INVESTIGATING CONTROLLER BLIND SPOTS

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When we talk of 'workload' we usually think of high workload and the strategies we have to adopt to cope with these situations. There is a danger that we may carry over these strategies to low-workload situations with unfortunate results.

Last year I was asked to investigate a series of incidents at a European Air Traffic Control Centre. The incidents were all in en-route airspace, involving losses of separation caused by overlooking an aircraft. However, they were compelling to say the least - in some cases very few aircraft were under control, and the two aircraft were very obvious. So, how could trained and experienced controllers, working in pairs, have missed them? That's what this article aims to explain.

My first port of call was the local investigator, who as usual had done an excellent job in analysing the cases and categorising their contributory factors. The next port of call was the controllers themselves. The safety culture at this centre is such that we did not need to interview controllers separately, and so we interviewed them in two groups. We had a form of incident replay available so each controller could talk over the replay and explain what they thought had happened (including 'no idea how I could have missed it!'). By having several controllers in each session, it enabled them to consider not

only their incidents but their colleagues' too. This led to good discussions and the two groups could search for 'systemic' factors, as well as those that were evident in each individual incident.

The next phase was more 'analytical', as I tried to piece together the puzzle, based on what I'd seen and what they

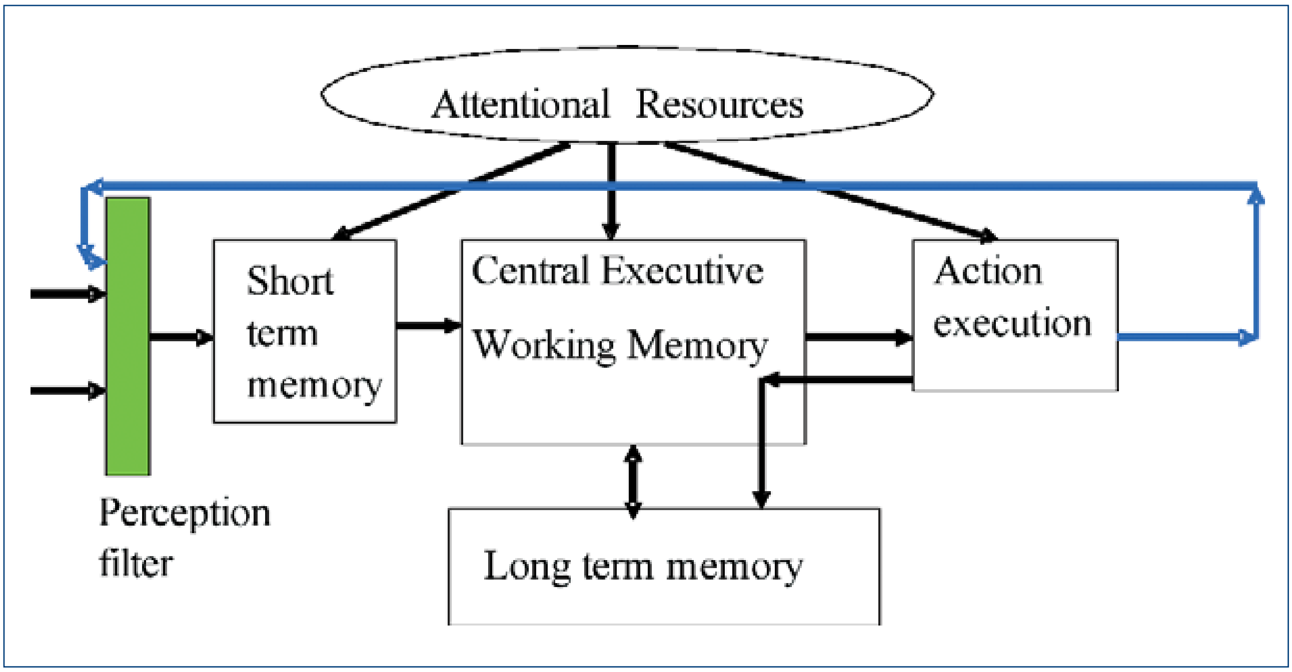

Figure 1 *- Information processing model*

had told me. I relied on one of Human Factors 'models' of how humans work, known as the Information Processing Model, pictured in ***Figure 1***. It's not rocket science, but it's quite useful and doesn't tie your brain in knots!

