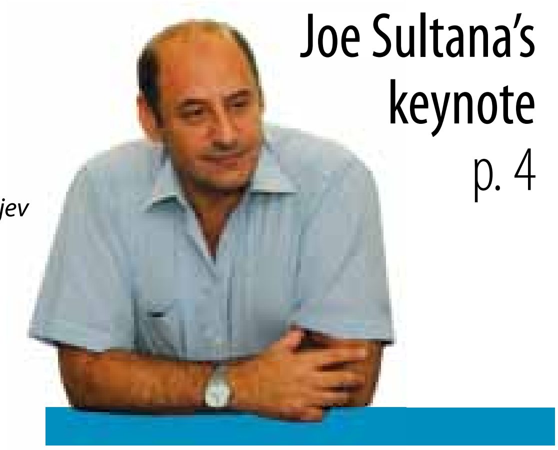

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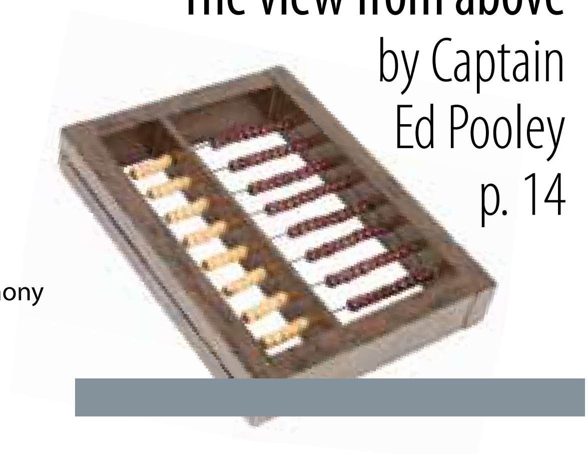

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FROM THE BRIEFING ROOM (cont'd)

CONTACT US

The success of this publication depends very much on you.
We need to know what you think of HindSight.

Do you find the contents interesting or boring?
Are the incident descriptions easy to follow or hard to understand?
Did they make you think about something you hadn't thought of before?
Are you looking forward to the next edition?
Are there some improvements you would like to see in its content or layout?

Please tell us what you think – and even more important, please share your difficult experiences with us!

We hope that you will join us in making this publication a success.
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EDITORIAL TEAM

European Networks

Joe Sultana is Chief Operating Officer of the Network Management Directorate.
He graduated with an Engineering Degree from the University of Malta in 1975 and joined the Air Traffic Services Unit in Malta in the same year. He obtained ATCO Licences in Aerodrome, Radar and Area Control and was a Watch Supervisor for four years.
In 1982, he was appointed Head of Air Traffic Services in the Maltese Department of Civil Aviation.

Dear Reader,

Please take a moment with me to share a perspective on what we are doing in the Directorate of Network Management of EUROCONTROL. Very recently the European Commission has put forward new proposals to make it easier for people to travel and do business within the European Union. This is known as the Single Market Act II and advocates the opening up of EU airspace so that it operates as a single entity. At NM, the Single Sky concept can only become a reality if those of us, involved in ATM network management strive to ensure that the network operates safely and efficiently.

Indeed, I'm sure that European citizens would like to be reassured that the ATM network is safe. Achieving and maintaining a safe network is a complex task that involves many players. You will hear the argument that it is the job of the regulators to keep aviation safe, but I believe it is our common goal as well – it should be the aim of all the actors working together with a distinct purpose. Just as public health is not only the responsibility of the Health Authorities, safety is a not a responsibility just of the Safety Authorities.

To make our contribution to a safe European ATM Network more tangible, those of us in the Directorate of Network Management of EUROCONTROL follow a structured collaborative process with our stakeholders to identify operational safety priorities and thus determine what we can do to make improvements. Consequently, we have collaboratively established our Top 5 Operational Safety Risks and have selected two of these for detailed review – Runway Incursion (RI) and Loss of Separation En-Route (LoS-ER). The detailed review took form of dedicated workshops with six Air Navigation Service Providers during summer 2012. The review was performed with the help of comprehensive operational safety barrier models which we have developed which we call 'Safety Functions Maps' – SAFMAPS. These SAFMAPS were populated with representative samples of data for European 'A' and 'B' severity ATM occurrences and the vulnerability areas were analysed. On the basis of that analysis we now have some very good ideas where to focus further effort and undertake targeted Operational Safety Studies (OSS). The subject of one of the six potential OSS we are looking at has a relation with the theme of this HindSight – it is about the risk of aircraft operations without a transponder or with a malfunctioning one.

Operations without a transponder or with a malfunctioning one constitute a single 'threat' with a potential of "passing" through all the existing safety barriers up to "see and avoid". One of the two incidents from the sample of LoS-ER that was prevented only by the "Providence" barrier involved a malfunctioning transponder. This single threat was also found in a sample of 'A' and 'B' Losses of Separation in TMA operations. This latter sample was constructed mainly to help validate the SAFMAP concept, but it contained an incident that was again prevented only by the "Providence" barrier because of operation without a transponder which arose after a departure from Controlled Airspace into Uncontrolled airspace where there was no transponder equipage requirement.

The Operational Safety Studies are still to be agreed and initiated but you, as HindSight readers, will have the opportunity to read more about them in future editions.

Finally, I would remind you as a HindSight reader that HindSight is a communication tool within a portfolio of activities we undertake which contribute to a safe Network. As such I would urge you to make the most of the magazine by discussing its contents with your colleagues and providing us with your feedback.

The average weight of one

How much is the average (or typical) weight of a group of one elephant and four ants?

You can choose either one tonne (yes! – 1000kg) or 0.3 milligrams, both are correct! Both those figures are valid averages or 'typical' weights. If the elephant weights 5 tonnes and the ants weigh 0.3 milligrams each then the arithmetic average, otherwise known as mean, can be obtained by adding up all the weights and dividing by five - the number of members of this strange group. The result is a mean value of one tonne for every ant. But there is another measure of average called the "mode", which is the most frequently met weight in our group – 0.3 milligrams – the weight of each of the 4 ants. One can use a different kind of average each time because the word "average" has this loose meaning. There is also a third 'definition' of an average called "median" but let us stop here.

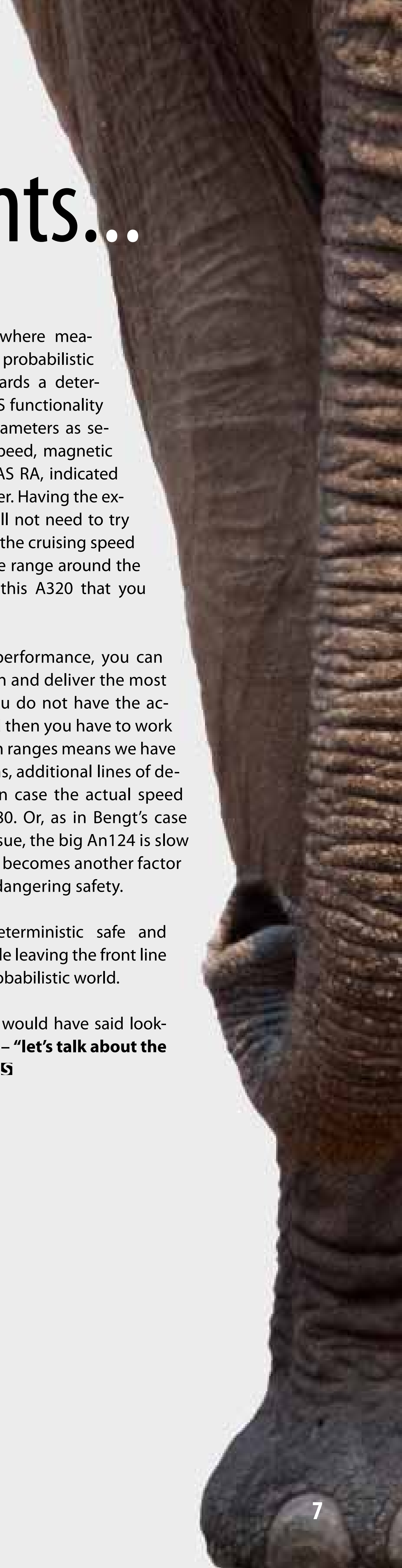
Tzvetomir Blajev

Editor in Chief of Hindsight
Fellow of the Flight Safety Foundation

All that said about the different ways of arriving at an average, what can you expect when you are told Mach 0.79 is the average cruising speed of an A320? It may help you if the aircraft flies just at this 'normal' speed without optimising it to take account of the consequences for the flight of maintenance costs, passenger delays and fuel. This speed may have meaning to an aircraft manufacturer or a certification authority. But, unless we are speaking of a great difference in the ranges – like in the case of en-route spacing between a wide body jet and a regional jet, it does not tell you a great deal about the actual speed of the aircraft you will have on your frequency today. One can go further with this argument. It is not uncommon for procedures and safety assurance calculations to assume a single performance value rather than a range within which the value can lie. The result is a rather simplistic expectation of performance, not only for aircraft, but also for ATM systems.

Working with ranges has a clear drawback – you do not know precisely where in the possible range the cruising speed will be. Or to take another example – in the case of High Intensity Runway Operations at busy airports, the time which aircraft spend on the runway needs to be minimised in order to achieve maximum capacity. This runway occupancy time for a landing aircraft can vary quite a lot and depends on a number of factors, including the touchdown speed of the aircraft, its deceleration capability, the availability of Rapid Exit Taxiways, the actual braking action, etc. This makes the expected occupancy time for a given aircraft only a guess, or expressed more for-

elephant and four ants...



mally, probabilistic. There are well-known human biases when our brain "rejects" thinking in strictly probabilistic terms. In these cases, we have a difference between what actually happens and what we thought would "probably" happen.

What can be done?

One solution is to work towards better measurement, seeking to make the world more deterministic and less probabilistic and turning away from the guess work. At an airport which relies on high-intensity runway operations, you can measure the actual duration of runway occupancy over time and find, for example, an "average" of 50 seconds for this occupancy. This average may not be enough to get the capacity you need and, on top of that, delivery of the desired occupancy will be very uncertain. It will vary within quite a wide range and you can get 40 seconds in some cases but also 1-2 minutes with crews not familiar with the airport missing the exit by just a little and rolling slowly to the next available exit. Yet saving just 5 seconds often provides an opportunity to add another movement to the hourly total achieved. A common practice in this case is to reduce the range of possible occupancy time by working with the aircraft operators and their crews with a view to raising awareness and encouraging crews to expect and plan for a given exit.

Another great example where measurement moves the probabilistic guess world of ATC towards a deterministic one is the Mode S functionality for downlinking such parameters as selected altitude, ground speed, magnetic heading, vertical rate, TCAS RA, indicated airspeed and Mach number. Having the exact Mach number, you will not need to try and figure out how much the cruising speed will "dance" in the possible range around the "average" Mach 0.79 for this A320 that you have now in your sector.

If you know the actual performance, you can run the most optimal plan and deliver the most efficient operations. If you do not have the actual performance to hand then you have to work with ranges. Working with ranges means we have to add in extra protections, additional lines of defence, one more buffer in case the actual speed is Mach 0.65 or Mach 0.80. Or, as in Bengt's case study elsewhere in this issue, the big An124 is slow to vacate the runway and becomes another factor in the chain of events endangering safety.

One cannot ask for deterministic safe and efficient performance while leaving the front line operators working in a probabilistic world.

Or, as the astonished ant would have said looking at its "average" weight – **"let's talk about the elephant in the room..."**. S

When the airplane is more technically advanced than you

by Sidney Dekker

"University 185, weren't you going to climb?" I knew it. I knew the question was going to come. Here I was flying a small TAA, or Technologically Advanced Airplane, boring along at 2,500 feet and not climbing at all. "Ah, Centre, University 185, I'm still figuring out the automation," is my limp reply.

And I was. I was on my own in this new airplane, trying to figure out how to get the autopilot into Vertical Speed mode, and to dial in the new altitude I had been directed to go to so that it would not overshoot it, not even worrying yet about how much engine power I might need to accomplish the climb, all the while staying on the GPS track that I had programmed when still on the ground.

Should I not have studied all this in a bit more detail before getting into the airplane? I asked myself that question too. But let me tell you something. I did. And it didn't help much. When was the last time a guy read the manuals of a set of interrelated and technically complicated devices, while not having those devices in action or in interaction, and actually knew what to do? Let me know if you are that guy. It would be nice to meet you.

In the meantime, I was getting trapped. Trapped into the belief that the best way to solve my automation problem was to try more automation. Lots of pilots do that. They think: "There is a way to get this thing to do this. I know there is a way." And then both pilots go heads-down some more and pound away at the keys of the flight management system. And the airplane either does something that nobody had expected, or stubbornly keeps doing what it was doing without responding to the pilots' ever more insistent pleas to the contrary. My TAA was doing the latter. It refused to climb.

Interestingly, there is an easy way to make any airplane climb. I had this explained to me on one of my first lessons ever. I must have been fourteen or so. "To climb, you pull the houses lever," the instructor said. "The houses lever?" "Yeah, the houses lever. You pull, and the houses get smaller. You push, and they get bigger." "Ah." I pulled the houses lever. And the houses got smaller.

But that was when I was fourteen, and the airplane I was flying was anything but technically advanced. In fact, it wasn't much of anything. Now I was thirty-something and half a decade into the twenty-first century and I was going to get the automation to do what I wanted. So I did not pull the houses lever. In fact, in this TAA, I was afraid of pulling the houses lever. What would happen to all the carefully programmed tracks and restrictions and waypoints and everything that I had so meticulously put into the machine before take-off? Would I ever find it again? I was motoring my way to a rather big international airport, granted still at 2,500 feet, and I found it very nice to know that I had all this automation watching my flight for me. I did not want to risk flushing it all away. And of course, I truly thought that there was a way to get this thing to do what I wanted. I'm that kind of guy, what can I say? Again, tell me if you're not. It would be nice to meet you.

Now the controller in this saga was actually very patient. And perhaps that is the right thing to be – you have that luxury of course. Pilots do not typically make their automation or their airplanes do funny things because they are deliberately bloody-minded. They themselves get surprised by the automation.

A decade before my hunt for the vertical speed mode in that TAA at 2,500 feet, I had been getting my doctorate at The Ohio State University. Researchers there were working hard on documenting and trying to understand automation surprises in the cockpit. Automation surprises, they concluded, happen when the automation does something on its own (or refuses to do something) without immediately preceding pilot input. It may refuse to comply with a limit on a level crossing, for example. Or it may refuse to climb. Or it may suddenly level off, with two pilots looking at it, and then each other, going, "Did you make it do that?" And, of course, neither did make it do that. It was an automation surprise.

One of the problems of technologically advanced airplanes (both big and small) is that indications about the future behaviour of the automation are typically weak. There is still no obvious vertical profile on display in most automated cockpits, for example. The vertical intentions of the automation need to be read from a map display, which shows the lateral, not the vertical. So the vertical gets conjured into this map with underspecified symbols like moving green bananas (I am not making that up) and dots and lines of various colours. It is like reading the runes to divine the future.

Professor Sidney Dekker

is Professor and Director of the Key Centre for Ethics, Law, Justice and Governance at Griffith University, Brisbane, Australia. Author of best-selling books on human factors and safety, he has had experience as an airline pilot on the Boeing 737.

> If pilots are to avoid automation surprises, which surprise not only them but controllers too, then they have to have an accurate model of how the system works.

If pilots are to avoid automation surprises, which surprise not only them but controllers too, then they have to have an accurate model of how the system works. They have to call to mind the portions of this knowledge, this model, that are relevant for the current situation. They have to recall past instructions to the automation, which may have occurred when they were still on the ground, or at least some time ago, and which may have been put in by somebody else. They have to be aware of the current and the projected state of those various inputs to the automation, and how they might all interact. They have to monitor automation activities and integrate all of this into a coherent assessment of the current and future behaviour of the automation.

Did you get all that? It is a tall order. A tall order indeed. And the way we train pilots for automated flight decks may still have some way to go before it really rises to the challenge. See a new pilot go into 737 training? He or she's all smiles walking into the classroom for the first time, because eventually, this is the first jet they are going to learn to drive. Four hours later, they come out of the classroom, not having seen a simulator or airplane yet, and they are lugging more books than they can carry. The smile is long gone. Their flight bag(s) are overflowing with manuals that are chock-a-block with static, dead details of a machine not in action, and not in interaction. Go and study, see you tomorrow in computer-based training. And then, after that and after all those simulator sessions, you're outside, in the airplane, on the line, where you will learn the rest. Or learn how these things really operate.

As I said, we haven't risen to the challenge yet. And this is perhaps even more the case for the TAAs that get flown outside of airline supervision and training centres, by pilot-owner-operators who have nobody to tell them this or that, except perhaps their insurance company.

If you are the controller, maybe the best thing to do is try to be patient. If you can. Have patience with the guy who did not read the manual. Or did read it and found it to be rather useless. As we have seen in a recent accident, airplanes can pull off automation surprises that aren't even in the manual. So a pilot wouldn't know it – however diligently he or she studied the books.

Back in my TAA, I had finally been able to find the right mode and leave 2,500 feet. I announced as much on the frequency. And I did it without touching the houses lever! My pride and stubbornness were both confirmed. "University 185, I see you got it figured out now?" The controller sounded as relieved and proud as I did. Or perhaps that is what I wanted him to sound like. "Affirmative," I said. "I have. Thank you for your patience, Centre. University 185." "You're welcome," he answered. He told me to contact his colleague on the next frequency and wished me good luck with the automation on my journey northward. I wished it myself too. Because at some point, I was going to have to descend.

HI, TECH!

by Alberto Iovino

My six-year-old elder daughter is saving money to buy a PSP.
If you experienced a sense of momentary disorientation about what a PSP is, that means there's probably a good deal of added value for you in continuing to read on...

So, when my daughter first expressed to me her desire to possess one, I knew what she was talking about, but I immediately had to admit, to myself if not to her, that my knowledge of the dreamed-of device was actually quite superficial and definitely did not extend to its cost. After some investigation on the internet (which of course provides evidence that I am not completely out of date), I discovered that it not only allows you to play video games, which I already suspected, but can also function as a camera, an audio/video recorder, a GPS receiver and much more, all of this at a quite affordable price.

Following that, through a brief family council largely dominated by our one-and-a-half-year-old younger daughter articulating her opinion (I only wish I had been able to better understand what she meant), we as parents came to the inevitable conclusion. Although we disapproved of the idea of our girl becoming a video game addict at such a young age, a denial would have soon bestowed upon her the status of outcast from the circle of her fully-equipped friends and school mates. Perceiving us as unwilling to say yes, but unable to say no, she brilliantly resolved the situation by proposing to buy it on her own, thus offering us the psychological alibi for a trade-off between our concerns for her wider mental development and the valuable lesson of achieving a goal through dedication and consistent effort. Moreover, we (and no doubt she too) recognised that we would likely be the main financial contributors anyway.

Please! Don't take me away...
I want to stay as an air traffic controller and not become a number crunching traffic manager...

This anecdote offers some analogies with our approach to modern technology. Generally speaking, we each form our own mental picture of a new environment or experience with reference to models we acquired or developed on first exposure to it. Though, by definition, the aim of technology is to change and manipulate the human environment, inevitably the level of technology you were exposed to whilst growing up assumes, to some extent, the character of normality. For my generation, and in my country, cell phones are a novelty that, over a very short time, have led to dramatic changes in many aspects of our everyday life. For younger people, they are an essential communication tool and obsolescence in their present form can already be anticipated from how they are often used as anything but a telephone. Which closes the loop on those who, coming from the age of phone booths, still ask timidly, and after a fifteen minute lecture by their customer adviser about the wonders of the latest product, where the dial is.

Professionally, keeping oneself up to date is obviously a must. Training is consistently dedicated to new systems and functionalities, designed to address both new ways to do the same thing, and new things to do. Some more basic subjects, by the way, may simply be neglected.

On June 18, 2010, an Airbus A340 and an ATR 42 began near simultaneous take-offs on two intersecting runways at Zurich, one with but the other without an ATC clearance. The crew of a third aircraft alerted the control tower to an incorrect read back which had been inaudible to the controller, who was then immediately able to call the ATR to stop just in time for it not to reach the runway intersection, whilst the A340 performed its departure.

Through the subsequent Investigation by the Swiss BEA/BFU, it was established that the Airbus take-off clearance had been issued right after an instruction to the ATR to line up; the ATR flight crew had misheard the subsequent clearance as being for them. Both crews read back the clearance almost at the same time, with the two communications overlapping. The relatively stronger signal received from the A340 was all that was heard in the tower, but some of the ATR read back was audible to the pilots of the third aircraft, thus allowing them to appreciate what was happening.

About the fact that the controllers did not get any indications of simultaneous transmission, something surprising, to me at least, can be found in the Final Report of the Investigation:

"Air traffic controllers questioned were of the unanimous opinion that they would recognise a multiple transmission due to a superimposed whistling tone. This opinion is based on experience with older aircraft-side transmission equipment, which in the event of dual transmission generally caused a superimposed whistling tone in the receiver in the audible frequency range. However, this is no longer the case with modern transmitters equipped with frequency synthesizers, because these transmit very precisely on the nominal carrier frequency. However, this does cause a superimposed whistling tone (but it) is below the audible range of human hearing."

How many everyday practices do we rely upon, which come from our consolidated background, and which may have become obsolete without this being appreciated? Clearly, keeping pace with technological developments in one's own working environment is about what no longer applies as well as what is new. And this strongly supports a contention that in our job, interaction with other domains is so strong that a good awareness of other stakeholder's tools is paramount – that's what this issue of HindSight is about.

In my days as an airline employee I had the privilege of working with, for, on and inside the first Boeing 747s that ever flew. By the way, quite in line with a tradition which has more than once applied in time, whenever some significant technological innovation has been officially launched, the first 747 to operate on a scheduled flight was actually the second. I mean, it was the one standing from the bench on 22 January 1970, as the intended first option definitely refused to prove fit for its illustrious role. On that occasion, 352 passengers originally expecting to depart on the evening of the 21st, experienced a night-time delay of more than six hours at JFK airport; none of them is reported to have given up, thus providing another example of how humans stand up for their rights, especially if they have paid for a ticket to fly to Europe and are hoping for a story to tell to their friends and family.

These 100 series 747s, which were state-of-the art technology at that time, still required the presence of a flight engineer in the cockpit, like the 727, and used to carry flight attendants who looked like Hollywood stars. But by the late eighties/early nineties, the same aircraft had aged and you could see increasing maintenance time being required to keep them on line - maintenance involving a good deal of mechanics and, compared to today, relatively little electronics. According to the EUROCONTROL Aircraft Performance Database, they could typically climb at 1000 ft/min to 5000 feet whereas for the most recent (and much heavier) version, the B747-8, the corresponding figure is 2500 ft/min and even the Airbus A380 is stated as offering 1500 ft/min to 5000 feet. So wide-bodied aircraft on long haul no longer fly as "flat" after departure as their predecessors used to - although interestingly, they only continue to do better after 5000 feet at slower airspeeds!

This is the sort of change that is normally absorbed in a short time by controllers. Besides any official flow of information in your organisation, working impressions circulate quickly in an ops room, and you will soon hear, if not personally experience, how the newcomer behaves, and will not be caught by surprise. Surprise is more likely when an aircraft type with which you are very familiar begins to be flown in a way you have not previously experienced. I am not referring to isolated aberrations from the normal which may sometimes happen for a wide variety of reasons, but rather to changes in the way operations are conducted. This takes us a little further from understanding how modern aircraft perform, towards obtaining a clearer picture of how modern aircraft are flown.

How many everyday practices do we rely upon, which come from our consolidated background, and which may have become obsolete without this being appreciated?

My ATC generation grew accustomed to "the shorter, the faster, the better" but it is not like that any more. In times of economic crises, strong market competition and high fuel prices, even the most solid airlines are very careful with costs, while many other operators simply struggle not to run out of cash. And then there are new environmental concerns – and the associated potential cost penalties. "Short" is therefore still largely appreciated, though more and more in a strategically organised context like free-route airspace, rather than by means of frequent clearance amendments that sometimes appear to challenge pilots adapting to the increasing capability of aircraft automation. Pilots, as Michel Tremaud reminds us elsewhere in this issue, aim to "stay ahead of the aircraft", just like controllers need to stay ahead of air traffic. "Fast", however, has become a more delicate subject. Pilots aiming to fly continuous climbs or descents are sometimes reluctant to accept high vertical or horizontal speeds, which in the latter case may be procedurally proscribed anyway. What several pilots will increasingly be looking for is less uncertainty and more predictability in both space and time (the so called 4D trajectories), with "management" progressively replacing any other key word, including "control".

