OPAL-RT TECHNOLOGIES

ELECTRIFYING FLIGHT

magniX

APPLICATION

- Electric Motors and Aircraft

RELATED PRODUCTS

- RT-LAB
- eHS | FPGA-Based Power Electronics Toolbox
- OP5707

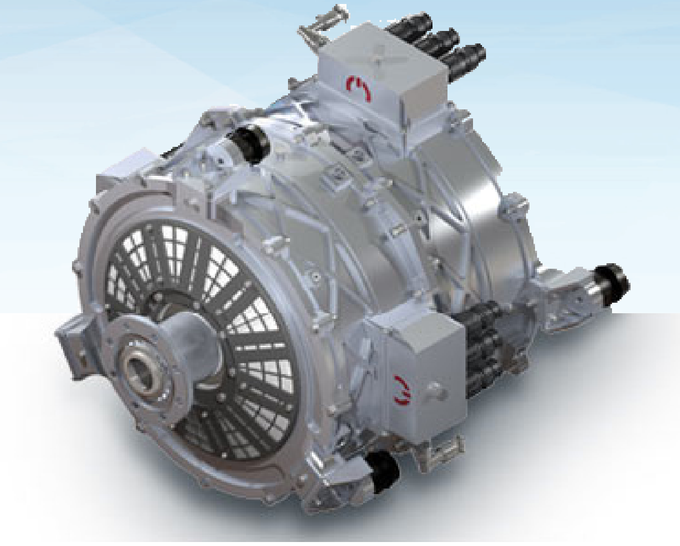
TYPE OF SIMULATION

- Hardware-in-the-Loop (HIL)

SUCCESS STORY

INTRODUCTION

Commercial aviation is one of the world's most regulated industries due to stringent safety requirements placed on it by its governing bodies. For this reason and those of economy and risk, sea changes do not happen very often in the area of commercial airplane design. While the automotive and transportation industry is being electrified rapidly, the idea of electric passenger aircraft has long been considered both technically and commercially unfeasible.



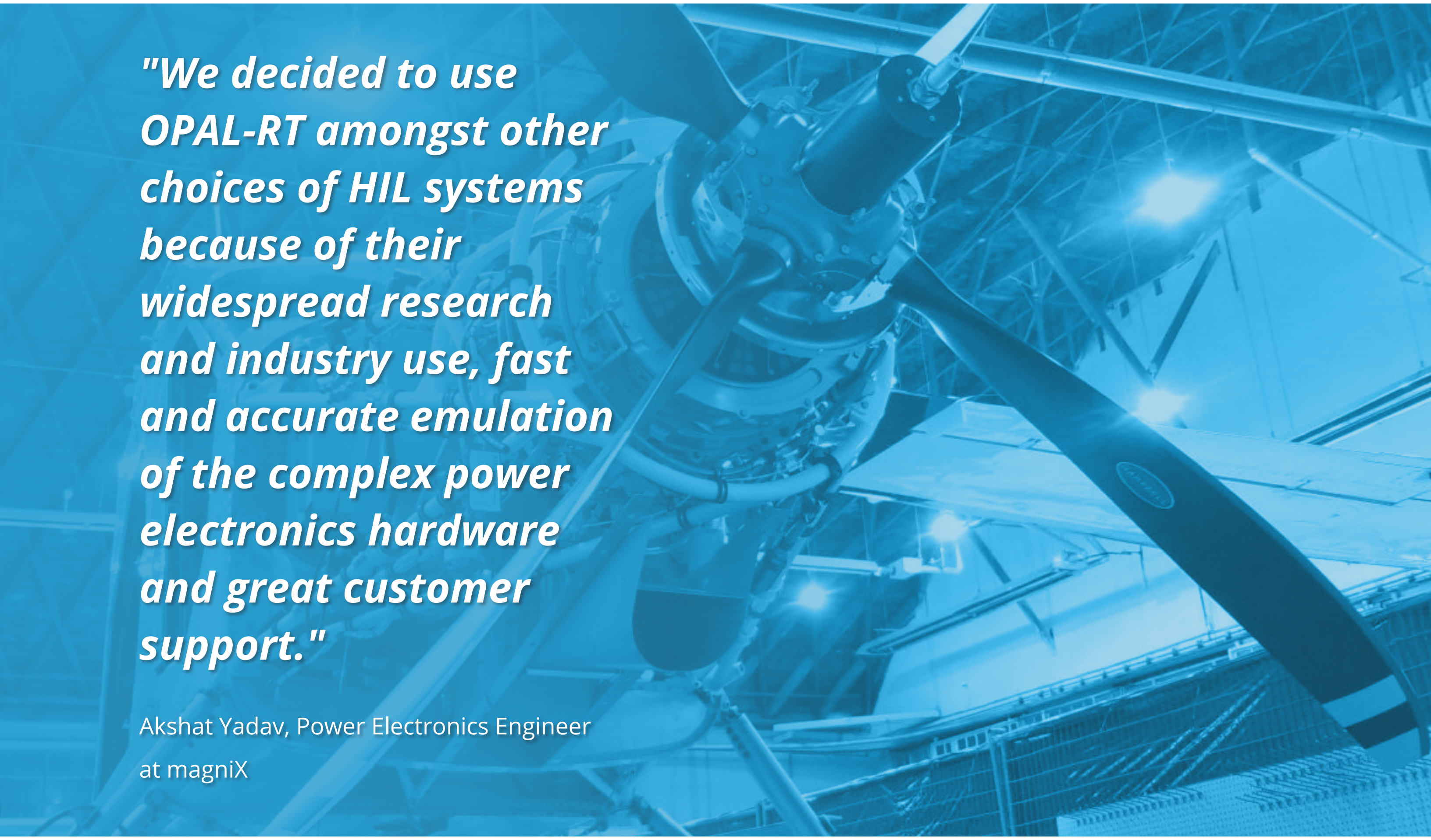
magniX's magni500 electric aircraft motor

