The first of this suite of new products to be launched this year – in February – was a high-efficiency examination light designed principally for use by clinicians undertaking minor procedures. Designed ‘from the ground up’, the Brandon Coolview CLED23 (see panel, page 67) incorporates features including ‘best-in class light intensity’; 360 degree lamp head rotation; ‘bright natural light’, and a colour-corrected light source and adjustable colour temperature, ‘to allow for accurate representation of tissues during examinations’.

Brandon says the latest Coolview model, and a smaller new variant, the CLED11 FX, offer ‘uncompromising lighting performance’ and low running costs, features which should please clinicians and healthcare estate personnel alike.

‘Near perfect’ colour rendition
Following hard on the heels of the Coolview CLED23’s introduction, however, with a launch planned for this month – and indeed just one of a raft of new lighting products to be unveiled by Brandon in 2014 – will be a range of enhanced HD-LED operating theatre lighting offering ‘near perfect colour rendition with red balance control’.

The new Quasar eLite range has been developed as a substantial progression from Brandon’s successful existing HD-LED technology, first seen in its Galaxy Ultra, Astralite, and Quasar lighting products.

Serving surgeons better
When I met Brandon Medical MD, Graeme Hall, and marketing manager, Ria Cusimano, at the company’s impressive new visitor centre at the Morley site, they explained that the technological refinements in the Quasar eLite theatre lights address a number of key issues for surgeons; for example the improved beam configuration, colour rendition, and red balance, are designed to facilitate distinguishing different tissue and blood vessels during complex procedures, a process made more difficult by the human eye’s relative insensitivity to red light. Another goal in the Quasar eLite’s development was to reduce the need for surgeons to regularly re-focus the theatre lighting during procedures.

The new examination and operating theatre lights are just two notable recent

Collaborative project optimises LED lighting

Early 2013 saw Brandon Medical, which designs and manufactures equipment ranging from operating theatre lighting to medical AV and control systems, celebrate ‘20 years of innovation and growth’, with a move to a new £2 million, 50,000 ft² headquarters in Morley near Leeds, twice the size of its former premises. A milestone year then for the entrepreneurial Yorkshire company, but, as HEJ editor, Jonathan Baillie, discovered, when he met with joint MD, Graeme Hall, 2014 should prove an equally exciting one for the medical technology specialist, with the launch of several new ‘field-leading’ medical lighting products designed for use in operating theatres and minor examination settings.
Medical lighting

examples of Brandon’s forward-thinking and engineering expertise, which underline how, despite being considerably smaller than many of its multinational competitors, the company punches considerably above its weight on the innovation front.

Looking back at the company’s history, the business that is Brandon Medical today was originally established in June 1993, when Eric Hall and his oldest son, Graeme, both keen to acquire their own manufacturing business, bought a company, Brandon Engineering, which had gone into receivership. Two years later, Graeme’s younger brother, Adrian, joined the Brandon Group, and today plays a major role in the company’s running as joint MD alongside his older sibling.

Theatre lighting track record
One area where Brandon has enjoyed particular success, establishing a reputation for both quality and innovation – indeed such has been its growth that, in January 2013, having outgrown its former Middleton premises a few miles away, its workforce moved to the new Morley site – is in the design and manufacture of advanced operating theatre and examination lighting. Brandon’s medical lighting systems are now sold, alongside associated control equipment, medical AV systems, and medical architectural products, to leading healthcare facilities both across the UK and overseas.

In ‘constantly evolving’ such lighting, with some of the most notable advances achieved since the advent of LED technology, the goal, Graeme Hall explained, has been to develop and commercialise lighting that offers surgeons, GPs, and other clinicians, the market’s highest performance, and most useful, ‘added value’ features. “Simultaneously,” he explained, “we have striven to address some of the common ‘issues’ surgeons and other clinicians report to us, and to develop and incorporate features that enable such personnel to work optimally, particularly during longer, more complex, procedures.”

