SIMULATING SMART DEVICES FOR INNOVATION AND COMPLIANCE

MODSIM enables accelerated, cost-efficient development

DASSAULT SYSTEMES

MEETING TECH INDUSTRY CHALLENGES

In consumer technology hardware, innovation means survival. Successfully launching a new smart device means competing with some of the largest companies on the planet as well as agile start-ups. R&D budgets in the tech industry have never been higher, with device manufacturers investing billions of dollars in new products[1,2].

Connected device manufacturers are facing development demands around the ongoing 5G rollout, the development of 6G, and high data-rates from increasingly advanced processors and sensors. Consumer devices and backend electronics require regular design updates to accommodate new standards. For example, 6G is likely to support THz or even optical operating frequencies, requiring **a new generation of antennas and electronics** to be developed. Generally, printed circuit boards (PCBs) and semiconductor packaging must handle much **higher data rates without thermal, signal integrity or electromagnetic compatibility (EMC) issues**. The Federal Communications Commission (FCC) standards, other local regulations worldwide and European Ecodesign rules must be met. There are new form factors and designs, such as folding and modular phones, and devices must remain slim and lightweight.

Manufacturers know that shortening development cycles and being first to market with innovations is key in gaining a competitive advantage. Virtual prototyping can help cut costs and reduce risk, giving confidence that a new product meets specifications and passes regulatory certification. This can be accomplished with simulation using a virtual twin.

KEY TAKEAWAYS FROM THIS E-BOOK

- Multiphysics simulation on a virtual twin can offer a major productivity boost.
- Electromagnetic, structural and thermal simulation can identify potential issues and optimize holistic device performance.
- MODSIM on the **3DEXPERIENCE®** platform, gives designers and engineers the ability to collaboratively work on the CAD design, multiphysics simulation, requirements & project management, enabling shorter product cycles.
- Virtual prototyping and pre-compliance testing pave the way to full regulatory certification.

1 https://www.statista.com/statistics/273006/apple-expenses-for-research-and-development/
2 https://m.pulsenews.co.kr/view.php?year=2022&no=729968

VIRTUAL TWIN

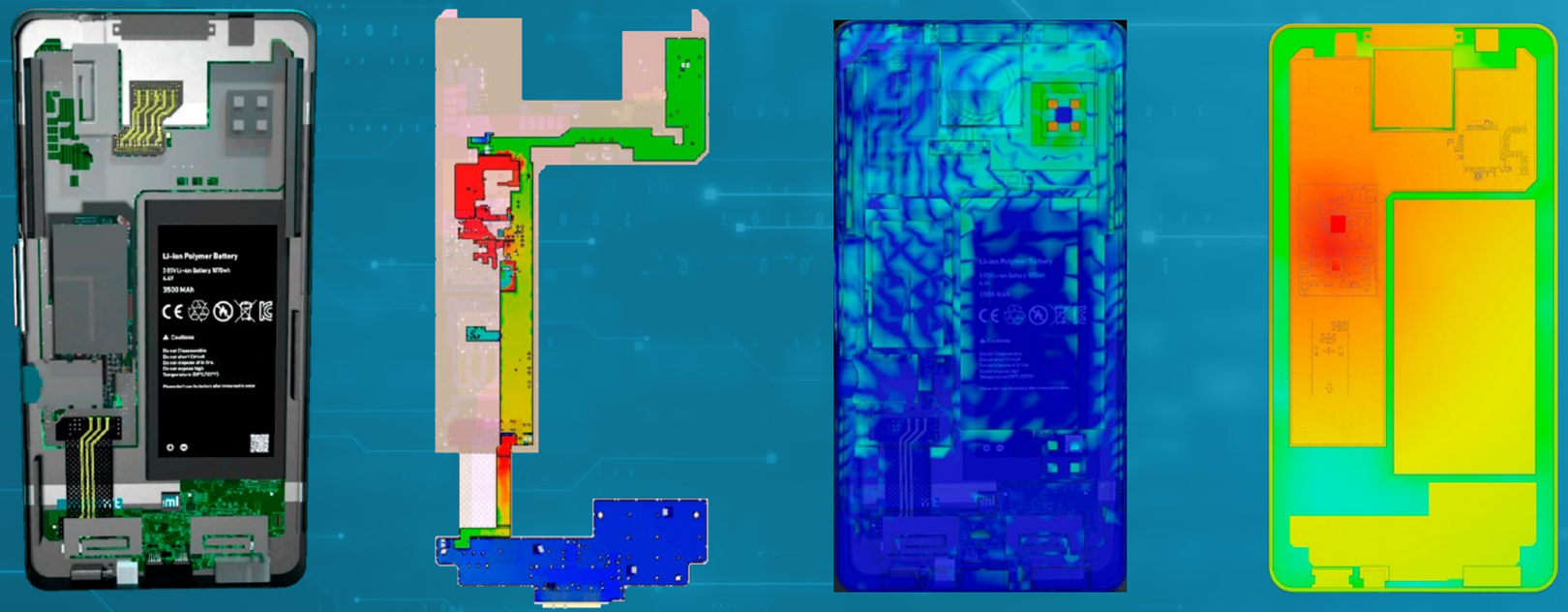
A Virtual Twin is a digital representation of a real product and the entire experience around it. It contains all relevant data, including requirements, geometry and test results, in a single source of truth.

