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SPECIAL REPORT: CT – THE FIRST LINE OF ENQUIRY

This feature explores the evolution of modern CT scanning systems and how they will continue to support healthcare providers moving forward

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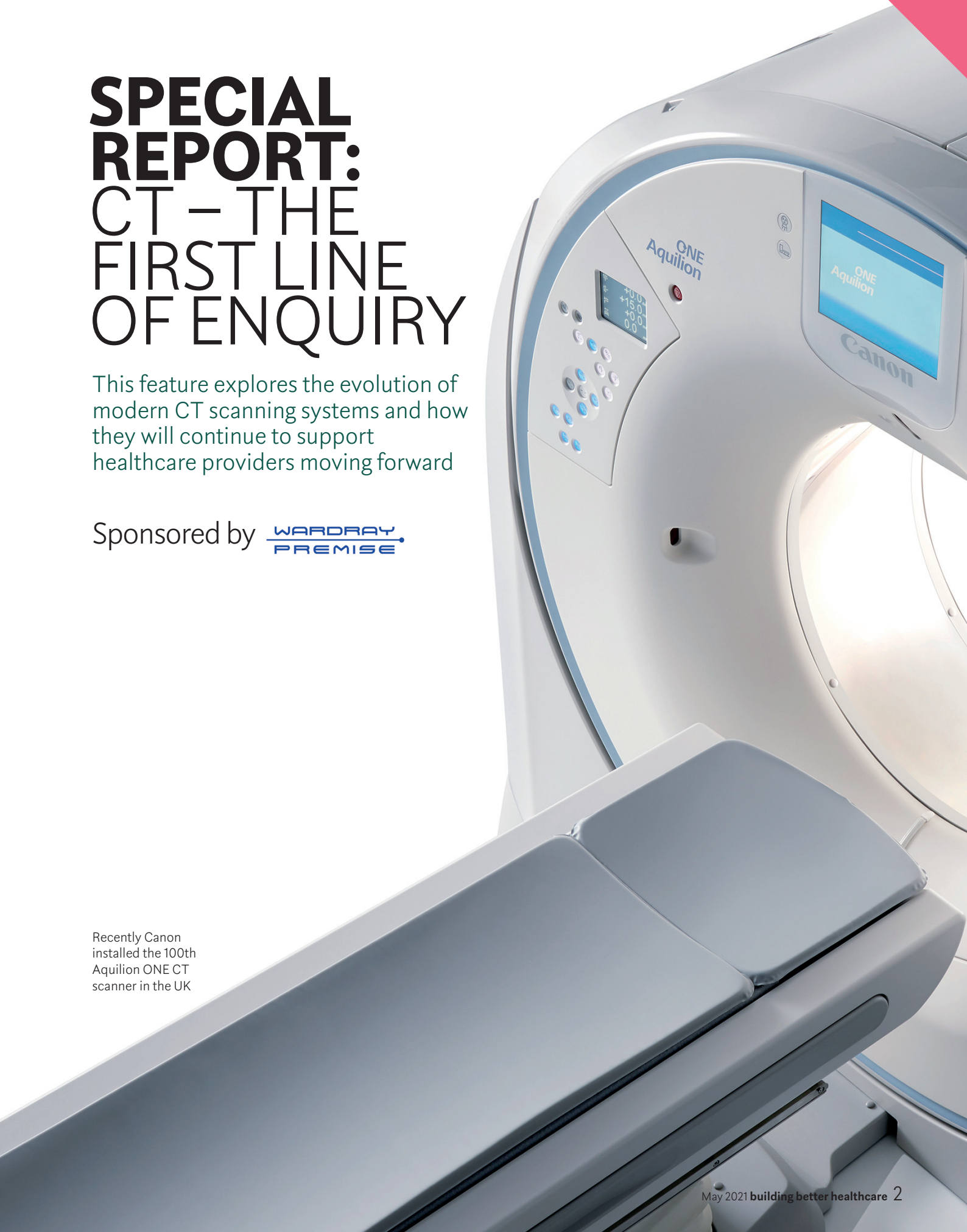


Recently Canon installed the 100th Aquilion ONE CT scanner in the UK

At the end of 2019 the Government pledged £200m in new funding to help the NHS replace ageing diagnostic imaging equipment, including MRI and CT scanners and mammography systems.

