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GFA Simulation Project

Report to the Board of the GFA

The State of the Art Report - 2016

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Executive Summary

In Australia, we are at an exciting junction of bringing modern training technology and technique to the world of gliding. Through their own dedication, quite a few clubs have built fully functional simulators. However, they don't get the attention that they deserve due to missing support from the general gliding community - simply because they have outrun the rest of our community. We need to catch up.

In the aviation world, the use of artificial environments for flight training has been accepted practice for many decades in both military and civilian circles. Gliding, as a recreational sport, often has an overlap of commercial and military pilots involved and this has resulted in many individual projects to bring their professional experience into the gliding world. As a result, ad-hoc installations are used, and formal support from the gliding community is not yet available. What has become clear is that the physical part of the integration - construction, even on a mass-scale - is effectively solved at this point in time. The remaining challenge is dealing with people - some operational, and plenty of dismissive attitudes. With some thoughtful guidance at the national level and some minor rules tweaking, simulation can become a first class companion in our training practices, with many positive benefits.

- Introduction
  - Background
    - What is covered
    - What is not covered
  - Simulation vs Simulators
- Current Practice
  - Current Construction Trends
    - Fixed and Mobile Construction
    - Software Used
    - One Seat versus Two
  - Current Usage
  - International Trends
    - Australian Air Force Cadets
    - UK
    - India
    - USA
    - Chile
    - OSTIV
- Operational Assessment
  - Impacts and issues
  - Existing CASA frameworks around simulation
  - GFA Operational Issues
    - GFA Operational Regulations
    - MOSP Part 2 - Operations
      - The Ground Supervisor Rating
      - Currency Management
      - Logbook Time Tracking
    - Instructors Handbook
  - Dealing with People
    - Reactivating Retired Instructors

Wanting to Fly, Not Instruct

Simulation isn't Real Flying

Unsupervised Training Causes Problems

Positive Impacts of Having Simulators in Clubs

Helping Retain Members Both Old and New

Additional Introductory Flight Takeup

Mechanical Assessment

Types Of Simulators

Desktop PC Simulator

Basic Cockpit Simulator

Realistic Full Cockpit Simulator

Requirements for Effective Training

How Many Screens are Enough?

Fool me once....

Commercial Support For Gliding Simulators

Hardware Manufacturing

Software Options

Condor

Silent Wings

X-Plane

Prepar3D

Recommendations

Support Recommendations

Training Recommendations

Simulator Recommendations

Open Questions

References

Appendix A - Cost Estimations

Simulator Equipment

Desktop PC Simulator

Simple Simulator

Full Cockpit, two seater sim

Training Syllabus

Syllabus Development

Scenario Development

Scenery Development

Appendix B - Marketing Simulators

Construction Options

Building for Mobility

Building for Entertainment

Costing

Introduction

Background

Simulation, as a method of training pilots has been around almost as long as pilots. Documented history show various forms of simulators being used as far back as 1910[1]. In the military and commercial aviation world, simulators are even an expected part of standard training. Hours spent in the simulator are used in whole, or in part of the certification process for any new type of aircraft and count towards logbook hours on type. The value of simulation in flight training is considered great enough that in 2012 CASA mandated that simulator time is required for flight training in most categories beyond general aviation[2]. So widespread is the use of simulators, that a visit to almost any private flying school that offers Instrument ratings will find at least a simple instrument/procedural trainer available in the office for use.

With pervasive use of simulators at the General Aviation level, and so many glider pilots being commercial or ex-military pilots, it is thus somewhat perplexing that simulators are not more widespread within our community. Indeed, they are popping up sporadically - typically around the larger clubs that have a body of people interested in the subject. However, their use is ad-hoc, and the support for widespread use is not there either locally within the club's instructor panel, nor at the state or national levels.

In this report, we will examine the current field of gliding simulators and in particular look at what the GFA as a national body can do to encourage and support their usage so that they may become a first class component within our training system - putting us on equal footing with the rest of the general aviation world.

What is covered

Simulation is a big topic that can cover many different forms. To give it complete justice would require many volumes of writing. In order to limit the scope of the report, the topics will be limited to the following discussions:

- Simulators specific to gliding, or have gliding capabilities
- Training Objectives that can and cannot be usefully addressed with Simulators
- Impacts on clubs that have already built and used simulators - particularly the positive aspects
- Simulator options to support training objectives
- Issues and concepts on how simulators interact with the legalities of being a CASA delegate

What is not covered

On the opposite side of the coin, there are many areas that we will not address:

- Simulators that have marketing uses only. Only considering clubs and training. Where a simulator may have a dual use purpose, such as a high traffic club with many trial passengers, this is considered as part of the simulator options available. (a discussion of marketing only simulators can be found in Appendix B)
- Market assessment of how many new pilots would simulation attract, nor how many existing pilots would be retained that might have otherwise left the sport.
- Specific simulator mechanical and computer configuration recommendations

- Recommendations for the AAFC system - even though the two research projects are working in tandem and sharing information and research

Simulation vs Simulators

In practice, often the word simulators and simulation are used interchangeably. For the purposes of this report, we make a distinct difference. Simulation is a means of creating an artificial environment to practice something. We do this often today in our normal training without the need to involve computers - such as when an instructor pulls the rope release at a low level to simulate a rope break during ab-initio training. In the context of this report, simulation is about the use of computer-aided training that does not involve sitting in a real glider involved in actual flight.

Simulators are the physical construct in which we might perform simulation of flight. While this might be as simple as some dice rolling and a set of cards, again we will limit ourselves to systems that involve the use of a computer with gliding-specific software installed, that the student is controlling.

Current Practice

Around the world, simulation is in much the same state as here in Australia. There are islands of individuals or clubs making use of simulators and/or simulation in training. The one standout exception to this is the French, where a national program has integrated simulation into the syllabus and provided a scheme to supply a standardised simulator to all clubs. Leaving aside the French system for now, the rest of the current practice is all at a similar level of technical competence and operational use and will be outlined next.

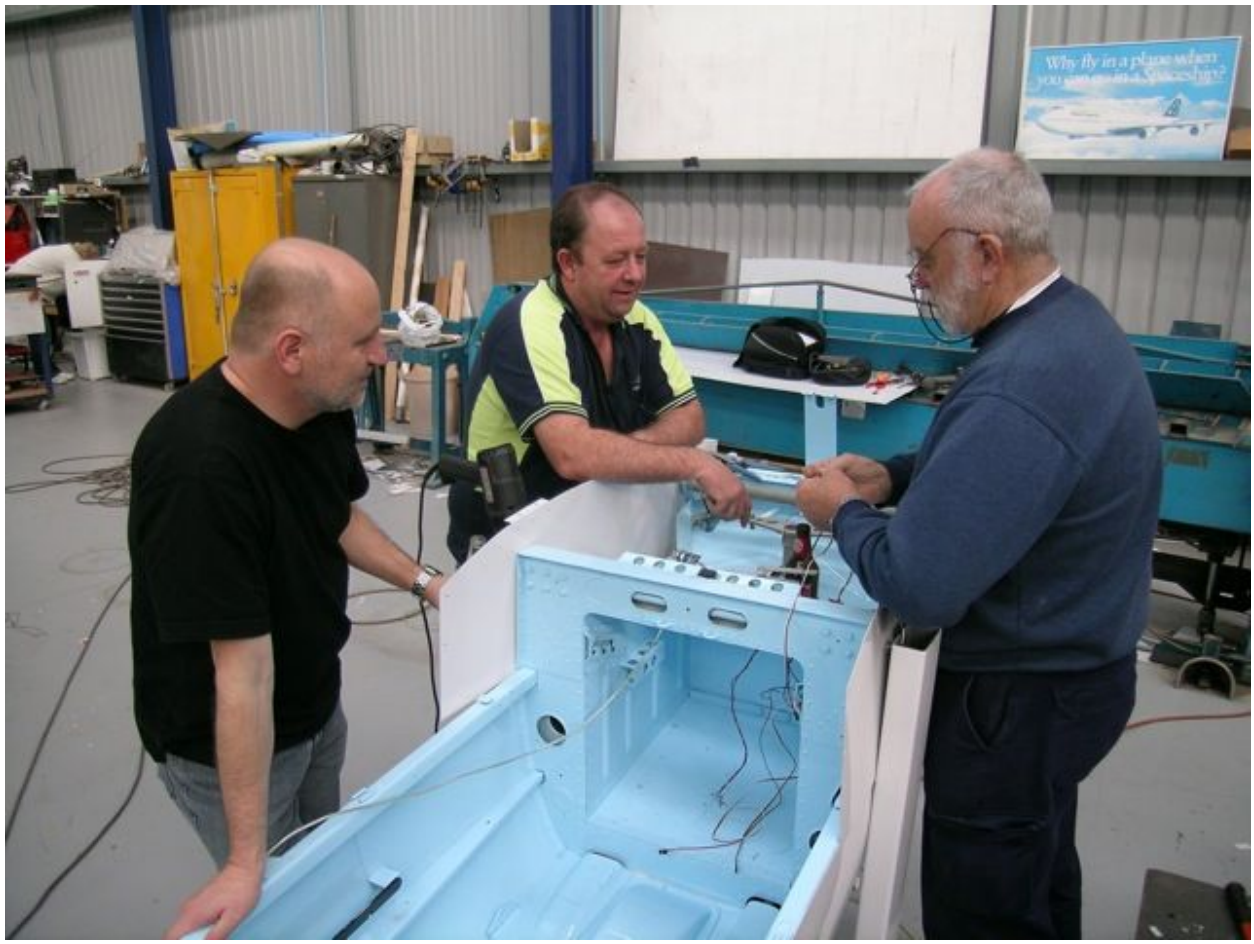
Current Construction Trends

As can be expected for an early-stage industry, simulators that do exist are all individually constructed. The quality of the construction generally depends on the skills of the individuals in each project, and their source materials.