Exploiting LED’s benefits
Brandon Medical’s more recent surgical lighting products have harnessed LED’s well-cited benefits, including its longevity, efficiency, low energy consumption, and high reliability – characteristics which have seen LED enthusiastically embraced by many healthcare estates professionals. Yet while LED has its advantages, in current form, at least, it also has its limitations, and indeed, Graeme Hall made clear, getting the best out of the technology still presents some significant challenges.

The fact that, while physically challenging – the Brandon MD acknowledged that the ‘science’ of lighting ‘seems to get more complex the deeper one delves’ – such obstacles can be overcome, is evidenced not only by the past 4-5 years’ positive reception to Brandon’s existing HD-LED lighting portfolio, but also by the success of the recent EU-funded Project Hercules (standing for High Efficiency and Rendered Colour Using LED Solid State lighting; see http://www.hercules-project.eu/) that Brandon has led.

The project saw Brandon collaborate, with five other European organisations drawn from the NHS, industry, technology consultancy, and academia, including three SMEs – see panel, page 70 – to co-develop a new LED lighting technology that builds on the strengths and selling points of its own existing ‘HD-LED’. The resulting enhanced ‘Fat Beam’ HD-LED technology is set for its first commercial deployment in Brandon’s new Quasar eLite operating theatre lights. Sagentia (a renowned technology advisory and development consultancy with which Brandon has worked previously) says the technology will enable LEDs to be driven ‘using low cost electronics, at efficiency levels significantly in excess of existing techniques’. It adds: “Importantly, this would represent a step-change away from conventional pulse-width modulation (PWM) and linear driver approaches currently used in LED products.”

Aiming to lead the field
The Project Hercules partners believe the technology, which will subsequently be rolled out into other Brandon lighting systems, offers performance, particularly in areas such as ‘near perfect colour rendition’ – the red balance control so important in enabling surgeons to distinguish different tissue and bone during surgery, and illumination, ‘far in advance’ of anything competitors can offer. ‘Brandon now has several years’ experience in honing LED’s inherent benefits to create high performance theatre and examination lighting, although it stresses that the input and expertise of all the Project Hercules partners was crucial in ensuring that the LED technology developed was genuinely ‘state-of-the-art’.

Graeme Hall says: “In 2006 and 2007 Brandon developed, and commercially launched, a technique for producing high colour rendition lighting LEDs, dubbed HD-LED, which we patented.”

The technology was first incorporated into Brandon Medical surgical lighting in the company’s Galaxy Ultra, Astralite, and Quasar products, launched in 2007.

‘Questionable’ colour
“While LED technology has many practical advantages in lighting applications,”

Graeme Hall continued, “it has some potential drawbacks too. Essentially, although the lights are highly energy-efficient, colour quality is questionable, while another issue, particularly for surgical applications, is their relatively low red colour content. Unfortunately, if the operating lights provide little red, the surgeon finds it harder to distinguish different tissue and skin tones.” The ‘usual answer’, he explained, was to ‘turn up the brightness’, although the upshot was ‘a lot of glare’.

Focusing next on how different lighting technologies have struggled to reach the nirvana of high efficiency, good colour rendition, and accurate red, the Brandon MD explained that LED’s immediate
precursor for operating theatre lighting was halogen, although there had also been a ‘minor foray’ into high intensity discharge, or HID.

**Obtaining sufficient red light**
He said: “The problem with ‘traditional’ halogen lights is that they produce a lot of infra-red light, which is heat – bad for the patient, and uncomfortable for the surgeon. You can filter this out, but this also removes a substantial proportion of the visible red light. You thus face the same issue – light that is not great in the red part of the spectrum.

“High intensity discharge and fluorescent lights, conversely, both produce a discontinuous colour spectrum, and don’t contain much red; much of their light is at the spectrum’s blue end,” he continued.

