Moving the needle in coil development: the vision behind AIR Technology

For more than a decade, the patient experience has been at the forefront of product research and development at GE Healthcare. The initiative to humanize MR with the launch of the Caring MR Suite and apps like SilentScan was clearly focused on addressing one of the key limitations of MR imaging: patient discomfort and non-compliance due to claustrophobia, noise and bulky, heavy coils.

Fraser Robb, Chief Technology Leader for MR Coils, says, "We started a project almost 10 years ago with the goal of developing the ultimate blanket coil. We had looked at other concepts because we found traditional hard shell coils often severely restricted patient size. In the end we realized we can't beat physics. The coils have to be close to the patient to capture the electromagnetic radiation coming from the patient."

Bob Stormont, Principle Engineer, and Robb, are both part of a laboratory that looks at advanced technology for product roadmaps—the next generation and beyond.

"We were interested in extremely flexible and lightweight coils," Stormont says. "We always believed we could develop what became AIR Technology™."

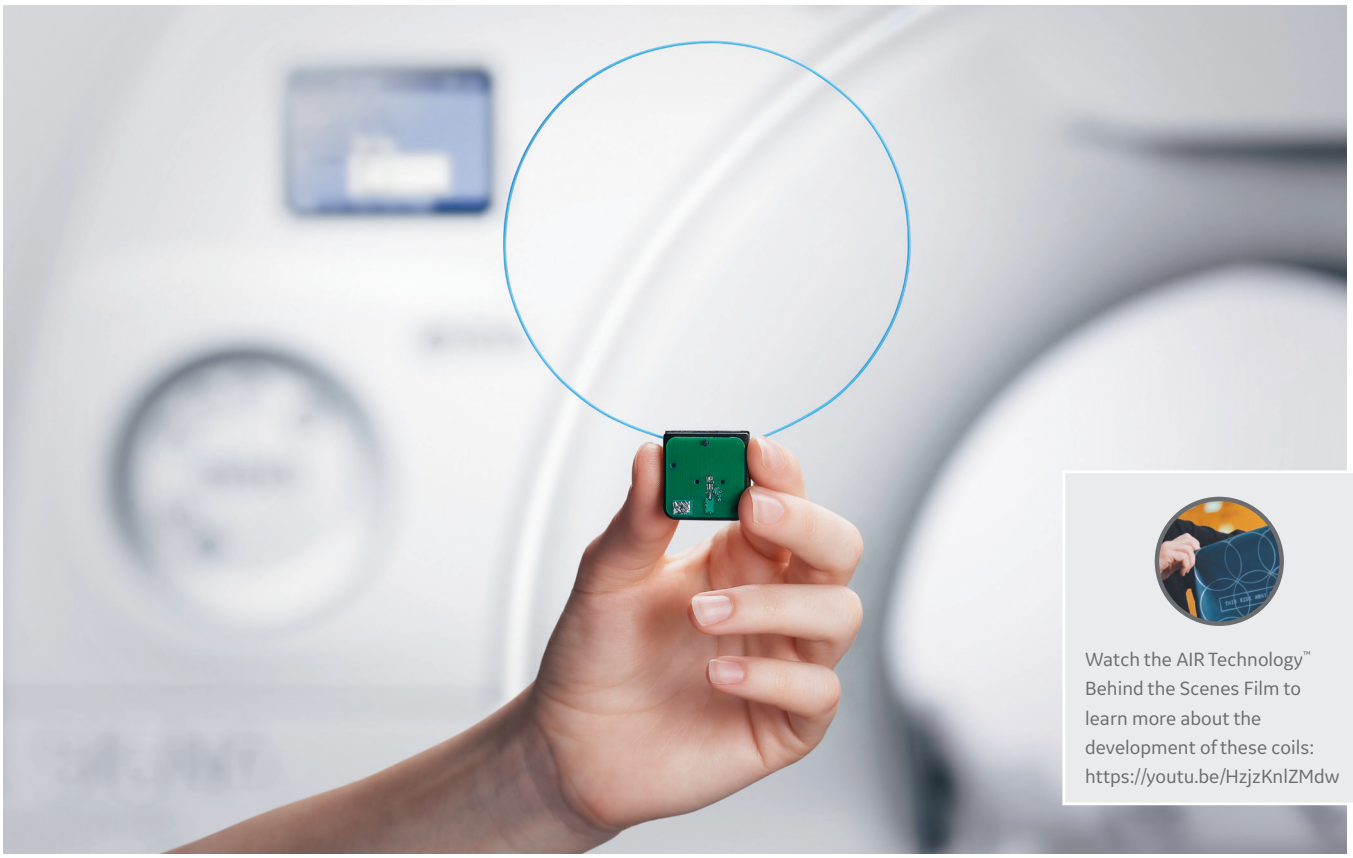
It was just a matter of getting there.