Physics-based simulations are run on that virtual model to explore how the product will behave when assembled, operated or subjected to a range of events.

Virtual testing helps optimize and validate the design, materials and production processes. Because it is virtual, expensive, time-consuming and wasteful prototypes are kept to a minimum.

"Simulation on a virtual twin helps us predict what's going to happen in the real world. This is incredibly valuable when doing design work, since you can see what's going to happen before building anything."

Jonathan Oakley, Director, High Tech Enablement, SIMULIA



The Virtual Twin (1) connects MCAD and ECAD to simulation of electronics (2), antennas (3) structures and heating (4) using a common data model.

ANTENNA DESIGN FOR COMPLETE CONNECTIVITY

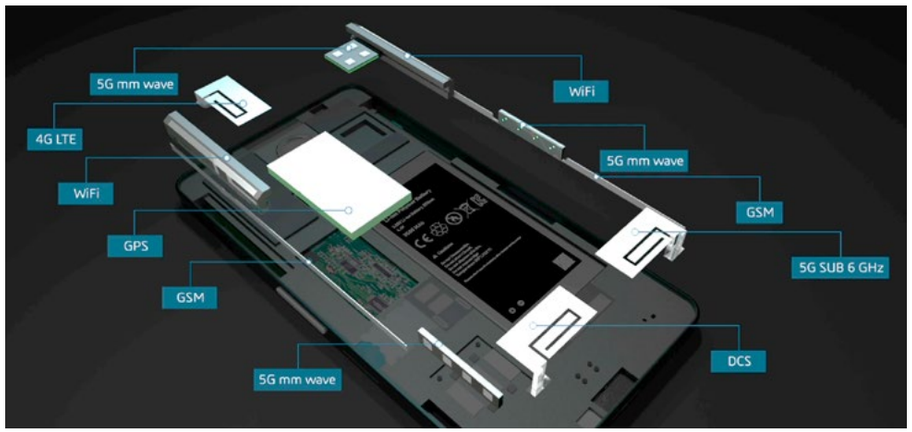
Antennas are the key components that ensure connectivity and need careful design and placement if they are to operate reliably. The antennas in a device must meet their KPIs such as spatial coverage and total radiated power (TRP), while avoiding neighboring antenna (co-site) interference and staying within specific absorption rate (SAR) and maximum permissible exposure (MPE) limits. 5G and in particular high-band 5G above 6 GHz, requires new methodologies for antenna placement, massive MIMO (Multiple-Input Multiple-Output) and beam steering.

Antenna engineers must design complex, integrated antennas that meet the demands of modern data connectivity. Electromagnetic simulation is crucial for understanding the behavior of antennas, particularly when installed in complex environments. Simulation can be applied at every stage of antenna development, from initial design to final performance verification.

A modern smartphone incorporates multiple antennas that must meet numerous KPIs and regulatory standards. In 5G mm wave, coverage and compliance require the whole phone to be simulated. A virtual twin of the smartphone includes all the details necessary for an accurate analysis.

"Simulation helped us to optimize the antenna design process and to achieve a revolutionary payment experience on our mobile devices."