This followed research from the European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry (COCIR) which indicated that, at the end of 2018, 14% of CT scanners in the UK were 10 years old or over, compared to only 1% at the end of 2011.

And, three years on, the situation is even more critical, especially when you consider that diagnostic imaging technology that has surpassed the 10-year mark is considered obsolete or inadequate for some procedures.

A growing market

Replacement, or at the very least upgrade, of equipment is therefore becoming essential.

CT imaging is increasingly used in every aspect of clinical diagnosis – from trauma, oncology diagnosis, treatment planning and follow-up, screening, orthopaedics, interventional, cardiac, and everything in between.

An easily-accessible, relatively-cheap examination and diagnostic tool, CT scans are frequently one of the first lines of investigation.

Russell Lodge, CT business manager at Siemens Healthineers, told *BBH*: "CT scanning provides visualisation of anatomy, pathology, and function and is a fast, simple procedure that can be performed on an outpatient basis.

"Imaging such as coronary angiogram examinations, renal tract obstruction, and colon imaging with barium studies are increasingly transitioning to this modality with the benefit of additional pathology being picked up on CT examinations.

"CT is also increasingly used for interventional procedures and advanced examinations such as complex biopsies or radiofrequency ablations, which can be accurately guided by CT imaging."

A rich history

CT was first launched in the UK in October 1971, with the first scan taking place at the specialist Atkinson Morley Hospital in south west London.

The first commercial installation followed at Manchester Royal Infirmary in 1972.

And, by 1980, three million scans had been performed across the country..

Fast forward nearly two decades and between September 2018 and September 2019, 5.8 million scans were undertaken in the UK alone.

This highlights the importance of the technology, and its continued adoption across the NHS and private health sector.

How it works

CT – or Computed Tomography – is also known as 'CAT scanning' (Computerised Axial Tomography) and provides a different form of imaging, known as cross-sectional imaging.

The origin of the word 'tomography' comes from the Greek word 'tomos' meaning 'slice' or 'section'; and 'graphe' meaning 'drawing.'

A CT system produces cross-sectional images or 'slices' of a patient's anatomy, like the slices in a loaf of bread.

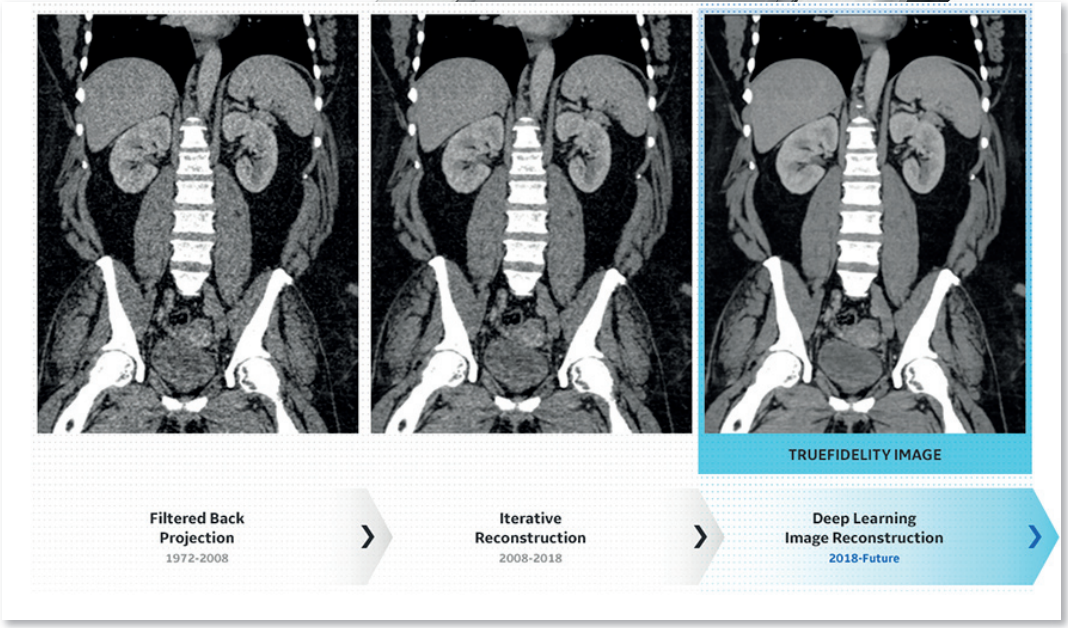
And these cross-sectional images are used for a variety of diagnostic and therapeutic purposes.

