AIR TRAFFIC CONTROL SIMULATORS

A PRACTICAL GUIDE TO PURCHASING THE RIGHT SIMULATOR FOR YOUR ORGANISATION
THE ESSENTIAL TRAINING TOOL

A well-designed Air Traffic Control (ATC) Training Simulator substantially reduces training and operational costs through improved training and rating times. It also provides for on-going studies allowing students to enhance their skills and learn in real-world situations.

This guide has been developed to assist ANSPs in obtaining a quality training tool that meets the organisation’s objectives and helps develop new recruits into safe, talented and effective Air Traffic Controllers.

THE COMPLEXITIES OF SIMULATOR PURCHASING

In making a purchasing decision for a piece of equipment as complex as an ATC simulator, an organisation needs to navigate through a significant volume of conflicting advertising material and technical language.

Often, a simulator is purchased by management or technical personnel without a full understanding of its teaching or operational requirements, or by training personnel without a full understanding of the technical aspects of managing and maintaining such systems.

This guide has been designed to help organisations successfully navigate the buying process.

Quite simply, the ANSP needs to firstly understand its own requirements, so that it can apply these to the tender documents it receives. What is the expected purpose of the simulator, and why does the organisation need it? What should it do? How will it be implemented and maintained during its operational life? And most important of all, what will it cost?
WHAT IS THE SIMULATOR FOR?

There are principally two different uses for a simulator: the training of new recruits (ab-initio training) and advanced ATC training.

1. The training of new recruits (ab-initio training), which requires a solution to teach ATC basics. Training under ICAO 051-055 courses requires the ability to use the ANSP’s local procedures to train if the ICAO curriculum recommendations are to be followed.

2. Advanced training of rated Air Traffic Controllers requires the ability to deliver training with local procedures and also simulate their local environment.

It is therefore essential that any simulation conforms to both ICAO standards and the procedures as defined in the applicable Aeronautical Information Publication (AIP). The AIP and associated airspace standards are a Civil Aviation Authority mandatory requirement, and so the ANSP needs the ability to create or develop ATC training for the intended environment.

A simulator must replicate local AIP requirements

Many simulators do create a simulated 25 – 50 nautical mile area. However in today’s ATC environment, the airspace is made up of interconnecting sectors that need to be linked. If training requirements go beyond a single sector, or if performance based navigation is a factor, then simulation of the full Flight Information Region becomes a mandatory feature. ATC equipment shows traffic in adjoining sectors so that ATCs can make decisions around the boundaries. For greater realism and training value simulation should allow training across all of the sectors and the design of traffic flows.

WHY IS THE SIMULATOR NEEDED?

There are a variety of simulators on the market, with varying functionality for different purposes. It is important to first define the organisation’s technical aviation training requirements so the simulator purchased meets those requirements. One example is the ‘competency’ of situational awareness.

MEASUREMENT OF SITUATIONAL AWARENESS

This important competency differentiates people who will succeed as ATCs from those who will not. Crucially, however, most simulator designs do not provide the ability to measure or enhance a student’s situational awareness.

In a tower environment, situational awareness includes scanning the
environment for moving objects and identifying environmental changes to plan and manage the traffic flow.

Two-dimensional simulation in this environment provides procedural training only, which has some value, but does not cater for the most important element of situational awareness.

3D simulation on a few screens set up in front of the students also fails to address this objective. It does not allow the student to effectively scan what is in front of them, or to mentally visualise and confirm the true position of an object.

Ideally, simulator design should provide controllers with the ability to scan and view traffic exactly as they would in a real tower.

**SIMULATOR CAPABILITIES**

**TOWER SIMULATOR**

Simulators are produced in a variety of perspectives, and often there is a misconception that a 360° simulator must be best. However, unless the airport has parallel runways with the tower located in the middle, a 360° simulator is not an absolute necessity, and a less expensive option may be equally as effective.

For tower simulators, the visualisation and the simulator configuration should be based upon the relative location of the tower to the runways, replicating
what is observed out of the control tower window.

In a tower where the view and position of the controller is at the front of the tower, rear view is limited, although the controller will still occasionally have to look behind them. While the simulator solution should be able to quickly rotate the view (noting that all simulators actually model 360° internally), the preset display for the majority of airfields only requires about 240° to provide the required level of training.

When defining such a need, again the AIP is extremely useful as it shows the positions of the tower and runways. It also shows the approach and departure procedures which, when combined, provide the main requirement for visuals. If a controller cannot see the departure and arrival flight paths for the required distance (3NM to 8NM depending on procedures) then the tool will not meet the minimum requirements.