So, understanding technological developments in a rapidly changing world requires flexibility and a willingness to adapt, which we all possess in differing degrees. We can generalise and say trivially, and with exceptions, that younger people look better equipped, since they face less novelty in the short term and, probably also because they jumped on board when the average speed was already high. Still, one day they will in all likelihood have to face the same feelings of inadequacy their older colleagues sometimes experience today. As air navigation and ATC are gradually becoming something else, curiosity and an open mind are the only way through.

In any case, once the required sum has been raised, I am looking forward to playing one or two of those video games myself. S

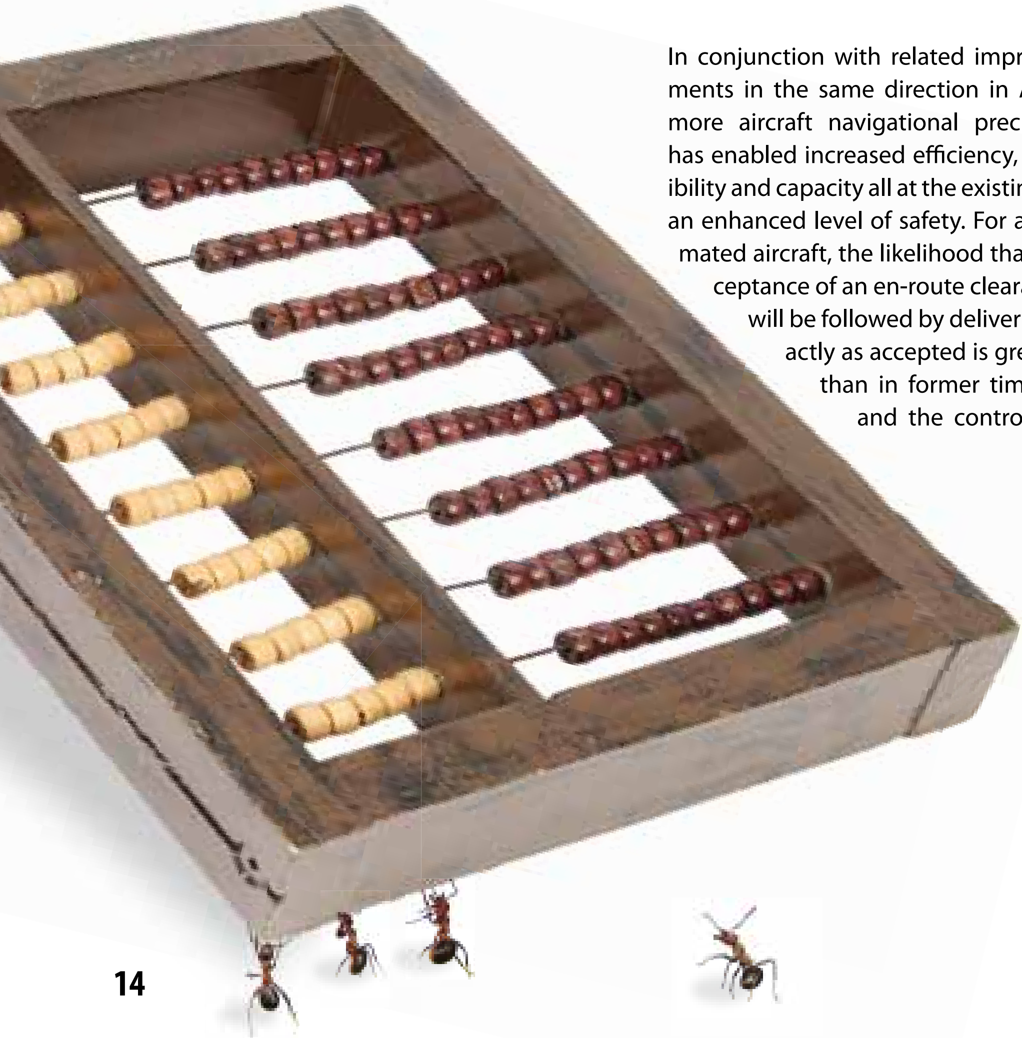
Alberto Iovino

is currently head of ATS Operational Procedures Unit of ENAV Italy. Formerly an airline employee for 8 years, he became an ATCO in 1997, working as tower, approach and area controller.

REVERSION – the other side of automation

by **Captain Ed Pooley**

Most of us recognise that the arrival of high levels of commercial aircraft automation and their major effects on the precision with which aircraft performance can be delivered has had a huge impact on the ATM world.



In conjunction with related improvements in the same direction in ATM, more aircraft navigational precision has enabled increased efficiency, flexibility and capacity all at the existing or an enhanced level of safety. For automated aircraft, the likelihood that acceptance of an en-route clearance will be followed by delivery exactly as accepted is greater than in former times – and the controller's scope for clearance issue is also greater. But poor pilot use of automation in a fast-moving aircraft can quickly lead to problems exacerbated by the expectation of usually more reliable outcomes that have allowed more aeroplanes to use the same skies. And anyway, the skies are full of a complex mix of aircraft with a range of performance capabilities even before you add in the pilot factor!

Of course, apart from such occasional misuse of automation, the everyday issue if it is functioning properly – and it is very reliable – is twofold. Firstly, how well do pilots understand its capabilities? and secondly, if it or the inputs on which it depends malfunction, how well do pilots cope with reversion to 'less automation'?

Quite some years ago, but a long time after flight with auto pilots and auto throttles became routine even for approaches, almost all the simulator time spent on training and checking pilots on their task competence was conducted without the use of the autopilot. The 'excuse' was that to allow it to be used reduced the workload which could be imposed upon pilots to see if they could 'survive' under high pressure. Such pressure was equated at that time with the pressure that might arise if unspecified abnormalities arose. Eventually, as this early level of automation moved into the era of the Flight Management System, directives changed to a requirement to use the autopilot most of the time. However, since the required minimum simulator time stayed the same, operating the aircraft with autopilot out became something to do in the aircraft on a nice day line flying. Back in the simulator, with the exception of a few key (memorised) emergency task competencies[1], the focus in the era of increasingly complex (but also increasingly reliable) automation moved to a combination of the everyday and the **anticipated** departures from it. Because there were now so many SOPs for loss of automation scenarios, it was tacitly assumed that there would be one for most situations provided that (when using a QRH in book form in pre ECAM/EICAS days) you could correctly identify it!

But this understandable focus on mitigating the 'regular' causes of accidents led to far less attention being paid to the wide range of infrequently encountered (for any particular pilot) abnormal events, for which a procedural response was (entirely understandably) not specified or only partially specified. What seems to have been overlooked is that what used to be called 'thinking on your feet', an essential process for situations where no specific procedural response exists, often demands rapid recall of acquired and retained technical knowledge, both generic to all aircraft flight and specific to the aircraft type involved. Such a background goes well beyond how to get the best out of the SMS and how to optimise aircraft performance in 'normal' operations. But how widespread is this 'competency' nowadays?

Joe... does the emergency NAV kit work or should I call MAYDAY?

Could there be a parallel in ATM as systems are increasingly automated to make sure that ATM performance continues to match modern aircraft performance? I think so. Performance of any system which depends on high levels of automation to deliver efficiency, flexibility and capacity with no reduction in safety also demands an ability to cope with reversion to a lower level of system performance. Crucially, just as for pilots, this includes both reversion to expected or anticipated conditions, which can be addressed by prescribed responses and the infrequent, perhaps very infrequent, unexpected and unanticipated conditions. Here again, the ability to respond effectively is, as for pilots, is likely to be dependent on acquired and retained knowledge which will only very rarely be needed.

These 'reversions' may be internal to the ATM system or a consequence of changes to the automation status of an aircraft being handled. Has ATM training risen to this challenge? I suspect that, just as in pilot training, in the areas of background knowledge it has not yet caught up with the rapid arrival of reliable automation in both ATM systems and on the flight deck. If I am right, it is time to ensure that expensive recurrency simulator time for controllers is preceded by classroom preparation for infrequent reversions of all sorts which goes beyond 'learned responses' for the expected and presents 'unpredictable' or 'unexpected' scenarios. For such scenarios, there will not be just one particular and prescribed correct response but several equally acceptable ones. Of course, such background training for the unexpected will undoubtedly also provide a deeper understanding of performance issues in the everyday world. S

Captain Ed Pooley is an experienced airline pilot who for many years also held the post of Head of Safety for a large short haul airline operation. He now works as an independent air safety adviser for a range of clients and is currently acting as Validation Manager for SKYbrary.

1- Such as engine failure on take-off, emergency descents and responses to activation of the Stall Protection System, the TAWS and the TCAS

Modern times

by Eileen Senger

In the last 12 months, two important new aircraft types have begun appearing in Maastricht airspace and elsewhere in the world: the Boeing 747-8 and the Boeing 787. ...

Eileen Senger

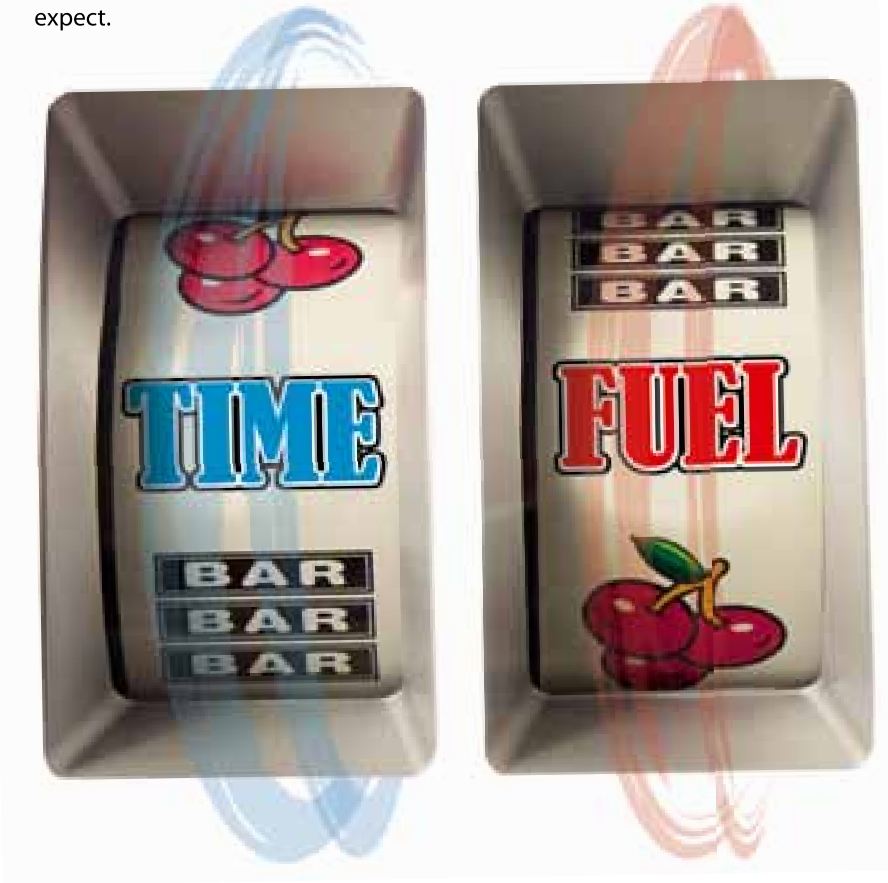
is an Air Traffic Controller at EUROCONTROL's Upper Area Control Centre in Maastricht. She works in the Hannover Sectors which cover north-western Germany and is an OJTI.

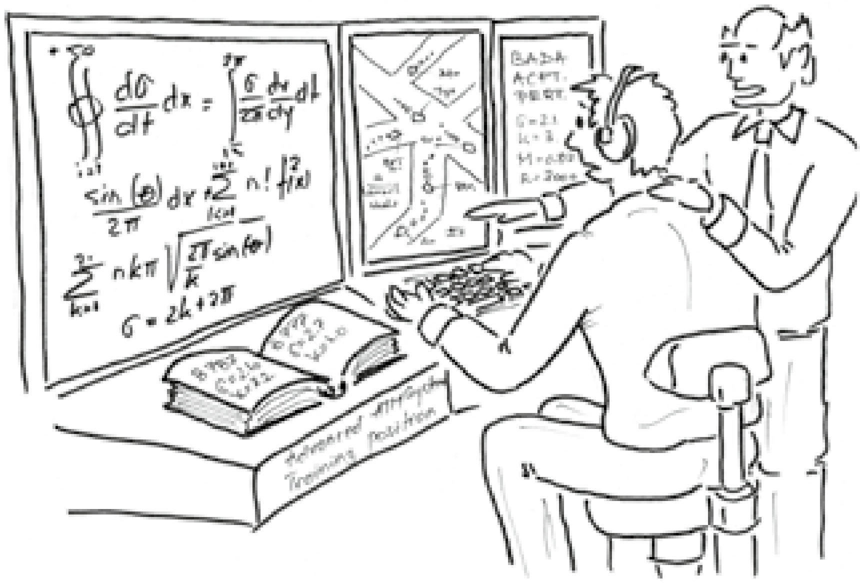
I found out by coincidence. Before, I had read in newspaper and flight magazine articles that both were about to be introduced into service. I had also read about the usual development problems and setbacks and about the expected performance. And then at once it is there, in my airspace, a square symbol looking like all other aircraft. And I have no clue how it will behave and perform on its climb out from Frankfurt. I had received no briefing, no information sheet with indicative performance data, nothing.

When the Airbus 380 entered into service a few years ago there was more activity beforehand. There were concerns about the wake turbulence. So we received briefing sheets about the introduction of this type of aircraft but all they said was: Do not worry about it in upper airspace, it is only an issue for Tower and Approach. Again no performance data, speeds, climb rates etc. So what do you do? You expect the worst. Take an A340-300 on a hot summer day and downgrade from there. I must admit that so far the A380 is doing better than that but that is not the point. The point is that all of us have to gain our own experience with new aircraft types from scratch. The -8? It is a 747 so we can expect it to climb well and fly fast! And we guessed right. But the 787? No clue what to expect. The first time I had it on the frequency it climbed like a rocket and I was very pleased, the next time it climbed like it came from the aircraft factory from the other side of the pond… So how does it perform? I still don't know.

Is all that guesswork really necessary? The data is available and it would be such a nice service to air traffic controllers to provide them with a quick data sheet giving them a rough overview of what rates of climb and speeds to expect.

Now another issue! In these 'fifth generation' aircraft, the pilots' task has shifted from aviator to input operator. It is the computer which is really flying the aircraft. When it comes to automatic flying of a TCAS RA manoeuvre, I think this is a real improvement. Pilots sometimes overdid what TCAS told them to do, not on purpose but in the context of the surprise and the urgency of the situation, occasionally even making the potential conflict worse. A computer has no emotions so it flies the manoeuvre exactly as it is calculated. In our busy airspace, it uses minimum airspace for maximum effect, thus not involving other aircraft. On the other hand this will lead to fewer and fewer TCAS RA manoeuvres





And now all you'll have to do is to use the information from the catalogue with the simple formula from the left screen and you'll get accurate performance data for that aircraft...

being flown manually – what if the Autopilot is not available? And then there is a TCAS RA? With the ever increasing automation one should not underestimate the impact if that automation fails. The training challenge increases and more visits to the simulator for additional and different training become more and more important.

When it comes to estimating what performance an aircraft will be able to deliver, it has become a guesswork as well – for the pilots! "Are you able to climb with 1500 ft/min until passing FL300?" I can only recommend a re-read of Philip Marien´s article "The "OTHER" level busts" from Hindsight 10[1].

In the section "Climb? YES WE CAN!" he sheds light on exactly those situations where "the pilots seem as least as surprised as the controllers to see the aircraft reduce its rate. It seems that predicting or knowing what the aircraft (i.e. the computers) will decide is possible and what is not has become more difficult over the years." Perhaps this is not all that surprising given the greater capability of automation.

And lastly, we are entering a period not only of change but of uncertainty. One of the newest phenomena resulting from the economic crisis in Europe which has put airlines under even more pressure than usual to cut costs is aircraft flying at very low speeds during cruise. Of course this is a result of company policy rather than the performance of modern aircraft types, However, it is mainly due to modern computers and GPS, which monitor every second of a flight in terms of fuel economy vs. time flying, that this is now exercised as rigorously as it is by one German airline. Pilots are given a cost envelope in which their flight has to operate. When I was training I learnt by heart: An A320 cruises Mach .78, when it is in a hurry up to M.80. Today, I see them flying at speeds between M.62 – M.64. And when they are behind schedule M.80. So I never know what to expect. Sequencing has become an adventure. Some pilots are happy to deviate from their slow speed "on ATC instruction", others answer, when asked to speed up, that they do not mind becoming last in sequence. The general opinion amongst air traffic controllers is now that it is impossible to work properly with that airline anymore. Why make an effort to get them in quicker when they are flying so slow anyway! Meanwhile, it seems other airlines have noticed this fuel-saving strategy and have started crawling as well. I am curious to find out whether this is merely a short-term phenomenon or whether this is the start of a change of approach. All we air traffic controllers can do is watch, learn and adapt our way of working.

EDITOR'S NOTE

This problem of the wide range of speeds which controllers now see an aircraft type being flown at is even more complicated where aircraft operators take a comprehensive view of costs. A significant influence on whether fuel-saving by slow flying is conducive to overall cost-saving is dependent on the extent to which scheduled maintenance costs are predicated on flight hours rather than flight cycles and on whether aircraft are owned or leased and, if leased, on the applicable payment terms. Since these factors can and do vary both between and within the aircraft type fleets of different operators, there is little prospect of simple clarity in speeds anytime soon…unless speed declarations on flight plans are to be "enforced"!

1- See http://www.skybrary.aero/bookshelf/content/bookDetails.php?bookId=965

Modern aircraft performance is not alone!

by Maciej Szczukowski

Aviation is great – from shiny airplanes in 70-year-old black and white pictures, with smiling pilots and their white scarves and impeccably trimmed moustaches, to today's complex cockpits and hundreds of flashing lights, with smiling pilots and their white shirts and impeccably tailored uniforms. The huge changes in aviation fashion have been mirrored by the evolution of aircraft performance. What once used to be only a trial in Kitty Hawk is now a huge industry and business with millions of people involved. What used to be a simple "refuel – clear prop – depart – land" scheme is now one of the most complex fields not only in engineering science but also in IT, management, psychology and medicine.

I think that we have also reached a time when modern aircraft performance and present-day ATC performance are not always in step. When did they divide? It is a topic for a whole book, I guess, but let's follow up one or two clues.

I admire the variety of airplanes flying on our skies nowadays. I like to learn about them, see new aircraft types or new airlines landing on the runway of the airport I work at. I like to know that, although still limited by the laws of nature, engineers are able to set new records for maximum altitude, speed, minimum fuel consumption.

These new high-performance aircraft are real pieces of engineering art, but the airspace is one and they share it with others. These same aircraft often fly in the same airspace, are served by one and the same air traffic management system and use the same airports as all the others that are able to "cheat" the law of gravity. Vintage aircraft, business aviation, military, recreational aviation, gliders, paragliders, UAVs, rockets, birds, Santa Claus and occasional witches…

Do you know the expression "the chain is only as strong as its weakest link"? This implies that any chain, system, organisation, or ATC, performance is going to be determined by the least reliable element in it, i.e. by the least reliable airspace user.

This expression may be an interesting proverb, but mathematically speaking it is not true. Systems and organisations are designed to have redundancies, back-ups and protections for their less reliable elements. The chain becomes more like a network and a failure of one element makes a hole in the network but does not break it completely.

The ATC system is a very well protected system, layer after layer…but sometimes, for some situations, it is more like the chain made by the varying performance of the aircraft this system serves. The links in this chain range from very sophisticated modern aircraft, like the Airbus 380 and the Boeing 787, to "war birds" from WWII. And like the proverb above, the reliability of the most sophisticated elements in the chain can be compromised by the less reliable ones.

Let me give you some examples.

Some advanced Air Navigation Service Providers have recently been introducing functionalities in their systems based on Mode S technology. Mode S is a surveillance technology that, together with the usual surveillance position, provides much more information that can be used for all sorts of not only cool but also useful applications. These include aircraft identity, altitude, speed, heading, vertical rates and downlinked TCAS resolution advisories. The benefits may be enormous – take a look on SKYbrary at the video[1] for Mode S implementation in Maastricht UAC. Likely level busts can be captured by the Air Traffic Controllers as soon as the pilot selects the wrong altitude and the same is true for identifying mis-set radar headings and mis-set speeds. Cool!

However, these Mode S equipped aircraft sometimes share the same airspace with aircraft with no transponder at all! Or an inoperative one, or one transmitting incorrect information. Such an aircraft can be invisible or appear with the wrong position for an ACC using only secondary surveillance. STCA systems cannot capture the conflict affected by these problems and TCAS too will be totally ineffective in preventing collisions. You may say that this will not happen or that it is "extremely improbable". Well, it has happened more than once, as you can see from the article that has been already published in HindSight[2].

1- http://www.skybrary.aero/index.php/Mode_S
2- http://www.skybrary.aero/bookshelf/books/1418.pdf

???? and controllers are sometimes confronted with rapid-onset, dynamically developing situation

In this case the single transponder fitted was faulty but still operating and the altitude information was incorrect. SSR Mode C indicated FL 270 but the aircraft was actually flying at FL 290. Surveillance was misled, neither STCA nor TCAS was triggered and the collision was averted only by a 'last-minute' see and avoid. You can see more on this in SKYbrary, which also has a copy of the Investigation carried out by the French BEA (Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile).[3]

What we have now is a chain aircraft with sophisticated surveillance performances potentially in the same airspace with an aircraft with critically affected surveillance performance or no surveillance performance at all (at least secondary surveillance). Think about our proverb now!

My second example highlights the opportunity for teamwork and cross-monitoring on a multi crew flight deck. You may have in one and the same airspace aircraft with two or more flight crew and also small single-pilot aircraft. I know it is simplistic to look only at the number alone, as there should be procedures and other means to ensure an equivalent level of safety no matter how many pilots you have. But do not tell me that the challenges facing two aircraft flying the same non-precision approach are necessarily the same. One aircraft may be operated by a highly trained, professional crew with regular exposure to non-precision approaches. The other could also be legally acceptable in the same airspace, but flown by a private pilot who has not flown such a non-precision approach anywhere for several years.

The story of the Qantas A380 uncontained engine failure on 4 November 2010 is a great example of teamwork in which the Captain had the good fortune to share the flight deck not only with the usual extra co-pilot for the planned long flight but also two more pilots – a Check Captain and a Supervisor Check Captain. This team of five made this story a success with a careful division of tasks[4].

Take another story[5] – the incident on 12 January 2011, when the single pilot of privately operated Socata TBM850, with some 12 hours of flight experience in the 28 days before the incident, lost radio contact on a non-precision approach, continued the approach without landing clearance and landed over the top of DHC8-400, which had lined up ready for take off. The PPL-licensed Socata pilot had a heavy workload in trying to perform an NDB DME approach for the first time in four years and failed to stabilise the approach, mistuned the radio, carried on without landing clearance and finally failed to see an aircraft on the landing runway threshold, missing it by pure chance.

And in general how do you think a single pilot, flying manually copes with copying complex ATC clearances?

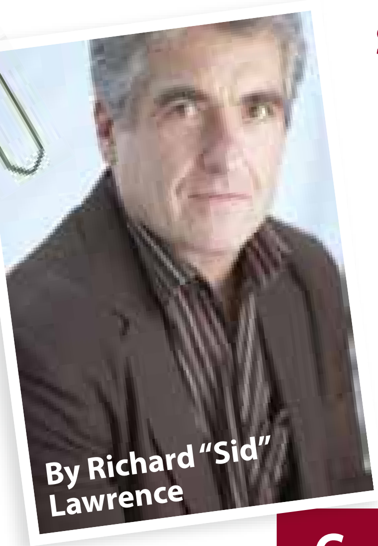
So our ATC network system is highly protected, and we have these sophisticated modern jets with high performance, but sometimes it takes very little for this airspace user community to look more like a chain than a network. This makes it more vulnerable to failure, which is why I would argue that modern aircraft performance and present-day ATC performance are not always in step.

Isn't it about time they werereunited?

Maciej Szczukowski

has been an Air Traffic Controller, for over 10 years, at Warsaw Okecie Airport, Warsaw, Poland. He also holds a PPL.

3- http://www.skybrary.aero/index.php/PC12_/A318,_en- route_north_east_of_Toulouse_France,_2010_(LOS_AW_HF)
4- You can see more about this and access the official investigation report at http://www.skybrary.aero/index.php/A388,_en-route_Batam_Island_Indonesia,_2010_(AW)
5- http://www.skybrary.aero/index.php/TBM8,_Birmingham_UK,_2011_(AGC_LOS_HF)



By Richard "Sid" Lawrence

SAFETY REMINDER MESSAGE

ICAO aircraft operator and radiotelephony designators and abbreviation of 'Type C' call signs

Synopsis

Released on 11 May 2012

EUROCONTROL has received a growing number of safety reports from air navigation service providers and aircraft operators related to the use of ICAO aircraft operators' three-letter and radiotelephony (R/T) designators and the abbreviation of 'Type C' R/T call signs – the latter usually associated with alphanumeric bi-grams (e.g. BA) at the end of the call sign.

