The Future of Real-Time Control Room Simulation

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Abstract. Real-Time Simulation (RTS) has been used in Air Traffic Control (ATC) for many years. It has experienced problems of reliability, verisimilitude, specificity and cost. Consoles are increasingly standardized. Control rooms are more alike, more computer-moderated and less industry-specific. The underlying software is more modular. The investment required to perform RTS is decreasing, as it becomes more general. RTS will become part of standard control rooms. Generalized RTS will become an economic and useful part of the control room design process.

Keywords. Real-Time Simulation, Standardisation, Control Rooms, Future Development.

1. Introduction

EUROCONTROL (The European Organisation for the Safety of Air Navigation) was established in 1968 to provide a unified Air Traffic Control system for Northern Europe. One of its first actions was to develop the EUROCONTROL Experimental Centre (EEC) at Bretigny-sur-Orge, near Paris, France. The main instrument for development was the world's first Digital Real-Time Simulator. Initially used to develop and test equipment and methods for the Maastricht Upper Airspace Control Centre, it was adapted to simulate many other ATC control rooms. Although most of its parts have been replaced several times, it is still in use, providing services to the current 34 member states of EUROCONTROL.

After more than 50 years, it is time to assess the probable future of Real-Time Control Room Simulation.

2. Methods

To attempt a reasoned estimate of the future course and utility of a technology, it is useful to examine its current problems, the field to which it applies, technical and social developments that may affect it, and to estimate their probable consequences.

3. Results

Contemporary Real-Time Control Room Simulators.

The EUROCONTROL Experimental Centre Real-Time Simulator is a good example of a large real-Time Simulator. It consists primarily of a large space with a false floor, under which cables and air ducts are positioned, and on which the simulated control positions are placed. David (2010) shows three different console suites used in this space. From two to forty working control positions can be accommodated. In addition to this space, which includes the control suite used by the simulation supervisor and his assistants, a separate room contains up to 20 simulator staff. These are in two groups. One is of 'simulator pilots' who provide the dialog with the controllers, receiving and transmitting messages, and inserting the corresponding orders to the simulator. The other group are experienced Air Traffic Controllers who simulate the adjacent Air

Traffic Sectors and the underlying Terminal Manoeuvring Areas, as far as is necessary to maintain a realistic flow of traffic. Up to 80 people in all may be involved in a run of the simulator lasting 90 minutes and involving the simultaneous presence of up to 200 aircraft in up to 20 sectors. Four runs may be made in one day and a simulation may last up to four weeks. Enormous quantities of data are recorded

Although this simulator has performed its duties successfully for half a century, it has certain inherent disadvantages.

- It is very costly in equipment and manpower.
- Realistically, it is limited to about six simulations per year.
- The simulated control room can rarely be an exact copy of the control room simulated.
- The controllers carrying out the simulation are not a 'team' as they are in real world, since it is rarely possible to detach an entire 'watch' from their normal duties.
- Representative traffic is hard to define, and samples must be adjusted so that they are neither too easy nor too difficult, so that differences due to the organisations being tested can show up.
- The synchronisation and level of detail of recording can be extremely difficult to adapt to different purposes. For example, recording of keystroke times, identification of incomplete or incorrectly formulated orders, and starting and ending conditions all present continuous problems.

There are several other large Real-Time Simulators in existence. The USA, which operates a large number of identically equipped centres, uses one set of each version of the standard equipment as a real-time simulator at its experimental centre in Atlantic City. Other nations have complete or partial simulators of their ATC control facilities, but there are no generally available generalised simulators.

Contemporary Control Rooms

Wood (2010) describes a variety of control rooms in contemporary use, with an insightful discussion (Ivergard et al, 2010) of the design of future control rooms which advocates the use of simulators (among other developments). Ivergard et al (2010) also contains two examples of control rooms, one designed for training, with what is becoming a 'de facto' standard – pairs of working positions with several large screens, and a single very large VDU (Visual Display Unit) for an overall view. The other, which has a direct view of the process being controlled (replacing the large VDU) illustrates the use of a balcony and advocates the use of high ceilings in control rooms on psycho-social grounds.. Li et al (2010) presents a small Australian control room, Anokhin et al (2010) describes the modernisation of the control room at the large (4 1000MW RBMK reactors) at Kursk, in central Russia, and Wood (2010) describes the control room for the Large Hadron Collider. As well as showing the geographical range of control rooms, these studies illustrate the convergence in design. (However, Sathikh (2010) shows that cultural influences are important even at the level of physical layout – for example, some Asian cultures are unhappy to have the main door at the back of the control room.)

Trends in Control Room Development

Considerable effort has been exerted on the ergonomic design of control rooms, and ISO (the International Standards Organisation) has issued a seven part standard covering everything from overall control layout to display and control design, including evaluation methods. (ISO 11064 parts 1 to 7 1999-2008). It does not discuss software standards. SBFI (2015) catalogues a range of standardised ISO-compliant furniture. SBFI claims to have supplied 60 control rooms since 1976. It should be noted that there is a strong trend to have operators work in pairs, and to provide a single very large display on the wall facing the operators.

