The Role and Importance of Software and Simulation in MEA Design, Validation, and Testing

Over the past decade, the aerospace industry has increasingly shifted toward replacing pneumatic, mechanical, and hydraulic systems with electric powered alternatives. These More Electric Aircraft leverage complex systems of electronics to run an increasing number of functions including flight control, engine management, landing gear, brakes, and environmental control. An increased number of electrical systems offers a variety of benefits such as cost-reduction, increase reliability, reduced weight, and simpler maintenance. However, these benefits can potentially be negated by the increased complexity of the power systems in MEAs.

The integration of a wide variety of aircraft systems into a cohesive electric power system can present a number of issues. In many ways the MEA vision rests in the optimization of systems to use shared resources. This results in a vastly increased number of system dependencies and interactions compared to more conventional aircraft systems. Insufficient or improper design, validation, and testing of conceptual systems can result in excessive project costs, cascading system defects, and challenging maintenance. In the case of Airbus' development of its A380 aircraft, one of the most advanced MEAs currently in commercial use, a design error caused the over 500km of wiring and cabling to be manufactured too short. [i] This is demonstrative of the potential complications presented by More Electric Aircraft.

In order to address these potential engineering issues for MEAs, aircraft developers need a more relevant toolkit of software and hardware solutions. Through research and modeling, the industry can learn more about the design implications and considerations specific to More Electric Aircraft. This data can be used to develop new engineering software and testing simulations that can accurately predict the efficacy of new prototype electric power systems. Only through the continued development of this toolkit can the More Electric Aircraft vision be fully realized.

Currently Available Software Solutions

Software design, validation, and testing tools are becoming increasingly important to the aircraft development process. Physical prototyping and testing are expensive and time-consuming processes. Even partial replacement with virtual solutions will represent significant savings. Additionally, the reduced time commitment of engineers to testing will mean greater capacity to conceptualize and create new aircraft innovations. This advantage makes increased use of software essential to the realization of More Electric Aircraft.

Airbus has been leveraging Siemens' PLM software and LMS test and simulation tools to maintain its industry leadership. Through virtual testing, Airbus has been able to significantly reduce the number of physical tests necessary to develop and certify new aircraft components.[ii] Through more accurate simulation, Airbus' development teams are able to better understand both the implications of a given design and the possible effects of that design failing on the rest of the aircraft's systems.

Figure 1: Airbus Group Innovations

One such example of Airbus effectively using this technology is in their recent innovations in composite materials. Using the material simulation tools provided by LMS Samcef, the Airbus Group Innovations team was able to effectively validate and test the use of new composite materials in aircraft. "Thanks to the implementation into LMS Samcef of advanced composite material laws […] Airbus Group gained much deeper physical insights, thus extending the gap with its competitors," said Didier Guedra-Desgeorges, vice president and head of the Technical Capabilities Center Structure Engineering, Production & Aeromechanics at Airbus Group Innovations.[ii]

Airbus Group Innovations' head of Structure Analysis, Serge Maison Le-Poec noted: "LMS Samcef software provides a robust, state-of-the-art technology environment in an industrial context [which] is strategic for us."[ii] This project is representative of the value of software and simulation to the aircraft design and development process. These newly developed composite materials will be used to support the infrastructure of More Electric Aircraft and will enable future innovation to evolve.

Similarly to Airbus, Russian aircraft manufacturer IRKUT incorporated software based testing and validation practices into its development of its new MS-21 aircraft. The engineering team working on this project used Siemens' LMS Amesim to design and validate new concepts without first building a prototype. [iii] This virtual-only testing pipeline would be extremely valuable the development of MEAs, as the innovative power systems of the aircraft frequently need significant conceptual refinement before practical testing.

IRKUT took advantage of this software to test designs of the MS-21 from a cumulative perspective. By leveraging the integrated systems simulation tools offered by LMS Amesim, the design team was able to examine systems interactions and dependencies. Using these tools, the aircraft manufacturer estimates that it was able to reduce expensive physical testing by as much as 80%.[ii] Anton Poplavskiy, deputy chief of the Engineering and Simulation department at IRKUT said of LMS Imagine.Lab: "they provide us with a proven high-performance methodology to secure and optimize our modeling process."[iii]

This project is an early example of the Virtual Integrated Aircraft (VIA) concept. [iii] VIA will enable aircraft designers to more accurately assess systems interactions in the early stages of new projects. This concept will be very valuable to the development of MEAs, because the integration and dependencies of electric systems is one of the most significant considerations in their design.

Part of LMS Imagine.Lab' offering is a simulation tool specifically focused on the electrical components of aircraft. This can be used independently or in conjunction with other tools to effectively simulate a More Electric Aircraft's components.

Other providers are also beginning to release software aimed specifically at the design and development of MEAs. For example, OPAL-RT's DINAMO simulation tools can be used to effectively model and simulate the electric power systems of MEAs. Additionally, Mentor Group's Capital suite is intended specifically for the design of aircraft electrical systems, making it ideal for MEA design.

Evolution of Software Solutions Through Applied Research

In order for these and future software solutions to remain effective as aircraft advance, continuous practical simulation and modeling is necessary. Through the study of real-time simulations of aircraft components, tools can be accurately designed for More Electric Aircraft.

Dr. Natalia Petrovskaya of the University of Birmingham in the United Kingdom has made significant forward strides in the research of fluid dynamics. Ultimately, this research was used by Boeing to greatly reduce the amount of wind-tunnel testing necessary for the development of its new 787 Dreamliner.

