Ansys

SIMULATION SOLUTIONS FOR AVIATION: ELECTRIC PROPULSION SYSTEMS

/ SUSTAINABILITY IS CHANGING COMMERCIAL AVIATION—AND OPENING NEW DOORS

The commercial aviation industry adds more than one billion tons of CO2 to the atmosphere per year, and as global air travel increases in the years ahead, that figure is likely to rise even higher. There have been attempts to reduce that figure by decarbonizing existing fuel sources and creating alternatives, such as sustainable aviation fuel (SAF), a biofuel with a smaller carbon footprint than traditional jet fuel. Those efforts alone, however, are unlikely to have enough of an impact on emission levels to achieve the industry's long-term sustainability and emissions goals. This has led the industry to explore alternative propulsion systems likelier to help it reduce its environmental impact in the decades to come. At present, there is no singular, sustainable propulsion solution for commercial aircraft. Hybrid-electric, hydrogen, and electric systems each show significant promise, but it will be years (decades, in some cases) before these systems are ready for commercial flight. Commercial aviation manufacturers must therefore develop each type of propulsion system on their own discrete timelines.

All-electric systems have shown less maturation than hybrid-electric systems and will require additional research and development going forward. To offset issues arising from the batteries' energy density, engineers must improve their storage capacity and efficiency significantly to make an all-electric system viable onboard a long- or even medium-range commercial flight.

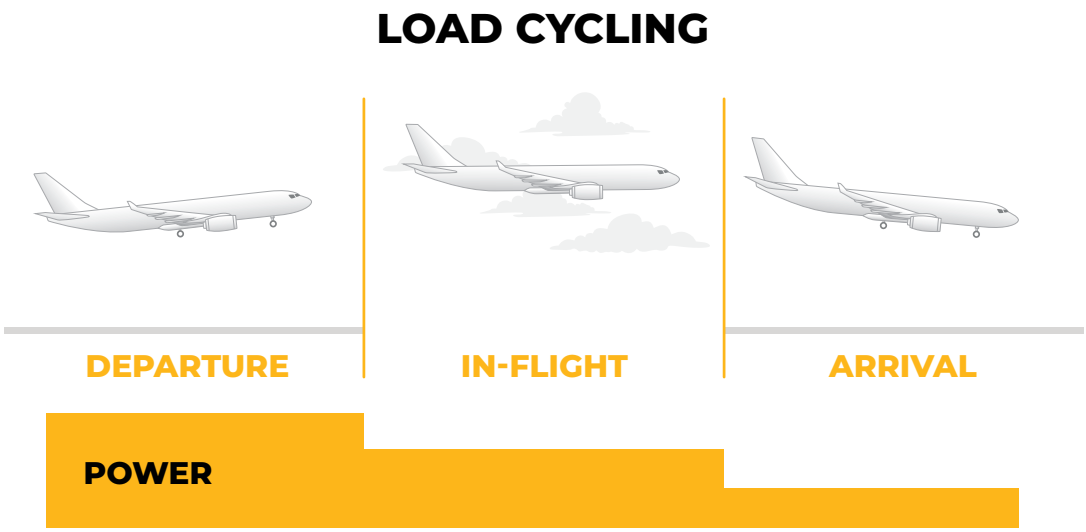
But large commercial aircraft won't be the only home these systems have. As they proceed, manufacturers will also be able explore other markets and applications for them. Electric vertical take-off and landing (eVTOL) vehicles are one such example. These smaller, highly automated aircraft are designed for Advanced Air Mobility (AAM), that is, they transport passengers or cargo at low altitudes over short distances. The development of all-electric propulsion systems will be an enabler for eVTOL vehicles, which will be viable for passenger flight far sooner than an electric, long-range commercial aircraft. In fact, eVTOL vehicles represent a significant opportunity for smaller companies to jump into the new market as a result of those vehicles' existing feasibility.

