Institution of MECHANICAL ENGINEERS

NEWSLETTER

IMechE West Cumbria Area

COAL FOR THE FUTURE

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SPRING SUMMER 18

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NEWSLETTER

SPRING SUMMER 2018

EVENT WRITE-UPS

UPCOMING EVENTS

SPRING/SUMMER EVENTS CALENDAR
Keep up with the latest engineering ideas, inventions and thought leadership at our local events. Check out the back page for our upcoming events and visits. Go on, get yourself booked on some!

"Our Vision is to improve the world through engineering, by inspiring the next generation, developing professional engineers and setting the agenda."

IMechE Vision Statement

CHAIRMAN'S COMMENT

Welcome to the Institution of Mechanical Engineers West Cumbria Area Spring/Summer 2018 Newsletter. We are just commencing the second half of another packed IMechE West Cumbria events programme, which you can find on the back page of this Newsletter. Further information about any of our events can be found on our nearyou.imeche.org website. In the meantime, I would like to share with you some of the highlights from our Autumn/Winter season and give you a taster of what's still to come in the months ahead. As with all our events, booking early is essential to secure your place.

Our season began in September where we delivered a variety of events including; a lecture on Coal Mining Re-birth in West Cumbria, a talk on Createc Fukushima and a visit to wood-based panel manufacturer Egger UK Ltd. Our winter season came to a close in January, with a talk at the United Reform Church in Whitehaven on the engineering behind cathedral organ refurbishment.

Turning to educational activities, and following the success of our annual dinner last June, in November we ran a second Bloodhound event with schools in our area. Attracting young people into Science, Technology, Engineering and Maths (STEM subjects) is key to developing future generations of engineers. Over 1000 primary school children attended our Bloodhound events in 2017 that were designed to inspire young people; so please support and encourage your local schools to get involved in future events.

Looking forward in our events calendar, we are planning five lectures/visits, plus our 14th Annual Dinner. Please feel free to share our calendar with friends and colleagues, as you don't have to be a member of the Institution to take advantage of our events. In particular, I would like to draw your attention to our trip to First Milk Creamery in Aspatria, as places on this visit are limited - book early to avoid disappointment.

Finally, work has started on the planning of this year's Annual Dinner on Thursday 28th June, which will once again be held at Lakes College West Cumbria in Workington. I'm delighted to announce that we are also working towards securing a complimentary event similar to last year's Bloodhound one. The dinner will be linked to an educational theme where during the day on Thursday 28th June, local schools will be invited to attend Lakes College for an interactive session involving cutting edge technology and British Engineering at its best.

Best Wishes and I look forward to seeing you soon.

Simon Mandale BSc(Hons) AMIMechE
Chairman – IMechE (West Cumbria)
simon.mandale@sellafieldsites.com

BLOODHOUND EDUCATIONAL EXTRAVAGANZA TAKE TWO

Thanks to the generosity of our sponsors, IMechE West Cumbria was able to re-run the Bloodhound Educational Extravaganza, which first took place in conjunction with our Annual Dinner back in June 2017. The three day event, from 29th November to 1st December, attracted 600 students from 20 local primary schools. This adds up to over 1000 pupils and 35 local primary schools engaging in this fantastic STEM Outreach Activity to date.

The day, which came hot on the heels of the successful Newquay airport 200mph trials, involved the pupils learning about the history of land speed attempts and how the Bloodhound SSC team hope to reach 1000mph in South Africa later this year. There were also discussions and demonstrations based around the educational life-size model of the Bloodhound vehicle. This was followed by workshops, which included building, running and fine-tuning air powered K'Nex vehicles, before racing in a number of heats and finals. The winners of each morning and afternoon session will have their team name emblazoned on the tail fin of the actual Bloodhound SSC as it races across the Hakskeen Pan in South Africa.

The winners were; **Lowca Spinners** (Lowca Community School), **Denominators** (St Gregory's School), **The Flash** (Derwent Valley Primary School), **Supersonic Car** (Richmond Hill School), **Super Seascale** (Seascale School) and **Blood Shark Racing Car 10** (Victoria School) - congratulations to all those involved!

The Bloodhound Educational Team were fantastic and enthused the students immensely, with the atmosphere and engagement of the students being inspiring. We would like to thank all our sponsors, with special thanks going to Arup and Lakes College for being key sponsors. Thanks also go to React Foundation for coordinating with the schools and organising pupil attendance.

Institution of MECHANICAL ENGINEERS

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COAL MINING FOR THE FUTURE

WEST CUMBRIA MINING LIMITED (WCM) IS A PRIVATE UK COMPANY FOCUSED ON LEADING THE UK COAL INDUSTRY INTO THE MID-21ST CENTURY BY DESIGNING, CONSTRUCTING AND OPERATING A DEEP UNDERGROUND METALLURGICAL COAL MINE.

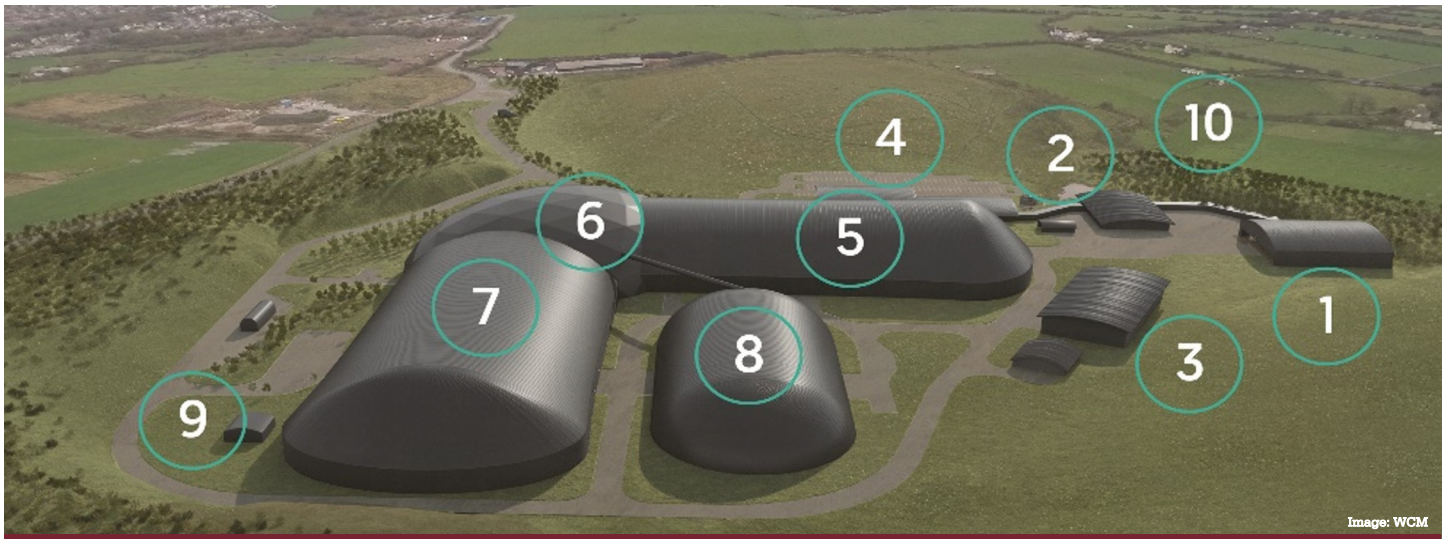


Image: WCM

1. Mine drifts portal building
2. Workshops
3. Mine ventilation building
4. Offices
5. Mined coal storage
6. Process Plant
7. Clean product coal storage
8. By product storage
9. Underground train loader conveyor
10. Landscaped building

On 16th September 2017, Steve Reece CEng FIMMM delivered a presentation to members and friends of the IMechE on the development of the Cumbrian Metallurgical Coal Project (CMCP), which hosts one of the world's largest undeveloped resources of premium high volatile, hard coking coal.