Tony Honkanen, VP Technology, Aava Mobile



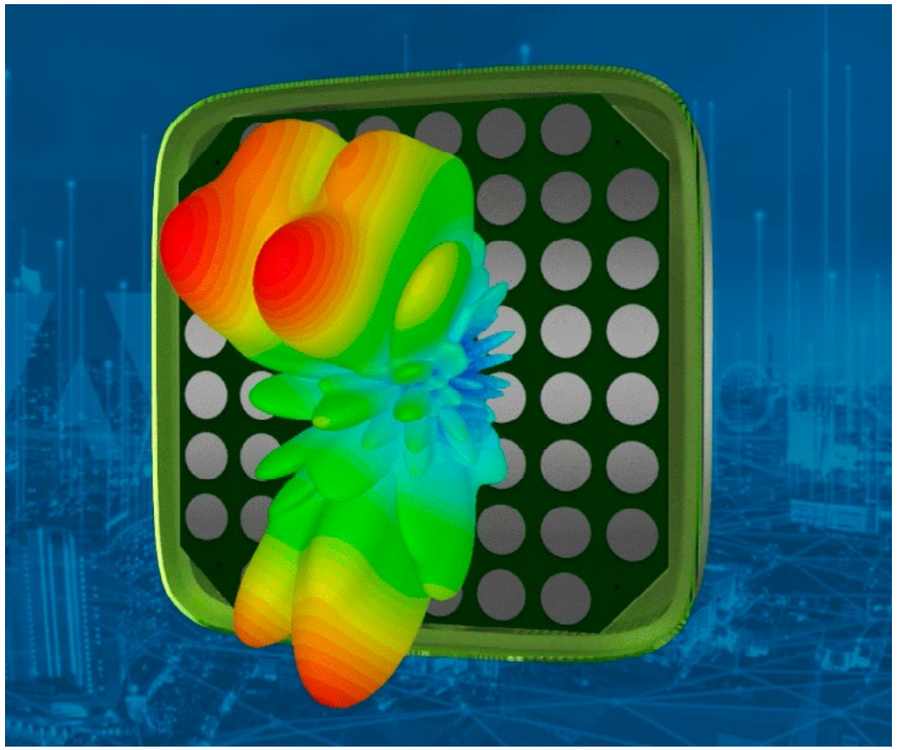
Increased complexity: 4G: 5 antennas, 5G + 4G: 11+ antennas

ANTENNA DESIGN FOR COMPLETE CONNECTIVITY

Antenna design—Modern device antennas are usually custom-designed and constrained by space and form factor. Optimization allows engineers to fine-tune antennas to meet exacting requirements and constraints. Antenna synthesis tools help engineers find the right antenna for the job. **Synthesis directly generates simulation-ready 3D geometry for optimization or placement**. The synthesis workflow is fast, and analysis can be started in minutes without waiting for a physical prototype.

Antenna placement—The device itself and the surrounding environment (including the presence of the human body) affect antenna performance. Understanding installed performance is critical to ensuring that the device operates as expected in everyday use. **Simulation reveals how antennas behave in complex real-world scenarios**, including ones that are difficult to measure. Antenna manufacturers can deliver encrypted simulation-ready models to their OEM customers or system integrators for placement analysis without revealing sensitive intellectual property (IP).

Arrays, MIMO and beam steering—To enable reliable connections and higher bandwidth, more data channels are needed with higher data rates per channel. Various approaches facilitate this. Beam steering uses phased array antennas to shape the beam and direct it at the base station. MIMO and multi-path propagation use the environment to reflect beams to create more spatial channels and capacity. Simulation can model the complex interaction between the many antennas on a device. Synthesis tools can accelerate array design and 5G mm-wave codebook optimization greatly.



Equipment antenna with beam forming.

"CST Studio Suite simulations replace prototype builds for mobile phone antennas and shorten time-to-market by 35%."

