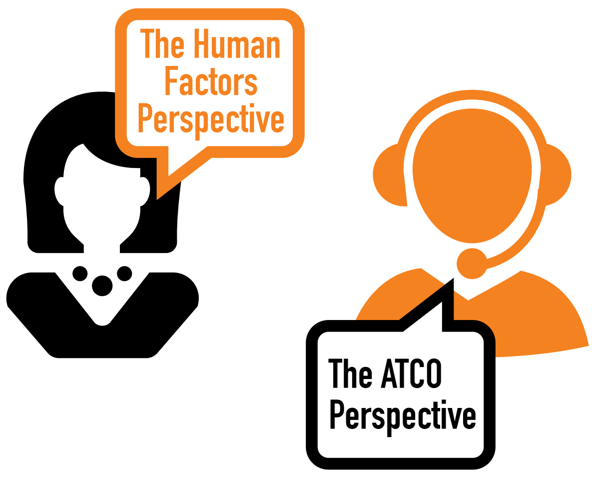
How much workload is workload?

by Michaela Schwarz and Fuat Rusitovic



How much workload is workload? (cont'd)

The ATCO Perspective

Being an ATCO, workload is an omnipresent factor in my daily business. Questions like; 'What is an optimal workload for an ATCO?' 'Can we define thresholds?' 'How can we measure workload?' are with me every day. Before I continue, I want to give you some examples of how I personally perceive workload during parts of a typical shift.

10:00 UTC. I start my first run in position as executive controller on a sector which is known for having a high volume of vertical movements. The traffic load is pretty low, only a couple of aircraft on the frequency and with a not very complex traffic distribution. After about 15 minutes, traffic increases and reaches its peak after another 20 minutes. 90% of the flights have to perform vertical movements as they are inbound and outbound from aerodromes in the area. The frequency is very busy and there is not much time between transmissions. I am feeling good, very good. I am still ahead of the situation and everything is working out as planned. After this peak, the traffic level reduces to a moderate level for the rest of my run. Break.

12:00 UTC: For the second run, I am working as a planning controller on a different sector which is usually combined with another sector most of the day as there is not a lot of traffic in it. However, this time the sector is not combined because there is a rush of inbounds to a major aerodrome and another wave is expected soon. There's almost nothing for me to do and after about 20 minutes, the challenge is to stay focused and alert. A short chat now and then with my sector partner helps, but I wonder for how long. I ask myself "is there something I can do?", "have I missed something?" over and over again. Fortunately, an anticipated increase in traffic begins but I get released from position before it gets really busy. Break.

Let's jump to the last run of the day. 17:00 UTC: It's in the same position as my first run. I take over during a busy period. There are no ongoing conflicts, but still plenty to do and I feel fine. Traffic load is high but absolutely do-able. My planner is busy too and time flies. After about 40 minutes traffic reduces, but it's only a brief respite and traffic increases again until we are at the same peak as earlier. It gets really busy but we are doing fine. A lot of vertical movements, moderate traffic complexity but nothing special. I am feeling fine but I catch myself missing initial aircraft calls from time to time. "Station calling, say again?" I am fine. Am I? Am I really? There is nothing different than on my first run but my situational awareness is not quite as good as it was. Then, my shift is over and I am released.

Obviously the workload that was perfect for my first run wasn't so perfect for my last run, although according flow management measures it should have been the same. And what about my second run? How do we define under load? Couldn't that lead to equally or even more potentially dangerous situations than overload?

There are plenty of factors that contribute to workload. But often only one is measured and taken into account by flow management and/or operational management. This factor is related to occupancy counts (the number of aircraft within a certain sector per minute) or sector capacity (the number of aircraft there are in a certain sector per hour). Both factors are based on a generic definition of sector complexity, number of vertical movements and traffic flow, but do not consider overall traffic complexity.

But, what about other factors like:

- How many hours have I already been on duty?
- How many shifts did I work in a row without a day off?
- What time of day is it (circadian rhythm)?
- Who is my sector partner? (if we understand each other instinctively, it's easier to handle more traffic)
- What is the complexity of individual traffic situations?

