Intentional innovation of a new MR foundation for patients, technologists and our world

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An MR system is a complex and intricate system of technologies. Comprised of high-tech hardware managing thousands of amps of electrical current with nanosecond precision and sophisticated software that processes gigabytes of data for each patient, MR systems leverage advanced physics and mathematical principles and require significant computational power. Headline-grabbing features like deep-learning applications or surface coils are often the focus of MR imaging publications. However, these flagship features would not be possible without foundational technologies not often discussed in publications such as this. The legacy of innovation among our SIGNA™ MR colleagues has produced several foundational technologies that have become ubiquitous in modern MR—the zero boil-off magnet, the phased-array surface coil, and active shielding for both magnets and gradient coils. These foundational technologies have had a substantive, lasting impact on MR imaging. Today, we're excited to share several technologies that are destined to shape MR imaging for years to come and meaningfully improve the environmental profile of the entire MR system.

Launched in 1983 by GE Medical Systems, the SIGNA™ 1.5T was one of the first high-field, whole-body MR systems. In the years that followed, the practice of medicine has evolved to a stunning degree, such that in 2025, imaging is a ubiquitous element of differential patient care decisions. Compounded with technological innovations, the quantity of imaging studies that must be performed and reported has grown significantly. To no surprise of many readers, this phenomenon has been developing in tandem with mounting staffing shortages across radiology departments and persistent declines in reimbursement.[1] Observing these patterns over the past years and the impact they have on patient care, our global team identified several key technologies that would enable a step-function in how providers care for patients. We are pleased to share these technologies and how we believe they support providers to overcome this inflection point between rising demand, limited resources and the need to provide care for billions of people the world over.

Across GE HealthCare, we embrace an intentional Design Thinking approach (Stanford d.school) to innovation that teaches us to first empathize with our customer and users before embarking on the design journey. Over the course of years of work, we arrived at three key needs of today's customers that gave us a north star by which we navigated the design process.

- Our customers need sustainable, affordable solutions that facilitate access to quality care.
- Equipment must be long-lived, upgradable and resource efficient.
- MR systems must deliver state-of-the-art clinical capabilities to enable precision care.

The culmination of this process is embodied in the development of GE HealthCare's Next Generation MR Platform.[‡] This platform realizes a system-level approach to MR design, in which each component

[‡] Technology in development that represents ongoing research and development efforts. Not for sale. Not CE marked. Not cleared or approved by the U.S. FDA or any other global regulator for commercial availability.

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has been intentionally engineered to complement others and unlock benefits that exceed the sum of the individual components.

- **Platform gradient coil‡ and body coil‡:** Designed to work in harmony with the sealed cabinet and single-loop cooling system, these coils benefit from optimized coolant flow and temperature control, improving thermal stability and scan consistency while also increasing clinical gradient performance.
- **Single-loop platform integrated cooling cabinet (PICC)‡:** A simplified cooling architecture that supports both gradient and body coils, reducing complexity and improving reliability and efficiency—decreasing the total cost of ownership by reducing electricity spent cooling equipment and patient spaces with chilled air.
- **Modular cabinet layout‡:** The air/liquid heat exchanger is flexibly positioned (left, right or center) and mounted on slides for easy serviceability, while temperature sensors provide real-time feedback for fan speed control.

Figure 1. (A) GE HealthCare corporate campus in Waukesha, Wisconsin. (B) GE HealthCare Technology Park in Beijing, China. (C) John F. Welch Technology Centre in Bangalore, India.

- **Consolidated gradient power supply (CGPS)‡:** A next-generation, flexible power supply that supports several performance tiers to enable scalability. By using a single component across various products, CGPS can be tailored to meet a wide range of performance needs, increasing serviceability and reliability for all customers.

This intentional philosophy of innovation across the MR system ensures that performance, serviceability and sustainability are not achieved at the expense of another; rather, they are optimized to collectively produce results expected by our customers. In the context of these components, our Next Generation MR Platform delivers tangible benefits:

- **For patients:** quieter, more comfortable exams
- **For operations:** decreased total cost of ownership
- **For technologists:** faster, more reliable equipment

The three-legged stool: our design thinking approach

Many engineers learn early in their careers that engineering is the art of optimizing a three-legged stool—where cost, performance and design effort must be optimized. In the case of the Next Generation MR Platform, we applied significant design effort to ensure we exceeded cost and performance expectations from our customers.

