# Using workload data to manage the deployment of change: defining the limits of safe workload

**by Nic Turley and Brian Janes**

The world is full of good advice: derive user requirements; involve operational controllers in the design process; conduct formal human error analyses; provide high fidelity simulations under varying workload conditions and so on – but what happens when this is not enough?

In 2012, NATS successfully introduced Electronic Flight Data (EFD) into the Prestwick Area Control room. EFD represented a significant change from previous paper operations and was another step on NATS' journey towards fully electronic operations.

The deployment of EFD at Prestwick posed significant challenges due to the nature of the system (paper to glass), changes to working practices and the limitations of simulations in the validation of complex socio-technical systems for live operations.

The first attempt at deployment was temporarily withdrawn from service due, in part, to workload. However, with the innovative application of some straightforward Human Performance measurements to define the safe limits of workload and some practical support from controllers and front line supervisory staff, EFD was successfully introduced into full operational service.

## Safety Margins of Workload

There are many different aspects of a system that need to be considered when implementing new technology into live operations safely and efficiently such as the different roles involved (e.g. Planner/Executive/Assistant/Supervisor), sector types, traffic volumes/complexity, fallbacks, handovers, coordination, aircraft emergencies, steady state, combined roles, and combining and splitting sectors.

Also, when evaluating or validating a new design in a simulated environment, there are limitations due to the fidelity of the simulation (even high fidelity simulators are limited), the number of runs within the allocated timeframe, the number and skillset of controllers avail-


Erosion of Safety Margin as Workload Increases

## Using workload data to manage the deployment of change: defining the limits of safe workload (cont'd)

able, critical roles that cannot be replicated (e.g. supervisor roles not replicated due to limitations of some simulators), interconnection between systems (e.g. operating as stand-alone), replication of real life traffic/pilot interaction, weather, the experience of the controllers and their experience/training with the new system. The list goes on.

Because of these limitations, when new systems are being introduced into service it is important to understand that the safety margins for workload observed in the simulated environment may be different to those observed in the real world. It is therefore critical to identify the size of the buffer between manageable workload and overload in the real world system as quickly and as reliably as possible.

The change in workload safety margins when implementing new systems has been likened to 'Q' corner of a fixed wing aircraft (the margin between stall speed and over speed reduces with increasing altitude). If the system is new and the changes are significant, it is much more difficult to identify the triggers for overload. Therefore the margin between manageable workload and overload may be reduced and become a 'cliff edge' which is much more difficult to anticipate and respond to.

Identifying and defining the changes in the safety margins of workload during implementation is extremely difficult to achieve. However, NATS has been working on innovative methods to do just that, making it possible for any erosion of safety margins due to an increase in workload to be restored quickly.

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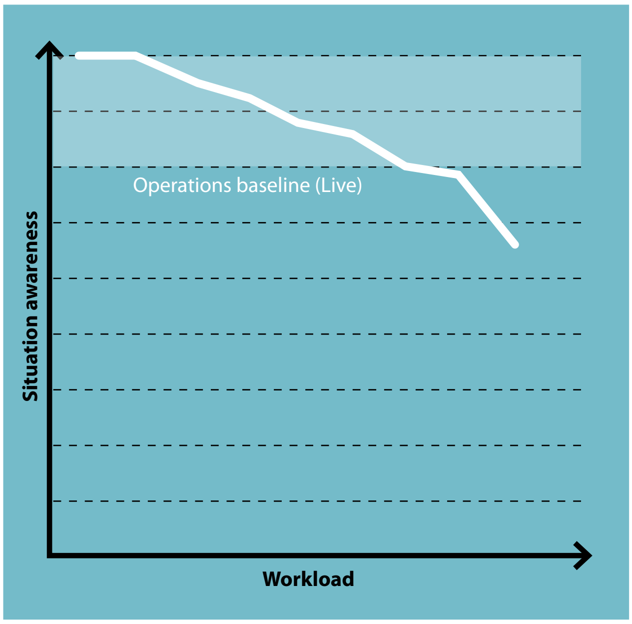
## Development

The EFD work began with the development of an in-house workload scale; more than 18,000 data points were collected from air traffic controllers in live operations across NATS centres (Terminal Control and En-Route) at Prestwick and Swanwick over an 18 month period.

A second measurement relating to controller situation awareness was introduced alongside the workload measure and further data points were collected from live operations. Together, the workload and situation awareness scores for the same period provided an insight into the workload levels under which situation awareness remained above what was considered to be a safe level. This then provided a means for comparing the relative tolerance of different systems to varying levels of workload.



