

ADI Simulation Systems Help Speed Aircraft Development from Preliminary Design through Certification

Rapid advancements in avionics systems require moving from concept to certification as quickly and efficiently as possible. Simulation has proven to be invaluable in reducing development cycle times by enabling more efficient development work earlier in the design process.

INTRODUCTION

Simulation, model-based software development, integration simulators, and other rapid technology deployment techniques reduce development cycle times and cost and enable more efficient product certification.

With rapid advancements in avionics systems, advanced cockpit controls, advanced cockpit displays, fly-by-wire technology and more, the need to move expediently from concept to certification is a fundamental requirement for a successful aircraft development project.

The use of simulation to develop a superior aerospace or defense product has been embraced across the industry. Simulation has enabled quieter engines to produce more thrust with less fuel. Simulation has also reduced the weight of the aircraft, improved aerodynamic efficiency, extended aircraft range, and resulted in more passenger and cargo room. As successful simulation-dependent aircraft development projects reach completion and designers look back to ask, "How could we have done things better?" A common response is: "More accurate simulation."

Many Aircraft Systems, Wide Range of Simulation Tools

A seemingly endless array of simulation tools is available to engineers today. Different tools demonstrate superior accuracy in the design and simulation of different pieces of an aircraft.

Among the simulation methods available for aircraft systems design are:

- + hydraulic modeling for aircraft hydraulic systems
- + fluid dynamics modeling for aerodynamics modeling and design
- + discrete system modeling for electrical system design
- + control system modeling for avionics and FADEC controller design
- + thermodynamics for jet engine combustion simulation
- + multibody simulation for mechanical design and simulation

Using a single tool to simulate the complete aircraft not only results in reduced accuracy but also locks the manufacturer into a single supplier and can result in rapidly escalating costs. Preliminary design teams are using up to a half dozen simulation tools for the development of next-generation aircrafts. Popular simulation tools include:

- + Adams
- + AMESim
- + Dynasim
- + Easy5
- + Matlab / Simulink / Stateflow
- + MatrixX / SystemBuild
- + Rhapsody
- + Statemate

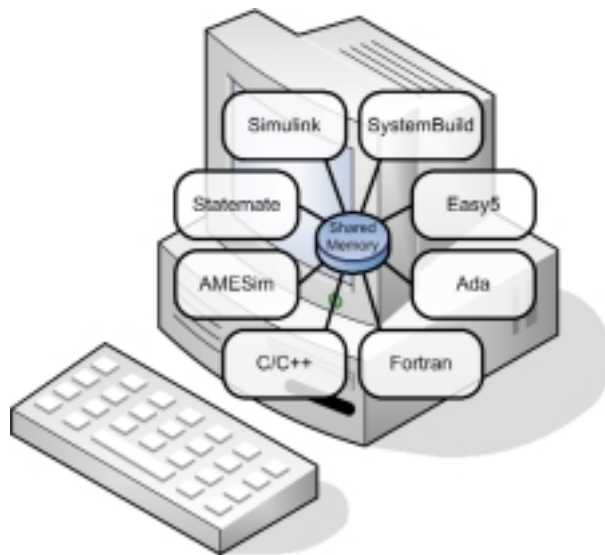
An average aircraft development program will use an assortment of these tools.

Integration Testing with Cosimulation

An increasingly popular step in aircraft development is multi-model cosimulation using a universal simulation platform like ADI's Advantage for GP.

Once independent piece-wise simulation of the aircraft is complete, the next step is to bring the pieces together. Each piece may behave as expected in isolation but may not behave the same way when combined with others. To make matters more complex, legacy code-based simulation models from previous development program are often used to reduce design effort. These code-based models can take the form of the following:

- + Ada
- + Fortran
- + C/C++



The challenge faced when assembling multiple simulation pieces is the integration of dozens of disparate models created using different simulation packages. ADI's Advantage software provides a proven solution for model integration.