West Cumbria Mining (WCM) was established in April 2014 with the aim of producing high quality metallurgical coal for the domestic and European steel industry. The Cumbrian Metallurgical Coal Project (CMCP) is strongly aligned with the UK Government's Industrial Strategy and Northern Powerhouse Initiative.

In his role of Operations Director, Steve Reece oversees all aspects of the design, development, construction and operation of the coal mine and associated facilities. His talk began by briefly outlining his career history, which began with the National Coal Board where he became a Colliery Manager in the South Wales and Durham coalfields during the 1980s. During the mid-1990s Steve then became Mine Manager and Chief Mining Engineer at Compass Minerals Winsford Rocksalt Mine where he was a key member of the team responsible for the planning and implementation of Minosus®and Deepstore®, a major underground document storage archive. Steve also held roles as Head of Design for Radioactive Waste Management Ltd and Technical Services Manager at Tellus Holdings in Australia before joining WCM as Operations Director.

The CMCP is located immediately south of Whitehaven, with project licences covering a 200km^2 area in the historically productive West Cumbria Coalfield. The area has 700 years of steel making and mining heritage in the region with Haig Colliery being the last operating mine, situated to the immediate north of the CMCP resource. It closed in 1986 after almost 70 years of coal production.

WCM holds three contiguous 'Conditional Underground Licences', issued by the Coal Authority, which grants exploration rights for the purpose of underground mining. The licenced area has an extensive historical database of over 16,000m of drill data from 70 drill holes and an extensive offshore seismic survey database (British Coal 1970s and 1980s for extension of Haig Colliery, NIREX 3D Seismic survey for nuclear waste disposal and UK Oil and Gas exploration data). Historic underground mine workings and records from adjacent mines provide important information for the project.

At the time of the presentation, Steve explained that WCM were embarking on Phase 4 of their exploration programme. The exploration programme has the aim to generate key geological and geotechnical data used to establish an Indicated and Inferred Coal Resource, with standards defined by the Australian JORC (Joint Ore and Reserve Committee) Code. By the time of publication, the four exploration phases will have delivered data from eleven onshore boreholes and six offshore boreholes.

Estimations from independent consultants expect the total 11,000m of drilling will be successful in expanding the resource to over 200 million tonnes. The target coal succession is typical of Upper Carboniferous deposits, with the four resource target seams of Ten Quarters, Bannock Band, Main Band and Six Quarters. The Bannock Band and Main Band seams are the focus of the mine plan for the initial mining area.

The wider onshore coalfield shows intricate interaction between faults on many trends. North-east faults are truncated by a series of northwest trending faults. The structural fault density offshore reduces significantly from the complexities onshore, building into WCM's mining strategy to target the offshore mining areas. The mining depths are around 400m to 500m, with the seam consistently dipping at five degrees. The seam thickness variability is low with the seam qualities largely predictable, averaging 2.5m thick.

WCM intend to develop a fast, low risk, low environmental impact access route to the target coal measures via an existing disused anhydrite mine. Two parallel 2,500m drifts were initially driven in 1953. WCM intend to rehabilitate, enlarge and extend the drifts to facilitate early coal access.

Between September and November 2017 WCM re-entered the disused Sandwith Anhydrite Mine drifts to undertake a conditions assessment. WCM were able to remove concrete stoppings and establish a forced ventilation circuit through approximately 633m of the drifts. From the inspections, WCM were able to assess ground conditions, informing the future mine access works.

The drift portals are on a brownfield site (former Marchon Chemical Works) where the surface infrastructure will be located. Following processing on site, the clean coal product will be transported via an underground conveyor system to a rail loading facility 2.3km south-east of the project. All coal product will be transported by rail to UK Steelworks and Redcar Bulk Terminal on the East coast.

WCM has produced a mine development plan that maximises the mined tonnage using the exploration work, geotechnical information and up to date design principles. The production panels will utilise a Run-out and Pocket partial extraction system to achieve a panel extraction ratio of around 64%, whilst maintaining flexibility within the mine during the development and operational phases.

The orientation of the panels is designed, where possible, to align with the direction of maximum horizontal principal stress. This ensures that the panel gateroads are developed in the favourable stress direction for longevity. Whilst this means the main roadways are perpendicular to the stress, their increased support density will act to ensure stability for their intended purpose. Run-outs will be developed across the panel, perpendicular to the gate roads and pockets will flank the runouts on retreat.

Bolter Miner machines will be used to simultaneously excavate and support development roadways. Resin grouted rock bolts, meshing and straps will be used to support roof and sidewalls as is common in deep underground coal mines globally. Pockets will be developed by Continuous Miners, with mobile roof supports providing immediate roof control. Shuttle cars will support mining machines, transferring coal from the faces to the conveyor system.

A conveyor system will deliver 500 tonnes per hour of coal into the coal cleaning circuit. The well-proven coking coal processing technologies are split into; initial crushing and screening, heavy media separation circuit, fine clean coal recovery & dewatering circuit, tailings recovery & dewatering circuit.

A standalone fully clad & insulated building (as main means of noise reduction) is to be housed

within a Geometrica® dome (ref# 6 on the computer-generated image of the surface infrastructure). The dome structures are constructed of lightweight and strong galvanized steel or aluminium tubes which are prefabricated in their computer-based manufacturing system and are connected on site via aluminium hubs.

An underground conveyor will transport material from the main mine site to a new rail loading facility on a brownfield site in the Pow Beck Valley. The conveyor will be installed using conventional cut and cover technique with excess spoil used as landscaping material on the main site. A modern fleet of Freightliner Class 70 locomotives will haul almost 1,600 tonnes of coal at a time across the national rail network, connecting WCM to the UK and Europe.

Redcar Bulk Terminal Port provides access to European steelmaking markets. The port, located 241km from site, is fully operational with extensive coal handling facilities and capacity. The fully licensed and permitted terminal has a deep-water berth accommodating 80,000 tonne Panamax vessels, and boasts an 18 hour sailing time to Rotterdam.