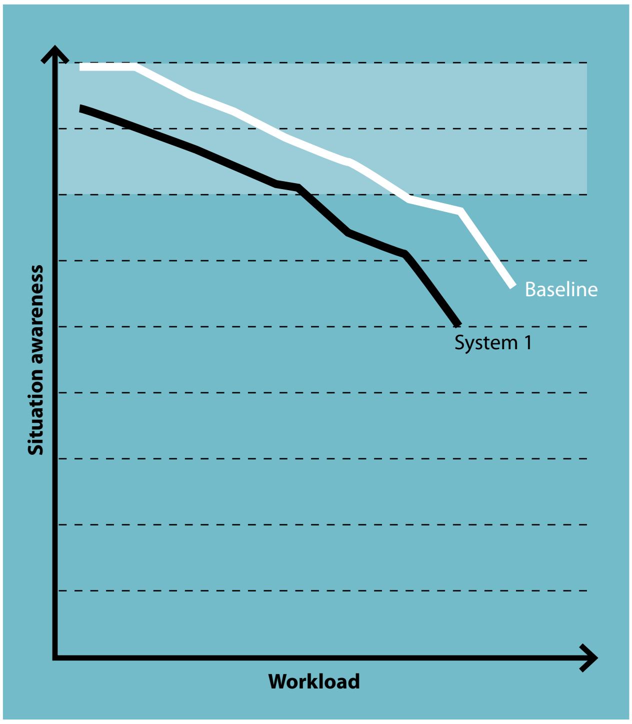

The observed link between high workload scores and situation awareness scores appeared to be related to the point at which the controllers found it difficult to maintain the 'picture' (a term used within NATS to describe the capacity of the individual to maintain sufficient situation awareness to manage current and future anticipated traffic scenarios). If this was the case then this would provide a means for protecting safety margins during the introduction of a new system: ***keeping workload levels below a known critical level would (theoretically) ensure that situation awareness would remain above a desired critical level and thus enable continued safe operation of the system.***


## Application to EFD

The temporary withdrawal of EFD from service provided an opportunity. We had data from a number of sources: simulations; live operations; pre implementation simulations; live operations during implementation and live operations post-reversion to paper. These data sets provided a clear insight into the events which took place following the initial introduction of EFD and the subsequent reversion to paper operations.

This now meant we had a clear 'picture' of the current operational profile (baseline) to compare against and were no longer implementing 'blind'. Data showed that the percentage of time that controllers were experiencing non-satisfactory situation awareness scores was higher for EFD than the current operating system at similar levels of workload.

One very clear finding related to the limitations of using workload data alone from simulations in the absence of situation awareness indicators. A clear limitation of the simulations related to key workload factors not being replicated (e.g. phone calls interrupting planner actions). Live traffic scenarios, which would be classed as high workload in live operations, did not invoke the same workload experience for controllers in the simulator.

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## Introducing EFD back into live service

In order to facilitate the introduction of EFD back into live service, efficiencies and improvements were identified in order to reduce task demand. These included:

- Electronic (Forward) coordination
- Auto population of initial levels
- Carry forward of previous sector heading and speed data
- Data entry
  - Heading, level and speed
  - Co-ordinations
  - Oceanic clearance times
- Strip interactions

The changes were identified and implemented through working closely with a core team of controllers to ensure they would be effective.

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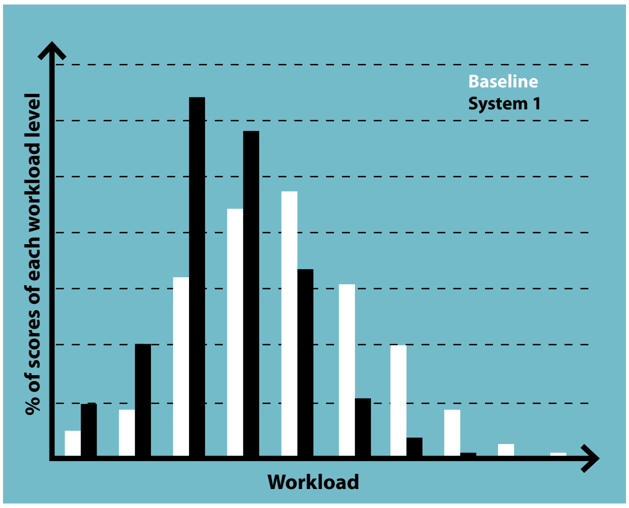
## Live Ops Validation

EFD was reintroduced during a period of Limited Operational Service. The supervisors were tasked with maintaining the workload of the controllers at or below LOW-MODERATE levels as defined by the in-house workload measurement tool (data showed that this was the level at which the controllers could maintain good situation awareness).