/ ELECTRICAL SYSTEM DESIGN CHALLENGES

All-electric aircraft propulsion systems present multiple engineering challenges. Often, these challenges arise because of the systems' competing requirements. Engineers must make tradeoffs throughout the design process to satisfy those requirements while optimizing the system's safety and efficiency.

Electric machine design offers a glimpse into the complexity and importance of these tradeoffs. Electric propulsion systems must, for example, generate enough power to function effectively in different power configurations throughout the flight cycle. But the more power a design produces, the more heat it creates. Without an effective cooling system, this heat can degrade materials, affect system performance, and even require the motor to be replaced. This kind of give-and-take occurs throughout the design process. It is essential that engineers deliver designs that balance these kinds of tradeoffs and perform effectively as they cycle between the different power configurations required for takeoff, flight, and landing.

Managing energy storage and distribution is another design issue engineers must contend with. Today's batteries store energy at relatively low densities, which means more batteries are required to power larger aircraft. But adding more batteries to generate more power adds a substantial amount of weight to the aircraft, which limits their range. It's one reason why these systems are currently only viable for smaller short-range aircraft such as eVTOL vehicles. In addition to designing batteries capable of storing enough energy to power an aircraft, engineers must ensure that the system's power management controls safely regulate energy discharge and mitigate risks to batteries, cables, connectors, and the motor during operation. Design tradeoffs will also influence subsystem design concepts and their requirements. Material selection is also an important component of engineering and can be a source of innovation and differentiation. But materials can be expensive, and the choice of the material influences the product through its entire life from design, the type of manufacturing process, its robustness (life expectancy), and ultimately its recyclability. This makes the ability to identify better materials earlier in design a meaningful advantage for aviation companies



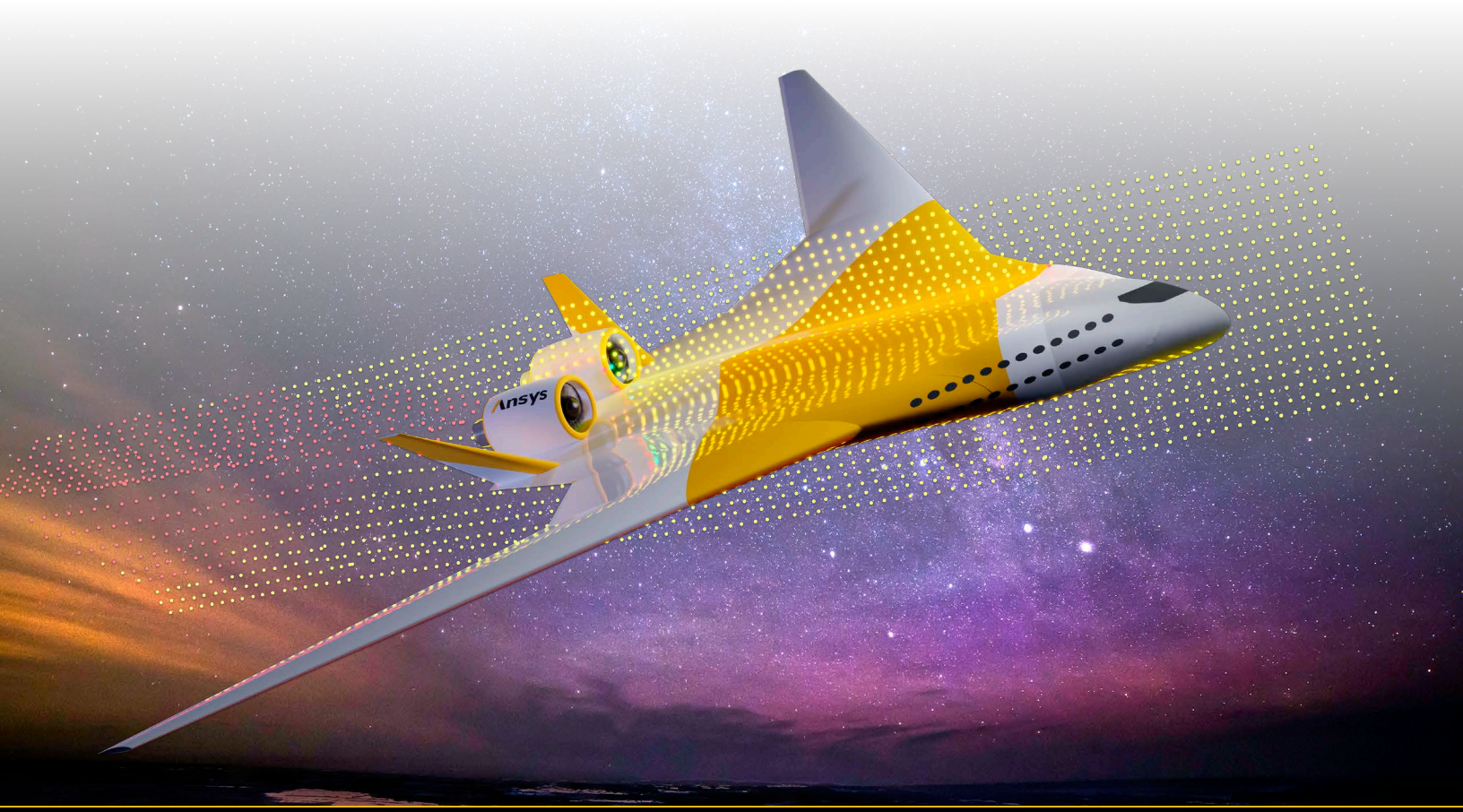
/ Electric propulsion systems must be designed to withstand the stress ofrepeatedly cycling between the multiple power configurations required by an aircraft's flight cycles.