Cosimulation is the technique of taking numerous simulated components, designed using one or more modeling packages, and/or written in one or more code languages (Ada, C, C++, Fortran), and performing a combined simulation of these multiple components. The goal of cosimulation is to assess how well the components play together. For example, a complete aircraft cosimulation project could involve the following:

- + Engine simulation using a Fortran model
- + FADEC simulation using an Ada model
- + Aerodynamics using a Simulink model
- + Aircraft hydraulics using an Easy5 model
- + Electrical system simulation using Statemate
- + Landing gear simulation using Dymola
- + Databus communication modeled in C++

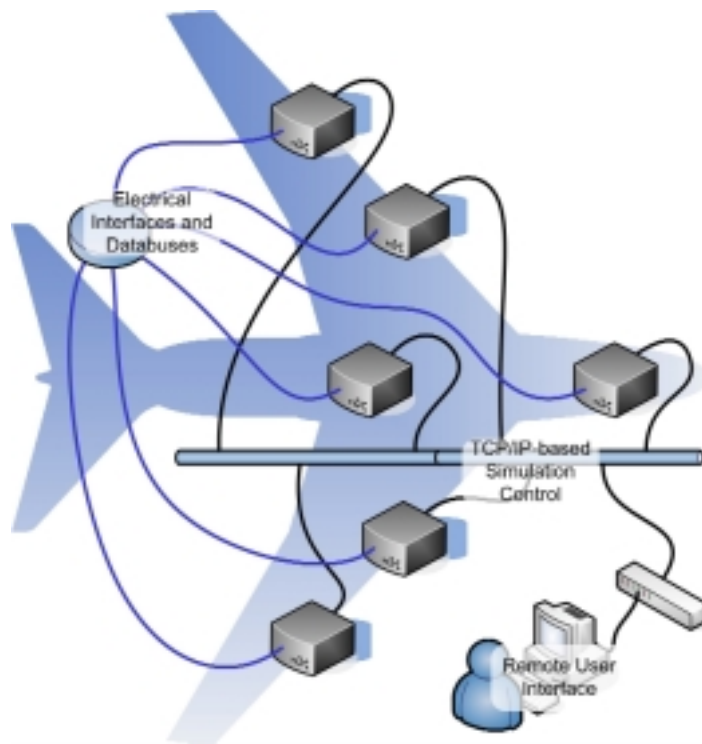
During cosimulation, all models are executed in a lock-step synchronized manner using a cosimulation platform. The cosimulation tools are run on a PC or Unix workstation. The cosimulation platform executes the simulation models, provides results logging and analysis, test automation, visualization and control. The interaction of each simulated component is analyzed against requirements. Design errors are detected early in the development cycle and can be corrected quickly and with minimal expense. The output from a successful cosimulation project is a collection of exhaustively tested simulation models. These models are then delivered to the next phase of development where they drive the behavior within rapid development units.

Rapid Development Unit Integration Testing

RDU simulation enables complete and accurate simulation of the entire aircraft; providing important insights into aircraft performance early on in the development cycle.

Rapid development units (RDUs) are gaining popularity in aircraft and defense vehicle development. The concept is to use many small real-time simulation computers, each behaving like a component of the aircraft, connected using real databus and electrical interfaces.

ADI's VME-based RTS real-time simulation computers and PC-based rtX real-time expandable simulation computers are often used as RDU targets. The multi-computer real-time simulation provides the first step toward a full integration-testing simulator. A mocked-up cockpit can be added with cockpit displays and controls and the first elements of human factor testing may begin. The goal of RDU integration testing is to assist with the design and test of system interfaces and sensors.



RDU integration testing enables more efficient design and test of system interfaces and sensors.

Each real-time computer executes a model that was developed during pure simulation and tested during cosimulation. The addition of real electrical interfaces and real databus communication introduces a new layer of behavior. The performance of these electrical interfaces and databuses has a major impact on the overall performance of the aircraft. The goal of RDU integration testing is to provide a platform where interface communication may be assessed as well as the impact of this communication on each aircraft system. Development testing of these electrical interfaces can be divided into network development and sensor selection.

Network Development

The use of vehicle and aircraft networks continues to grow. Implementing networks such as ARINC 429, MIL-STD-1553, CAN, and AFDX rather than direct cabling between systems and sensors greatly reduces the amount of cabling and thus reduces the weight of the aircraft and the number of points of failure in the electrical system.