To deliver a platform that enables state-of-the-art MR imaging, we knew our platform must exceed the performance of SIGNA™ Premier—our flagship clinical and research system—yet be scalable and compatible with all the other MR systems and subsystems. We also determined it was necessary to maintain backward compatibility to ensure upgradability to disseminate the benefits to as many customers as possible, which is the hallmark of our SIGNA™ Continuum promise. This proved to be easier said than done. Predecessor platforms, systems and subsystems were designed individually. We made a major investment with our Next Generation MR Platform to develop a unifying design that bridged decades of disparate designs from various engineering teams across the globe. The complexity of an undertaking of this scale necessitated a new way of working.

We met the challenge head on, embracing the high expectations and investing significant time to develop designs that truly exceeded. We navigated time zone differences in excess of 12 hours, language barriers and even a global pandemic. Deep, technical discussions were made more complex by meeting virtually, but those challenges have been more than offset by the advantage of diversity. By bringing together teams from across three continents, we've been able to bring different ideas and incredible diversity in engineering expertise in areas such as manufacturing processes, supplier capabilities and even new technologies. This global approach was also important when developing manufacturing plans, since our products will be realized through localized supply chains in both Asia and the Americas.

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This Design Thinking approach also leads us to iterate and prototype our concepts to find the final design. We leveraged our globally diverse team of engineers, scientists and experts to solicit feedback on emerging designs to refine and increase the probability of success. We sought feedback far and wide—collecting inputs from colleagues in field service, manufacturing and clinical development, to name a few—to ensure the final product addresses the needs of users.

Our SIGNA MR team works each day to create a world with equitable and sustainable access to MR across the globe. Access to MR imaging technology assumes adequate infrastructure, trained staff, affordable technology, and the resources to operate and maintain the equipment over its entire life, which can exceed 15 years.[2] Nations such as the U.S. and Japan enjoy a high level of access when considering the quantity of MR scanners per capita; however, in regions with unreliable electrical infrastructure or the inability to attract or retain trained staff, patients are impacted by significantly less access to MR. It is with this knowledge that we developed several technologies that reduce reliance on high power infrastructure and even reduce the knowledge barrier to operating the equipment.

Here we will discuss five foundational technologies developed for our Next Generation MR Platform. These innovations have been intentionally designed to enable sustainable, affordable MR that increases patient access to quality care, realizes a product that has long life, is efficient and upgradable for our customers, and consciously reduces the reliance on resources such as electricity and helium to enable a world that maximizes access to precision care.

Platform gradient coil

If the superconducting magnet is the heart of an MR system, the gradient coil is the muscle—the source of the horsepower. Not surprisingly, gradient coils consume 30% to 40% of the total energy of an MR system—primarily when encoding spatial data during image acquisition. By optimizing the electrical performance of the gradient coil, it is possible to reduce overall energy consumption and reduce CO_2 emissions into the environment. We anticipate a significant reduction in energy use with our new platform gradient coil, eliminating 7.5 tons of CO_2 each year.[3] We didn't compromise performance to achieve this. Instead, we developed new materials and methods that deliver a 20% reduction in energy consumption (a significant energy cost savings) without compromising gradient amplitude or slew rate performance, as demanded by customers.

Approximately 70% of the new platform gradient coil is manufactured within a GE HealthCare facility. This approach provides greater control of our supply chain, increases our manufacturing capability to more rapidly deliver customer orders, and significantly reduces CO_2 emissions by eliminating the need to ship subassemblies within the supply chain.

By developing a gradient coil as an extension of the power subsystems (see the *Intelligent Power Subsystems* section below), we were able to achieve a single gradient coil design that accommodates a variety of input profiles from the power subsystems that, in turn, produce discrete clinical performance levels. We introduced the use of alternative conductor materials in the design of the coil that allowed us to reduce the impedance and increase efficiency. By having a single gradient coil design, we maximized the time spent improving reliability and performance, optimizing manufacturing methods and testing the design, resulting in a higher quality product for our customers.

Platform body coil

The radiofrequency (RF) body coil generates the energy needed to excite spins and the signals essential to MR image generation. RF body coil quality is judged on its ability to generate a uniform field necessary for the image quality expected. This coil also plays a critical role in patient experience and safety since it surrounds (and contacts) the patient during an exam. We evaluated body coil designs based on their ability to deliver performance and comfort. We extended the design philosophy used in our gradient coil, wherein we designed one body coil per field strength that is

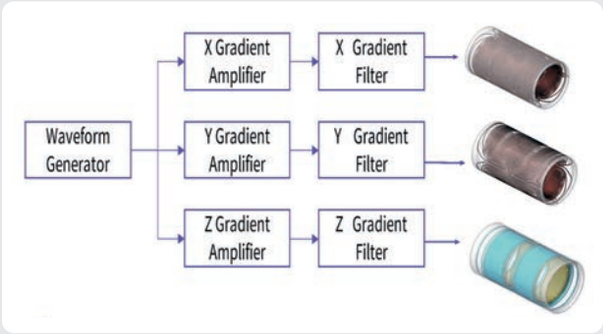

Figure 2. Schematic demonstrating the design of the new platform gradient coil.