A planning application for the mine was submitted to Cumbria County Council (the Mineral Planning Authority for the CMCP) in May 2017. The council have been involved in an extensive 'pre-screening' process.

The submission was accompanied by an Environmental Statement, incorporating a Project Description, as well as a Design Statement, Statement of Community Involvement and Non-Technical Summary. In addition to the legal requirement for planning permission, certain aspects of the development of the mine and its associated facilities are also covered by legislation that requires environmental permits and licences. A decision on the planning application is anticipated in early 2018.

WCM has engaged extensively with the local community using public feedback to modify the design of the mine. WCM employees have presented to technical audiences, schools and the public. The communications team also provide regular updates on Facebook, Twitter and LinkedIn as well as to the local press groups. A political adviser is retained by WCM to raise awareness amongst Members of Parliament and the national press.

There has been a strong interest in employment over the last 3 years with more than 500 direct jobs and 50 apprenticeships being offered by the project. WCM have also pledged a range of commitments, including a community fund of at least £500,000 per annum to support employees and their families.

WCM is hopeful for a positive decision in early 2018 with a schedule of planning conditions, which is normal for a development of this scale. Steve concluded his presentation by outlining the implementation timetable for the CMCP which has an overall construction timetable of around two years due to the reuse of previously abandoned infrastructure.

David Williamson, IMechE West Cumbria

DOMESTIC MARKET: UK STEEL INDUSTRY

The UK steel industry generates £3.2bn in revenues from high quality steel products that require high quality raw materials including High Volatile, Hard Coking Coal.

Tata Steel Europe
(Port Talbot, South Wales and Rotherham, Yorkshire)

- Supplies steel to Aerospace, Construction, Packaging, Energy & Power and Automotive.
- Currently in merger talks with ThyssenKrupp.
- Unions vote mid-Feb on pension cuts to secure £1bn investment.

British Steel (Greybull Capital)
(Scunthorpe Steel Plant, Lincolnshire)

- Supplies steel for Wire Rod, Rail, Construction, Automotive
- Recently returned to profitability


Image: WCM

WEST CUMBRIA 'FIRST LEGO LEAGUE' COMPETITION

On Tuesday 16th and Wednesday 17th January, Sellafield Limited STEM Ambassadors, some of who are IMechE members, took part as judges at the West Cumbria FIRST LEGO League Competition.

FIRST LEGO League is a global science and technology challenge for teams of students to encourage an interest in real world issues and develop key skills that are crucial for their future careers. The students work together to explore a given topic and to design, build and program an autonomous LEGO robot to solve a series of missions.

FIRST LEGO League is for children aged 9 to 16 years, working in teams of up to ten students with a supporting adult coach. Each year FIRST LEGO League releases a new challenge for the teams, the challenge involves a robot game and a research project, and students will need to demonstrate the FIRST LEGO League core values throughout all their work.

Teams usually have twelve to sixteen weeks to work on the challenge before they compete in their chosen Regional Tournament. Teams build a robot using a LEGO MINDSTORMS kit that they program to autonomously complete a series of missions on a specialised field and to score as many points as possible.

Through the project, teams learn more about the science and engineering behind the challenge theme. The teams identify a problem related to the theme, research the issues and propose a solution. While competing, the teams have to demonstrate core values including Gracious Professionalism® and Coopertition®, encouraging high quality work, unqualified kindness and respect and learning.

The winners of the Regional Tournaments go forward to the UK and Ireland final. The top teams from the UK and Ireland final will then be invited to compete at the FIRST LEGO League World Festival in the USA or at other international FIRST LEGO League events.

FIRST LEGO League is CREST Accredited: Students can complete either a Bronze or Silver CREST Award during this project. For further details please visit The British Science Association.

Titled "On your mark, get set, flow!" this year's challenge was HYDRO DYNAMICS with the aim to learn all about water – how we find, transport, use, or dispose of it. The 2017 FIRST LEGO League Challenge, engaged with over 250,000 students from 80 countries.

Teams met three panels of judges on the tournament day. They presented their project and answered questions about it which include being interviewed about how they implemented the FIRST LEGO League Core Values and discussion on the design of their robot. It is now that the teams pit their robots against the FIRST LEGO League Game, where they gain or lose points for successfully completing various challenges associated with water supply and disposal infrastructure problems.


Eaglesfield Paddle School – overall Winners on Wednesday 17th January 2018

Engaging with several local schools in West Cumbria, we were encouraged by the level of knowledge shown by students at this highly successful event.

David Williamson, IMechE West Cumbria

West Cumbria West Cumbria FIRST LEGO League Winners

Tuesday 16th January:
Overall Champions: Keswick A (Keswick School), Core Values Winner: Keswick B (Keswick School), Robot Design: Seascale (Seascale School), Project: Jericho Kinetics (Jericho Primary), Robot Game: Wolf Splash (Casterton Prep School)

Wednesday 17th January:
Overall Champions: Paddle Academy (Eaglesfield Paddle School), Core Values Winner: St Bees (St Bees Village School), Robot Design: Millom (Millom School), Project: VJS Roboteers (Victoria Junior School), Robot Game: Old School (Casterton Prep School)

Both Keswick School and Eaglesfield Paddle School will now go forward to the UK and Ireland Finals, to be held in Bristol on 24th February, with the winners of that going on to the World Finals in Houston/Detroit, USA in April.

Schools which took part this year:
Ashfield Junior School, Beacon Hill, Beckstone Primary, Belle Vue Primary, Casterton Prep School, Cockermouth School, Eaglesfield Paddle, Ennerdale & Kinniside, Fairfield Primary, Gosforth Primary, Jericho Primary, Keswick School, Lamplugh School, Millom School, Moresby Primary School, St Bees Village School, St Benedict's RC HS, St James CofE Primary School, St Patricks Cleator Moor, Ullswater CC, Valley Primary School, Victoria Junior School and Waberthwaite CofE Primary School.

MANUFACTURING EMPEROR OF NORTHUMBERLAND

AS ONE OF EUROPE'S MOST TECHNOLOGICALLY ADVANCED CHIPBOARD PRODUCTION PLANTS AND THE LARGEST MANUFACTURING COMPANY IN NORTHUMBERLAND, EGGER HEXHAM HAS INVESTED MORE THAN £400 MILLION INTO STATE OF THE ART FACILITIES SINCE 1984.

Image: Egger

One of IMechE West Cumbria's most fascinating and informative industrial visits took place on Tuesday 10th October, with a coach trip to EGGER (UK) Ltd at Hexham, Northumberland.

For those that attended this trip, they were rewarded by a visit to "the cloud factory", as it is affectionately called by local school children, due to the prominent chimney that dominates the landscape, which emanates waste steam that has had every scrap of energy scavenged from it before being released to the environment. The visit took in all the processing stages that go into the production of chipboard that is widely used in everyday life, from kitchen and furniture manufacturing, to laminate flooring and floor boarding used in modern building construction.