Dr. Petrovskaya's research has focused on "improving the accuracy of the mathematical models used in the field of Computational Fluid Dynamics (CFD), which uses mathematics to analyse and predict the flow of air over an aircraft's wings and fuselage."[iv] Through her research, she was able to identify certain issues with the currently used fluid dynamics model. This led Dr. Petrovskaya to create a new approach to data analysis that would help to resolve these issues. This new model represents a significant step forward in the way that CFD calculations are performed.

Using this new model developed by Dr. Petrovskaya, Boeing was able to better mathematically predict the impact of its designs for the 787 Dreamliner. This resulted in around a 30% reduction in the amount of physical prototyping and wind-tunnel testing relative to the development of the 777[iv]. A reduction of this magnitude has significant economic implications for aircraft manufacturers. Additionally, the immediacy of results from computational analysis means that designers are able to spend substantially more time focusing on new ideas instead of validating existing ones.

Similar advancements are resulting from a September, 2013 paper published by Leonardo Montealegre Lobo, of Instituto Costarricense de Electricidad, Jean

Mahseredjian, of École Polytechnique de Montréal, and Christian Dufour, of Opal-RT Technologies. I n this paper, they examined real-time simulations to test the electrical systems of aircraft, particularly MEAs. They examined Simulink and OPAL-RT Simulator to test the power system of the Bombardier Global Express (GLEX)[v].

In their paper, the trio noted the particular relevance of a full-systems approach to simulations when designing for MEAs. By developing a relatively complex testing methodology, they were able to more accurately model the various interconnected components of modern power systems. Similar to Dr. Petrovskaya's work, this study has enabled the improvement of computational models that will help to drive the further development of aircraft design tools.

The Continued Evolution of MEA Design and Testing Solutions

Although this existing research into design considerations and computational models for MEAs is promising, the industry needs to continue to invest into the further development of simulation and modeling capacity. One such upcoming investment is Applied Dynamics International's More Electric Aircraft Power Systems (MEAPS) Development Facility, which is proposed in an April, 2014 whitepaper. [vi] The intent of this project will be to enable high-fidelity simulation that can be combined with real aircraft power system devices and data to produce accurate simulation of various aircraft components.

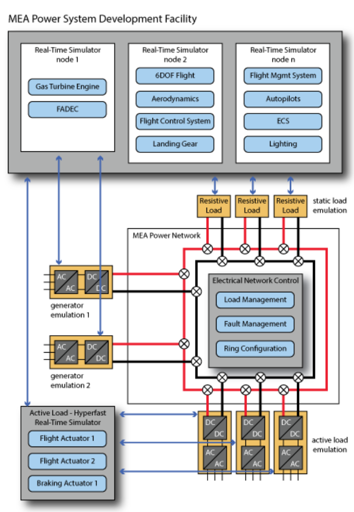

Figure 2: ADI's MEAPS Development Facility

This facility promises to be a new frontier in simulation for the power systems of MEAs. Derived from Applied Dynamics current technology and contribution to the MEA vision, the MEAPS Development Facility will be a state of the art system for testing and validating technology concepts and prototype for aircraft power systems.

For the MEA vision to be fully realized, careful design, testing and validation is necessary to ensure robustness and optimization of systems. However, the number of dependencies and interactions between previously discrete systems means that these phases of the development process are more challenging and potentially costly. Additionally, the added complexity of MEAs' systems means that the likelihood of undetected fault lasting into late development is greatly increased. The creation of purpose-built tools for MEAs can help to alleviate these problems and guarantee continuous forward progress toward the realization of a more efficient aircraft.

Maryruth Belsey Priebe

Maryruth can't help but seek out the keys to environmental sustainability - it's the fire that gets her leaping out of bed every day. With green writing interests that range from sustainable business practices to net-zero building designs, environmental health to cleantech, and green lifestyle choices to social entrepreneurism, Maryruth has been exploring and writing about earth-matters and ethics for over a decade. You can learn more about Maryruth's work on JadeCreative.com.

Sources

[i] Clark, N. (2006, December 11). *The Airbus saga: Crossed wires and a multibillion-euro delay - Business - International Herald Tribune*. Retrieved from The New York Times: http://www.nytimes.com/2006/12/11/business/worldbusiness/11iht-airbus.3860198.html?pagewanted=all&_r=0

[ii] Siemens. (n.d.). *Realizing technological excellence and breakthroughs in aircraft composite design using Siemens PLM Software technology*. Retrieved from Siemens PLM Software: http://www.plm.automation.siemens.com/en_us/about_us/success/case_study.cfm?Component=223155&ComponentTemplate=1481

[iii] Siemens. (n.d.). *Russian aircraft company reduces modeling time for new commercial airliner by 80 percent using LMS Imagine.Lab*. Retrieved from Siemens PLM Software:

http://www.plm.automation.siemens.com/en_us/about_us/success/case_study.cfm?Component=226384&ComponentTemplate=1481

[iv] University of Birmingham. (n.d.). *Case study: aircraft design at the Boeing Company*. Retrieved from University of Birmingham: http://www.birmingham.ac.uk/schools/mathematics/research/case-study-aircraft-design-at-boeing.aspx

[v] Lobo, L., Mahseredjian, J., & Dufor, C. (2013, September 3). *Real-time Simulation of More-Electric Aircraft Power Systems* . Retrieved from OPAL-RT Technologies: http://www.opal-rt.com/sites/default/files/technical_papers/EPE2013%20More%20Electrical%20Aircraft.pdf

[vi] Applied Dynamics International. (2014, April). *More Electric Aircraft Power System* . Retrieved from Applied Dynamic International: http://www.adi.com/wp-content/uploads/2014/04/meapsDevFacWeb.pdf