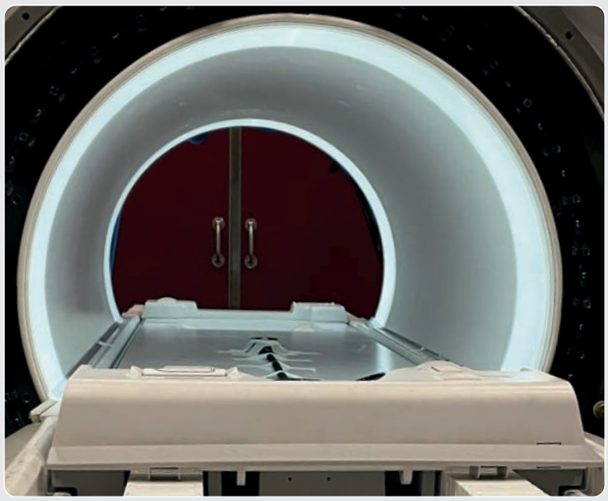

Figure 3. Bore lighting in the body coil designed to improve the patient experience.

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optimized for the best electrical and thermal performance and an improved positive patient experience.

Patient claustrophobia can lead to exam termination in 1% to 2% of MR exams.[4] We believe that the patient's environment during an MR exam can contribute to the feelings of anxiety and claustrophobia. As such, a patient environment that attempts to reduce the sense of isolation, confinement and enclosure may support a more positive experience with fewer incidents of claustrophobia. During the design of the platform body coil, we invited dozens of colleagues to evaluate design prototypes of the body coil interior, using a variety of lighting designs, patterns and brightness levels to identify the optimal experience.

The body coil is sensitive to its surroundings and interacts with nearly every subsystem in the MR system at a mechanical, thermal, RF and acoustic level, mandating a tremendous degree of collaboration across teams, time zones and continents. A primary design consideration is the interaction between the body and gradient coils. With high gradient amplitudes and slew rates, we took careful design effort to ensure the thermal behavior of the coil remains in a safe range. Knowing this Next Generation MR Platform must support upgradability over the lifetime of an MR system, we rigorously validated multiple combinations of gradient, body and surface coils to ensure our designs can support a vast number of customers with existing GE HealthCare systems, both today and in the future.

To achieve our goal of designing a system that is resource efficient, we first evaluated our current coils to understand opportunities to improve. To reduce power consumption, we redesigned the electrical components of the coil to reduce heat generation and decrease the energy required to cool the coil—and, by extension, the patient. The result of these designs is a body coil that efficiently delivers RF for our Next Generation MR Platform and may support upgrades to existing systems in the future.

Intelligent cryogenics

A cryogenic system to maintain the 4-degree Kelvin temperature and sustain superconductivity is a fundamental technology within an MR system. These cryogenic systems inherently consume significant energy, as they must regulate the magnet's temperature continuously, averaging 7 kW to 8 kW of power per hour. This can represent anywhere from 25% to 50% of the total power consumption of an MR system. Reducing this consumption without compromising the integrity of the magnet was a logical aim in our efforts to improve the sustainability profile of our Next Generation MR Platform.

Our team developed a new monitoring method for magnet temperature and pressure and a more tightly managed control logic. This allows the new compressor system to enter a reduced power consumption mode when the pressures are within a predetermined range. The new compressor consumes 30% less power than conventional units, translating to 10,000 kg fewer CO_2 emissions each year and significant energy cost savings.

Within a superconducting magnet there are no moving parts—with the exception of the cryocooler system. Unsurprisingly, the helium compressor is one of the most commonly serviced components of the magnet assembly. To improve reliability and total cost of ownership, several reliability improvements were incorporated into the compressor and magnet monitoring controls. With fewer service events come less downtime, higher patient throughput and improved access to MR imaging. By rethinking our approach to cryogenics, we were able to deliver an intelligent cryogenic system that benefits both customers and the environment.

