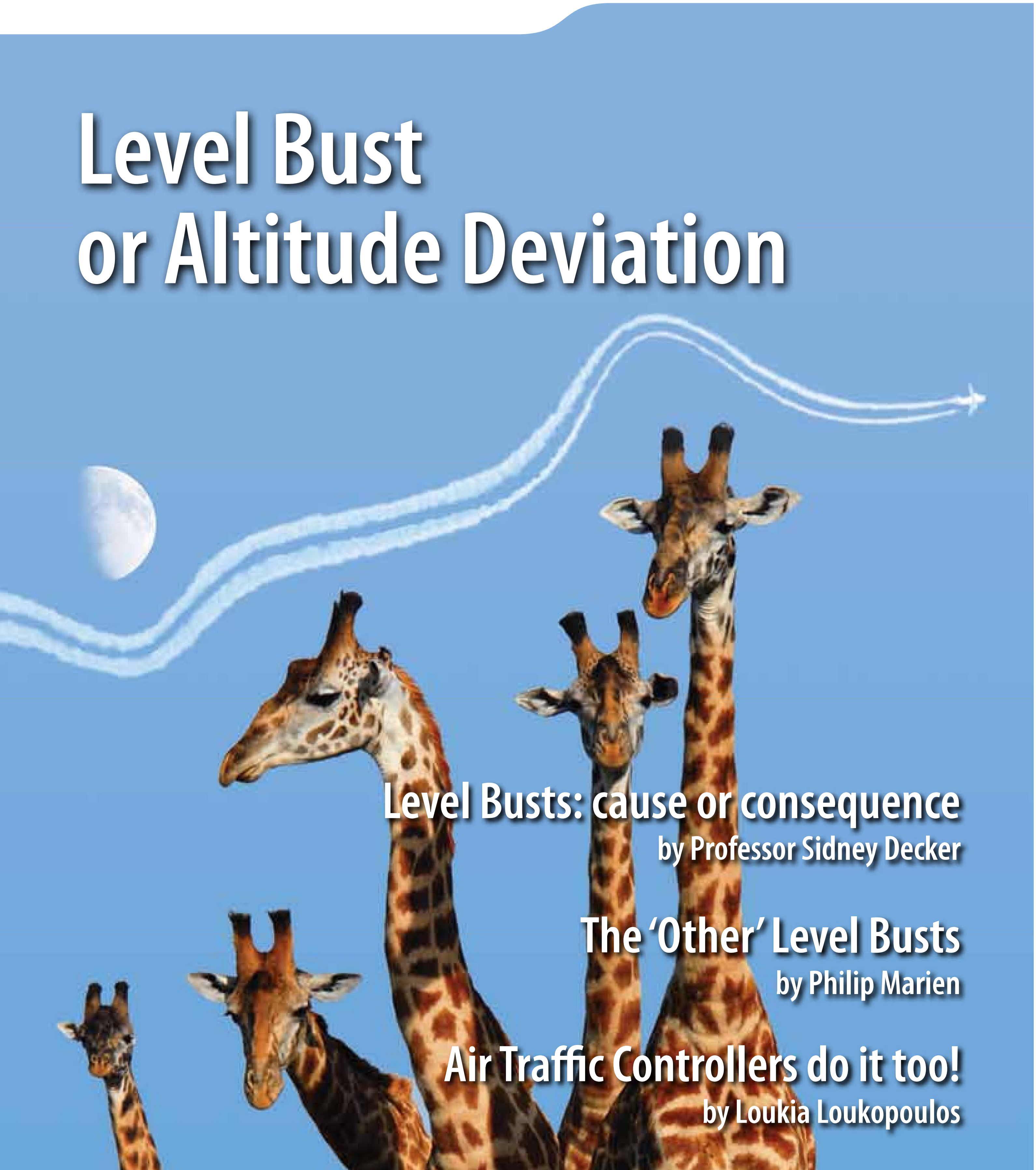
HindSight 10

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

EUROCONTROL

Level Bust or Altitude Deviation



Level Busts: cause or consequence

by Professor Sidney Decker

The 'Other' Level Busts

by Philip Marien

Air Traffic Controllers do it too!

by Loukia Loukopoulos

Air Traffic Controllers do it too!

For a number of years now, my colleagues and I have been studying multitasking in the cockpit and have made a number of observations[1,2]...