The model says that an individual (e.g. a controller) first receives information from the environment (e.g. the radar screen or oral information), via perceptual ***filters*** that discriminate between 'noise' and 'signals'. These filters generally operate in an 'unconscious' fashion (e.g. ignoring background voices when talking to someone), but are affected by experience and attention. The information taken in then goes into a 'buffer' called ***short-term memory***, which can hold information only for a limited amount of time (e.g. remembering a call sign such as AFR214). Short-term memory can only hold small amounts of information (e.g. a call sign of AFR21683472 would be difficult to hold in short-term memory very long - try it!) unless it is repeated or refreshed (e.g. by remaining on the radar screen or a strip). ***Working memory*** is where the 'conscious' mind resides, and is sometimes considered as a 'blackboard' upon which we put things (visual or verbal information or ideas, etc.). Working memory is closely related to 'situation awareness', and when we talk of a controller having or holding a mental 'picture', we are referring to the working memory. It is the active part of memory, and includes the capacity to make judgments and decisions. ***Long-term memory*** is by contrast passive, a data-store - it holds all the information and experiences for an individual, such as procedural information (including unofficial procedures, workarounds, short-cuts) and factual information (e.g. aircraft performance characteristics). ***Attentional resources***, particularly relevant to this study, concern the mental resources necessary to remain aware of the key aspects of the task (what we refer to as vigilance), and the resources necessary to concentrate. Lastly, the model refers to ***action execution***. In ATM this is usually a physical action (e.g. a mouse click; opening up a track data block menu, etc.) or an oral communication to a colleague or air-crew.

Okay - so we have a model - so what? Well, this is what I did with it.
The analysis of the incidents suggested that they were happening via what may be called ***'layered situation awareness'***. Layered situation awareness relates to the need to handle significant traffic and their demands, against a background of other traffic. The controller, in order to deliver high capacity and a quality service, focuses on traffic that are demanding, e.g. a need to climb or descend, or be at a certain XFL, but before that, remaining at a cruising altitude as long as possible. The controller therefore mentally suppresses, or in the extreme case 'filters out', certain aircraft under control as well as those which are not under current control - those that are relatively 'invariant' in their passage across the sector (e.g. they are staying at cruise level). This approach to controlling traffic is borne from a proactive strategy that is continually looking ahead, playing 'a more complex game' than in lower-workload centres. This more complex approach is partly proactive, partly opportunistic, and is focused on giving an excellent service; but it means the controller is thinking ahead much of the time, rather than focusing exactly on what is on the radar screen at the time. The end result is that what you see is no longer what you get.

This theory explains the incidents at busy times. However, in order to explain the incidents which took place during low workload periods, it needs to be expanded. The first additional aspect is that this way of working carries over into low and/or medium workload times after a busy period, when the vigilance 'resources' of the controller are lower or even depleted. Therefore, this filtering process may become 'second nature', and so be more likely to continue to operate when the controller is tired or the normal required vigilance level drops. It can also operate when the controller is less experienced, and has not yet had what may be called a 'correctional' incident (one that teaches controllers not to go too far when being 'proactive').

The evidence for this theory is primarily in the incidents reviewed, where aircraft under control were clearly in conflict but were overlooked. Generally speaking, it is as if the controller has certain aircraft (the main 'players' according to the controller's strategy) that are in focus, whereas the others are out of focus. In terms of the model presented earlier, the ones in focus are in the working memory, and the rest are not (at least they are not 'active' - they are treated as 'noise' rather than signals). When tired or preoccupied, it is possible for 'secondary' aircraft to fall out of focus too, even if the traffic level has dropped, since there is little demand to stimulate the controller.

What about the second controller or

co-ordinator? Well, it appears that in the incidents reviewed, this defence is not always working in 'post-peak' situations. In busy periods there are definitely 'two pairs of eyes', but afterwards, when the traffic level drops, there is a need for a recovery period, probably for both controllers, and so the two pairs of eyes no longer work together. This is not helped by the general lack of training in air traffic management for low traffic and post-peak strategies. This may signal the need for a more proactive approach by controllers and supervisors in low traffic scenarios, and their general minimisation via methods such as collapsing sectors etc.

I used a Swiss Cheese diagram to try and capture the various factors we found in these incidents, as shown in ***Figure 2***. Here's a summary of what it is saying:

SUMMARY OF ANALYSIS

The analysis suggests that there is an awareness problem whereby controllers work at different 'layers', filtering out aircraft at less important layers. In non-busy periods (where vigilance may decline), or when the controller becomes preoccupied with a problem (therefore occupying all the available vigilance resources), this may lead to overlooking an aircraft, even if in the central area. The 'second pair of eyes' is not a strong enough barrier to detect all such omissions, and STCA may occur too late to be effective in conflict avoidance in the vertical dimension (thus leading to a reliance on TCAS).