If the tower does sit between parallel runways, a 360° simulator is usually the best option for the same reasons mentioned above, i.e. the need to visually see the procedures (as found in the AIP).

The area to be seen, the size of the desk, and the style of training will determine if the simulator should be room size (projection), LCD with a defined area of display (such as 240°), or a desktop configuration

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**RADAR SIMULATION**

Air Traffic Management Systems (ATM) are used in many different ways depending on the sector that they provide information for.

A Controller’s workstation position is made up of the actual radar display and a number of supporting ATM tools, such as flight strips, weather information, and communications panels.

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*There are currently two types of simulators that provide radar simulation: SIMULATED and STIMULATED*

“Simulated” simulators imitate the radar display, whereas the “Stimulated” variety provides messaging to a real ATM position using real ATM equipment. Generally the use of real equipment is less flexible from a training perspective than simulated equipment but provides a higher realism value. Consequently, it is more often used by current, rated controllers. Simulated equipment tends to be used for new trainees and emergency training where flexibility is a higher requirement, although not always.

The ANSP needs to consider whether it requires both solutions - driving real ATM training positions as well as using a computer based radar simulator.

Both solutions need to be able to display the environment and targets
as would occur in reality, and should include all of the tools which controllers utilise to manage traffic in the local environment.

Most countries have radar blank spots due to terrain factors or no radar coverage areas at some altitudes, so the ANSP should determine whether the simulated coverage of the surveillance area matches the environment if training includes aircraft flying in these areas.

Ideally, radar screens in the control centres are 2000 x 2000 pixels, although significantly smaller in ATC towers due to space restrictions. The larger screen size reduces eye strain and 30 inch monitors at 2560 x 1600 pixels provide higher quality at a more affordable price.

The requirement for a tower simulator will often include a requirement for radar simulation, if there are surveillance screens in the tower or if there is tower and ground radar.

**SIMULATOR DESIGN**

ATC towers are typically designed with high windows and located above the airfield, providing the ability for the ATC to look down on the runway and taxiways and with a view across the landscape and sky.

This design provides the ultimate functionality and visibility, as it’s widely understood that situational awareness is one of the key skills for controlling aircraft. Unfortunately many simulators, especially LCD based solutions, are not built to mirror what a controller actually sees or experiences in their real work environment.

While the small screen LCD systems still have some training value, the ability to provide situational awareness training is impaired, making the simulator more of a procedural or part task trainer. As these do not replicate an actual tower environment they are of limited value for advanced training.

To provide full value, the solution should cater for all the tower visual aspects and be designed accordingly.

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**True tower visuals – allowing full situational awareness**

These observations extend beyond aircraft in the sky. They also apply to objects on the ground and environmental conditions such as weather and sun spots.

Window formats are generally described as being portrait (upright) or landscape (wide). Tower windows by definition are portrait (tall and narrow), yet many simulators are based on landscape designs.
A design that captures the true window shape in a tower will offer more training value than one that does not. With the change from basic skills training to real life ATC training environments, this is an important differentiator.

Teaching situational awareness dictates the simulator design should be similar to that of an actual tower so that when scanning for objects the same experience is generated as in a tower.
AIR TRAFFIC CONTROL TOOLS

In a tower, a set of tools are located in front of the Controller. These range from clocks to visual range indicators. In more modern towers, the tools often include lighting panels, radar displays, ground radar displays, meteorological displays, and a communications panel. The number of tools needed affects the size of the desk required to fit the screens for these tools. The size of the controller desk space plus the number of positions has a significant impact on simulator design and the room space required for the simulator.

It is not often that all towers in a country are the same, either due to cost or simply because most towers have different environmental elements and traffic, and therefore different tools are required for the controllers. Emulating the equipment functions onto touch screens within the simulator is an effective solution to this issue. The result is that when the tower location is loaded onto the simulator, the set of controller panels can be displayed in a similar layout to the real tower. From a training perspective, having the common tools helps with assessing the student’s multi-tasking abilities when controlling the airspace.

A panel builder function allows the trainer to create and update a variety of equipment and tools associated with simulator changes.

Determine the tools required for training
ENVIRONMENT

The environment could be described as what a controller sees when they look out the control tower window. Buildings, hills, navigation sites and other obstacles are all important reference points used by controllers to manage their airspace and separate traffic.

For example, Muscat Airport in Oman has a tower building in the nearby city and an island that can be seen from the tower. These visual aids tell the controller what the visibility margins are, even though they may have instruments to do this. In this case it is important to simulate objects outside the airport zone and in some cases a long way from the airport.

