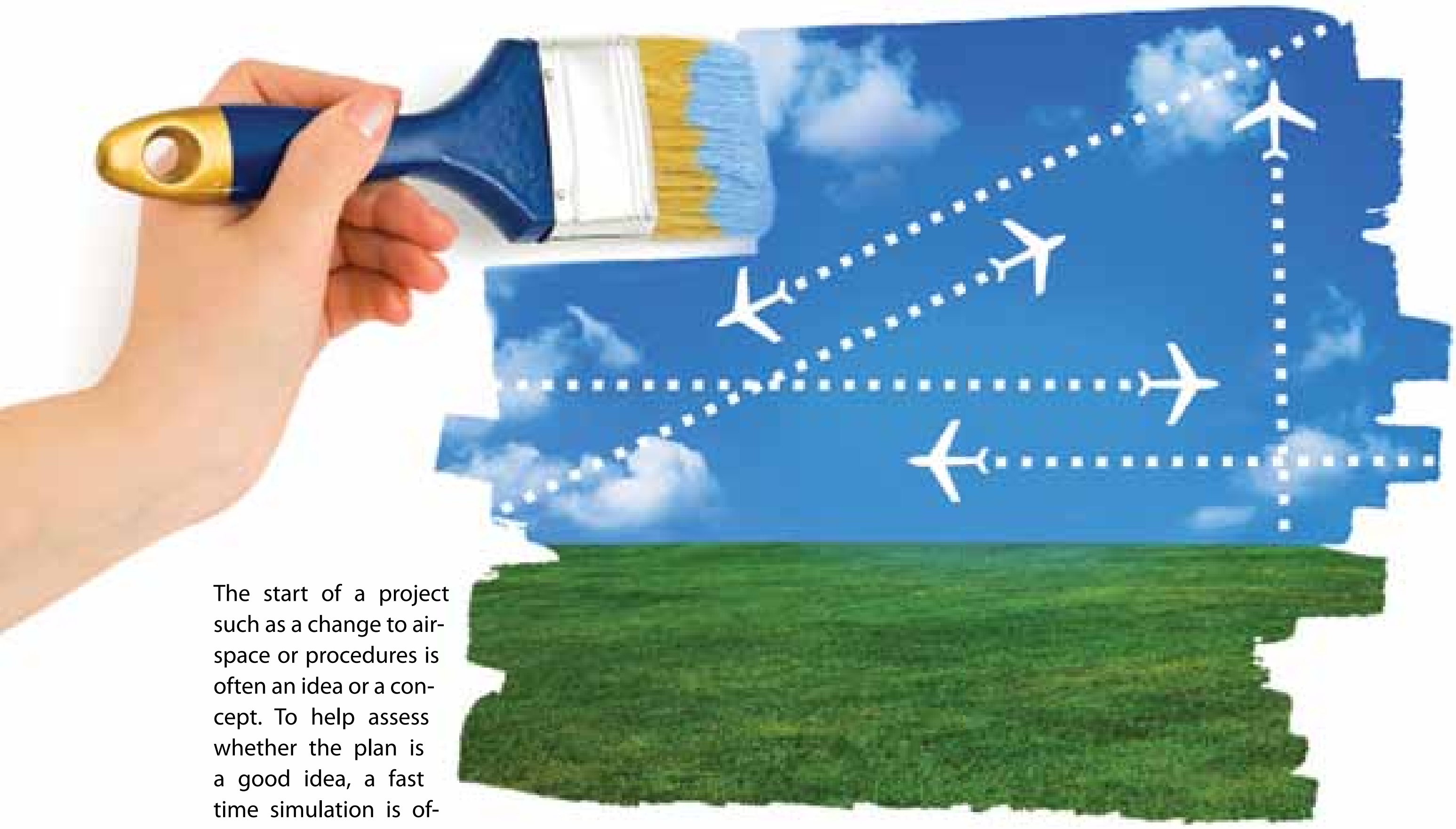
Designing simulations

by Emil Karlsson

Most people think back to their training when they hear the word simulator. Today the use of simulators is much wider than only for initial/refresher training of controllers.



The start of a project such as a change to airspace or procedures is often an idea or a concept. To help assess whether the plan is a good idea, a fast time simulation is often used to analyse the likely effect of the change. Such a fast time simulation helps to validate the expected benefits as well as identify drawbacks. Often, the result of a simulation is further questions which might need more simulation to get an answer.

Once a new concept is considered mature enough to be considered for implementation, the next step is often a real-time simulation to get further details of the effect on both controllers and systems. Any major change also needs a safety case and here, the outcome of a well-designed real-time simulation is a vital aid for the decision whether or not to finally implement. Depending on the outcome of the safety case, staff might need training before implementation and here too, the real-time simulation is a valuable tool.

Most people are not aware of the amounts of data and work needed to create a real-time ATC simulation. After all, most of what is shown on the simulated radar screen is not that different from any other "normal" day at work - it might be a little different in traffic load or contain experimental traffic flows, but often nothing spectacular.

The difference between a simulation and any normal day of work is of course that there are no real aircraft with pilots and passengers flying around, just a computer that generates radar tracks. This data feeds other computers which do a more or less realistic job of replicating the ATC system components and their interaction both with each other and with adjacent ATC systems. Ideally a fully manned replica of both the online system and the neighbouring systems is used since this will give the realistic behaviour that everybody is looking for. However, with all the demanding budgetary requirements around at the moment, this is not always the case.