When undergoing an examination, a motorised table moves the patient through a circular opening in the CT imaging system.

As the patient passes through the system, a source of X-rays rotates around the inside of this circular opening, with a single rotation taking less

Streamlining workflow and speeding up scanning times is a key focus for manufacturers such as Philips

USING SMART FINANCE SOLUTIONS FROM A SPECIALIST FINANCIER, HEALTHCARE INSTITUTIONS CAN ACCESS CUTTING-EDGE TECHNOLOGY WITHOUT PUTTING A STRAIN ON OPERATING COSTS



GE Healthcare's Revolution Maxima system with auto positioning uses real-time depth-sensing technology to generate a 3D model of the patient's body (main image) and a Deep Learning Image Reconstruction algorithm generates TrueFidelity images (left)

than a second.

The X-ray source produces a narrow, fan-shaped beam of X-rays used to irradiate a section of the patient's body.

The thickness of this fan beam may be as small as 1mm, or as large as 10mms.

In typical examinations there are several phases; each made up of 10 to 50 rotations of the X-ray tube around the patient in co-ordination with the table moving through the circular opening.

The patient may also receive an injection of a contrast material to facilitate visualisation of vascular structure.

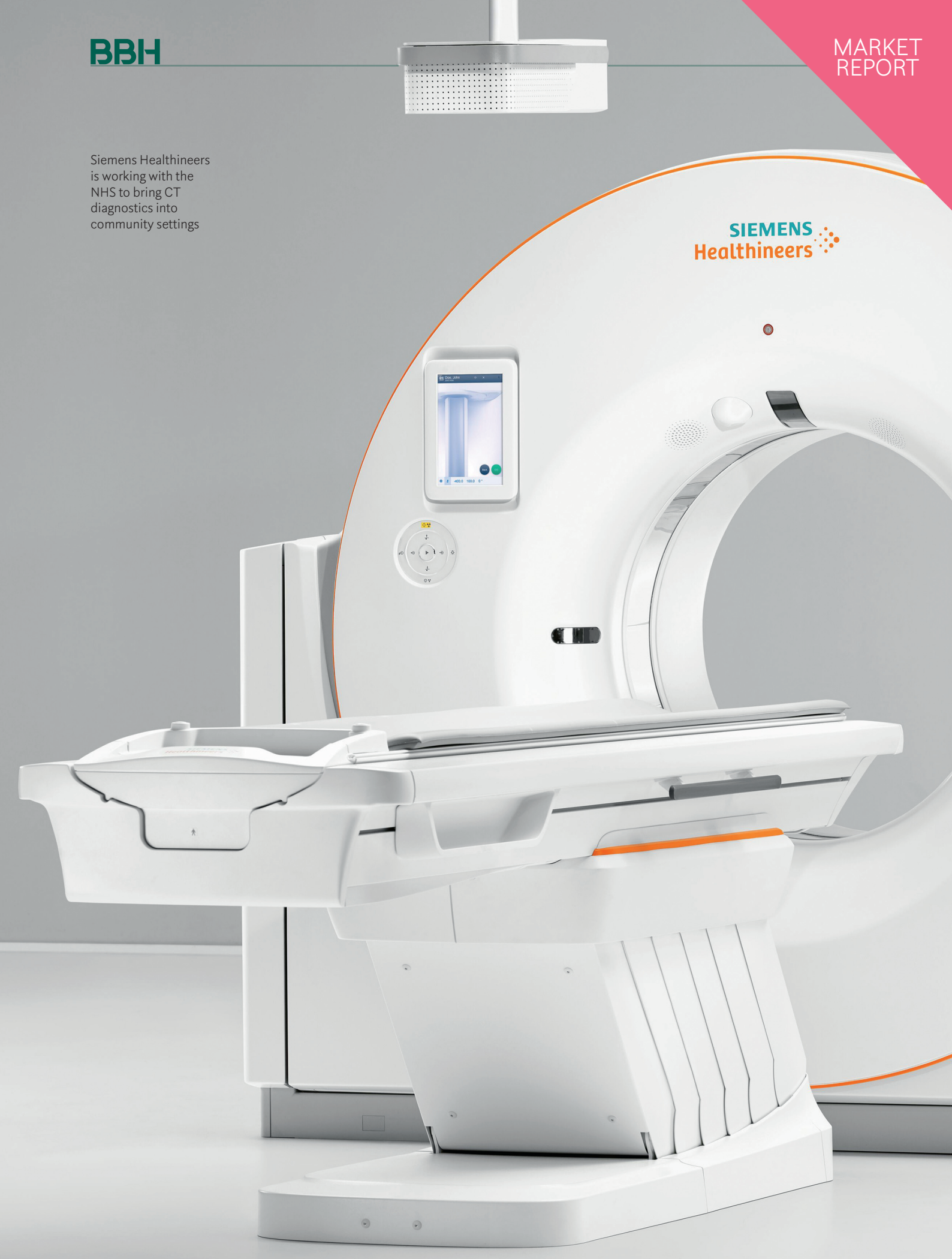
Detectors on the exit side of the patient record the X-rays exiting the section of the patient's body being irradiated as an X-ray snapshot at one position (angle) of the source of X-rays.