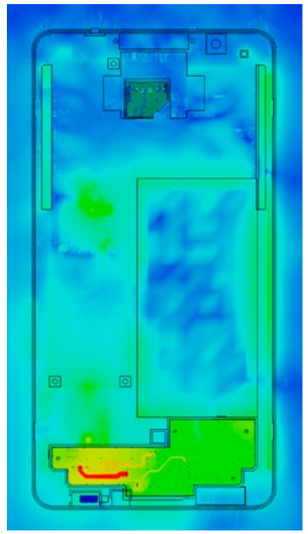
Si Li, Antenna Expert, OPPO

HIGH-SPEED, RELIABLE ELECTRONICS

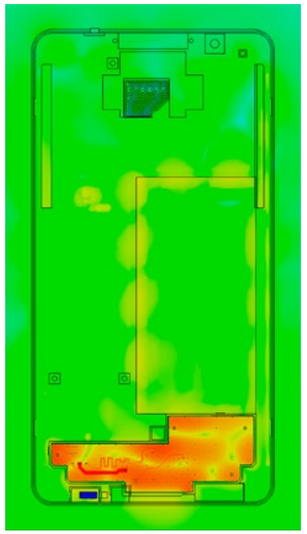
Data flows from the antennas to the processor through PCBs, connectors and cables. Impedance mismatches and poorly designed transitions can cause signal integrity (SI) issues and crosstalk as well as unwanted radiated emission and increased susceptibility to outside interference. These effects reduce the reliability of the electronics and can lead to failure in the certification process. As data rates increase and electronics become more compact and 3-dimensional in nature, traditional circuit simulation and 2D planar simulation cannot fully capture the propagation of high-frequency signals. **Only 3D electromagnetic simulation can capture all the field and current behavior** that causes SI problems, reducing the risk of issues emerging during hardware testing.

- **Virtual testing**—Standard tests exist for EMC and SI-relevant measurements such as time domain reflectometry (TDR) and eye diagrams. To test these physically, requires manufacturing prototypes and long and costly lab time. With a Virtual Twin, these **measurements can be replicated in simulation without needing to build prototypes**.
- **Integration into EDA workflows**—Widely used electronic design automation (EDA) layout tools, as well as many proprietary and open-source formats, can interface with simulation. **PCB layouts are automatically converted into accurate, simulation-ready 3D models**. These can be combined with cables and connectors for a full channel simulation or can be integrated into housing to analyze shielding and leakage (see inset box). The 3D structure can even be bent and stretched for flex-PCB simulation.

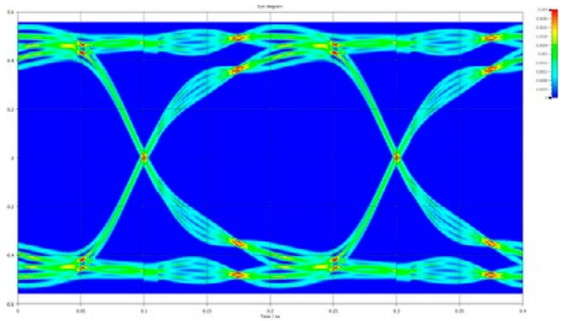
High-speed data lines can behave like antennas, leading to interference, unwanted emissions and increased susceptibility. Virtual twin-based simulation clearly reveals bands where emissions exceed FCC limits and helps engineers identify the correct mitigation and shielding strategies.



Radiation below FCC limit.



Radiation above FCC limit.



Typical eye diagram for end-to-end data channel.

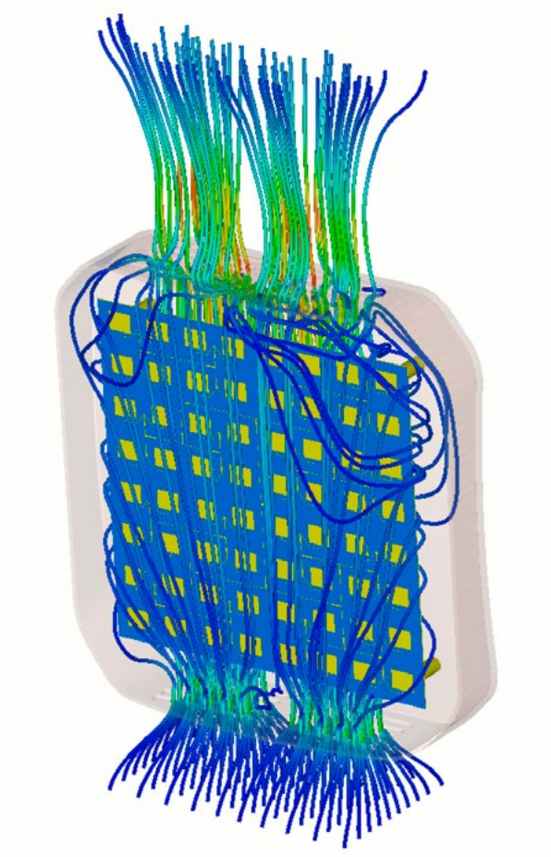
THERMAL MANAGEMENT

Overheating adversely affects device performance and can cause damage or even an explosion[3]. In the case of batteries, this has led to some high-profile device recalls that damaged brand reputation. Thermal simulation can be coupled to electromagnetic simulation to calculate heating, and to fluid simulation to model airflow through the device to ensure efficient heat dissipation and cooling. Results are provided faster than by physical testing, and engineers can also **quickly analyze different scenarios**—for example, extreme weather or blocked air vents.