It is extremely important that these environmental elements are incorporated into the simulator for operational training. In this case, a photo-real model, one that uses digital photos taken from the control tower to create the environmental model, will produce the most accurate results.

DYNAMIC WEATHER MODELLING

Weather is an element of Air Traffic Control that holds extremely high importance, but is often overlooked as an aspect of simulation. Weather controls the runway in use and the flight paths to be used. Weather affects the entire flight plan.
One of the main tasks for a controller is to monitor the changes in weather over time and to plan for when that weather may start to affect the traffic.

In the real world, weather moves from one location to another and slowly evolves.

Most simulators allow the trainer to switch on rain or snow, select a cloud type back drop or adjust the weather manually. However, simulators which provide true dynamic weather reflecting all aspects of how weather builds and dissipates, allow for accurate measures of ATC competency in the real world.

Weather cells at ground level covering parts of an airport are referred to as surface weather. Wind on the runway at some airports has a different bearing at each end, often due to the surrounding terrain. Wind slowly increases or decreases in intensity and gusts and moves location over time, which affects the selection of the runway in use.

Weather in a simulator should also be dynamic, changing its elements and location over time and, if competency based training is to be conducted, it should be part of the exercise lesson plan, if not part of the exercise itself.

Weather does not simply switch on and off, and so effective training needs to simulate weather changing over time.

Instructor controlled weather panels are useful in training, but usually only for ab-initio training so different weather conditions can be demonstrated to a student. After this point in training, truly dynamic weather is what the controller will be dealing with for the rest of their working life.

EASE OF USE

Ease of use equates on a daily basis to how easy the simulator is to use for two key functions; piloting and exercise creation.

PILOTING

Piloting is the ability to easily place an aircraft where expected, when expected. Essentially how well an exercise is created determines the level of piloting required.

With aircraft, even when using instrument flight rules (IFR), no two flights are likely to be identical. To increase simulator realism, a solution is required that allows for pilot individualism within the flight rules.

Exercises are essentially a collection of traffic conflicts that visually stimulate a controller to do something. Simulator pilots therefore need the ability to create visual stimuli for training controllers.

Often there is a desire to remove pilots for alternative methods like voice
recognition and response. In practice this is not a very successful alternative, with the exception of demonstrations and very basic exercises.

If the piloting tool is designed well, it can provide training benefits itself. A good three dimensional pilot screen allows pilots to view the procedures and see what flight paths are planned. From a training perspective, this allows trainees to see procedures and the separation in three dimensions.

If the simulator is easy to use, pilots will be piloting the exceptions to the flight plan, which in turn greatly reduces the pilot workload and reduces the need for as many pilots.

With exceptional systems, trainees can self-pilot for others with minimal training.

3D piloting is best suited to tower training environments. These exercises require visual prompts to be provided to the trainee, and the pilot can see that these will occur ahead of time.

3D piloting for radar training has a similar advantage, because the pilot can see what the aircraft will actually do, while radar screens (2D), often used for piloting, do not show this. Displaying the 3D and radar view for pilots can enhance this aspect in radar exercises.

Visual prompts provide a lot more information and training value than a radar interface for piloting.
MANIPULATING AIRCRAFT AND VEHICLES

A good system should provide an override capability to allow aircraft to be re-positioned during an exercise if requested

Piloting should be based on the normal performance of the aircraft with limitations based on that aircraft's maximum and minimum performance parameters.

All objects need to be able to be manipulated as they would be in a live airspace or airport. Often, however, simulation systems have many restrictions, such as an inability to drive a vehicle anywhere on the airfield. The best simulators allow the ability to move objectives, such as vehicles, anywhere on the airfield.

An ANSP can also identify its requirements for a simulator by noting common ATC instructions to aircraft or vehicles.

Most airports do runway checks on a daily basis, so a call such as “Tech 1 - vacate runway immediately” is common place. The correct piloting is to drive on the grass a safe distance from the runway and wait until given clearance to resume the checks.

Another requirement is the ability to divert from compliance with the clearance rules on the ground, such as responding to an aircraft which failed to stop at a stop bar. The simulator solution should replicate what an object on the ground might do.

Objects on the ground need dynamic ground and flight path creation and should not be restricted only to taxiways and runways.

There are several other common directions given by controllers which also should be simulated. These calls will be defined by terrain, airspace design, aircraft type, traffic mix and other elements which essentially make up the airspace. The solution must cater for a variety of air traffic, including general aviation, commercial, and military.

