SIMULIA
COMMUNITY NEWS

#**19** May 2018

ELECTROMAGNETICS
POWERING INNOVATION

COVER STORY
TactoTek

DASSAULT SYSTEMES | The 3DEXPERIENCE® Company

In this **Issue**

May 2018

Contributors: TactoTek, UMass Lowell, Airbus Defence and Space, Luceda Photonics, Parker Group

On the Cover: Sini Rytky, Vice President of Product Management and Anne Isohätälä, Antenna Specialist, TactoTek
Photo by Petri Mast Photography, Finland.

SIMULIA Community News is published by Dassault Systèmes Simulia Corp., 1301 Atwood Avenue, Suite 101W, Johnston, RI 02919, Tel. +1 401 531 5000, Fax. +1 401 531 5005, simulia.info@3ds.com, www.3ds.com/simulia
Editor: Tad Clarke **Associate Editor**: Kristina Hines **Graphic Designer**: Todd Sabelli

VISUALIZING THE UNSEEN

You can't see, hear or feel radio waves as they race around you—and through you—but these high-frequency electromagnetic (EM) waves are what connect you to the world's information. EM simulation is the art of calculating electric and magnetic fields, making their behavior visible to the engineer.

You, our customers and future customers in electromagnetic design, create devices that push communication to the next level, with 5G and the internet of everything. You make cars electric and driving autonomous and produce medical devices that can not only see inside the human body but treat diseases such as cancer. You invent new green solutions to the problems of energy and the environment. From the heart of the city to the depths of space, EM devices are everywhere, and simulation is key to their design.

One potential but significant risk is that the EM fields surrounding us can interfere with other devices and wreak havoc—even the brief spark of a static shock can be enough to destroy a microchip. Identifying and mitigating these kinds of problems is a growing application of EM simulation.

Electromagnetics is integrated with almost every other area of physics. As your microwave oven can attest, electric currents and high-frequency waves can heat material considerably, while anyone who has ever raced between cities on a high-speed train has experienced the tremendous forces motors and magnets can generate. Thermodynamics, mechanics, optics, particle physics, materials science, biological physics—all of these branches of physics have crucial overlap with EM.

CST—Computer Simulation Technology—was founded in 1992 to tackle precisely these kinds of problems. Since joining the Dassault Systèmes' brand SIMULIA in 2016, we've found synergies between our EM simulation tools and the other simulation and design tools on the **3D**EXPERIENCE platform. In this edition of the SIMULIA Community News you'll find articles covering a wide range of EM simulation and multiphysics co-design topics.

The examples in this magazine cover both some obvious applications of EM simulation and some that might be more unexpected. It will probably come as no surprise that satellites require high-performance microwave components, and on page 15, you'll find an article based on an interview with Paul Booth at Airbus Defence and Space where he discusses how simulation and additive manufacturing can be combined to develop custom devices that couldn't be assembled conventionally. Articles featuring Sini Rytky and Anne Isohätälä at TactoTek (page 7) and the NextFlex 2.5 team at the University of Massachusetts Lowell (page 24) meanwhile show how electronics can be seamlessly integrated into components and even bend, twist and stretch.

This magazine isn't just about what has already been done; it also highlights what's to come in the field of electrical engineering. Professor Claudio Paoloni of Lancaster University explains his work to produce a new innovative type of amplifier to enable the upcoming fifth generation (5G) of mobile communication (page 25), while CST engineer Christian Kremers demonstrates how EM simulation can be used to design electric vehicles that can charge wirelessly on the road (page 13).

Intrigued by the applications mentioned so far? Learn more about the principles of EM simulation, as CST's head of R&D and managing director Peter Thoma explains the state of the art in the Future Outlook (page 5) and Brian Woods, director of the CST subsidiary Magus, offers a practical example of design democratization with the tool Antenna Magus (page 25).

From all of us who've helped put together this issue, we hope you enjoy reading.

Best wishes,

BERNHARD WAGNER,
CST Managing Director

DASSAULT SYSTEMES COMPLETES ACQUISITION OF EXA CORPORATION

Enhancing the Value of CFD and Multiphysics Simulation through Industry Processes

Have you ever heard the expression, "The whole is greater than the sum of its parts?" It's the idea that the connection among individual elements offers more value than each one could alone—a concept also known as synergy. At Dassault Systèmes, we are passionate about connecting the dots between technology domains, and the ability to visualize the "bigger picture" is integral to our company culture.

We are on a journey to strengthen our technology strategy from connecting dots to providing seamless technology connections that revolutionize our customers' innovation processes. Our goal is to create synergy among all of our product offerings, bringing them together to provide more value than they could on their own. This includes expanding and enhancing our multiphysics / multiscale applications for Industry Processes on the **3D**EXPERIENCE platform.

Exa Corporation is the market leader in providing proven, industrialized solutions for highly dynamic fluid flow. Their solutions are mission-critical for applications including aerodynamics, thermal management, aero-acoustics, and multi-phase flow through porous rock. They are adding value to the SIMULIA simulation portfolio with their patented fluid flow/CFD solver, Digital Physics, based on the Lattice Boltzmann method, which they launched in 1991. Their portfolio of applications, including the main product, PowerFLOW, is validated with every physics release using highly complex benchmarks, along with test cases from industry partners.

GAIN CRUCIAL INSIGHTS

PowerFLOW and the related Exa products enable engineers and designers to augment or replace conventional methods of evaluating design alternatives that rely on expensive and inefficient physical prototypes and test facilities, such as wind tunnels used in vehicle design, with accurate digital simulations that are more useful and timely. These modeling, simulation, and visualization applications enable customers to gain crucial insights about design performance early in the development process, reducing the likelihood of expensive redesigns and late-stage engineering changes. As a result, customers realize significant cost savings and fundamental improvements in their vehicle development process.

The Exa team also brings significant experience and expertise in providing their software on the cloud. They provide secure, web-based access to their complete simulation suite anywhere, at any time. ExaCLOUD provides access to a virtual, secure, high-performance computing facility.

Over time, we will integrate the PowerFLOW suite of products into our Industry Solutions on the **3D**EXPERIENCE platform. This will expand the business value of simulation as we extend the application of SIMULIA Fluid Dynamics into many new industry processes. Our new colleagues from Exa share with us the same values and passion for technology leadership, best-in-class solutions, innovative technologies, and user-focused relationships with superior technical support.

Our combined teams will be working closely with our customers to help you apply our technology to transform the innovation process and achieve your engineering and business goals.

"Both Dassault Systèmes and Exa believe in the value of an integrated focus on science and industry. It is a critical part of our commitment to delivering **3D**EXPERIENCE universes that harmonize products, nature and life."

Bernard Charlès, Vice Chairman and CEO, Dassault Systèmes

For More Information
www.3ds.com/products-services/simulia/products/exa-powerflow

ELECTROMAGNETIC SIMULATION ON THE 3DEXPERIENCE PLATFORM

Electromagnetics (EM) is the field of physics concerned with electric and magnetic fields. The foundations of this field, Maxwell's equations, were laid over 150 years ago, but the solutions to these equations are still crucial to understanding the behavior of any product with EM components, from a telephone to a particle accelerator.

More broadly, there are numerous connections between EM and other fields of science. Motors and magnets produce forces and torques. Electric currents generate heat, which implies a link to thermodynamics. Electronics rely on the properties of semiconductors described by solid-state physics, while batteries produce a voltage due to chemical effects. EM is, therefore, a key part of the multiphysics simulation tool box.

CST helps engineers meet the challenge through our complete technology for 3DEM approach to simulation. We built a platform for the EM space with a large number of general purpose and specialized EM solvers, the ability to hybridize them, and to consider thermal effects and mechanical stress. This allows users to simulate complex systems with many components and consequently many physical effects in a straightforward workflow, without the costs and overhead time associated with switching between different software applications.

"Since joining the SIMULIA family, we've been able to take this further with CST POWER'BY **3D**EXPERIENCE," says Peter Thoma, Managing Director for Research & Development at CST. "Electromagnetism is just one field of physics, and as devices become smarter and more connected, their EM properties are increasingly entangled with other considerations such as mechanical performance, material properties, aerodynamics and product design. The **3D**EXPERIENCE platform provides software solutions that allow collaboration for all these disciplines."

THE FUTURE OF TRANSPORTATION AND MOBILITY

The rise of autonomous vehicles and electric mobility demonstrates the importance of EM and multiphysics simulation. A typical autonomous electric vehicle has numerous components and subsystems interlinked in a complex network of interdependencies, and there are numerous trade-offs made in order to optimize vehicle performance. Minimizing the electromagnetic inference (EMI) emitted by the device while ensuring immunity to external EMI is one of the key considerations.

Let's start with the battery. Its electrochemical properties need to be balanced against its thermal safety and its crashworthiness. The **3D**EXPERIENCE platform enables access to the BIOVIA Materials Studio, to simulate the chemistry and thermal runaway of the battery, and other SIMULIA applications to calculate the structural integrity. Wireless battery charging will increase the usability and acceptance of electric vehicles (EV). Electromagnetic simulation helps to improve efficiency and operational safety of charging devices and procedures.

An autonomous car needs to be aware of its surroundings. There are navigation systems such as GPS, GLONASS and Galileo to determine the current position and plan the route to the destination. The immediate environment of the vehicle can be monitored by radar systems. Vehicle-to-vehicle (V2V) and vehicle-to-everything (V2X) communication systems gather information about potential threats and optimize traffic flow, enabled by the 5G communication standard that powers the Internet of Everything.

Electric pulse on a cable harness inside an electric vehicle

Future Outlook

"All wireless communication requires antenna systems, and if we add devices supporting multimedia to the list above such as keyless entry, radio and personal communication, there are dozens of antennas on a single vehicle," says Thoma.

Every antenna individually has to fulfill its specifications, but it is not sufficient to do so in isolation. It has to work inside the product it is designed for and be matched and optimized for the place it will be installed. There might be design constraints to follow, the shape of a car body or the space in a home multimedia device, and every design change may strongly influence the performance of the antennas. In addition, all of the antennas must operate together at the same time. The co-site interference depends on the car body and the installation place.

PICKING THE RIGHT ANTENNA

Antenna design is a specialist job that requires a deep knowledge of electromagnetics. However, not every development has to start from scratch. For many products, particularly low cost devices, the need for an antenna specialist was avoided by either resorting to very simple designs or buying off-the-shelf antennas. In both cases, the solution is not ideal. The CST product Antenna Magus was developed to fill this niche in antenna design.

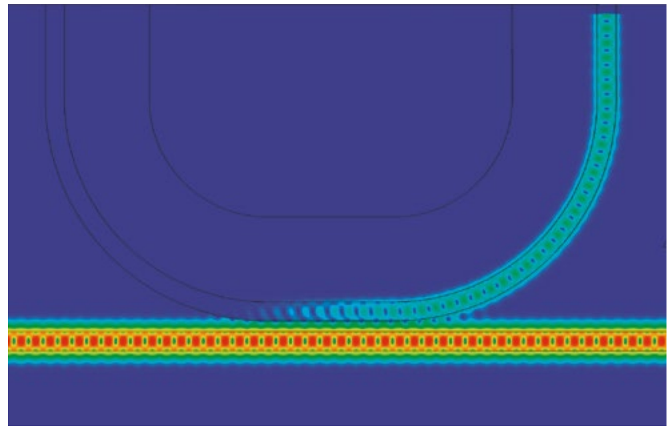
Antenna Magus includes a database of antenna designs and an accessible information browser. Given a set of specifications, Antenna Magus suggests suitable antenna types and produces a model tuned to the specified frequency bands. This means that designers can get antennas specially created for their application and integrate them into their devices without needing all the expertise of an antenna engineer.

ADDITIVE MANUFACTURING

The limitations of conventional manufacturing and prototyping methods are shown clearly in the high-tech development cycle. The process of constructing a one-off prototype is expensive and time-consuming. Simulation combines with additive manufacturing to reduce these costs.

Additive manufacturing also allows the construction of devices that could not be machined or cast by conventional methods, with significant potential space and weight savings. Integrating EM simulation into the additive manufacturing workflow means that engineers can go directly from design to production. CST offers synthesis tools such as Antenna Magus and Filter Designer 3D to meet this need, as well as powerful built-in optimizers for tuning devices to meet tight specifications and optimize performance.

"Virtual prototyping with simulation can reduce the number of prototypes needed, while additive manufacturing techniques, such as 3D printing, make the production of physical prototypes easier," adds Thoma. "Moreover, additive manufacturing opens up the possibilities of generative design that enable solutions that were previously impossible to create with traditional manufacturing methods."



Electric field of an optical directional coupler.

FLEXIBLE ELECTRONICS

Flexible electronics is another field where advances in manufacturing are overcoming production shortcomings, allowing devices to be more compact and more durable. The deformation of electronic structures due to bending, twisting and stretching affects their performance. The design and analysis of such structures represent a significant new market for EM simulation.

PHOTONICS

As the electronics industry reaches the limits of what's possible by miniaturizing existing technologies, the entirely new field of photonics is beginning to mature. Photonics uses photons of light, just as traditional electronics uses electrons, and requires far higher frequencies as well as specialized non-linear optical materials.

"CST, in partnership with Luceda Photonics, has developed an integrated photonic design workflow for the layout and analysis of photonic circuits," explains Thoma. "This allows engineers to synthesize and simulate photonic components and analyze their performance as entire systems."

CONCLUSION

Electromagnetics is a fairly specialized subject but is increasingly important for a wide range of applications—even those without any obvious electronic components, such as buildings that must withstand lightning strikes and packaging that contains RFID tags. "By integrating CST software into the **3D**EXPERIENCE platform," Thoma concludes, "we aim to make our applications available alongside all Dassault Systèmes software solutions, and make EM simulation an invaluable part of product design."