Many different snapshots/angles are collected during one complete rotation and the data is then sent to a computer to reconstruct all of the individual snapshots into a cross-sectional image – or slice - of the internal organs and tissues for each complete rotation.

Clinical outcomes

Matthew Trevail, image guided therapy modality manager for GE Healthcare UK and Ireland, said: "CT's clinical use and diagnostic power have rapidly increased in recent years, with the introduction of volumetric imaging, faster rotation speed, iterative and AI-based image reconstruction, dual energy, and dose-reduction technologies.

Siemens Healthineers is working with the NHS to bring CT diagnostics into community settings



"And, for nearly 50 years, it has proven to be a vital imaging tool used by clinicians to detect cancer, heart conditions, and other diseases, large and small.

"But, over the past decade, there has been an increased focus on providing new digital tools to help healthcare providers achieve clinical and operational excellence."

Mark Thomas, CT modality manager at Canon Medical Systems UK, adds: "Today, CT is a core imaging modality in all hospitals.

"From CT Pulmonary Angiography (CTPA) in COVID-19 patients, to diagnosing heart or brain conditions and guiding tissue biopsies; it is an essential tool in the medical practitioner's arsenal.

"It helps to diagnose disease and conditions earlier, and to improve life expectancy and outcomes for patients."

And Lodge told *BBH*: "Examinations using CT are well tolerated by patients as the scan acquisition speeds are short and the image reconstruction speeds fast, providing a real-time image overview."

AI drives innovation

And the recent COVID-19 pandemic, as Thomas states, has really shown the power of CT technology.

Hannah Timbrell, modality sales specialist for CT advanced molecular imaging at Philips, said: "In many ways, the pandemic has proven what we already knew – that data, AI, and connectivity are central to helping those on the frontlines to deliver intelligently-efficient care.

"GE Healthcare is not only providing new tools to help hospital staff keep up with demand without compromising diagnostic precision; but we continue listening to, and rapidly responding to, customer needs using all tools at our disposal – including AI."

The evolution of AI and its use within CT imaging is one of the key improvements seen in recent times.

AI – or Artificial Intelligence – uses machine learning to provide more data using low-dose scans.

And it has the potential to vastly advance medical imaging, particularly CT scanning, by reducing radiation exposure and improving overall image quality.

For example, GE Healthcare's Deep Learning Image Reconstruction algorithm generates TrueFidelity CT images, which offer exceptional image quality and preferred noise texture.

To do this, it uses a dedicated deep neural network to generate the images,, which have the potential to improve reading confidence in a wide range of clinical applications, such as head, whole body, and cardiovascular, for patients of all ages.