EGGER Group was founded in 1961 by Fritz Egger Snr at St. Johann in the Tirol, Austria. The company has grown to be one of Europe's leading manufacturers of wood-based panels used in construction and furniture manufacturing. The founder's sons Michael and Fritz Egger still sit on the advisory board today.

The Group has 18 plants across Europe, including; Austria, Germany, France, Romania, Russia and Turkey. A recent acquisition in Argentina and two new production sites being built in Poland and North Carolina (USA) have also been added to it's portfolio, plus 25 sales offices worldwide. In 2016/17, the company had a turnover in excess of EUR 2.38 billion and has the capacity to produce 7.9 million m³ of wood based products every year. The company currently has approximately 9,000 employees and even has its own brewery. EGGER prides itself on being a full-range supplier, producing a range of goods including: melamine faced chipboard, MDF and OSB board, laminate flooring and edging.

In the UK, EGGER (UK) Limited has two production sites: EGGER Hexham in Northumberland and EGGER Barony in Auchinleck, Ayrshire. On average, EGGER UK manufactures 1.1 million m³ of chipboard. Of this, approximately 15% is rawboard, 18% Tongue & Groove Building Products and 67% MFC (Melamine Faced Chipboard).

Both Hexham and Barony have ISO 9001 international standard for quality management systems and ISO 50001 international standard for energy management systems. In 2017, EGGER was also the first wood-based panel board manufacturer in the UK to be awarded the upgraded ISO 140001 for environmental management systems. This new accreditation is only awarded to those companies who satisfy a rigorous, externally audited programme and can demonstrate an ongoing commitment to the environment.

EGGER Hexham is Northumberland's largest manufacturing employer with around 600 employees, while Barony has over 100. For the whole of EGGER UK, there are approximately 800 employees (includes EGGER Hexham, EGGER Barony, Campact, Timberpak and EGGER Forestry).

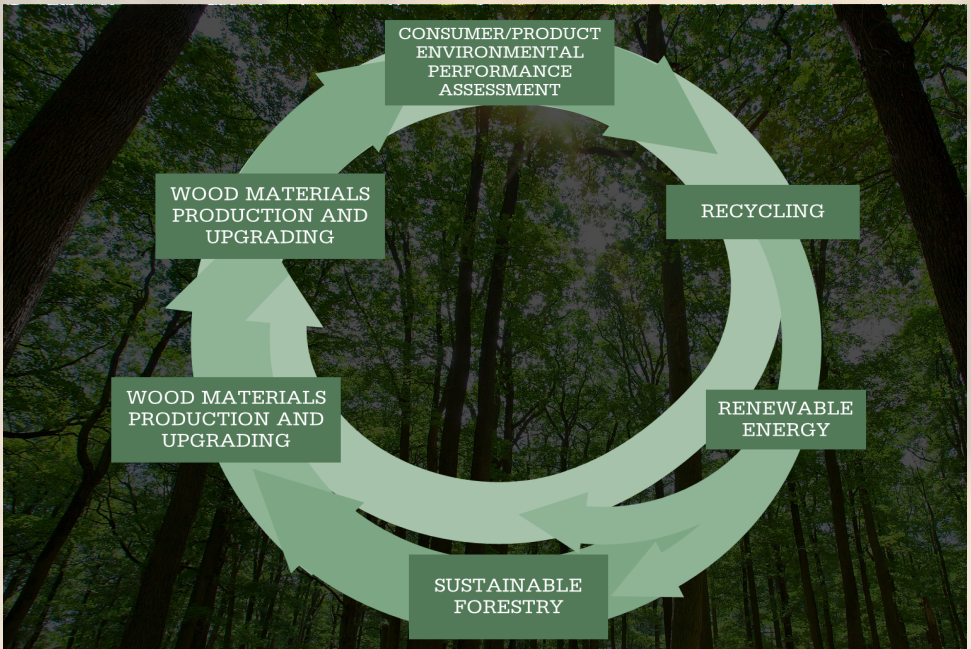
There has been a chipboard plant on the Hexham site since the 1960s. In 1984, EGGER acquired the former Weyroc site. This was the first foreign investment for the EGGER Group. The plant's close proximity to Kielder Forest and locally-based sawmills means that it is ideally situated to obtain the roundwood, hackchips and sawdust used in the manufacturing process. EGGER Barony was purpose-built in 1997 to help meet the rising demand for EGGER's wood-based products. The plant supplies raw chipboard to Hexham where it is then upgraded (laminated to become MFC, or is given a tongue and groove profile to become structural flooring).

As a private family enterprise, EGGER works according to a long-term strategy which focuses on long-term relationships. There are no shareholders, profits are therefore redistributed throughout the Group, allowing for continual improvement. This is reflected in the considerable amount of investment in the Hexham plant: in the past 10 years alone, over £250 million has been put into the site. This makes EGGER Hexham one of Europe's most technologically-advanced production sites.

The largest investment was £110 million in 2007/8. This increased the 1984 site from 20 acres to 75 acres (41% of which is undercover) and included the development of a recycling plant and a heat plant, and the introduction of environmental filtration technology.

In over thirty years that Hexham has produced chipboard, the site has laminated enough melamine-faced chipboard to build a large kitchen in every home in the UK and made enough tongue and groove flooring to floor more than 2.4 million homes.

Ron Graham, IMechE West Cumbria



THE EGGER ECO CYCLE

EGGER stands for the responsible use of the raw material wood. Like in nature, processes are organised in cycles that conserve resources. The focus is on a closed material cycle. For timber leaving a harvesting site, it's not the end of the process but the start of a journey that could see it spending the next 40 years being used time and again as it creates jobs, sustainable products and brings environmental benefits.

THE RAW MATERIALS

ROUNDWOOD

This starts with forest management and harvesting of timber from well-managed, sustainable forests. EGGER's subsidiary company, EGGER Forestry, has two branches; Harvesting and Management. This helps secure the supply of raw material. EGGER's products are accredited to FSC (Forest Stewardship Council) and PEFC (Programme for the Endorsement of Forestry Certification). This accounts for 20% of the raw materials.

HACKCHIPS & SAWDUST

A further 40% of the raw materials is made up of sawmill co-products such as wood chips and sawdust, sourced from various mills across the region.

RECYCLED MATERIAL

The remaining 40% is wood fibre that has enjoyed a previous life as perhaps a pallet, packing case or a piece of furniture. In order to help secure supply, EGGER invested in its own wood recycling company – EGGER Timberpak. There are four depots: Leeds (established in 2000), Belshill and Washington (2011), and a joint venture with Pearce Recycling to form Timberpak Pearce in St Albans (2016). Timberpak has the capacity to supply 95% of the recycled wood needed by EGGER UK's operations.

Recycled material arrives in a roughly-broken format and must be further reduced in size before it can be cleaned and made into chips. Contaminants such as glass, plastic, stones, sand, metal, paper and fabric need to be removed using a series of machines. Once segregated into their separate groups, EGGER works with its waste management partners to achieve a 98% recycling figure. Ferrous and non-ferrous metals are sold as scrap, small stones used in road construction, glass in the white lines used for road markings, plastics for clothing and play mats, with any fine wood dust remaining being used as fuel in the energy plant.