Fixed and Mobile Construction

In Australia, both forms of simulators have been constructed. For those that are mobile, the reasons vary quite a lot. Marketing uses are not the sole driver of making a simulator mobile. In the case of the SoarAbility simulator, it was made mobile to allow potential handicapped students to try it out first since it is easier to take a simulator to the student than the other way around. The others that were made mobile were done so for ease of transport to move between clubs and private usage. However, what has resulted is that the mobile simulators have effectively become marketing tools rather than training tools. The reason for use in marketing is obvious, but why they haven't been used for training is less so.

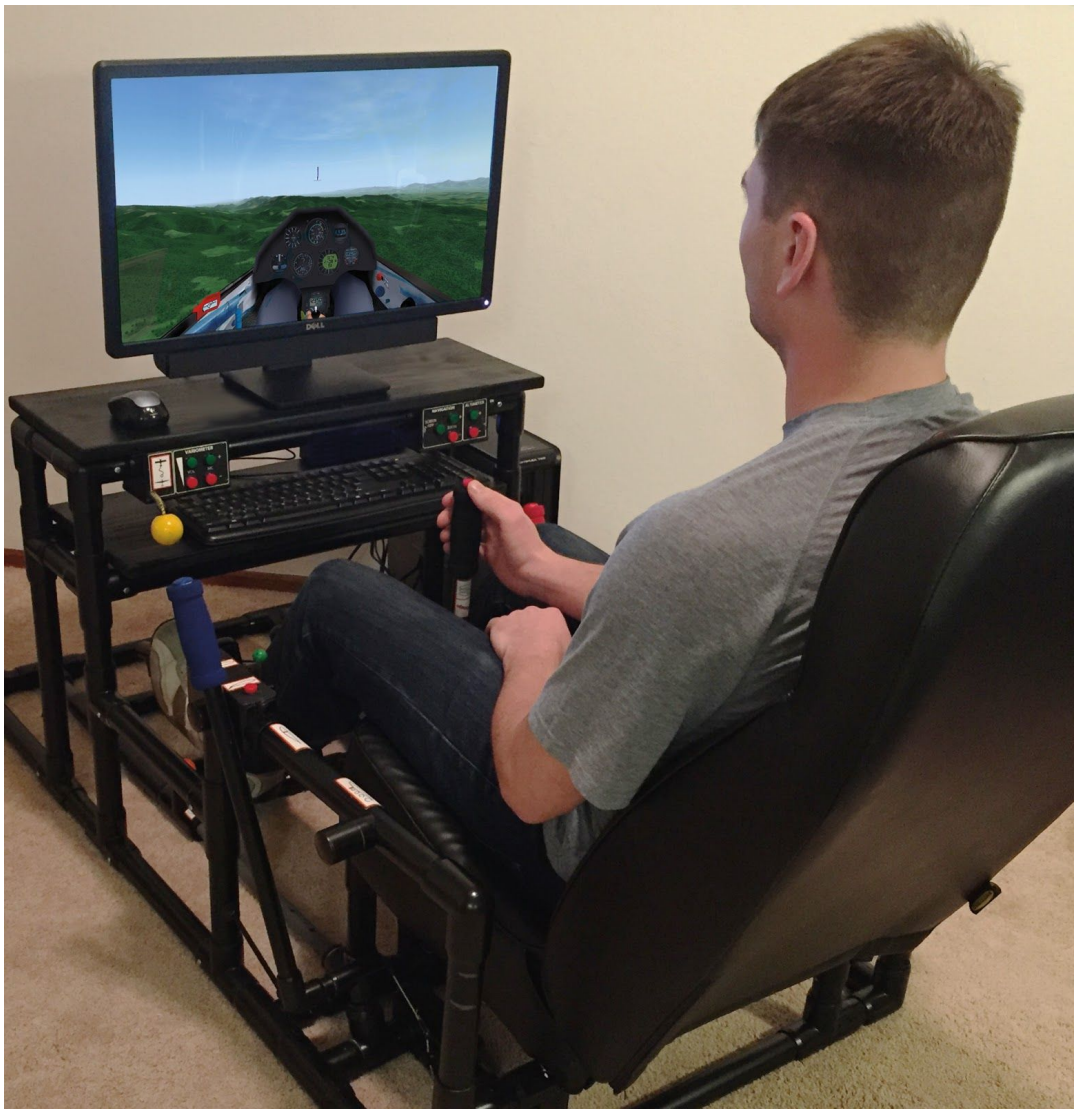
When fixed simulators have been constructed, they have all followed a similar pattern: A source cockpit is found from a wrecked aircraft, a suitable corner of a clubhouse or hangar is found and then construction begins. After a lot of trial and error, and consultation with other groups, a simulator is produced that mostly replicates an existing aircraft. In all the fixed instances, it is interesting to note that they have elected to use multiple screens in a wrap-around layout, though a couple in the UK have stayed with just a single screen. Another common element is that they have all elected to use speakers for audio - since audio is such an important and implicit part of the gliding experience.



People love projects that have a personal interest. Several members of GCV at Benalla discussing build strategies for a simulator based on an IS-28 fuselage

At the far end of the fixed options is the desktop PC. This is no different to your typical gaming setup - a highend PC is purchased, along with a joystick and (usually) rudder pedals, and placed on an office desk with a normal office chair used to sit in. Headphones or speakers are used to provide audio. It is unusual to see this configuration provided at a club or other shared environment. You are more likely to find this at home where an individual pilot has an already existing PC to work with.

What is interesting to note is that the simulators don't have a middle ground: either a full lifelike cockpit is used, or it's an office chair and desk with a PC. No intermediate systems that provide a reclined seat with centrally mounted joystick and instruments are found around the clubs. Several reasons probably exist for this, but the most common one is that the simulators have all been constructed by people that want a project, or have been involved in simulation outside of gliding without assessment of the actual needs of the training scenarios to be taught. That is, coolness factor has greatly outweighed the practicality aspects. A setup such as the commercial offering[4] pictured below isn't as attractive, despite being as effective as a realistic cockpit in the training scenario, simply because there's no construction to be done. Simply unpack the box, plug it in and hey presto - Instant Simulator. Like many sports, gliding exists because the members enjoy it, so a simple plug and play device doesn't gain any real following. When considering options, the personal involvement should be considered strongly. We are a volunteer-based community sport and things don't get done unless the community has some vested interest.



An example of the commercial Mach 0.1 simulator in action

Software Used

For gliders, there is a very limited range of software available. The 4 major options are:

- Condor
- Silent Wings
- X-Plane
- Prepar3D

Microsoft's Flight Simulator also supports a gliding option, but is considered so bad that nobody has considered using it in a simulator.

Of the above four options, the first two are dedicated glider simulations and cannot be used for any other type of flight. The later two are capable of being used for powered flight as well, and used extensively in General Aviation, Commercial and Military industries. In particular X-Plane is used in a number of CASA Certified simulators that are used around Australia and elsewhere.

The particular software being used on any given simulator doesn't have any pattern, other than one item of note: Many builders started with Condor as they have used it on desktops at home, so continue with it when building the simulator. If the simulator uses more than a single screen, then

Condor cannot be used, so typically one of the other packages are then used. Detailed discussions on the software options can be found later in this document.

One Seat versus Two

When looking at the simulation options, the option of a single versus two seats is mostly split along the marketing lines. Where a simulator mostly has a marketing use, then a single seat is used. When the simulator has two seats, then it is primarily used for training. Looking at this a different way - it is easier (smaller, lighter) to move around a single seat cockpit on a trailer, than a two seater.

It is interesting to note that the simulator constructors have individually converged on providing two seat cockpits for training purposes without any formal guidance in that direction. Of further interest is that this also mirrors the French syllabus guideline that training in a simulator should be just the same as a real aircraft - two seats with the instructor sitting in the back - though often with additional controls for the software that a normal glider would not have. While this makes sense when the simulator is used for instructor training where the instructor has to sit in the back and work through training pater like in a real flight, for ab-initio it is more interesting. The general consensus is that with the instructor sitting in the aircraft with the student, they can see what the student is seeing like normal training, so don't need to adjust the way they teach moving between real and simulated aircraft.