Stormont was leading a team of engineers that looked at how they could accelerate coil development and possibly leap forward to land where they wanted to be—a flexible coil that could conform to the body and challenge the longstanding limitations of traditional rigid coils.

The team set their sights on the highest attainable goal: lightweight and ultra-flexible.

"From the start, the vision of this project was to improve how our instruments are received and used by customers," says Michael Brandt, Chief Marketing Office, Global MR. "Every day when a patient is in an MR scanner, they experience a certain level of discomfort. If we can help to make them more comfortable and facilitate getting the coils closer to the anatomy, then we can improve image quality to some extent. If we can help technologists to set up the patient in an easier fashion, then we can reduce the number of repeats and make their lives easier."

It boils down to designing the best coil for each body part.



Watch the AIR Technology™ Behind the Scenes Film to learn more about the development of these coils: https://youtu.be/HzjzKnlZMdw

GE Healthcare commercialized the phased array in 1991, yet there are still limits to this design. Robb explains, "The design emphasis was to overcome these traditional limitations of conventional phased arrays, which are heavy, bulky and not flexible, by developing something soft, flexible and pleasing."

With conventional phased array coils, such as an Anterior Array (AA), the technologist would lay the coil on top of the patient and scan the liver or pelvis, for example. "However, if they wanted to scan a different anatomy, the technologist would have to go back into the scanner room to physically move the coils and re-landmark the patient," says Holly Blahnik, MR clinical development specialist. "Patients who were too sick or in pain often couldn't conform to the rigid coils."

According to Brandt, the development process for AIR Technology™ was strikingly different. The design team had a much broader scope to find a solution to the problem.

"We allowed them the capability to trial this as many times until they got it absolutely right, instead of tolerating a bigger compromise," Brandt explains.

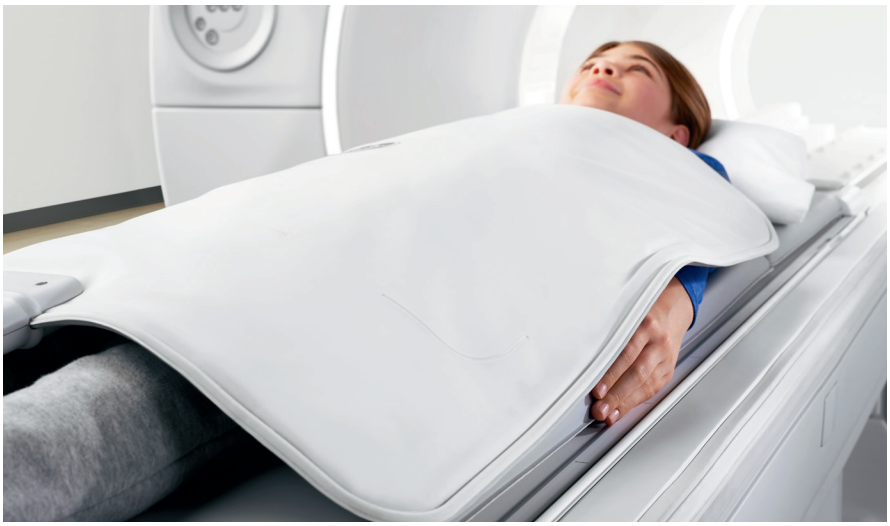
> Never compromise. From the start this was the design team's philosophy. And every time they found themselves starting to compromise, they started over.