"Over the past few months the EUROCONTROL Safety Alert service has been approached by a number of stakeholders requesting the publication of a safety alert. In the pages that follow, I will describe three of the alerts, covering a variety of topics that I hope will spark your interest.

As previously, my intention is to try and bring new information to the table. The aim is to feature more in the way of feedback, responses, comment and analysis to get the most from each alert.

*If you would like to know more about the EUROCONTROL safety alert service, register as a subscriber, submit a suggestion or have a subject that you wish to consider then please contact me at **richard.lawrence@eurocontrol.int.***

This time, all three featured alerts are safety reminder messages."

Alternatively, register your interest through SKYbrary: ***http://www.skybrary.aero/index.php/Portal:EUROCONTROL_Safety_Alerts*** *where you can access the Alerts featured here and previous Alerts.*

ICAO Provisions

- **ICAO Doc 8585, Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services** describes the use of, and lists, aircraft operators' ICAO three-letter designators (e.g. HJT) and R/T designators (e.g. 'HIGHJET').
- **ICAO Annex 10 Vol II, Chapter 5**

  § 5.2.1.7.2.1.1 states that "An aircraft radiotelephony call sign shall be one of the following types… Type c) - the telephony designator of the aircraft operating agency, followed by the flight identification".

  § 5.2.1.7.2.2 states that there is no abbreviated form for 'Type C' call signs.

Analysis

The use of standard R/T phraseology is a cornerstone of safe operations. The correct use of aircraft call signs is an integral part of the pilot/controller communication loop.

Most commercial operations use 'Type C' call signs. Consequently, pilots expect to be addressed by their assigned ICAO R/T designator rather than the company three-letter designator. Routine use of the R/T designator is, therefore, more likely to trigger an accurate and timely response from flight crews; the converse may also apply.

Flight crews should be aware of their own R/T designator but controllers are confronted by a multitude of designators. It is acknowledged that correlating/memorising the ICAO three-letter designators with their R/T designators is challenging, in particular as there are constant changes. In recognition, many ANSPs provide controllers with support information tools/systems to access the designators listed in ICAO Doc 8585.

Using a non-standard call sign designator and/or inappropriate abbreviation of the call sign flight identifier can increase the risk of flight crews and controllers missing a call or taking/making an incorrect instruction. Moreover, repeat broadcasts by controllers and/or flight crews increases workload on the ground and in the air.

SAFETY REMINDER MESSAGE (cont'd)

SOME EXAMPLES OF REPORTED ICAO DESIGNATOR USAGE

Aircraft operator	ICAO aircraft operator designator	ICAO R/T designator	Reported controller/ pilot use	Comments
Thomas Cook	TCX	KESTREL	TOMSON	Controller uses another R/T designator.
Titan Airways	AWC	ZAP	ALPHA WHISKEY CHARLIE	Controllers sometimes do not know the ICAO R/T designator and instead spell out the three-letter ICAO Aircraft Operator designator (AWC).
Regional Europe	RAE	REGIONAL EUROPE	REGIONAL	Pilot shortens the R/T designator which is then repeated by controllers. In this case 'REGIONAL' belongs to another airline.
Volga Dnepr	VDA	VOLGA DNEPR	VICTOR DELTA ALPHA	Pilot spells out the three-letter ICAO Aircraft Operator designator (VDA) instead of using the assigned ICAO R/T designator.

Note: (1) Some aircraft operators do not have an assigned ICAO R/T designator but do have a three letter aircraft operator designator. These airlines often, but not always, use their company name as the R/T designator.

ABBREVIATION OF 'TYPE C' CALL SIGNS – FINAL TWO-LETTER BI-GRAMS

As per ICAO Annex 10, 'Type C' call sign 'HIGHJET 12BA' should be read out as 'HIGHJET, WUN TOO, BRAVO ALFA' and must not be abbreviated to, for example, 'HIGHJET BRAVO ALFA'.

However, in France, in accordance with a national decree, controllers routinely abbreviate 'Type C' call signs that end with a two-letter bi-gram, but they will not abbreviate other formats such as 'HIGHJET 3456' or 'HIGHJET 345B'.

The introduction of alphanumeric call signs and the use of final two-letter bi-grams is increasing as more aircraft operators use this format of call sign as part of their call sign similarity deconfliction strategy.

Your attention is required

Air navigation service providers and aircraft operators were invited to:

- share their experiences, as well as the practices and techniques they use in their operations to manage the issues described (e.g. sector/frequency management and monitoring processes, FDP/HMI track labelling, availability of R/T designators to controllers, use of alphanumeric call signs etc);
- remind both controllers and flight crews about the ICAO SARPs related to the use of call signs in general, and in particular, that:
  - 'Type C' call signs consist of the assigned ICAO aircraft operator R/T designator (rather than the three-letter designator) followed by the flight identification;
  - 'Type C' call signs should not be abbreviated - whilst noting the France exception for call signs ending with two-letter bi-grams;
- consider applying, in accordance with ICAO Doc 8585, an ICAO R/T designator for airlines that do not already have one - aircraft operators to action as applicable.

Feedback

- The Titan Airways/ZAP/AWC combination is still causing problems even after the SRM has been published. ICAO doc 8585 says, "a three-letter designator should reflect to the maximum extent practicable, the name of the aircraft operating agency or its telephony designator…" In this case there is no obvious link between the three-letter designator, the telephony designator and the airline's name and this makes it more difficult for controllers to make and remember a mental association between the three elements. The company has considered changing either AWC and/or ZAP to something that is more readily recognisable with Titan, e.g. TTA as the 3-letter designator. However, it considers that there could be more risk attached to a change than the current position and so wishes to maintain the status quo. EUROCONTROL will continue to monitor the situation.
- To help mitigate the issue described above, Titan Airways includes the call sign "ZAP" in the Field 18 remarks on the flight plan. However, some ATC systems cannot read Field 18 data and in those that can it cannot always be displayed to, or retrieved by, controllers easily. Consequently, this tactic of raising ATCO awareness is largely ineffective.

Further reference

- SKYbrary - Air Ground Communication Briefing Note No2 - **http://ww.skybrary.aero/bookshelf/books/110.pdf**
- SKYbrary - Safety Reminder Message: Abbreviation and Misinterpretation of 'Type C' R/T Call Signs - 5 August 2010. **http://www.skybrary.aero/index.php/Abbreviation_and_Misinterpretation_of_%27Type_c%27_Call_Signs**
- IATA Phraseology Survey 2011. **http://www.skybrary.aero/index.php/Pilots_and_Air_Traffic_Controllers_Phraseology_Study**
- ICAO Annex 10, Volume II Chapter 5.
- ICAO Doc 8585, Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services.
- ICAO Doc 9432, Manual of Radiotelephony.

SAFETY REMINDER MESSAGE

Misuse of international aeronautical emergency frequency 121.5 MHz

published on 19 June 2012

Synopsis

The EUROCONTROL Agency has been notified on numerous occasions about the misuse of the international aeronautical emergency frequency, 121.5MHz, most recently involving inappropriate 'chat' related to the ongoing EURO 2012 football championship.

ICAO Provisions

ICAO Annex 10, Volume V, § 4.1.3.1.1 states that frequency 121.5 MHz "shall be used only for genuine emergency purposes" broadly covering the following activities:

- the handling of a emergency situations;
- air-ground communication with aircraft with airborne equipment failure;
- search and rescue operations and the operation of emergency locator transmitters (ELTs); and
- air policing/interception action.

Note: Some states have filed differences to ICAO SARPs related to the use of 121.5 MHz – for instance, in the UK it can also be used for practice PAN calls to ensure pilot familiarity with the process. Such differences are detailed in national AIPs.

Analysis

Inappropriate 'chat' on 121.5 MHz could interfere with its legitimate use and should be avoided in order to maintain the integrity of the frequency for the purposes for which it is intended.

Your attention is required

- Aircraft operators were invited to remind their flight crews about the correct use of the international aeronautical emergency frequency, 121.5MHz, according to ICAO/national requirements and company policy.
- Air navigation service providers and state aviation authorities are invited to note the subject and share their experience with similar cases.

EUROCONTROL comment

The misuse of the 121.5MHz has been raised on a number of previous occasions. Although the message was primarily aimed at the pilot community, since publication EUROCONTROL has also been made aware of inappropriate controller 'chatter' on the emergency frequency. It is clear that, whoever the culprits may be, there is no place for inappropriate 'chat' on 121.5MHz. The international aeronautical emergency frequency is first and foremost a facility to serve flight safety needs and its use must be reserved for its intended purposes.

Further reading

- ICAO Annex 10, Vol V.
- SKYbrary Safety Alert: Request for Support Message, "Guarding 121.5", 12 March 2007. **http://www.skybrary.aero/index.php/Guarding_121.5_MHz**

Lessons learned from a power outage incident

published on 18 July 2012

Synopsis

A European ATM service provider reported an incident following a planned intervention on the electrical supply system. During the switch-back to mains power a significant system failure occurred. The effects of the event included the unavailability of various operational systems for 01:37 hours. The event was caused by aging STS (Static Transfer Switch) components of the electrical supply system.

Analysis

- The incident occurred during planned maintenance and renovation works on the high tension power network. At regular intervals, interchanges between the public power grid and the emergency power generators were performed. During the last interchange, a power cut lasting some 100 minutes occurred.
- The effects of this event lasted for 01:37 hours, during which time various operational systems were either unavailable or unable to distribute messages.
- A detailed analysis of power network measurements, equipment logs and IT-system logs, followed by factory tests of power system components made it possible to determine the following:
  - A succession of fluctuations in electrical frequency synchronisation between the power system components led to a slight change from the normal frequency of the electrical power signal.
  - Factory tests of STS components showed that this fluctuation exceeded the tolerances in these components because of their variation from design tolerance attributed to ageing (10 years old).
- As a conclusion, the root cause of the unintended power cut was determined to have been STS components erroneously recording a degradation in the power quality (a frequency tolerance overshoot) and leading to a very short cut in power supply to operational systems.

Reported actions and lessons learned

- Short-term solution: the automatic transfer of power source between the STS components was temporarily disabled to avoid recurrence of the incident if similar synchronisation fluctuations should appear.
- Permanent solution: the degraded STS components will be replaced. In addition, the architecture (involving power supply to the entire IT platform via two redundant STS components) and settings of the entire power supply system will be reviewed and, if found necessary, improved.
- Decisions in crisis or system degradation events should be practiced to ensure quick reaction in such critical outages. The prescribed procedures should be made as simple as possible.
- All maintenance interventions on power supply systems should be preceded by a formal safety analysis of potential significant operational effects.
- Crisis management checklists should be developed to promote consistent and rapid decision making.

Your attention is required

- ATM service providers were invited to note the subject and share their experience with similar cases.

EUROCONTROL comment

- It is essential that ANSPs can react promptly and efficiently to emergency situations, degraded modes of operation and longer-term contingencies. Scalable emergency/crisis response regimes should ensure a coordinated approach to most eventualities. A key component to successful and safe outcomes is effective communication between all affected parties.
- In this context, keeping the Network Manager 'in the loop' is important so that collective decisions can be made to not only manage the direct local impact but also the side-effects that might afflict other parts of the ATM Network.

Further reading

- SKYbrary - Safety Reminder Message: ANSP Preparation for Emergency, Degraded modes of Operation and Unusual Situations.
  http://www.skybrary.aero/index.php/ANSP_Preparation_for_Emergency,_Degraded_modes_of_Operation_and_Unusual_Situations
- SKYbrary – Category: ANS Contingency Planning.
  http://www.skybrary.aero/index.php/Category:ANS_Contingency_Planning

Case Study -
The plane spotter

By Bengt Collin, EUROCONTROL

The Cargo Airport Tower

It was a grey misty and cold November day. The wind was from the north, the clouds almost touched the pine trees, in a soft woolly way. Gina was sitting by herself in the old, very old, tower. It needed updated equipment; the whole airport needed an overhaul.

It was the anniversary of her move to the cargo airport, three years to the day. Following her graduation from the ATC Academy some eight years back, she had worked at one of the airports in the very north and had hated it! She hated the cold blistering weather, hated the snow, almost started hating herself for the life she lived.

Being desperate to move, she informed everybody she knew of her situation. One day Tony called. A private company had won the contract to run a cargo airport about an hour south of the capital, they were looking for controllers.

She liked her new job, although the working conditions were different. They could be simply summarised in one sentence: "No we don't have any money for improvements". Everybody was very pleasantly surprised when work began to replace the main airside electrical system. Big machines were digging up the old system, installed by the air force some fifty years ago. The ILS went out of service.

The Plane Spotters

As every Saturday, Brent took the commuter train northbound. Most weekends he dedicated to his hobby. This was not just his hobby, this was his HOBBY, plane spotting. His friend Sid, dressed in a warm green anorak matched by an orange cap, joined him at the main central station. Sid was almost as eager as Brent to visit the international airport. After thirty five minutes on the train, they changed to a local bus and finally arrived at their destination fifteen minutes later. They returned to the excellent location they had found two weeks earlier on the top of a hill just south of the airport. Sid started eating one of his home-made sandwiches, herring with orange marmalade, topped with vanilla yogurt. Brent checked his camera. Sid switched on his air band radio; it was their regular habit to carefully monitor the Tower frequency. How could they otherwise know what aircraft were arriving or departing? "Fascinating, how do these magical controllers do it?", Sid commented as he slowly took a sip from his white tea. "That was a strange call sign" he suddenly said to Brent. One minute later an enormous aircraft passed overhead. like an albatross growing and growing in size. It almost entirely filled the sky above them. "An An-124 cargo plane, got some nice photos" Brent calmly replied.

The International Tower

For the fourth time that day the supervisor changed the runway configuration. Why should we be offering departing and landing aircraft a tail wind, one of the controllers asked. It was a fair question, at the Academy one of the basic things he learned was that aircraft should ideally land and take-off into a head wind. However, his time at the Academy had been well before the local politicians, while enjoying the benefits of the international airport, began arguing that aircraft should not fly over their neighbourhood. They considered that noise was the main local environmental issue, easy to understand for everybody. So consequently, the political compromise was to spread the problem of noise equally, it was as simple as that.

You will get some diversions from the south, the supervisor informed the runway controller. The ILS has been out for almost an hour at the cargo airport.

The tail wind component on the runway was almost ten knots. Someone decided, he did not know when, that up to ten knots tailwind was perfectly alright.

The Approach Control

Three diverting aircraft joined the standard inbound flow. It was a mixture of different types and sizes, an An-124 from an airline Lucia had never heard of before was followed by a business jet with a foreign registration and finally a low-cost carrier plane ten miles behind. Plus all the other scheduled traffic. The wind situation was a bit strange; she knew how to handle this though, she went on doing her job as always. Lucia vectored for runway 36, today being used in mixed mode for both take-off and landings. The An-124 descended very quickly then started to slow down earlier than most aircraft normally did. She understood why - the tail wind aloft was stronger so the ground speed was higher than usual. The business jet behind had a much higher altitude and a much higher ground speed. Their flight crew asked for the ILS frequency, first time visiting this airport?

The International Tower

The line of departing aircraft at the holding point was growing, not that it bothered him, it never did. The approach control delivered the inbound aircraft with exactly the agreed distance in between; Lucia was always professional. An An-124 called, the first time I'd talked to the crew of one of these and I'd never seen one before. The Macchiato coffee was excellent.

The Approach Control

The business jet was still well above the glide slope; Lucia did not like to break him off though. Something told her that their fuel endurance was not that great and to follow a diversion with a break from the straight-in approach would extend their airborne time by another ten minutes, possibly fifteen. But she did not know for sure of course. Lucia asked the pilots to reduce speed as much as possible, it did not help much. When she told the business jet to contact the tower, the distance to the preceding aircraft was just on the agreed minimum and she knew it would be less moments later. The speed was still high too, but the tower controller could handle this couldn't he? "Say again tower frequency", she repeated the frequency; you could tell by the voice of the pilot that their workload was high. "Thanks", the business jet had left the approach controller.

The International Tower

The An-124 landed and the next departure, a Boeing, lined up. "Vacate first right"; it was a rapid exit leading to a parallel taxiway. He could not see the aircraft now, it had started snowing and the visibility was reduced. He checked the A-SMGCS display, the Multilat symbol was off the runway and the SMR reply confirmed this. He saw the next inbound on the radar screen, it was only two miles out, why did it not contact him? Unusually high speed too, he thought as he cleared the departure for take-off. "Tower, be advised that the right wing of the just-landed aircraft is still out over the runway". The aircraft remained stationary at the threshold. The comment made him confused, the landed aircraft was clearly off the runway according to the HMI display. Then seconds later came "he has vacated now" and he could hear the increased sound from the engines as the aircraft started rolling. The business jet was on a half mile final.

The Plane Spotter

"It's started snowing mate, let's go home", Brent said to Sid as a business jet passed over their heads. "Emmerdale on television in two hours. It's looking like a good bet if the weather carries on like this".

At the same time, at a cargo airport to the south, the ILS returned to operational. S

Bengt Collin

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Bengt has a long background as Tower and Approach controller at Stockholm-Arlanda Airport, Sweden

Case Study Comment 1 by Captain Ed Pooley

Not an unfamiliar situation! A potential for conflict between a late go-around and the departing aircraft or a very late landing clearance, either of which will have the added excitement for all parties of restricted visibility.

Captain Ed Pooley

is an experienced airline pilot who for many years also held the post of Head of Safety for a large short haul airline operation.

He now works as an independent air safety adviser for a range of clients and is currently acting as Validation Manager for SKYbrary.

We get a tailwind runway with a lack of positive controlling at both positions. I will concentrate on what I think of the controlling style and leave the question about operating runways right up to the same tailwind component limit as applies to most aircraft types for another day.

Let's look at Approach first. Is there any sign of delivering the usual 'hand off' to Tower? I don't think so. Radar surveillance allows approach controllers to target closer spacing, but if they do that, then positive controlling in required. Speed control for sure. Not accepting an aircraft into the landing sequence until it is at an altitude appropriate to range. Surely this (sometimes) busy international airport has at least one holding stack available? It should be used if necessary to regulate inbound traffic. Pilots always have an option (and these days often an obligation in their SOPs) to decline a clearance which will lead them into an unstabilised approach. Of course they know that if they do so, delay for their landing may follow. If that means their final reserve fuel may be eaten into then increasing numbers of operators now require the declaration of a PAN. And if it becomes obvious that some of it will certainly be used, a MAYDAY. Less prescriptive operators leave equivalent action to the aircraft commander's discretion. Either way, there is no case for the controller not to adjust their normal way of working to a busier situation in order to perform as reliably for Tower as usual.

And then the Tower. I find it surprising that the controller was permitted to issue low-visibility take-off clearance based on automation that doesn't deliver for the whole range of aircraft types which the airport accepts. And once he has been told that the runway is still not clear and knows the next landing aircraft is close in and fast why on earth is the take-off clearance not immediately cancelled and the approaching aircraft told to go around?

But I don't see a problem with individual controllers here, I see an ANSP which is being badly managed by somebody several pay grades removed from the front line. The procedural response to the unexpected has failed because it offered the same relaxed routine that usually works for a situation in which it wasn't going to work. Individuals were left plainly performing outside of their comfort zone and – I surmise without the benefit of proper guidance – probably additional training. Of course, I know the airport loves to get extra landing fees for zero marginal cost – it probably adds to the performance bonus of the top team!

A RECOMMENDATION

A full review should be undertaken of the robustness of ATM procedures to the range of traffic loading which may occur, however infrequently, and of the range of accepted aircraft types which may go with it, preferably by a suitably qualified and independent outsider.

Case Study Comment 2 by Dragan Milanovski

The business jet on final, without a landing clearance, came too close (half a mile) to the active runway which was still occupied by the departing aircraft already cleared for take-off.

It is not quite clear from the story what the exact outcome of this incident was, however all the options I could think of were not "pretty". Except for the plane spotters- it must have been fun to watch the "magical" work of the controllers, but for them anything would probably be considered fun, given the alternatives.

The story describes a set of circumstances that significantly contributed to the event. The cargo airport operator that never had money for improvements all of a sudden decided to replace the main airside electrical system. The big machines, involved in digging the old system out, were probably the reason for the ILS going out of service at the cargo airport, just as it started snowing and the visibility started reducing at the international airport, to which three aircraft (all of them significantly different types) had to divert. At the same time, the runway configuration had to change due to noise spreading to a less preferred option wind-wise (10 knots tailwind).

It appears very unfortunate at first glance (and probably is), but nothing extraordinary that the "system" could not deal with. ILS could go out of service at any point in time for many reasons. Although this is not a common event, safety should not be compromised should it happen. Handling aircraft diverting to another airport is introduced early in controller training and, other than a bit more consideration and understanding, it does not require any special skills. Working in low-visibility conditions with regular runway configuration changes is "operations normal" for many controllers, too. The approach controller recognised that the circumstances were a bit strange but she never had doubts whether she can handle the traffic safely.

It looks like both (Approach and Tower) controllers at the international airport were doing their job as usual and did not make any significant mistakes that contributed to this incident, but it also looks like they could have done more to prevent it. As soon as the flight crew of the business jet asked for the ILS frequency, the Approach controller should have realised that the situation required special attention and addi-

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is an ATC training expert at the EUROCONTROL Institute of Air Navigation Services in Luxembourg.

Most of his operational experience comes from Skopje ACC where he worked for a number of years in different operational posts.

Now, his day-to-day work involves ATC training design as well as Initial Training delivery for Maastricht UAC.

Case Study Comment 2 (cont'd)

I am very much against including safety buffers into control actions by default, but this case was different.

tional safety buffers. Don't get me wrong, I am very much against including safety buffers into control actions by default, but this case was different. For a start, she should have considered passing information about track distance to touchdown (a few times during the approach). Since it was a straight-in approach this would not have been a problem for her workload. Considering the aircraft's speed and its failure to reduce it, a "plan B" for increasing the distance to the preceding aircraft in sequence should have been employed as soon as possible. Even when the sequence was already established and it was evident that the aircraft was above the glide slope and faster than expected, it was not too late to do something about it. She had doubts as to whether the remaining fuel on board the aircraft was sufficient for taking it out of the sequence (which is reasonable), but she never asked. There was a slight chance that there was enough fuel, but we will never know. Her mind was set on a positive outcome of the situation and a hope that the Tower controller can deal with it. Well, he probably could have dealt with the situation if he had known what to expect earlier. The Approach controller should have coordinated with the Tower controller in time about this fast diverting business jet with minimum distance to the preceding aircraft in sequence. The Tower controller would have probably kept the departing aircraft on holding point. Finally, transferring the aircraft form Approach to the Tower frequency also took longer; this was not difficult to predict given the situation. The last safety buffer should have been an attempt to transfer the aircraft a bit earlier than usual.

Bearing in mind that the preceding landing aircraft (An-124) was also diverting to the international airport, it is to be expected that vacating the runway might take a bit longer than usual – especially in low visibility conditions (another argument for the Approach controller's plan B). The Tower controller should also have considered an additional safety buffer in his actions; he should have checked the distance and speed for the next aircraft in the sequence before lining up the departure. After that, he had only one chance for preventing the worse but he also missed it. As he cleared the departure for take-off, he realised there was a fast aircraft on final (two miles) that had not contacted him. By then, he must have been aware that if the departing aircraft did not start rolling immediately the landing aircraft would have to go around. When this did not happen (preceding aircraft slow to vacate) he should have immediately cancelled the take-off clearance for the departure, to ensure a safe missed approach path for the landing aircraft.

A RECOMMENDATION

All the actions described above that could have been taken by the two controllers are very basic and probably well known to both of them. It also appears that they were professional in their jobs, with a good understanding of the situation and aircraft performance. However, both of them failed to realise that it was no longer business as usual, but a situation that required special attention and increased safety buffers. I would recommend an additional Human Factors topic in their regular refresher training dealing with this issue.

Case Study Comment 3
by Mike Edwards

What happened next? ...

As the business jet passed the hill upon which Brett and Sid where sitting, the FO, whose name was Dick, said to the Captain, whose name was Dom, "Hey look at those sad anoraks, bet they wish they were up here". Dom did not answer as he was busy trying to raise the Tower but was getting no reply. The frequency was strangely quiet.

The International Tower controller, whose name was Phil le Gap (being of Gallic extraction) phoned the Approach controller to ask for the business jet to be transferred to his frequency. She was leaving it very late this time.