“A key driver for HID lighting’s surgical use was its energy efficiency, and the fact that the halogen lights of the time weren’t great; a number of manufacturers thought they could overcome the problems with HID’s low red content. In reality, however, all these lighting technologies, certainly for surgery, have since been killed off by LED.”

**Ahead of competitors**
While Brandon is now recognised as one of the field-leaders in surgical LED lighting, the company first got involved in a somewhat fortuitous way. “Basically,” Graeme Hall explained, “the advent of HID pretty well passed us by; we never felt it was a viable technology, and, by the time we did begin looking at it, we realised there was a new technology – LED – coming along. This proved an advantage; we were one of the first companies to look seriously at LED for surgical lighting, and certainly the UK’s first major player.” Brandon’s first approach to the colour rendition issues which had dogged existing LED technology was to ‘combine various different-coloured LEDs to produce a reasonable colour’. “However,” Graeme Hall explained, “all this does is produce something quite energy-inefficient. We then discovered that our HD-LED technique, which entails modifying the white light with particular frequencies of red and orange, worked well, and this was the technology (co-developed with Sagentia) that we patented in 2007. Sagentia brought to the table first-class optical engineering and pure science expertise, whereas we are better at actually developing technology and then marketing it.”

**Bridging the gap**
Brandon’s first commercial use of the then new HD-LED lighting technology was in 2007, when it simultaneously launched its Galaxy Ultra operating lights, Astralite LED minor surgery lights, and Coolview LED examination lights – effectively a complete package of clinical lighting. The Astramax HD-LED light, designed to ‘bridge the gap’ between the biggest and smaller operating theatre lights, followed in 2011. Graeme Hall said: “At the time the HD-LED technology was pretty ground-breaking, but, having already overcome a number of technical issues, we knew we could improve on it further – one of the reasons Project Hercules came about.

“One of the main goals – as part of a broader goal of developing LED lights that could deliver both high power efficiency and good colour rendition, – was to take HD-LED a significant step further for both surgical/clinical task lighting and room lights. We knew, for instance, that there was still considerable scope to improve both the pattern and beam shape generated by the HD-LED task lights.”

**Improving the lighting field**
Usually, the Brandon MD explained, such a ‘spotlight’ has a ‘normal’, or Gaussian, intensity distribution, with peak intensity at the centre, which falls off quite markedly towards the perimeter of the illuminated spot. He said: “If you imagine undertaking complex surgery with a spotlight just 200 mm in diameter, with perhaps a light intensity of 160,000 lux in the centre, but only 16,000 lux at the perimeter, this is not ideal. The ideal is to achieve similar brightness across the beam, which, based on the laws of physics, generally requires about four times the lighting power.

“A key obstacle to achieving this was never having sufficient lighting power without all the accompanying extra heat.” Graeme Hall explained that surgical lighting can have a light intensity of up to 160,000 lux, with the ‘edge’ of the spotlight’s effective field determined by the point at which intensity is just 10% of that in the centre. He said: “Our goal, and indeed we had already gone some way towards this with our earlier Quasar HD-LED theatre lights, was to develop an operating theatre light beam with 160,000 lux illumination all the way across, giving a quality of light far easier to work under.

**Solid state route adopted**
“We had effectively designed and built our first generation Quasar HD-LED lighting with what we dubbed ‘Fat Beam’
technology using a telephoto lens focusing concept. However, although users recognised the benefits of a ‘fatter’ light beam, the market didn’t particularly like the light head’s shape, which had an optical focal length of about 140 cm; thus it ended up quite big. We thus decided, via Project Hercules, that we would seek to achieve similar lighting characteristics, but using solid state technology that could be ‘packaged’ into a thinner unit.”

Another of the project’s goals was to create a ‘better, and fatter beam, and deeper column’ of light, meaning surgeons would have to re-focus the beam much less frequently during an operation. Graeme Hall said: “Whenever a surgeon touches a light, there is a fair chance that they will contaminate either it, or themselves.” (Studies of orthopaedic surgery undertaken by Brandon and London’s Imperial College had shown that some 30-40 per cent of operating theatre lighting became thus contaminated during surgery).