By Loukia D. Loukopoulos

Multitasking, the act of performing more than one task at the same time, is a highly prevalent and practically inevitable practice in the cockpit because of multiple, concurrent operational demands. Pilots regularly multitask with confidence and a business-as-usual attitude and they, like all humans, over-estimate their ability to multitask successfully. They readily accept the challenge without full appreciation of the risk(s) they take when doing so. Whilst multitasking pilots have a very high rate of success, errors and compromises to safety still occur.

To derive these observations, we first analysed flight operations manuals (and the training based on these manuals) and determined that the tasks regularly performed by pilots during routine flights are, in theory at least:

(a) **linear** – first do one task, then the next, then the one after that, etc., always in the same sequence

(b) **predictable** – externally-provided information and other cues are always present, at the time they are needed

(c) **controllable** – pilots have full control of the timing of activities and the time available to complete them

Next, we observed operations from the cockpit jumpseat, with a fair degree of appreciation that the real world would not be quite as "clean" as that expressed on paper. Indeed, we discovered that even the most routine of flights is far more dynamic and unpredictable than anticipated because of a large volume of perturbations – normal (i.e., not emergency) operational events that are familiar but nonetheless often unpredictable in their content and/or their timing. To address such perturbations pilots weave their responses within the linear and predictable sequence of cockpit tasks and end up with a dynamic, unpredictable situation over whose timing they ultimately have less than full control. Pilots treat such situations as just another day on the job. Incident reports, however, show that a large number and variety of errors can be traced back to one under-appreciated culprit: multitasking.

Of course pilots are no exception – our observations about multitasking extend well beyond the cockpit to all operators working in highly-complex and safety-critical jobs. Like, say, air traffic controllers…

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This article is a first attempt to look at the air traffic control environment using controllers' own reports of their operational errors at facilities in the USA.[3] Reports were selected to show that multitasking situations arise from the presence of operational perturbations to ATC tasks. Like pilots, controllers' attempts to multitask in response to these perturbations increase the potential for errors.

Let's look at some of the examples we found:

"I HAD TRAFFIC LANDING ON BOTH RUNWAYS 28 [L AND R] WITH ANOTHER PAIR OF ARRIVALS APPROACHING THE 2 MILE FINAL… AIRCRAFT Y WAS HOLDING IN POSITION ON RUNWAY 1R. AIRCRAFT X WAS HOLDING IN POSITION ON RUNWAY 1L WITH A WHEELS-UP TIME [COMING UP SHORTLY]… I CLEARED AIRCRAFT Y AND AIRCRAFT X [FOR TAKEOFF] IN A TIGHT HOLE WITH LANDING TRAFFIC ON A 2 MILE FINAL… BECAUSE I WANTED TO MAKE THE WHEELS-UP TIME [OF AIRCRAFT X]… I DID NOT NOTICE THAT AIRCRAFT X WAS… ON THE SAME DEPARTURE SID THAT AIRCRAFT Y WAS ON [BOTH WOULD BE MAKING RIGHT TURNS AFTER TAKEOFF]… [THESE] FLIGHTS [DEPARTING 1L] USUALLY GET [A LEFT TURN DEPARTURE]… AIRCRAFT X WAS REROUTED AND TAXIED TO RUNWAY 1L BY GROUND CONTROL BUT NOT MARKED WITH RED "L" ON THE AIRCRAFT STRIP [BY GROUND CONTROL]. MY ATTENTION WAS PRIMARILY FOCUSED ON THE LANDING RUNWAYS TO ENSURE THAT THEY WERE CLEAR ON FINALS." (ASRS REPORT 784838, MAY 2008)

Coordinating arrivals and departures at the airport ranked number 24 in the world in terms of aircraft movements is not an easy matter, but it is business as usual for an appropriately trained and experienced controller. To respond to the demands of the situation, she[4] **switches attention** between the tasks at hand: coordinating the arriving aircraft, listening and responding to their radio calls, visually verifying their position and progress, issuing landing clearances, and monitoring to identify a "hole" in the stream of incoming traffic that will allow her to send the aircraft holding on the runway safely on their way. Interleaving tasks in this manner makes it possible to maintain a constant flow of incoming and outgoing aircraft without interruptions and delays, while meeting the operational goal of maximum throughput.

With few exceptions (highly automated tasks), humans are practically unable to do two things at the same time. Multitasking primarily relies on **interleaving** activities, that is, directing attention to one task for a short while, switching attention to another task, then back to the first task, and back and forth in this manner among all tasks at hand. Individuals vary in the number and type of tasks they can handle well in this manner but resources are always finite and, regardless of personal limits, everyone sacrifices attention to one task or aspect of the environment when forced to devote attention to another. This then means that the more tasks a controller does at the same time, the less attention he or she can pay to all the details and nuances involved in each and the less foresight he or she can have to consider, check, and respond to possible contingencies.