For More Information
www.3ds.com/products-services/simulia/products/cst-studio-suite

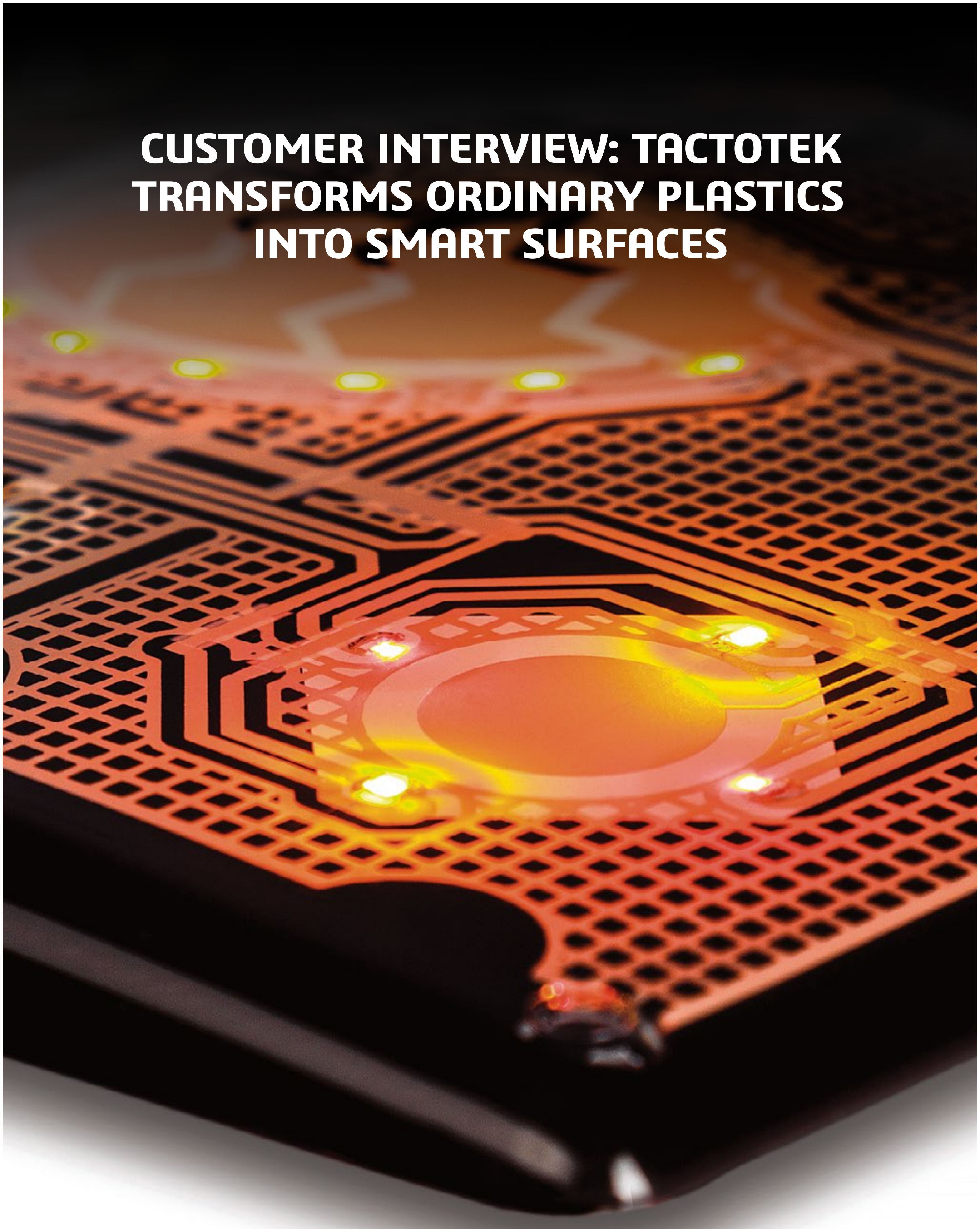


Image Courtesy of TactoTek

As electronic systems become smarter and more embedded, users need intuitive interfaces to let them control their devices easily. TactoTek uses patented injection molded structural electronics (IMSE) technology to transform ordinary plastics into smart surfaces and produce sensors and control panels that are durable, compact—and look great too. We went to TactoTek's headquarters in Oulu, Finland, and spoke to Sini Rytky, Vice President of Product Management, and Anne Isohätälä, Antenna Specialist, about the latest advances in smart surfaces, and how they use SIMULIA simulation tools to design their unique products.

What are injection molded structural electronics?

Injection Molded Structural Electronics (IMSE) is a combination of printed electronics and discrete electronic components printed and placed on a film, thermoformed to 3D geometry, and finally injection molded to a fully-sealed part structure.

What applications does the technology have—some specific examples would be good (e.g. in automotive). IMSE is a perfect match when creating seamless surfaces inside cars or appliances. IMSE part thickness is usually 2–3mm, which makes it ideal for space-limited locations such as door trims. Typical use cases in car interiors include overhead control panels, door trims and seat control units. For appliances such as washing machines, this could be front panels, light switches and other similar control panels.

What are the benefits of IMSE, for users and for OEMs?

1. Technology

- Creating electronic functionality on 3D seamless surfaces made out of plastics, wood, leather. Industrial designers are not limited or restricted by traditional form factors but they can create intuitive user experiences by placing electronic functionality to locations that are not accessible with traditional electronics and mechanics
- 90% less depth for products
- 50-70% less weight for products
- Excellent touch response and antenna performance since we are able to print very close to the product surface (NFC performance improved 40% in one of our use cases)

2. Total Cost of Ownership

- +30% savings in assembly costs due to "single-part assembly"
- Reduced amount of tooling needed due to fewer parts (for example typical overhead control panel has some 50–80 different parts, whereas IMSE less than 10)
- Service time reduced by up to 40% due to single part assembly
- Faster product updates due to "single-component customization"

3. Durability and reliability

- Shock and impact resistant

Image Courtesy of TactoTek

- Protected from moisture and debris due to fully encapsulated structure
- Operating temperature range Celsius −40°–+80°, we have even tested our products in boiling water (>100) and they are still functional afterwards

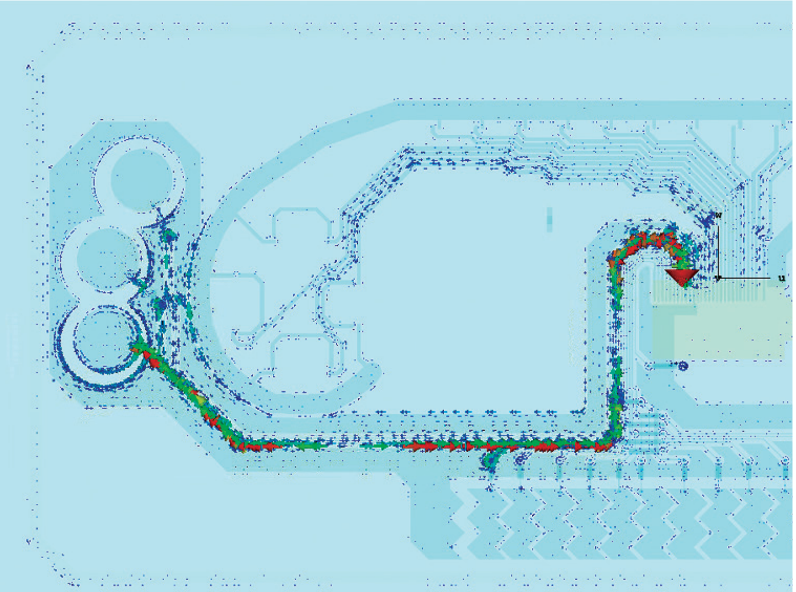
What are some of the design challenges of IMSE?

Typical design challenges (that TactoTek has solved and has the design guidelines on) include:

- Optimization and behavior of the material stack to achieve optimal performance for different geometries (selecting the right film-ink-adhesive-component-resin combination). This is something that we would like to highlight the most, and which is one of the most important elements based on our own research
- Geometrical properties for in-molded illumination
- In electronics design, we are currently facing some limitations from the design tool point-of-view. We are forced to manipulate the traditional PCB layer stack whereas in film we are not able to create different layers the same way as with PCBs. This creates a lot of manual work and extensive need for manual checking
- Component placement and component-to-component distance for LEDs to achieve needed brightness and uniformity, still eliminating the light leakage

What new opportunities prompted your team to start using simulation?

Our team is developing a new processes and technology where traditional design rules do not apply anymore. Simulation was seen as a solution to both verify the operation of electrical functions before building real parts and to speed up the design and time for fine-tuning.



Surface currents at 1GHz on the lines of the ControlSurface™ demonstrator. Image Courtesy of TactoTek

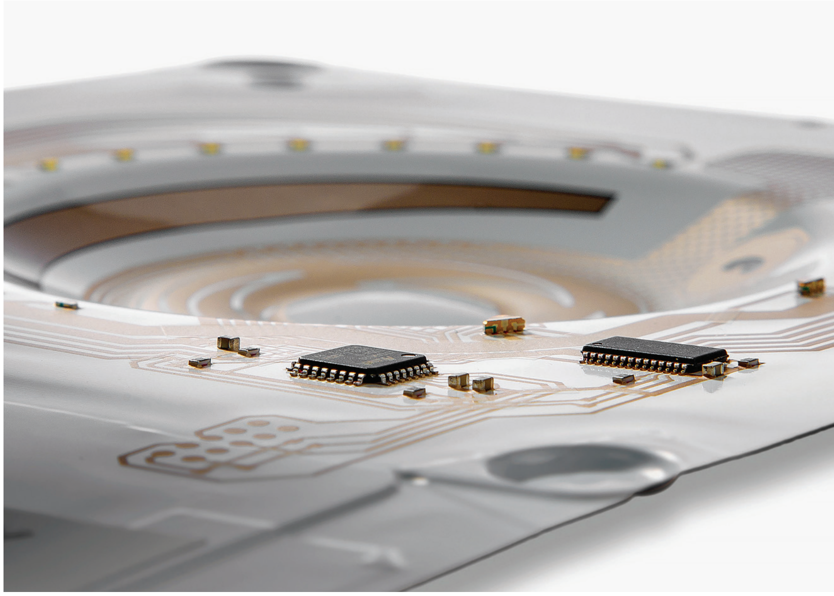


Image Courtesy of TactoTek

What were the simulation requirements for IMSE design?

The main requirement was to get a realistic estimate for the operation of electrical functions of IMSE design with a virtual prototype.

Describe how and where TactoTek got its start using SIMULIA simulation tools, including CST STUDIO SUITE.

Our antenna specialist had used CST MICROWAVE STUDIO for antenna simulations before joining the team. In the company it was already seen as an inevitable task to start building simulation capabilities in order to accelerate the development process of IMSE technology. The team started the evaluation of CST STUDIO SUITE to find out how well it was able to estimate the performance of other electronics besides antennas.

Explain how the team used CST STUDIO SUITE for this particular use case.

Since typical IMSE products integrate a significant number of electrical functions into a single product, simulating all of them requires the use of several different numerical methods. The CST STUDIO SUITE Electrostatic Solver (a low-frequency solver for simulating static electric fields and potentials) was used for capacitive buttons and slider and the Frequency Domain Solver (one of CST's general purpose high-frequency solvers) for simulating NFC coil performance, LED trace impedance behavior and conducted emissions. For simulating antenna performance, radiated emissions and immunity, the Time Domain Solver (CST's flagship solver, for high-frequency and transient simulation) was used.

What were the key factors that led you to choose SIMULIA products for the complete simulation lifecycle?

Good correlation with measurements and reasonable simulation time were the key factors why CST STUDIO SUITE was chosen to be the EM-simulation software in TactoTek.

What were the primary results/key takeaways from this simulation effort? What was your team able to do that it wasn't able to accomplish with prior design flows?

Electromagnetic simulations play an essential role in IMSE design workflow. EM simulations with a virtual prototype give IMSE designers feedback and confidence in moving forward to production of physical units. Earlier, several iteration cycles in production were needed before the design was functioning as it was intended. When EM simulations were included in the IMSE design workflow, design time was less and costs lower than before.

Are there any key metrics (time saved, cost, other efficiencies) associated with use of SIMULIA for this and other design studies you've undertaken throughout the product development lifecycle?

Time, cost and better performance can all be associated with CST EM simulation of IMSE designs.

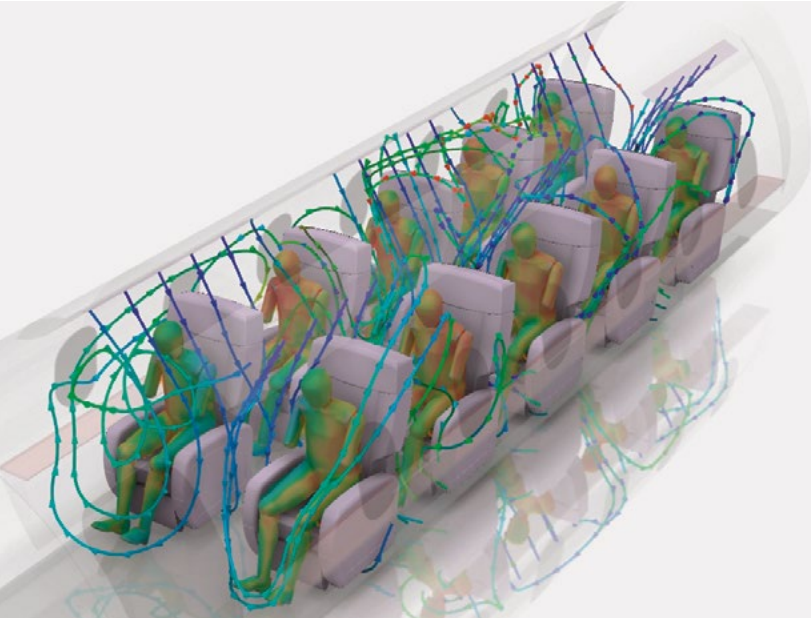
What other CAD/CAE tools do you use in your process and why?

CATIA V5 & V6, SolidWorks, Altium, Eagle, SPEOS, CorelDRAW to mention some of the most common ones.