/ ADVANTAGES OF SIMULATION CAPABILITIES

Engineering simulation solutions provide engineers the opportunity to evaluate system behaviors much earlier in the design process than the traditional prototyping and testing approach allows. With insight into the system's electromagnetic, thermal, and mechanical performance, engineers can make better-informed design decisions well before the first prototype is built, which improves product quality. These capabilities also speed up development and allow engineers to produce innovative designs (and progress toward certification) much more quickly and efficiently than would otherwise be possible.

Not only can simulation simplify and quicken the prototyping and testing process, it can also play an important role from the earliest stages of design. By gathering and analyzing feedback on the system's performance as they design, engineers can identify and address flaws well before the design is set. These benefits extend to the energy storage challenge as well. Engineers can simulate battery performance to better understand how flight and charging cycles affect batteries' longevity and inform the economics of replacing them. They can also simulate energy discharge to ensure that the system's other components are not unduly affected by the variations in power draw.

Simulation also makes identifying optimal materials, sub-systems, and components for mechanical and electrical design (and ensuring they perform effectively) far more efficient. This results in an improved initial design and greater opportunity for innovation, as engineers are more free to experiment with changes throughout the process. Exploring and optimizing the design space is one example of this kind of innovation, but engineers can also use simulation to mitigate performance issues and safety risks and advance the maturation of the technologies these propulsion systems rely upon.



/ ANSYS ADDRESSES ELECTRICAL SYSTEM DESIGN CHALLENGES

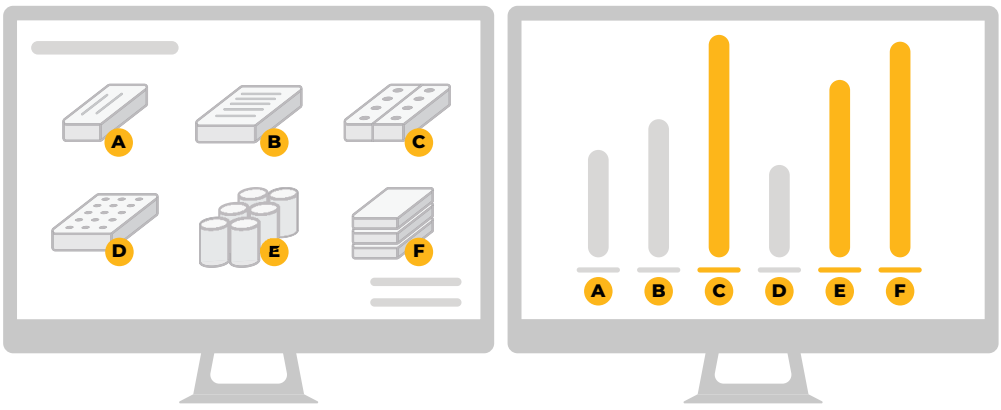
Ansys solutions offer engineers the simulation capabilities they require to overcome the design issues inherent to all-electric propulsion systems. Using Ansys tools, engineers can quickly optimize electric machine designs and develop battery systems that safely and effectively power an eVTOL or other all-electric aircraft.