The company's Revolution Maxima system with

Siemens Financial Services works with Siemens Healthineers and other technology vendors to provide cost-effective financing solutions for a wide variety of medical equipment, including CT machines

auto positioning uses real-time depth-sensing technology to generate a 3D model of the patient's body, or a specific area.

Focusing on what's important

Then, using a deep-learning algorithm, Auto Positioning pinpoints the centre of the scan range and automatically centres the patient for a completely hands-free positioning experience.

In one case, a site scanning more than 60 patients per day, and as many as 17 per hour, saw a 93% utilisation rate, allowing staff to automate most of their scans and freeing up additional time for technologists to focus more on patient care and comfort.

Trevail said: "New AI solutions and automated applications help expedite processes and streamline workflows to allow technologists more time to focus on what is important: the patient.

Philips' Incisive CT System also harnesses the power of AI.

"Anything that can help reduce patient dose without reducing image quality has become an essential part of any scanner, whether this is with reconstruction algorithms, auto-positioning, or built-in dose modulation," said Timbrell.

Thomas adds: "Artificial Intelligence will herald greater rewards with CT and its introduction has been a game changer for healthcare.

"Only a year ago the first CT with Advanced intelligent Clear-IQ Engine (AiCE), a deep learning reconstruction AI algorithm, was installed into a UK hospital, and many more orders have followed since.

"Our customers have referenced 'phenomenal' patient dose reductions, up to 90% below the National Diagnostic Reference Levels, at the same time as benefitting from extremely-high-quality clinical images, and all in a rapid timeframe suitable for everyday clinical use.

What's next?

"And the low doses have even been achieved when examining people that have traditionally been difficult to image, such as severely-ill patients with their arms by their sides, those unable to hold their breath, and bariatric patients."

Siemens Healthineers' focus has been on improving speed of acquisition; the advancement of dose optimisation technology, such as its Tin Filter system; and a move towards lower kilovoltage imaging.

Lodge explains: "The general rule in CT has been that lower doses make it harder to reconstruct images of sufficient quality.

"But iterative reconstruction technology is changing that.

"Advanced Modelled Iterative Reconstruction (ADMIRE) offers powerful dose reduction, excellent image quality, and everyday suitability, with fast reconstruction speeds, using high-speed processing computers, making it practical for routine use."

So what's next in terms of R&D?

Most manufacturers believe photon counting CT technology (PCCT) will be key.

"With photon counting CT, the system can more accurately count the photons produced by the X-

A year ago the first CT with Advanced intelligent Clear-IQ Engine (AiCE), a deep learning reconstruction AI algorithm, was installed into a UK hospital by Canon Medical Systems

rays to create an even-clearer image and provide more information to the clinician," said Trevail.

"It's like throwing thousands of darts at a dart board all at once. With traditional CT, we capture some of the darts – or photons – but some stray off course or bounce off the board," he adds.

"With photon counting CT and Deep Silicon detectors, we can capture more of those darts/photons."

While this technology is still in development and is not yet cleared or approved for commercial sale, it is a focus for all leading manufacturers.

Timbrell told *BBH*: "Future technological advancements of CT will certainly include photon counting.

"Anything that makes use of all the information provided by the radiation given to a patient will play a part in future technology."

Other advancements include solutions to mitigate radiological distortion from metal objects, such as orthopaedic plates or medically-implanted coils; and the improved visualisation of soft tissue structures surrounding these implants.

To address this, Canon launched SEMAR – a Single Energy Metal Artifact Reduction reconstruction technique – which improves the visualisation of medical images for clinical interpretation with no increased patient dose; a timely innovation for the growing number of people with replacement hips or knee joints and other medical implants.

The patient experience

And Philips says its Spectral CT scanners are fast becoming a benchmark for standard scanner requirements in the future.

"Research in Munich has enabled the Spectral information on the Philips IQon system to be used to gain DXA-equivalent data from the scout/surview image – an image that historically has only been used to plan scans and has not given quantifiable data," said Timbrell.

"By doing this, they have made productive use of all the radiation given to the patient, obtaining Bone Mineral Density measurements of the spine.