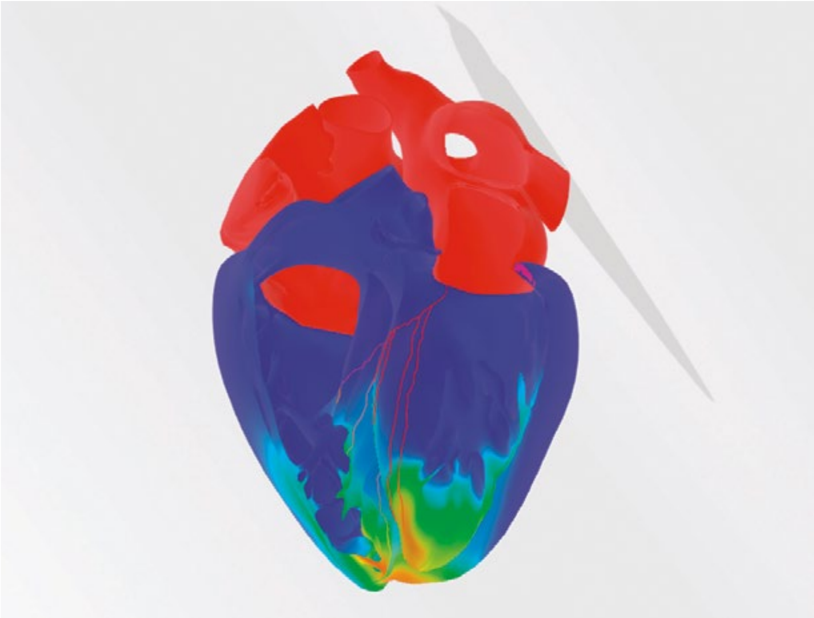
For More Information

www.tactotek.com

R2018X FOR SIMULATION: WHATEVER YOU NEED, WHEREVER YOU ARE



Fluid Mechanics Analyst (FLA)



Living Heart Human Model (SHH)

As a Simulation user—whether you use just one, or many, of our simulation tools—you may view new software releases with both anticipation and hesitation. Now that R2018X is here, you're curious about what new capabilities are available to power-up your job—yet you're also wondering how you can get what you need easily and cost-effectively. Is it time to consider these new offerings on the platform and the cloud and how will that affect your workflow today and in the future?

We understand! We're on the same journey as you as we continuously research, refine and grow SIMULIA capabilities with ongoing input from our customers. Pulling together the best-possible set of applications that will enhance your ability to innovate and collaborate involves balancing complexity with ease-of-use—and, increasingly, ease-of-access.

R2018X strikes that balance very well, we think. As you read below about the latest enhancements in our Simulation products, we hope you'll be impressed with the powerful capabilities we've integrated for you. You'll also see how much easier it's become for you to take advantage of many new offerings that are just a click away.

So yes, it's time to explore the platform and the cloud, if you haven't already done so. "Ease-of-access" has become a key phrase for everyone working in simulation—and R2018X is all about that. No matter what size your company, if you want to be nimble enough to compete, you have to become more efficient and more connected to your colleagues and your customers.

The world is undergoing an industry renaissance, moving toward a highly integrated engineering department from end-to-end: from ideation and concept to design-to-manufacture to marketing to end-of-life. It is about knowledge and know-how: capturing, sharing, and building on prior learning to efficiently deliver better products and experiences to your customers. This transformation is unfolding inexorably and it is time to get on board.

For SIMULIA users, R2018X significantly improves your ability to access whatever you need to ride this transformative wave successfully. It's the easiest it's ever been to discover the benefits of what the **3D**EXPERIENCE platform offers. Not only does the platform make new technologies from our sister brands available to you, it also provides an opportunity for non-users to access the power of simulation. This strengthens your entire team, helping to compress the design-to-manufacturing cycle so you can deliver the right products to market in the shortest time.

With this year's release, nearly all of our design and engineering portfolio is now available as software-as-a-service (SaaS) on the cloud. This is metered access, on an as-needed basis, and it can be very cost-effective. Cloud access also provides platform-as-a-service (PaaS) in which the **3D**EXPERIENCE platform is available to users on cloud with no need for extensive local platform installation. To give you an idea of the fundamental value of cloud computing, Dassault Systèmes' cloud customers were seamlessly upgraded to R2018X within a few hours earlier this year over the entire scope of the **3D**EXPERIENCE offering.

But what's in it for you, the simulation user? Let's take a look at some specific highlights.

"STANDALONE" PRODUCT USERS CAN NOW CONNECT TO THE PLATFORM

Yes, you can continue to use your existing Abaqus tools, but now you can power these on the **3D**EXPERIENCE platform in ways you've never been able to before to enable collaboration, sharing and simulation management. R2018X now enables the connection of many of SIMULIA's standalone products on the platform—including Abaqus for structures, XFlow for fluids, Simpack for multibody simulation, and CST STUDIO SUITE for electromagnetics. And you can capture and publish best practices, share and collaborate on results and methods, and integrate fully with non-experts on your team. This makes your work instantly more visible, and hence more valuable, without disrupting existing methods and tools. It allows you to execute end-to-end industry workflows including both native **3D**EXPERIENCE and standalone tools.

One more bonus for Abaqus users: running Abaqus on the platform provides on-cloud burst compute licensing, which means you can access additional compute horsepower, wherever and whenever you need it.

NEW ROLES IN DESIGNING FOR ADDITIVE MANUFACTURING

The complexity of additive manufacturing (AM) begs for digital support in so many ways. AM is more than just 3D printing—you're not just printing a part, you're designing it so it is printable, with the least amount of the right material, with support structures, with as little distortion as possible, as quickly as possible. AM may offer "true freedom" to print anything, but the full story is much more complex than that—and it clearly calls for simulation.

What should you print that serves the needs of the design optimally? This is where R2018X's new Additive Manufacturing Researcher and Additive Manufacturing Programmer roles, backed by CATIA-based Functional Generative Design, come in.

With the exceptional strength of CATIA, starting from an optimization analysis which evolves the best "organic" shape of a design, Functional Generative Designer automatically recreates that shape with CAD-Type surfaces needed for 3D printing. The Researcher role provides multiscale, multiphysics realistic simulation of the print process while the Programmer role connects with the parameters of a particular AM machine, its build-bed, and the printing process itself.

SIMULATION ENGINEER FOR SOLIDWORKS USERS

Increasingly, even non-experts need simulation in order to fully participate in projects with their engineering teams. The new Simulation Engineer role in R2018X allows a user of SolidWorks desktop to import on-the-cloud in one-click, their Solidworks simulation model into the **3D**EXPERIENCE platform for additional analysis with Abaqus structural technology. This provides advanced simulation in a very easy and accessible way to the SolidWorks user.

ADVANCED CFD FOR SIMULIA USERS

As you'll see in R2018X, Dassault Systèmes is rapidly expanding its portfolio of CFD offerings. This is a natural evolution of our long-term multiscale/multiphysics philosophy. To really power innovation and solve the valuable end-to-end workflows that are needed from design to simulation to manufacturing, you've got to have a full quiver of technology "arrows" available—and CFD can be a critical one of those for many applications.

Our CFD offerings include Mainstream CFD technology, built right into the **3D**EXPERIENCE platform. Numerous enhancements in R2018X include support for the analysis of high Mach number flows, rotating domains, the interaction between different phases, and many more specialized functions. There's also more guided assistance for users to help streamline setup for the Fluid Mechanics Analyst role.

CFD on the platform also now includes accessing XFlow in connected mode (as mentioned above), which provides users with a mesh-free particle solver for transient/complex flows in a tailored, easy-to-use environment.

(Not yet on the platform, we also offer PowerFlow technology focused on providing the automotive and aerospace industries with highly customized and validated vertical applications and workflows that include CFD.)

THE LIVING HEART ON THE PLATFORM

Simulation for the cardiovascular community has been transformed by the well-known Living Heart Project, which has built a truly functional, virtual digital twin model of the heart for medical research, diagnostics, and device-development purposes.

In R2018X the Living Heart Human Model role includes the 2.0 version of the Living Heart, which is available on the platform and the cloud with considerable enhancements to the model based on input from nearly 100 life-science organizations worldwide. Included are coronary arteries, all four valves, and detailed electrical networks—all of which provide a more physiologically accurate response.

This role enables clinical researchers and medical device analysts to virtually test the effectiveness and durability of devices (such as valves, stents and pacemakers) right inside the Living Heart Model. Forward-looking capabilities include evaluating the effects of pharmaceuticals on the beating heart model as well. The Living Heart Human Model on the **3D**EXPERIENCE platform is the only solution for this highly advanced technology which enables collaboration with colleagues and partners around the globe.

Continued

Product Update

WHAT'S NEW FROM SIMULIA IN 2018

Below is a summary of new capabilities in our standalone product offerings. **For the full roster of enhancements, just click on each product name below.**

Abaqus 2018

The scalable Abaqus Unified FEA product suite offers powerful and complete solutions for both routine and sophisticated engineering problems covering a vast spectrum of industrial applications. Abaqus is now available in connected model on the **3D**EXPERIENCE platform on the cloud.

- The multiscale material modeling capability has been enhanced to support: Heat transfer, coupled temperature-displacement, and linear perturbation procedures
- The linear pyramid element C3D5 and linear hybrid tetrahedron C3D4H are now available in Abaqus/Explicit
- General contact in Abaqus/Standard now supports analytical rigid surfaces
- General contact in Abaqus/Explicit now supports 2D and axisymmetric analysis
- A hybrid CPU-GPU implementation of the steady state dynamics procedure significantly improves linear dynamics performance
- Usability of the bolt loading capability in Abaqus/CAE has been significantly improved
- Linear constrain equations defined in Abaqus/CAE can now include multiple nodes
- Predefined field variables can now be defined in Abaqus/CAE
- Results can now be imported from multiple previous simulations
- Partial activation of elements can be specified during a simulation
- The Abaqus Scripting Interface supports multiscale material modeling commands
- Energy output is now supported for structural, acoustic, and coupled structural-acoustic eigenvalue procedures
- New contact output variables including scalar integration of contact pressure over the surface

fe-safe

The fe-safe suite of software is world-leading technology for durability analysis from FEA, directly interfacing to all major FEA suites. The first commercially available fatigue analysis software to focus on modern multiaxial strain-based fatigue methods, fe-safe continues to set the benchmark for fatigue analysis software. fe-safe is available with Extended Licensing as part of the Abaqus 2018 product suite.

- fe-safe can be run inside an optimization loop to allow designs to be optimized for fatigue performance. fe-safe interfaces to Isight and Tosca
- Critical distance methods for crack growth prediction
- Property mapping for casting or forging simulations
- Vibration fatigue and fatigue of welded joints
- Automated Integrations with Simpack, Tosca, and Isight
- Coupling between Simpack Flex bodies, Abaqus and fe-safe

Tosca

The Tosca optimization suite provides fast and powerful structural and flow optimization solutions based on FEA and CFD simulations. Tosca Structure is for optimized structural designs, and Tosca Fluid provides optimized fluid flow design concepts. Tosca is available with Extended Licensing as part of the Abaqus 2018 product suite.

- Support on nonlinear analysis models
- Hybrid sensitivity calculation support to combine the Tosca sensitivity calculation with Abaqus derived sensitivities
- Advanced operators referencing multiple load cases/steps
- Support of lattice structure optimization

Isight

Isight provides simulation process automation and design optimization solutions that help reduce analysis time and costs while improving product performance, quality and reliability. Isight is available standalone and with Extended Licensing.

- New high-dimensional scatter bubble plots
- Adaptive DOE is a new space filling technique suitable for both DOE and Optimization studies
- New high-dimensional scatter bubble plots
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Simpack

Simpack is a general purpose multibody simulation (MBS) software used for the dynamic analysis of any mechanical or mechatronic system. It enables engineers to generate and solve virtual 3D models in order to predict and visualize motion, coupling forces and stresses.

- Introduction of new modeling technique based on new connection and initial condition elements
- Extensive library of connection and initial condition elements available
- Automatic drivetrain assembly support
- Formula editing enhancements for tree views (e.g. Substitution Variable editing)

R2018X is an important step along the journey we're taking together, towards allowing the promise of simulation to be fully realized with greater impact as a core business process in your end-to-end industry processes and workflows. For more information about how to start your own journey please contact your SIMULIA representative.

For More Information

www.3ds.com/products-services/simulia/products/

WIRELESS ELECTRIC VEHICLE CHARGING— DESIGN AND ANALYSIS WITH CST STUDIO SUITE

By Christian Kremers

Increasing the use of electric vehicles is an important part of reducing greenhouse gas emissions and essential for improving air quality in cities. By the end of 2016, there were over two million electric cars worldwide—almost twice as many as there had been at the start of the year. Battery electric buses are already a staple of many Chinese cities, while electric vans are becoming a key part of postal and courier fleets.

To support the new generation of electric vehicles, a comprehensive network of charging points is needed. At present electric vehicles are usually charged with a cable, often at the driver's home. This limits the use of electric vehicles in everyday situations: returning a bus or delivery van to the depot for regular charging puts the vehicle out of use and wastes driver time.

Wireless electric vehicle charging (WEVC) offers a solution. Rather than transferring power by cable, WEVC uses electromagnetic coils buried in the road to transmit power to vehicles through inductive coupling—the same principle used in charging mats for mobile phones. However, the power requirements for WEVC are much higher, on the order of kilowatts—the system demonstrated in this article complies with the WPT 2 level, 7.7kW at 85 kHz—and efficiency and safety are key considerations when designing a WEVC.

The electromagnetic simulation tool CST STUDIO SUITE allows the performance of charging coils to be optimized early in the design process, and analyzed as part of the complete electric transmission system. The LF Frequency Domain Solver in CST STUDIO SUITE is ideally suited to this application, with realistic numerical coil models, eddy current simulation, and support for materials including lossy metals and nonlinear magnetic materials such as ferrites.

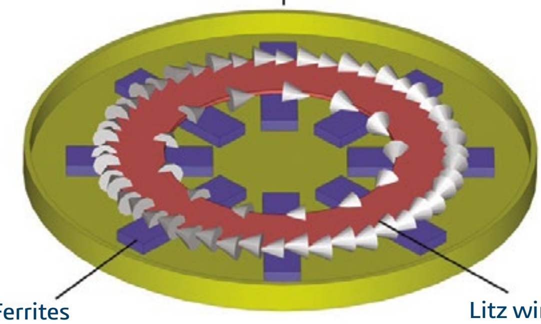


Figure 1: Coil diagram, showing the main components.