Current Usage

Without exception, a common picture of simulator usage within Australia, is that of an ad-hoc environment. Simulators have been constructed first, and then thought put into how they are to be used - many times without input from the instructor panel of the local clubs. There is typically some overlap in that some members of the build team may be an instructor, however, the panel, or the local RTO/Ops has not had any influence on the system and how it is used.

While trials of the simulators have been conducted with Level 1 and Level 2 instructor training, usage of the simulators in more general purpose situations, such as ab-initio or remedial training has been based on the instructor initiating the usage. Clubs have not put any thought into developing a standardised syllabus or packaged scenarios that allows any instructor, or student, to work through a systematic training regime. As a result, takeup is sporadic - sometimes simulators sit for months with no use. Just pointing a student at a sim, with no formal guidance will result in it being treated as a toy, and all effective value is lost. One anecdote passed on that illustrates this was that from an Air Cadet instructor that had been given a previous generation of simulator. The cadets had a "Friday Night Flight Night" on the start of a camp and let loose on the sim with no guidance. As it only contained a simple joystick with no feedback, they treated it like a game, with no regard to training. This then carried over into their mid-week flying training camp the following week.

Separately, there is significant resistance to the use of simulators within the instructor community. Despite overwhelming evidence from almost every other area of the aviation community for decades, many feel that simulators are worthless, and the only true way to train a pilot is in the air. Typically this comes from the elderly members of the instructor group - those that are naturally resistant to change and new technology. As an adjunct to this feeling, another is that many instructors typically are so due to limited financial means (such as retirement). Instructing is the only flying they are able to do, so by having some or most of the training moved to a simulator, they feel that their flying will be greatly reduced. While this should not be a reason why someone is instructing, it is an opinion expressed regularly in many sites. There is a valid concern here however, in that a side effect of that is

maintaining currency, since GFA Ops Regs require instructors to be instructing every 30 days to maintain currency.

International Trends

Internationally the movement around incorporating simulators into the training system is somewhat mirroring that happening here in Australia, although lagging behind in the formality. As a general statement, there seems to be individual simulator projects in most countries that have significant gliding populations, but no move to formalise them, beyond the French.

Australian Air Force Cadets

In parallel with our work in the GFA, the cadet branch is also exploring the use of simulators in training. Being military, they already have extensive simulator capabilities for full time professional members. Given their extensive experience and trust in the use of simulators, they are looking to introduce a simulator to the cadet branch, though the desire is to possibly have a dual function simulator that is capable of both glider and light aircraft simulation.

UK

An extensive list of clubs are using simulators. Direct contact has been established with two clubs (Lanchishire & Derbyshire, and Yorkshire), and extensive web searching has revealed at least 3 other clubs discuss simulators on their websites (Booker, Black Mountain and Cambridge), though details are unknown currently.

In addition to the clubs, the RAF Cadets have an extensive simulator system in place[5]. This simulator is a more general purpose simulator capable of both powered and unpowered flight, and will be similar in nature to what the Australian RAAF Cadets will be investigating.

India

Mention has been found on official websites of the use of simulators for their air cadet branch[6]. At this time, no details can be found.

USA

Due to the different style of training and integration within the aviation system in the USA, simulators don't appear to have gained any traction at all - even at the individual or club level. However, what has been quite a surprise is that there is a large following of instructors and their trainees using desktop-based training with Condor. This started with an instructor named Scott Manley back in about 2010 and has slowly spread through other instructors in the USA. Often conducted *completely remotely* using tools like webcams, many students have gone through this system of training. Based on discussions with Scott and others, there appears to be no loss in quality of the students skills relative to traditional methods, or other simulator-based training systems.

Chile

At least one individual simulator has been constructed in Chile. This came from some experience by the builder with the Benalla-based group, and has continued on since then. No further details are available at this time.

OSTIV

As news of the Australian research into simulation-based training spread, we were contacted by the OSTIV Training and Safety Panel and invited to provide additional input. They have been recently preparing some questionnaires to send out to member countries to establish a current baseline and begin work on recommendations about the use of simulators. This is expected to be a bi-directional partnership where they will observe our progress and use it to inform their recommendation making, as well as gaining us additional contacts and sources of knowledge from other countries that we have not yet researched.

Operational Assessment

Impacts and issues

In the previous sections we outlined the current state of the art of simulation usage in gliding. In the following two sections we discuss a collection of issues that have come up, and look at potential problem spots that need to be addressed. Mechanically we can consider that Simulation is a solved problem and we just need to answer some policy issues. There are, however, quite a range of open operational areas that need to be brought into the open for discussion and resolution in order to smooth the way for further acceptance.

Existing CASA frameworks around simulation

With CASA supporting and mandating that simulators be used for many areas of general and commercial aviation training, it should not be a surprise that they have a large section of rules devoted to simulators. GFA, as a delegated body, should be aware of the existing rules within CASA and ensure that we either don't run afoul of them, and/or we seek exemptions from them to ensure that our simulation plans can be fulfilled.

Under *CASR 1998*, Part 60 regulates how simulators are to be used and maintained - based on ICAO Document 9625[7]. Sections are devoted to both the use of simulators and the construction and maintenance of them. Of particular interest is the section devoted to certification. Why is this important? Certified simulators can be used in a number of ways that uncertified simulators cannot. The primary area of interest to us in this discussion is the intersection of the use of simulators with anything to do with logbooks - currency, ratings/endorsements and so on. A non-certified simulator cannot be have official time recorded in the pilot's logbook, so if an instructor is spending time training students on a simulator, these hours can not be counted for maintaining currency.

Currency requirements have a related issue with insurance - if a pilot gets a discount on the insurance for having X number of hours, then time in training on a simulator will not count, even if their proficiency is higher than a pilot that has not used simulators.

Arguments can be made for either direction in certification. Under the CASA rules, there is a significant financial burden as simulators need to be recertified every 6-12 months. A small club would not be able to justify this cost - let alone getting a CASA-certified examiner to travel to a distant country location to check on the simulator. That said, in the GA world, there are a lot of relatively simple sims that are barely above the desktop PC that are certified by CASA, particularly for IFR training, so we may be able to leverage that experience into the gliding world.

GFA Operational Issues

Training and instruction under the GFA is maintained through several different documents.

- GFA Operational Regulations (OPS 0001)
- Manual Of Standard Procedures Part 2, Operations (OPS 0002)
- Instructors Handbook - Parts 1 and 2 (OPS 0006a and OPS 0006b)

In the following sections, each document will be looked at for issues and modifications that will arise due to the introduction of computer-based simulation training.

GFA Operational Regulations

The GFA Operational Regulations document (OPS 0001) defines the levels and minimum requirements for instructors but does not define how the training is to be conducted or the ratings maintained (Section 3.4). As such we see no need to suggest any modifications to this document.

MOSP Part 2 - Operations

All aspects of how instruction is to be run, and instructors managed fall under this part. In examining the details of the regulations, we feel there are a number of impediments to making simulators first class citizens in our training regime. The primary area of concern is the instructor requirements to gain and maintain a rating.

The Ground Supervisor Rating

Section 11.5 defines a Ground Supervisory Instructor rating. The goal appears to be to keep old instructors in the system, but what they are supposed to be capable of is unclear. The statement is that the position is to assist with the club's operations, without giving much details. Beyond in-flight instruction, there is very few other operational items for this instructor to manage. In fact, in talking with local instructors, they were not even aware that this rating existed. This rating would be the best target for a simulation instructor, with the goal of keeping potentially retiring (medical or otherwise) instructors in the system. With some modification, this rating would be very useful for simulation instructors.

- The current wording requires that it be for ex L2 instructors. Simulator training should be available to L1 instructors as well as coaches, depending on needs
- It is unclear whether this rating is part of the "Active Instructor Report" that a CFI needs to maintain. If a simulator is being used for training ab-initio pilots, then it would be advisable that these instructors are also included in the active report
- However, active instructors must have a valid aviation medical. Many of the reasons for being a ground-only (simulator-only) instructor is that they are medically unfit to fly, but mentally still capable of training students or assessing pilots for competency. So modify the active instructor section to list what ratings qualify and place the medical certificate in the specific ratings that require it.

If it is desired to keep the Ground Supervisor rating as-is, then an additional simulator-only instructor rating can be created. Using the suggested modifications for the Ground Supervisor rating above, should give a reasonable base to work from. While it is possible that the rating is used for existing instructors to "retire" to, the GFA should also consider whether it would useful to train up new instructors that are only qualified to teach on simulators first, before moving onto real aircraft. Since a pilot cannot go solo on simulator time alone, then training instructors to first teach on simulators

before then “advancing” to teaching in real aircraft will help them refine their technique in a less high-pressure environment. It will also give the club’s CFI/Instructor Panel more confidence in whether to advance an instructor to a higher level of rating as they can be observed instructing someone else in this situation - something that cannot be done currently.

Currency Management

Currency requirements for ratings is also an issue. If an instructor decides to work with students in the simulator, then this should count for staying current. However, this opens up the can of worms with recording hours in the logbook based on the simulator time - as this is the official record of the pilot’s flying time. In order to record hours, the simulator must be certified by CASA - which is something we probably want to avoid. Why is this a problem?