The test of any solution is the ability to ‘fly’ the terminal airspace correctly as it is a small size and normally has high traffic volumes. The solution must include the full missed approach procedure and the ability to change the procedure mid-flight if requested.

The simulator should have the toolset to quickly remodel the airspace design and procedures

Given that an AIP changes every few months with regular updates, procedures also need to be easily changed. The simulator should have the toolset to quickly remodel the airspace design and procedures, and the ability to train on the new airspace and the old at the same time.

While being able to fly procedures is essential, so is the ability to manipulate the simulator and alter the flight path to
do whatever aircraft and vehicles might do in the airspace.

**USING VOICE RECOGNITION**

Often discussed as an option to reduce the need for, or eliminate, simulator pilots, the use of Voice Recognition software in simulators can cause more issues than it solves. The software usually performs adequately for a simple exercise or demonstration, but it has not yet matured to a technical level that suits the complexities of ATC training.

Using students as pilots, rather than voice recognition, increases the training experience for those students and also reduces training costs. Piloting systems should have the ability to be taught quickly, show the full flight procedure in 3D, and promote teamwork between pilots, similar to that found between controllers.

Voice Recognition can be useful for self-practise in some less complex scenarios. ANSPs considering a voice recognition package should do substantial research, to ensure that it meets expectations.

**EXERCISE CREATION**

The creation of student exercises is an important task for ATC instructors, but the ability to do so varies immensely between simulators. Some solutions require the instructor to ask the manufacturer to create the exercise, which takes a day or more, while others provide the instructor with the ability to easily create and edit exercises in a matter of minutes.

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**Simulators should provide the instructor with the ability to easily create and edit exercises in a matter of minutes**

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A simulator which requires the instructor to revert to the manufacturer to build new exercises becomes an expensive and time consuming training tool. It usually indicates a simulator built on a database of strict rules that often make it difficult to pilot and use, and one which is inflexible in meeting likely future changes of the airspace utilisation.

A solution should be able to create an exercise of any sort in minutes. This requires the creation of conflicts in any part of the airspace or ground that will stimulate the senses of the controller being trained, and goes much further than simply copying a flight plan database row and renaming the flight.

During training it is highly likely that at some stage an instructor will want to make a modification, either at the time or after completion. This requires instructors to be able to easily and quickly modify and create exercises.

In tower exercises, the ability to scroll back and forward in time to watch
the traffic patterns and conflicts, and what the controller will see, is essential to validating the exercise. The requirement to preview in a full size simulator reduces the value that can be obtained from the investment. The simulator should be fully booked for student use so exercise creation should be able to occur at any desktop that is available.

Exercise by definition is the creation of a number of conflict points that a controller is measured against to see that they can solve the problem competently. The exercise builder should allow the visual view (3D for towers) to be viewed at any point of the exercise (3D over Time = 4D exercise creation).

The easier it is to create an exercise that can measure capability and performance, the more usable the solution will be and the more training value it will provide.

**CONTROLLING AN EXERCISE**

Exercise control is significant to the learning experience. The ability to go backwards and forwards to any point in an exercise and start from that point, or to add or remove aircraft or objects, while learning and trying different solutions to the problem, is a powerful learning tool. Students using these tools will quickly build their skills and raise their level of expertise.

An instructor needs to be able to measure student competency based on a controlled exercise level. The lead up to this level of testing requires flexibility to take a trainee from their current set of abilities to a point that the competency measures can be achieved. This requires a level of functionality in the simulator that allows the instructor to teach and adjust their teaching scenarios to fit that of the situation.

Some of the abilities in the following table may be limited if a chosen simulator uses real ATC systems, as most ATC systems are designed for showing the present state and often cannot support a rewind function. For fully emulated or simulated environments these abilities should be available to give instructors the maximum flexibility to conduct training.
OPTIMUM EXERCISE CONTROL FUNCTIONALITY

**SPEED**
Ability to control an exercise run speed and playback speed at a faster or slower rate than normal.

**RUN**
Ability to start an exercise in live and playback mode from any point in time. A playback session can be started at any point as a live new training session.

**FAST FORWARD**
The ability to move from the current time in an exercise to a future time period in live or playback mode while watching the simulation at a faster speed.

**REWIND**
The ability to go back in time from the current exercise to review and run again from that point during a live exercise, and the ability to rewind a playback of an exercise from the current point to a previous point in time. A new live session should be able to be started from this point in time. During rewind the system should be viewable as it rewinds.

**PAUSE/CONTINUE**
The ability to halt an exercise and playback for a lengthy period, then continue again when ready.

**BOOKMARK**
The ability during a live or playback session to tag a point in time, providing the ability to quickly return to that event time.