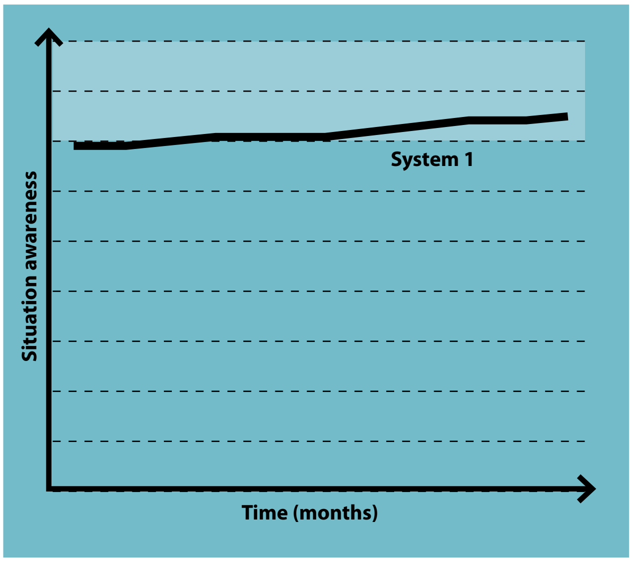
Supervisors have expertise in controlling workload (as part of their day job) and use a large amount of information to support this task (e.g. traffic information; number of controllers present; sector configurations; specific sector issues etc.). At the end of each controlling session, controllers reported the actual level of workload and situation awareness they experienced and this was fed back to operational managers and supervisors to ensure that workload and situation awareness had remained within acceptable limits.

To provide complete safety assurance, a paper back-up team was utilised during each period of operating with EFD. This allowed reversion at any point (either prompted by the supervisor or the controllers).

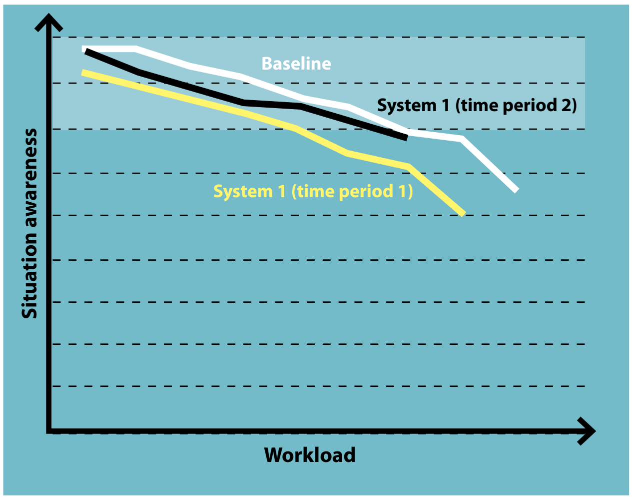
From the data it became clear that the supervisors were able to maintain the workload of the controllers within the desired range. A buffer had been built in and during this period there were no overload reports.




90% of the situation awareness scores during this period were 'Good' or above (very similar to baseline scores of 91% 'Good' or above). Over time, as workload was maintained at a low to moderate level, an increase in situation awareness scores was observed. This was taken to indicate a gradual increase in the buffer relating to workload, possibly resulting from increased familiarity with the new system.




Being able to 'see' the progress taking place allowed for increases in the defined workload level at a gradual rate, with constant feedback that situation awareness wasn't being eroded. The improvements could be seen when looking at the workload/situation awareness profiles at different points in time.




After a few months, the paper back-up was removed and the utilisation of EFD in live operations continued to increase until all controllers were using EFD on a full time basis and traffic was able to be managed at the same levels as when the previous systems were in use.

Due to this success, this process was repeated on further projects (e.g. iFACTS, the London 2012 Olympic Games, airspace changes). Previous issues encountered during project implementation (e.g. overloads) were not experienced. We now have baseline data from live operations (how the current system performs), more accurate data from simulations, and limited operational service applied sooner (as we know the levels of controller workload to maintain safety and clear indicators when these levels need to be adjusted). The approach also allows significant amounts of data to be collected (e.g. in the 1000s, with 100+ participants). Investigation to broaden the use of this technique for live operations monitoring is currently being explored.