As with other elements of the Next Generation MR Platform, maintaining compatibility with existing MR equipment was a primary need. This was especially challenging, as we needed to develop a single design that accommodated many system configurations in

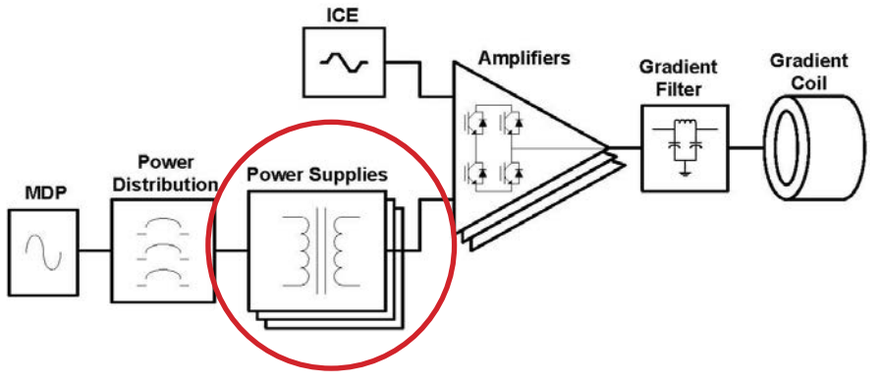

Figure 4. The new CGPS serves all three gradient amplifiers with a single module.

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our installed base today. Coordinating with different teams globally helped get us to the right solution that would work with the various cabinets and also deliver the reliability and power savings that are hallmarks of this new platform.

Intelligent power subsystems

Our holistic approach to gradient coil and power system designs in the Next Generation MR Platform required us to completely rethink our approach to the power subsystem. We intentionally used a scalable chassis design that accommodates several power output levels in a single design. The CGPS marks a significant leap forward in subsystem design, as it can be tailored to meet a wide range of performance needs, making it the foundational gradient power platform for future MR technologies.

At the heart of CGPS's innovation is its ability to serve all three gradient amplifiers with a single module—an advancement that dramatically reduces the cabinet space required relative to previous generation platforms. This compact design paves the way for a smaller equipment room footprint and more streamlined installations.

CGPS also integrates advanced features, such as an active front end (AFE) and energy storage (ES) circuits. These technologies average the input power, significantly reducing the size and cost of the power systems that feed the MR unit. The result is a more efficient, cost-effective and space-conscious solution that supports the evolving demands of modern medical imaging.

One of the driving goals behind the development of the CGPS was ambitious—enable the siting of a 80 mT/m / 200 T/m/s gradient system like SIGNA Premier within the compact footprint of a 44 mT/m / 200 T/m/s system like SIGNA™ Architect. Historically, systems with this level of performance demanded hospital infrastructure capable of handling very high peak power loads, often requiring upgrades to electrical panels. Upgrades like these can cost hundreds of thousands of dollars.

CGPS changes the game. With its AFE and ES circuits, the system intelligently averages input power, delivering SIGNA Premier performance from average rather than peak power demand. This innovation not only simplifies installation but also significantly reduces the burden on hospital power systems.

Packing this level of performance into a compact form factor was no small feat. Integrating AFE, ES and 12 isolated V_{DC} output circuits—each sized for SIGNA Premier output—posed serious challenges. These components are large and require generous spacing to meet stringent IEC safety standards, especially to maintain isolation across the three gradient axes and preserve image quality. To overcome these hurdles, our engineering team collaborated closely with manufacturing teams in Bangalore, India, applying the 3P (Production, Preparation and Process) methodology. This global partnership included multiple prototype builds in our Waukesha Innovation Center and verification in Bangalore. Through iterative design and hands-on collaboration, the team successfully optimized the layout, ensuring all components fit within the space-efficient enclosure while passing ICE compliance testing.