**GO TO**
The ability to enter a time or defined bookmark to have the live exercise or playback return to that time in the exercise.

**RECORDING**
The saving of a live exercise to a media where it can be archived and played back. All simulator sessions should be automatically recorded with the option of retaining them for future use. Recording should include all live synchronised changes to the simulated traffic, equipment and voice.
The key to the successful implementation of a simulator is the quality of the training supplied to the instructing and technical support staff. Effective training allows the ANSP to become self-sufficient in its use of the equipment, and provides a quicker return on investment.

The cost of the simulator should include the training necessary for in-house staff to competently deliver training and maintain the system. It should also include at least one week per annum of quality assurance with a specialist on site to monitor skills and retrain if necessary.

**Simulator Capacity**

Simulators have finite capacity in terms of daily usage and the number of persons that can be trained at once. Depending upon the structure of an ANSP’s training regime, each trainee should ideally spend some time in a simulator on any training day.

A simulator can have multiple positions. For radar training, the maximum number of positions is generally two and for tower training generally four, but each position performs a different role. Training for a role includes a set amount of time for each lesson, with a set number of lessons per course.

The ANSP needs to consider the training need (number of trainees), the number of lessons required and the training time available to determine the number of training positions (and simulators) to meet capacity.
COST OF OWNERSHIP

An ATC simulator is training technology at its best and most useful. Buying a simulator, therefore, requires some understanding of technology and how it will affect the life and the running costs of the training system.

All assets need to be maintained and supported. Hidden or on-going support costs can sometimes represent a larger cost to the organisation than the original purchase price, so it is important to identify these before purchase.

Daily running costs and life time costs make up the Total Cost of Ownership (TCO) and should be broken down for the ANSP by the manufacturer.

Basing the purchase on a ten year life span, on-going costs are likely to include:

- **Software:** What is the on-going annual support or software rental and what does this include?
- **Updates:** What does it cost to add a new equipment panel or to update the graphics?
- **Enhancements:** In ten years the operational environment will change. Can the simulator adapt to meet the new training requirements?
- **Hardware:** How often does each component need to be replaced?
- **Consumables:** Which items wear out or are consumed regularly?

Other items that many not be factored into the TCO could be:

- Training
- Installation
- Testing
- Commissioning

Simulator tenders should provide a detailed breakdown of the equipment, training, maintenance and upgrade costs for its full life expectancy. The ANSP should consider the cost of retaining specialist technicians on staff if required, compared to the cost of the vendor managing upgrades, maintenance and training.

Produce the highest standard of ATCs, at less cost, with outstanding functionality
SUMMARY

The purchase of a simulator to train future Air Traffic Controllers, and to upskill existing staff, is one of the most important decisions an ANSP will make for training. These are new generation pieces of equipment, designed to train in a way that was unheard of even ten years ago. The investment is significant, and there is a great deal to consider.

Starting with a solid understanding of how the organisation would like to undertake its training is the key to success. Too often, solutions are offered which simply don’t match the needs of the ANSP, and which will fail to meet training requirements once installed.

AIRWAYS — THE WORLD’S FIRST FULLY COMMERCIAL ANSP

This Practical Guide to Simulator Purchasing has been produced by Airways to ensure that ANSPs around the world are as educated as possible about the technological opportunities available in the simulator market. We are recognised leaders in this field, having spent the last decade researching, developing, and producing a best in market product.

Airways is a world-leading commercial ANSP, operating in New Zealand as a State-Owned Enterprise, and providing services throughout 34 million square kilometres of airspace. In addition, we provide ATC and engineering training, and we deliver air traffic management, Flightyields revenue management solutions, navigation services and consultancy in more than 65 countries.
TOTAL CONTROL SIMULATORS

Designed by the specialist Airways team, and tested over many years in our own organisation, Total Control is now in use around the world, providing ease of use and fast-tracked training.

Total Control has been developed by ATC instructors and training specialists

Pilots can be trained to use the system in 12 hours, and instructors can design exercises or introduce dynamic weather patterns in a matter of minutes.

Total Control offers unparalleled realism and graphic fidelity supported by a 3D engine, with sophisticated, real-world simulation.

Our specialist team are experienced in identifying our client’s needs, and we’ll work with you to ensure we provide the best, and most cost-effective solution to provide you with higher training success rates at a lower cost.

Our Total Control team are available to provide additional advice on simulator purchases, and to discuss your requirements today.

We offer scalable, flexible options, including tablet, desktop, LCD, 180°, and full 360° simulators.
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