The coil shown in this article (Figure 1) comprises 12 turns of stranded litz wire with an inner diameter of 190mm and an outer diameter of 286mm on a ferrite MnZn core. For safety reasons, the coil is surrounded by a 5mm thick aluminum shield. The coils on the car and in the floor are considered to be identical, with the car coil placed directly on the underbody shield and the floor coil buried in the road (Figure 2).

One area where simulation is used is to reduce power losses. The coil needs to be shielded in order to confine the magnetic field, but eddy currents induced in the shield will cause some power to be lost. Other sources of power loss include the ferrite cores used to guide the magnetic flux to increase the coupling, the resistance of the coils themselves, and misalignments of the coils. Electromagnetic simulation can calculate these losses and allow different design configurations and material choices to be compared in order to find the most efficient combination (Figure 3).

Figure 2: The wireless charging coils mounted underneath a car.

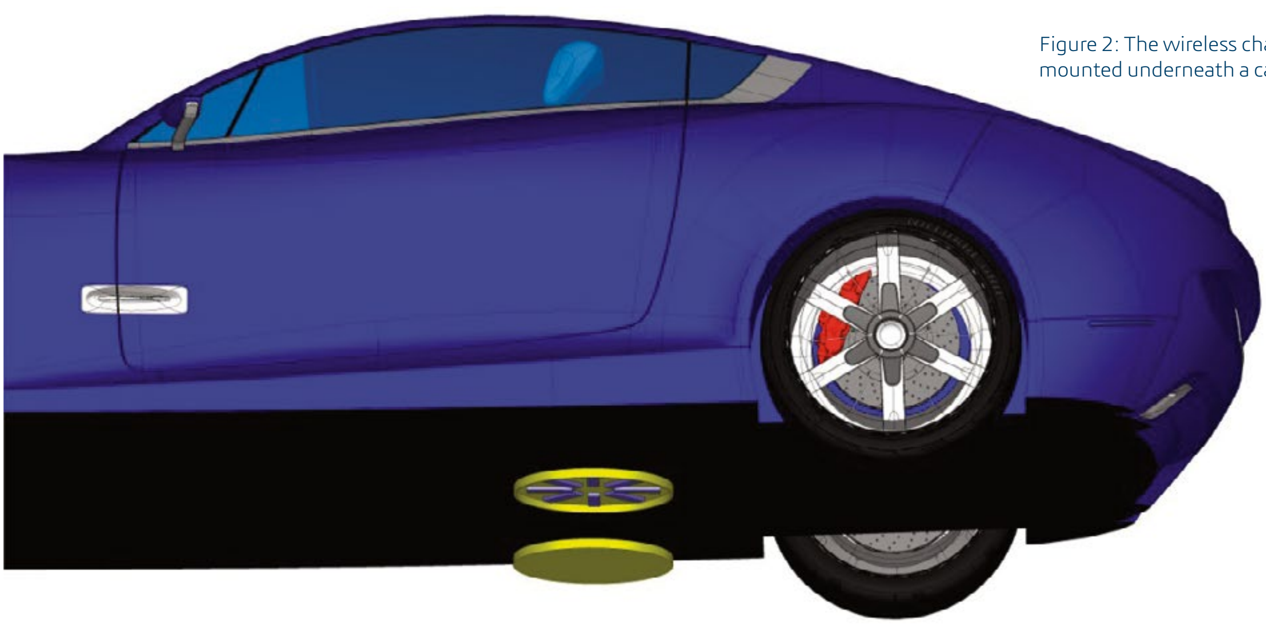
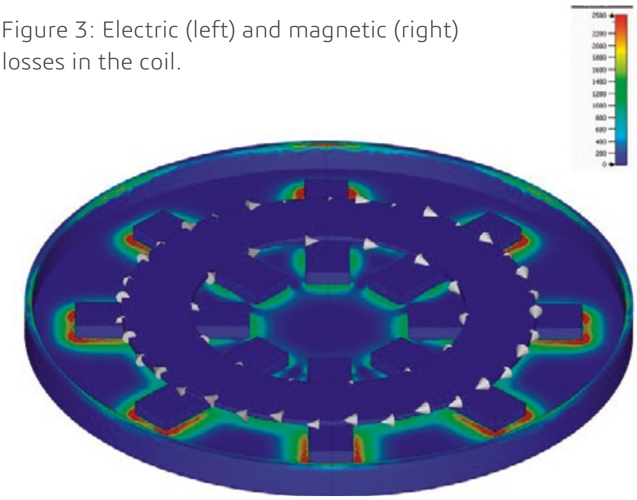
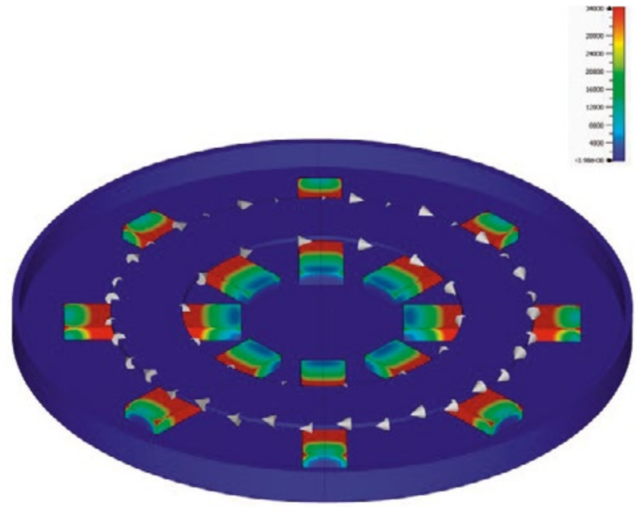


Figure 3: Electric (left) and magnetic (right) losses in the coil.





Often, the properties of the materials and the characteristics of the components are not fully known, and EM simulation can be used to extract their properties. For instance, litz wire has a complex internal structure, which reduces proximity and skin effect losses in the coil (Figure 4). With simulation, the resistance of the litz wire coil can be calculated, taking into account the realistic cross-section of the wire and the skin and proximity effects. Similarly, the losses from the nonlinear magnetic properties of the ferrite can be implemented with complex permeability to fit measurements.

One of the most important results from coil simulation is the efficiency of the coupling in order to minimize losses in surrounding materials or from mismatched coils. CST offers a tool for automatically calculating the performance of coupled coils including the maximum efficiency, the coupling coefficient between the base coil and the car coil, and the optimal load condition—the load under which the best power efficiency occurs.

Using this information, engineers can optimize the performance of the charger. In order to match the coils, WEVC systems include compensation networks. These are circuits used to tune the coils for better power transfer efficiency. The direct link between circuit simulation and full-wave 3D simulation in CST STUDIO SUITE allows the compensation network to be created alongside the 3D model and optimized to reach optimal load impedance and reduce power losses further.

The performance of inductively-coupled coils will depend on their exact alignment—this is especially important for vehicles, since in many situations the coils cannot be easily lined up. With a parameter sweep, efficiency can be calculated for multiple different alignments in order to investigate how this affects coil performance and to help tune the compensation networks.

Another application of circuit simulation is for a system level simulation of the whole charging system, from the 3-phase AC power source, through the rectifiers and inverters, to the battery. The goal here is to find the duty cycle of the inverter such that sufficient DC power reaches the battery. With the full system, the real operating point can be calculated and factors such as interference and human exposure can be analyzed in a realistic scenario.

Charging is just one factor of electric vehicle design. Other related design considerations include the motors and motor controls, the cabling, the onboard electronics, and the chassis as a whole, as well as human exposure. These combine high-frequency and low-frequency electromagnetic simulation, thermal and mechanical elements, and can all be designed, simulated and analyzed with CST STUDIO SUITE and other SIMULIA tools for a more integrated workflow.

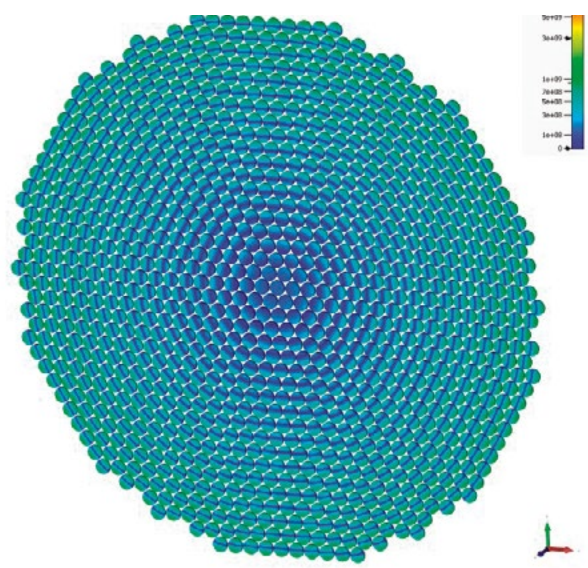
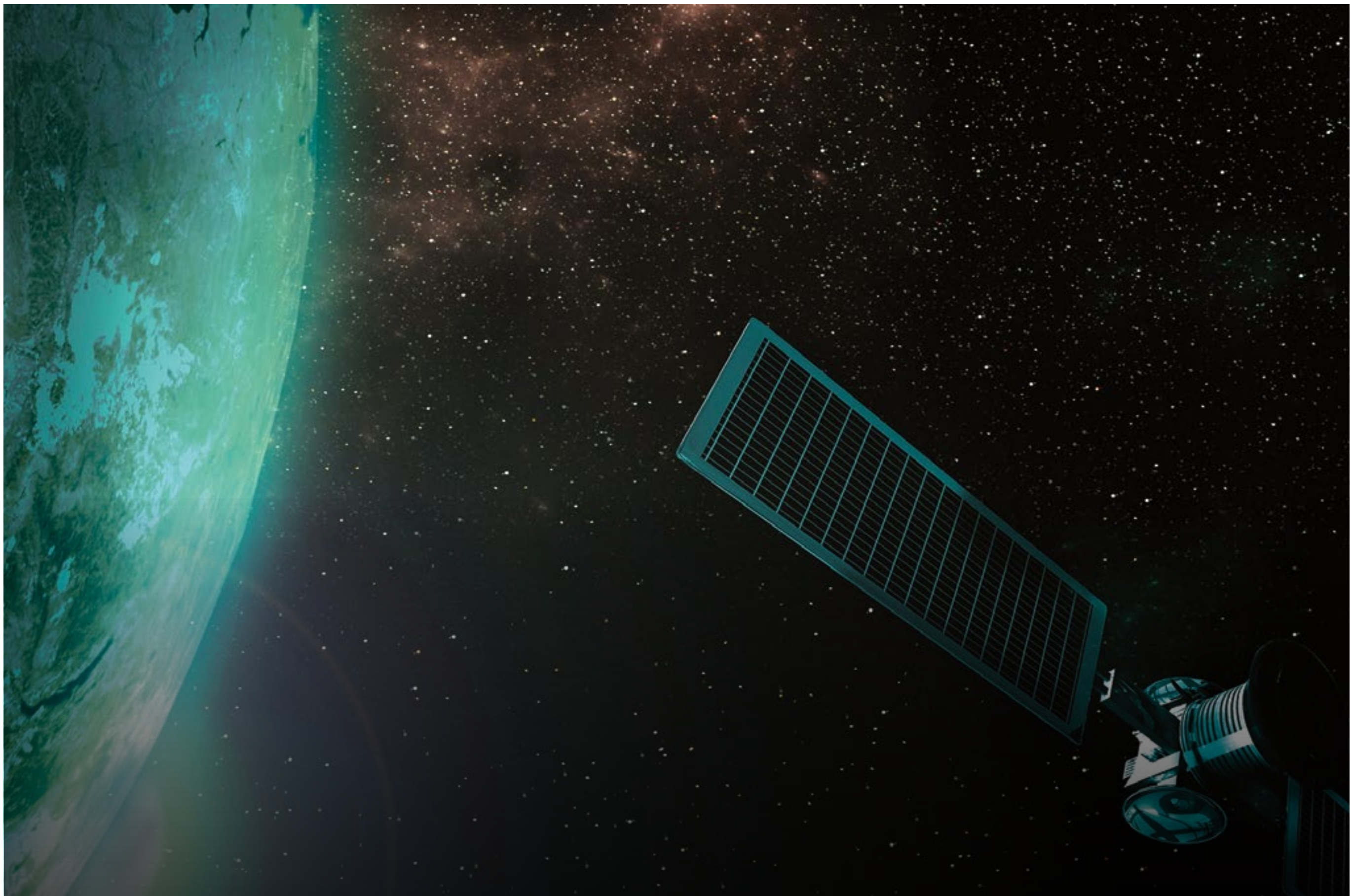


Figure 4: Current density in a short section of Litz wire, showing the skin and proximity effects.

For More Information

www.cst.com/wirelesscharging



SIMULATING FOR SPACE COMMUNICATIONS WITH CST

Airbus Defence and Space designs 3D-printed satellite-antenna components with the help of SIMULIA's CST STUDIO SUITE software

There's a lot of noise going on out there in space as men and machines send electronic messages back and forth across the void. To enable everyone to hear each other better, radio-frequency (RF) waveguide filters have been key technologies for communications since the earliest days of the Space Age.

Although the sky is crammed with radio signals, these filters serve as gatekeepers that screen out unwanted frequencies while allowing selected channels to pass through. A typical modern telecommunications satellite can carry hundreds of such filters. These are designed with complex internal contours specifically chosen to work with very distinct frequencies that allow for multiple signal beams.

Airbus Defence and Space Ltd. has worked on a variety of projects with the European Space Agency (ESA) for decades; the Space Systems division of Airbus supports ESA with satellite-antenna design. Lately, building on previous research and the increasing potential of additive manufacturing to revolutionize design thought, Airbus Defence and Space has been developing 3D-printed RF filters for ESA with the help of SIMULIA CST STUDIO SUITE software.

Heading the design team for the latest ESA project, Airbus RF Engineer Paul Booth studied electrical and electronic engineering at Leeds University. A specialist in waveguide and coaxial filters, Booth read a Request for Proposal (RFP) from ESA that piqued his interest.

AN OPPORTUNITY TO APPLY 3D PRINTING THOUGHT TO A CONVENTIONAL DESIGN

"We'd already done some other work on 3D printing with ESA and this seemed the perfect opportunity to extend this to waveguide filters," he says. "At the start of the previous project ESA were in the early stages of considering additive manufacturing for mechanical components and we suggested using metal as the material for 3D printing of RF components in a multi-beam feed array."