- **Multiphysics simulation**—There are close connections between thermal and other disciplines. How much power can a component dissipate before overheating? Does changing the layout of the PCB affect airflow? Is there electromagnetic interference (EMI) caused by electromagnetic field leakage through the vents? Multiphysics simulation lets engineers analyze many different physical domains—electromagnetic, structural, thermal, fluid flow and motion—on the same model. This allows complex interactions between physical phenomena to be studied on the Virtual Twin.
- **Battery design**—When installed in a device, a battery must be kept cool to avoid thermal runaway effects that can damage the battery or lead to a fire. Structural integrity is also important, as drop or impact damage to the battery can also cause overheating or worse. Specialized battery simulation tools analyze installed battery performance to reduce the risk of overheating. Furthermore, electro-chemical, electro-thermal, and cyclic and calendric aging simulation can ensure that battery cells are optimally designed.

3 https://www.pcmag.com/how-to/why-phones-explode-and-how-to-prevent-it-from-happening-to-you

Modern devices with high-speed processors and compact form factors can get hot and uncomfortable to hold. By studying worst-case scenarios using thermal simulation, the heat can be managed and dissipated without causing damage.



Equipment antenna showing airflow and heat dissipation.

STRONG, ROBUST DEVICES

Broken screens, damaged charging ports, worn-out buttons are familiar to many mobile phone users. This can cause high warranty repair costs and damage manufacturers' reputations. **Virtual testing helps to improve quality and reduce warranty costs**.

Meet sustainability objectives—The need to improve sustainability is increasing the demand for longer-lasting and repairable devices. New European Ecodesign rules regulate and label durability in the same manner as current energy-efficiency regulations. **Simulation helps engineers design and build more sustainable devices by ensuring strength and durability KPIs are met throughout the development cycle**.

- **Virtual testing**—Structural simulation can virtually replicate common tests such as **assembly pre-stress, drop test, three-point bending** and **water immersion**. Hundreds of tests must be carried out to ensure all orientations, situations and model variants are characterized. Simulation automation and Design of Experiments (DOE) can **automatically set up and run complex test scenarios** without the time and expense of running hundreds of controlled physical tests.
- **Lightweighting**—Optimization and **generative design** can minimize weight and material usage, without compromising on strength or thermal and electromagnetic performance.
- **Fatigue simulation**—Repeatedly pressing buttons or inserting USB connectors will wear out components over time. Fatigue simulation is an efficient way to **model years of use in just hours**.

Drop testing requires hundreds of cycles for numerous variants and scenarios. It's expensive and time-consuming. Structural simulation can predict device resilience over many drop cycles rapidly and accurately.

- **Multiphysics simulation** can assess whether damage to a device is likely to degrade its performance. Will changes made to improve electromagnetic or thermal performance make the device less durable? **Simulation reduces the risk of unforeseen behavior and ensures the correct trade-offs are made for an optimal design**.