For me, the last one is the most important one: traffic complexity.

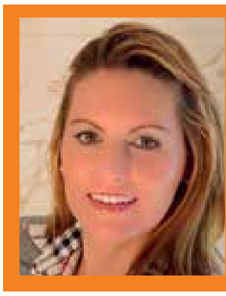
But how can we measure that? It's easy to calculate frequency occupancy values and to create figures about how many aircraft a sector is able to deal with. And with sectors that are not very complex, frequency occupation is the bottleneck. No doubt about it. With Controller Pilot Data Link Communication (CPDLC) we have a technology which can expand that bottleneck to a certain degree but what about the resultant complexity? How many vertical movements do I have to oversee? How many turns due to conflicting traffic do I have to give? Do we have a tool to measure that? I think we do.

Fuat Rusitovic

works as an ATCO and on-job-training instructor at the ACC Vienna. He is involved in the planning and development of pre-on-job simulator training and the coordination of the Team Resource Management program at Austro Control.

Workload for Air Traffic Controllers is a well-known and well-researched concept. Human Factors experts generally refer to Hilburn & Jorna (2001) who distinguish task load (i.e. the demand imposed by the ATC task) from workload (i.e. the ATCO's subjective experience of that demand). Hilburn & Jorna (2001) also provide an excellent summary on research related to task load factors including but not limited to:

- Traffic load / number-of-aircraft-under-control (Hurst & Rose, 1978; Stein; 1985)
- Number of traffic problems/ conflicts (Kalsbeek, 1976)
- Number of flight altitude transitions (Cardosi & Murphy, 1995)
- Mean airspeed (Hurst & Rose, 1978)
- Aircraft mix and variations in directions of flight (Wyndemere, 1996)
- Proximity of aircraft and potential conflicts to sector boundaries (Wyndemere, 1996)
- Weather (Scott, Dargue & Goka, 1991; Mogford et al., 1994)
- Mean aircraft separation, sector area, mean airspeed, sector flow coefficient (Arad, 1964)
- ATC position (oceanic versus terminal) (Wickens, Mavor & McGee, 1997)
- ATCO interface (visual displays, data entry systems) (Jorna, 1991)



Michaela Schwarz
works as a Safety Management and Human Factors Expert at Austro Control in Vienna. She is a registered Aviation Psychologist with more than ten years of practical experience in the aviation industry including assignments at EUROCONTROL and Qantas Airways.

Workload for ATCOs can be assessed through subjective, behavioural and psycho-physiological measures (adopted from Hilburn & Jorna (2001). See table.

Whether or not and if so to what extent a person can manage task load depends on personal, team and organisational factors. **Personal factors** include the ATCO being well rested and fit for work, leading a healthy lifestyle, taking regular restorative breaks and being aware of his own capabilities and limitations. **Team factors** include team quality and climate, adequate leadership and supervision, appropriate communication and assertiveness etc.

Finally **organisational factors** include duty roster, break plans, sector opening/collapsing, flow control/ management and a pleasant work environment aiming for optimal task and workload conditions. So knowing all the task load and workload factors and how they can be managed, why are we restricting ourselves to occupancy counts?

Subjective	Behavioural	Psychophysiological
■ NASA Task Load Index (TLX) (Hart and Staveland, 1988), ■ The Air Traffic Workload Input Technique (ATWIT) (Stein, 1985) ■ Subjective Workload Asessment Technique (SWAT) (Reid and Nygren, 1988) ■ The Instantaneous Self-Assessment of Workload (ISA) (Jordan & Brennan, 1992) ■ Mobile ISA available at http://www.think.aero/isa/	■ Communication efficiency ■ Communication times, message length, content ■ Flight data management ■ Inter-sector coordination ■ Number of control actions Summarised by Hilburn & Jorna (2001)	■ Heart Rate Measures (ECG) ■ Eye blink rates (EOG) ■ Eye movements, pupil diameter, fixations (Eyetracking) ■ Brain activity (EEG) ■ Electrodermal activity (EDA) ■ Biochemical Activity (cortisol, adrenalin) ■ Muscle activity (EMG) ■ Body temperature ■ Respiration Summarised by Schandry (1998)