A team was formed with Airbus Innovation Works, and Space Engineering, who would provide manufacturing know-how and design support, respectively. "We won the contract and then tried to think a little out of the box with 3D printing, rather than relying on tried-and-tested standard realizations and just putting rounded corners onto the filters to improve RF performance," says Booth.

At present, communication between satellites and Earth is almost exclusively RF-based, with improving performance an ongoing goal. "There are some experiments using lasers but these are mainly restricted to inter-satellite communications at the moment," Booth says. "So for most current filters you still need a directional antenna for the up and downlinks. The payloads tend to be 'bent-pipe' so that the satellite receives a signal at one frequency and transmits it back to earth down-converted in frequency. This is beginning to change though as operators seek more flexibility."

For the ESA project, Booth's team recommended aluminum for its low density and good thermal conductivity, which is important for high-power filters to allow the heat to be effectively diffused away. It is also a full melt process which decreases porosity, essential if the component requires silver plating.

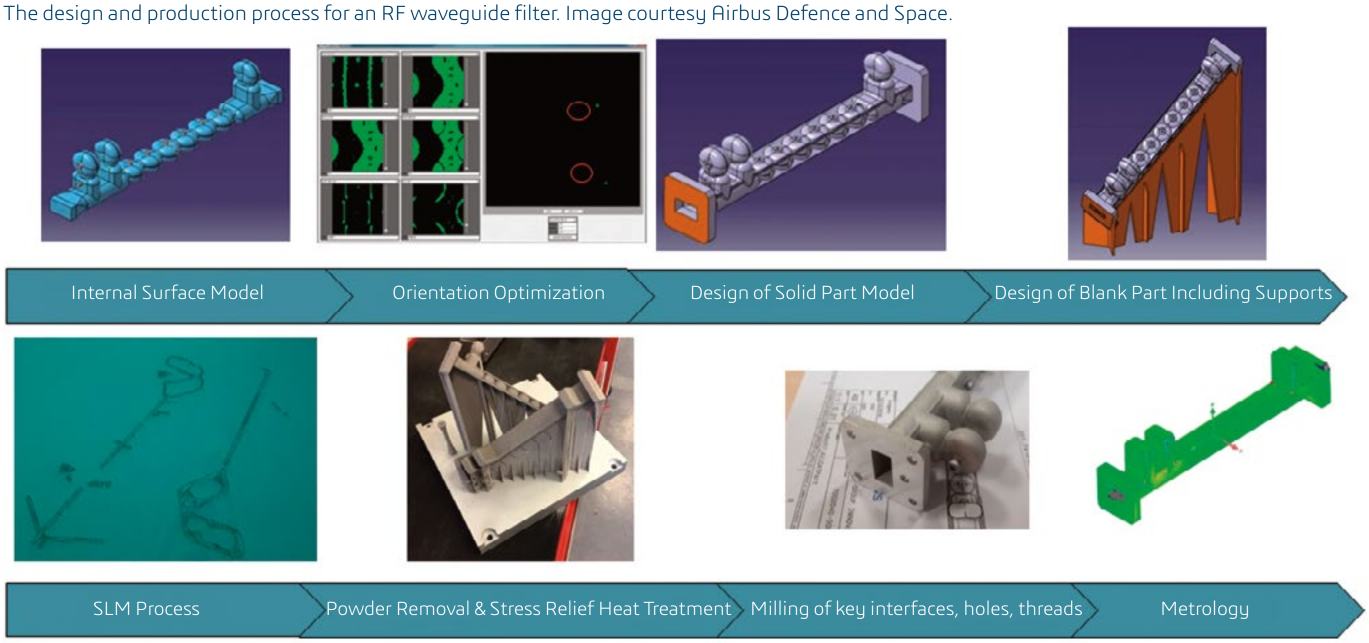
"Our experience with the technology certainly helped us to secure the waveguide filter contract," says Booth. "It was during this project that we realized that some of the challenges of 3D printing could be overcome with a bit of thought to create a better overall product."

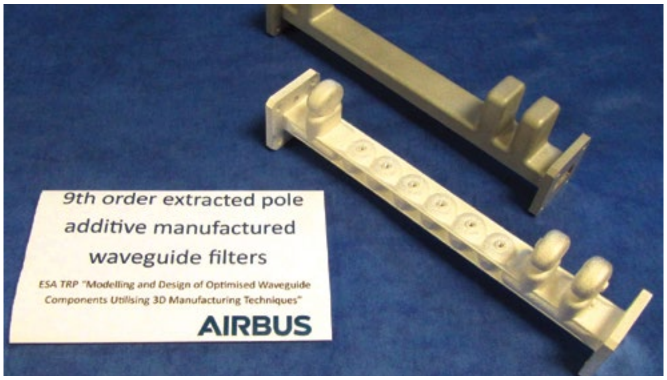
PRODUCTION AND PERFORMANCE ADVANTAGES

So what advantages do 3D printed waveguides have over conventionally designed and manufactured waveguide filters? Booth sees quite a few.

"With conventionally designed waveguide filters the design software can be quick and accurate using variations of mode matching techniques," he says. "But initially this meant waveguide filters with sharp corners everywhere that required electro-discharge machining of the parts. The parts are also usually made in two pieces, either two mirror image halves or a body and a lid, that all require assembly, usually with fasteners. Things progressed with the software to allow machining radii to be included, which certainly helped the manufacturing time—but this slowed down the design time."

The design and production process for an RF waveguide filter. Image courtesy Airbus Defence and Space.





3D printed filters made by the Space Systems division of Airbus Defence and Space for the European Space Agency. Image courtesy Airbus Defence and Space.

In contrast, 3D printing of waveguide components allows for optimum "organic" shaping without sharp corners, enabling better wide performance or lower insertion loss—or a trade-off between the two. "There are also savings in mass that can be made if a monolithic part can be produced, and we have typically found the mass to be reduced more than 40% compared to conventionally machined parts," says Booth. "If more functions can be consolidated into a single part then the mass savings can increase as there is no need for connections between what would be individual components. There is also the added benefit of reduced assembly time; two halves no longer require bolting together and potentially separate components do not need assembly. This can have quite an impact on overall cost."

The potential freedom of design offered by additive manufacturing must nevertheless be expressed within strict RF allowances, which is why the Airbus team turned to SIMULIA's CST software for electromagnetic simulation. The CST STUDIO SUITE comprises CST's tools for the design and optimization of devices operating in a wide range of frequencies, static to optical. Analyses may include thermal and mechanical effects, as well as circuit simulation.

DESIGNING THE SPACE INSIDE A COMPONENT FIRST WITH CST STUDIO SUITE

Booth describes how the team employed CST STUDIO SUITE for the ESA filter design: Starting with proprietary software, they first looked at the RF requirements to determine the filter order and whether there might be any particular challenges in achieving their aims. "We then use the CST tools to obtain the best starting geometry for the resonator using the Eigen mode solver," he says. "Next we connect two resonators via a coupling aperture and create a graph of coupling versus aperture width—again using the Eigen mode solver. From this we can determine the size of each aperture required in the filter along with individual resonator sizes. We then create the filter in CST STUDIO SUITE and use the frequency domain solver to analyze and optimize the design. At any of these stages we may take a little step back or adjust a few parameters to improve the performance."

The particular beauty of the CST tool is that the internal geometry of a filter—the empty space inside the component that will produce the desired RF frequency configuration—can be considered the starting point of the design process. "At the very beginning of this project with ESA we looked at specific geometries," remembers Booth. "But now, for anything we design for satellites with CST software we only need the RF requirements to start."

With the completed design in hand, the final geometry is exported in .stp format and sent to the manufacturer, in this case Airbus Innovation Works. (The group also uses 3D Systems in Leuven and has recently added its own metal printer in Stevenage, U.K.). Finished filters undergo vibration testing to simulate space launch, as well as tests over temperature extremes in a vacuum to simulate the operating environment.

BENEFITS EXTEND DOWNSTREAM

The benefits of using 3D printing to produce the filters have proven significant, Booth notes. "It is quite easy to reduce the mass of such a component by 40–50% with 3D printing, compared to conventional machining," he says. "On a very recent project we achieve greater than 60% mass reduction. In terms of turnaround, from the start of the design process to shipping the finished part, we can see a 10% reduction. However, for high-throughput satellites requiring a large quantity of the same design we expect this to improve significantly. Most of the cost and schedule savings are from reduced assembly processes."

Airbus Defence and Space's work for ESA has definitely been a team effort. "For the filters we've produced so far we have really needed the buy-in of all parties, but they are quite low-stressed items so the mechanical design has not been too demanding," Booth says. "This is the same with the thermal aspects." However, for larger, longer antenna feeds he sees the need for a much more multidisciplinary approach to allow the entire feed to be optimized as one. "Ideally, if we can use tools that are compatible with each other, maybe even integrated in a common platform, then the design process can be much more efficient," he says.

The ultimate proof of the success of the filter project is already circulating earth, Booth notes: "I'm pleased to say that we have a filter in space at the moment with another pair to be launched hopefully at the end of this year or early next year." The message is coming through, loud and clear.

For More Information
www.airbus.com/space

Academic Highlight

CST UNIVERSITY PUBLICATION AWARD

Every year, CST acknowledges the importance of academic research through the CST University Publication Award. The award, which is open to university researchers who used CST STUDIO SUITE software tools in published work, offers licence upgrades to the winners. We evaluate the submissions on a number of criteria including originality of the application or the theory, clarity of presentation, as well as the skillful use of CST software features.

Here are comments from some winners of the 2017 prize:

"As CST STUDIO SUITE early adopters, we're very honored to have been recognized by CST as an example of good practice in using their design tools. However, getting our simulations done with CST, helping us to do our daily research tasks on high frequency and space, is the real prize that the CST family gives us every day."—Dr. Miguel Laso, Universidad Navarra

"This program is really a big encouraging smile to the users of CST, which greatly inspires, in particular, the students and new researchers from universities to continue their career in creating new ideas. We are very honored and pleased to see our awarded work on metasurface antennas being strongly and continuously supported by CST."—Dr. Chen Zhining, National University of Singapore

Congratulations to all the winners! This year the following four papers won the award:

Dual-Band Electronically Beam-Switched Antenna Using Slot Active Frequency Selective Surface

Chao Gu, Benito Sanz Izquierdo, Steven Gao, John C. Batchelor, Edward A. Parker, Fan Qin, Gao Wei, Jianzhou Li, and Jiadong Xu

This group used CST STUDIO SUITE to design a new type of antenna which can be electronically steered, so it can sweep a full 360° angular range in two frequency bands without the need for moving parts.

doi:10.1109/TAP.2016.2647578

Chirping Techniques to Maximize the Power-Handling Capability of Harmonic Waveguide Low-Pass Filters

Fernando Teberio, Ivan Arregui, Adrian Gomez-Torrent, Israel Arnedo, Magdalena Chudzik, Michael Zedler, Franz-Josef Görtz, Rolf Jost, Txema Lopetegi, and Miguel A. G. Laso

doi:10.1109/TMTT.2016.2586479

In this paper, the participants show how a "chirping" technique can be used to design a filter that can handle high power with low losses, using both CST STUDIO SUITE and the CST waveguide analysis tool FEST3D.

Low-Profile Wideband Metasurface Antennas Using Characteristic Mode Analysis

Feng Han Lin and Zhi Ning Chen

doi:10.1109/TAP.2017.2671036

This paper uses Characteristic Mode Analysis (CMA)—a function of the CST STUDIO SUITE Integral Equation Solver—to develop a new antenna type that is wideband but compact.

Dual Circularly Polarized Series-Fed Microstrip Patch Array with Coplanar Proximity Coupling

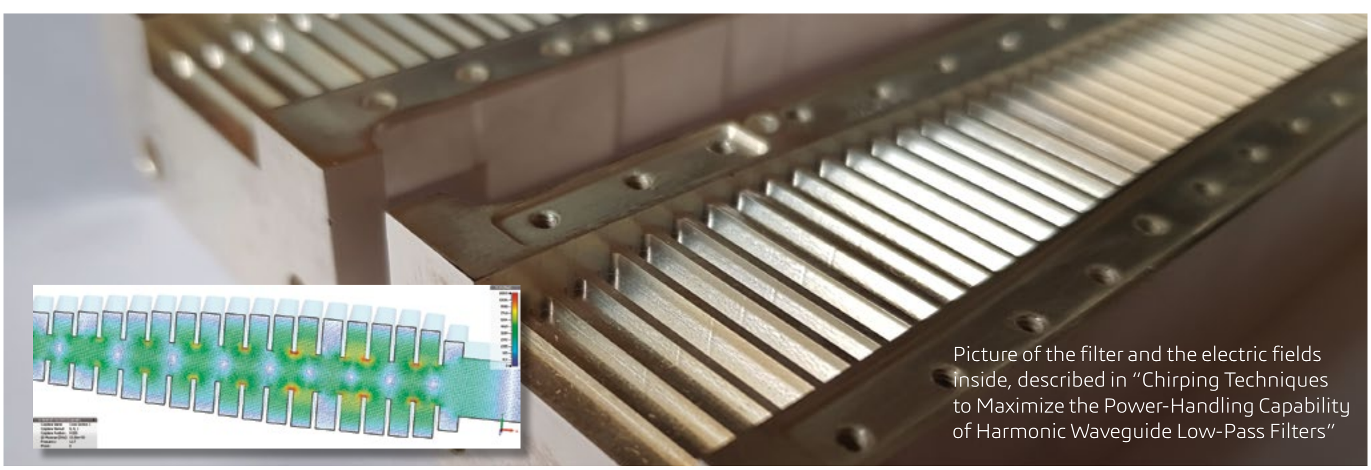
Shengjian Jammy Chen, Christophe Fumeaux, Yasuaki Monnai and Withawat Withayachumnankul

doi:10.1109/LAWP.2016.2647227

This short paper demonstrates a compact and high-efficient antenna array design, using CST STUDIO SUITE to validate the design and investigate the antenna's performance parametrically.

Submissions for the 2018 CST University Publication Award are open.