In addition to providing design templates that can serve as the starting point for evaluating numerous electric machine concepts, Ansys solutions also allow engineers to simulate system performance across a range of harsh conditions as the design process moves forward. Using data from these simulations, they can then fine tune design tradeoffs and address any related issues well before prototyping and testing is required. Additionally, engineers can use simulation data to identify and propose improvements to discrete subsystems such as the system's cabling and electromagnetic interference (EMI) filters, improving robustness and therefore reducing the likelihood of failures. When engineering teams can confidently verify their choices and design selection early in development, they can shorten the process and achieve even more significant innovations.

Energy storage and distribution difficulties can also be overcome using Ansys solutions. From materials selection to optimizing electrochemical performance, these solutions allow engineers to design batteries equipped to handle the energy demands of all-electric propulsion systems and integrate effectively with the drivetrain. The solutions' integrated battery management system design software also offers quick, efficient systems development, testing, and verification. Engineers can even simulate a battery's performance across its entire lifecycle to better understand how charging cycles and other factors affect its lifespan.

Ansys tools not only reduce friction throughout the design process, but they also allow companies to produce more fully optimized prototypes that reduce testing costs and get systems — and the aircraft they power — to market more quickly, a crucial advantage in what is sure to be a highly competitive space.

BATTERY OPTIONS



/ Design teams can use Ansys solutions to optimize a battery's multiphysics performance to determine an optimal structure and maximize its efficiency and lifespan.

/ RECAP AND TAKEAWAYS

The commercial aviation industry is entering an era of change and innovation. Driven by a need to improve aircraft sustainability, industry manufacturers must develop more environmentally friendly propulsion systems in the decades to come. As they do so, it is essential that these companies make sound, data-driven engineering decisions by leveraging digital simulation solutions to optimize the performance of the new systems and accelerate their development.

Key Takeaways

- To discover the most viable propulsion solution for different markets and applications, industry manufacturers must develop new hybrid-electric, hydrogen, and all-electric propulsion systems on discrete timelines.
- The multitrack, multitimeline approach will allow manufacturers to explore other applications for all-electric systems, such as highly automated eVTOL vehicles capable of short-distance flight.
- Electric machine design is one technical challenge facing engineers as they develop electric propulsion systems. Engineers must carefully manage design tradeoffs to ensure that the system works optimally for the majority of the flight cycle but can also sustain itself when higher energy loads are required, such as during takeoff or while maneuvering.
- Managing energy storage and distribution is another significant technical challenge when developing electric propulsion systems. To optimize safety and performance, engineers must identify the most effective materials for the system's construction, determine the best way to store and extract energy, and manage the batteries' thermal and electrochemical performance.
- Open and flexible digital engineering workflows from Ansys provide the interoperability that enable aviation companies to efficiently collaborate throughout the full design and development process. This enables cross-functional teams to amplify the benefits of simulation as they explore and disrupt new markets.

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When visionary companies need to know how their world-changing ideas will perform, they close the gap between design and reality with Ansys simulation. For more than 50 years, Ansys software has enabled innovators across industries to push boundaries by using the predictive power of simulation. From sustainable transportation to advanced semiconductors, from satellite systems to life-saving medical devices, the next great leaps in human advancement will be powered by Ansys.

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