Minor colour shadows
Eliminating the ‘minor colour shadows’ that can occur with lighting that uses multiple colours, due to a mismatch in the optics of the different coloured-LEDs, was another goal. Graeme Hall elaborated: “Take two LEDs, one red and one white, slightly displaced physically, and, by the time the light has converged onto a focal plane, any slight mismatch in the reflective systems will generate fringing. With good design this can be rendered negligible.”

Project Hercules was initiated after Graeme and Adrian Hall developed a concept, and built a proposal, to create a multi-disciplinary consortium. He said: “We knew we needed a fairly sizable amount of cash, and had identified the EU’s Framework 7 programme, under which money is available for suitable collaborative research projects in the EU.

“We sought funding via an EU Framework 7 scheme called ‘Research for SMEs’, securing £1.043 m in late 2011, which we shared among the project partners, and the two-year project then commenced in earnest.”

Considering available options
One of the first steps, Graeme Hall explained, was to ‘look at all the potential ways to create high colour rendition LED light to see what the various competitive solutions were’. He elaborated: “There are effectively three key potential techniques – the first being to improve the phosphor on the LED. A white lighting LED is essentially a blue LED with yellow phosphor mounted on it; the combination gives a very crude approximation to white. Although you can enhance the colour by adding other phosphors that emit light in other parts of the spectrum, the more you apply, the less light you get out. You can also obtain reasonable colour rendition across the $R_9$ Colour Rendering Index spectrum, but it is impossible to also achieve high visible red colour rendition unless you compromise the LED energy efficiency with a lot of phosphor coatings. The result is a white-looking light, but with poor red – technically defined by the $R_1$ measurement.”

Measurement of colour
Graeme Hall explained here that when measuring the colour rendition of light, users take 14 measures of colour – from $R_1$ to $R_{14}$. He said: “Someone describing colour will nearly always be referring to $R_9$, indicating how white a light is, the average reading between $R_1$ and $R_9$ in the spectrum. This gives you a number out of 100, 100 being ‘perfect’.”

(£$R_9$ reading had, however, he explained, been designed for light with a continuous colour spectrum, incandescent light source; those who launched the system had never considered the advent of light with discontinuous spectra with very little red.) He added: “The $R_9$ does not include the strong visible red colour which is the ninth measurement – technically referred to as $R_9$. If you require high colour rendition, particularly in environments with a lot of red colours like surgery, it is essential to consider the $R_9$ and the $R_1$."

Returning to adding phosphor to LEDs, Brandon’s view was that, although this could work fairly well for general LED lighting, it was less suitable for medical/healthcare applications.

The second method of achieving good colour rendition involved using primary colour combinations. “Most will know that if you mix red, green, and blue light you get white light,” said Graeme Hall. “However, as LEDs have a very narrow waveband, you only get a bit of each of the three colours, resulting in a pretty average light quality, and the need to add a fourth. This tends to provide good $R_9$ and $R_6$ colour rendition, but culminates in low efficiency lighting, largely due to both green and red LEDs’ low efficiency. You thus end up with something complex to engineer, but pretty inefficient.”

Use of orange and red
The third route to excellent LED colour rendition and quality was (as used in Brandon’s HD-LED system) to take the highest efficiency LEDs and modify them using red and orange light. Of the three techniques, this was ‘the only one able to achieve both good $R_9$ and $R_1$ colour rendition, and high efficiency’. “Having thus revisited the most practical, workable potential ways to achieve good LED colour rendition in the early stages of Project Hercules,” Graeme Hall explained, “the next step was to identify how we could make the technology better.” One of the routes pursued saw the project partners, and in particular, Sagentia, spend considerable time optimising the optics of HD-LED.