All this is good news for the environment – a log can be processed by EGGER, made into a chipboard panel that is used in a domestic kitchen until the owner grows tired of it, is recycled by Timberpak and enters the production system again, happening several times over decades. Only when the wood fibres lose their structural integrity does EGGER believe they should be used for end-of-life purpose – i.e. energy generation.

THE LOG YARD

The raw materials are stored in the log yard until they are required for production. For Roundwood, this entails storage of up to nine months – this helps to even out the peaks and troughs of supply and demand, but importantly allows the wood to dry out naturally.

PRE-PRODUCTION DRY / CHIP PREP

Roundwood is broken down by a HOMBAK flaker that can flake 25 tonnes of fibre per hour, and 6 tonnes of hack chips are broken down by each of the three Knife Ring Mills every hour. A constant woodchip size is ensured by an automatic sharpening and setting robot.

HEAT PLANT & DRY CHIP PREP

The first stage is drying, where the wood chips are delivered by belt conveyors to two huge rotating drums – the core dryers. Each is capable of drying off 33 tonnes of water per hour. The water vapour extracted by the dryers passes through the Wet Electro Static Precipitator, or WESP, which washes out solid particulates and wood fume impurities that may be present in the steam. Electrically-charged honeycombs creating a static charge within the WESP. This static electricity attracts the fine particles present in the air, before the factory's distinctive plume of steam is vented into the atmosphere.

THE CONTI HALL

Next, the variously-sourced wood chips are brought together in the ContiRoll Hall and chipboard production can begin. The 48.7 metre long machine takes in the wood chip material after it has been mixed with resin, hardener and wax. A first layer is spread onto the forming line. This produces the bottom of the board, then the core material is spread on and passed under rollers to smooth it out before the final surface or top layer is added. The three layers of chipboard are called the 'mat' with the centre or core of the board containing recycled material and the two outer layers being made up entirely of virgin material to ensure an ultra-smooth finish. The mat is compacted, evacuating most of the air, before passing through the press where the introduction of heat and pressure cures the resins and creates chipboard.

LABORATORY

The laboratory is where boards are tested to destruction, testing the quality according to both European and Group standards. A minimum of one board for every 8 hours of production is sampled and tested from both Hexham and Barony, and for MFC – one board, per line, per shift, per day. A key step in this compliance is setting up a factory production control (FPC); FPC involves testing Eggers products to strict methodologies that have been specified in the European Standards which enables the company to maintain its CE marking.

INNOVATIVE SURVEYING SOLUTIONS

CREATEC IS AN ENGINEERING BUSINESS SPECIALISING IN TECHNICAL CONSULTANCY AND R&D IN APPLIED IMAGING AND SENSING. IN PARTICULAR, THEIR PIONEERING USE OF ROV ROBOTIC PLATFORMS FOR PLANT INSPECTION TO RADIATION SURVEYING AT FUKUSHIMA.

Fukushima, Japan

On 16th November 2017, IMechE members and friends were privileged to listen to a presentation from Createc's Dr Matt Mellor, on Autonomous Radiation Survey Inside Contaminated Buildings at Fukushima Daiichi.

Nuclear decommissioning is constrained and defined by radiation and radioactive contamination. Where radiation is high and its distribution is unknown, simply gathering the data needed for project planning can become a challenge. Fukushima Daiichi epitomises this challenge. The complex sequence of events at the plant following the March 2011 earthquake and tsunami has resulted in extensive physical damage and an essentially unpredictable distribution of contamination.

The Tokyo Electric Power Company (TEPCO), which operated the Fukushima Daiichi nuclear power plant, has applied a range of manual and robotics techniques to map the status of the plant, but many significant areas have remained no-go zones due to a combination of high radiation, physical hazards and obstacles. Further, even in areas where manual survey is feasible, there is strong desire to minimise human exposure to radiation by deploying robots where possible.

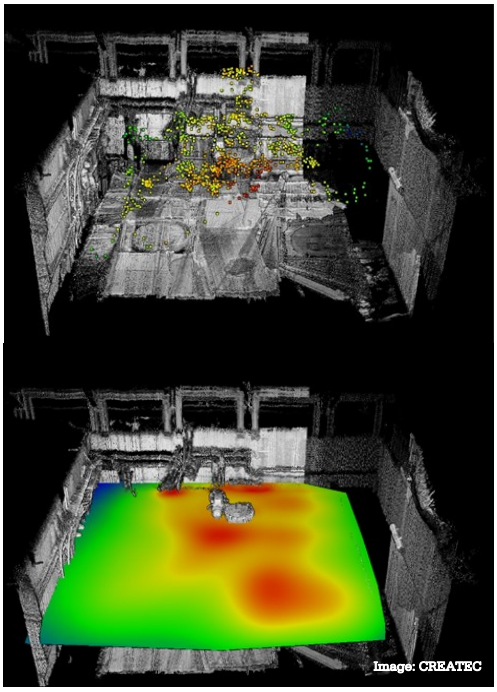
As one of the founding directors of Createc, Matt Mellor is a source of new ideas and novel approaches, being Createc's key project starter. He was initially recruited into REACT Engineering after post-doctoral research work that applied and concepts of information engineering to medical imaging. Since then he has developed the spin-off company, Createc, as a specialist problem-solving company. Createc works with partners, initially to explore and clarify key problems and then to commercialise (and finish) its projects.

Matt began his talk by explaining robotics in a variety of forms have been used in nuclear decommissioning since the outset. Despite this, nuclear robotics remains far from a 'solved problem'.

Mainstream robotics has traditionally focussed on manufacturing applications, where qualities such as speed and precision are essential to success; much of this development has therefore not been directly relevant to nuclear D&D which demands robustness and adaptability. Recent years have seen the debut of a new generation of robotics systems which focus on using autonomy to enable basic robots to operate within complex environments to complete complex tasks. The robots can in some sense see and respond to their environments.

In the application described here, a drone - RISER - is enabled to undertake a gamma spectrometry survey in an unknown environment using a technique called Simultaneous Localisation And Mapping (SLAM). SLAM uses on-board sensor data to both build a map and infer the current location of the robot within that map in real-time. SLAM itself is a passive process, but if the output of the SLAM algorithm is fed back to the robot controller, it is possible to enable to the robot to perform closed loop position control. This enables the operator to interact with the robot by specifying position objectives rather than motor inputs.

One benefit of such a system is that the on-board control system keeps the drone safe and stable without user input. This means that there is no need for piloting skills to operate the drone; when the drone needs to be moved forward for example, the operator simply clicks the corresponding button and the drone executes the command. When the system is described as autonomous, this refers to its behaviour; RISER does not make its own decisions about what to do or where to go, but autonomously translates high level 'intent' commands into low-level actions.