For More Information
www.cst.com/academia/university-award



Picture of the filter and the electric fields inside, described in "Chirping Techniques to Maximize the Power-Handling Capability of Harmonic Waveguide Low-Pass Filters"

A BOLT FROM THE BLUE— SIMULATING LIGHTNING STRIKES ON AIRCRAFT

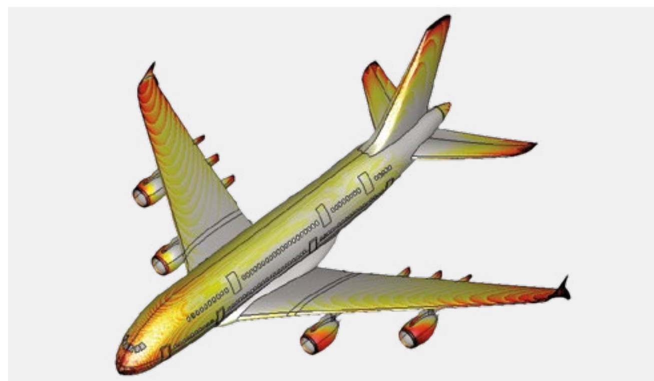
On average, a commercial airliner will be struck by lightning around once a year [1]. A bolt of lightning carries thousands of amps of electric current and millions of joules of energy, and the aircraft needs to bear this without suffering either damage to its fuselage or interference to on-board electronic systems.

Traditionally, aircraft were made of metals such as aluminium and titanium, which are effective conductors and can tolerate lightning strikes without much concern. However, to reduce weight manufacturers are turning to composite materials such as carbon fiber. These are much less conductive, and provide less shielding for electronics inside. As a result, it is now more important than ever for aerospace engineers to understand how an aircraft behaves during a lightning strike.

Physical testing with a full-sized prototype is difficult, while scaled-down models don't accurately capture how lightning behaves. EM simulation with a digital mock-up (DMU) is an alternative approach that offers engineers a fuller picture of exactly what happens to the aircraft during a lightning strike.

The first stage is lightning zoning, or attachment analysis. The electric field around a metal object is concentrated at sharp edges and points. The same principle that explains why it's dangerous to put a fork or crumpled foil in a microwave oven also explains why lightning tends to strike aircraft on the wing, nose or tail. Electrostatic simulation on the aircraft model can locate the parts of the airframe which produce the strongest fields, and therefore the places where lightning is most likely to attach, helping inform the next stage of simulation: transient analysis.

A lightning strike may be over in the blink of an eye but it has distinct phases, with a very rapid increase in current, a peak, and then a slower exponential decay. Time domain EM simulation is therefore necessary to capture the full transient behavior of the lightning pulse. The lightning current is injected into one part of the aircraft, and allowed to leave through another. The electric current on the skin of the aircraft can be monitored, as can electric fields inside. Often, fields



Aircraft model following attachment analysis. The red areas are those with the highest electric field where lightning is most likely to strike.

enter the aircraft through very small features such as seams and cables. These crucial elements can be included in the CST STUDIO SUITE simulation.

The large currents seen during a strike can heat the airframe, and multiphysics simulation is essential to analyze this heating effect in order to verify the integrity of the materials. Coupled EM-thermal simulation takes the electric losses calculated by the time domain solver and uses these as the basis for further simulations to find the temperature change and heat distribution on the aircraft.

EM simulation offers an effective way to visualize and explore the effects of lightning on the aircraft from the earliest stages of development, and help engineers ensure their design meets the rigorous safety standards. The same principles can be applied to any structure that might be struck by lightning, including ships, rockets, wind turbines, broadcasting towers and buildings.

[1] "What happens when lightning strikes an airplane?", Edward J Rupke, Scientific American

For More Information
www.cst.com/lightningattachment

ANTENNA DESIGN FOR A CONNECTED HOME MULTIMEDIA DEVICE

Figure 1. The smart projector "Beamy".

As the Internet of Things (IoT) establishes itself, more and more connected devices are finding their way into the modern home. The "connections" are of course wireless and antennas are the key enabling technology that provides that wireless connectivity. This article will use the example of a smart projector (Figure 1) to talk about the simulation techniques and tools that allow new antenna concepts for connected IoT-enabled devices to be developed and tested quickly at a very early design stage, leading to a device with improved connectivity and a reduced overall design time.

Antenna design is not an activity performed in isolation. The antenna engineer has to keep pace with changing constraints during the multiple stages of a dynamic product design cycle, being able to respond quickly to the question of how many of what kind of antenna should be placed where in the device in order to have acceptable communication links. Current communication standards are of immediate interest, but the antenna engineer must also be equipped to explore concepts for future standards such as 5G. The tools and approaches described here allow the engineer to do just that.

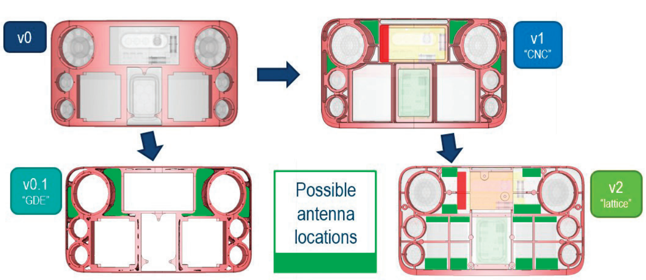


Figure 2. Three design iterations of the aluminum projector frame. Possible antenna locations are marked in green.

ANTENNA SELECTION

The objective of the antennas is to provide connectivity for the device for particular communication standards – in this case WLAN 2.4 and Bluetooth – so it has to operate efficiently in the relevant frequency ranges. A key constraint in compact devices such as our projector is the amount of space available for the antennas. One option is to source an off-the-shelf antenna module from a supplier and assign space for it on the printed circuit board (PCB). However, better performance and more design flexibility can be obtained by using multiple custom-designed antennas integrated at suitable locations. The combination of the antenna design tool Antenna Magus and CST STUDIO SUITE makes custom design a realistic option.

As device design constraints change over several design cycles—see for example the range of projector frame shapes and available antenna locations in Figure 2—the constraint based design ability of Antenna Magus is invaluable. Given a frequency range and a size constraint, Antenna Magus produces a shortlist of suitable antenna types that can be further filtered visually by the antenna engineer.

Changes in the available space can be introduced to the constraints in Antenna Magus. The shortlist is automatically updated and new parametric antenna designs filter to the top of the list. Having a range of options is important since it allows the engineer to make trade-offs in terms of manufacturing, feeding, and robustness, but also in order to allow complementary antennas chosen to provide better overall reception coverage.

ANTENNA PLACEMENT WORKFLOW

The initial antenna design is not done with a particular placement in mind. The antenna performance is highly dependent on its position in the device, so this effect has to be evaluated and the antenna design adjusted, or matching circuitry added, so that it still performs according to specification.

In order to investigate multiple possible configurations quickly, it is essential that set-up and simulation of the model is robust and fast, and that relevant key performance indicators (KPIs) are produced directly without additional user input. An efficient set-up of the simulation model is facilitated by the System Assembly Modelling (SAM) framework, which

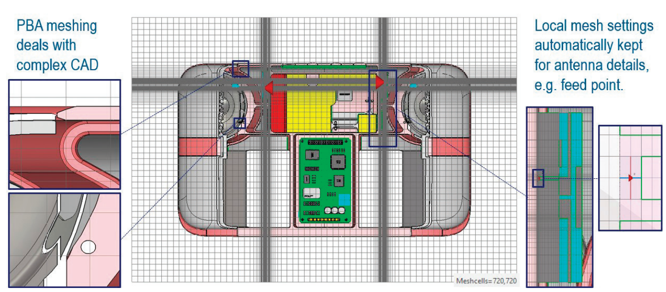


Figure 3. An accurate time-domain simulation can be performed in a short time for the fully detailed device without simplification when using a hexahedral mesh with the PERFECT BOUNDARY APPROXIMATION (PBA)® technology to mesh the complex CAD geometry.

allows multiple components to be easily assembled, each contributing their geometry, materials and mesh settings to the full device model, as shown in Figure 3.

A time domain simulation based on a hexahedral mesh with the PERFECT BOUNDARY APPROXIMATION (PBA)® technology to accurately resolve complex CAD without simplification or healing gives all relevant results – S-parameters near-fields (Figure 4) and farfields (Figure 5) – quickly.

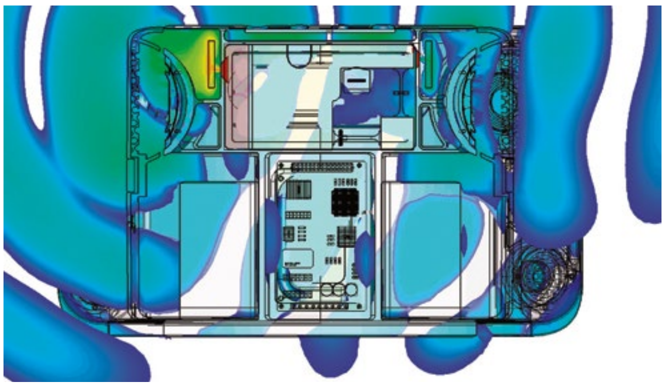


Figure 4. Electric field distribution at 2.45 GHz for an antenna tested in a potential placement.

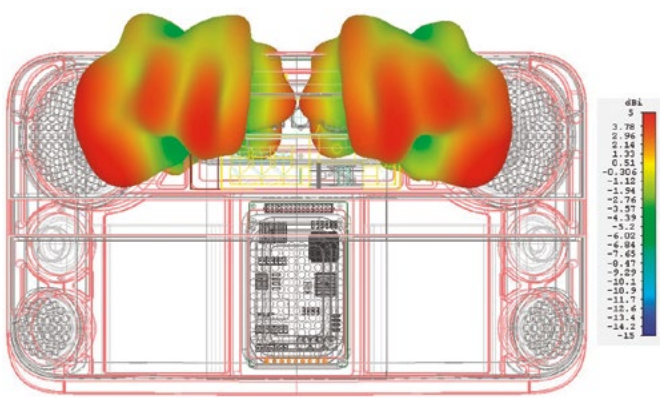


Figure 5. Farfield radiation patterns for two identical antennas installed at two locations inside the projector.

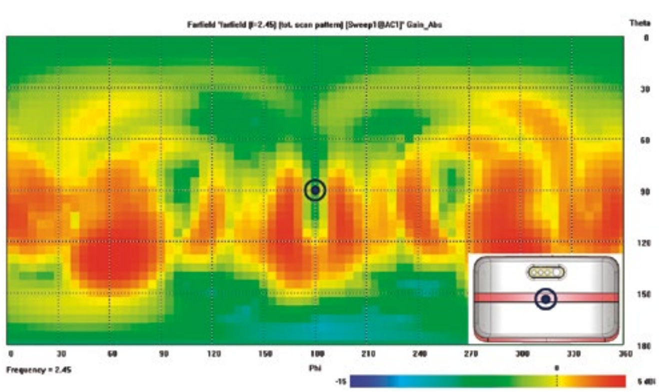


Figure 6. The total scan pattern shows how two antenna farfields might complement each other to provide coverage in all directions. In this case, 57.6 % of the solid sphere can expect an antenna gain of better than 0 dBi, which is better than an isotropic radiator.

When multiple antennas are installed, it is not only their individual farfield behavior but their combined performance that is of interest. Automatic post-processing allows quantities like the Total Scan Pattern (TSP) coverage to be evaluated, as shown in Figure 6. The TSP gives the maximum gain of either antenna in each direction, and can be used as a figure of merit to compare multiple antenna placement scenarios with each other. The type of marked difference between configurations shown in Figure 7 could not be predicted without using simulation.

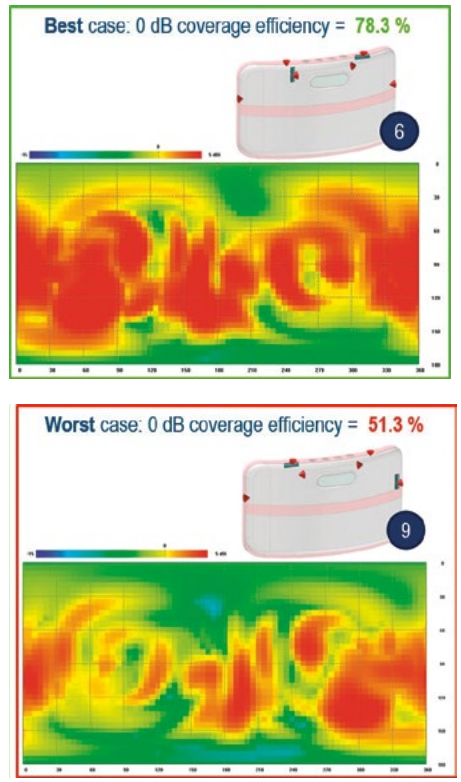


Figure 7. The difference between seemingly similar antenna placement scenarios can be dramatic. In this case the antenna combination at top gives a 27% higher 0 dB coverage efficiency than the combination on the bottom.