“LED chips are of different shapes and sizes, so with a white and a red chip from the same manufacturer, the size of silicon, and the form factor, are often dissimilar.” Graeme Hall explained. “Sagentia developed an optical modelling system that enables us to design an optic for each chip, so the output of the optical element compensates for its size. The result is that when you create the luminaire, there is no colour separation.” This part of the design process, he explained, involved looking at the aspheric polynomial curves of the reflectors.

Compound curve solution
Changing the shape and design of the reflectors so the resulting curve was a compound curve between all of them, in
conjunction with compensating for different-sized LED ‘chips’, was in essence how Brandon and its partners created the enhanced Fat Beam technology used in the new Quasar eLite. The bulk of the optical physics work was undertaken by Sagentia.

Project Hercules ended on 31 December 2013. Graeme Hall said: “The end goal was to produce two final deliverables, in the form of product demonstrators – one a small surgical task light for interventional procedures not normally carried out under anaesthetic as a demonstrator for a larger version, and a room light. In the process we also developed the new Quasar eLite operating theatre light, into which some of the technology developed during Hercules has already been incorporated. The work we did in creating the two demonstrator products will result in further product launches towards the year-end.”

**Improving bedhead lighting**

The second of the two demonstrators (both can be seen ‘in action’ in a video on YouTube at http://www.youtube.com/watch?v=OKJ9kxVilGes) is a multi-function LED bedhead light. Graeme Hall said: “Today’s bedhead lights tend generally to be pretty multi-purpose – providing reading light, part of the general room illumination, night lighting, and even examination capability. One of the major disadvantages of fluorescent bedhead lighting is poor colour rendition: the light is not one you would choose to relax under. You can get ‘warm white’ tubes, generally better than ‘cold white’ fluorescent strips, but these are still not great to live under 24 hours a day.

“Having developed what we believe is a fantastic LED surgical light source during Project Hercules, the resulting lighting should suit other healthcare applications. Clearly hospital patients will spend some of their time under artificial light, but if this has really good colour rendition, they are at least under something akin to sunlight. We should also be able to provide many other lighting functions, such as running the lights to work in tandem with circadian rhythms, giving lighting control to patients, for instance via an ‘app’ on a tablet device, and even controlling groups of lights to provide the best ‘average’ light for patients in a room. Equally, you can have different ‘apps’ for staff.”

**Added-value feature**

A key added-value feature of Quasar eElite is the incorporation, as standard, of Sony HD-SDI video cameras and zoom controls in the lamp head. Graeme Hall said: “This not only saves purchasers money, but also aids infection control, by eliminating the need for excessively large handles which are not generally sterilisable, and ‘restricted rotations’.” The Qasar eElite operating theatre lights will also feature ‘moulded in’ antimicrobial additives, while their ‘smooth continuous surfaces’ are designed to be easy to wipe clean. The lamp heads are sealed against dirt and liquids, while the availability of wireless remote controls means surgeons do not need to touch the lights during operations.

Although the enhanced ‘Fat Beam’ technology developed during Project Hercules makes it (Brandon says) ‘ideally suited to healthcare’, Graeme Hall said the company believed the lighting had many other potential applications, being suitable for anywhere where users required high
quality, excellent colour rendition, and high efficiency lighting in combination.

**Progress meetings all over Europe**
Throughout Project Hercules, Brandon co-ordinated regular progress meetings at different European locations, and, last November, co-hosted with the Bradford Teaching Hospitals NHS Foundation Trust, a demonstration day, in a surgical ward simulation centre at Bradford Royal Infirmary. Graeme Hall explained:

“Here we demonstrated the capabilities of both the task and the bedhead lighting developed during the project. A sizeable number of clinicians attended, including a consultant ENT surgeon, Chris Benn, who works for the Trust, and who led the clinical team in assessing the demonstrator units. We also took valuable feedback from a senior theatre and infection control nurse, Debbie Sykes. This was the first time that clinical staff from Bradford saw the completed lighting demonstrators – user feedback is clearly vital – although throughout the project we had valuable input from our clinical director, Professor Jonathan Sackier (who joined Brandon Medical’s Board last May, and is probably most famous for performing the world’s first laparoscopic cholecystectomy using robotic assistance. As a Professor at George Washington University, he founded, and funded, the Washington Institute of Surgical Innovation in the US, and is a visiting professor of surgery at the University of Virginia.)