As the business jet popped out of the last low cloud about one mile final, Dick and Dom were stunned to see a departing aircraft just beginning its roll. The conversation on the business jet was something like this:

Dom: *Tower Yankee Echo Tango*
Dick: *Go around*
Dom: *Tower Yankee Echo Tango*
Dick: *Go around*
Dom: *Land*
Dick: *Go around*

At which point the aircraft, whose name was Joey, decided that enough was enough and plonked itself firmly on the runway. Joey chased the other aircraft down the runway but gave up and came to a stop. Dick and Dom's faces were whiter than the snow that was now falling all around them

The Approach controller was pleased with herself as the business jet did not come out the other side "see, knew it would work" she said to her assistant.

This story is about a lack of positive control both in the air and on the ground. The Approach and Tower controllers did what they always did and ignored all of the clues that should have raised the hairs on the back of their necks. There was no defensive controlling. Sometimes we need a reality check about what we are about and when necessary add a mile or a minute for the wife and the kids.

The Approach controller was aware that the business jet was fast and above the glide path. She was concerned for the fuel state of the aircraft and so did nothing. We are there to assist the pilot, not second guess. Tell the pilot what you can see and ask him if he is happy or wants to re-position. The Approach controller was aware that the separation between the An124 and the business jet was eroding, but she did nothing, she did not even tell the Tower controller. Team work guys! Remember that it does not always go okay. Think back to Mexico and the business jet that crashed on approach in similar circumstances. If nothing else, think about your own rear end.

The Tower controller did not change his plan at all, despite all of the pieces that began to stack up against it. A heavy landing aircraft with a pilot that had not planned on being at this airport, plus some other clues:

- decreasing weather, visibility and runway state, possible long landing run, slow vacation, unfamiliarity.
- A business jet that was faster than expected and not on his frequency.
- Decreasing ability to see anything out of the window, your main mode of working.

The final nail that ensured the incident was going to happen – fill the gap – the day job in mixed mode, one in, one out, always fill the gap between arrivals. The gap was going to be tight regardless but in these conditions it was asking for trouble.

The lesson to be learnt – it does not matter if you lose the odd gap. You must be prepared to vary the plan. This is not about pride. You are there to get everybody home safely and never forget it.

As for Dick and Dom, their situation got slowly worse by degrees, the boiling frog, but Dick did not even seem to appreciate the rise in temperature. An unstable approach, or what our friends across the pond call a "slam dunk" and, when the excrement finally hit the fan, a complete breakdown in decision-making. Dick was left with a very strange desire for a herring and marmalade sandwich.

A RECOMMENDATION

When you hear the voice inside your head telling you to make it work, pause, take a deep breath and remember that a few seconds lost is better than the ultimate cost.

Mike Edwards

is Head of Safety Investigation at NATS (the UK Air Navigation Service Provider). He has held this role for 7 years and prior to that he was Head of Investigation at London ACC. He had been an ATCO at Edinburgh and Heathrow before becoming the manager of all student controllers and then a Supervisor at London Terminal Control. He holds a PPL with Group B rating.

Case Study Comment 4
by Anita Đuretić Bartolović

This story is a great example of how the aviation system is formed and affected by various expectations from various domains.

Even though, at first glance, it appears that the incident was caused by objective circumstances - adverse weather, inoperative ILS, strong wind, a politician's decision on noise abatement and runway configuration – careful reading reveals circumstances that are related to the manner in which the controllers performed their tasks. And not in the professional sense of the word, I would say, rather in the human sense. Their behaviour reveals that they too are human, with their attitudes, thoughts, and feelings. In this case, I would say that the contributing factors to the incident are largely in the realm of human factors - especially the team-related aspects.

Let us start with a few words about the objective circumstances which must not be overlooked in this type of review. The first factor is the winter weather with all its characteristics – grey skies, the cold, low clouds, snow, wind. Adverse weather is always a signal, to controllers and pilots alike, to increase alertness and attention and to be more vigilant.

Anita Đuretić Bartolović

Anita is psychologist and human factors specialist . Currently, she works in the Human Resource Department at Croatia Control Ltd as a psychologist. She is a Lecturer for the subject Human factors at the undergraduate study program of Aeronautics, Faculty of transport and traffic sciences Zagreb.

Additionally, the ILS at the cargo airport was out of service, so cargo aircraft were being re-routed to the international airport, thereby increasing workload in the international tower. For the An-124 pilots and the business jet pilots alike, it was their very first landing at that airport, a fact which should have been considered by the controllers, but also by the pilots.

The situation where the runway configuration had been changed four times and where take offs and landings were being performed in a manner conflicting with the standards of the profession due to a political decision, created additional load for the controllers because it required them to operate outside their normal routine.

The Approach controller concluded that "the wind situation was a bit strange", yet she disregarded it and – at least in her thoughts and actions – she did not give it much attention but carried on with her tasks because she believed in her ability to handle the situation. The Approach controller saw the problem of the rapidly decreasing distance between the An-124 and the business jet, but she was preoccupied with her reflections on why it was happening, and did not inform the Tower controller about it. From the conversation with the pilot, she understood that the pilots were busy and their workload was high, but she still did not ask any questions nor did she offer any assistance. Maybe they couldn't find the charts they wanted - they asked for the ILS frequency – they had never landed there before and they had tailwind. As the distance between the business jet and the preceding aircraft was decreasing, she assumed that the Tower controller would be able to handle it, but she was not certain. Despite that, she neither contacted him nor warned him of the insufficient distance problem and of the potential difficulties that the business jet pilot was experiencing. This in turn caused problems to the Tower controller, who found himself under heavy load.

Finally, stress was also a factor contributing to the error – the excessive workload on the Tower controller as three things happened simultaneously: the business jet approaching at very high speed, the fact that it was two miles behind the preceding traffic and still had not contacted the Tower, and the information received after a take-off clearance had already been issued to an aircraft on the ground that the An-124's wing was still over the runway. All this caused severe stress to the controller, and the incident happened.

Although a part of the above explanation is already related to human factors, one of the biggest problems that occurred is the communication problem, specifically the lack of communication and poor communication. The law of human communication states that non-communication is impos-

The law of human communication states that non-communication is impossible – we even communicate by being absent.

sible - we even communicate by being absent. When I call a colleague on the phone, I verbally transmit a piece of information to him/her, thereby helping him/her, but myself as well, because I am sharing important information. If I do not call the colleague on the phone, I also transmit information, but since there is no verbal mode of operation, such information is more prone to interpretation – it is neither reliable nor certain, as the colleague does not in fact know why I am not calling. If I have an important piece of information and I do not forward it, but I instead believe, maintain or am certain that the colleague can manage without it, then it is detrimental to both me and the colleague. This is precisely what happened in the case in question. The International Tower controller had his hands full with both arrivals and departures and did not communicate with the Approach controller because he completely trusted her to be doing her job professionally as she always did. The Approach controller was thinking the same way.

I suppose that her not contacting the colleague was caused by over-reliance on his capabilities, without verification. This, of course, also leads to error - just as overconfidence does. When we are not completely certain, we take things for granted, and the assumption leads to error. There was no communication between the two colleagues from different positions as both of them believed that they were performing their own tasks in a professional manner and that they could handle complex situations. They thought that coordination was not required. Yet this time, it appears to have been more than required. Each controller worked independently, forgetting about the team, teamwork and coordination.

What must not be overlooked in this case is the pilot-controller communication, which was also deficient. The pilots of both the An-124 and the business jet were new to the airport, they had never been there before, and they did not ask much. The controllers did not ask questions either, nor did they initiate communication, especially the Approach controller. Instead of requesting verbal information on what was going on in the business jet's cockpit, the controller made conclusions based on para-verbal communication, which was equal to taking a guess. From the para-verbal signals in the pilot's voice (the tone of his voice, pitch, volume) she concluded that both pilots in the aircraft were very busy and that the workload was high. When we monitor non-verbal and para-verbal signs in communication, we do not aim at reading thoughts but at understanding behaviour. Para-verbal and non-verbal communications are even more prone to misuse and misinterpretation than verbal communication. Since radio communication is in question here, the interpretation of information is limited to voice characteristics because one cannot see the person and has no other non-verbal signals – such as facial expressions, gestures etc. – and verbal communication is limited by phraseology. Had the Approach controller known that verbal communication serves to convey information, and non-verbal communication to convey attitudes and emotional conditions, she would probably have communicated more in verbal mode.

A RECOMMENDATION

How can such human-factor-related errors be avoided? The CRM (Crew Resource Management) programme which has existed in airlines for years now as training in interpersonal skills and TRM (Team Resource Management) is being introduced into ATC. The aim of these programmes is to reduce errors related to poor teamwork, provide both pilots and controllers with behavioural strategies for improved communication and more successful teamwork and to enhance flight safety. The focus is on the skills required for a person to function more efficiently as a member of a team. It would also be possible to develop and introduce a training programme in interpersonal skills and teamwork enhancement for controllers and pilots together.

Case Study Comment 5 by Dirk de Winter

Is the event I consider to be a threat for you really affecting you? Communicate and you will know. Threat and error management philosophy and techniques are nowadays well established in the worlds of both flight crew and controllers. The main idea is that a perfect world does not exist and in real life operations threats and errors are present that have to be managed successfully by all stakeholders to maintain flight safety.

Dirk de Winter

is has over 11,000 hours flying time over the last 22 years. He started as a cadet pilot with SABENA in 1987 flying Boeing and Airbus aircraft. Before starting his flying career Dirk obtained an academic Master degree in Electronic Engineering at the University of Brussels. Since January 2009 Dirk has been working part-time in EUROCONTROL Agency.

Techniques to identify, anticipate and manage these threats and errors are part of the Crew Resource Management (CRM) training for flight crew or Human Factors training for controllers. Training focuses mainly on solving these issues within their own area of competence and there is seldom a focus on how threats evolve when they pass from one controller to another or from controller to flight crew or vice versa.

The approach controller was presented with additional diverting traffic from the cargo airport. They were of unfamiliar aircraft type, and unknown operators. Instead of mitigating the threat associated with this she focussed on the possibility of low fuel. But was low fuel likely? Maybe the flight crew of the business jet were advised by NOTAM that the ILS would be out of service and in view of the weather forecast were carrying additional fuel. Clearly the flight crew was under pressure: they had to ask for the ILS frequency, missed the tower frequency and were too high and fast on the descent profile. These were real threats which mitigated against the flight crew being able to make a stabilised approach. Knowing the runway was being utilised in mixed mode with a significant tailwind and that the preceding An-124 was not familiar with the airport, the approach controller still passed the speeding business jet to the tower controller.

The tower controller too was unfamiliar with the size of the An-124 and expected him to clear the runway immediately via the rapid exit taxiway. A B737 which had probably received a conditional line-up clearance was already lined-up but was unable to take-off immediately as the An-124 could be seen still not clear of the runway. The tower controller was now faced with an aircraft rolling for take-off and an aircraft in short final being too fast.

Could this situation have been avoided? Was the controller sure the business jet was low on fuel? Did she request his fuel state? She could have told the flight crew she would give them some extra track miles because they were getting too close to the preceding aircraft. The flight crew would probably have been delighted with the extra time to prepare the approach and if they really had been in a low-fuel state they could still have declared an urgency or emergency situation.

Instead she acted in support of the supposed low-fuel state but passed the increasing real threat (reduced separation, rushed approach) on to the next controller and the flight crew. The tower controller is faced with an aircraft rolling late for take-off and the business jet appearing fast on short final. The flight crew of the business jet is also under pressure because they find themselves on short final with an aircraft rolling for take-off in front of them.

A RECOMMENDATION

Always ask yourself if a threat you're considering is a real threat to you or your colleagues. If it's a real threat mitigate it. Never pass it on. Small threats will become bigger for your colleague(s) especially when combined with other unexpected threats.

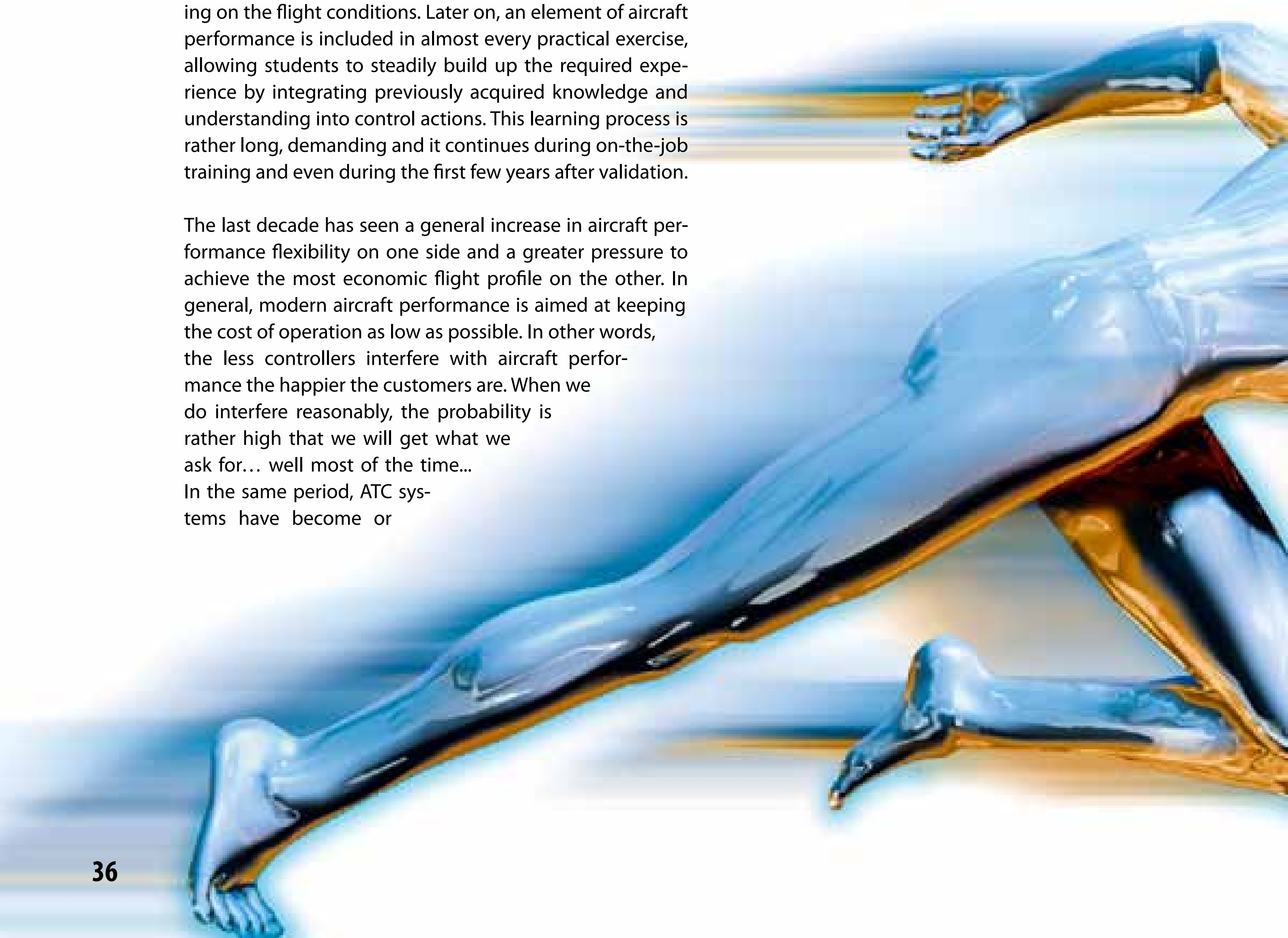
Training aircraft performance for modern/future ATC systems

by Dragan Milanovski

Knowledge of aircraft performance is essential for the provision of a safe and efficient air traffic control service. Every day, every hour, controllers are using this knowledge to provide separation, decide the allocation of cruising levels, create approach or departure sequences, use speed control for sequencing, provide wake turbulence separation and exercise other air traffic control techniques.

Understandably therefore, aircraft performance has been an important part of ATC training since the very beginning. It starts with memorising basic aircraft performance data for the most common aircraft types and understanding how these performance parameters may vary depending on the flight conditions. Later on, an element of aircraft performance is included in almost every practical exercise, allowing students to steadily build up the required experience by integrating previously acquired knowledge and understanding into control actions. This learning process is rather long, demanding and it continues during on-the-job training and even during the first few years after validation.

The last decade has seen a general increase in aircraft performance flexibility on one side and a greater pressure to achieve the most economic flight profile on the other. In general, modern aircraft performance is aimed at keeping the cost of operation as low as possible. In other words, the less controllers interfere with aircraft performance the happier the customers are. When we do interfere reasonably, the probability is rather high that we will get what we ask for… well most of the time...
In the same period, ATC systems have become or are becoming technologically more advanced, with a lot of tools to support controller decision making. For example, having an arrival or departure manager deciding the sequence is a more and more routine part of the job now.



The cruising speed in Mach number form as well as rates of climb and descent are available to controllers through enhanced Mode S. MTCD is used to project ahead and predict potential conflicts and CPDLC has been enhancing controller-pilot communication for quite some time now. In reality, not all the ATC systems are equally advanced but this is nevertheless the broad direction for expected developments in the near future.

Considering all of the above, inevitable questions arise for the two possible directions for aircraft performance learning in future ATCO training. Will controllers still need to do all that hard work to build up their aircraft performance-related competence as we do today when clearly this will be required less and less in the future? Or, will controllers need a more complex type of competence, considering that they will not need to use these skills very often, but when they do, it will be at a higher level of complexity, which involves achieving minimal adverse effects on the economics of the flight profile?

I would not exploit the common argument (used whenever something new is introduced in ATC) that controllers must have the required competence available should the automation fail. This argument has been abused and over-used in the past and it has been proven wrong in many instances. Maintaining an unused competence over long periods is practically impossible when the automation works as expected and without failures. Despite this, the subject continues to be one of the most popular in many discussions – but that is another story…

Instead let's have a look at a few examples in the search for an answer to the questions above.

Use of Rate of Climb (RoC) to ensure separation on opposite tracks

This technique is often used to ensure that vertical separation is established when an aircraft is climbing with conflicting traffic on the opposite track, where the level cross will take place head-on, before the aircraft pass each other. It can also be used as a follow-up, when an aircraft has already been cleared to climb through the level of the opposite direction traffic at significant distance, but by monitoring the rate it has been determined that unless positive action is taken the aircraft will not reach the expected level at the required distance prior to crossing the opposite direction traffic.

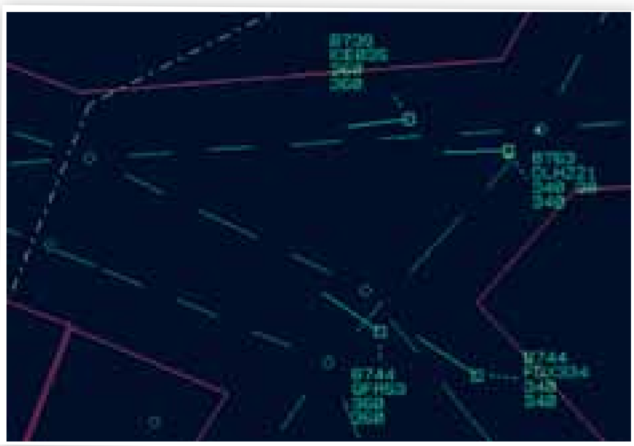
To achieve the most economic flight profile, modern jet aircraft need to fly the best climb rate for a given speed. The objective is to reach the cruising level (where jet engines are more efficient) within the shortest possible time while maintaining optimum forward speed. Requesting an aircraft to increase its rate of climb, even for a small portion of the climb phase, has a negative economic consequence. The rate of climb is increased at the expense of the forward speed, so the aircraft will probably reach its cruising level sooner but will also take longer to get to its destination. It is also worth mentioning that the maximum rate of climb is limited by the minimum climb speed of the aircraft so the rate assigned has to be reasonable and for a short period. Once the restriction is cancelled, most of the excess thrust will initially be used to increase the forward speed at the expense of the rate of climb.

Alternative solutions for these sort of traffic situations involve either use of an intermediate flight level until passing the opposite traffic or radar vectoring. From the economic point of view, levelling off at a lower altitude rather than the cruising level has a greater negative impact than assigning a specific rate of climb. Radar vectoring is usually a more efficient option, but it cannot completely replace the rate of climb solution (because of airspace restrictions, workload etc). In addition, it also increases the distance the aircraft will have to fly.

Allocation of cruising levels and speed control

Another typical situation is when two streams of traffic are converging into one, where the controller's job is to merge them by grouping aircraft types with similar performance at same levels. The usual control actions include a combination of assigning a lower than requested cruising level, speed control to ensure longitudinal separation and/or radar vectoring for sequencing (mainly to delay an aircraft).

Allocating a lower level for the cruise has a negative impact on aircraft fuel burn. Usually, assigning one or two levels below for a part of the cruise phase of flight is manageable, but more than that might have significant consequences later on in the flight. Requesting aircraft to fly at higher speeds than the optimal also increases the fuel burn but reduces the flying time to destination. The opposite happens when lower speeds than optimal are assigned – the fuel burn reduces but the flying time to destination increases. Both options have a negative overall effect on the economics of the flight profile achieved. Radar vectoring for sequencing generally increases flight distance, so it also has an adverse economic effect.



To make things more difficult, most of these actions are planned well before the controller can even talk to the aircraft concerned – consequently knowledge, understanding of aircraft performance and experience are crucial for minimising any unavoidable negative cost impact. Another important point is that controllers also have to deal with "unknown factors", such as routing and requested levels made by an aircraft which are beyond their control area, conflicting traffic in the downstream sectors, wind, weather, turbulence etc.

Top-of- descent (ToD) and/ or use of Rate of Descent (RoD)

Finally, let's have a look into another typical scenario where one aircraft needs to descend and pass through the level of one or more other aircraft which are on a crossing track when the minimum distance between the descending and the crossing track aircraft would be well below the necessary minimum radar separation. The two most common solutions involve either delaying the aircraft top-of-descent point so that it passes above the crossing traffic or initiating its descent early and setting a minimum rate of descent to ensure that vertical separation is re-established at a safe distance prior the crossing point.

For jet aircraft, the most economic flight profile is with the engines at idle from the ToD until the aircraft arrives at the appropriate altitude and speed at the point where the approach for landing begins. If the ToD is delayed, the aircraft will have to descend with a higher rate after passing the crossing traffic. Increasing the rate with engines at idle is generally not a problem because it can be resolved by adjusting aircraft pitch attitude. The secondary effect, which is also a limiting factor for the maximum rate of descent, is the concomitant increase in speed. If ToD is delayed within reasonable limits, then the excess speed can usually be dissipated by extending the speed brakes. In extreme cases, the aircraft may then have to fly additional track miles at lower levels to reduce the speed. On the other hand, if initiating descent early and assigning a minimum RoD until passing the level(s) of crossing traffic is deemed more appropriate, then the descending aircraft will reach the approach altitude earlier than planned and will probably have to maintain level flight at these lower altitudes.

Honey, there's a robot at the door that says it's your colleague I Predictor. He missed the shuttle and asks if he can plug in for the night.

Radar vectoring to ensure radar separation whilst vertical separation does not exist – in this case a very short period of time, as one of the aircraft will be descending – is usually considered a less appropriate solution as it increases the distance that the aircraft will have to fly. But in exceptional cases, where the vectoring also provides a shortcut or when the minimum distance is close to the minimum radar separation and vectoring does not involve significant turns (>5 degrees), it might be the best option.

The "unknown factors" mentioned in the previous example have an even more significant role when the downstream sectors are lower and often busier airspace.

Now let's have a look at all three examples together, let's say it is the same aircraft that is affected during different phases of flight. The negative cost impact can accumulate as the aircraft passes through different sectors. Luckily, in reality the overall effect can be that successive impacts cancel each other out or, more likely, their cumulative effect will be lower than just a pure sum of the individual restrictions. For the time being we have neither the overview nor any control on how the various performance restrictions are accumulating during a flight, but at least there are developments for the future that look promising (4D trajectory management).

Instead of an answer

It is challenging to predict the future, but looking ahead is part of the job and I will give it a try. The traffic situations described above are likely to continue to exist in the future. I am sure you can think of many others too. Furthermore, flying free routes will probably add to the need for positive control actions which will usually have a negative cost impact. At the same time, future ATC tools will probably be available to support the controller decision-making so that we can provide the best possible service whilst minimising the negative effects of both , the "unknown factors" and cumulative effects. The required ATCO competence regarding aircraft performance will probably change, but this change is likely to be gradual and evolving to meet the future demands. Until then, here is a general guidance for assigning aircraft performance restrictions.