"This could potentially allow large-scale, opportunistic osteoporosis screening, which could assist in early diagnosis against a disease that it is estimated three million people in the UK suffer from; but is frequently left undiagnosed until a patient experiences a fracture."

The patient experience is another area coming under the spotlight.

Thomas said: "The external design of CT has stayed in tune with the changing shape of patients around the world.

"Table capacity is now at higher weight tolerance, adapting to the growing waistlines of UK populations, and the central bore hole of scanners has been getting wider over the last 10 years to accommodate larger patients more comfortably."

He adds: "Recently we welcomed the 100th Aquilion ONE CT scanner order here in the UK, from the latest generation, the Aquilion ONE PRISM Edition.

"This milestone is an opportunity to reflect on how far we have come with the system and convey our excitement of what the future holds.

"It was just over a decade ago that CT scanning was defined by the number of 'slices', referring to the number of rows of detectors in the z-axis.

"However, the Aquilion ONE burst onto the stage in 2007, taking everyone by surprise with its new technological CT innovation, and the competitive slice wars was eliminated forever.

"Today, to be CT cutting-edge is about the balance of low dose, high speed, and clear image quality."

But it is also about helping clinicians to make

THE PANDEMIC HAS PROVEN WHAT WE ALREADY KNOW – THAT DATA, AI AND CONNECTIVITY ARE CENTRAL TO HELPING THOSE ON THE FRONTLINE TO DELIVER INTELLIGENTLY-EFFICIENT CARE

Philips' Incisive system harnesses the power of AI

sense of the images the equipment is capturing and, increasingly, modern equipment is helping to address the global shortage of radiologists and ease growing pressures.

Under pressure

The latest Royal College of Radiologists Workforce Report highlighted growing concerns over a 33% shortfall in radiologists, set to reach 43% by 2024.

Yet, at the same time, the volume of CT imaging examinations across England is increasing.

Thomas says: "In response to workforce pressures, we continue to innovate CT workflow automation to help give some time savings that, over the course of a full day or week, translate into more patient appointment slots.

"And the advancement of AI-driven CT is a massive time saver to speed up procedures, with none of the traditional compromises on image quality or dose."

Trevail adds: "When considering workflow, we deploy artificial intelligence in the Revolution Maxima, with an auto-positioning camera.

"The radiographer can then focus on the patient, answering questions or putting them at ease while the auto-positioning camera sets the patient up in the correct area for the scan.

"Furthermore, our protocol management capability suggests a suitable protocol to select direct from the gantry side."

So, with NHS and private health trusts charged with replacing outdated equipment, what are the main questions they should be asking when looking to procure the very-latest in CT technology?

Respondents to an IMV survey in 2020 put their priorities for CT in the following order:

- Improve patient satisfaction
- Improve staff satisfaction and morale
- Satisfy the needs of referring physicians
- Improve CT department workflow and productivity
- Improve capability to reduce radiation dose

This shows that, when looking to replace a CT scanner, departments should look at workflow efficiencies to cope with an increased volume of patients, reliability features to ensure maximum 'up time', dose-reduction methods, image reconstruction algorithms for image quality at low dose, as well as patient and staff safety and

Siemens Financial Services has seen an increase in healthcare clients looking for finance arrangements which enable them to invest in the latest CT equipment without a massive capital outlay

satisfaction features to increase comfort and compliance.

A costly problem

"Philips Incisive, for example, is fully in-room upgradable, has a Tube for Life, a target of zero unplanned downtime, and AI at every step of the workflow to reduce dose, improve consistency, and ease of use," said Timbrell.

Trevail adds: "From our customers around the world we hear that key considerations when specifying a new CT system usually include: How will my new system assist with workflow? How will my system be continuously upgraded to suit my changing clinical demands? And what new technologies have been incorporated to bring true clinical and patient value?"

And Lodge advises radiology leads and procurement managers to take time to review the type of examinations carried out within a department and the examinations anticipated to be performed with newer technology.

"For example, if the scanner is to be used in trauma imaging, then speed, accuracy, positioning and coverage should be considered," he adds.

"It is also important to consider the need for advanced intervention and the intervention aids available to guide precise examination.

