DIGITAL INDUSTRIES SOFTWARE

Achieving earlier virtual integration of aircraft systems

Executive summary

Although commercial and military aviation development has matured quite a bit, major challenges still exist. Looking at the current aircraft structural concepts, propulsion options and systems architecture, you can see that technology has revolutionized the process over the last 40 years, but current development concepts have nearly reached their limit. In order to respond to the many challenges related to tomorrow's air traffic demand, radical new technologies and concepts will be needed. The industry will face numerous challenges on a global scale, ranging from new public policies and regulations to changing individual values and more mobile lifestyles. Like other industries, aviation must also address the limited availability of energy resources while reducing its carbon footprint. Managing climate change, congestion and increased safety and security requirements will heavily influence future air transportation concepts. As the world economy becomes more interconnected, it is increasingly apparent that the industry as a whole must work together to develop the best possible air transportation concepts for future generations. To do this, the aviation industry needs a major paradigm shift. In short, the industry must reinvent itself.

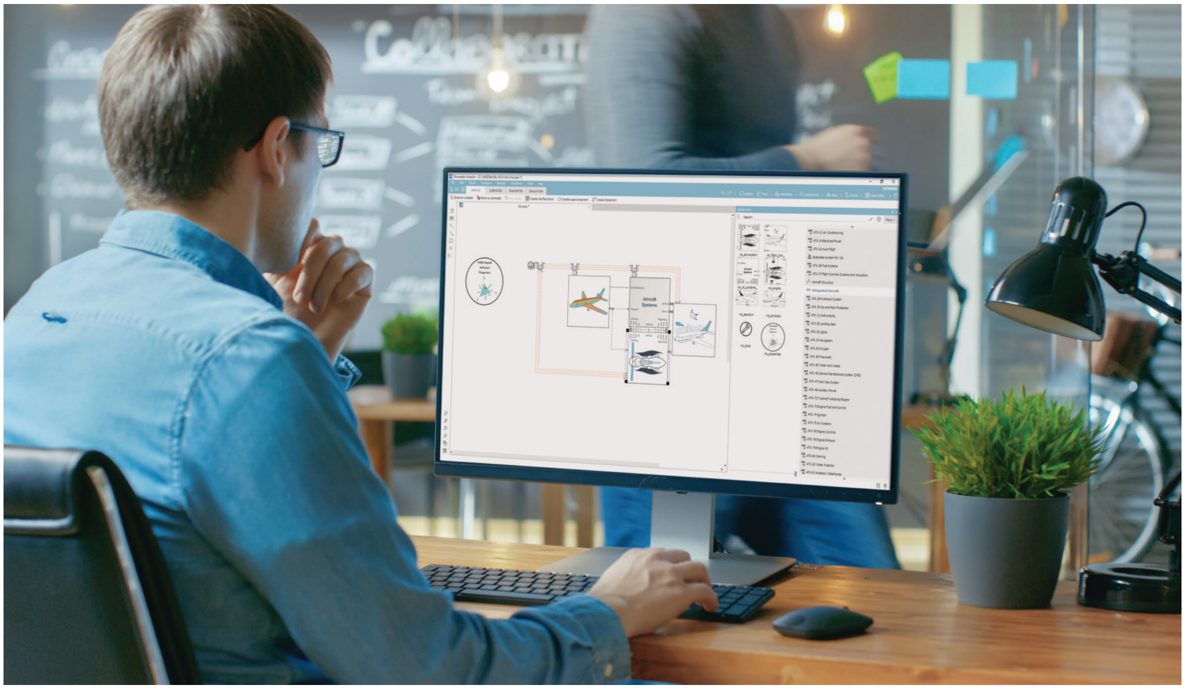
An industry in need of a paradigm shift

In the quest to design lighter, more economical and greener aircraft, system functions must become more integrated.

The aircraft community is pushing engineers to envision new design concepts and technologies. The resulting concepts are promising, but aircraft have become increasingly complex. How do you go about engineering and assembling the next generation of aircraft if we have difficulties with the ones we are manufacturing today? Luckily, we are already identifying the underlying integration issues: a higher amount of dynamic interaction between subsystems and an exponential increase in control software. To meet environmental legislation, there is a need to move to a more electric aircraft and new lightweight material such as composite. Challenge is issued from the fact that using more numerous electric equipment increase drastically heat loads. And most importantly, airline passengers are demanding more comfort and safety and a reduction in the carbon footprint.

The November 2010 Aviation Week article, “Design for Success – Systems engineering must be rethought if program performance is to improve” by Graham Warwick and Guy Norris captures the essential issues faced by aircraft industries when going from a complicated to complex aircraft management. Although everything you can think of is taken into account during the definition of an aircraft program, these programs often suffer major development delays and huge cost overruns. Indeed, one can roughly estimate that a one-year delay on a major commercial aircraft program creates an unforeseen cash burn of US $1 billion per year.