Whenever possible, aircraft should be allowed to fly the shortest possible routes at their requested cruising levels, own speeds and rates. When positive control action must be taken to ensure separation, the economic factors should also be considered with high priority before selecting the most appropriate solution to a given traffic situation. Performance restrictions should be kept to the minimum necessary to ensure separation and as much as possible should be distributed among the aircraft concerned in a balanced way. Adding extra buffers by default ("just in case") is not a good practice and neither is applying double restrictions ("just to be sure"). It is always a good idea to assign a limit for any restriction too, since this will allow pilots to plan ahead. When this is not possible, do remember to immediately cancel the restriction once it is no longer required. S

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Automation, workload

by Captain Harry Nelson

During my first period as a test pilot I worked at the Blind Landing Experimental Unit (BLEU) at the Royal Aircraft Establishment, Bedford in England. One of the research topics that was very high on our work agenda was workload.

The research was led by Dr Allan Roscoe, who was well ahead of the times in his thinking and work. What it meant for us pilots was that we were heart rated on every flight and every task, some of which were very demanding indeed. We also used eye marker tools to "see" what we were looking at. We coupled this to skin acidity measurements and we also rated each task in terms of workload. In fact we used a workload rating scale to assess our level of workload. It was developed from the famous Cooper-Harper rating scales for aircraft handling qualities. For those interested, a quick look on the internet will provide many details on these interesting areas of research.

In brief, I learned a lot about workload, which was to stand me in good stead over the rest of my test flying career. I also believe that there are real parallels with workload in the air traffic environment and I thank Hindsight for giving me an opportunity to share some of what I have learnt.

If we look at the aviation definition of automation, it is "something that is designed to decrease workload". Oh, that it were so simple! If we take the autopilot, we have seen the progression from basic attitude hold systems through to modern day, very sophisticated auto flight path control systems which are perfectly capable of controlling an aircraft from just after take-off through to touch-down. The day of the auto take-off is, I suspect not too far away as more and more experience is gained through RPV types of aircraft and then who knows what may come next?

control manually, sort out whatever has happened and then, when happy with the flight path, energy situation and technical configuration, select the autopilot back on again. However, an increasing trend is for pilots to use up significant workload capacity in getting the automatics to do what they want, sometimes at the expense of accurate flight path control. .Exceptionally, this can lead to situations where the safety of the aircraft may be put in question.

Ok, so I have introduced a new term, workload capacity. We all know what that is or we all have an idea of what it is about. Let us look at it in a bit more detail.

> ...an increasing trend is for pilots to use up significant workload capacity in getting the automatics to do what they want, sometimes at the expense of accurate flight path control.

Certainly the autopilots of today do reduce workload and they are extremely successful at doing it. This, coupled to the greater reliability of modern jet transport aircraft can lead to pretty low general arousal states for the crew. Most flights are completed in a very easy and low workload state. But what happens when things do not go as expected?

For most pilots of my era, the natural tendency is to immediately take

It may be helpful for all controllers (and pilots) to consider that at any moment you have a given workload capacity and it changes with many variables. Your health, your fitness level, your degree of stress, your training level, your experience, your fatigue level, your age, and your circadian rhythm are just some of the many factors affecting your capacity for work when examined on an instantaneous basis. You will notice from

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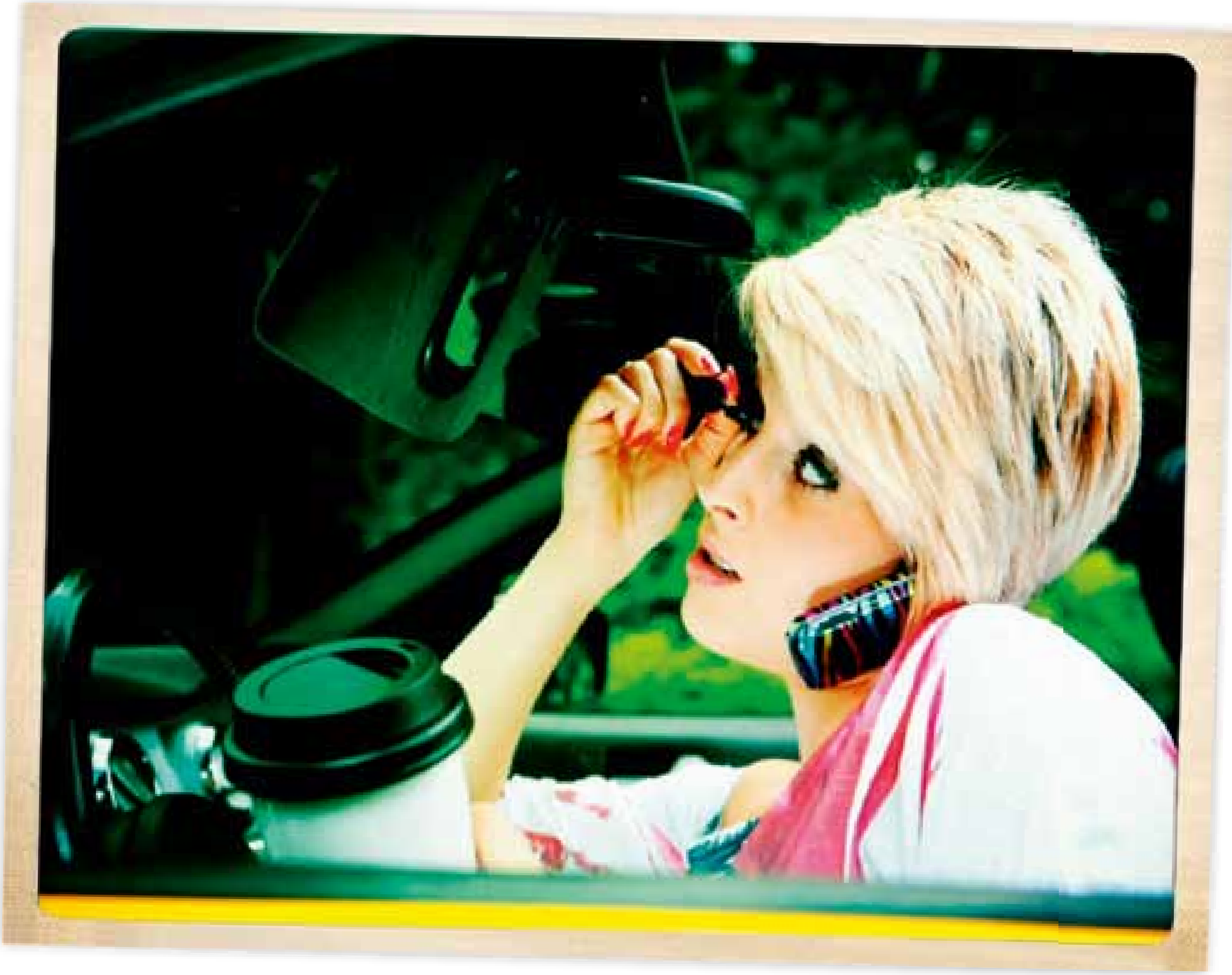
and safety



even this list that some of these are under your control and others are not. For ease of understanding I will group mental workload together with what I call motor function workload or physical workload. When a pilot takes control from the autopilot, his motor function workload takes a step change upwards and immediately demands the use of more of his spare workload capacity. If he was using this capacity for mental tasks like trying to resolve an issue with the aircraft or communicate on a detailed route change, then he potentially may have a problem. As workload gets closer and closer to his capacity limit, several unfortunate effects start to become evident. Firstly he sheds tasks by priority. It may be that one of the first to go is the longer-view monitoring of his situation. He stops "tracking mentally ahead of the aircraft or at least he may not look so far ahead in terms of threats and things to avoid. Later, with a further increase, he focuses only on what is happening inside the flight deck and finally he may tend to "fixate" on an issue or a parameter or a course of action at the expense of others which may be more important or more helpful. His hearing may well be affected. He hears sound but maybe does not register the content of the communication in a normal way. If he hears it then he may not be able to resolve what he is being told and messages may have to be repeated several times before they "get through". Of course this tendency will also cut across the potentially helpful Crew Resource Management (CRM) behaviours that all airline pilots are aware of today and effectively isolates that crew member in his "close to becoming overloaded" state. As the overload condition takes its full grip, Automation, workload and safety (cont'd)

he may well be focusing on only one instrument or even one parameter.

A simple analogy may be useful here. Imagine you are driving an older generation car and you want to change the radio channel. On an autoroute, motorway or autobahn it is easy. On a two lane road with traffic coming towards you, albeit separated by a white line, you need to take some care because more of your capacity is being used in ensuring the trajectory of your car remains on your side of the road. And finally, if it is night and you are driving along narrow country lanes it becomes a task not without risk and you may either switch the radio off or develop a new technique to do it. You reach for the knob without looking and then verify with a quick glance that you have the right one. Then you tune by ear using minimum eye movements as you carefully steer the car along the difficult bendy road. During this action it is quite possible that you would not hear a passenger in the car talking to you or letting you know that you had just passed the intended turn off point. You can build up this workload scenario by imagining that you are driving on a route unknown to you so as well as the motor function efforts needed to steer, accelerate etc you are also thinking hard about the route. Add a crying child in the back of the car and things can go critical as many husbands and wives will testify – and hopefully laugh about it later.

Learning to recognize your personal symptoms as you reach your workload limit is something I would commend to everyone but you must go further and also decide before you get into such a situation, what you will do about it as you see those symptoms starting to impact your performance. You need to formulate an action plan. One of the best action plans before you hit the "black hole" as I call it, is to call for help. Inform someone immediately as soon as you feel that capacity is becoming limited. Ask the other pilot to take over control. Leave it and it may become too late.

Looking from afar I know that much work has been done on this subject in the world of ATC regarding the number of aircraft a given controller can handle during "normal flow" and also how many if the situation changes, let us say by one aircraft declaring an emergency. I am also sure that ATC supervisors try to be aware of the capabilities and workload capacities of their individual team members so that they can keep the whole operations safe but we also know from the real world that occasionally expediency rules and "there is simply no one else". The same applies to pilots. Once again, I must put some of the responsibility onto the shoulders of each pilot and ATC controller. Only you know how you feel right at this moment. Only you know whether the new baby kept you awake all last night and you are feeling really tired. Instead of being "macho" about it, recognize your potentially degraded workload capacity state and inform the other pilot, the supervisor, or the controllers operating the adjacent sectors. They can help and all will have experienced similar situations.

We know from our Human factors studies that there is an optimum arousal and activity state in terms of workload. Too little and our battle is with boredom and inattention and all that can follow from that. Too much and we can hit the black hole. We work best when working within our capacity in an alert and active manner. That must be the target of each one of us as we go about our business in this safety-driven industry.

The mechanisms I have learnt to help me through those potentially very high workload periods include the following:

(1) In general I try to shed unnecessary workload so as to maintain a greater level of spare capacity.

(2) If it is quiet and low arousal that is the threat, imagine an emergency and run through it in your mind what you would do in detail. If you have forgotten something go and check the books.

(3) If it is busy, I try to be a bit schizophrenic by fulfilling my primary task for sure but also trying to stand outside myself and "observe" my own behaviour as if I am in one of those video car racing games where the car is ahead of you. This way it becomes possible to see some potentially risky behaviours before they happen.

(4) As soon as I sense the early warning signs of a significantly building workload situation, I ensure that the other pilot is aware and get him to take more of the non flying tasks, leaving me free to concentrate on flight path and energy control. If he gets overloaded it may slow down communication or delay a procedure but if I, the flying pilot, get overloaded the situation would be much more serious. It was interesting to note that Captain Sullenberger, in the Hudson accident, left his co-pilot to deal almost completely with the drills and attempts to relight while he focused on the water landing.

(5) Of course the doctors are also right. It is important to stay fit and to ensure the right amount of rest and food. In the RAF years ago it was a punishable offence not to take breakfast. So it became normal to do so, a routine that still works and frankly for me, it remains the most important meal of the day.

(6) Finally, a word about the "black hole". The hole is like a whirlpool in that you tend to get drawn progressively into it without the apparent strength to get out again. If one finds oneself at the very edge of the black hole, the only mechanisms I know for a recovery are to take a mental seat in the video game viewing place and take a fresh look at what is going on and to force oneself to examine all the instruments, starting with the attitude indicator, to seek out those instruments that are giving good information. I would guess that the corresponding situation for controllers is fixation on one "tricky" aircraft at the expense of others that may become threats to the overall safe situation. Releasing the thing or parameter that you have fixated on in favour of good parameters is not easy. We all have the desire to make the facts fit the belief or decision that has already been made. Even when faced with overriding evidence that the initial assumption was wrong, we still cling to it and try to get a "fit" from the other parameters. It is vital to re-examine the data in front of you in a fresh way.

In conclusion

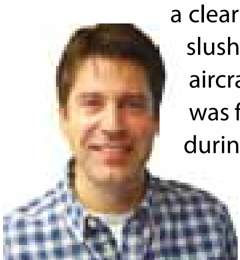
Pilots and controllers can help each other in this workload issue. It is reasonably easy for an experienced pilot to judge how hard a controller is working and I am sure that the reverse is true. Why is it then that I hear pilots putting even more pressure on controllers who are dealing with, for example, a low visibility operations situation. Complaints about holding times, expected approach times and the rest do not help anyone. They add to the overall "noise" and cause irritation to all real professionals. What both the pilots and the controllers need is clear minimized information. From the pilots, the controllers need to know if there is a real fuel shortage or any other operational constraint so that the right prioritization can be made. From the controllers, the pilots need to know the changing weather situation, when they can expect to start the approach so that their passengers and company can be informed, fuel can be managed and maybe in exceptional circumstances, the aircraft can be diverted or an emergency declared. The rule has to be the greater the workload – the greater the assistance we need to be giving each other.

Water/slush on the runway and What every tower controller should know about it

by Gerard van Es, Senior Consultant, NLR-ATSI, The Netherlands.
Analysis of accidents that occurred in the last 20 years has shown that the risk of overrunning the end of the runway on runways covered by liquid contaminants such as water or slush is about 10 times higher than on a dry runway.

The hazardous effect of water/slush on aircraft field performance was first brought into prominence after the accident to the BEA Airspeed Ambassador aircraft at Munich in 1958 in which 23 people were killed. The increasing prevalence of tricycle undercarriages and higher aircraft operating speeds in the late 1950s were associated with this new hazard to aircraft operations. In the early 1960s investigations on the effects of water/slush covered runways were carried out in the United States, the United Kingdom and France. Tests were conducted using catapult-driven test carriages as well as actual aircraft. These early tests gave a clear picture of what water and slush on the runway do to an aircraft that takes off or lands. It was found that the acceleration during take-off was reduced due to the drag effects on the tyres displacing the water or slush and drag due to impingement of the spray on the aircraft thrown up by the tyres. It was shown that this drag increased with increasing water/slush depth. It was also discovered that there was a possibility of loss of engine power, system malfunctions and structural damage due to spray ingestion or impingement. Also directional control problems were found when crosswind conditions existed. Furthermore the problem of very low braking friction between the tyres and surface was identified in which aquaplaning of the tyres played an important role. The problem of water/slush on the runway is more acute for turbine engine aircraft than for piston engine aircraft because of their higher ground speeds and their increased susceptibility to ingestion and impingement due to their design.

Let us have a look at some typical numbers of the effect of water/slush on take-off performance. Just 13 mm (0.5 in.) of slush can subject a large jumbo jet to a drag that is equal to approximately 35% of the thrust of all its four engines. This number increases to 65% for 25 mm (1 in.) of slush making



Gérard van Es

works as a Senior Advisor flight safety and operations for the NLR-Air Transport Safety Institute - Amsterdam, the Netherlands. He is currently involved in the European working group for the prevention of runway excursions.

Now I understand the importance of good information about the water on the RWY; at least for me it saved an expensive pair of shoes...

Some examples

(1) On 14 August 2005, a British Airways Regional Embraer 145 overran Runway 27L at Hannover by 160 metes after flying a stable approach in daylight but then making a soft and late touchdown on a water-covered runway. Dynamic aquaplaning began and this was followed by reverted rubber aquaplaning towards the end of the paved surface when the emergency brake was applied. The aircraft suffered only minor damage and only one of the 49 occupants was slightly injured.
http://www.skybrary.aero/index.php/E145,_Hanover_Germany,_2005_(RE_HF_WX)

(2) On 10 November 2010, a Kingfisher Airlines ATR 72 made an excessively steep and unstabilised tailwind approach in light rain to runway 27 at Mumbai in visual daylight conditions. After touching down late, the aircraft was steered off the side of the runway when it became obvious that an overrun would otherwise occur. The Investigation found that ATC had failed to advise of water patches on the runway and aquaplaning had occurred. It also found that without aquaplaning, the available distance from the actual touchdown point would have been sufficient to stop the aircraft in.
http://www.skybrary.aero/index.php/AT72,_Mumbai_India,_2009_(RE_HF)

(3) On 24 November 1998, a KLM uk Fokker 100 overran runway 20 at Southampton after a late and fast daylight touchdown in rain was followed by poor braking. The Investigation found that the assessment of the runway as 'wet' passed by ATC prior to the incident was correct but that sudden heavy rain shortly before the aircraft landed had caused a rapid deterioration to somewhere between 'wet' and 'flooded'. Slow drainage of water from the runway was subsequently identified and the runway was grooved.
http://www.skybrary.aero/index.php/F100,_Southampton UK,_1998_(RE_HF_WX)

a take-off impossible. In general for a multi-engine transport aircraft, just 13 mm (0.5 in.) of water/slush can increase the take-off distance by some 30-70%.

Additionally, there is another potential hazard associated with taking off and the presence of slush. There is possibility that the slush will be taken into the air on probes and in wheel wells and then freeze quickly as air temperature drops in the climb.

Slush can have an adverse effect on the landing performance too. Braking can be difficult because aquaplaning is likely to occur on water/slush covered runways. This will increase the landing distance compared to a dry runway. However, although it sounds strange a thicker layer of water/slush can be better for landing performance than a thin layer. The drag generated by the water/slush helps to stop the aircraft. The more water/slush you have on the runway the higher drag on the aircraft. This also applies to rejected take-offs and can lead to strange performance restrictions when taking off from water/slush covered runways. For instance more water/slush can give lower take-off weight penalties. Not all aircraft manufacturers account for these affects during the landing.

There is another important difference between an aircraft taking off and one landing on a runway contaminated with water/slush. The former can assess the situation before and during the early stages of the take-off roll whereas the latter has just a few seconds to complete a much more subjective assessment. Night operations can make both judgements much more difficult.

CONSIDERATIONS FOR CONTROLLERS

- For pilots it is extremely important to have the most accurate, complete and up-to-date information regarding the runway condition and weather conditions that could influence this (e.g. heavy rain showers).
- Controllers should realise the potential impact of a water/slush covered runway has compared to a wet runway. There is a big difference in influence on operational safety between a wet runway and a water/slush covered runway.
- Air traffic control plays an important part in this information provision. There have been cases in the past in which incorrect or outdated information regarding the runway condition was provided by the controller to the pilots, leading serious incidents.
- Controllers almost always rely on the aerodrome operator to provide information on the runway surface condition. Inaccuracies in these reports are always possible and difficult to identify by the controller. During daytime the controller might observe areas with water puddles or slush on the runway and inform the crews about this.
- Any 'pilot reports' passed to subsequent aircraft by ATC in respect of water or slush should be accompanied not only by how old they are but by an 'unofficial' comment as to whether it appears from the Tower as though the situation has materially changed.

by Captain Hans-Joachim Ebermann

BLACKOUT

new findings regarding decision-making

A 747 en route from Germany to Los Angeles. The Captain takes the final crew rest break. The plane had been a little heavier than usual on departure. En route, the winds are somewhat stronger than expected and the planned eventual flight level is not achieved. Nearing Las Vegas, the two First Officers on the flight deck decide to call the Captain back from his break, because they believe that on arrival in LA they will no longer have minimum diversion fuel on board and want to recommend a fuel stop in Vegas. The Captain initially wants to fly on but the First Officers' manage to convince him that they should land and refuel. Reluctantly and still tired, the Captain initiates an en-route diversion to an airport which is unknown to all three of them.

Las Vegas is extremely busy and is situated in a valley that does not allow long radar vectors. The approach is steep and, as the aircraft joins the final approach track with a very high crew workload, it is travelling much too fast. So fast that later in the subsequent interview with his flight safety manager, it becomes clear that the aeroplane may well have failed to stop on the runway had a landing been attempted. Although this must have been more or less clear to each of the three pilots on board, nobody at first said "go around" even after the 1000ft gate was passed. It was not until very late, close to touchdown, that one of the two First Officers finally said "go around" and thus prevented the certain crash.

How could this almost fatal blackout have occurred? Was the crew totally incompetent?

While they may have been incompetent, research reported by Etienne Koechlin, Head of the Cognitive Neuroscience Laboratory at the ENS (Ecole Normale Supérieure) in Paris to a recent Conference suggests a more likely scenario.

One third of the entire brain looks after decision-making in the prefrontal cortex. Three areas of the prefrontal cortex can be distinguished: the middle sector controls motivation, the lateral area controls the selection of action options and the lower area processes emotions, personal preferences, etc. All three areas work independently, but communicate with each other constantly. But the brain can only ever make one decision at a time even though two or three situations needing a decision can be monitored simultaneously and the actions initiated after a decision can be monitored to see whether the desired outcome is achieved.

Translated into the FORDEC decision-making model, this means that steps F, E and C (Facts, Execution and Check) will be processed in parallel, while

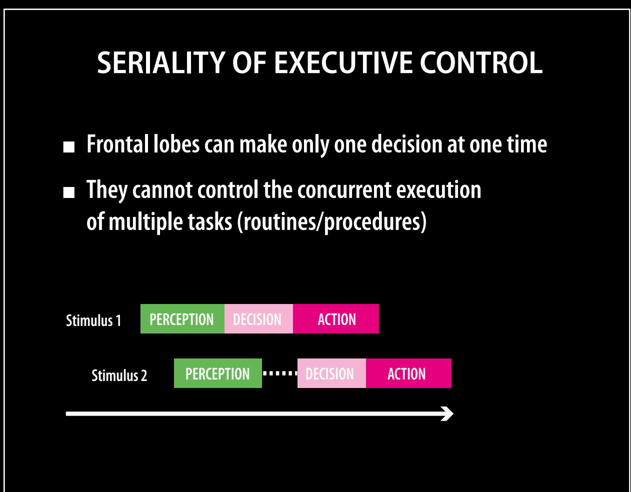


Figure 1: The brain can only make one decision at a time.

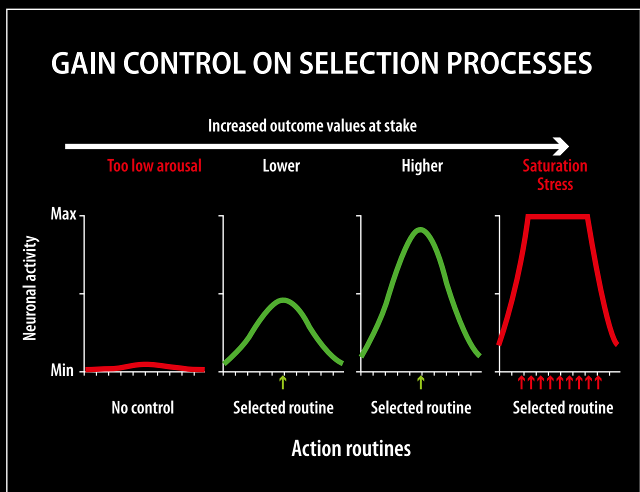


Figure 2: An overload may temporarily prevent the brain from taking any decisions whatsoever.

steps O, R and D (Options, Risks and Decision) will only be processed in succession. These are physiological laws which cannot be influenced by training (see figure 1).

To speed up and simplify decisions, after each decision with a satisfactory outcome the brain stores a routine or strategy to which it will refer in a similar future decision-making situation.

Therefore experienced pilots are able to take decisions more quickly and with greater certainty. On the other hand, if objectively dangerous situations such as unstabilised approaches have been individually found on several previous occasions to be manageable, this can be critical. The brain then stores the "continue instead of go-around" routine and modifies this routine only after a failure. In this case, after a landing overrun. This appears is a somewhat unsuitable learning process. Which is why our SOPs and limits are so important, because only they define the boundary between safety which is objectively necessary and safety which is individually (and wrongly) perceived as manageable.

Equally important here is our training, for example in the simulator, where by handling as many different problem situations as possible, routines and strategies are stored in the brain, to be relied on in an emergency. Savings in training, such as shortened transitions and only three instead of four recurrent simulator events per year, are therefore potentially unsafe.

It is obvious from what has been said so far that the brain cannot deal adequately with situations where it is overloaded. Too many stimuli and/or too many tasks to be handled in parallel place us under excessive strain. Enormous stress is generated particularly where serious consequences are likely - an accident such as an overrun, but also "just" a failed competency check. Such overload can lead to a situation where the brain is temporarily no longer capable of taking any decisions (see figure 2).