A second very important benefit is that any measurements recorded by on-board sensors can be located in space. When measuring radiation, knowing the position and attitude of the detector is essential to meaningful interpretation of the radiation data. Matt described a semi-automatic process to extract activity information from observed radiation spectra from RISER using an inverse modelling software called N-Visage. The overall effect of the system is to enable a non-expert team to carry out a task that would normally require significant expertise in both operating drones and radiological characterisation.

The Physical System

RISER consists of a custom designed drone developed by Bluebear System Research Ltd, coupled with an on-board navigation system developed by Createc Ltd. The drone is designed with indoor flight in mind, with the intended application of radiological characterisation in hard-to-reach areas.

The physical dimensions of the system are approximately 0.9m by 0.9m in width and length by 0.2m deep and is less than 4kg. The practical flight time is 15 minutes including a 30% contingency in battery capacity.

Although it has been assumed that it is not possible to keep RISER completely free of contamination under practical conditions, it has been designed to make managing contamination as easy as possible. The parts that are most likely to become contaminated are treated as semi-disposable parts that can be readily removed and replaced. The more expensive components are contained within a smooth-shelled body that can be easily decontaminated.

Sensor Suite

RISER carries a number of sensors for a variety of purposes. It is equipped with forward and downward facing video cameras which are fed back to a ground station for inspection and operator orientation. It has two planar lidar sensors one mounted in the horizontal plane, one mounted in the vertical plane, which are used for navigation and to build a 3D pointcloud. An IMU is used for attitude control and a CZT spectrometer with replaceable crystal provide radiation sensing capability.

There are two separate sensor fusion tasks running in the system. The first fuses IMU and Lidar data to produce a current position and attitude estimate, and also update the 3D point

cloud map. The second combines the position and 3D pointcloud data with the radiation data to produce an estimated contamination map which can help the operator guide the survey.

SLAM

The process of taking raw sensor data and using it to both update a map and deduce the location of the sensors within that map is known as SLAM – Simultaneous Localisation And Mapping. SLAM has been a very active academic research field for around 10 years, and a plethora of techniques are described in the literature. The techniques we used for RISER are based on an extension to 3D of the 2D techniques used by the well-known HectorSLAM algorithm. Because RISER has to do all of its SLAM computations on-board in real-time, Createc has developed its own SLAM approach which simplifies the 3D SLAM process into series of robust 1D and 2D processes.

Radiation Data Fusion

As RISER flies, the on-board CZT gamma spectrometer continuously records radiation data. Because the position of the drone is known during each exposure, it is possible to associate each individual spectrum file with a zone in space. Spatial trends in the observed radiation intensity contain implicit information about the location and magnitude of radiation sources. This information can be extracted in real-time to produce an approximation of the three dimensional contamination distribution which can be used to guide the survey.

The real-time contamination distribution estimate is produced by building and inverting a simple radiation transport model. First, the pointcloud is converted into a coarse 'voxel' model in which the world is represented by a three dimensional grid of cubes. Each cube is considered solid if it contains more than K lidar points, where K is a small number in the range 2-5. Contamination is assumed to be located on solid voxels. At any given moment in time, RISER will have recorded N radiation readings and be aware of M solid voxels. Ignoring shielding, the effect of the mth voxel on the nth radiation reading can be approximated by k/r(n,m)2, where k is a sensitivity factor for the detector and r(n,m) is the distance between the nth radiation reading and the mth voxel. If the radiation readings and voxel activity values are resented as the vectors R and V respectively, then the entire system can be succinctly described by the equation R=AV, where A(n,m) = k/r(n,m)2. An approximate solution to this equation can be calculated on-the-fly by a variant of the Algebraic Reconstruction Algorithm (ART) modified to be able to accept variable N and M.

Operation

The drone is operated from a ground station comprising two laptops and a Wi-Fi receiver station. The drone operates autonomously in the sense that the on-board autopilot takes full control of the motors; however, under normal operation, the system is configured such that the drone will only take action without user input under two very specific circumstances: if communication with the ground station is lost, or if the operator supplies a command which would obviously result in an impact. In the former case, RISER will simply hold station waiting for communications to be re-established. In the latter case, RISER will move as close as possible to the requested location, while remaining a safe distance from any objects which it would have collided with or got dangerously close to had it followed the command as given.

The operator interacts with the drone via a computer game control pad. The operator does not have direct control over the altitude or velocity of RISER. Instead, the control pad moves the location of the target position coordinate supplied to the autopilot. The operator is aided by various sensor feeds presented through the ground station: a 2D map of the flight area showing the current position and recent track; a forward looking camera showing potential obstacles ahead of RISER and a downward-facing camera.

Deployment at Fukushima

RISER has been deployed in a number of locations around the turbine buildings and similar locations at Fukushima since March 2017. The turbine halls provide a range of challenges to operating the drone, and a series of missions of gradually escalating difficulty has been implemented. The earliest flights were in a semi-outdoor area outside the turbine buildings informally called 'the pit', which provides access to the sea water cooling lines. Subsequent flights were at various locations within the turbine buildings, including both a turbine hall and some more spatially constrained areas.

The 'pit' area was the smallest area that Createc have flown the drone in. The pit is half subterranean, with the upper half protected from rain by a roof, but without solid walls. The ground station was set up outside the pit, with no direct view of RISER, while the safety pilot was located closer to the pit with a partial view of the drone through the open walls. The pit is on the seaward side of the turbine and on the day of the survey there was an onshore breeze gusting up to 30 kilometres per hour. This created turbulent conditions in the pit itself, which meant that RISER could typically only hold station to within +/- 1m of its target location. Combined with the small physical space (largest dimension 10m) this made the flying quite challenging and the survey plan had to be adjusted to avoid RISER flying too close to walls and other structures. Nevertheless, an adequate radiation survey was completed, over four flights.

One of the turbine halls was also surveyed. In contrast to the pit, the turbine hall is a large open area with longest dimension in excess of 100m. The maximum effective range of the lidar sensors is 60m, with many darker objects becoming invisible beyond 30m. This means that in many locations in the middle of the turbine hall RISER could only see the hall as two long parallel walls with no obvious end; the only features RISER could use to judge its position down the length of the hall at some heights were small features such as cable conduits. In order to ensure that RISER always had a stable position reference it was therefore necessary to design the survey plan with landmarks in mind, such that when RISER was near the middle of the turbine hall it always had suitable features in view.

The turbine hall was also very dark, with some cables and rebar dangling down to floor level as a result of damage to the roof from the reactor explosions. This also meant that flying in areas more than 20m from the safety pilot and operator (the vast majority) had to be conducted slowly and carefully, requiring many individual flights.

Figure 4 shows a view of the whole turbine hall survey area. The end of the turbine hall on the right of the figure was never visited by RISER, so the point cloud in this area is quite sparse, but in most other areas a reasonably dense point cloud was produced. The radiation readings clearly show a trend of rising dose rate from left to right in the figure, which was known before the survey, but subsequent analysis using the radiation data fusion technique described above showed/found that the origin of much of this radiation was two relatively localised piles of contaminated debris. Knowing this will potentially provide TEPCO with better information to guide future dose rate reduction and decontamination activities.