Imagine the following scenario: An instructor has taught some flying in an aircraft on day 1. On day 29 they do some training only in a non-CASA certified simulator with a student. On day 35 the instructor is back in a real aircraft, and has an incident that requires reporting. Upon investigation, CASA would find that the instructor was non current as per our Ops Regs, resulting in them, and possibly the club, being open to legal action - including voiding any insurance coverage.

One option for dealing with this is seeing if we can get another exemption to CASA’s Part 60 requirements for gliding simulators, or getting a blanket accreditation of known gliding software. Either might be difficult, but if we can come up with something to satisfy CASA, and thus legal issues surrounding hours tracking, then the GFA’s requirements are some relatively minor adjustment in wording.

Logbook Time Tracking

In CASA logbooks a separate section is used for simulator time - something that our simpler GFA logbooks don’t have. Simulation time is tracked independently of other times, as per CASA’s guidance[8]. Separate tracking of simulator time would be a little more challenging in current GFA log books, though with a little thought we can make do. The important takeaway is that CASA do treat simulation time as a separate trackable entity, but it does count officially for various ratings. We should adopt a matching approach at the GFA level - including modifying our Ops Regs as needed to address the above concerns.

Instructors Handbook

This is the core guide that an instructor uses to train a student, and used to train the instructor. In Part 1, the section on Methods of Gliding Instruction does not include any mention of the use of simulation as part of the training. However, simulation is used in various parts of training today - whether that be using wooden aircraft models, or walkthroughs on the grass outside the piecart, simulation is already an important part of the instructor’s toolkit.

To bring computer-based simulation into acceptable use, sections must be devoted to it in the handbook. Guidance should be provided about when simulation is a useful exercise, and when it is too much. Focus should be placed on effective use, and when the instructor should step away from the computer and take to the air again to reinforce lessons learnt in the virtual environment.

Additional areas can focus on simulator-specific techniques - both for teaching ab-initio pilots and for training an instructor. Without getting into specific techniques, when this manual is revised, the GFA team should call on the extensive membership resources available. There are currently quite a few professional simulator instructors within the rank and file GFA membership who can be used to help

develop useful guidance. Additionally calling in non-instructors, but those who teach professionally (high-school, university etc) will help ensure useful guidance is given to instructor.

The manual, however, should stay away from being a handbook about how to start up the simulator software, load scenarios etc. Separate documentation should be developed for this.

Dealing with People

Previous sections have dealt with topics that are quite concrete in nature - rules, regulations and so forth can be easily changed as they are just words in a document. The difficult part in any process change is the soft part of dealing with actual people that have to adapt to the changing environment.

Reactivating Retired Instructors

As the gliding population ages, many instructors are having to give up their ratings due to inability to pass the medical requirements. With the previously mentioned changes to the Ops Regs, many of these instructors may be available to continue helping train the next generation. Of this group, we first assume we are only working with those that would like to continue training, but cannot. No point trying to force reluctant instructors into something they have no interest in.

For this to work, significant hurdles need to be overcome

- Medical retirement also implies that the instructor's ability to get to the airfield in the first place will be a problem. With the exception of the few city-based clubs, most instructors travel distances at least several hours to their clubs.
- Older people also tend to be less able to adapt to new technology. Operating simulators will require a reasonable level of technical competency in order to start, select and load scenarios

Wanting to Fly, Not Instruct

As with any volunteer group, the members are there because they enjoy the activity. For gliding, that is mostly the flying part. Instructors volunteer because they enjoy not only teaching others to fly, but because it puts them in an aircraft in the air. To teach others on the ground means that one of the major reasons they are there is no longer available.

A similar statement can be made about students interested in learning to fly. However, this can be easily addressed as part of the training package. When they sign up with the club, ensure that they understand that some amount of training is performed in the virtual environment. Several UK clubs include this in the sales material for their courses and this has not seemingly had an impact on attracting students. If anything, anecdotal evidence suggests this helps retain students as it means they can plan their flying schedules regardless of the weather. Generally speaking Australian clubs don't have as many unflyable days as UK, European and Northern American clubs, but the basic pitch to students can still be made.

Simulation isn't Real Flying

Another standard response, particularly from the instructors has been that "simulators aren't real flying". This is correct - simulators, by their nature are an approximation of the real thing. However, that approximation can be used to our advantage, rather than disadvantage. For this group, we will need to emphasise how the simulator will let them work through many scenarios that are not available in the real aircraft - classic low altitude spin into the ground, many rope break scenarios etc.

A simulator can still be used to teach the basics of flying - coordinated turns, takeoffs, landings etc, with each phase of the flying individually taught and mastered, before heading to a real aircraft when the components can be brought together to cement the earlier training.

Unsupervised Training Causes Problems

In the use of simulators, there's a general feeling that if you let the student also train at home then they will train in bad habits. The situation is that it happens now anyway. Ask around any gliding club, and you'll find a significant portion of the members are already flying one of the simulators at home anyway.

Rather than deny the reality of the situation, we should seek to embrace it and use it to our advantage. With a properly constructed curriculum, and the available exercises provided from the GFA website, an instructor can work with their student and give them exercises to work on at home so that the next time the student is at the club facilities, the instructor of the day can assess and correct any deficiencies that have crept in. Along with this, some guidelines of reasonable equipment should be provided to prospective students that wish to study at home in order to make the most effective use of their time.

Positive Impacts of Having Simulators in Clubs

In the UK, several clubs have made simulators a core part of their training regime, even without official support from the BGA. For much of the year in the UK, the weather is unflyable, so simulators fill a vital gap in their training regime, as well as the club atmosphere.

Helping Retain Members Both Old and New

When simulators are available, anecdotal evidence from the clubs has shown an increased retention of membership during the winter months. Pilots can come to the club, hang out with other members and still have a fly in the simulator. Organised sessions, similar to our winter Skills Nights that are held around Australia, focus on demonstrating or practicing skills that ready the pilot for the summer. Even in bad weather, a simulator is always available. Rainy days just mean focusing on specific skills rather than on more general flying.

For students, simulators have an added bonus: schedulable time. Many just learning gliding have not yet adapted to our relatively laid-back whole day activities. Particularly for young kids that are often engaged in team sports or other activities with friends they don't have the time or inclination to devote to a whole day, at least not in the early stages. Having a simulator available that they can book ahead of time for a fixed period has helped retain more young members, and even the older ones just starting. Since they can continue to train even when the weather is unflyable, the regularity helps to retain new members past that critical first 12 months. Figures have not yet been requested to confirm the anecdotal evidence, however two independent discussions with clubs both mentioned the same observation so the truth would be worth exploring.

Additional Introductory Flight Takeup

Another anecdotal item to come from discussions with UK clubs is how they believe it positively affects the image of the sport with the trial flights. One club, in particular uses their simulator to target the friends of someone engaging in a real introductory flight. Specifically they look for the friends or family that come out with the interested person and see if they would be interested in a flight. For those that are not interested due to some element of fear (particularly seeing a winch launch from the ground for the first time), they are offered a ride in the simulator. More often than

not, this experience from the simulator encourages them to try a flight in a real glider. Since the simulator is on the ground, the fearful person feels much more comfortable that it won't "fall out of the sky", overcoming that initial fear.

It is for this reason that, while it can be argued that a full cockpit simulator is not needed for effective training, the marketing impact of having a nice shiny-looking realistic aircraft can bring great positive impact to member acquisition into our sport.

Mechanical Assessment

Types Of Simulators

Generally speaking, simulators can be grouped into three categories:

