Selecting the Right Aircraft Simulation Tool

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ABSTRACT

When planning to build an aircraft simulator, everyone faces the same difficult decision: what type of tool should be used to create the application? There are three different types (or categories) of tools on the market: game, shareware and professional tools. With hundreds of flight simulation tools available on the market, how does one decide which is best? The decision should be based on the users goals and specific needs.

The purpose of this article is to help users in their selection by providing technical facts with which to base their decision. Three use cases are presented to help developers and end users come to their own conclusions about various aircraft simulation tools, and allow them to choose the most appropriate solution. The use cases are meant to help engineers avoid making premature decisions or imposing these on upper management.

ABOUT THE AUTHOR

Stéphane Roy, President and Consultant, Roy Aircraft & Avionic Simulation, has more than 20 years of experience as a Control Systems Expert. He also has recognized expertise as a Systems Engineer in fixed and rotary wing aircraft simulation model and FMS system design. As an Avionics Systems Engineer (radios, AFCS, FMS, MC, etc.), Stéphane has upgraded many aircraft simulators (aerodynamics, AFCS, flight control, landing gear, radios, engines, etc.). He has also designed simulator and avionic systems and modular avionics tests (DO-178B, CMM, qualification and certification).

“Stéphane Roy worked with my team of engineers in upgrading a Tigre Helicopter Simulator for the French DGA Using his in-depth knowledge of helicopter and flight simulation dynamic models allowed us to deliver a new version of the simulator, whose behavior is now very realistic (validated by Tigre flight test pilots). In fact, the result exceeded the customer’s expectations. Faced with a lack of usable data to tune the helicopter dynamic model, Stéphane proposed a method based on closed loop development with flight test pilots. After only 5 tuning/testing steps, the model was validated by 2 flight test pilots (Tigre experts). Throughout the project, Stéphane’s work was exemplary. In fact, he was the main reason for the project’s success. As well, everyone involved (both my team and the customer) greatly appreciated Stéphane’s human qualities.”

David Ganieux, Oktal Project Manager, April 10, 2011

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BACKGROUND

When planning to build an aircraft simulator, everyone faces the same difficult decision: what type of tool should be used to create the application? There are three different types (or categories) of tools on the market: games (e.g. X-Plane), shareware (e.g. Flight Gear), and professional tools (e.g. Presagis FlightSIM). With hundreds of flight simulation tools available on the market, how does one decide which is best? The decision should be based on the users goals and specific needs. The purpose of this article is to help users in their selection by providing technical facts with which to base their decision.

WHAT ARE THE DIFFERENCES BETWEEN GAME, SHAREWARE AND PROFESSIONAL TOOLS?

The question is not whether one tool is better or worse than the other; they can all provide a good solution. The difference lies in how an aircraft simulator will be used, how accurately the chosen tool can render the model, and how easily this can be accomplished.

GAME TOOLS

With game tools, the joy and experience of flight is the driving purpose in its design. To achieve this, you can use a user-friendly aircraft model, a nice visual database of the world, good sound effects, easy plug-ins, such as flight devices, and open software so the player community can customize the simulator.

The plan is to customize visuals with more precise items, for example, a cockpit, instruments, outside and inside views of the aircraft, and other visual items. Game tool architecture is open to help the user calibrate the aircraft model, however, some restrictions exist. The architecture allows the user to use pre-defined parameters to calibrate specific models, but cannot change the interred model for better accuracy (for example, the engine, the AFCS outer-loop, the control system, etc.). In many models, the ability to modify, or even access, the internal model is not possible (for example, AFCS inner-loop, NAVAIDS, etc.). This type of tool is inexpensive and easy to integrate, but technical support to customize aircraft accuracy is almost non-existent. Developers must rely on the player community to help overcome challenges and obstacles.

PROFESSIONAL TOOLS

Professional tools are designed to improve all aspects of the accuracy (performance) of the aircraft (aerodynamics, control systems, AFCS inner and outer loops, FMS, NAVAIDS, hydraulics, electricals, GPS, MC, etc.). Like game tools, easy plugs-ins, and even more complex plug-ins, are available to improve flight realism, such as a control loader. Because professional tools are completely open, many specialized third-party products exist to help improve and test the accuracy of the aircraft model. Although the user community that works with professional tools is relatively small, their members are highly qualified. The architecture allows users to calibrate actual pre-defined parameters, or completely change the model to achieve better accuracy. Professional tools provide users with many specific libraries to help them build and/or modify the actual model more quickly (for example, AFCS, FMS, control loader, aerodynamics, mathematical, etc.). The initial cost of this type of tool is high, but with easy integration via the open architecture, users can develop an accurate aircraft model rapidly. Professional tools include a fully trained support team, and offer the services of leveraging professional consultants. For rotary wing aircraft models, the difference between professional and game tools is much greater because of the complexity of the models (Downwash, inter-velocities effect, CSAS, vibration, mechanical transmission, skids, AFCS, inter-coupling aerodynamic effects, etc.).