RISER has successfully demonstrated that an autonomous flying system can access areas beyond the reach of other less automated systems. Createc believe this is the beginning of a trend that will become increasingly valuable in nuclear clean-up over the coming decade. In particular, we expect that the form of autonomy used here – a transparent layer that translates user intent into controlled action – will be very valuable, as opposed to the 'full automation' that is used in a factory setting. This transparent form of autonomy works particularly well in nuclear clean-up because it compensates for the loss of dexterity and perception inevitable in remote working.

RISER itself has successfully completed every mission so far at Fukushima, but it is also true that as the missions have become more challenging, RISER has needed continual development to enhance its perception and autonomy capabilities. It is hoped that the maturity that is building in the RISER system can be transferred to other robots in the future by simply transposing the navigation and autonomy algorithms. If so, RISER may become the first of a series of autonomous nuclear operator platforms with the potential to transform decommissioning.

After a question and answer session, IMechE event organiser Simon Mandale thanked Dr Matt for the highly informative presentation. Following usual IMechE West Cumbria tradition, Simon presented Matt with the customary 'Pit-Tankie'.

Simon Mandale, IMechE West Cumbria

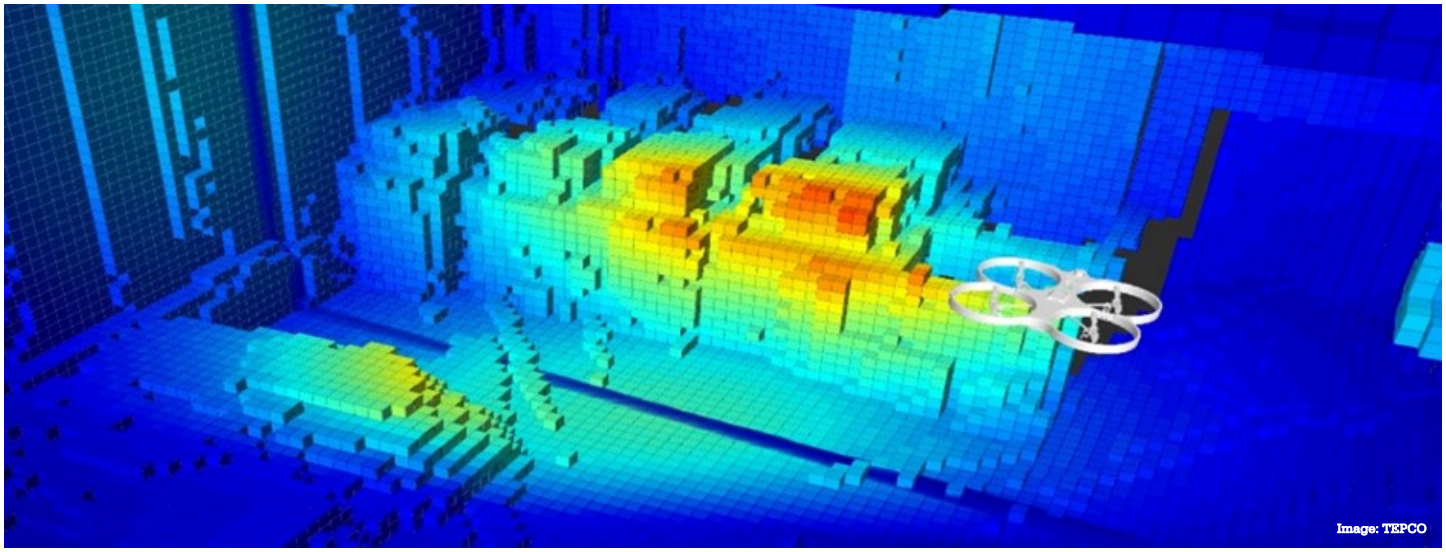


Image: TEPCO

SKILL AND ARTISTRY ENGINEERING IN WOOD

PIPE ORGANS ARE "FEARFULLY AND WONDERFULLY MADE", WITH HARRISON & HARRISON INSTRUMENTS HAVING A REPUTATION FOR LONGEVITY. A H&H ORGAN COULD EXPECT TO RUN SMOOTHLY FOR 50 YEARS BEFORE ITS FIRST MAJOR MAINTENANCE WORK.

Our first event of 2018 was a different and somewhat new slant for an educational talk; the engineering of a Cathedral sized pipe organ. The talk was given by Duncan Mathews a senior member of the Harrison and Harrison organ builders based in Durham.


Image: H&H

An example of a Harrison & Harrison organ, similar to that used in the URC in Whitehaven.

Established in 1861, Harrison & Harrison are makers and restorers of pipe organs - organs which stand firmly in the English tradition. With over 150 years of experience and development behind them, the company has refined meticulous standards of design and construction to ensure that H&H organs have a reputation for longevity.

It was particularly appropriate that the talk was held in the United Reformed Church (URC) in Whitehaven Cumbria, the instrument in the church containing an excellent example of a Harrison & Harrison instrument. The organ was built in 1906 with the specification first drawn up by famous Edinburgh blind organist/composer Alfred Hollins, together with the St Bees-based Lt Col George Dixon. Ideally situated in a tall case at the front of the church, the organ remains as something of a miniature musical masterpiece

In a series of high-profile restorations, the firm have demonstrated their ability to enter into the spirit of historic organ builders from different periods. One of their more well known large-scale organs are those in King's College Cambridge, Westminster Abbey and St Mary Redcliffe. However, like the one in Whitehaven's United Reformed Church, H&H have built and refurbished smaller organs for churches, halls and private houses throughout Britain and abroad, with their services extending to comprehensive tuning and routine maintenance.

In accordance with the laws of physics, tuning varies with the ambient temperature. Organs can malfunction if dirt gets into the mechanism, the timber shrinks or the leather dries out. The firm's highly experienced tuners are skilled at making sure that the organ remains in good working order.

The URC instrument provided the attendees a realistic setting of the engineering which underpins these somewhat complex instruments. Duncan described the beginnings of early instruments and the development of a mechanical action organ where a series of mechanical linkages connected the keyboard to the pipe and how this was then extended to utilising a tubular pneumatic system. This engineering system allowed the organ pipes to be placed a far great distance away from the console. An early example of this was in St Pauls Cathedral where tubular pneumatic technology permitted the instrument to be effectively cut in half and divided over the Cathedral.

The "tubular pneumatic" is the type of "action" which is utilised on the URC instrument. The audience were able to see the array of pneumatic lines connecting the console to air valves located underneath the pipes. By pressing a key at the organ console; with a set of pipes available, chosen by pulling out a stop; air is transmitted along a pneumatic tube to an air motor which in turn activates a pallet under the pipe to allow air into the pipe and so the pipe "speaks". Duncan then went on to explain the development of the action initially utilising electrical devices and finally the more modern "solid-state" action based on digital multiplexers and de-multiplexers.