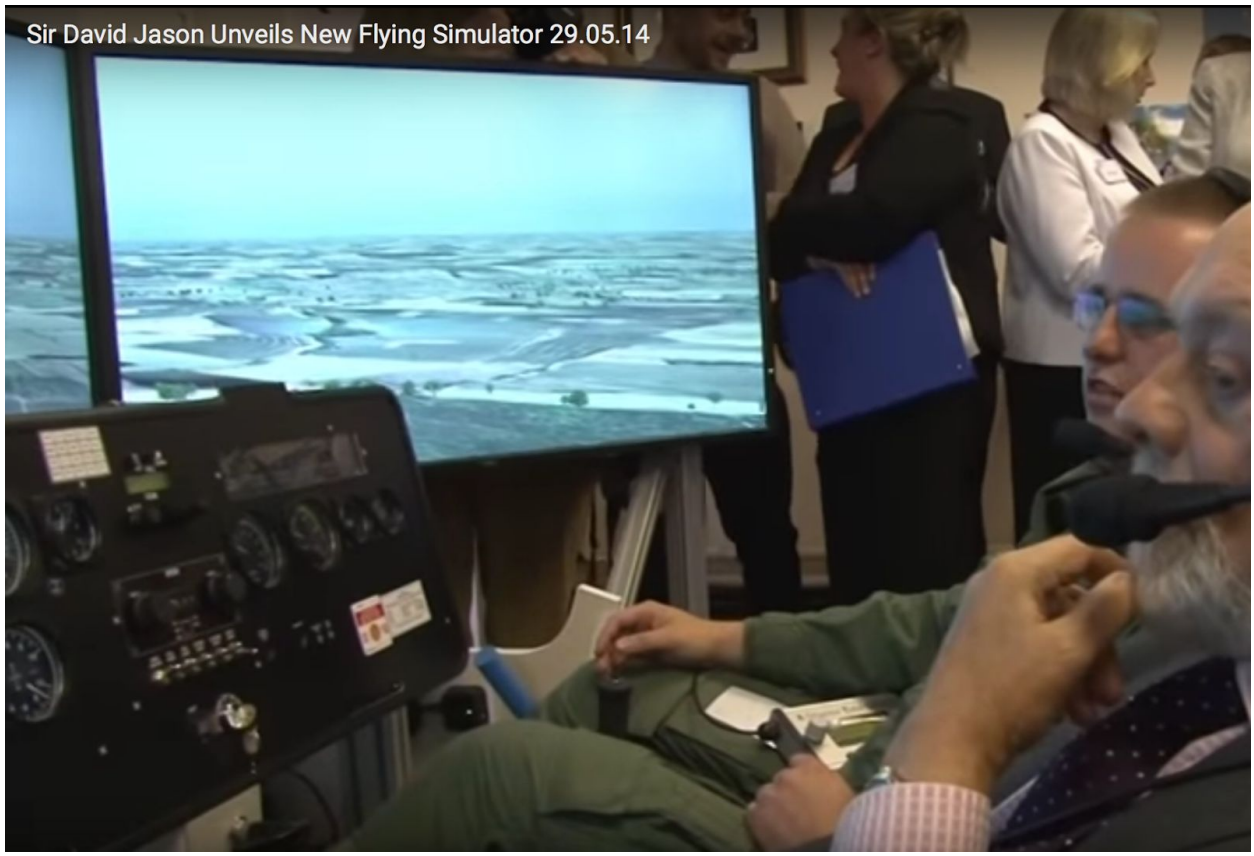
- Desktop PC
- Basic Cockpit
- Realistic full cockpit

Desktop PC Simulator

The most common form of simulator in Australia - the typical office or home computer PC, typically includes a basic joystick. Some users may also have rudder pedals as well, but not guaranteed. Most gliding simulator software includes either automatic rudder coordination or the use of keyboard or alternative joystick input to manage yaw during flight. Even where a club may have a more advanced simulator, individuals in a club will most likely have this at home. Rarely found within the club itself (eg at the club house, hangar or separate training facility). Recently the use of consumer-grade head-mounted displays has become of interest to this market, though penetration is still small.

Basic Cockpit Simulator

In this setup, a simulator is constructed that takes the basic desktop PC as shown above, but places the pilot in a more natural setting. Typically flight controls are located in the rough location that a real aircraft would have - control column between the legs, real rudder pedals, semi-reclined seat and airbrakes, trim, undercarriage etc to the side. A single screen is placed in front of the pilot, though occasionally a multiple-screen setup can be found. It is rare to find one of these at home, and not particularly popular in the club environment as the marketing/geek draw of constructing a full cockpit simulator is very high.



Screenshot from a YouTube video of the launch of the RAF's gliding simulator. Basic construction based on a G109 cockpit, with 3 screens

Realistic Full Cockpit Simulator

A simulator is constructed using a cockpit from a glider, typically cut from a wreck or life-expired fuselage. Due to this, all the controls from the real aircraft are wired into sensors that then transfer the movement to the simulation software. Typically the cockpit is from a two-place glider, but occasionally a single place cockpit is used. Commercial-grade simulators may include a motion platform that will move the cockpit based on simulator output, but for the typical club-built simulator this will be omitted as the cost is far beyond the reach of clubs, and the usefulness is debatable. The use of single or multiple screens is evenly split.

Requirements for Effective Training

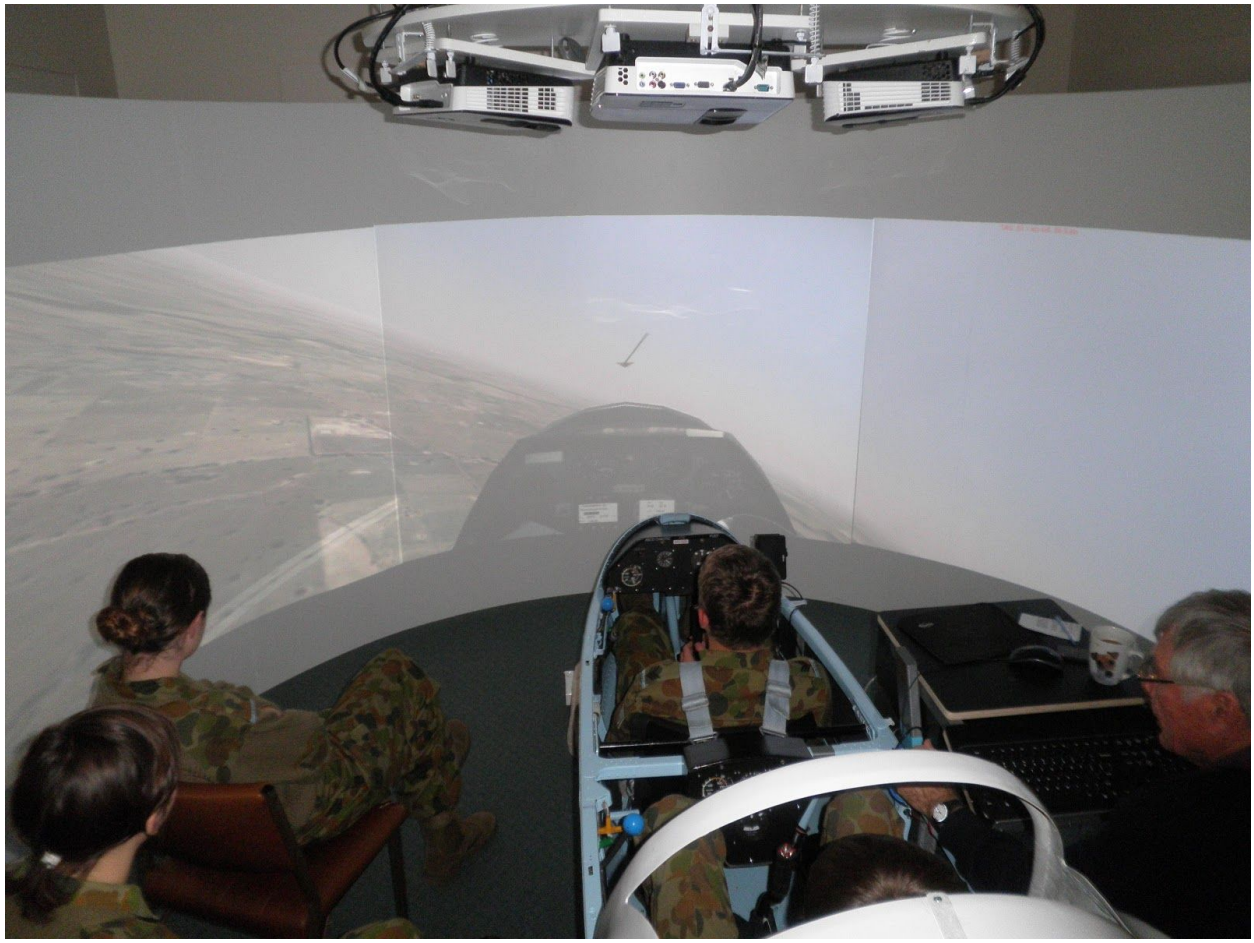
How Many Screens are Enough?

Regardless of the type of simulator used, a constant discussion point revolves around how big the screen should be for the display of the outside world. Roughly speaking, the camps are divided between a single screen placed in the centre view of the pilot and enough screens to surround the pilot.

Single screen setups are much simpler to install and use as this is the typical home computer setup. For those in favour of this approach, the argument is that the simulator is for teaching the basics, particularly the procedural elements. Actions that require the turning of the pilot's head to look out to the side of the aircraft can be trained separately later with the real aircraft. Proxy motions in the simulator, such as using a keyboard shortcut to look to the side, or head tracker (eg NaturalPoint's

TrackIR system) ensure that the user does actually look, but the motions are not full physical motions. Debate exists about whether this transfers readily from small screen to big world without retraining, and should be an item for future investigation.

For those that have the room and the additional budget, the concept of lookout and scanning is addressed by adding more screens. In a typical system that can be run by an average screen, three screens are used in a horizontal layout, like the below photo of the setup at Benalla. In typical installations, three projectors are used and the visual field of view is at least 180 degrees. Where the software supports it, the two side screens can be moved to be perpendicular to the front screen resulting in full natural field of view coverage of 210 degrees or more depending on screen versus pilot placement.