SHAREWARE AND FREEWARE TOOLS

Shareware is designed for educational purposes, as an alternative to professional tools in order to build accurate aircraft models at a lower price. To use shareware, the user must have the time to reverse the engineering on the tool and build the aircraft model from scratch. This type of tool is not expensive, but the user must be a software and design expert in order to customize the performance of the aircraft model. Similar to game technology, no technical support is available, only the user community.

FINDING THE RIGHT TOOL USING A 4-STEP DECISION PROCESS

STEP 1: DEFINE THE TYPE OF PROJECT

Define the needs. How will the simulator be used: for pilot training (Ab initio, CBT, PTT, FNPT, FTD, FFS, etc.), for avionics stimulation, for human factor research, for marketing, for maintenance, etc.

STEP 2: DEFINE THE COMPLEXITY OF THE SYSTEM

Define the complexity of the system to simulate: Automatic Flight Control System (AFCS), Flight Management System (FMS), Mission Computer (MC), Performance aircraft model, engines, Primary Flight Display (PFD), Multi-Functions Display (MFD), Flight By Wire (FBW), Control Stability Augmentation System (CSAS), vibration, etc.

STEP 3: LIFE CYCLE OR SUSTAINABLE PROGRAM

Define the life cycle of the simulator, and how its maintenance will be undertaken. Does the simulator need to evolve (aircraft model, new avionics boxes, new software model, etc.) or will it only be used once? Will the company need to train new resources, or will it use existing personnel? Who will maintain the simulator in the long-term? Will the company hire consultants, or will it outsource the work?

STEP 4: UNDERSTAND THE TOOL

How much does the tool cost? What will the tool be connected to, or integrated with (software and/or hardware)? What are the limitations of the tool? Does a user community exist? If so, what type and what size of community? What kind of support is available? What are the tool's capabilities (what can be achieved with it)?

ASSETS, RISKS AND ROI ASSESSMENT

Once these 4 steps have been completed, the Return on Investment (ROI) can be calculated. The ROI can only be determined once the cost of the resources, including overhead, has been determined. A general cost estimate for engineering in North America is $5,000 US per week.

CASE STUDIES EXAMPLES

The following use cases show why it is important to complete the 4 steps before calculating the ROI.

CASE 1
USING A GAME BASED APPROACH

A customer had built an avionic bench to use as a marketing demonstrator for their MC, and a new suite of MFDs.

The customer needed a fighter aircraft model that could be hooked to their MC and MFDs rapidly. The simulation variables had to simulate the MC and MFDs and be integrated into a visually pleasing cockpit.

The customer chose X-PLANE because it is not expensive, has nice visuals, a large user community, and many available plug-ins. X-PLANE was the perfect selection given the promotional show where the customer would demonstrate the company's products.

Since the demonstration was a success, upper management imposed that the engineering team use the marketing avionics bench for their avionics systems and modular tests. No ROI study was undertaken to select the right tool.

The needs of the engineering team were different than those of the marketing team. The engineering team needed an accurate fighter model, which was initially not a problem because they were told that hundred of aircraft models were available from the large community of players. After searching for 3 days, the engineering team finally found an appropriate aircraft model. After one week of integration and tests, they found that the accuracy of the aircraft model was not what they needed. Again, the engineering team was told that it was not a problem since the tool was designed to modify the performance of the aircraft. After 3 weeks of study/investigation, and changing the

model parameters to calibrate the aircraft model, the team realized that they could not achieve the desired level of performance. They then obtained a better model, but it could not achieve the accuracy required.
The integration problems were quickly compounded:

- Fly By Wire (FBW) model - no access to the AFCS inner-loop, only a cheat to hook the AFCS outer-loop, insufficient accuracy even after 4 weeks of work
- The AFCS logic and outer-loop needed to be calibrated or changed; this goal was not achieved even after 7 weeks.
- Models for IRS, ADC, DME, VOR, ILS, TACAN, ADF, RA, GPS, fuel system, surfaces position, etc. Code had to be added between the X-Plane raw data and the output data for the stimulation of the MC and PFDs. After 15 months of work, the result was still not satisfactory.

It took the engineering team approximately 75 weeks to complete the integration of X-Plane using an average of 2.5 engineers. The total cost came to $937,500, not including the project engineer and the management costs related to many meetings organized to fix problems and control the overrun.

CASE 2
USING DEDICATED COTS SOFTWARE

In parallel, my team built a Dynamic Test Bed (DTB) to perform system tests for an FMS.

The FMS had to simulate the environment and conditions of a real aircraft, reduce the number of flight tests, prepare and run the entire engineering and TCCA flight tests before the actual flight tests on real instrumented aircraft, reproduce customer problems using real-life environmental conditions, perform flight testing in IFR conditions, and evaluate and test the dynamic performance of the FMS's vertical navigation.