The major reasons for bad program performance can be attributed to the fact that engineering organizations are not set up to tackle the complexity of the current aircraft. In the past, manufacturing an aircraft was less complicated and involved fewer partners. Today, development is organized into a system-of-systems process that is split into subsystems. The development organization basically takes up each subsystem individually as a separate department. For example, in commercial aviation, the engineering divisions very often distribute the work according to the Air Transport Association (ATA) reference standard. For example, ATA 32 is landing gear and ATA 24 is electrical power. The entire aircraft development community, which most often includes risksharing partners (RSPs) in aerospace jargon, actually communicates through documents.



Simcenter Amesim provides a set of off-the-shelf physical libraries that can very easily be extended with a customer's own industrial property.

The issue is how this all works together: the whole does not necessarily equal the sum of its parts. Unlike a complicated system, a complex system is not devisable into a set of isolated subsystems. It is a system or unit itself. And this is the core of the issue. In the quest to make lighter, more economical and greener aircraft, the aircraft system function has become more integrated and interconnected with various onboard software programs that control the aircraft.

One can imagine that devising this complex system is quite a challenge, but the issue is designing a complex system that captures the dynamic or active integration of the various systems. Today the big issues are caused by dynamic interaction between systems, such as the power system, structure or controls. Unfortunately, the way the current engineering processes and organizations work does not offer a means to tackle this complexity. Dynamic interaction is not captured in document-based systems engineering. Proof of this can be found throughout the aviation community, a community of highly experienced and professional organizations that systematically suffer integration problems.

> “Systems engineering must be rethought if program performance is to improve.”
>
> Aviation Week

Adopting model-based design

With today's technology, there is a huge potential to improve engineering processes by implementing model based design approach. Product lifecycle management (PLM) systems, such as Teamcenter software from Siemens Digital Industries Software, can be used to capture and track requirements extremely early in the process and then continue to document the requirements and check compliance throughout the entire product lifecycle. The process starts with the bill-ofmaterials (BOM) and manages every change, keeping track of the requirement verification throughout the aircraft subsystems until the integrated system testing processes.

On the systems and structural engineering level, scalable multi-domain engineering tools such as Simcenter System Simulation solutions can be used to implement a model-based design approach and capture the complexity of aircraft systems from the component level to the aircraft system level.

Engineering a system is all about understanding how the different physical phenomena affect a product's functionality under normal and abnormal conditions as well as throughout all operational cycles. Clearly, a subject like aircraft complexity mandates engineering tools that are truly multi-domain.

Developing a typical aircraft system often requires mastering structural, mechanical, electrical, hydraulic, pneumatic, thermal and controls engineering. Simcenter Amesim™ software captures the various physics domains in an integrated way, addressing both physics and dynamic interaction. The tool provides a set of off-the-shelf physical libraries that can easily be extended with the customer's own libraries.

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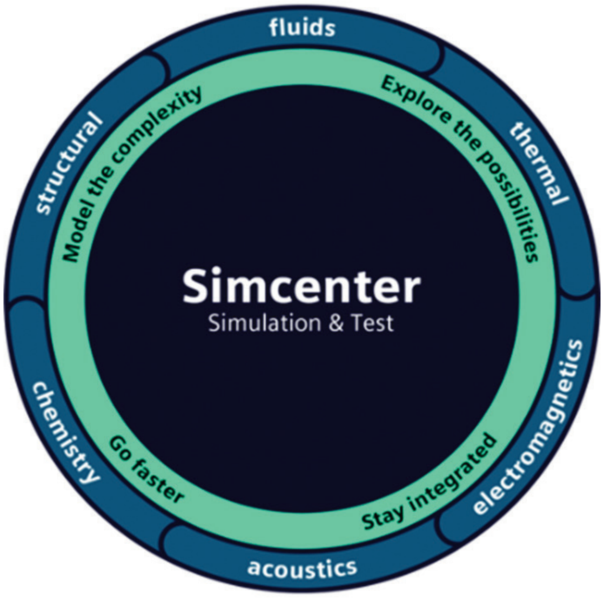


An additional requirement to initiate the shift from document-based to model-based systems engineering is to provide a systems integration environment you can use to integrate and simulate subsystems on the aircraft system level. Indeed, when you want to capture the actual dynamic interaction as soon as possible during concept development and detailed system design, you must consider how the systems would interact in the real world.

The industry recognizes there is a huge potential to conquer integration issues by front-loading systems integration testing using virtual testing strategies. This typically requires integrating a multitude of models of a heterogeneous nature. Simcenter system simulation solutions allows engineers to perform exactly these types of integration tests.