The Benalla simulator in use - complete with audience

Recently Virtual Reality (VR) headsets have again hit the popular press with products like the HTC Vive and Occulus Rift. The headsets fully cover the eyes and, with head tracking, will follow wherever you look - eliminating the need for screens entirely. While suitable for single pilot training, in a two seater they are not effective. Because the headset completely masks your outside view of the world, the instructor cannot tell what or where the pilot is looking, nor can either participant see where physical objects like the controls are located. There are workarounds for this, but they involve far more expensive systems that also involve hand and body tracking so that your hands can be projected into the view of the headset, allowing for reasonable coordination. At this point in time, VR headsets are not considered to be good tools to use in a training simulator.

The midpoint that solves both of these problems is the concept of Augmented or Mixed Reality (AR/MR). In this setup, the wearer still sees the outside world, but has computer generated imagery

overlaid. Some systems are starting to come near the consumer grade pricepoints, such as Microsoft's HoloLens, but it still requires quite precise setup and calibration, as well as software custom written for it - rather than the existing off the shelf simulation apps. At this point AR headsets are not considered practical for simulators. Perhaps in 5 years or so the maturity will be good enough for mass market usage, and thus in non-technical club usage environments.

Fool me once….

When training anyone with any form of simulator, the key component to effectiveness is immersion. The body is capable of being tricked into believing things are happening that are not really happening at all. In gliding simulators, the two primary keys to training effectiveness are visual and aural.

Gliding primarily relies on seeing the pitch of the glider on the horizon (as well as assessing terrain, clouds etc), and audio cues are used to determine speed and for flight indicators such as the vario. Advanced pilots will also talk about the seat of the pants flying - feel - the small nudges on your backside as the glider goes through rising and sinking air. However, with effective visuals, you can trick the body into believing it is feeling those sensations without actually having to physically create them. The key to doing this is to not allow the body to experience anything other than the visuals of the screen and the audio. To keep the focus on the screen, all other distractions must be removed. That means no-one else in the room with the pilot and instructor, and, for added benefit, ensuring that there is no lighting other than the screen(s) that the simulation software is projecting on to. Any form of other light, such as gaps in curtains, and even lights off the PC can break the immersion. The earlier photo of the Benalla sim with several observers sitting next to the cockpit in a partially lit room is a good example of what not to do when training pilots.

On a related note, most simulator groups have commented about the need for some amount of physical feedback in the controls. With zero feedback students tend to over control as aerodynamic effects are not felt. Several commercial software packages provide this when using commercial joysticks, but if using a full cockpit sim that does not use a computer joystick then other mechanisms need to be incorporated.

Commercial Support For Gliding Simulators

Hardware Manufacturing

Despite the French experiment, there are no commercial vendors offering full cockpits, and only one that offers a limited basic cockpit. If bulk purchase is desired, the GFA will need to organise with local members to build a limited run. While it would be possible to continue along the existing path of just building new simulators as wrecks can be sourced, the merits will need to be debated before setting on a path forward.

With DIY simulator construction, each simulator is locally built from available parts - both airframe and computer display systems. This is limited by the budget available to the local builders. With DIY, the airframe is locally sourced from a wreck, thus minimal cost. The interface devices for communicating control inputs to the computer system are not expensive, but quality components can be difficult to obtain. Cheap parts mean constant maintenance, thus end user's complaints and eventually decline in the use of the system. Displays are the most critical part for the user experience when actually flying, and are also the highest cost item. Typically quality is directly proportional to cost of the projection and computer hardware used.

Looking at the list of possible deployment locations for full cockpit simulators, most of the target sites already have a DIY simulator built. This would leave approximately 4 simulators to be constructed

(Brisbane, Sydney, Adelaide, Perth). Volume discounts on parts purchase would be minimal, nor would fabrication from cockpit moulds be much at much of a discount. That said, available fuselages from wrecks is minimal - unless clubs decide to sacrifice IS-28s rather than get them airworthy again.

In favour of bulk manufacturing is the consistent parts. From the long-term maintenance perspective, having a consistent bill of materials that everything was built from makes maintenance much simpler. Standard parts from suppliers allows for a small stock to be kept for eventual failures that need to be fixed. Similarly, training in the maintenance can be simplified rather than each location having a specialised knowledge.

One argument for bulk manufacturing is the ability to build something that is easier to maintain. For example, instead of a complete cockpit that has the floor all the way around, you could build a frame that the seats and controls sit in, and then place the simpler cockpit that only comes down to seat level over the top. Fixing broken wires or sensors is just a case of lifting the top off and having direct access to the controls - rather than pulling a seat pan and even instrument panel out.

Note that for the cadets, maintenance issues are expected to be less of a concern. This will be contracted out to one or more third parties, rather than maintaining in-house.

Software Options

Earlier in this document, four options for software were described. In this section, detailed analysis can be found. To recap, the options are:

1. Condor
2. Silent Wings
3. X-Plane
4. Prepar3D

Condor

Arguably the most well known of the gliding simulators, this simulator started life as a competition soaring package. Controls and facilities around the ground were quite minimal, and the ability to load canned scenarios was very limited and buggy. This feature is called Flight School and has improved over time, but is not considered a primary capability of the software.

Several useful features are available - direct force feedback, 3D sound, good modeling of stall and spin characteristics as well as other edge-of-the-envelope characteristics. Additionally it will support NMEA output so that trainee pilots can practice using various flight computers like XCSoar. On the negative side is that it only works on MS Windows platforms and with a single screen only. Support for various new VR Goggles is unknown. Several comments have been received that creating custom terrain packs is quite difficult. These comments can be tempered with the knowledge that quite a number of terrain sets have been developed by the community already. Development of the project is either non-existent or so slow as to be considered dead. Fixes and patches seem to only happen every few years. In fact, the original discussion of version 2 of the software dates back to 2006, with no sign of it anywhere.

As the most popular glider simulation software, the community forums are very busy - hundreds of posts a week is pretty normal. Community support for issues is high, even if support from the developers appears to be non-existent.

Silent Wings

Currently the most popular software amongst simulators that wish to use multiple screens. One advantage Silent Wings has over Condor is that it runs on all three major operating systems. For those that chose to have non MS-Windows machines at home, content and training developed for this package can easily be used for home-based training between visits to the instructor.

Features in Silent Wings are more adaptable to the training environment. Terrain and aircraft models, based on various reports, are easier to develop. However, support for the application seems to be close to gone. The community forums have zero traffic (last post 6 Feb 2016 at the time of writing - June 2016). Comparisons between Condor and Silent Wings are frequently made. The general feeling is that Silent Wings has a better aerodynamic model, while Condor has the better atmospheric model.

X-Plane

X-Plane is a generic flight simulator that is capable of both gliding and powered flight. It's main development focus has been on the powered flight. It is currently used in many certified flight simulators here in Australia, particularly procedural trainers in IFR flights. As such, commercial support and development is extremely high, leading to confidence that it will be around in the future. All three major operating systems are supported, as well as some simpler mobile apps (not that they will be much use for a gliding simulator...) As a modern, actively developed software package, the hardware requirements for the computer are also much greater than either of the dedicated soaring simulators.

Extending the package to cover additional glider types does not seem to be particularly challenging, nor is adding new terrain sections (It comes with a pre-built, whole globe terrain package if purchasing the commercial version). The only complaint given to the package is the atmospheric model is not very realistic for soaring. One example noted was that thermals were very uniform and round - unlike reality. However, at least two clubs in the UK are using it for ridge soaring training with a custom built ASK13 model, so the capabilities are sufficient for everything except advanced training.

Prepar3D

The only commercial software package developed by a major corporation (Lockheed Martin). Comments so far indicate terrain support is very good while gliding models are not very good, but can be customised reasonably well. Taking the X-Plane software model even further, this is a general simulation package. All types of vehicles, such as cars, boats and submersibles can be simulated. Obviously this is superfluous to our needs, unless some gliding clubs would like to moonlight as driving instructors for some of their junior members!

Like X-Plane, multi-screen support is available. Coming from a large company, traditional cost models are used - if you wish to develop add-ons (scenery or flight models), then a separate restricted developer license must be purchased. Due to the community nature of gliding in Australia, this is a significant drawback on getting individual clubs to help develop the future flight simulation capabilities. Comments on the weather model simulation haven't been provided by any current users.

Recommendations

The situation in Australia is very positive for full-scale application of simulators to training, at whatever level the GFA choses. To make the most effective use of resources, the following recommendations are put forward for consideration:

Support Recommendations

In order for simulators to be not only accepted, but also successful, GFA must focus most of its available resources on the syllabus and support side. Without this, there will be little to no advancement from the situation as it is today.

Firstly, the various operational regulations issues noted previously will need to be addressed. Those will go a long way to toward tipping the instructors corps from anti-simulator to at least neutral.

Secondly, once a standard software package has been chosen, then the syllabus needs to be managed. A complete, standardised training package of scenarios that can be easily loaded into the software package will remove the rest of the impediments to general adoption.

Lastly, Australia is at the world-wide forefront of simulators in gliding. Many are looking on at what we are doing with eager eyes. GFA is seen as a leader in many aspects of gliding, particularly airworthiness and it would be a great boost for us to be also seen as leading the way and shepherding the acceptance of simulators around the world. One particular aspect of this that has come from the research into this report: Simulators and simulation right now is many tiny islands around the world, connected tenuously by one or two people knowing someone else. We can connect them together by establishing a common forum and documentation resource that is available and open to all in the world gliding community.