CONCLUSION AND OUTLOOK

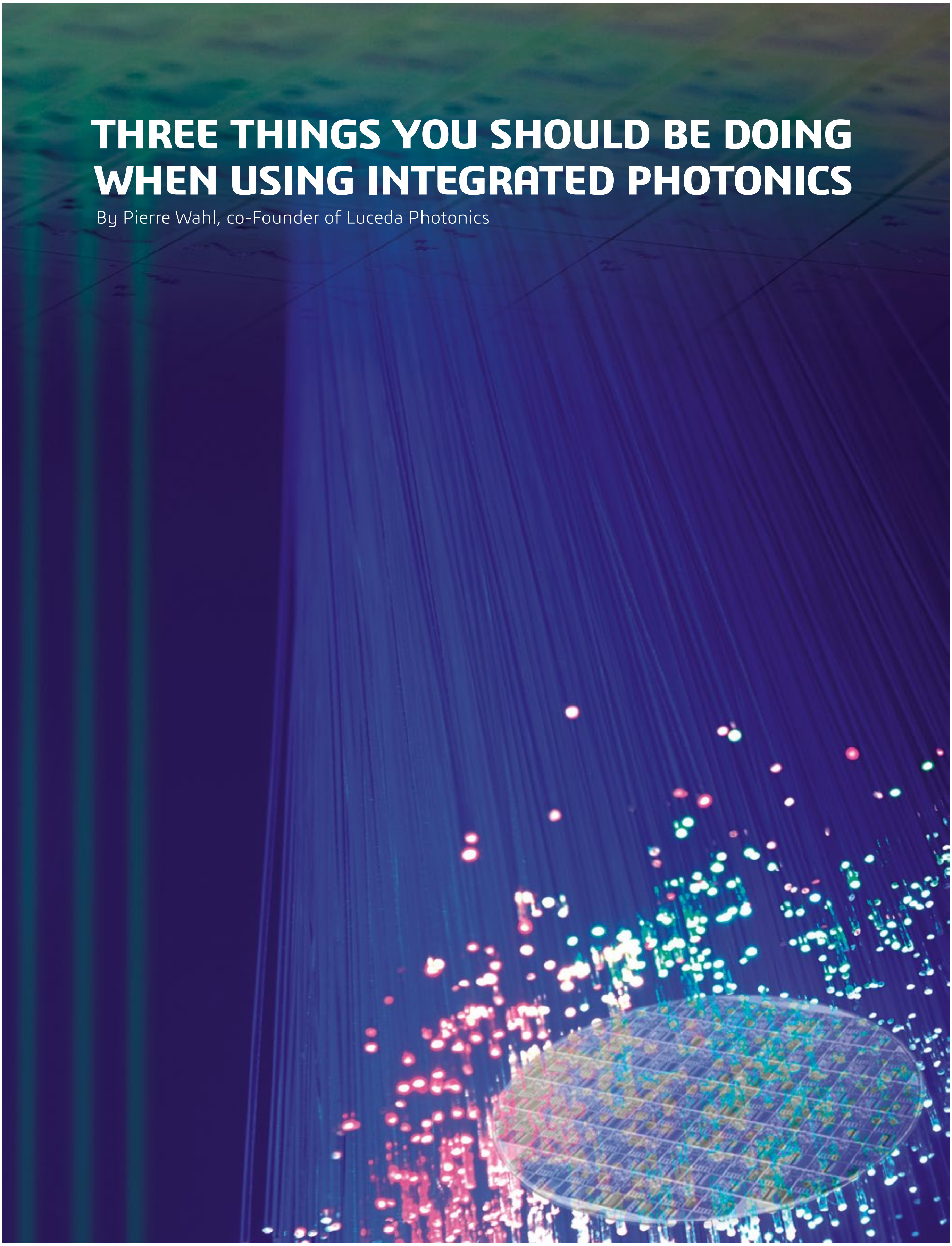
In order to design a functioning communication link for a complex consumer electronic device, the antenna engineer needs tools that allow them quickly and accurately to evaluate multiple integrated antenna design scenarios. The tools and methods described in this article show a viable approach. As communication bandwidths increase and higher frequency standards such as 5G establish themselves, new antenna technologies may become viable. The antenna will likely have to be designed as an integral part of the device housing itself. Multidisciplinary simulation across different physical domains will be required and the combination and interaction of tools accessible through the **3D**EXPERIENCE platform will present the ideal environment for sustainable innovation in the future.

For More Information

www.cst.com/beamy

THREE THINGS YOU SHOULD BE DOING WHEN USING INTEGRATED PHOTONICS

By Pierre Wahl, co-Founder of Luceda Photonics



Images courtesy UGent / imec.

The use and manipulation of light has always been a key component in technological fields such as telecommunications, medicine, sensing and defense. The science behind the manipulation of light is broadly known as "optics" or "photonics." Over the last decade the possibility of integrating photonic capability on a chip has started an unprecedented wave of innovation in the optics community such that it became a field of its own: "Integrated photonics." Already today, the use of integrated photonics has enabled order of magnitude improvements in the cost, performance and energy consumption of telecommunication while other fields are catching up quickly. Having supported R&D teams of major corporations and research institutes all over the world, we advise the following to teams hoping to reap similar benefits of this exciting technology.

CONSIDER ALL THE COSTS AND BENEFITS FOR YOUR APPLICATION

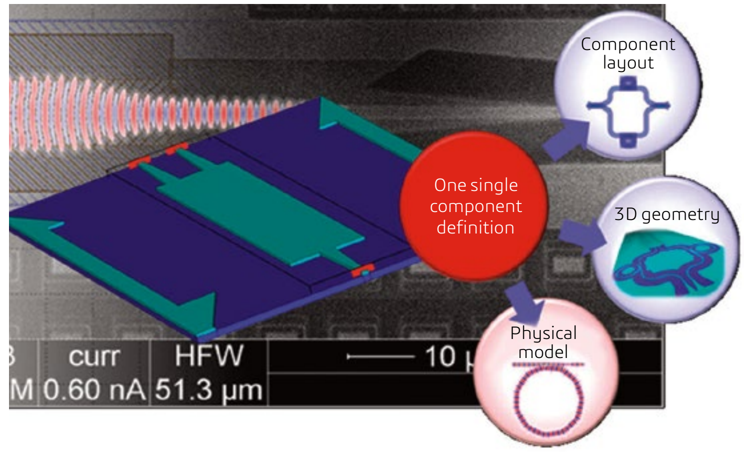
While the use of integrated photonic systems almost always improves the performance of their non-integrated counterparts, an integrated photonic chip is always part of a broader system in which it has to be integrated. As integrated photonic chips have different R&D processes, production facilities and cost models than their bulk counterparts, one needs to carefully consider both the technological and economic implications of the switch. For instance, it is true that integrated chips can have a very low unit cost but that is only the case when you need a large number of them. Sweat the details about this before you start making major financial commitments.

PROCESS DESIGN KITS (PDKS) AND MULTI PROJECT WAFERS (MPWS)

To help lower the adoption risk of industrial players, the research foundries active in integrated photonics offer you the possibility to share the cost of a full development wafer among different participants by combining their designs onto a single wafer. On top of that most foundries provide process design kits or PDKs that contain tested building blocks you can easily assemble and reuse. We therefore strongly recommend recent adopters to fully utilize this option to benchmark the technology.

INVEST IN A ROBUST WORKFLOW

Electromagnetic field simulations are a very important aspect of integrated photonics design. Nevertheless, we see that in practice, photonics design teams struggle with the organizational aspects required to consistently configure such simulations properly. It is necessary that the simulated geometry is a correct representation of the final fabricated structure, that the material models used are correct under operating conditions and that the simulation settings are set sensibly to obtain an accurate result in a reasonable time. Often, designers have to consult a range of sources and people (PDK handbook, process information data and the expertise of an engineer specializing in simulations) to get their simulation configured properly. As those sources are continuously



updated, ensuring that your EM simulations are consistently correct is mostly an organizational challenge. The use of software that can handle all aspect of the design flow is very important. At Luceda we collaborate with Dassault Systèmes to bring the best possible flow to our shared customers.

ABOUT THE AUTHOR

Pierre Wahl co-founded Luceda Photonics in 2014 where he is in charge of sales, support and training operations. At Luceda he trains and supports R&D teams of major corporations, research institutes, foundries and universities in China, North America and Europe.

He completed a PhD in opto-electronics at the Free University of Brussels and Stanford University on ultra-low energy optical interconnects in 2014 and obtained a Masters degree in photonics from the University of Gent and the Free University of Brussels in 2010. He has co-authored multiple journal publications and delivered various talks around specialized design, simulation and optimization techniques used in integrated photonics.

ABOUT LUCEDA PHOTONICS

LUCEDA PHOTONICS

Luceda Photonics wants photonic IC engineers to enjoy the same first-time-right design experience as electronic IC designers. Luceda Photonics' tools and services are rooted in over 50 years of experience in photonic integrated circuit (PIC) design and are used by several research institutes and industrial R&D teams worldwide.

For More Information
www.lucedaphotonics.com

ELECTRONICS THAT BEND, NOT BREAK

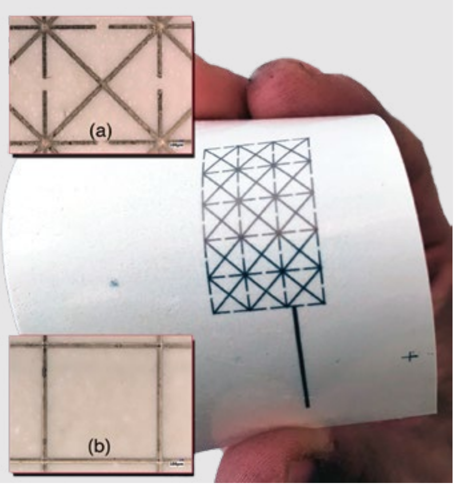
Heralded by many as the next great advancement for printed circuitry, flexible hybrid electronics (FHE) are becoming increasingly widespread. By printing electronic circuits that can be bent, twisted and stretched, devices can be made smaller, lighter and more versatile.

The challenges of FHE design are both mechanical and electromagnetic. The materials that go into a flexible device need to be able to withstand bending cycles without breaking—even slight damage to the electrical conductors can degrade device performance—and to tolerate environmental effects such as heating, sunlight and exposure to air, water or other chemicals. As the device includes both a conductive layer and a substrate, the adhesion of the ink to the substrate also needs to be ensured. Meanwhile, the deformation will change the electrical properties of the device. For example, the length of an antenna is directly related to its resonant frequency—if the antenna is stretched, its performance may change.

Researchers at the UMass Lowell Nanomanufacturing Center, together with Raytheon, are developing next-generation asset-monitoring platforms using FHE technology. Tunable electromagnetic filters or frequency selective surfaces (FSS), utilizing a functionalized substrate based on BST/LDPE composites, can replace current transmit arrays for beam-steering, alleviating complex structures and designs. The FSS can be printed on a flexible substrate and incorporated into an applique that can be attached directly to the asset and adapt to its shape.

To produce a successful product, the team needed to find a substrate material that was strong and flexible enough to survive in the challenging environment, while also meeting the necessary electromagnetic requirements. The team used mechanical simulation with Abaqus to model the bending and stretching of the device, and electromagnetic (EM) simulation with CST STUDIO SUITE to simulate the performance of the deformed FSS. In addition, by simulating the EM properties of the substrate material, the team was able to calculate the biasing voltage required for tuning the FSS and study the effect of manufacturing variation on antenna performance.

Printed FSS structure on custom-designed flexible substrate (a) is front structure and (b) is the back structure.



NextFlex 2.5 team (from left to right): Mary Herndon, Engineering Fellow, Mechanical, Materials and Structures (MMS), Technology Area Lead at Raytheon IDS; Claire Lepont, Senior Technical Program Manager at UMass Lowell; Scott Stapleton, Assistant Professor in Mechanical Engineering at UMass Lowell; Alireza Amirkhizi, Assistant Professor in Mechanical Engineering at UMass Lowell.

The success of the concept led to the UMass Lowell team winning a grant from NextFlex—a public-private consortium founded in 2015 to facilitate technology innovation and commercialization—to accelerate workforce development and develop a sustainable advanced manufacturing ecosystem. The next step for the researchers is to refine the concept and produce a complete asset-monitoring system using the technology.

With the enabling power of simulation for rapid design and virtual prototyping, it is important to characterize materials with simulation in mind. In a second project with the UMass Lowell Nanomanufacturing Center, Raytheon and several partner companies are designing mechanical tests that will fully characterize flexible electronics. These are not only designed to provide the inputs vital for realistic simulations, but the tests themselves are designed using simulation models.

For example, interface properties between the printed ink and flexible substrates are needed to design flexible electronics that push the failure envelope during use. Traditional interface tests are unfeasible, so a suite of new tests is needed. The large deformation and advanced material model capabilities of Abaqus are being utilized to design tests that yield interface strengths and energies in the face of nonlinearities. If successful, the methods developed here could serve as a blueprint for obtaining material inputs for increasingly complex and challenging material systems.

For More Information

www.uml.edu/research/nano

HOW DO I FIND THE RIGHT ANTENNA FOR MY DESIGN?

Antennas are crucial parts of any connected device, from phones to medical implants. With so many different use cases and frequencies, there is a bewildering range of antenna types all suited to various applications.

For example, a Bluetooth earpiece requires an antenna is small, cheap, and omnidirectional, while a spacecraft may require a high-power, high-gain antenna capable of receiving very faint signals from earth.

Antenna Magus is a tool for exploring, designing and synthesising antennas based on the requirements of the application. To illustrate its use, this article shows how Antenna Magus can be used to design two antennas for a real-time location system used in sports: a tag antenna worn by the players, and a sensor antenna to monitor the tags' position.

ANTENNA CHOICE

The first step is to find which antenna designs can meet the specifications. Antenna Magus contains a library of over 300 antenna types, each tagged according to their properties. For common applications such as Wi-Fi and GPS, Antenna Magus offers pre-defined Specifications which can be chosen immediately upon starting a project. For bespoke applications, a custom Specification is created, which can be stored for re-use in future projects.

From these, Antenna Magus selects the antennas in its library that can meet the Specifications. These can be further refined through the use of additional keywords. For the sensor application, a printed antenna is needed for ease of production; after being given the frequency band, dimensions and the keywords "printed" and "circular polarization," Antenna Magus suggests a number of possible antenna types. The "sequentially rotated 2-by-2 array notched circular patches" antenna is easy to manufacture and fits all the specifications, and is a good choice for the application. For further analysis, Export Mode is then used to create a 3D model for simulation in CST STUDIO SUITE.

For the tag antenna, a second specification is created with the frequencies, 3dB beamwidth and dimensions specified. Antenna Magus suggests the "short-circuited quadrifilar helix antenna". This too is then exported to CST STUDIO SUITE and simulated.

3D SIMULATION

When Antenna Magus creates the model, the mesh and solver settings for the simulation are already set, so the model is ready to simulate in CST STUDIO SUITE immediately (Figure 1). 3D simulation allows the antenna to be analysed in a realistic environment, taking into account the antenna casing and the structure it's mounted on. These can affect the performance of the antenna, changing its frequency and directivity. It is quick and easy to do a re-design and export from Magus to compensate for effects, or the built-in optimizers in CST STUDIO SUITE can be used to re-tune the antenna to take these into account.