This brings us back to the example at the beginning: there was no motivation on the part of the Captain to make an en-route diversion; the crew did not know Las Vegas; the aggressive radar vectoring was a surprise; the plane was allowed to fly too fast; the go-around was difficult; ATC and traffic monitoring also played a part, etc. It is therefore highly likely that while the flight crew involved were "knowingly" clear about the consequences to be expected, they were for a short time unable to decide to abort the approach.

This is a possible explanation of the concept of target fixation: temporary overload leads to this state of "inability to take a decision". People knowingly rush headlong towards an accident and if they survive are subsequently unable to explain their behaviour. It is therefore obvious that overload situations should wherever possible not be allowed to arise in the cockpit because they cannot be managed with a sufficiently high probability that a safe outcome will result.

There are several ways of preventing overload situations arising, or mitigating the consequences if they do:

- Staff selection: the individual resilience and ability to cope with stress of those applying to be pilots should be as great as possible at the time of their selection.

- Training: four recurrent simulator events are the industry standard. Initial training should have an empirical basis in terms of scope and quality. Making cuts with no thought for the long-term effects spells suicide for airlines.

- Better individual stress and fatigue management

- Active intervention in overload situations to rectify matters:

  In the latter respect, accident review shows that whilst intervention is usually very good from the Captain to the First Officer, but it is often poor where the Captain is the person who is overloaded. Particularly where he is the also PF and the First Officer is the Pilot Monitoring (PM, a more recent alternative designation for the PNF). After a significant deviation from an SOP in particular, the First Officer may no longer be sure when he should intervene. Such significant deviation from an SOP can be a consequence of an overload but it can be difficult to judge if it is. Captains who routinely fail to follow SOPs (keywords: private procedures, operational pressure) are liable to discourage intervention from their First Officer at precisely the time when they might really need it as they find themselves in overload.

  This alone is a pretty convincing argument for adhering to SOPs.

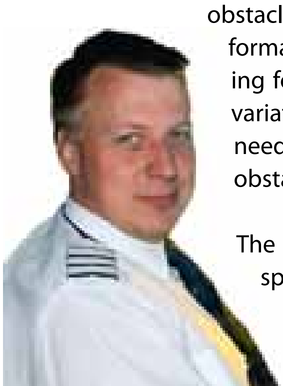
Engine failure on take-off
"hey, what's it doing now?"

"BestAir 11, runway 18, cleared for take-off, left turn..." The old Airbus 340 of Best Airways starts its take-off run and is gaining speed majestically. Just when it is passing the halfway point of the runway, a flock of birds ahead thinks they had the clearance first. As the inevitable collision occurs, the number 1 engine takes a direct hit and emits some flames to show its displeasure. Soon the aircraft's nose starts to rise…

Mac, let's try and set up the FMS just once without saying "Oopsy daisy"...

In normal operations an aircraft should fly according to the given departure clearance, which may be using a published SID or using some other ad hoc clearance.

Acceptance of such clearances assumes that all engines are functioning normally. For engine-out situations the aircraft operator is responsible for checking obstacle clearance and performance data and detailing for each departure any variations which might be needed to retain sufficient obstacle clearance.



Sami Laine

completed an MSc in accident and safety investigation at Cranfield University. He is a First Officer on the Finnair A340/320 fleet, flight safety analyst and Editor of the Finnair safety magazine. His earlier working experience was with the Maritime Rescue Coordination Centre, Helsinki.

The engine failure response procedures adopted may vary from operator to operator. The operators may also have outsourced obstacle clearance evaluation and the planning of engine-out procedures to an external service provider - although of course that does not affect their responsibility in this matter. It is normal to keep these procedures as simple as possible. The procedures are planned for each runway separately. Typically, an engine-out initial flight path will continue on the extended centre line of the runway to a pre-determined distance and/or height, after which a turn towards an engine-out holding position may be specified. These procedures are planned so that an aircraft can continue climbing after level acceleration and clean up of the aircraft configuration.

…In the fictitious example we began with, the Captain was the pilot flying and the First Officer was the monitoring pilot. "V1", the First Officer called when the aircraft passed 130 knots, "Oh my… birds! many birds!" As several large birds hit the aircraft, a number of thumping sounds were audible in the flight deck along with a momentary vibration of the airframe. The cabin crew heard this too. The engine failure drill appeared on the ECAM. The Captain maintained directional control and after the "Rotate" call from the First Officer, he began a rotation towards the engine-out target pitch attitude…

In modern air transport aircraft, the take-off performance is established before each flight. This can be done using an EFB or more traditionally by reference to the performance manual or by use of pre-calculated take-off weight tables and a speed booklet. Performance calculations take into account a number of factors such as runway characteristics and conditions (e.g. runway slope, length, possible contamination etc), weather factors (e.g. temperature, wind velocity), aircraft weight and intended engine thrust settings (full or reduced to extend engine life).

Applicable regulations define margins for each part of the take-off and initial climb, which must be met for every take-off. The main principle is that the most demanding requirement defines the maximum weight of the aircraft for take-off. The required take-off distance is defined as the distance from a standing start to a height of 35 feet and both all engines and the engine-out scenarios are considered. The obstacle clearance of 35 ft may be reduced to 15 feet if the runway is wet or contaminated. The obstacle clearance requirement is based on calculated net flight path, which is the gross, or theoretically achievable, flight path reduced to account for an aircraft flown in a typical way rather than with perfection.

... many aircraft operators expect their pilots to at least inform ATC of a problem that will affect compliance with a clearance early on...

… Meanwhile the aircraft started to lift off from the runway surface. After checking, the First Officer called "positive rate" and the Captain responded by calling "gear up". From the Tower it looked like the aircraft barely avoided hitting the runway lighting installations. There was no transmission from the pilots and it quickly became obvious that the aircraft was not going to follow its departure clearance. The aircraft had passed the SID initial turn and appeared to be flying straight ahead. At last there was a PAN call advising of an engine failure and the pilots' intention to turn towards the VOR after they had passed 1700 feet…

In the flight deck, the priority is to fly the aeroplane. The priority is "aviate, navigate, communicate". However, even with this priority, many aircraft operators expect their pilots to at least inform ATC of a problem that will affect compliance with a clearance early on without getting involved in what the alternative will look like by following with a "stand-by". This allows flight crew resources to be focussed on the initial piloting and engine failure tasks.

Typically, when abnormal check-lists are being performed, the pilot flying temporarily takes over communications with ATC to allow the monitoring pilot to focus fully on the prescribed engine failure tasks. Whether this happens or not, the priority for the pilots is to establish and maintain overall situational awareness.

… The flight joined the holding pattern over the VOR about 20 miles from the airport. Once the aeroplane was in the hold, the First Officer finished the engine failure checks according to the ECAM and started to prepare landing distance calculations for an overweight landing. The First Officer took over as pilot flying whilst the Captain called the cabin crew chief and explained the situation and requested appropriate preparations for landing. He also made a public address announcement to the passengers to keep them informed and asked them to follow any the instructions given by the cabin crew…

Landing performance is calculated in a similar way to take-off performance, with corresponding safety margins. Landing performance calculations must also take account of go-around performance. Again the operator is responsible for ensuring that the engine-out climb gradient would meet obstacle clearance requirements. If the normal published go arounds can't be used in the case of an engine failure, the operator can use higher decision altitudes or publish a special procedure, which may differ from the ATC expectations - at least if the flight crew don't remember to tell ATC about it.

… Finally the aircraft joined the ILS for runway 18 and the Captain made a smooth touchdown, selected full reverse on the three still-functioning engines and the auto brake took effect. Almost the whole length of the runway was used and as the brake temperatures rose, the tyre safety plugs began to melt and some of the main gear tyres deflated. As the aircraft could not now taxi, it blocked the only runway at the airport. The passengers had to disembark to buses down external stairs. Although the flight ended without any drama, the working day of the crew and the ATC still had some way to go.

SIDESTORY / FACT-BOX – the pre-departure briefing for engine failure during take-off given by the pilot designated as the pilot flying.

These briefings will vary from operator to operator and between aircraft types. They are often only given in full on the first flight if the crew will be operating more than one flight. But the following example of one shows the increased workload for pilots during the initial stages of an engine-out situation. Remember, the priorities of cockpit crew are aviate, navigate, communicate!

"After V1 continue take-off, when you call positive rate, I call for gear up. Initial target 12.5 nose up, when indicating - follow SRS. Fly and trim, after trim and at least 100 feet radio altitude – autopilot on. After 400 feet I call for the ECAM actions. In case of a flame out, continue to master switch, if fire or severe damage, continue to fire bottles according to ECAM. At acceleration altitude, push to level off, accelerate, clean configuration. At green dot speed (optimum engine-out climb speed) set safe altitude and pull the altitude knob. The local procedure here is to continue ahead to 8 miles, and then turn left to the beacon. Safe altitude here is 2300 feet. The SID assumes an early turn, so inform ATC with mayday and tell them to standby..."

Close interactions of

by Loukia Loukopoulos and Immanuel Barshi

Note: this article is based on voluntary reports by pilots and air traffic controllers to NASA's Aviation Safety Reporting System (ASRS), which give the reporters' perspective on events that they believe compromised safety. As such, it refers to flight operations that take place in the United States national airspace system.

The relationship between a pilot and a controller is a complicated one. It is critically intimate, yet pragmatically distant. It is built on mutual trust, yet cannot afford blind reliance. Safely seated at his or her station inside a building, the air traffic controller issues instructions and clearances to the pilot of an aircraft way up in the sky, often many miles away. The interaction, which often lasts no more than just a couple of minutes, is highly proceduralised. And yet, despite its highly critical function of getting an aircraft safely to or away from the ground, and the fact that it is carried out between experts, conscientious professionals, there are occasions when this interaction goes wrong. When it does, it compromises the integrity of a flight and potentially puts an aircraft (and its crew and passengers) dangerously close to an accident. Let's examine three such cases:

Case 1. Captain (pilot flying) reporting: *"On descent into ATL on the CANUK Seven… we were asked to keep our speed up … [and] given the clearance to cross CANUK at 12,000 ft at 250 kts. We began our descent to comply with the restriction. Approximately 30 miles from CANUK, …our clearance [was revised] to level at FL230. Our descent rate was close to 4000 ft/min. [There was] no way we could level at FL230… [the PM] transmitted "Unable to comply"… as we descended through FL210…*

[ASRS 878704, March 2010, B757, IFR on descent]

the disconnected kind

While flying into a busy airport, the crew of this aircraft, is expecting (per the published procedure) to cross CANUK "at 14,000 or as assigned by ATC." Having let the aircraft automation calculate the optimal path to the 14,000 ft restriction (in line with company policy), the crew is letting the autopilot determine the appropriate angle and speed that will bring the aircraft to CANUK, at the right altitude and the right speed. The controller, concerned with managing the flow of traffic, perhaps also in an effort to help the aircraft arrive sooner at its destination, issues a new instruction. This instruction requires the aircraft to reach a lower altitude sooner, something that requires a steeper descent. When the controller reacts to changes in the traffic flow, however, and issues a different level-off altitude, the aircraft is in a high rate of descent – so much so that the crew hardly has time to respond to the controller that it will not be able to comply with the new instruction before the aircraft has already passed the desired level-off altitude by 2,000 ft.

An aircraft in motion has a lot of momentum and high inertia. The faster it moves, the harder it is to change its direction and the more time, space, and distance it requires to change or arrest its movement. It is also possible that during steep climbs and descents, the controller's display of the aircraft altitude could be misleading because the altitude encoder on the aircraft's transponder lags behind the actual altitude.

Case 2. Captain (pilot monitoring) reporting: ***"We were descending…with clearance to descend via. We did not get a runway (24R) until almost the end of the STAR … I selected the runway and the transition, but could not close the discontinuity that showed up on the flight management computer. The pilot flying reselected the same and executed. We both then realized ENGLI was behind us and LNAV had disengaged… Since this was a [Boeing 737]-500 without a moving map, I relied on the FMC to know which fixes the aircraft had already passed. .. About the same time, ATC gave us a vector and cleared us direct to KONZL. We then flew the ILS 24R uneventfully to a landing."***

[ASRS 929900, January 2011, B737-500, IFR on Descent]

Long before reaching the top of descent point, the crew has entered the designated arrival route (STAR) in the flight computer and has (in line with company policy) selected the appropriate autopilot mode (LNAV), which is now taking the aircraft through the designated waypoints in compliance with the necessary path and speed restrictions. The only piece of information that is still missing is the tail end of the arrival, the approach and landing information. As soon as the controller provides that, the pilot monitoring attempts (in line with company procedure) to enter that information in the aircraft's flight management computer, so that the aircraft automation can continue leading the aircraft to a safe landing. Without the quick awareness afforded by a moving map, such as the one available on later generation aircraft of the same type and model, the crew wastes valuable time (and undoubtedly experiences frustration) by attempting to enter "invalid" information into the computer. In fact, the aircraft autopilot has already (in accordance with its design) "dropped" the commanded automation mode in response to the invalid information, and the aircraft automation is not in the mode the crew expects.

The crew relies on the approach controller to provide timely information, and also relies on the automation to the point of not always paying careful attention to their location and path. Both ATC and the automation are so reliable so much of the time that pilots are sometimes lulled into over-reliance. An early issue of the approach and runway clearance would have saved the crew from fighting the automation. But so would have more careful attention to their actual path and location.

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She is currently also a human factors consultant to the Hellenic Air Accident Investigation and Aviation Safety Board and involved in a number of aviation human factors research and teaching activities.

Close interactions of the disconnected kind 'cont'd)

Many airlines now require their pilots to engage the automation to the full and to make all adjustments to flight path via the flight management computer. Yet, although its proper use can lead to an accurate and efficient flight, its programming can present the crew with substantial workload.

Case 3. **Captain (pilot flying) reporting:** ***"We were cleared for [the] approach and to land on runway 21... Citation traffic ahead touched down and was asked to hold short of [the] south runway for departing flight... Tower then … instructed the Citation to back taxi on runway 21 [so as] to turn off at one of the taxiways that they had already passed. At this point we were 300 feet above the ground within a mile to touchdown… We were in the process of beginning a go-around when Tower instructed us to cancel landing and climb to 4,000 feet."***

[ASRS 885498, April 2010, IFR on initial approach]

The final approach to land phase is a busy time for pilots even if all goes according to plan. For many pilots, a go-around, especially one that has not been anticipated, is a potentially stressful time despite their simulator training. As a consequence, it is not unknown for pilots to exceed speed and altitude restrictions on a go-around, since many modern jet aircraft require the initial selection of a great deal more thrust than the crew is expecting (or used to). At busy airports, where the controllers work hard to sequence arrivals and departures carefully, a single go-around can mess up many good plans. This may be an unanticipated consequence of the effects on the pilots of late changes or it might be a direct and almost inevitable consequence of an ill-judged back taxi clearance in the face of traffic on short final.

It is not the point of these selected cases to say that controllers or pilots make mistakes (which they, like all humans, undoubtedly make). The point is to illustrate that, to a certain degree, the intimacy of the relationship between controllers and pilots can also be accompanied by a paradoxical disconnect. This disconnect stems from the fact that controllers don't always know enough about aircraft and pilots' capabilities and limitations, or about the demands and constraints of the cockpit as an operational environment. Other than its make and model, what else does the controller really know about the flight capabilities of the aircraft s/he is controlling? Other than the airline's name, what does the controller know about the policies and procedures the pilots must comply with?

The actions of the controllers (and their repercussions) in the cases cited above have a direct relevance to these questions. These controllers cannot tell whether the crew is using the aircraft automation to guide the aircraft, and if so, at what level. Different air carriers have different policies regarding use of automation, and different pilots, to the extent that they can exercise discretion, have different preferences for when and how to use the automation. Different aircraft, even of the same model, "wear" different technologies so controllers cannot know whether every aircraft of the same type necessarily has, say, a moving map display on board. Controllers have a generally good understanding (mostly built through experience) about differences in descent capabilities of, say a Boeing 737 versus an Airbus A320 - as a function of aircraft design - but lack more in-depth knowledge about speed, altitude, or other criteria dictated by air carrier policies that would affect the details of how the particular aircraft is flown and what instructions the crew can comply with.

As a result, whether it is the outcome of a sincere intention to help (expedite traffic, assign a requested runway, etc.), or of an intense focus on the ultimate goal of managing complex traffic flows from their radar scope, controllers sometimes make judgments and calls that inadvertently introduce risk to a flight. Drastic, unexpected changes in altitude level-offs, landing runway changes with little notice, late runway assignments, and other such instructions on approach may introduce considerable extra workload in highly automated aircraft (reprogramming of the computer, reviewing charts, re-briefing, assuring compliance with stabilised approach criteria, conducting checklists, etc.). Sometimes, an early decision to perform a go-around may be the best option. Leaving a go-around until nearer the ground in the hope that the necessary pilot response to late changes can be completed can end up making the task more difficult, especially if the flight crew rarely experiences go-arounds. There is also the concern felt by some passengers as the expected imminent touch-down suddenly changes to a steep climb.

Pilots are frustrated when such interaction disconnects occur. In their own words:

> **Case 1:** *"My only thoughts as to how this happened … [was the] controller's failure to understand [the] aircraft level-off capabilities."*

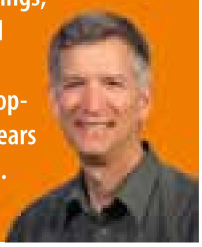
> **Case 2:** *"ATC should give us more time to program the correct runway arrival."*

> **Case 3:** *"From our perspective, ATC failed to have adequate awareness of the traffic they were controlling. In the future, I think back taxis should only be allowed if there is no conflicting landing traffic within 10 miles."*

The issue is not new. Recommendations have been produced[1] to help address certain aspects of this disconnect, and the subject of stabilised aircraft approaches has been presented specifically for controllers[2]. There have also been efforts to alleviate such disconnects through familiarisation programmes that encourage controllers to ride the "jump seat" and gain a view of operations from "the other side." Such programmes were suspended in the USA after the 2001 terrorist attacks but they were due to be reinstated this year. Based on our own research, we are passionate believers in focusing any type of training on real-world operations. It would therefore be interesting to explore the actual level of participation in such familiarisation/training programs, as well as to examine just how they are structured and what elements and means would be required to really acquaint controllers with aspects of operations that are critical to their jobs and that could alleviate the occasional disconnects.

Immanuel Barshi

Immanuel Barshi is a Senior Principal Investigator in the Human Systems Integration Division at NASA Ames Research Center in California, USA. His current research addresses cognitive issues involved in the skilled performance of astronauts and pilots, as well as mission controllers and air traffic controllers, their ability to manage challenging situations, and their vulnerability to error. Dr. Barshi holds PhDs in Linguistics and in Cognitive Psychology. He holds an Airline Transport Pilot certificate with A320, A330, B737, and CE500 Type Ratings; he is also a certified flight instructor for airplanes and helicopters, with over 35 years of flight experience.



1- Effective Pilot / Controller Communications. Airbus Flight Operations Briefing Notes. Available at http://www.skybrary.aero/bookshelf/books/172.pdf

2- Stabilized Stabilised Approach Awareness Toolkit for ATC. Developed jointly by the Civil Air Navigation Services Organisation (CANSO), the Flight Safety Foundation, EUROCONTROL and Cotswold Airport. Available at http://www.skybrary.aero/index.php/Solutions:Stabilised_Approach_Awareness_Toolkit_for_ATC

Unnecessary TCAS RAS caused by high vertical rates before level off

by Stanislaw Drozdowski,
Captain Wolfgang Starke and
First Officer Felix Gottwald

TCAS warns flight crews of an imminent risk of collision by generating Resolution Advisories (RAs) to the flight crew. However, monitoring conducted in core European airspace in 2011 and 2012 shows that roughly three out of four TCAS RAs are in level off geometries[1]. The causal factor in most of these RAs is a high vertical rate of climb or descent by one of the aircraft involved during the last 1000 feet prior to level-off when the adjacent level is occupied. This is despite ICAO publishing a recommendation in November 2008 to reduce the vertical rate to 1500 ft/min in the above situations.

In the first part of this article, TCAS expert and editor of EUROCONTROL's ACAS Bulletins Stanislaw Drozdowski explains why such RAs are generated. In the second part of the article, Wolfgang Starke and Felix Gottwald, both current commercial pilots and members of the German Air Line Pilots' Association Air Traffic Services Committee give the pilots perspective.

1- Source: Analysis of downlinked RA messages for SESAR project 4.8.3

The TCAS experts point of view

by Stanislaw Drozdowski

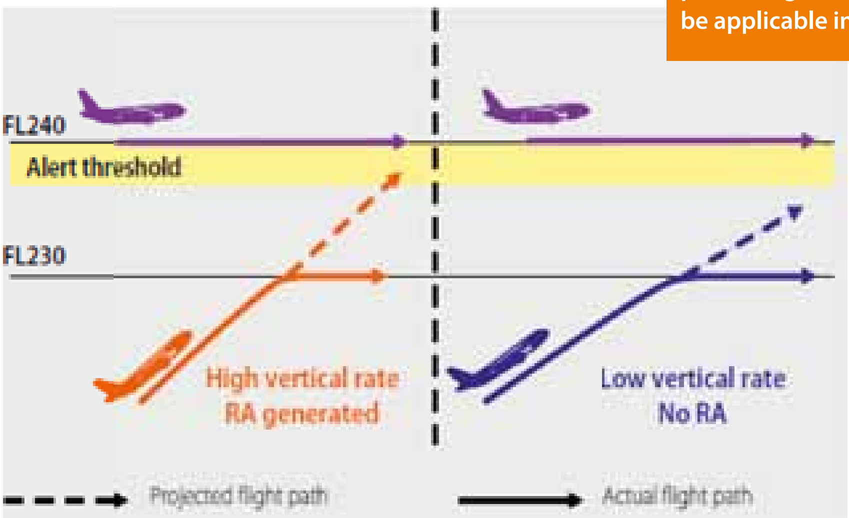
The performance of modern aircraft allows pilots to climb and descend with high vertical rates. While this can provide operational benefits (i.e. fuel or time savings), it can become problematic when aircraft continue to climb/descend with a high vertical rate close to their cleared level when the adjacent level is occupied or another aircraft is descending/climbing towards the adjacent level.

Stan is a Senior ATM Expert at EUROCONTROL HQ in Brussels, working in the area of ground and airborne safety nets. He focuses on current operational issues as well on enhancements to existing systems. Before joining EUROCONTROL, Stan worked as an ATM system engineer with Northrop Grumman in Baltimore (USA) and as an en-route air traffic controller in Poland and New Zealand.

TCAS RAs due to high vertical rates before level-off

TCAS will issue an RA when it calculates a risk of collision based on the closing speed and vertical rates. A high vertical rate before level-off may cause the TCAS logic to predict a conflict with another aircraft even when appropriate ATC instructions are being correctly followed by each crew. This is because TCAS does not know aircraft intentions – autopilot or flight management system inputs are not taken into account because TCAS must remain an independent safety net.

If, simultaneously, another aircraft is approaching an adjacent level, the combined vertical rates make RAs even more likely. The majority of all RAs occur within 2000 feet before level-off at the cleared level. TCAS will typically generate: an "Adjust vertical speed, adjust" RA (in version 7.0) which requires a reduction of the vertical rate as indicated on the flight instruments; or a "Level off, level off" RA (in version 7.1) which requires a reduction of the vertical rate to 0 ft/min (i.e. a level-off). In extreme cases, involving very high vertical rates TCAS may diagnose that insufficient time remains to assure safe separation by a reduction in vertical rate and instruct a crossing RA, announced in the cockpit as "Maintain vertical speed, crossing maintain".



Always follow the RA

Pilots and controllers sometimes judge these RAs as operationally not required and refer to them as "nuisance" RAs. However, in real time the pilot cannot (and should not) assess whether the RA is in fact operationally required. Once an RA has been issued it must be followed without delay and it takes precedence over any ATC instructions.

Therefore, it is best to avoid approaching the cleared level with a high vertical rate when the pilot is aware of another aircraft at the adjacent level – based on ATC traffic information, observation on the TCAS traffic display or as a result of a Traffic Advisory (TA). In this way the occurrence of nuisance RAs can be minimised.