The challenge when using aircraft networks is to ensure that the network topology can perform as expected when experiencing worst-case network traffic loads. RDU integration testing is designed specifically to iron out aircraft network design problems. RDUs are connected to real aircraft networks and communicate with one another as the real aircraft system would in the final aircraft. Simulation models behaving in a realistic manner drive network traffic. Taking the RDU-based simulator through realistic tests such as simulated take-off, landing, and other system-stressing maneuvers identifies periods of high network traffic. Simulation data is logged and analyzed to compare different network topologies.

In addition, the impact of network communication can be assessed in terms of performance impacts on aircraft systems. For example: Is discrete messaging degrading engine performance? Does the network design provide good human factor feel for fly-by-wire flight controls? Are aircraft cockpit displays giving a smooth update of instrument output?

By performing high-fidelity simulation with network hardware in the loop, these questions are answered through the analysis of simulation data well before real aircraft systems are made available.

Sensor Selection

The next important application of RDU integration testing is the selection of sensors. Different sensor types have strengths and weaknesses such as varying accuracy over different ranges, cost differences, and application specificity. Using RDU integration testing, a selection of potential sensor candidates can be tested in the RDU aircraft simulator early in the development cycle. Sensor behavior can be simulated in real time using sensor data and the effect of a particular sensor on the performance of the entire aircraft can be measured. Alternatively, real sensors can be connected to RDUs using an appropriate electrical interface. Real sensors are then evaluated based on how well they match the application. The RDU flight test provides an incredible amount of insight into the aircraft's final characteristics early in development.

Benefits of RDU Integration Testing

The alternative to RDU integration testing has historically been to over-engineer the aircraft. Aircraft systems were designed for worst-case behavior with little insight into the real behavior of the final aircraft. This resulted in a higher price tag, greater aircraft weight, higher cost per passenger mile, and ultimately a less marketable aircraft.

Using RDU simulation, the complete aircraft is simulated with varying levels of accuracy. Real electrical interfaces and databuses provide communication between systems. The final step in the development cycle is to begin replacing RDU simulation systems with actual aircraft components as they become available.

Aircraft Systems Integration Test Labs

Integration test labs are the last step in the development cycle prior to flight test and allow problems to be identified and addressed earlier in the development cycle.

As actual aircraft components become available, the components are added to the integration test lab by removing the RDU and connecting the actual component using the electrical interfaces and databuses previously added and tested.

Aircraft avionics systems, flight controls, and cockpit displays are prime candidates for integration lab testing. These systems are highly complex, highly interconnected and require a great deal of human interaction. Long hours of man-in-the-loop testing are required with these systems to eventually have them certified. These systems are added to the integration test lab flight deck and are connected to the rest of the aircraft using databuses such as ARINC429 as well as other electrical interfaces. Pilots sit at the controls and perform highly accurate flight simulation. Pilots look for anomalies in the LCD displays, assess the feel of the advanced flight controls, and assess the overall handling of the aircraft. This testing occurs before a production aircraft ever rolls off the assembly line. Problems are detected and addressed early in the development cycle.

Integration labs are ideal for the development of new versions of existing aircraft. An integration test lab already in existence is fit with new systems. Ideally the new systems are added in a manner such that they may easily be swapped out for the older systems. This quick-swap approach enables the integration lab to test any version of an aircraft at any point in time. New systems are added to an integration simulator previously verified and the development test process is able to minimize the amount of expensive flight test.

SUMMARY

Simulation Model as the Development Stage Deliverable

Simulation modeling at each stage in the development cycle results in more efficient use of technology and aircraft certification with minimized cost and time.

As the aircraft development cycle moves from pure simulation to cosimulation to RDU simulation to integration test simulation, each stage presents, as a deliverable, numerous simulation models to the next. Each successive development stage benefits from the one preceding it, and duplication of effort is thus minimized.

When improvements are made to a pure simulation model, the improvements trickle down from one stage to the next, improving the accuracy of each. The final result is the efficient use of technology and the certification of an aircraft with minimized cost and time.

For more information about how ADI real-time simulation solutions can enhance and optimize each stage in the simulation/cosimulation/RDU simulation/test integration process, please contact us at:

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