The audience got a fascinating insight into the different types of sounds the organ is capable of producing from the basic organ sound to imitations of stringed instruments (for example violins; cellos and viola da Gamba's); brass instruments including trumpets, tubas and horns and woodwind instruments such as oboes, flutes and clarinets. The audience were shown how different pipe shapes and ideas were developed over the last two hundred years to create this wealth of sound.

Since the mid-1980s the majority of new H&H organs have employed mechanical action, although the firm still willingly uses the pneumatic action where considerations of architecture or musical style make it the best choice.

Another technical, engineering feature of the instruments, often forgotten about but critical, is the blower plant and bellows inside the organ. These generate and subsequently supply air to the pipes via the wind chests on which the pipes are housed. Duncan described how the chests are designed to accept air from the bellows and allow the performer to choose, via operating sliders within the wind chests from stops at the console the different sounds they wish to use in their performance.

One of the great benefits of having the talk in the URC was the capability of seeing inside the Instrument from the upper galleries in the church. Duncan described to the audience the idea of the "Swell" organ. Here the pipes are engineered inside a wooden box which has a series of shutters on the front of it. The shutters are controlled from the organ console. If the shutters are open this allows the pipes inside the box to sound, almost as if they were free standing in the church. If the shutters of the box are closed this dampens the sound. By opening and closing the shutters the performer is able to crescendo (make the instrument louder) and diminuendo (make the instrument quieter) as required by the music they are performing.

The second half of the talk focused on an equally fascinating slant; the Whitehaven connection to organ design and building during the Edwardian era. The audience heard of the characters involved during this period; the first a local to the area, Lt-Col George Dixon from St Bees had been a significant influence on the magnificent Willis Instrument of St Bees, however, ultimately decided to team up with the Harrison company from Durham to carry forward some of his ideas. The culmination of many of the ideas of Edwardian design were initially incorporated into the instrument in St Nicholas Church in Whitehaven. This instrument was strongly influenced by the thoughts of Lt-Col Dixon, who in turn had been influenced by the work of the organ builders Schultz and Hope-Jones. This instrument was succeeded by the contract for Ely Cathedral being awarded to Harrison and Harrison which firmly placed them in the premier division of designers, builders and maintainers, to which they have maintained this reputation to the present day.

Finally, the instrument in the URC was utilised for a small but entertaining demonstration of the instrument, given by the Branch Secretary, Mike Farrer. Overall this was a highly successful event which gave a fascinating glimpse of the engineering and creativity which underpins these instruments. The Committee would like to sincerely extend their special thanks to the URC in Whitehaven and Duncan Mathews of Harrison and Harrison for such an entertaining and informative evening.

Mike Farrer, IMechE West Cumbria

Mike Farrer presents a pit-tankie to Duncan Mathews at the end of a highly interesting talk.

BEP Delivery Team

The Box Encapsulation Plant Delivery Team (BEPDT) are delighted to work with the West Cumbria branch of IMechE to inspire future engineers by supporting the educational work they do in local schools.

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Institution of MECHANICAL ENGINEERS

UPCOMING EVENTS
IMECHE WEST CUMBRIA

NOTE: ATTENDANCE TO OUR EVENTS MUST BE BOOKED THROUGH OUR WEBSITE

TALK: How Evidence Informs the Management of Flood Risk

15 March 2018, 19:00 (registration from 18:30)

A talk about how environmental data is used by the Environment Agency across the flood risk management business; from recording of real life data to the development of hydraulic models which informs the design and construction of flood alleviation schemes. This data is the backbone that supports and justifies the work of the Environment Agency's flood risk management function.

Location: Lakes College West Cumbria, Lillyhall, Workington, CA14 4JN
Organiser: Ned Furness (ned.furness@sellafieldsites.com)

TALK: Elastomers - A Special Engineering Material

17 April 2018, 19:00 (registration from 18:30)

A thought-provoking talk and demonstration about elastomers, designed for engineers in many roles, and for anyone aspiring to be engineers. What is an elastomer? Why is it a special engineering material? What do datasheets actually tell you? How do you compound a rubber batch? Why are there lots of different types? Did you even know there were different types?

Location: Lakes College West Cumbria, Lillyhall, Workington, CA14 4JN
Organiser: John Foster (johnf@lcwc.ac.uk)

TALK: It Runs Like Clockwork

08 May 2018, 19:00 (registration from 18:30)

A talk by another of Cumbria hidden engineering gems. Keith Scobie-Youngs will look at the work that he and his team at Cumbria Clock Company carry out with the maintenance, conservation and repair of clocks across the country, which includes those on world famous buildings such as the Palace of Westminster (Big Ben), Hampton Court Palace and the Liver Building.

Location: Lakes College West Cumbria, Lillyhall, Workington, CA14 4JN
Organiser: Simon Farrell (simonf81@yahoo.co.uk)

VISIT: First Milk - Lake District Creamery

LIMITED PLACES

04 June 2018, 18:00 (registration from 17:30)

A visit to the UK's only major dairy company owned by British family farms; Lake District Creamery who supply the retail, foodservice and milk markets with a wide range of dairy products and ingredients, in the UK and internationally.

Location: Aspatria Creamery, Aspatria, CA7 2AR
Organiser: Caroline Hamilton (caroline.hamilton@igguesund.com)

TALK: Decarbonising Bricks and Mortar

14 June 2018, 19:00 (registration from 18:30)

The UK's property and construction industry is a huge contributor to the country's carbon emissions. This talk looks how the British Energy Coast (BEC) is putting low carbon at the heart of its development with two major projects: the installation of a smart energy microgrid at Westlakes Science Park, and the development of Whitehaven's North Shore with low carbon aspirations.

Location: Lakes College West Cumbria, Lillyhall, Workington, CA14 4JN
Organiser: David Williamson (djw7@sellafieldsites.com)

IMechE West Cumbria Annual Dinner 2018

28 June 2018, 19:00 (pre-dinner drinks reception from 18:30)

We are delighted to once again be holding the 14th IMechE West Cumbria Annual Dinner at Lakes College West Cumbria, with special VIP guest, Geoff Baker, the 2018/19 President of the IMechE, as part of his Presidential Visit to West Cumbria. More guests to be announced.

Location: Lakes College West Cumbria, Lillyhall, Workington, CA14 4JN
Organiser: Simon Mandale (wcumbchair@imechenearyou.org)

For more details and to book your place on any of the events please visit;
nearyou.imeche.org/near-you/UK/North-Western/West-Cumbria-Area/events

Pre-booking your place on an event is mandatory, each event will become active for bookings nearer its date. Events are for all ages with no specific requirements unless specified. You do not need to be a member of the IMechE to attend our events, all are open to the public and free entry unless stated. Visit the events page of our website for more information or contact the individual event organiser.

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