Training Recommendations

Having club members arrive one morning to find a nice shiny new simulator on their clubhouse front doorstep will do little to help adoption as nobody will know what to do with it. This applies not only to individual clubs, but to the GFA as a whole.

In order to help adoption rates, it is recommended that the GFA phases in the use of simulators through several steps. Firstly simulators for instructor training at the L1 and L2 level. This will ensure that instructors are familiar, and competent, with their use before trying it out on students. Put another way, an instructor can make many mistakes and learn how to use the sim with someone that already knows how to fly and is accepting of the inevitable bumbling that happens with new technology and procedural introductions, rather than trying it out on an impressionable first timer to gliding.

Once instructor training system is underway, in parallel the coaching aspects can be explored for cross country training. Finally ab-initio training can be introduced - hopefully with all the kinks sorted out in the support and syllabus side. Those clubs that already have simulators should not be held back from ab-initio training, however. They can begin immediately the work of sorting out the common scenario library, along with the development of and trial programs with new students. It would be wise to not try this out early on with the intensive course students, as the concentrated timespan means little spare time would be available to sort out the inevitable teething problems.

Simulator Recommendations

In combination with the GFA's recent focus on providing intensive week-long training courses, and simple Australian demographics that concentrate most of our pilots near the major capital cities, and the GFA providing partial or complete funding to purchase simulators, the two seater trainer using a full cockpit model is the preferred option. Here the greater cost and additional support required to keep the simulator running will be offset by the greater utilisation. The specific clubs can be the subject of separate discussion, but most will be self-evident. For the smaller clubs that would like to also make use of simulators, then the basic cockpit simulator can be provided. This recommendation does not preclude these clubs from adopting the larger two-seat, full cockpit simulators, however, practicalities of utilisation and maintenance need to be considered. If they can present a reasonable case, then why not?

Open Questions

After all the dust has settled from the above reading, it is important to realise that not all the aspects of simulation in gliding have been solved or recommendations provided. The following points are open questions that the GFA must contemplate and provide answers to as part of moving forward:

- Several clubs have already invested significant amounts of money and time into building their own simulators. What should the GFA do to compensate them, should it decide to provide some sort of discounted purchase scheme for clubs that don't have a simulator.
- In order to promote simulators for the entire country, many will need to be purchased and/or built. What mechanism will the GFA provide to help this out? Bulk purchase of sims through the GFA or subsidy for purchases, or something else?
- Long term maintenance of the simulator hardware will always be a problem. Computers die, potentiometers wear out and so on. Will the clubs be left to fend for themselves or will some sort of parts pool be made available?
- The ever present CASA will eventually hear about our use of simulators and will want to know what is going on since they have their official finger on certification in Australia. GFA must be prepared and capable of answering the many questions that will inevitably come up.
- Should the GFA consider some form of commercial sponsorship or partnership with one of the gliding simulator software vendors in order to get improvements specific to our training objectives?

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Appendix A - Cost Estimations

Simulator Equipment

Desktop PC Simulator

Computer and screen $1000. Stick, Pedals $500. Good quality stick and pedals should be used that have force-feedback capabilities. Many different suppliers can be used for this. Cumulus Soaring is a popular purchase site by many in the gliding community and helps keep funds within our sport.

Simple Simulator

Mach 0.1 http://www.gliderbooks.com/training-sim.html

USD $1900 each. Bulk purchase discounts would be available (confirmed with supplier). Shipping to Oz is approximately $100 in flat-pack arrangement. Some of the more bulky items such as the seat that can be purchased locally would not be included in the cost - further reducing the cost. Complexity of the kit is on the level of Ikea type assembly. Mostly prefabricated and needing just a screwdriver and spanners to assemble.

Upper mid range computer and screen would be similar to the desktop simulator costs, but no need for the rudder pedals and stick as they are include as part of the simulator.

As a cheaper option, and more appealing to the DIY crowd the following site offers plans that can be purchased for assembly at home.

http://www.rogerdodger.net/diyflightsims.html

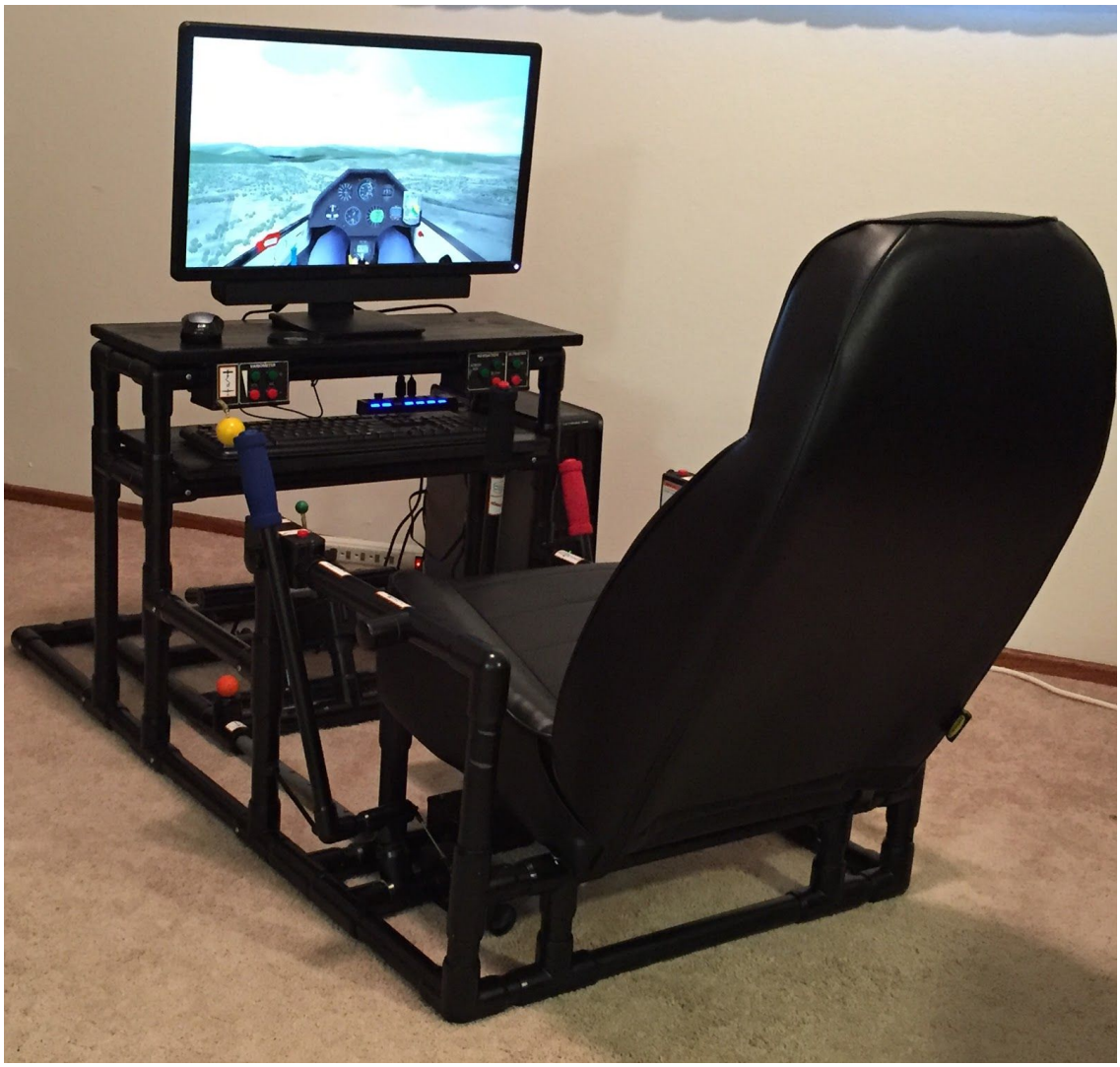
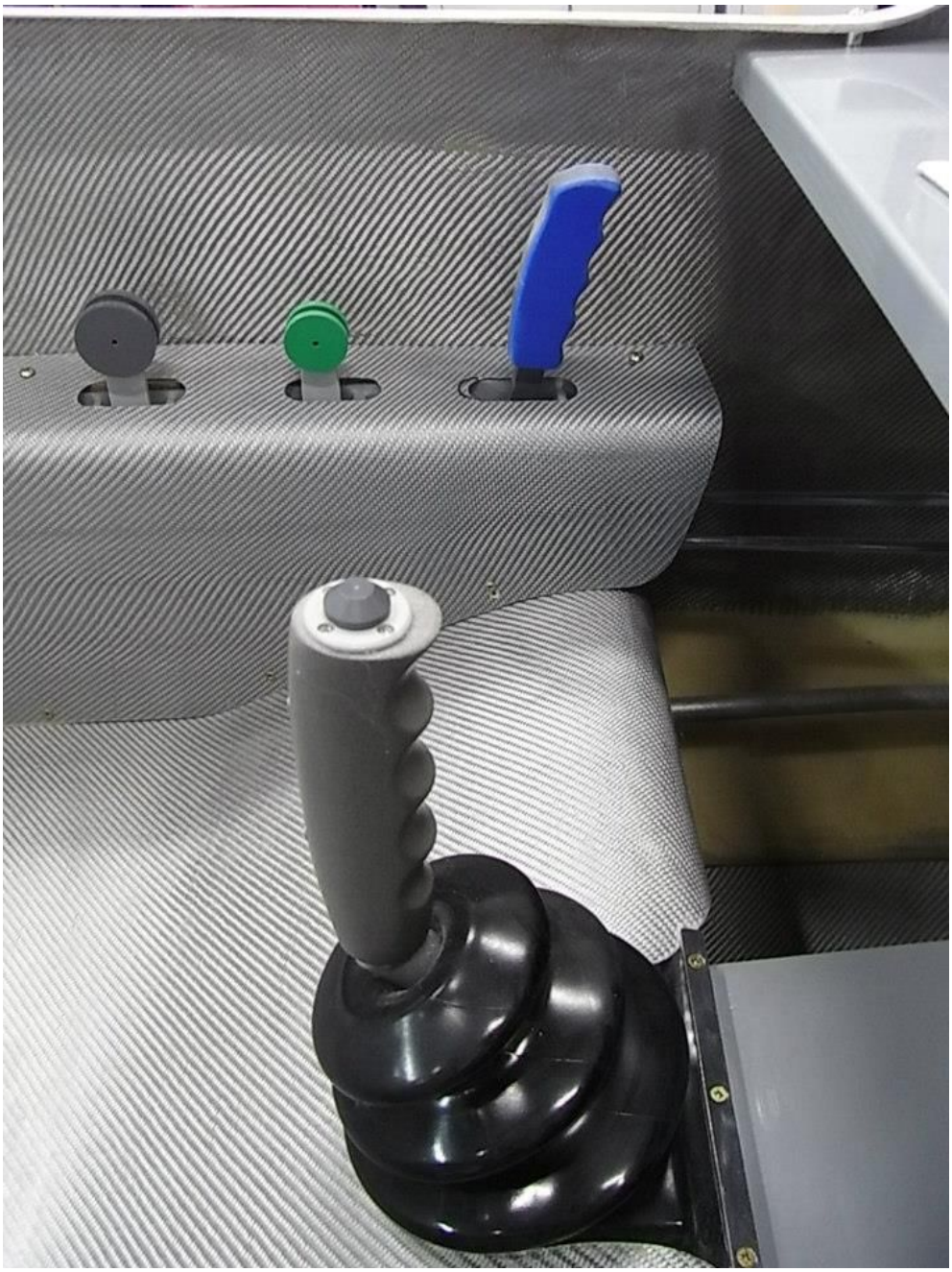