The result of this cost-benefit balance in respect of simulation design may be a stand alone "look alike" simulator or a replica which runs the most important parts of the ATC system in full and simulates the rest. In the second case, the external world such as tracks and flight plan messages needs to be created and "fed" into the ATC system. One of the problems of this is that any ATC system (both the local and the neighbouring) is completely dependent on inputs from either controllers or flight data staff and the effects of those sometimes time-critical inputs is harder to simulate. Both types of simulation have their positive and negative aspects.

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A free-standing "look alike" simulator often gives more freedom for the creation of scenarios and simulation of the external world, whereas a replica running a "live" system gives more realistic behaviour including the "touch and feel" but also adds the requirements and restrictions of the real world into the simulation. For example a flight might need to have a proper entry in the area of responsibility and for that to happen, a correct flight plan and ACT system message has to be received, otherwise a manual input of flight data might be necessary. Of course, this is not convenient if the simulated sector is 45 minutes' flight time away from the entry point, especially since many live systems are understandably not designed to run faster than real time.

With the help of competent simulator operators, the actions of real-life pilots, surrounding controllers and flight data staff can be simulated to a high level of realism but here we are again often knocking on the door of that old couple Mr. Cost and Mrs. Benefit. People and their training are always expensive so for each feature, the decision has to be made whether, and to what level, the human element is going to be needed. Maybe the feature can be simulated reasonably merely by manipulating data. The typical example of this is the work of flight data staff, which in many cases can be excluded by injecting error-free messages and keeping to tested scenarios. Another step in this direction is to replace controllers with trained simulator staff for the surrounding sectors and environment. Some go even further and use voice recognition as a complete replacement for or as a means to reduce the number of 'simulator pilots' required. As with many things in life it is hard to take anything from Mr. Cost without also affecting the life of Mrs. Benefit negatively, but if you do manage it, you can be sure it will be worth the trouble.

The problem with the past future

All simulations face the problem of time passing by although it can be handled in different ways. Most simulations are aimed at the future - trainees will work the future traffic and it is future airspace which needs validation or future systems which need testing. In the operational world, airspace may change every 28 days and the control systems often evolve at a similar pace. One example of how to manage this in the simulator environment is the early training phases where a fictitious airspace is often used. This enables complete control over the contents of the simulation and ensures that all the training objectives are met. In this way the simulation does not have to be adapted, unless for training reasons. Another benefit is that it saves time for simulator staff, since every upgrade

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I've told you that the new Simulator is SUPER-realistic! Even when it fails, it does it like the real system!

means changes to systems and/or flight plans.

Later in the training sequence, during Unit training, the airspace becomes part of the objectives and the question of realism becomes more critical. Still it would be hard to achieve a high level of training if procedures and airspace were continually changing throughout the course. In this case the solution is often to freeze reality at the start of the course and stick to this version until the course is finished. Here, the selected type of simulator also has an impact. A stand-alone simulator has a strong point in that it does not evolve unless this is necessary, whereas when "feeding" a live system, evolution at some point is inevitable because components lose compatibility with each other or with older airspace. The benefit is that most of the components for upgrade are available "off the shelf" from the operational world. In some cases such as system testing, the simulation has to fully reflect a future situation. The airspace, traffic and the "feeding" simulator all have to be kept ahead of time so that they can communicate in a realistic way. Often those simulations are created by using traffic pictures from the past adapted to reflect the expected future traffic picture.

When simulating future airspace or operational concepts, the implementation date can be so far in the future that no accurate data exists. In those cases, the simulation must use system components from both the past and the future. When a simulation project is started, the system version might be for next month and the generic airspace and traffic from last week is then superimposed with the changes that are expected to take place maybe years later. At the time the simulation is up and running, the airspace and traffic it was based on is already months old and the system may soon need to be upgraded. Sometimes the simulation itself might need to be updated before it is even run for the first time just because of the extent of operational changes taking place during development.

Sometimes it is advisable to run a simulation which represents a reasonable step into the "past" but still has a high certainty of realism and consistency. Sometimes, too, it is necessary to project the systems/traffic picture into the future despite the inevitable eventual losses of accuracy.

One of the most important factors for the outcome of a simulation irrespective of its use is the pre-analysis. A good pre-analysis which produces a clear and shared view of what is to be achieved is the cornerstone of any successful simulation. A properly designed simulation can then itself become a cornerstone for a safety case, an ab-initio course or the development of new airspace or system functionalities. The question: "What is the purpose of the simulation and how is it best achieved." needs to be asked and answered every time, preferably with as much detail as possible.

It all boils down to the familiar generic solution of "it depends". Everything can be simulated, but of course some features require more development and/or imagination from the user than others. The only way to consistently take the right route through this maze of choices is to first figure out where you want to go. It should not be forgotten that the real focus of a simulation is always the processes going on inside the heads of the participants rather than what is actually displayed on the screen. A well-prepared scenario will frequently make a huge difference. Realism alone is never the only goal of a simulation; it is just one of the factors that need to be taken into account in order to satisfy whatever the objectives of a particular simulation are.