The underlying software systems of control rooms also appear to be becoming more similar, particularly in their modularity, and in their control of the controllers' interaction with the system. Rather than passively displaying information, these systems adapt what is displayed to the circumstances. In addition, the emphasis is shifting from 'hands-on' immediate action to anticipation, requiring displays which show what is going to happen rather than what is happening now, and even, "what will happen if the controller does this?" In addition to its standard behaviour, the system must be designed to cope with sudden unexpected events, displaying them in a useful form, and providing solutions or emergency procedures.

With the change from human monitoring to human intervention, the system should adapt the workload of the controller to make sure he is usefully employed to maintain a state of alertness.

Specialised Control Room Simulators – future trends

Many of the problems described in section 3.1 above are linked to the need to bring controllers, and their equipment to a different location, and to adapt the simulator software to the system being simulated. If a simulator of all or part of the control room is designed into the system from the start, it can be used to train and refresh teams of controllers – not necessarily a whole 'watch', but groups used to working together. The equipment, location and social situation are those of the normal working situation. Traffic may be taken from recordings, 'tweaked' as necessary to provide larger traffic flows or special events. Measurements can be derived using standard on-line techniques such as ISA or SWAT (David et al,1997) or questionnaire based strain assessments (Gawron, 2000) Verkerk (2015) describes various standard observation methods such as Viso, TrackLab and The Observer, although these may not be needed in routine use. Properly designed simulators can be used to maintain skills, to practice responses to potential emergencies, to train new staff (without the risks of having a trainee on a live system) and to examine accidents and near-accidents on the spot and close to the time.

Generalised Control Room Simulators – future trends.

At present, general purpose simulators are confined to a few specialised fields. In future, there may be more partly specialised simulators, although their operating costs are inclined to be high, and the problems of organising and preparing 'full-scale' simulations remain.

An alternative approach may be the truly generalised simulator, which uses a standard control room, with all the standard measurement techniques available. This type of simulator would use standardised modules to control interactions and measurements, with specialised modules to generate the simulated environment and feed the displays. Some subject experts may act as the equivalent of 'simulator pilots' where contact with outside individuals is required. Such a simulator could be used before the actual control room was constructed, to verify the planned system and demonstrate the inevitable problems. It could also be used to train control room staff, familiarising them with modern measurement and analysis tools (ISO 11064-7 (2006).

A cynic might comment that the existence of such a simulator at the site of a manufacturer of control room equipment would present a powerful sales tool, particularly if there was the chance of a ‘free run’. A live, working, model will always be more interesting than inert equipment or sheaves of glossy paper.

4. Discussion and Conclusion

4.1 Discussion

The future development of Real-Time control room simulation will depend, obviously, on the development of control rooms. As Ivergard et al (2010) have pointed out; there are several distinct trends in process at the moment.

The first, generally accepted, is towards a more uniform physical design of control rooms. While this trend is welcome, since it is based on the community of human physical needs, it may require caution where there are marked social differences between cultures. Jing et al (2015) demonstrate this phenomenon in aviation, as Sathikh (2010) did in control rooms.

A second trend depends on the rapid technical advance of display technology, and, to a lesser extent of controls. It may well be that well placed fixed and controllable cameras may provide better and more useful views of a working plant or a container sorting facility than can be obtained through looking through a window. Classical music audiences find that the skilful cutting between players, conductor, and ensemble views, provide a significantly more satisfying view of a concert on TV than that acquired from a seat twenty or thirty yards away from the orchestra.

Allied with this is the emergence within the control system of more or less sophisticated artificial intelligence, adapting displays and producing warnings. This combines with the tendency of control to change from ‘hands-on’ (Real-Time, in fact) to anticipatory. In most real-life situations, we operate by making short-term plans, rather than reacting to events. Occasionally, we are tempted to ‘coast’ when we recognise, or think we do, a previous situation. If we are right, it saves time and effort. If we are not, it may be catastrophic.

Ivergard et al (2010) refers to the need for operators to develop themselves within the system, rather after Maslow (1943) whose hierarchy of needs culminates in ‘self-actualisation’. Some managers may feel that this is taking things beyond their duties.

On a less exalted plane, modern systems will need to provide the operator not only with projections of the current situation, but with projections of the consequences of planned actions. This implies that the system must contain some internal model of the process controlled, so that it can project future states. Advanced thinkers, linking this to the advance in artificial intelligence, may suggest systems that record and ‘learn’ from past events to improve their model. So long as such systems are relatively simple and limited, this approach will have benefits. When such systems involve hundreds of data channels and complex chains of reasoning, they may arrive at conclusions that the operator, having access to the vast body of innate human knowledge, but not to the specialised specific data, finds are wrong. How such conflicts are to be resolved is a problem for the increasingly near future. Self-preservation suggests Real-Time Simulation to be the appropriate arena for such resolution, rather than reality.

4.2 Conclusion

Real-Time simulation will come into future systems as an auxiliary technique at control room sites, in daily use for training, drills, evaluation of performance and discussion of problems – possibly for self-actualisation.

It will also be available as a stand-alone facility for examining proposed systems, training staff for systems not yet operational, evaluations of system modifications, development of methods and evaluation and even sales.

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