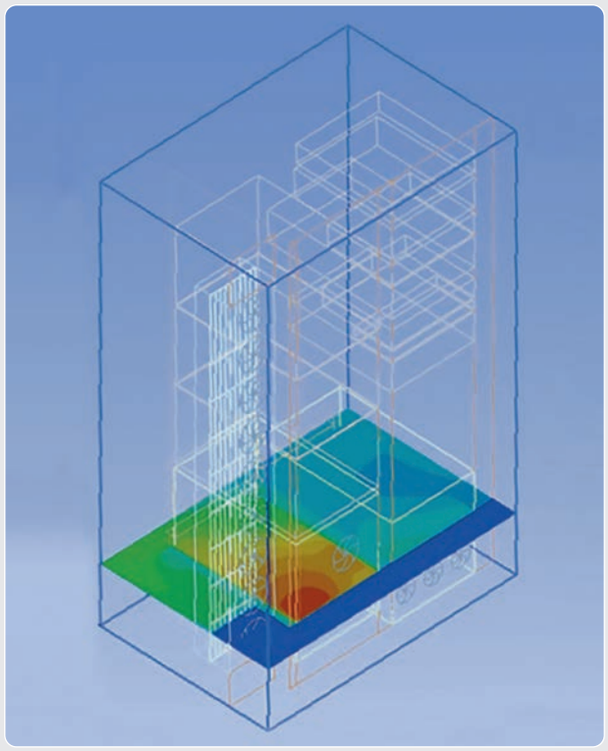

Figure 5. A new architecture for cabinet design that directs heat from components and efficiently cools system components, preventing the buildup of moisture.

The result is a compact, high-performance power supply that redefines what's possible in MR system siting—delivering SIGNA Premier capabilities with SIGNA Architect-level efficiency. With full 80 mT/m and 200 T/m/s gradient capability, CGPS eliminates the need to compromise gradient performance while maintaining power supply requirements.

Sealed cabinets

Traditional MR cabinets remove heat generated from system components by venting exhaust into the equipment room. Subsequently, these rooms need high-capacity ventilation and air conditioning systems to maintain the equipment in an operational range. In our Next Generation MR Platform, we're introducing a new architecture for cabinet design that directs heat from components into an embedded air/liquid heat exchange and dehumidifying system that will simultaneously—and efficiently—cool system components and prevent the buildup of moisture. This sealed architecture will also eliminate the requirement for costly air conditioning in the equipment room, along with the associated operating costs and the carbon footprint created from high cooling requirements.

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This design will protect sensitive electronics from condensation and enable a 34% reduction in equipment room size, offering hospitals greater flexibility in siting and infrastructure planning.

One feature the engineering team is especially proud of is the embedded dehumidifier—a passive, sensor-controlled system that activates only when needed, using facility water to remove moisture without generating dew drops or requiring manual drainage. This innovation reflects the team's commitment to smart, sustainable engineering.

The sealed cabinet and integrated cooling technologies in the Next Generation MR Platform represent a leap forward in MR system design. By aligning environmental responsibility with engineering excellence, we continue the GE HealthCare mission to deliver solutions that benefit patients, providers and the planet.

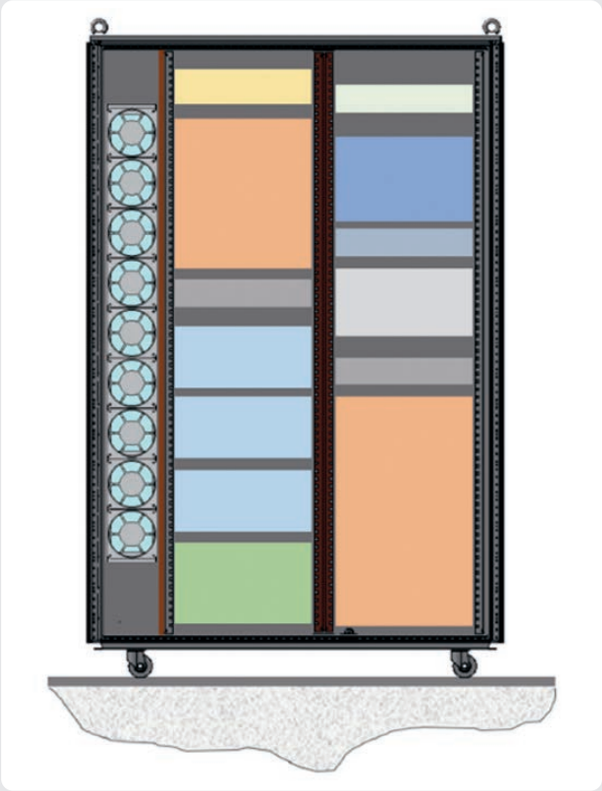

Figure 6. The new sealed cabinets are a leap forward in MR system design.

Summary

We're proud to be part of the history of intentional innovation at GE HealthCare and the legacy created from the 1983 RSNA Annual Meeting, where the world's first clinical MR scanner was introduced by our predecessors. In the years since, we've risen to the challenge of ensuring MR imaging technology meets the evolving needs of customers, patients and our global community. Along with hundreds of our colleagues across the planet, today we're honored to deliver MR technologies that will serve patients for decades to come. By leveraging intentional design thinking, we've taken concepts intended to expand access to resource-efficient yet state-of-the-art MR imaging technologies and transformed them into fully realized technologies that will make our Next Generation MR Platform one that serves patients for another 40 years.

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