Photo of the commercial Mach 0.1 simple cockpit simulator provided by Russell Holtz

Full Cockpit, two seater sim

A Twin Astir fuselage mould has been located in Australia that we could commission a local glider shop to build. An indicative cost per cockpit has been supplied. In addition to this, controls would need to be fitted aircraft, as well as the sensors needed to work with them. Since this is not a real aircraft being constructed, some simpler designs can be used, such as that seen below used by the French standard simulators. Screens, projectors and computers are a separate purchase. For a 3-screen setup, a higher-end computer is needed - specifically the graphics cards needed to run the displays, and projectors x3. Bulk purchasing discounts may be available for computers and screens.

Cost to outfit the room that the simulator is located in will vary tremendously based on location. Some places may have a readily available room, so all that is needed is some paint and general tidy up, while in others a complete new room would need to be built on the side of the existing clubhouse or hangar.



Simplified controls based on simple standard computer controls as used in the French standardised simulator.

PC		$2500
Projectors		$1500
Base Cockpit		$3000
Cockpit Controls and fittings		$1500
Room fitout		????
	Total	$8500+

Training Syllabus

Syllabus Development

This will be taking the existing syllabus and reworking it to incorporate simulation (assuming ab-initio, but similar development can be done with other areas such as Instructor or Cross Country training). Unfortunately, we rarely go to this level of review and development in our syllabus, so providing an estimate based on sound reasoning is difficult. Typically review cycles are around 1 year, so this would be a reasonable assumption to work with.

Scenario Development

Assuming a completed syllabus for ab-initio training, experience from the GliderCFI site using condor was averaging about 2 days per training scenario. Since then (2010-2014), the software package has improved a lot around training. Expected time to develop is around 1-1.5 days on average. This time is split between actual scenario development, and initial planning and design of taking the syllabus objective and developing the model for teaching that objective.

As with all tool development, the initial scenarios will take much longer as the developer(s) learn what is available and limitations of the tool in trying to match it to the syllabus requirements.

If Condor is selected for training, there are two pre-built sets of courseware already available on the internet that can be used. These are both developed in the USA for the american PPL system, so applicability of each scenario must be evaluated before usage.

Scenery Development

Depends very much on which simulator is agreed upon for the standard sim. Basic terrain data is provided for some, others will need to develop it from freely available online sources. Devoted time for an individual site using volunteers has an average time of around 2 months.

Appendix B - Marketing Simulators

For the purposes of marketing gliding, the needs of a marketing simulator are much simpler. There are two primary drivers

1. Ability to move the simulator to wherever an event is being held (mobility)
2. Look as attractive and lifelike as possible (sex-appeal)

Construction Options

When a simulator is being used for marketing purposes, many of the requirements of the training side are no longer relevant. When used at a public (or private) event there are no goals for the user of the simulator beyond simple enjoyment. If the user can have fun, and possibly be attracted to gliding, then the goals have been met. Part of this enjoyment is the less formal environment - someone jumping in and flying with a few mates around them and an attendant nearby to help them into and out of the aircraft and simple flight briefings.

Building for Mobility

Our first major requirement is mobility. GFA needs to be able to get the simulator to an event with a simple setup that can be taken there by the average member. Just looking at all the pictures of simulators in the main body shows that they are not small by any means - certainly too big to be dismantled and carried in a car. That implies that they must be towed as a trailer.

As a trailer, certain basic restrictions are needed for roadworthiness:

- Maximum weight under 700kg so that medium cars may be able to tow it, possibly even smaller (compact) cars, and to avoid the need to fit electronic brakes to the towing vehicle
- Size needs to be kept small enough that additional restrictions are not applied that can vary by state. Recommended that the average 2.4m box trailer be used as a guide since that gives plenty of room,
- Ruggedised to deal with long trips. Many shows are well away from where the trailer is likely to be located during storage. Several hour trips could be considered normal for the eastern states in particular. A small trailer will tend to bounce a lot, so construction must trade off weight for strength. Too lightweight construction will require constant repairs,
- Self contained: As much of the simulator must be built into the trailer as possible to avoid forgetting items. Projectors, screens, power cords, stability devices, stairs etc all must have secure spots in the trailer.

Building for Entertainment

When serious training is not involved, two of the biggest drivers of the simulator design can be removed. Firstly, there is no need to have a second seat. The pilot is there being guided by someone chatting them through things on the side, rather than being taught by an instructor that is sitting behind them.

Secondly since procedures are not being taught, good pilot skills such as lookouts are not needed, so there's no need to provide multiple screens. Single projectors and screens allows the full range of software options to be used (though Condor with its various visual display options seems to be far and away the most popular selection here).

When building for entertainment, an additional area to watch for is ruggedness of the simulator. In a day, hundreds of people could be climbing in and out of the cockpit - often with far less care than

your normal pilot would take. High wear areas such as the cockpit edges and seats will need to be built much stronger and wear resistant than a training simulator. Of course maintenance after the fact also comes in, so the sim has to be built with frequent maintenance in mind - easy to access control interfaces particularly.

Two design options can be considered here: a simulator in an enclosed box, much like the SoarAbility project uses, or an open display where the cockpit is open and visible to all. Since one of the main reasons for marketing is to attract people, the open design is much more favourable to this. The sight of someone sitting in the aircraft with a big bright screen showing flying will raise more interest than a box where someone sits inside and the activities can't be seen by incidental traffic walking by. The open design is much more susceptible to the elements and less tolerant of abuse, but weighed against the ability to attract interest from bystanders, the attractiveness is much higher priority.

Costing

Compared to the two seater full cockpit simulator, the expense should be cheaper. However, the less materials and controls is offset by the cost for the trailer construction. While the cockpit will be a standard design,

Starting with our basic PC with good quality graphics card and add on projector. Assuming a mould can be located for a cockpit (the author is aware of at least one Jantar full cockpit mould existing in Australia), the construction cost should be less than that of the two place model, though not much difference in labour costs. Fitting of controls and instruments should also be cheaper since there only needs to be one of each. For the trailer, specialised construction will be needed, however the availability of CAD drawings for the existing design used by the Victorian Soaring Association's unit will help production of multiple units.

PC		$1000
Projector		$500
Base Cockpit		$1500
Cockpit controls and fittings		$700
Trailer		$1500
	Total	$5200

Since training won't be performed, there is no need to consider costs or time for syllabus package development. The standard scenery that comes with the software can be used without modification.