The FMS was also to be used as a Vertical Navigation development test bench to demonstrate all FMS mode operations to customers and other interested parties. FlightSIM from Presagis was chosen because it can evolve along with the FMS and keep up with the latest aircraft technology and ever-changing pilot and aviation safety requirements (regulator). FlightSIM was able to meet the DTB evolution requirements, especially as concerns the accuracy of the model for FMS performance navigation tests.

The work to be undertaken included the integration of all AFCS (inner-loop, outer-loop and logic), full DME and VOR, IRS/INS, ADC, ILS, TACAN, ADF/NDB, GPS, RA, magnetic variation, fuel system (tanker), aerodynamics, engines and CPDLC (FANS) models with custom internal tools. Aircraft system malfunctions were added to achieve the accuracy requested by the FMS performance navigation.

Because we used a professional tool that is adaptable (flexible), extendable, high fidelity (accuracy) and has a long life cycle, we were able to build the DTB for a total cost of $283,500. Costs can be divided as follows: software tool, engineering, sub-contracting the building of an L1011 performance (accurate) aircraft model. The DTB was built in 4 months.

CASE 3
BUILDING AERODYNAMIC MODELS WITHOUT A DATASET

Another customer wanted to perform a proof of concept using a professional tool to build two UAV models without any available data related to the aerodynamics, control surfaces and control laws. They also wanted a tactical mission navigation system for both UAVs and have it integrated with their tactical environment software, all in 3 weeks. The customer wanted to compare the internal process to develop a UAV simulation application against the use of a COTS aircraft simulation tool.

We met the deadline by using a professional tool (FlightSIM) to build the UAVs.

We used the closest possible aerodynamic model to begin to build the model, and were then calibrated by comparing it to some of the performance data that was available. Using control law libraries and math libraries, we are able to quickly build all the control laws for all the surfaces. The tool included an FMS model. We used the tool's extensibility and libraries to modify and add functionality to build the tactical navigation system according to the UAVs' requirements. The API was used to quickly hook the UAVs to the customer's tactical environment. Instead of a team of 4 engineers and 3 months of work, we built the model in 3 weeks with one engineer and one software student.

CONCLUSION

These 3 use cases show the importance of planning the project thoroughly and identifying the limits of the software before a well thought-out, technical decision can be made.

The first use case shows that the customer made the right decision when the project was initiated, but when the company wanted to evolve it further, integration costs quickly went out of control. However, in the second example, the right tool was used to evolve and attain the accuracy of the aircraft model required by the project.
In the second example, more work was done in 20% of the time and at one-fifth of the cost as the first example. The DTB integration was ready to evolve with the future requirements of the FMS.

The third example shows the effectiveness of using a professional tool to develop a complex aircraft model, without having access to the actual aircraft data. The rich API makes integration with a third-party product easier and reduces the time needed to complete the project.

Before starting to build an aircraft simulator and choosing a tool to do so, it is imperative that an asset, risk and ROI assessment be done. Don't let yourself be fooled by the initial cost of the software or the promises of the game tool. Performing these 4 steps can help organizations avoid cost overruns. It is important to note that a well prepared project begins with the right tool. In the end, this will save a great deal of time and money.

REFERENCES

X-Plane manuals, version 9.21

FlightSIM manuals, version 10.1

Flight Gear manuals, version 2.0

CONTACTS FOR MORE INFORMATION

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To learn more about X-Plane, log on to the X-Plane web site: www.x-plane.com

To learn more about FlightSIM or HeliSIM, log on to the Presagis web site:www.presagis.com

To learn more about Flight Gear, log on to the Flight Gear web site: www.flightgear.org

ABREVIATIONS

ADC	Air Data Computer
ADF	Automatic Direction Finder
API	Application Programming Interface
AFCS	Automatic Flight Control System
CBT	Computer Base Trainer
CMM	Capability Maturity Model
COST	Commercial Off-The-Shelf
CSAS	Control Stability Augmentation System
DGA	Direction générale de l'armement
DME	Distance Measurement Equipment
DTB	Dynamic Test Bed
Eng.	Engineer
FBW	Flight By Wire
FFS	Full Flight Simulator
FMS	Flight Management System
FNPT	Flight Navigation Procedural Trainer
FTD	Flight Training Device
GPS	Global Position System
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IRS	Inertia Reference System
MC	Mission Computer
MFD	Multi Functional Display
NDB	Non-Directional Beacon
PFD	Primary Flight Display
PTT	Part Task Trainer
RA	Radio Altimeter
ROI	Return On Investment
TACAN	TACticAl Navigation system
TTCA	Transport Canada Civil Aviation
UAV	Unmanned Aerial Vehicle
VHF	Very High Frequency
VOR	VHF Omni directional Range