"Should a scanner be carrying out cardiac examinations, with the routine use of heart rate control and potential for scanning a range of heart rates and arrhythmia – native temporal resolution should be evaluated.

"And staff training is also key to getting the best results from a scanner.

"The introduction of AI-based guided workflows can be helpful, while online self-learning platforms, like PEPconnect, can support users, alongside clinical applications training."

But, with estimates that, over the next five years, it will cost £1.17billion to invest in new and replacement diagnostic technologies, including CT – and the Government pledging just a fraction of this – many organisations are looking for novel ways to ensure they can keep up with the demand.

And manufacturers are addressing this with a number of options.

GE, for example, has launched a Smart Subscription service which enables users to access the latest upgrades and new features through a subscription model.

"There are a number of options available allowing customers to tailor an upgrade model that suits them," said Trevail.

"For example, the customer may be undertaking cardiac CT and can select the cardiac subscription. However, if five years from installation the hospital is undertaking neuro procedures for the first time, the neurology smart subscription may be appropriate."

Financial help

And Siemens Healthineers is working alongside the NHS to realise a new vision for the delivery of diagnostics and elective care within community settings.

Lodge said: "The flexible provision of CT diagnostic imaging facilities is central to our focus on bringing diagnostics closer to patients, with our involvement in initiatives like the Targeted Lung Health Checks programme just one example of our work in facilitating local community diagnostic services.

"More recently, the introduction of modular CT imaging facilities suitable for siting within hospital grounds has allowed us to support NHS customers in their recovery from the COVID-19 pandemic and in meeting the associated rise in demand for diagnostic services."

But there are also other options.

Penny Pinnock, sales manager for healthcare and public sector at Siemens Financial Services, said: "Acquiring equipment is only part of the cost of extending radiography.

"Planning, installation, and development of building infrastructure are all costly elements of the process of acquisition that, without the right financial tools, have the potential to spike a hospital trust's operating costs."

Because of this, pay-for-outcomes arrangements, such as lease agreements which deliver fixed monthly payments over the financing period; or Managed Service Contract arrangements that guarantee an agreed level of equipment uptime, are becoming popular.

Pinnock explains: "Such financing solutions spread the cost of the technology over an agreed financing period, with payments arranged to align with the expected benefits of the use of the technology over time, such as improved operational efficiency.

Philips' IQon system could potentially allow for large-scale, opportunistic osteoporosis screening

"By removing the need for a large initial outlay, finance arrangements like these can help improve cash flow and working capital.

"Additionally, they have the potential to incorporate other costs, such as installation, as well as introducing the flexibility of future affordable technology upgrades, in line with technology developments."

Reducing pressure on capital

She adds: "Siemens Financial Services works with Siemens Healthineers, as well as other technology vendors, to provide cost-effective financing solutions for a wide variety of medical technology and equipment, enabling healthcare organisations to access the solutions they need without having to commit precious capital budgets.

"Such tailored financing packages tend to be offered by specialist healthcare financiers that have an indepth understanding of medical technology and its applications and who understand the profound impact up-to-date equipment and technology can bring to the daily operation and can expertly evaluate any associated risks.

"They are therefore more inclined, and more able, to create customised financing packages that fit the specific requirements of each individual organisation – for instance, by flexing the financing period to suit cashflow needs.

"This contrasts with the standard financing terms usually available from generalist financiers who often lack technical expertise or a thorough understanding of the healthcare sector."

She concludes: "As demand for state-of-the-art imaging equipment increases, new financial solutions are required for hospitals to keep pace with healthcare innovation.

"The latest scanning equipment provides patients with improved healthcare outcomes and can contribute to earlier and more-accurate diagnoses. This, in turn, has the potential to relieve mounting pressure on resources derived from the current health crisis.

"Using smart finance solutions from a specialist financier, healthcare institutions can access cutting-edge technology without putting a strain on operating costs."

TODAY, TO BE CT CUTTING EDGE IS ABOUT THE BALANCE OF LOW DOSE, HIGH SPEED, AND CLEAR IMAGE QUALITY

Philips says its Spectral CT scanners are becoming increasingly popular in the UK