That was until December 10, 2019, when electric motor manufacturer magniX and Harbour Air Seaplanes made history in Vancouver with the first commercial electric airplane flight test. The historic seaplane consisted of a modified de Havilland DHC-2 Beaver, powered by a 560kW electric propulsion system from magniX. While the maiden flight of the eBeaver lasted only fifteen minutes, it generated world headlines marking an important advancement in a carbon-heavy sector and a sign of potential things to come.

First Flight of eBeaver

On May 28, 2020, less than six months after the historic eBeaver flight, magniX built on their earlier success, this time test flying an electrically-propelled Cessna 208B Grand Caravan, a considerably larger plane than the DHC-2. (The eCaravan, meanwhile and for context, is capable of flying 4-5 passengers 160 kms (100 miles) today.)

Several recent technological breakthroughs are contributing to making electric airplanes like the eBeaver and eCaravan a reality. The first, which is magniX's primary specialty, was the development of highly optimized and power-dense electric motors capable of generating the thrust required for flight. The second has been the rapid advancement of power electronics efficiency, operating voltages and heat tolerance. The last, and the most significant constraint facing electric airplanes, is the status quo of battery technology. In comparison, jet fuel is over 40 times more energy dense than lithium-ion batteries, which adds significant weight and limits the total flight time. It is for this reason that short regional routes like those flown by Harbour Air are an ideal first market segment.



"We decided to use OPAL-RT amongst other choices of HIL systems because of their widespread research and industry use, fast and accurate emulation of the complex power electronics hardware and great customer support."

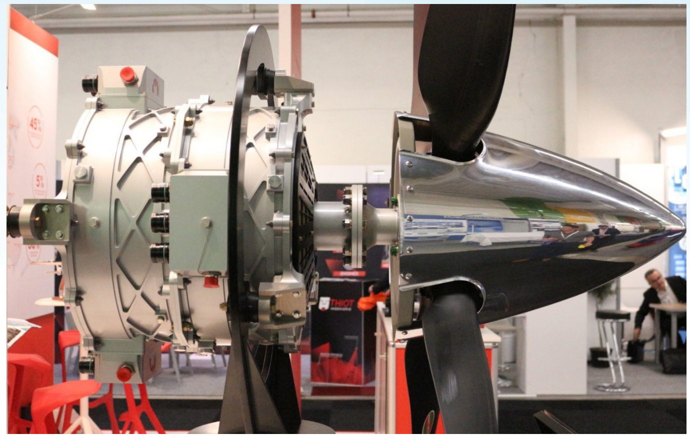
Akshat Yadav, Power Electronics Engineer at magniX

OBJECTIVE/CHALLENGES

For both the eBeaver and eCaravan projects, one of magniX's objectives was to rapidly test the electric propulsion controller software in preparation for test flights. To meet this challenge, both motor and inverter hardware were simulated using the OPAL-RT real-time simulator, so that the control software running on the prototype controller module could be integrated and validated.

magniX has made some modifications to the standard turbine engine as well while porting it to electric. In addition to redundant channels, they have engineered a way out of the traditional heavy gearbox required to translate movement traditionally from the motor to the propellors.

The strengths of real-time simulation for pioneering projects such as these are many and immediate: simulation enables users to analyze feasiblity and to make iterative changes to variables and witness their effect on the results. This can be done virtually, before the first physical modifications to the hardware must be made.



magniX's 750-hp electric motor

"The objective was to test the control software designed for the flight in a very short period of time. OPAL-RT systems helped in the rapid modeling and emulation of hardware used for the verification and validation of the software."