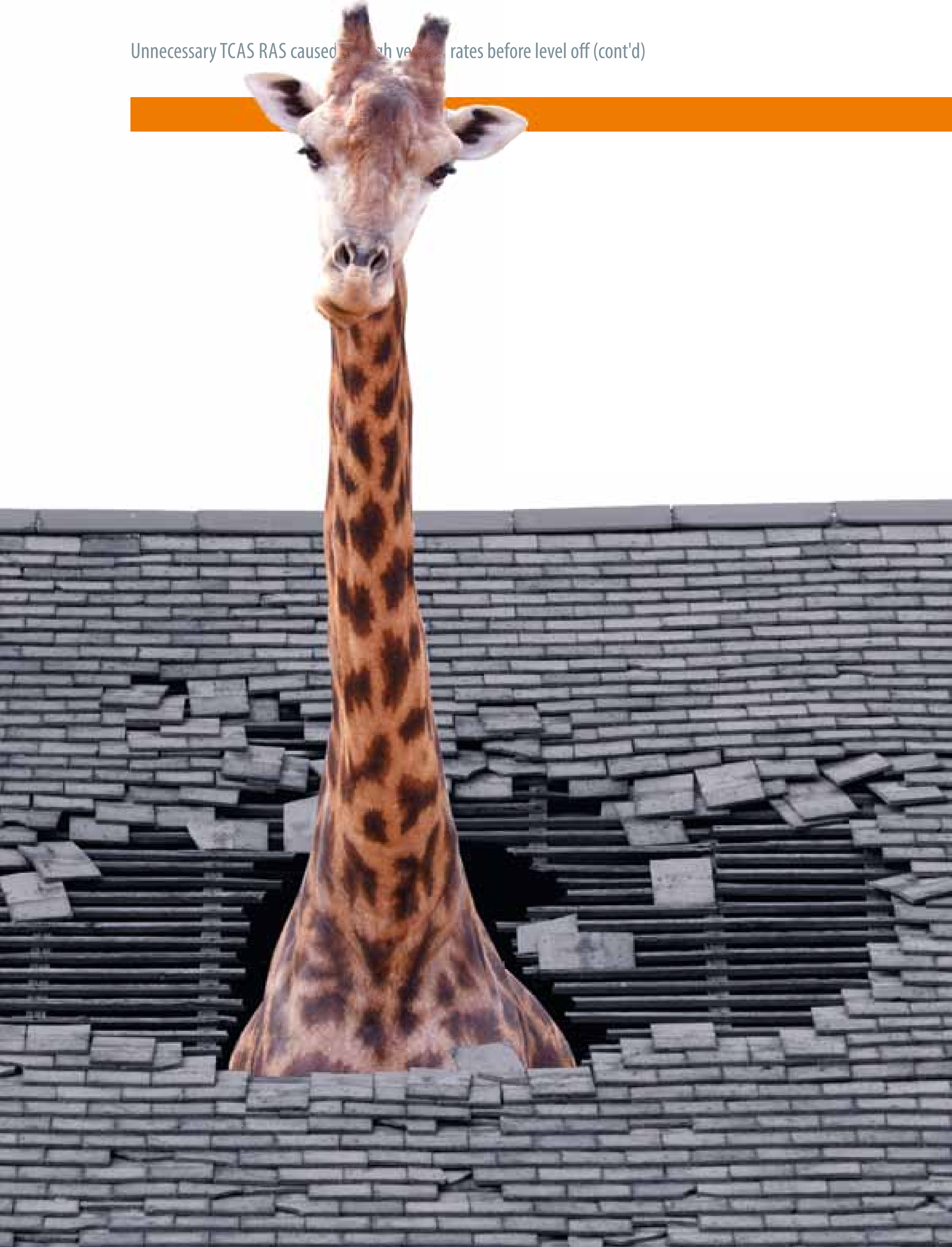
ICAO recommendation

In order to reduce the number of RAs caused by high vertical rates before level-off, ICAO in November 2008 published a provision recommending the reduction of vertical rates to 1500 ft/min or less in the last 1000 feet before level-off, when the pilot is made aware of another aircraft at or approaching an adjacent flight level, unless instructed by ATC to maintain a certain vertical rate. Some States have published or are considering publishing similar or even more restrictive measures to be applicable in their airspace.

The above is based on the text that first appeared in Issue 15 of EUROCONTROL's ACAS Bulletin. These bulletins discuss real-life TCAS events in order to spread the lessons learned and encourage best practice by pilots and controllers. Issue 15 is dedicated to Unnecessary RAs due to high vertical rates before level-off and can be accessed on the EUROCONTROL website and on SKYbrary.

http://www.skybrary.aero/bookshelf/books/1804.pdf

Unnecessary TCAS RAS caused [illegible] rates before level off (cont'd)



The pilot point of view

by Wolfgang Starke and Felix Gottwald

Following on from the first part of the article, why do pilots sometimes only fly shallow descents and sometimes approach their cleared flight level with a high and sometimes inappropriate vertical rate, knowing that there is traffic separated by just 1000 feet? To answer these questions we need to understand how the climb and descent phases are flown by pilots, and how the autopilot/flight director (AP/FD) systems on board the aircraft operate.

Wolfgang is a Bombardier Dash 8-Q400 line training captain with Air Berlin. He has previously flown Boeing 737-NG and classic aircraft. Wolfgang is a member of the Air Traffic Services and Airport and Ground Environment committees of the Vereinigung Cockpit (German Air Line Pilots' Association) and IFALPA (International Federation of Air Line Pilots' Associations).

Felix is an MD-11 first officer with Lufthansa Cargo. He has previously flown the A320 series aircraft. Felix is a member of the Air Traffic Services committee of the Vereinigung Cockpit (German Air Line Pilots' Association) and IFALPA (International Federation of Air Line Pilots' Associations). He is also an IFALPA representative to the IFATCA Technical Operations Committee.

Climb profile

In modern aircraft fuel burn reduces significantly with increasing altitude. At the same time, true airspeed increases and the speed of the aircraft over the ground is higher. In order to achieve the most economic flight profile, the Standard Operating Procedures (SOPs) of most airlines require pilots to apply full climb thrust while adjusting the indicated airspeed (IAS), or at higher altitudes the Mach number, by increasing the pitch of the aircraft. This results in aircraft always flying their maximum available climb rate at the optimum speed.

- Asking pilots to maintain a low rate or reduce their vertical speed will either lead to a reduction in engine thrust or higher airspeeds. Both situations result in a non-optimal flight profile.

- Asking pilots to increase their vertical speed or maintain up to a higher flight level will require them to trade off an aircraft's indicated airspeed against vertical speed. Such a trade-off is possible for short-term manoeuvring like following a TCAS RA, but the available climb rate after the manoeuvre will be significantly reduced for a period longer than the manoeuvre itself. Additionally, ATCOs are unaware of the speed of the aircraft relative to its minimum climb speed.

All of the above has one common consequence: higher and more economic cruise altitudes will be reached later into the flight, which increases the amount of fuel used and the flight time. Nowadays pilots rarely carry significant additional fuel for economic reasons so the increased fuel burn at lower altitudes could limit their options later in the flight. Longer flights also mean higher cost for maintenance, air crew salaries etc.

Descent profile

Practically all aircraft now operating within European airspace feature vertical navigation (VNAV) functions in their flight management systems (FMS). These VNAV paths are calculated at certain airspeeds with the engine thrust at flight idle. This is a simplified version of the climb case, engine thrust is kept constant while indicated airspeed is adjusted by changes in the aircraft's pitch.

Increasing the vertical speed of an aircraft during the descent when the engines are at idle leads to an increase in airspeed. This is only possible up to the maximum allowed airspeed, although increasing the descent rate further can be achieved to a certain extent by using speed brakes - usually in the form of lift spoilers on the upper surface of the wings. But speed brakes also disturb the very sensitive aerodynamic properties of the wing, wasting a lot of the aircraft energy, energy that had previously been generated by burning fuel. And of course, passenger comfort may be affected by the noise and airframe vibration which can occur with speed brake deployment.

In most instances, increasing the rate of descent causes an aircraft to be at a much lower altitude than planned at a given distance from the destination airport. Similar to the climb, the consequence will again be prolonged flight times, increased fuel burn and higher operating costs. Additionally, both the risk of having a bird strike and noise abatement issues increase at lower altitudes.

The pilot point of view (cont'd)

Nevertheless, increasing descent rate is possible most of the time, but pilots may have difficulty making speed reductions if required to maintain high rates of descent whilst doing so.

Timing the start of the descent

As already mentioned, the aircraft's descent profile is planned using idle thrust. Therefore it is not always possible to increase the rate of descent to the rate requested by ATC. If ATC keeps an aircraft at high altitudes and the pilots are not allowed to initiate the descent in time, or are only instructed to do so at a low vertical rate, the descent rate required for the remaining track miles to the destination will become more and more problematic. This can result in one of two scenarios; the pilots are required to descend at the maximum rate, or they are unable to descend without flying additional track miles. In the later scenario, on top of fuel burn and flight time penalties, the additional track miles will be flown closer to the ground and near an airport, so the margin for error is reduced and the chance of receiving a TCAS RA is increased!

A good question is why do pilots not programme a little "reserve" into their FMS to cater for unexpected ATC constraints? To be honest, operationally this would be a good idea. However, as descents work well most of the time, planning to be at lower altitudes earlier than necessary would be less efficient than descending at high rates or even additional track miles from time to time.

Level-off procedure – influence of the autopilot/flight director

ICAO recommends that the vertical rate be reduced to not more than 1500 feet per minute during the last 1000 feet altitude prior level-off. If followed, this would reduce the number of unnecessary RAs during level-off quite significantly. But not all operators have yet incorporated this guidance into their SOPs. So why do pilots not always follow this recommendation?

Part of the answer lies with today's autopilot/flight director (APFD) design. These systems fly the aircraft in the most economical manner and, by doing so, will use the maximum available climb rate for a given speed. However, as a flight would be highly uncomfortable if a high rate of climb transitioned to level flight too quickly, autopilots have an altitude capture or altitude acquire mode. This mode is based on a predetermined g-load, typically in the range of 0.25 to 0.3g, during level off. The point relative to the level-off at which the altitude acquire mode starts to operate is dependent on the vertical rate of the aircraft. At low vertical rates, such as 1000 ft/min, the altitude acquire mode will typically start to reduce the vertical rate between 300 and 100 feet before level-off. At very high vertical rates, such as 6000 ft/min, the reduction in the vertical rate should be expected to start more than 1000 feet before level off.

Generally modes such as the altitude acquire work well; nevertheless they do have one significant safety issue in common. Whenever pilots try to modify their aircraft flight path once altitude acquire mode is active, it is likely to drop out if already engaged, which in turn may well lead to a level bust. To prevent aircraft from overshooting their cleared flight level, many airline SOPs restrict the use of VS mode near to level-off. These SOPs render pilots unable to reduce a high vertical rate whilst keeping the automatics engaged. Although IFALPA (International Federation of Airline Pilots' Associations) is calling for a consequent improvement in the design of modern autopilots, this change has not been made yet.

A version of this specific to Airbus aircraft is the so-called "Alt. Star trap" (a star symbolises the altitude capture mode in Airbus-speak). Once the autoflight system has captured the level-off altitude, it maintains the climb rate and there is no way for the pilot to change the aircraft's mode to reduce the vertical rate – the crew are "trapped" in the altitude capture mode. One possibility is flying the aircraft manually, which is hardly ever practiced during the en-route stages of a flight. The other is to select a new altitude, change to vertical speed mode, reselecting the original altitude and hope all goes well within the few seconds before the Autopilot overshoots the cleared level. But such non-standard actions increase the likelihood of errors and reduce safety margins.

Pilot and controller errors

Of course, it is not always the system design which makes things worse; sometimes pilots just forget to reduce the vertical rate. But imagine the workload when approaching busy terminal areas like those around London, Paris or Frankfurt. Often pilots have to focus on other things, knowing that the autopilot capture mode is not perfect, but still will capture the cleared level. And there are also occasions where the controller instructs a vertical rate RA. A year ago, one of us travelled on the flight deck jump seat after a duty. When climbing through approximately FL210, ATC informed us about a company Boeing 737 levelling off 1000 feet above our cleared level of FL220. At the same time TCAS first gave a traffic advisory (TA), quickly followed by an RA instructing us to descend. At the time climb rate was about 1000 ft/min. We heard later that the company 737 received an RA to reduce vertical speed (an "Adjust vertical speed, adjust" RA) – a high rate being flown at the specific request of ATC!.

Communicating each other's intentions

Of course, mistakes do happen again and again and we will never able to change that. Yet, in aviation we have to find ways to mitigate the risks! Controllers and pilots are both experts in our very special jobs - pilots should not try to make adjustments to traffic separation, nor should ATCOs try to "fly airplanes". In our view, if a modern aircraft needs to be at a certain position at a certain airspeed or altitude, then it is better for a clearance to state exactly this requirement rather than make the sort of aircraft control request - such as "descend xxx with a rate of yyyy ft/min" which might suit older aircraft better. A clearance pilots love to hear is "be there at this altitude with that speed" because then we can do our job by manoeuvring our aeroplane efficiently to achieve that objective. Besides, this is current ICAO provision of PANS-ATM.

If as a controller you still need to instruct a defined vertical rate for separation, please always stick to ICAO and tell us when the specified vertical speed is no longer required. Otherwise we are not able to plan ahead, which is a prerequisite for safe flying.

Teamwork for ATC and pilots is best accomplished when both parties know each other's plan. For this we have to keep up proper communications and make sure our respective intentions are known. This allows everyone to do their job well.

EDITORIAL NOTE

See HS12 (Winter 2011) for more detail on this:
http://www.skybrary.aero/bookshelf/books/1417.pdf

TCAP – A solution to reduce nuisance RAs?

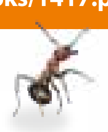
In an effort to reduce the number of unnecessary preventive TCAS RAs to 'Adjust Vertical Speed' during the approach to level off, Airbus have developed the TCAS Alert Prevention (TCAP) system for Airbus A380 and A350 aircraft.

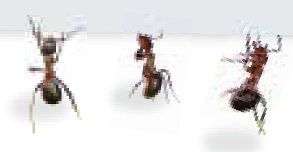
Recent data indicates that between 50 and 75 per cent of all such 'nuisance' RAs are caused by high vertical rates in geometries when one or sometimes two proximate aircraft are about to level off. To reduce these RAs, ICAO recommends reducing the vertical speed to less than 1500 fpm during the last 1000 feet prior to level off. However, even up to date autoflight systems fail to achieve this recommendation. So prior to level off, pilots may (if permitted by their SOPs) decide to change their flight guidance mode to manually reduce vertical speed. From a safety point of view this is potentially hazardous, as it can increase the chances of overshooting the cleared level.

TCAP is an enhancement of the autoflight system which ensures a reduction of vertical speed prior to level off to prevent these TCAS from nuisance RAs. TCAS itself is not changed by TCAP because it is merely an enhancement to the autoflight system. TCAP prerequisites are necessary to allow TCAP to automatically reduce the vertical speed after receiving a TCAS TA which has resulted from a proximity which may subsequently lead to an unwanted TCAS RA.

Pilots who have used TCAP certainly appreciate it, but TCAP can only be seen as a first step to improve modern autoflight systems. In fact, IFALPA have had a policy since 2010 that pilots should not be required to interfere with the normal autoflight system process for achieving level capture to prevent unwanted TCAS RAs as a result of an excessive vertical speed.

Whilst the possible disruption to air traffic control will be reduced as the numbers of nuisance RAs decrease, the real solution is for all autoflight systems to reduce the vertical speed as level off is approached to a value which does not even produce a TCAS TA. In other words, the system should be compatible with the ICAO recommendation and automatically reduce vertical speed to 1500 ft/min or less during the last 1000 feet prior to level off.

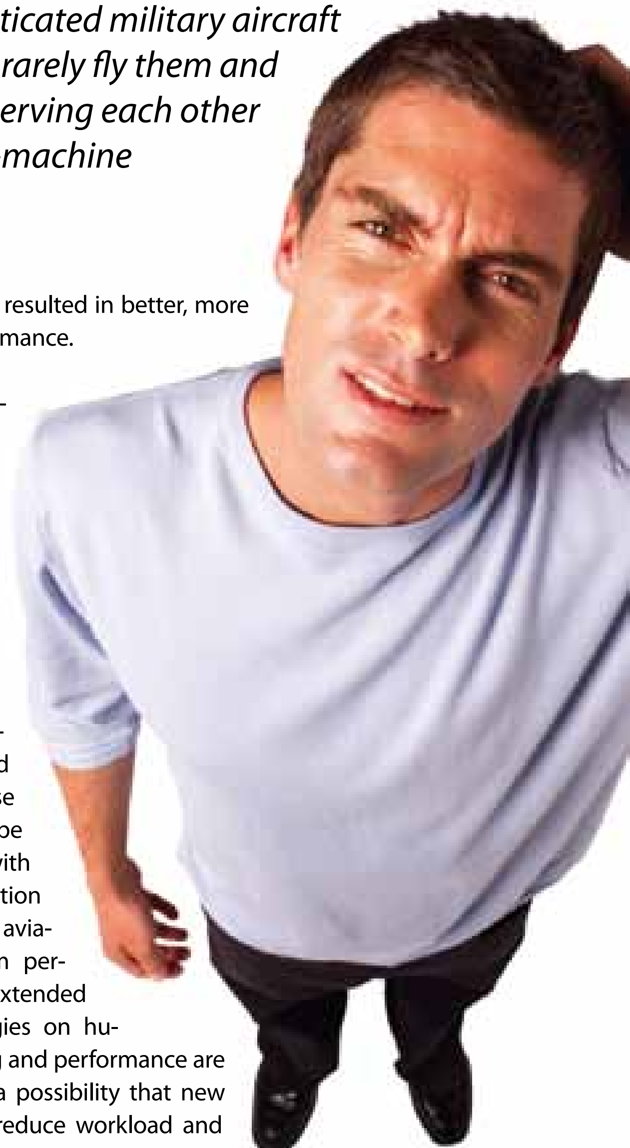




"So what's it doing now?" Training in new technology environments

by Anne Isaac and David Lord

"Fifteen foot banks of identical switches with small code numbers displayed in a nuclear power plant, sophisticated military aircraft that are so expensive to operate the pilots rarely fly them and ships that collide while the officers are observing each other on anti-collision radar all suggest human-machine problems in high technology systems"



Defining the problem

Engineers typically design machines according to engineering principles, rather than behavioural principles. That is, when a machine has been designed, relatively little consideration may have been given to how easy it is for a person to use or operate. Life is filled with such examples. In some cases, the poor design is a nuisance and not particularly dangerous, such as the size of door handles or the placement of spare tyres in cars that require you to unpack the entire boot to access. In others, the design is positively hazardous, such as the placement in some new control consoles of the switch to 'amend flight information' next to the 'screen shutdown' button.

There are several reasons why engineering principles dominate the design field. Many engineers who have not had the benefit of human factors training believe that humans are able to adapt readily to almost any environment in which they are placed; whether a work place is too hot or cold, too quiet or noisy, humans manage to perform their work. The real question, however, is whether they perform these jobs adequately and safely, and whether another design would have resulted in better, more economical and safer performance.

The assumption underlying the implementation of new technologies, such as electronic flight data systems, is that with the automation of functions which were once allocated to human control, the processing resources of the operator, their 'spare capacity', will be freed to deal more effectively with other required tasks. However, while the use of new technologies may be essential in order to deal with the ever increasing information processing demands of the aviation system, the long-term performance implications of extended use of the new technologies on human information processing and performance are largely unknown. There is a possibility that new technologies, intended to reduce workload and consequently enhance memory, will undermine situation awareness and safe aviation practices. There is a need for the task demands of the aviation system to keep the operators alert and actively involved in meaningful ways.

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David Lord flew a variety of aircraft in the Royal Navy as a pilot, flying instructor and examiner. His operational experience included Northern Ireland, the Falklands War, Bosnia and Haiti, the latter whilst on an exchange tour with the US Coast Guard. He commanded the Commando Helicopter Force at RNAS Yeovilton and completed 3 seasons as Swordfish display pilot. After leaving the Fleet Air Arm he flew B737s with British Midland (bmi) for 4 years and then joined Aviation Training International as the Apache program Chief Aircrew Instructor at Middle Wallop. David joined Flight Safety International in 2007 and was appointed as the Deputy Head of Training in 2011.

Operational complexity versus functional capability

Issues for pilots:
the further difficulties of co-ordinating the new technologies, and human capabilities, between the flight-deck and air traffic control environments?

There are some significant differences between the abilities of machines and the skills, abilities and traits of humans, and it is crucial in all high-risk environments in which new technologies are introduced, to research carefully how these two very capable 'systems' work together optimally. These principles of human-centered automation (Billings, 1991) advocate the design of automated systems with the human operator at the centre, rather than trying to exclude them. However, it can be seen that many new technological systems are often designed and installed only with regard for the operator's ergonomic requirements with no consideration from a systemic or operational stand point.

To consider human factors properly at the design stage is costly, but the cost is paid only once. If the operator must compensate for incorrect design in his training programme, the price must be paid every day. And what is worse, we can never be sure that when the chips are down the correct response will be made.

Or, as Rudyard Kipling put it:

But remember please, the law by which we live,
We are not built to comprehend a lie,
We can neither love, nor pity nor forgive –
If you make a slip in handling us,
You die.

The Secrets of Machines

Issues for both teams/crews:
Until pilots and controllers are provided with effective means of mastering the automation and technology in their workplace, with training processes and operating protocols that ensure survival, the successful reversion to manual core skills and standardised protocols for the avoidance or mitigation of technology-related errors and hazards, we are likely to go on hearing the phrase…

"So what's it doing now?"

It is therefore essential for both ANSPs and airlines which introduce new technology, to follow Billings' principles of automation. The three areas which need constant and comprehensive consideration are the selection of the right technology, the development of appropriate procedures and the selection of the most appropriate training.

- Selection of appropriate human/machine technology – it is essential that an automation philosophy, policy and guiding principles be developed to enhance the choices made when new technology is introduced and multi-disciplinary teams work together to detail the interface and operability of these advanced systems. It should also be realised that the more complex systems become, the less the operators will understand the linkages between the different teams and their specialist functions.

- Development of appropriate and robust procedures – legacy procedures are often adopted when new technology is introduced, in the belief that the operational staff will behave in the same way. Technology usually brings at least two behavioural changes; first, the operators will quickly adapt to the support which the technology brings, becoming less involved in thinking and intervention. Secondly the operators assume that the technology is always correct and become less 'afraid' of dealing with failures since they are rarely seen. Both these behaviours can lead to slow adaption and sometimes misuse of procedures which are often so subtle that the system itself does not recognise the degradation.

- The development of new and appropriate training materials and methods – automation requires behavioural modification in the operating environment. These different behaviours and problem-solving techniques must be identified, possibly from the automation principles, and highlighted in the training at ab-initio level. There is also a need for both controllers and pilots (and in many cases engineers) to collectively share their learning in a collaborative approach to cross-disciplinary aviation training. S

Dave: Open the pod bay doors, HAL.
HAL: I'm sorry, Dave. I'm afraid I can't do that...
Dave: HAL, I won't argue with you any more! Open the doors!
HAL: I know you and Frank were planning to disconnect me. And that's something I cannot allow to happen...

Stanley Kubrick's 2001: A Space Odyssey, 1968

Lost in modernity

by Jean Pariès

Having reached a veteran's age, may I indulge myself with a personal memory?

In 1992, I was invited by Dan Maurino, then the head of ICAO's programme on Human Factors and Flight Safety, to give the closing address to the second World Symposium he was organizing in Washington DC. In these cases, one generally accepts with a flush of pleasure, then bitterly regrets. So, I was suffering the agony of the white page, when I remembered that the first ICAO Human Factors symposium had been held two years earlier in a country that no longer existed (USSR), and in a city which had changed its name (Leningrad). I decided to talk about the challenges of change for safety. The world is changing at an impressive rate, I said in essence, so what will aviation look like in 10 or 20 years from now? What are the safety challenges we will have to meet? Is there a plane today that foreshadows this future? I was then immersed in the investigation into the crash of an Airbus A320 at Mont Saint Odile near Strasbourg, France. I bravely answered: I think this aircraft exists, it is the Airbus A320. I heard something like an offended whisper run across the meeting room. Designating an aircraft which had raised so much controversy and had suffered so many accidents in its introductory years as an archetype of the future was probably a bit provocative. Twenty years later, I believe it was a rather good guess. But anyway, the point I want to make here is that, whatever the answer, I unknowingly asked the question which is underlying this issue of Hindsight: what is a "modern" aircraft? Is it possible to speak of "modern aircraft" as there are "modern times" or "modern art"? Doesn't it simply mean the air-

Lost in modernity (cont'd)

This is your Captain speaking. My representative on the aircraft this evening is your Cabin Service Director. I wish you a pleasant flight and I will do all I can to ensure a safe and on-time arrival at your destination. If you have any concerns about the operation of the aircraft, just let me know via the on board cabin crew team.

craft which have recently left the assembly line? Well, obviously, some have an entirely new design, some are evolutions from older models, while they may benefit a "new" cockpit or newer engines. Which are "modern"?