Once the individual antennas have been optimized, the entire system can then be simulated. Simulating an entire football field with multiple sensor and tag antennas as a single 3D model would be challenging. Instead, each antenna can be simulated individually and the generated fields can be exported as a farfield or nearfield source. This source replaces the detailed antenna model in the system simulation, significantly reducing the computational requirements of the calculation.

The CST System Assembly and Modelling (SAM) approach means that these simulations can be combined into a coherent workflow with different solvers for each part. The individual antennas are best simulated by the general purpose Time Domain Solver, but propagation across the entire field—a very electrically large area which is mostly empty space—are more efficiently simulated by the Integral Equation Solver or Asymptotic Solver. The field source coupling allows the best solver for each part of the simulation to be used, which can speed up the simulation process significantly.

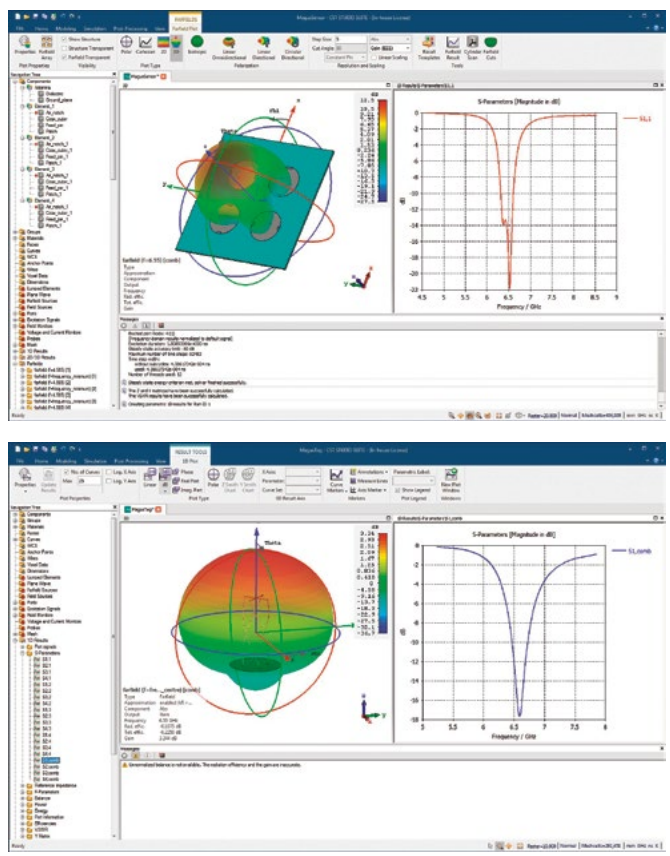


Figure 1: Farfield radiation pattern and S-parameters for the sensor (top) and tag (bottom) antennas.

For More Information

www.cst.com/products/antennamagus

NOVEL HIGH CAPACITY MILLIMETER WAVE WIRELESS NETWORKS ENABLED BY TRAVELING WAVE TUBES

Claudio Paoloni, Head of Engineering Department and Cockcroft Chair, Lancaster University

The huge increase of internet traffic wireless, fostered by video streaming, high-resolution cameras and the large number of connected portable devices—in addition to the need of operators assuring the best customer experience—has no other solution than the deployment of high density small cell networks, to serve less users for base station. The challenge is to provide cost effective backhaul to a high number of cells distributed in urban areas.

Fiber, due to the cost and difficult deployment, can only partially solve the problem. Wireless backhaul is, in principle, an attractive solution of easy installation and high flexibility. However, to support the increasing demand of multi-gigabit capacity, only the wide frequency bands available at millimeter waves (90–320 GHz) are suitable for the purpose. The high atmosphere attenuation and the low transmission power from solid-state devices have so far prevented the exploitation of the millimeter wave spectrum that needs a step change in technology.

Two European Commission Horizon 2020 projects, TWEETHER "Travelling wave tube based w-band wireless networks with high data rate distribution, spectrum & energy efficiency" and ULTRAWAVE "Ultra capacity wireless layer beyond 100 GHz based on millimeter wave Traveling Wave Tubes", respond to the quest of high capacity and high density cell backhaul to support future 5G networks by proposing, for the first time, the exploitation of the whole millimeter wave spectrum beyond 90 GHz.

The H2020 TWEETHER project is the first project to enable Point-to-multi-Point distribution above 90 GHz, by using a novel W-band Traveling Wave Tube (TWT) to provide millimeter wave transmission power at Watt level, to overcome the high atmosphere attenuation. Point-to-mult-Point permits to feed with a single transmission hub, with low footprint, a high number of terminals or base stations, distributed on a wide area. The 3-GHz bandwidth available in the range 92–95 GHz provides up to 10 Gb/s per kilometer square. The technology developed in the TWEETHER project will open the exploitation of the W-band with a new backhaul paradigm and will help to solve the digital divide by fixed access distribution in residential and suburban areas usually not covered by fiber.

The "beyond 5G" ULTRAWAVE project aspires to create an ultra capacity layer providing up to 100 Gb/s per kilometer square in Point-to-multi-Point at D-band (141–174.8 GHz) by a deployment of transmission hubs to cover sectors with up to 500 m radius. The transmission hubs are backhauled by novel G-band (275–305 GHz) Point-to-Point high-capacity links, with an unprecedented 30 Gb/s data rate, over up to 500 m range (Figure 1). The system is empowered by the convergence of three main technologies: vacuum electronics, solid-state electronics and photonics in a unique wireless system. The needed transmission power, at Watt level, is generated by novel D-band and G-band Traveling Wave Tubes (Figure 2).

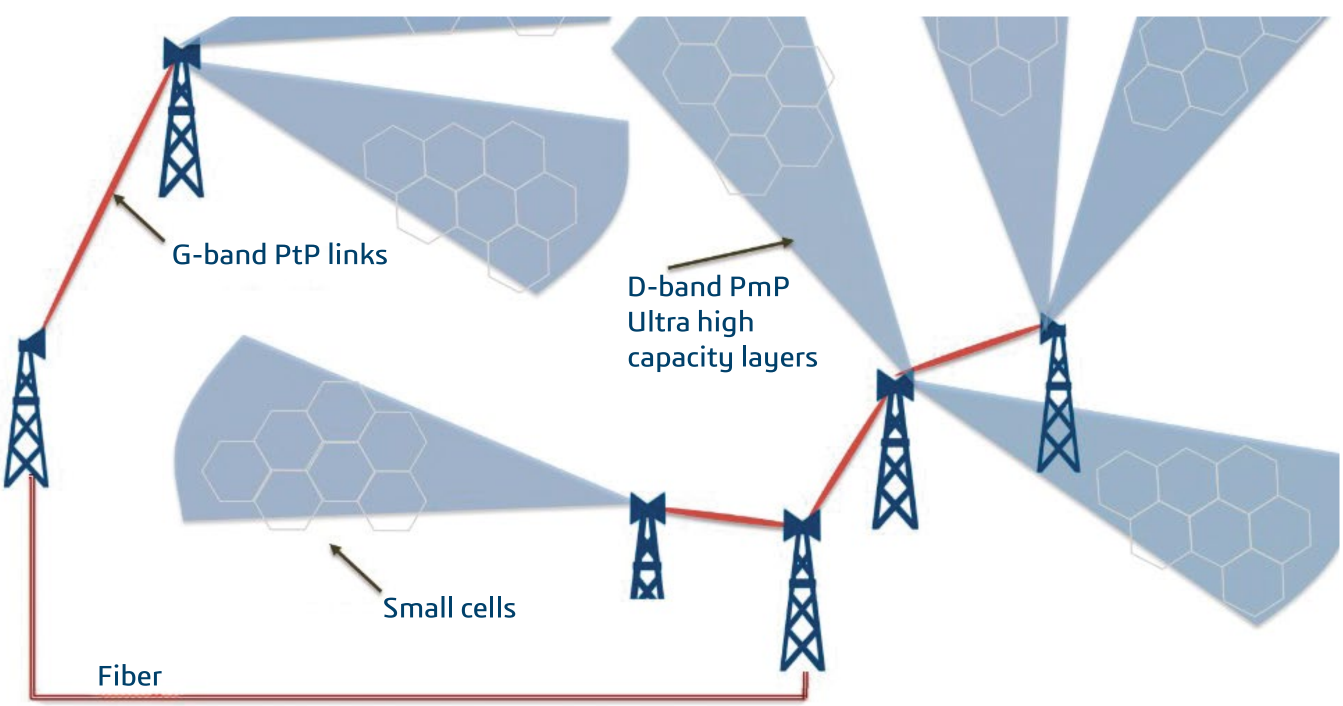


Figure 1: Ultra capacity wireless layer schematic for backhaul of high density small cells.

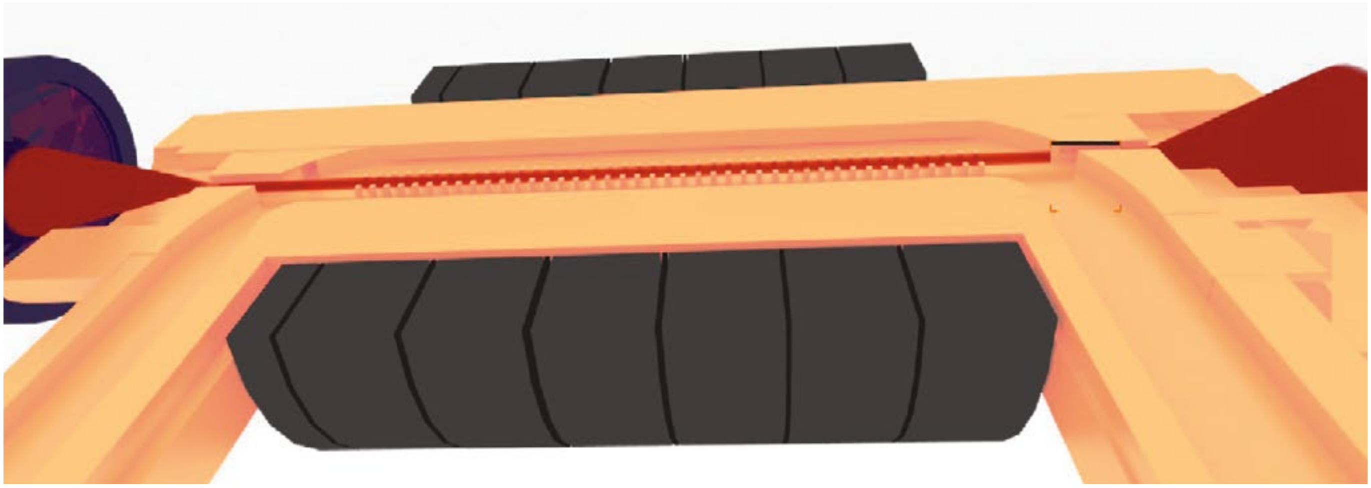


Figure 2: Rendering of a novel millimeter wave.

These novel millimeter wave wireless systems pose relevant design challenges due to limited experimental background, unconventional three-dimensional structures with sub millimeter dimensions and high development cost. In particular, millimeter wave TWTs are still at laboratory level and no consolidated procedures exist for their design and fabrication. A TWT consists of a waveguide of defined shape that slows down the propagating wave velocity to synchronize it with an electron beam flowing in the slow wave structures in order to transfer energy from the beam to the wave. The mechanism, in principle simple, when translated in the simulation domain, requires a substantial computational effort due to millions of particles associated to the electrons of the beam flowing in a complex geometrical structure, modelled by a high density mesh.

The availability of accurate and flexible three dimensional electromagnetic simulators, as CST STUDIO SUITE, is pivotal for the design and simulation of slow wave structures with dimensions of the parts in the hundreds of micron range and arbitrary shapes. The characterization of the electrical behavior of slow wave structures, including parameters related to materials and fabrication processes, is then followed from the more demanding prediction of the nonlinear performance, derived by the interaction of the electromagnetic field with the electron beam. The complex physic phenomena and the high number of particles needed to model an electron beam and the large 3D computational field requires accurate and efficient models and algorithms. The TWT design team mainly uses CST STUDIO SUITE, which permits extensive and fast simulations due to the optimized algorithm and the support of the most advanced GPUs, with a substantial reduction of the simulation time in comparison to similar CAD tool. Figure 3 shows the electron beam behavior while flowing along the interaction structure.

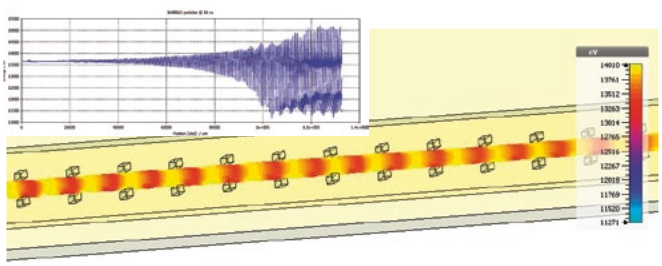


Figure 3: Particle in cell simulation in CST STUDIO SUITE of a novel TWT. In the inset the energy of the electron along the propagation axis is shown.

The fabrication and measurement of the millimeter wave and THz TWTs, will be a substantial step to calibrate 3D simulators on real devices.

Claudio Paoloni received the degree in Electronic Engineering from a University of Rome "Sapienza", Rome, Italy, in 1984. Since 2012, he has been a Professor of Electronics with the Department of Engineering, Lancaster University, Lancaster, UK Since 2015, he has been the Head of the Engineering Department. He is the author of more that 200 publications. He is coordinator of the Horizon 2020 projects, TWEETHER and ULTRAWAVE for millimetre waves high capacity wireless networks. His research fields are millimetre wave vacuum electronics devices and applications. He is an IEEE Senior Member. He is Chair of the IEEE Electron Device Society Vacuum Electronics Technical Committee.

Lancaster University is one of the UK's top universities, recently named the University of the Year by The Times and The Sunday Times Good University Guide 2018. The Engineering Department at Lancaster University is a General Engineering Department of recognised excellence in research and teaching, with a clear growth strategy. Engineering research there was rated as world leading in the 2014 Research Excellence Framework (REF), being placed 7th in the UK in the Times Higher Research Intensity league table.

For More Information

www.lancaster.ac.uk/engineering