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?

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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 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.

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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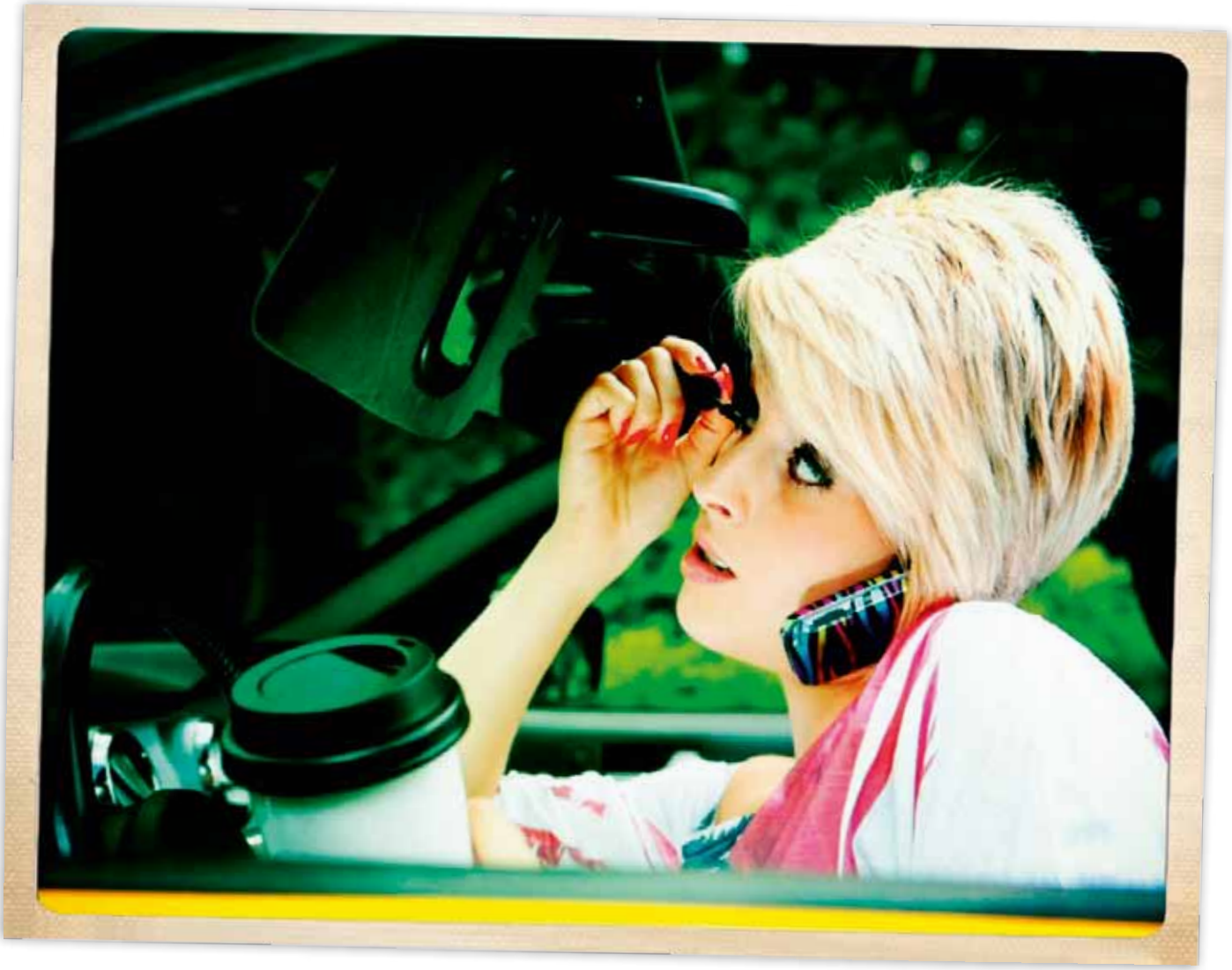

even this list that some of these are under your control and others are not. For ease of understanding I will group mental workload together with what I call motor function workload or physical workload. When a pilot takes control from the autopilot, his motor function workload takes a step change upwards 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 cor responding 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.