According to the Merriam-Webster dictionary, "modern" means either "contemporary" or "up-to-date", i.e. involving recent techniques, methods or ideas. I think modernity also often includes the dimension of a disputed change from what existed before (a quarrel between the ancients and the moderns..). But what is new is not necessarily modern. Modernity further implies a "sustainable change", that is to say, a change that sets the path of future changes, and defines the general trend for a new way of doing things. So we move from one modern time to the next one, from one "age" to the next one, in different time scales. Where will our current modernity take us? Let's take a step back. A big step: let's look at things at the scale of the history of mankind. A whole series of revolutions triggered transitions from one age to the next, and changed our relationship to the world: carved stone, fire, agriculture, bronze, iron ... According to the philosopher of sciences Michel Serres, three of them were even more important – writing, printing, and computers – because they have changed our relationship to knowledge. Writing made it possible to archive knowledge outside human memories (to outsource long-term memory) and to access it without the constraints and fragility of oral transmission. With printing, it became possible to provide a mass access to that external memory, without needing to cross the closed door of a few privileged libraries. With computers, both long-term memory and the central computation unit were outsourced. And with Internet and other networks, the entire knowledge of the world is theoretically accessible to virtually everyone. And Michel Serres goes on: it would be a waste of time and energy to try and keep that knowledge inside our students' brains. Sooner or later, it will be lost, as were lost, all along mankind's history, all those skills suddenly rendered useless by the corresponding socio-technical revolution.

What if we apply this kind of vision to aviation? I guess a first outcome is that what defines an aircraft's modernity is its cockpit, because it is where the handling of knowledge (cognition) lies. A second outcome is that modern aircraft are potentially connected to all the knowledge in the world. And they will use it to calculate present and future actions, and execute them. They know, or will soon know, the weather, the traffic, airport accessibility, the price of fuel. They will incorporate a complete digital simulator of themselves, and know their internal status through omnipresent detectors and monitors. They will know their performance limitations, and their likely evolution, and match it to their model of the environment. They will fly, navigate, and communicate intentions and trajectory forecasts with an accuracy of just a few seconds. They will define and negotiate with their "colleague" aircraft, and with what will stay as the ground-based component of the traffic management system, the

best navigation trade-off between safety, fuel efficiency, weather, environment, and passenger comfort. So what will be left to human operators: pilots, controllers?

"What is left to the human brain?" asks Michel Serres. He answers: creativity, imagination, serendipity, ethics. Let's translate this into operator language: sense-making, adaptability, judgment, common sense, airmanship, survival instinct. Is it enough to save human jobs in cockpits or control rooms? It's more than enough: it is essential! Because there is something the analytical computation of "intelligent" computers will not, for still a long while, be able to cope with: the unexpected, the irreducible uncertainty and unpredictability of a flight, of thousands of flights interacting within a worldwide network. Airport delays, blocked runways, flocks of birds and other kinds of flying objects, unprecedented combinations of failures, passenger emergencies, volcanoes, wars, terrorist attacks, and so on. But it means one should not fight the wrong battle. Needless to say, as long as the current generation of aircraft flies, as long as autopilots fail and disconnect, or do surprising things, there will be a need for pilots with manual skills enabling them to back-up. And since Lisanne Bainbridge's "ironies of automation" in the early 80's, we have known that maintaining those skills is both a need and a real challenge, as they are atrophied day after day like unused muscles, with pilots watching when things go well and suddenly required to fly when things go wrong.

But in the longer term, most "manual flight" skills will inexorably be lost. Lost in modernity. The next generation of "modern" aircraft will probably be "fly-by-autopilot" only. The issue will not be manual skills, but automation reliability: a failure of the "permanent autopilot" will not be an option anymore. Nevertheless, the next generation will share with the current one an extended version of the "ironies of automation". I call it the "ironies of predetermination". The "modern" safety strategy seeks the anticipation of all potential threats, and the predetermination of all the needed responses (automation is only the ultimate form of predetermination). This strategy makes the system more and more reliable within its envelope of designed-for uncertainties, and more and more brittle outside it. The competencies needed to cope with the unexpected at the front line are lost in this continuous effort to eradicate surprises. There is no "fundamental surprise" in the simulator, only listed emergencies. But the real world is irreducibly unpredictable, and safety strategies should rather get people both prepared… and prepared to be unprepared! Front-line operators should be trained to cope with the unexpected. Human-machine cooperation should be revisited in the next (cockpit, control room) generation to better support human operators in their fundamental role: managing the unexpected, managing uncertainty, making judgments and decisions. They should be provided with a clear display of their current position within the operational envelope, as well as of their margins for maneuver. A paradigm shift is needed. There may even be a word for it: resilience engineering. S

Jean Pariès

graduated from the French National School of Civil Aviation as engineer, and then joined the DGAC for several positions dealing with air safety regulations.

He was a member of the ICAO Human Factors & Flight Safety Study Group from its creation in 1988. In 1990, he joined the Bureau Enquêtes Accident as Deputy Head, and Head of Investigations, where he led the technical investigation into the Mont Saint-Odile Accident, 1992. Currently Jean is CEO - of Dédale SA.

He holds a Commercial Pilot Licence with Instrument, Multi-engines, Turboprop, and Instructor ratings and a Helicopter Private Pilot Licence.

Aircraft automation

by Michel Tremaud

It is very useful for air traffic controllers to have some understanding of the pilot's working environment. This includes the fundamentals of aircraft automation (understood in this article as automatic flight guidance), how pilots interface with automated systems and how optimal use of automation can contribute to the overall management of the aircraft flight path.

Although the extent to which automation is used has grown a great deal over the past 50 years, and many different levels of systems integration and automation remain in the skies today, the guiding principles which underlie automation have remained essentially the same.

Providing an aircraft is functioning normally, the high levels of automation which may be available are able to provide pilots with an increasing number of solutions to the task which they must accomplish, such as complying with ATC requirements.

I will try and describe some of the fundamental aspects of the use and monitoring of automation. Designers of automated aircraft systems envisage that strict adherence to the following guiding principles and golden rules of operation will enhance pilot situational awareness and prevent so called "automation surprises". Of course this model has humans in charge and so controllers should recognise that pilot mismanagement of automation at times is unfortunately a fact – and the evidence suggests that the risk of this is directly proportional to the complexity of the automation or procedure involved!

Michel Trémaud retired from Airbus as senior director and head of safety programs / initiatives. His career also included positions with the French Bureau Veritas, Air Martinique and Aérotour. Beyond retirement, Michel has continued to support safety initiatives led by EUROCONTROL and by the Flight Safety Foundation.

Understanding Automation

The design objective of an automatic flight system (AFS) is to provide assistance to the crew throughout the flight (within the normal flight envelope and with normal operation of all the systems it depends on), by:

- relieving the pilot-flying (PF) from routine handling tasks and thus allowing time and resources to enhance his/her situational awareness or for problem-solving tasks; or,
- providing the PF with attitude and flight path guidance through the flight director (FD), for hand flying.

Basically, the AFS provides guidance to capture and maintain the selected targets and the defined flight path, in accordance with the modes engaged and the targets set by the flight crew on the flight guidance control panel (usually referred to as the flight control unit – FCU – or mode control panel – MCP) or on the flight management system control and display unit (FMS CDU).

When seeking an understanding of any automated system, but particularly the AFS and FMS, it helps if the following questions are considered:

- How is the system designed?
- How does the system interface and communicate with the pilot?
- How can the system be operated in normal and abnormal situations?

The following are both important for optimal use of automatic flight guidance:

- The integration of autopilot/flight director (AP/FD) and autothrottle/autothrust (A/THR) modes (i.e. the pairing of modes);
- Mode transition sequences; and,
- Pilot-system interfaces for both:
  - Pilot-to-system communication (i.e. for selecting guidance targets and arming/engaging AP/FD - A/THR modes); and,
  - System-to-pilot feedback (i.e. for checking the status of modes armed or engaged and the correctness of active guidance targets).

made simple

AP - A/THR Integration

Integrated AP - A/THR systems feature an association (pairing) of AP pitch modes (elevator or stabiliser control) and A/THR modes (throttle or thrust levers).

An integrated AP - A/THR operates in the exact same way as a human pilot:

- The elevator/stabiliser is used to control pitch attitude, airspeed, vertical speed, altitude, flight- path-angle, vertical navigation profile or to capture and track a glide slope beam.
- The throttle/thrust levers are used to maintain a given thrust or a given airspeed.

Indeed, throughout the flight, the pilot's objective can be seen as to fly either:

- performance segments at constant thrust/power (e.g., take-off, climb or descent); or
- trajectory segments at constant speed (e.g., cruise or approach).

Depending on the task to be accomplished, maintaining the airspeed is assigned – automatically – either to the AP (elevators) or to the A/THR (throttles levers/thrust control), as shown in Figure 1.

	A/THR	AP / FD
	Throttles/ Thrust levers	Elevators
Performance Segment	Given thrust or idle	Speed
Trajectory Segment	Speed	Vertical speed Altitude Vertical profile Glide slope

Figure 1 - The AP / FD – A/THR Modes Pairing

Flight crew/system interface

The FCU constitutes the main interface between the pilot and the autoflight system for short term guidance (i.e. for immediate guidance).

Figure 2 - A340 FCU (typical)

The FMS CDU constitutes the main interface between the pilot and the autoflight system for long-term guidance (i.e. for the current and subsequent flight phases).

Figure 3 - A340 FMS CDU (typical)

When performing an action on the FCU or FMS CDU to give a command to the AFS, the pilot has an expectation of the aircraft reaction and, therefore, must bear in mind the following questions:

- What do I want the aircraft to fly now?
- What do I want the aircraft to fly next?

This implies an awareness and understanding of the following aspects:

- Which mode did I engage and which target did I set for the aircraft to fly now?
- Is the aircraft following the intended vertical and lateral flight path and targets?
- Which mode did I arm and which target did I preset for the aircraft to fly next?

To answer these questions, the roles of the following controls and displays need to be understood:

- FCU (mode selection-keys, target-setting knobs and display windows);
- FMS CDU (keyboard, line-select keys, display pages and messages);
- FMA (Flight Mode Annunciator) on PFD; and,
- PFD and ND (Navigation Display) displays and scales (i.e., for cross-checking active guidance targets).

Figure 4 - A340 PFD and ND (typical)

Effective monitoring of these controls and displays promotes and increases flight crew awareness of the available/active guidance for flight path and speed control. This includes:

- modes (i.e. AP/FD modes being engaged or armed); and,
- targets (i.e. altitude, speed or vertical speed or vertical navigation, heading or lateral navigation).

The safe use of the AP, A/THR and FMS needs a three-step approach:

- **Anticipate:**
  - Understand system operation and the results of any action.
  - Be aware of the modes being engaged or armed.
  - Understand mode transitions or reversions.
- **Execute:**
  - Perform action(s) on FCU or on FMS CDU.
- **Confirm:**
  - Crosscheck and announce the effective arming or engagement of modes and the correctness of active guidance targets (on FMA, PFD and/or ND scales and/or FMS CDU);
  - Observe the aircraft response and resulting trajectory.

User Strategy

The following principles should guide the operation and supervision of automation so that pilots can stay ahead of the aircraft and be prepared for possible contingencies.

Taking advantage of automation to reduce workload

The use of automated systems is intended to reduce workload and significantly improve the time pilots need to respond to unanticipated changes such as ATC instructions or adverse weather conditions. Some unplanned, abnormal or emergency conditions can also be best dealt with by the use of automation – but controllers should be aware that significant failures often lead to a reduction in the extent to which automation can assist.

Most aircraft operators expect both AP and A/THR to be routinely engaged, especially in marginal weather conditions or when operating into an unfamiliar airport.

Using the AP and the A/THR enables pilots to pay more attention to ATC communications and enhances their overall situational awareness, particularly in congested terminal areas and busy airport environments.

Of course, pilots need to maintain their manual flying skills too because they never know when they might be required. Training sessions in the full flight simulator are important for this but, in appropriate circumstances, pilots can be expected to periodically elect to control the aircraft manually or perhaps to select a lower level of automation than they usually use, to maintain all round proficiency.

Using the correct level of automation for the task

On the latest highly automated and integrated aircraft, several levels of automation are available to perform a given task.

The optimum level of automation depends on:

- The task to be performed:
  - short-term task (i.e. tactical choice, short and head-up action(s) on FCU, immediate aircraft response); or,
  - long-term task (i.e. strategic choice, longer and head-down action(s) on FMS CDU, longer term aircraft response);
- The flight phase:
  - departure;
  - en-route climb/cruise/descent;
  - terminal area; or,
  - approach; and,
- The time available:
  - pre-planned selection or entry or 'last-minute change';
  - normal selection or entry; or,

Once automated systems have been programmed, the pilot always retains the ability to change the level of automation and guidance for the task. This might include:

- adopting a more direct level of automation by reverting from FMS-managed guidance to non-FMS guidance (i.e., using the FCU for modes selections and targets entries);
- selecting a more appropriate lateral or vertical mode; or,
- reverting to hand flying (with or without FD guidance, with or without A/THR), for direct control of aircraft vertical trajectory, lateral trajectory and thrust.

Ultimately, the optimal level of automation likely to be the one the pilots feel comfortable with for a task in the prevailing conditions, which will be dependent on their knowledge and experience of the aircraft and its systems.

It has been noted that pilots with significant levels of experience on an aircraft type tend to use automation in a simpler way than pilots who are recently qualified on a type, who tend to explore higher levels of automation ... with the resulting risk of error or loss of mode awareness.

Being aware of available guidance at all times
The FCU and the FMS CDU are the prime interfaces for the flight crew to communicate with the aircraft systems (i.e. to set targets and arm or engage modes).

The PFD and ND are the prime interfaces for the aircraft to communicate with the flight crew, to confirm that the aircraft systems have correctly accepted the mode selections and the target entries:

- PFD (FMA, speed scale and altitude scale):
  - guidance modes, speed and altitude targets;
- ND (heading / track scale or FMS flight plan):
  - lateral guidance.

Any action on the FCU or on the FMS CDU (keyboard and line-select keys) should be confirmed by cross-checking the corresponding annunciation or target on the PFD and/or ND, and on the FMS CDU display.

The use and operation of the AFS must be evident to both pilots at all times by:

- announcement of changes made or observed to the status of AP/FD modes and A/THR mode on the FMA (i.e. mode arming or engagement, mode changeovers);
- announcement of the result of any change of guidance target on the related PFD and/or ND scales; and,
- supervision of the resulting AP/FD guidance and A/THR operation on the PFD and ND (i.e. pitch attitude and bank angle, speed and speed trend, altitude, vertical speed, heading or track …).

Both pilots must always be aware of the status of the modes armed or engaged and of the selected and active guidance targets.

Being ready and alert to take over, if required
Supervising automation can be summed up as simply "Flying with your eyes" - observing cockpit displays and indications to ensure that the aircraft response matches your mode selections and guidance target entries, and that the aircraft attitude, speed and trajectory match your expectations.

If any doubt exists regarding the aircraft flight path or speed control, pilots are encouraged to revert to a lower level or automation rather than attempt to re-programme automated systems unless an obvious entry error is detected.

Whilst there are routine ways to disconnect automation, if an AP or A/THR operation needs to be overridden following a malfunction such as a flight control runaway, pilots are expected to use the immediate disconnection methods provided. Only in emergency situations is it expected that pilots will manually override an engaged AP or A/THR.

Conclusions

Automation should match the pilot's mental model for flying the aircraft from gate to gate and should therefore be intuitive. However, effective use of automation requires that proper pilot understanding of it is achieved through ground training followed by supervised use during line training and finally consolidation in normal operations.

It should be acknowledged that automation may malfunction and that pilots may mismanage automation but it should equally be recognised that complex procedures (approach or go-around/missed-approach) or challenging ATC instructions may complicate the pilot task and his/her use of automation.

As an air traffic controller, you may have an idea of the level of automation which a particular aircraft type provides but you will not usually know the extent to which it is being used and how your instruction may affect this use. However, perhaps this article has opened your eyes to the scope and pilot use of automation in the flight deck and prepared you a little to appreciate both its potential and its pitfalls for pilots.

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SKY brary

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An article taken from **SKYbrary** is reprinted in each **HINDSIGHT**. For this issue, we have chosen **"Thrust Reversers : Flight Crew Guidance"**. At first sight of that title, and given that the majority of our readers are in the ATM community, you might wonder why! Actually, as controllers in the VCR see rather a lot of aircraft making good use of their thrust reversers, our guess is that it will be interesting to learn a little about how they function in relation to other deceleration methods – and be able see the sort of accidents and incidents in which their use, abuse or un-commanded deployment has figured.

Description

Thrust Reversers on jet aircraft provide a significant way of increasing the rate of deceleration during the initial stages of both a landing roll or a rejected a take off from high speed.

The following remarks are generic in nature and must, therefore, be considered in the context of instructions and guidance provided for specific aircraft types by aircraft manufacturers and aircraft operators.

System Dependency on air/ground status

The option of thrust reverser deployment on an airworthy aircraft depends on whether the system has been signalled with 'air' status or 'ground' status, the latter being a pre-requisite. Aircraft certification requires multiple defences against reverser deployment when 'in flight' but during the short period of transition between 'air' status and 'ground' status and between 'ground' status and 'air' status, there can be both system use and system malfunction issues which are directly attributable to the status being signalled. One example of the latter is a link by design between slat retraction and reverser unlocking.

Aircraft Runway Performance

1. In both the landing roll and after a rejected takeoff decision, thrust reversers have the greatest effect when deployed whilst the aircraft is at high speed. This will correspond to the period when directional control is reliant on rudder inputs rather than nose wheel steering systems.
   - **Don't delay deployment without a good reason (such as correcting runway alignment)**

2. Depending on the regulatory system under which an aircraft is operated, broadly speaking whether it is European or North American, an allowance for the effect of thrust reverser deployment is likely to be respectively either included in or excluded from the runway performance data which flight crew are instructed to use.
   - **Be sure you are aware which assumption is made in the aircraft performance data you are required to use.**

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Thrust Reversers : Flight Crew Guidance

3. The relative benefit of timely thrust reverser deployment is nearly always considerably less than the timely deployment of lift spoilers / ground spoilers / speed brakes. This is because of the way in which the increased pressure on the main landing gear which they create enhances the effectiveness of braking. Note that contrary to the situation with thrust reversers, the effect of lift spoilers / ground spoilers / speed brakes is always included in aircraft landing performance data.
   - **Whilst it is important to deploy thrust reversers promptly and check their correct activation, it is even more important to first ensure that the lift spoilers / ground spoilers / speed brakes have deployed correctly.**

4. When a landing is being carried out on a wet/slippery and/or otherwise potentially limiting runway, the desire to achieve a touchdown in the touchdown zone can sometimes result in initial runway contact which is even firmer than may have been intended. Whilst it is unlikely that a positive bounce will not result in the instinctive delay of reverser deployment, it is less well known that the selection of reversers during a transitory unloading of landing gear after a firm touchdown can result in a cycling between aircraft air and ground status before consistent ground status is achieved. Many reversers will lock out in transit if this happens and normal deployment with the aircraft in definitive ground status will not be possible until the selector has first been returned to the reverser stowed position.
   - **Crew briefing for potentially challenging landings could usefully include reference to the need for reverser deployment to occur without delay but only when lift spoiler / ground spoiler / speed brake deployment has been confirmed – after their manual deployment if necessary, since this will act as confirmation that sustained 'ground' status has been achieved.**

Rejected Landings

In almost all cases, the activation of thrust reversers after touchdown will remove the option to reject the landing because the time necessary to regain effective thrust will use considerable runway distance. If such runway distance is available, it will almost always be more effectively utilised in continuing with the attempt to stop. If it is not available, then other options to avoid a hazardous runway excursion are likely to be preferable to an attempt to get airborne again. In any case, many aircraft types are operated under a blanket prohibition on a go around once thrust reversers have been deployed.

Rejected Take Offs

Whilst the selection of reverse thrust will normally be part of the response to a decision to reject a take off at high speed, it should not be assumed that reverser deployment will necessarily occur if the reason for the reject decision is related to a possible or actual loss of airworthiness. In some situations, thrust reverser deployment might not be advisable anyway.

Thrust Reverser Unservicability

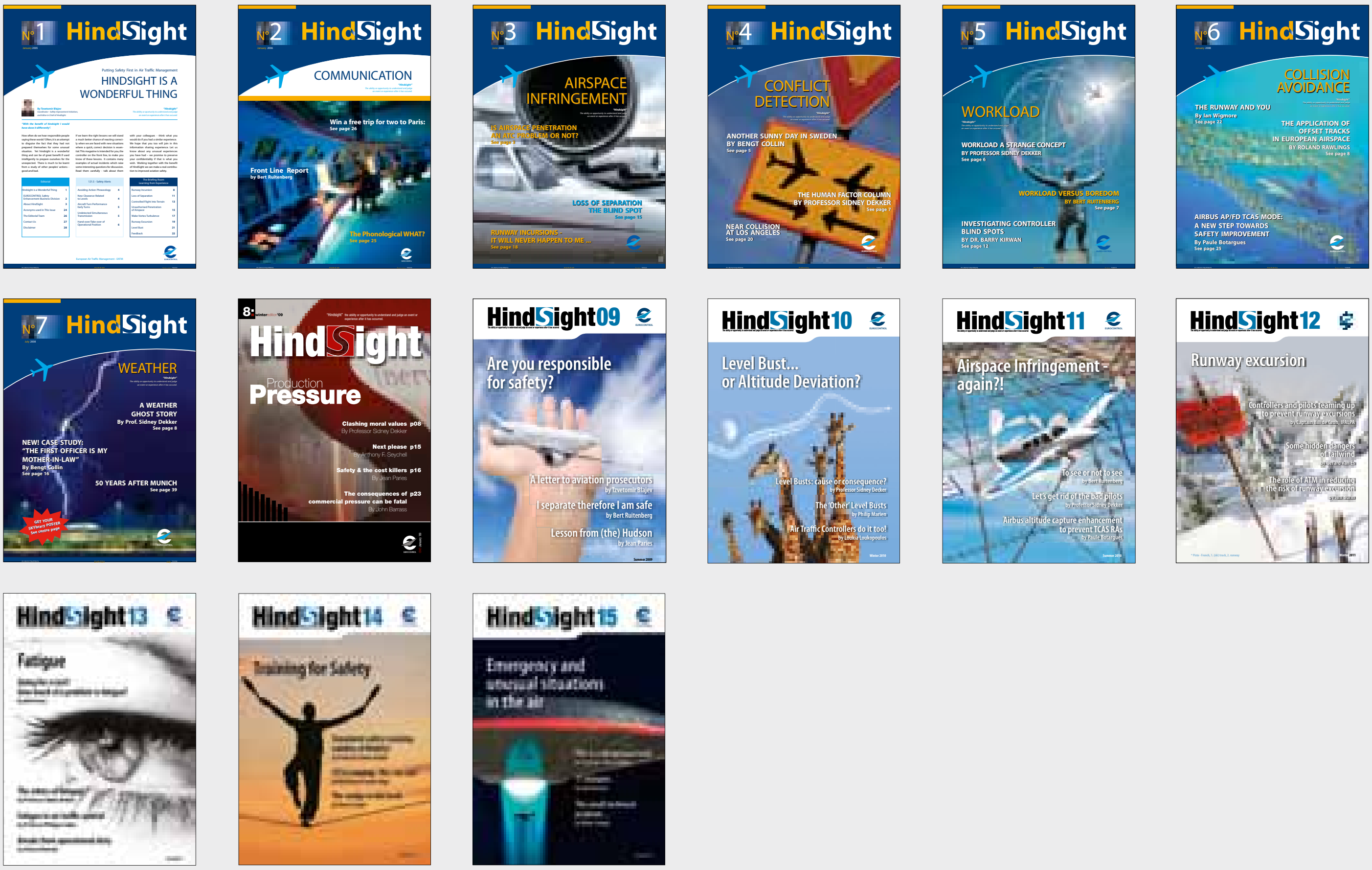
When one or both thrust reversers have been identified by maintenance as unserviceable, it is usually permissible to despatch under MEL relief. In the absence of MEL conditions which entirely prohibit the use of any remaining serviceable thrust reverser(s), any such use should be predicated on the existence of flight crew guidance provided or endorsed by the aircraft operator. This guidance should be expressly briefed prior to every landing with such status and then followed.

Use of Reverse Thrust

Use of Reverse Thrust on low wing aircraft with mounted engines should be limited to the time when the aircraft is on an active runway. Use of even idle reverse during runway exit and initial taxi in can result in engine damage due to ingestion of FOD or contamination of the air conditioning system with excess surface de-icing chemicals sometimes found on taxiways.

For Accidents and Incidents click here:
http://www.skybrary.aero/index.php/Thrust_Reversers:_Flight_Crew_Guidance#Accidents_and_Incidents

If you are interested in downloading the entire **HindSight collection:**
www.skybrary.aero



In the next issue of HindSight: Safety versus Cost

EUROCONTROL

Putting Safety First in Air Traffic Management

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