**Value of feedback**
“The input and feedback we get from surgeons and clinicians about our lighting and other products is invaluable when we develop new technology,” commented Graeme Hall. “As indeed it proved during Project Hercules, when we worked with some first-class partners with cutting-edge expertise and knowledge.

“What is particularly interesting is that, although many feel they understand light, it is a pretty complicated subject, and involves a bandwidth of frequencies which all behave in a different way. Working to get light where you want it via an optical system throws up challenges that you don’t anticipate. The vindication of all your efforts comes when you put a lot of work into, say, a surgical light, and the surgeon, doctor, or other user, tells you the lighting is considerably better than what was previously used, and has made their job that much easier. That is when all the research, development, science, and, at times, guesswork, you and your development partners have put in seems really worthwhile.”

**Impressive new building**
Having by this stage discussed Brandon’s latest HD-LED lighting technology and Project Hercules in some detail, I was next given a tour of the company’s impressive new Morley site. It transpired, as Ria Cusimano showed me around, that the new site took Graeme and Adrian Hall two years to find, while they simultaneously negotiated the sale of the Middleton site with two local supermarkets.

Ria Cusimano explained that, on acquiring the building in Morley in later 2011 from a bookbinding company, Brandon began stripping out and substantially refurbishing it. “We spent most of 2012 on this process, investing some £2 million in bringing the fabric and interior up to modern standards,” she explained.

**Dedicated visitor centre**
The work included fitting a new roof, major internal remodelling, in particular of the area now devoted to production, and the establishment of R&D facilities, laboratories, and cleanrooms. Ria Cusimano said: “We also have the new visitor centre here, located in its own wing, with both a meeting room, and a demonstration area.” The latter incorporates a simulated intensive care unit, a GP or minor procedures room, and a simulated operating theatre, all equipped with Brandon Medical lighting, pendants, digital operating room controls, audio-visual control, and processing equipment.

Ria Cusimano said: “Considerable time, effort, and money, went into the refurbishment. We have 53 staff working here, and it is quite likely that we will need to further expand our workforce.” Brandon is apparently expecting a Royal visit this summer; its winning of a Queen’s Award for Innovation in 2011, Ria Cusimano explained, was probably instrumental; while last September, the Rt Hon David Willetts, Minister for Universities and Science, visited the new site, as part of “a mission to understand the life sciences eco-system which exists in Leeds, between industry, the NHS, and academia.”

**A busy year ahead**
As our discussions concluded, Graeme Hall told me: “Our relocation to this new, much more spacious site early last year was extremely timely. 2014 looks set to be extremely busy, particularly new product-wise. This impressive new base, and particularly the enhanced production, R&D, and cleanroom facilities, have put us on an even firmer footing to continue designing, developing, and launching, some of the market’s most exciting medical technology, against a backdrop where healthcare facilities are increasingly looking to innovative equipment to boost their surgical productivity, broaden their range of procedures, and optimise clinical throughput and performance.”

**Project Hercules ‘partners’**
Alongside project leader, Brandon Medical, the other Project Hercules partners were:
- **Sagentia** – a Cambridge-based global technology and product development services consultancy.
- **TWI** – The UK-based technology consultancy specialising in materials, thermal modelling, welding, surface engineering, and structural integrity material processing.
- **Synergy Medical** – Ireland’s largest supplier of group 1 medical equipment, including medical trunking, examination lights, wireless nurse call systems, and patient hoists.
- **DTM Cumsa** in Spain – a specialist in PCB design and assembly, and integrator of systems for optical equipment.
- **Bradford Teaching Hospitals NHS Foundation Trust.**