The team began with trying to solve the problems that existed with flexible coils. On numerous occasions, they became trapped by existing design constraints and would inch closer to a conventional solution.

"We realized by doing that, we would end up with a conventional coil," says Stormont. "So, we would stop, back up and reassess where we were at. And leadership gave us that opportunity. The project was so compelling that even though we would stall, they continued to support us because we could show them the vision of what this could be and convince them we could get over this hurdle."

Another concept the design team embraced was to move away from coils built like industrial electronics to coils built like clothes or blankets. And, the coil needed to be intelligent.

Explains Dan Weyers, Global Product Manager, RF Coils. "It shouldn't matter if the technologist was only using five of



30 elements. We wanted each element to be optimized for versatility, so the coil could be used to image different anatomies, shapes and sizes."

For example, if using a conventional coil on a patient with skinny arms or legs, the technologist would have to be careful to ensure the elements didn't overlap. By designing an intelligent coil that could use certain elements and not others, it could be possible to overlap the coil. This capability required an innovative design, where the elements could work closely together to achieve a high SNR and at the same time, not interact or interfere with each other.

Ease of programming the coil was another key development concept. By enabling auto selection of the elements based on the region of interest and body part selected, the team believed they could help the technologist obtain the best possible image quality, Weyers adds.

"The goal of our design concept was not to just image what has been imaged before. Rather, the promise of AIR Technology™ is that we can apply elements and coils to parts of the body that would otherwise be extremely difficult to image," says Robb. For example, the neck, foot and brachial plexus—all areas that are difficult to image with conventional coil technology.

Mechanical constraints forced compromise in prior coil technologies. But not for this project. It took two separate and simultaneous research projects to develop the innovative technologies behind AIR Technology™.

GE's proprietary E-mode electronics reduce current noise, boost linearity and improve tolerance to varying coil loading conditions. It makes the most out of every centimeter to reduce component volume by more than 60 percent. The conductor material for the loop is lightweight and bendable and a series of linked resonators replaces the rigid circuit boards and lumped components that comprise conventional coils.

These two technologies work very closely together to get high SNR with minimal interaction between the two elements.

"That was the breakthrough," says Stormont. "We can select the size of the loops on the anatomy and position the loop where it is needed."

The team didn't stop with the introduction of AIR Technology™ at RSNA 2017. GE has recently introduced AA and Multi-Purpose (MP) Coils at 1.5T and 3.0T. There are additional plans to develop coils specific to other body areas, such as the shoulder and prostate as well as the brachial plexus, which could potentially be used for C-spine exams. There is also an effort to develop coils for use in radiation therapy.‡

Now, there's no turning back. AIR Technology™ is the new future of coil development at GE and based on feedback from customers, they don't want to turn back either.

"They'll hold it and say, wow, what can I scan with this?" says Blahnik. "And I'll ask them what do they want to scan? The excitement is there because they've never seen any coil like this before. It really does feel like a blanket."

Robb adds, "We have also recently shown at ISMRM a work-in-progress concept for creating an MR coil jacket with some outstanding images of the brachial plexus,‡ which is exactly the type of imaging that's so difficult with conventional coils."

Customer reactions keep driving GE's coil design team to continue innovating. There were no expectations with the first prototype, but now the team wants to keep pushing the boundary of coil design limitations.

"This really opens up the possibility of wearable MR coils in the future," Robb says. "Instead of placing heavy industrialized bulky electronics on a patient, we can provide a clothes-like experience to the patient."

‡Technology in development that represents ongoing research and development efforts. These technologies are not products and may never become products. Not for sale. Not cleared or approved by the U.S. FDA or any other global regulator for commercial availability.