The aviation environment is highly proceduralised. This leads to expectations that events will take place in certain ways. It is natural for a controller experienced with operations at this airport to expect that an aircraft taking off from the left runway will be making a left turn. Had she not been busy interleaving the many other pressing demands, she might have been afforded the time and foresight to check that the two aircraft waiting to take off on parallel runways are not, in fact, on conflicting trajectories. Multitasking as she is,

1- Loukopoulos, L.D., Dismukes, R.K., & Barshi, I. (2009) 'The Multitasking Myth: Handling Complexity in Real-World Operations'. Aldershot, Ashgate Publishing Limited

2- Loukopoulos, L.D., Dismukes, R.K., & Barshi, I. (2009) 'The Perils of Multitasking' in the August edition of 'Aero Safety World'. Flight Safety Foundation, pp. 18-23.

3- Reports were taken from the publicly-accessible U.S. Aviation Safety Reporting System (ASRS). The search criteria used were: type of error; air traffic control; the year range 2005-2009 and narratives to contain the word 'distract'

4- The controller's gender is not obvious from the reports – it is therefore randomly assigned to each narrative.

Air Traffic Controllers do it too! (cont'd)

however, the controller inadvertently "sheds" that portion of workload and relies on expectation alone. But contingencies – in this case, another controller not marking a change in routing on the aircraft flight strip – are always lurking around the corner.

The fact that aviation operations are highly structured around procedures means that humans, who are creatures of habit, learn through repeated practice and experience, to perform some tasks automatically, without much conscious effort. But functioning 'on auto-pilot' when multitasking is not always a good thing:

"I WAS WORKING SECTOR #9 BY MYSELF. SIGNIFICANT WEATHER, CAUSING NUMEROUS DEVIATIONS… SECTOR [#9] USUALLY COMBINED WITH SECTOR #8. TODAY, DUE TO VOLUME ISSUES AND WEATHER REROUTES, THE SECTORS WERE SPLIT. I ISSUED ALTERNATE ROUTINE TO AN AIRCRAFT… THINKING OF AVOIDING A BUSY SECTOR BY GOING UNDER IT… THE PROBLEM AROSE AS THE AIRCRAFT DESCENDED BELOW FL280, AS THAT AIRSPACE BELONGS TO SECTOR #8… I HAD INADVERTENTLY USED AIRSPACE THAT NORMALLY WOULD BE MINE BUT TODAY WAS NOT!" (ASRS REPORT 665421 – JULY 2005)

In this instance, under the strain of demands for multitasking of activities spurred by the volume of traffic and the weather, the controller subconsciously relies on a process normally used (and that through repetition, has become highly automated) to resolve a common coordination issue – and makes use of sector 8 to reroute an aircraft). In doing so, he forgets that today something is different - sectors 8 and 9 are split and he only has control of the latter.

As in cockpit operations, many operational perturbations demand intervention. In some instances, the intervention can be deferred to a later point in time, but in other cases, intervention must be immediate. This presents an interesting multitasking case, as it forces the interruption of ongoing activities which the operator is expected to resume after addressing the interruption:

"[AIRCRAFT X] DEPARTED… AND WAS VECTORED TO A 230 DEG HEADING [TO AVOID TRAFFIC IN THE AREA]… AS THE AIRCRAFT WAS CLEAR OF CONFLICTS, I CLIMBED IT TO 13000 FT. THE DEPARTURE ROUTE [OF THIS AIRCRAFT] IS THROUGH A 5 MI WIDE CLIMB CORRIDOR NEAR THE CORNER WHERE 5 FACILITIES AIRSPACE COME TOGETHER… I WAS DISTRACTED BY AN AIRCRAFT THAT I HAD ALREADY HANDED OFF TO A DIFFERENT SECTOR AND WAS ABOUT TO TRANSFER ITS COMMUNICATIONS. THE PILOT INFORMED ME THAT THE CEILING LOOKED LOWER AHEAD AND WOULD SOON NEED AN ALTITUDE CHANGE… THE OTHER SECTOR HAD JUST HANDED OFF A DIFFERENT AIRCRAFT HEAD-ON AT 5500 FT… AS I TOLD THE OTHER CONTROLLER ABOUT THE PILOT'S NEED FOR LOWER... AND POINTED OUT THE CONFLICT PREVENTING AN IMMEDIATE ALTITUDE CHANGE, AIRCRAFT X FLEW PAST THE CORRIDOR I WAS SUPPOSED TO TURN THEM INTO." (ASRS REPORT 808358, OCTOBER 2008)