REGULATORY COMPLIANCE

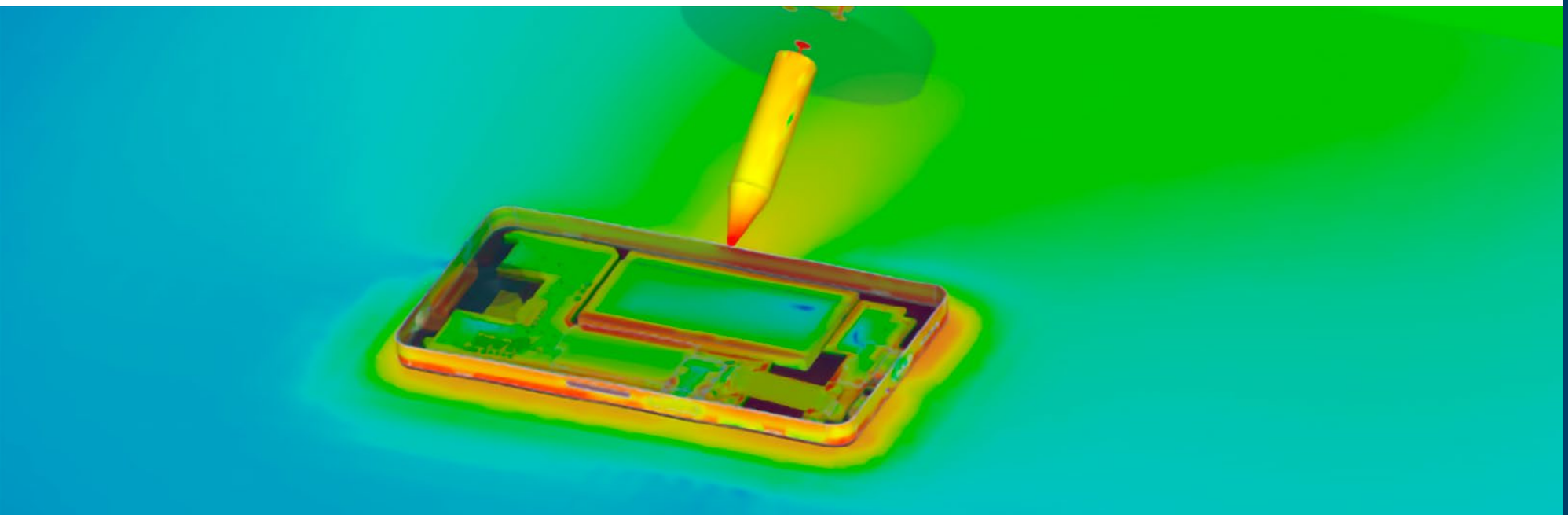
To enter the market, a device must pass a series of regulatory tests. These compliance standards vary across geographic regions, with some industries such as aerospace and defense imposing additional safety-related rules. Simulation can significantly accelerate the certification process, reduce risk and make the regulatory environment less daunting. Increasingly, regulators accept simulation results for certification. For example, instead of requiring a series of time-consuming physical test results, the FCC accepts simulation results for SAR & MPE.

Electrostatic discharge (ESD) susceptibility testing requires specialized equipment and facilities. The full test scenario with device under test (DUT) and ESD equipment can be replicated in the virtual twin.

SIMULIA is recognized as a market leader for virtual twins of ESD generators for virtual testing.

"Product designers have to get it right, so pre-compliance simulation, using a virtual twin, can help meet regional compliance regulations before a prototype has been built."

Jonathan Oakley, Director, High Tech Enablement, SIMULIA



REGULATORY COMPLIANCE

Applications of simulation for regulatory compliance include:

- **EMI and EMC**: A device must not interfere with nearby devices and it must resist interference from other devices. Simulation can analyze and predict EMI and EMC performance. 3D visualization allows engineers to understand the root causes of interference and how it can be mitigated with shielding, filtering and other techniques. ***Ref: CISPR 32/35, FCC Title 47 CFR Part 15***
- **ESD and surge resistance**: ESD and electrical fast transients (EFTs) are brief high-voltage surges that can damage devices. Simulation can replicate laboratory tests using virtual ESD guns and model both contact and non-contact discharge scenarios. ***Ref: IEC EN 61000-4 Series, ISO 10605***
- **SAR, sPD (MPE) and human RF exposure:** When electromagnetic fields interact with human tissue, some power is absorbed by the body, resulting in a heating effect. For safety reasons, there are strict limits on exposure to radiofrequency (RF) fields. Simulation is essential for analyzing SAR and sPD (MPE) required in high-band 5G. ***Ref: FCC Title 47 CFR 1.1310, IEC/IEEE 62704 and 63195 standards series***
- **Waterproofing and dust ingress**: Devices must be able to resist the ingress of contaminants and accidental contact with electrical parts. ***Ref IEC Ingress Protect (IP) standards, IP67, IP68***
- **Ruggedization and eco-design**: In some markets—for example, defense—standards regulate physical strength and robustness. The new European Regulation on Ecodesign for Sustainable Products (ESPR) standards will bring these to consumer devices as well. Destructive tests such as drop testing can be performed virtually with simulation. ***Ref: MIL-STD-810G***
- **Battery certification**: The occurrence of past high-profile battery fires[4] led to strict rules for device battery safety, especially for air shipping. ***Ref: UN 38.3, UL 2054, IEEE 1725***

4 https://edition.cnn.com/2023/03/09/tech/lithium-ion-battery-fires/index.html

WHY SIMULATE

The modeling and simulation technology from Dassault Systèmes helps engineers to design, understand, optimize and validate their smart devices at an early stage of the product development cycle. Virtual twins give high confidence that a device will pass regulatory compliance certification and meet required KPIs before physical testing is started.