How much workload is workload? (cont'd)

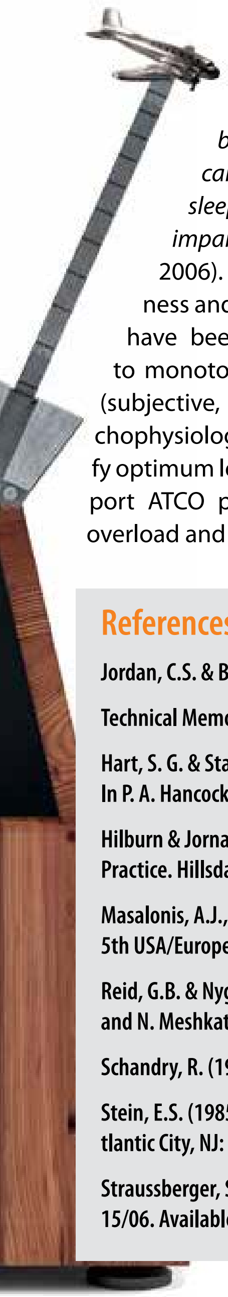
The ATCO Perspective

Modern air traffic management (ATM) systems provide pre-calculated conflict predictions up to 30 minutes before aircraft enter a sector based on their flight plans, actual radar-derived position, aircraft performance and local Air Traffic Services (ATS) procedures such as exit conditions. For example, in the case of an aircraft entering the sector at FL300 that has to exit the sector at FL220, such a system will predict potential risks taking into account the best estimates of complete aircraft trajectories. Wouldn't using such conflict predictions be more accurate as a means to measure workload than only referring to occupancy counts?

ANSPs and ATCOs would benefit from a tool that provides a complexity value for the expected traffic in addition to occupancy counts. The benefit for the ATCO would be the avoidance of potential overload situations attributable to traffic complexity. And the ANSP would profit from a more efficient use of human resources. So called 'Dynamic Density and Complexity' Models (Masalonis, Callaham & Wanke, 2003) already take various complexity metrics into account (e.g. sector aircraft count, sector volume, aircraft speeds and distribution of aircraft relative to sector structure). This could be a good start for developing a tool that considered actual traffic complexity and which could proactively increase safety performance.

Monotony *'is indicated by reduced physiological activation, subjective sleepiness and behavioural impairments'* - Straussberger, 2006

A tool to calculate actual traffic complexity should also be able to take human capabilities and performance variability into account. ATCOs perceive workload differently depending on their individual condition, personal experience and workload management strategies. Both overload (excessive workload) and under load (monotony/boredom) should be part of the assessment. Monotony *'is indicated by reduced physiological activation, subjective sleepiness and behavioural impairments'* (Straussberger, 2006). Both traffic repetitiveness and dynamic traffic density have been found to contribute to monotony. Workload measures (subjective, behavioural and psychophysiological) can help to identify optimum levels of task load to support ATCO performance and avoid overload and monotony.



I agree.
As well as defining a limit for the maximum safe traffic complexity there should be a limit for the minimum as well. The situation of an ATCO in under load is hard to describe. It's a feeling of uncertainty as to whether everything is OK, which is as bad as being in overload. Additionally you have to cope with staying focused and alert on the task when you have almost nothing to do. In these cases it would be good practice to ask the supervisor to collapse sectors to distribute the workload better. However, often this is not possible because it may create an overload in another sector so developing a tool that considers traffic complexity in all sectors taken together is important.

So what is the optimal workload for an ATCO?

To be honest, we don't know. We doubt that it is possible to set a value for optimal workload but we can get as close as possible to a value for good workload. Putting occupancy counts and traffic complexity together and calculating a number which would keep an ATCO at a steady and fairly busy level would be a major step in the right direction. Human Factors experts can help with measuring workload of ATCOs during live operations in order to evaluate such new tools and establish the maximum and minimum desirable values on the new workload scale.

Until then we can only suggest that you call for help if you need it, like asking for another ATCO to supervise. Or ask the supervisor to open a new sector in case of overload or collapse sectors if in underload. S

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