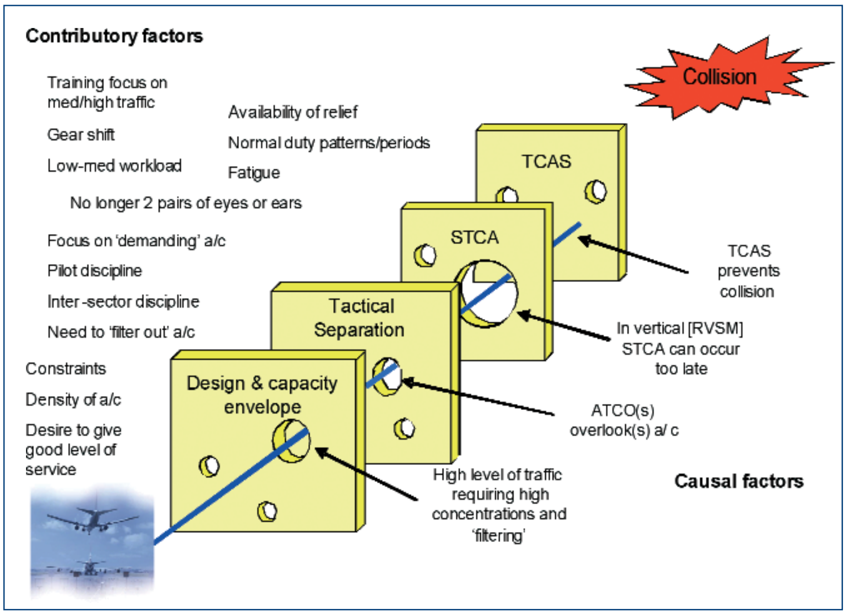

Figure 2 *- Characterisation of the incident pattern*

The causal factors are relatively straightforward, but there are many contributory factors. This means there is no clear single 'magic bullet' solution. Instead a set of counter-measures was proposed, for example:

CONTROLLER

- Give controllers training for low and 'gear-shift' (e.g. a sharp decline in traffic level) workload patterns over extended periods (e.g. >2hours). This will enable controllers to develop more robust working practices for these types of duty periods.
- Develop 'defensive control' strategies and training.
- Give refresher training (busy and non-busy traffic) without STCA (with standard separation).
- Develop individual and team-based guidance on detection and recovery from attention/vigilance lapses.
- Develop guidance on optimal and permissible duty times according to workload patterns.

TECHNOLOGY

- Downlink Selected Flight Level to STCA parameters.
- STCA utilise CFL information input by the controller.
- Adaptation of tools such as Medium Term Conflict Detection.

ORGANISATION

- Develop a suite of low vigilance counter-measures: rest pauses; role rotation; sector collapse; etc., and an associated supervisory checklist for maintaining a 'sharp watch'.
- Ensure sufficient human resources: availability of spare controllers.
- Improved ATM discipline: ensure only 'clean' a/c are handed over even within internal sector boundaries; develop a common under-

standing and practice to give a safe and reasonable quality of service; and develop approaches to reinforce pilot discipline.

- Take TRM to its next logical stage of Threat and Error Management (TEM), determining the day-to-day risks and best ways to mitigate them.

If such incidents as these continue (they have abated for now), then it suggests that (European) ATM has a serious problem, and perhaps we need to review capacity, quality of service, and their impacts on safety more precisely. My belief is that controllers in the front line, and the supervisors and investigators who support them, are best placed to tell us how close to the unsafe edge of the ATM 'performance envelope' we really are. What we in Safety, Human Factors, and System Design could do with however, is more feedback from controllers on exactly where those 'edges' are.

The TEM approach in particular may offer a linking structure to a number of the counter-measures (both organisational and human-focused), and give controllers themselves more 'control' over their safe performance. At the same time, the potential benefits from advances in safety nets and conflict probes should be realised to give further safety assurance. The third main area is to develop low vigilance recognition processes, by the individual controllers, their team-workers, and their supervisors. A more flexible approach to rest pauses and 'vigilance resources management' needs to be developed and supported by management in terms of assuring that relief is available.

Whilst this incident pattern is disconcerting, it offers a chance to take positive steps towards enhancing safety management at the operational level, and generally improving safety culture in a tangible and demonstrable way.

For more information concerning Human Factors, Team Resource Management and other matters discussed in this article refer to the EUROCONTROL Human Factors web-site: *http://www.eurocontrol.int/humanfactors/public/subsite_homepage/homepage.html*