First to Market

Use virtual twins to reduce or even eliminate the need for physical prototypes. Rapidly obtain design feedback, identify issues and resolve them.

Innovation

Test the viability of innovations early in development. Use DOE to explore the design space to find potential solutions.

Regulatory Compliance

Simulation can significantly accelerate regulatory compliance certification, reduce the risk of failure and increase confidence that the final design passes first time.

Optimize Products

Simulation powers optimization that can reduce weight and cost, improve space usage, reduce energy consumption and improve performance.

Virtual Testing

Virtual twins let you visualize and simulate multiple real-world test-cases and can model years of use in just hours.

Cost Savings

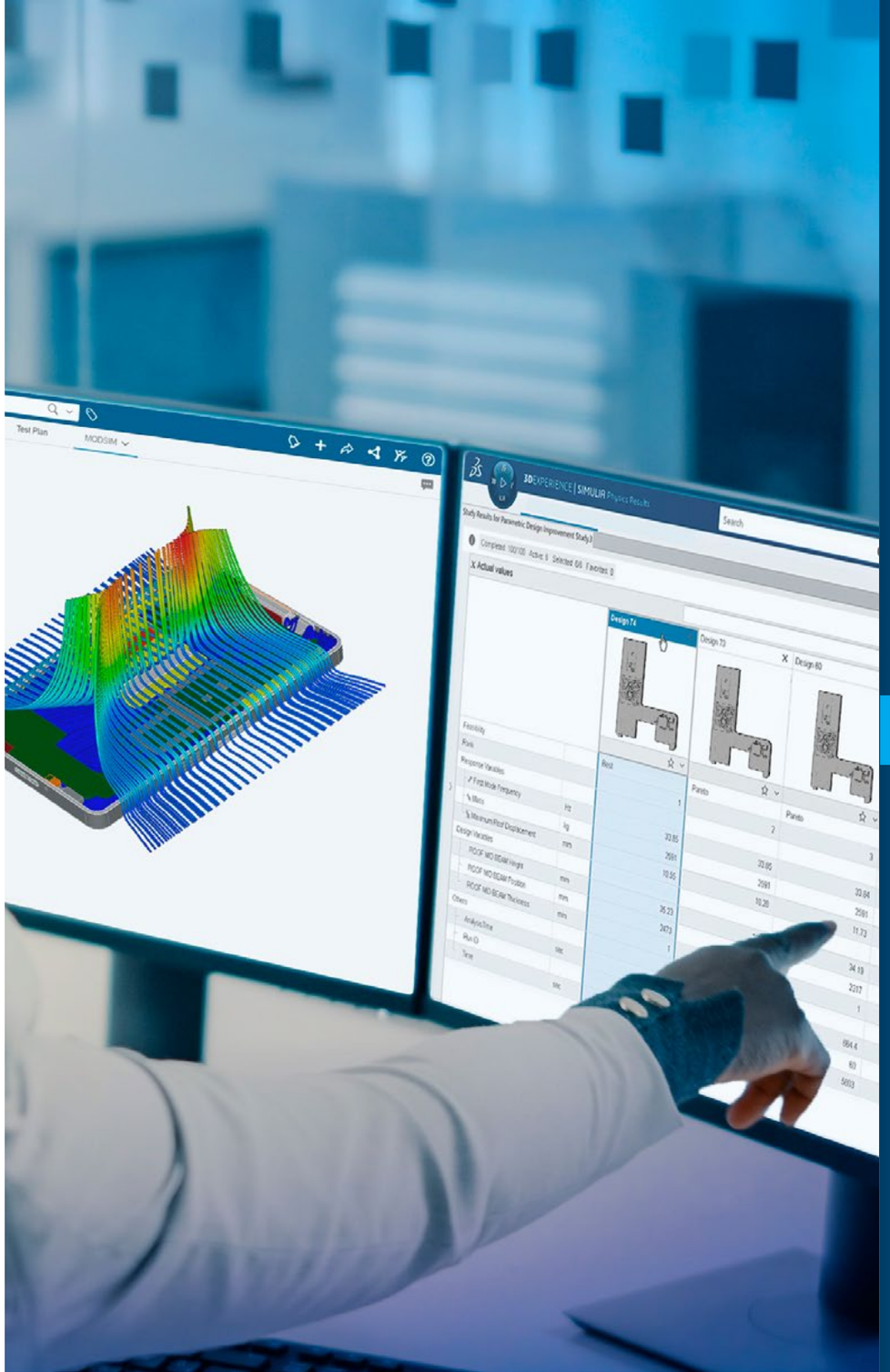
Accelerate product development cost-effectively using virtual twins. Avoid the risk of expensive late-stage design changes.