Siemens Digital Industries Software has implemented dedicated functionality for the virtual integrated aircraft (VIA) which covers all the V cycle from early design stage to Harware-in-the-loop and virtual iron bird. And now with new information technology (IT) capabilities, the different ATA departments will be able to bridge the departmental gap and check whether one integrates well within the system environment as a whole. We strongly believe that this change in process will prevent problems with aircraft systems integration by identifying detrimental dynamic interfacing issues sooner.

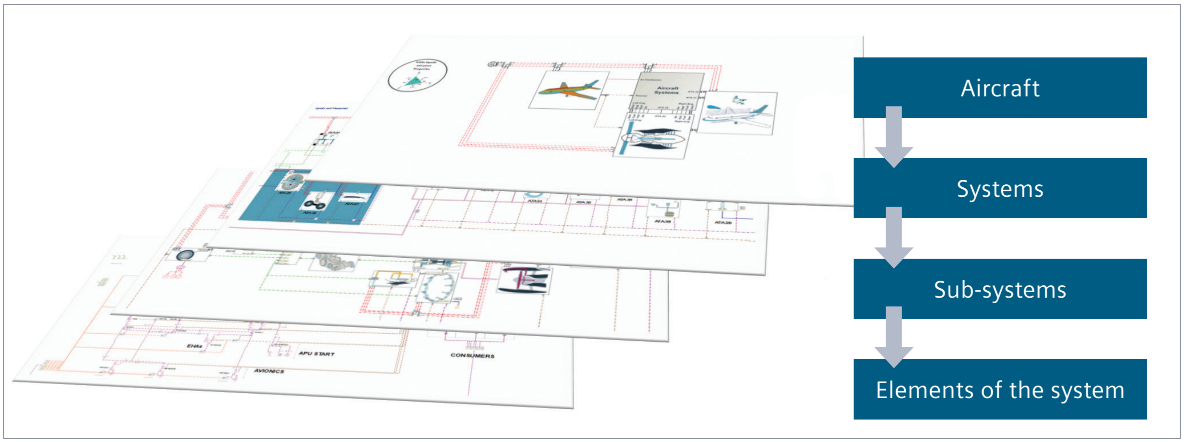
Benefitting from enhanced integration

Designing the modern-day aircraft with more electrical systems requires a bigger electrical power system. Inherent in every electrical system is the need to dissipate heat. The environmental control system (ECS) ensures the correct ventilation and cooling of the aircraft, the cabin and its systems.

This represents a change from previous aircraft architecture. Safe operation of the electrical system powering critical functions inherently depends on the availability of the appropriate cooling. In the past, these systems were seen as quite separate.

With aircraft that has more electrical components, neglecting the dynamic interaction between the environmental control and electrical system will open the door to more potential integration problems.

Today, aircraft architecture needs to inherently reflect not only the dynamic interaction and the physical systems, but also performance factors, such as fuel economy, safety, emissions and cabin comfort.



Composition of a virtual integrated aircraft.

A partially integrated aircraft model integrates the air system, including the ECS, the electrical system, the two engines, the auxiliary power unit (APU) and the fuel system. The model is completed by accounting for thermal balance in the structural block where heat flows are gathered.

Interaction between the major subsystems in the integrated model is defined by interface contracts, standardizing communication protocol between departments. And behind each ATA model is a multi-level, detailed physical representation of the individual ATA system.

With an integrated model, aircraft architects can work in a collaborative system environment and check the impact of system architecture choices on a total system level. They can make decisions to balance an aircraft's energy usage and thermal system. This often affects fuel consumption. Using this system-level approach and complementing it with physical system modeling will lead to smarter decisions, better choices and, ultimately, superior products.

Conclusion

Clearly, model-based design with system simulation is becoming increasingly important in the field of aircraft development. This approach will enable engineers to accelerate the requirements definition process and design to certification-level performance. It is the best route for achieving earlier aircraft maturity and a reliable way to reroute integration issues that the industry currently faces.

The good news is that there are tools out there to help the industry initiate the engineering methodology shift; tools that will let engineers represent all the physics in an aircraft, such as structural, mechanical, fluid, electrical, thermal and simulate their dynamic interactions. These tools address the component level up to system level, and can be integrated into a PLM process.

Ideally, system simulation allows a product to evolve in the best-possible manner throughout the development timeline, from the early concept phase until final verification and into the in-service cycle. This approach is the answer to close the loop between physical and digital world, enabling true collaborative engineering processes throughout the extended enterprise of the aviation industry.

Siemens Digital Industries Software

Americas: 1 800 498 5351

EMEA: 00 800 70002222

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