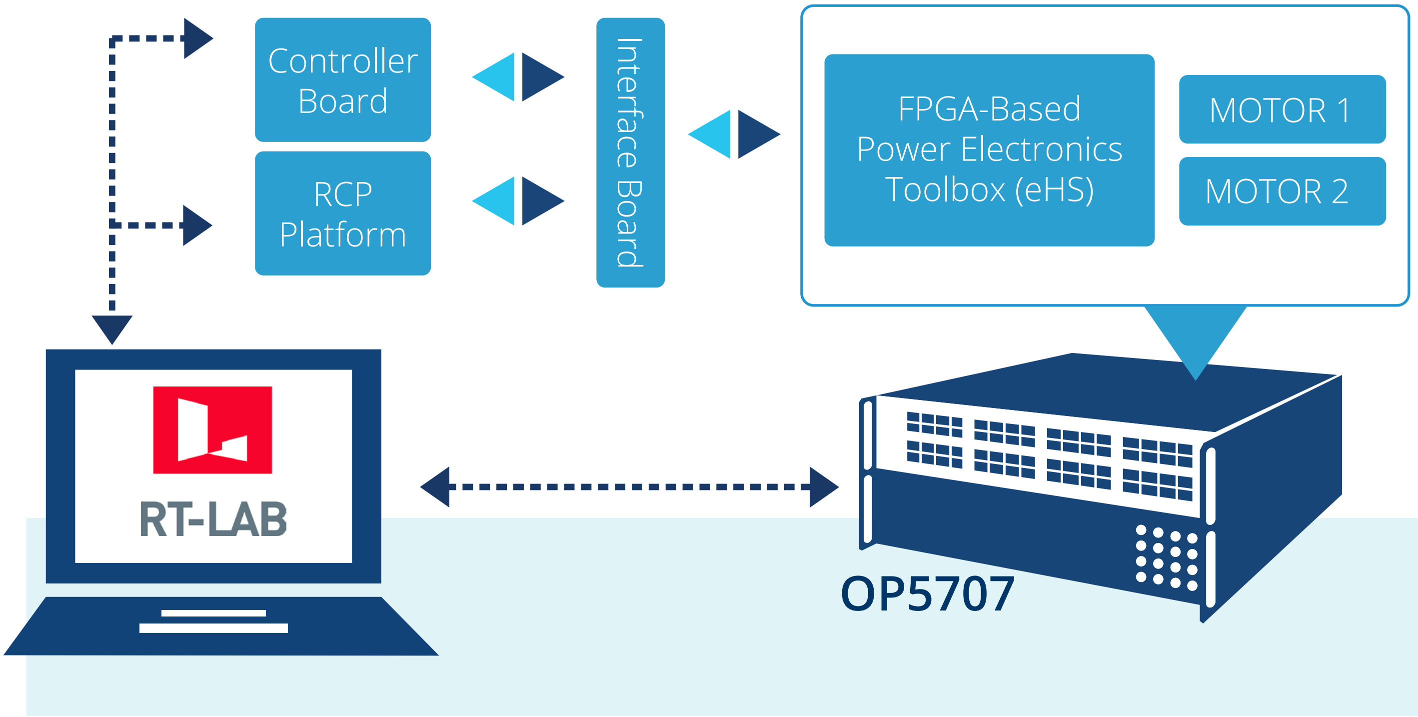
Akshat Yadav, Power Electronics Engineer at magniX

SOLUTION

The plan was to start with the emulation of a simple R-L (resistor, inductor) load model to start the hardware/software integration and move to integrate the complete motor model. The R-L load model was created using the FPGA-based Power Electronics Toolbox (eHS) running at a time step of less than 400 ns emulating in real time an inverter model with connected RL load.

The eHS toolbox provided access to real-time measurement of various essential parameters. After the successful integration of the controller with the R-L load, the actual motor model was integrated in the system. The motor model supplied within the toolbox gave access to various motor parameters which provided an insight into the functioning of the software, essential for the validation and verification.

The Python-based API helped to automate the testing to save a lot of time and reduce human error. The OPAL-RT simulator helped in the rapid modeling and emulation of complex power electronic systems and helped in fixing software bugs in the initial stage of the development.



magniX used an OP5707 with OPAL-RT's FPGA-Based Power Electronics Toolbox (eHS) to simulate their magniDrive inverters and magni-Series motors for controller development and testing.

RESULTS

The iterative development and HIL validation using the OPAL-RT system helped develop and validate the control software for the magniDrive inverter which was integrated in the magni500 propulsion system. This propulsion system helped propel the world's first commercial electric aircraft (eBeaver) and the world's largest all-electric commercial aircraft (eCaravan).

One of the strong points for electrical aviation remains: the power cost for the eBeaver's 30 minute flight was approximately $8.20. The standard beaver's fuel cost for the same flight would be approximately $135.00.

magniX decided to use OPAL-RT among other choices of HIL systems because of their widespread research and industry use, fast and accurate emulation of the complex power electronics hardware and great customer support. During the setup and installation, the OPAL-RT team was very supportive and responsive.

"During setup and installation, the OPAL-RT team was very supportive and responsive. The connectors and peripherals provided by OPAL-RT were seamless and easy to integrate with the control module and the measurement units. The documentation, examples and training provided by OPAL-RT helped to set up the system in no time."

Akshat Yadav, Power Electronics Engineer at magniX

magniX team in the hangar after its successful first flight. The eBeaver in the back.