The perturbation, in this case a routine operational request (a pilot requesting a lower altitude), arrives during an ongoing activity (monitoring a climbing aircraft to issue an instruction to turn when appropriate), and generates the need for a series of related activities (coordinate with another controller). Judging that there is some time remaining before the climbing aircraft will reach the turning point, and because resolving the developing conflict is clearly more urgent, the controller interrupts his monitoring of the aircraft and responds to the new demands created by the perturbation. He obviously fully intends to issue the turn instruction at the appropriate moment, but allows his attention to be diverted to another aspect of the environment to prevent the developing conflict. In doing so, he inadvertently loses track of time. In a matter of seconds, the intention to turn the climbing aircraft into a safe air corridor is forgotten, thus compromising the safety of an otherwise routine situation.

Forming the intention to do something in as little as a few seconds ahead of the present has the effect of engaging prospective memory, which is something none of us is terribly good at. It is difficult to monitor a situation actively, maintain an intention, determine when the time is right to perform it, and remember the full and correct content of that intention spontaneously with no external prompt. The probability of success is perhaps fair when workload is fairly low but decreases with the number of concurrent tasks being managed. Like pilots, controllers probably underestimate their vulnerability to errors of omission in these situations.

To reduce the chances of forgetting a deferred intention, pilots sometimes explicitly (or subconsciously) set cues to alert them when it is time to perform it. Controllers do it too:

"I WAS WORKING A BUSY SECTOR... I TOOK A HANDOFF ON AIRCRAFT X... DESCENDING FROM FL300 TO FL250… I NOTICED THE AIRCRAFT WAS HEADED FOR [A RESTRICTED AREA] … I DIDN'T HAVE TIME TO CALL THE CONTROLLER [WHO HANDED OFF THE AIRCRAFT]… I FIGURED I WOULD TURN THE AIRCRAFT WHEN IT CROSSED INTO MY AIRSPACE. THE AIRCRAFT NEVER CALLED ME… THE OTHER CONTROLLER PUT THE AIRCRAFT ON THE WRONG FREQUENCY… THAT WAS TOO BUSY TO ANSWER HIM, [THE AIRCRAFT] WENT BACK TO [THE ORIGINAL CONTROLLER] AND THEN FINALLY TO ME. BY THAT TIME HE HAD FLOWN THROUGH [THE RESTRICTED AREA]." (ASRS REPORT 651026 – MARCH 2005)

In this instance, the controller relies on a predictable cue (pilots establish radio contact with ATC when crossing airspace boundaries) to remember to perform an action (turn the aircraft away from a restricted area) that has to be deferred because she cannot accomplish right at that moment (there is no time to call the other controller). Associating (encoding) an intention with an event (cue) expected to occur at about the time when the intention will need to be performed is very good practice – it simply requires monitoring for that event to take place. Monitoring, as we already saw, however, is a tricky activity that requires discipline so that one can periodically self-interrupt ongoing activities to check on the event being monitored. That discipline is especially vulnerable to being inadvertently "dropped" during multitasking situations. To make matters worse, noticing the non-occurrence of an event is much harder than noticing its appearance. In this instance, when the cue (incoming call from aircraft) does not occur as anticipated, there is nothing to signal its absence – as a result, the associated intention is inadvertently overlooked.

These are just a few examples to illustrate that, like the cockpit, the ATC operating environment is inundated with "normal" perturbations to an otherwise highly proceduralised workload. Inclement weather, pilot requests, incorrect readback, similar call signs, splitting of sectors in real-time, working more than one position, noise, fatigue and congested radio frequencies - and the list goes on - can all intervene. Pilots deal with perturbations by multitasking – controllers do it too! Multitasking renders all humans vulnerable to errors, and this vulnerability is often poorly recognised. In our work with pilot operations, we have been suggesting ways to reduce the probability of errors brought about by multitasking. Further research is required to gain a better understanding of this inevitable feature of complexity in the ATM environment in order to eventually suggest ways to ease the effects of multitasking in air traffic control operations as well. ■

Pilots deal with perturbations by multitasking – controllers do it too!