WHY DO DEVICE MANUFACTURERS NEED UNIFIED MODELING & SIMULATION?

In a highly competitive market, where innovation and being first to market are deciding factors for the success of a product, manufacturers must ensure that their processes are up to the job. Rethinking processes so that product designers are connected and collaborating with simulation engineers and analysts, working on one common data model, enables better communication and faster feedback loops. **Left-shifting simulation to the earliest stage of the product design process enables shortened development and certification processes** and faster product delivery.

We call this the unified modeling and simulation process—MODSIM for short.

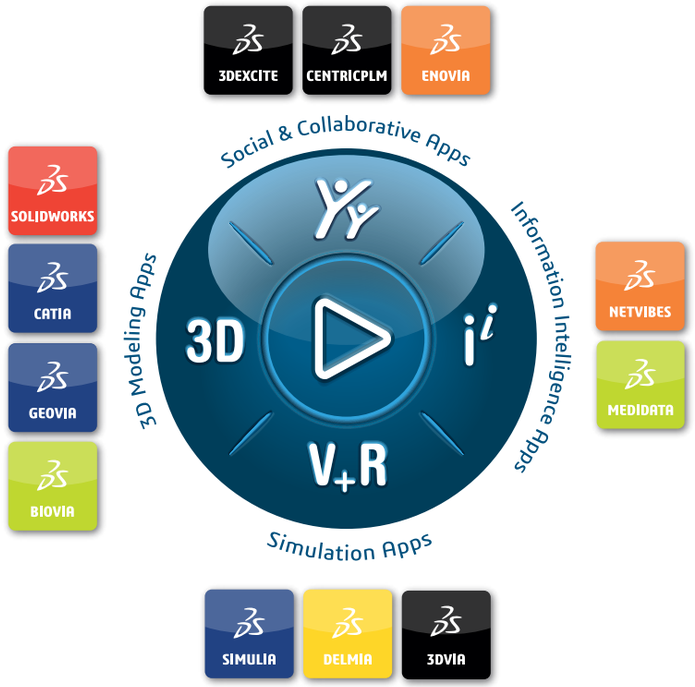
- **Accelerated development**: Under MODSIM, the model must be built only once. The **same data is used for all design and analysis tasks**, saving time and development costs and reducing project complexity.
- **Collaboration on a single source of truth**: Teams can collaborate effectively on the same model, reducing the risk inherent in file transfers and providing **full traceability**.
- **Design in any tool**: Flexibility to choose your preferred design tools: CATIA and SOLIDWORKS from Dassault Systèmes, or third-party CAD tools.



Our **3D**EXPERIENCE® platform powers our brand applications, serving 12 industries, and provides a rich portfolio of industry solution experiences.

Dassault Systèmes, the **3D**EXPERIENCE Company, is a catalyst for human progress. We provide business and people with collaborative virtual environments to imagine sustainable innovations. By creating virtual twin experiences of the real world with our **3D**EXPERIENCE platform and applications, our customers can redefine the creation, production and life-cycle-management processes of their offer and thus have a meaningful impact to make the world more sustainable. The beauty of the Experience Economy is that it is a human-centered economy for the benefit of all –consumers, patients and citizens.

Dassault Systèmes brings value to more than 300,000 customers of all sizes, in all industries, in more than 150 countries. For more information, visit **www.3ds.com**.



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