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THE PROFESSIONAL COMMUNITY FOR RAIL INFRASTRUCTURE ENGINEERING



# THE JOURNAL

APRIL 2021 | VOL 139 PART 2



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APRIL 2021
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# CONTENTS




*New Course*

We are delighted to launch the new PWI Electrification Engineering Course for 2021, following continued interest in this invaluable industry topic.

See page 56

# INNOVATION

## FOR A SAFE, EFFICIENT & MODERN RAILWAY

### RAILWAY PLANT & MACHINERY

Our next PWI theme is Railway Plant and Machinery and I am delighted to welcome our old friend Jack Pendle to introduce the subject as someone who has been involved in this area for most of his life. Mechanisation and automation are the key innovation aspects for a safe and efficient modern railway system to deliver maintenance and enhancement.

It is good to see that the PWI has an increased number of corporate members involved in the supply of plant and certainly all members have an input. Many of you use it on a day-day basis and all our designers need to be aware of the constructability of their work! This is why Construction Design Management (CDM) is so important and as it was not long ago that we celebrated 25 years of making work safer through these regulations, we must continue to strive to get the planning right. We are also delivering a major PWI event in November at Swindon Steam Museum.

Paul Baker talked in this Journal some years ago about the great developments in rail milling and two new trains will start soon across Network Rail (image 1). As we aspire to modernise high level work, the skyrailer is making a difference (image 2). Quattro, our Corporate Member, have an interesting rail crane which some readers may not have seen (image 3).

### REFLECTION

We have made much progress in a number of areas despite running the Institution virtually. I am pleased to again report that we have had a high focus on our core, the technical aspects of railways, such as presentations, training, professional development and communication. It has been another good period for high quality and well attended virtual Section meetings with one online national event, the PWI London half-day seminar in early December. The focus was trackworker safety with an insightful update from Nick Millington showing great progress on the reduction of lookout protection. Sadly, the UK railway did have a trackworker fatality in February at Surbiton and this can only remind us that whilst permanent way work is essential for passenger safety, as professional engineers we should always strive to do what we can to improve safe systems of work. Also, there were some very relevant infrastructure safety presentations as part of the programme which made us all think, as it is now over 20 years since the fateful Hatfield derailment in 2000.

Brian Counter
TECHNICAL DIRECTOR
technicaldirector@thepwi.org

# A LEARNING PROFESSION – EXPANDING OUR KNOWLEDGE

It's been all hands to the pumps in getting our Technical Hub ready for the new website. Andy Steele, Andy Packham, Stephen Barber and I have been categorising technical content to provide a more focussed service to members by enabling an easy search facility. The richness, quality and "state of the art-ness" of many PWI presentations both at seminars and Section meetings is an amazingly valuable resource. We have also recommenced our strategic review of textbooks and guides. Andy Steele starts us off with his "back to basics".

In the last Journal we discussed spreading knowledge about loading and stresses in track forms and how they degrade over time and with traffic. As permanent way engineers and infrastructure engineers we need to understand asset life. Gauge spread on timber bearers is nothing new but with limited access and possibly less experienced people, we need to pass on our knowledge of what the tell-tale signs are to colleagues. Understanding the lateral forces that trains exert may be different than when it was when our track was installed.

However, gauge spread on concrete bearers is not as well known. We have been installing these for over 40 years with many well researched and laboratory tested designs. Our knowledge was enhanced by presenters Andy Jones and Nick Carter at the PWI Wessex Section meeting on 11 February. They gave an excellent and honest insight into the issues of BBRT60 inclined S&C designs which led to track failures that caused a derailment at Eastleigh in January 2020. Fortunately, there were no injuries as the speed was 12 mph but lots of damage and delay. A number of housings failed due to fatigue after 15 years of service but unusually sheared 30 mm below the concrete surface. This shows that specified test loadings don't always match those experienced under traffic and underlines the importance of the loads considered during design. The important lessons relate to monitoring and non-destructive testing. There will be more on this in the next Journal (images 4-6).

# RESILIENCE OF RAILWAYS & CLIMATE CHANGE

It was another interesting but not surprising start to the year with flooding again affecting the UK railways and we appear to continue to have high water levels in our flood plains.

However, I don't think anybody expected another Beast from the East which was more excessive than 2017. I mentioned the new record of +20° C in Scotland in February 2019 as an interesting record and two years later we now have -20° C in Scotland in February 2021. Never was track maintenance weather precautions a more challenging issue. We will continue this theme and I welcome some practical experiences we can pass on to our members as Journal articles. Joan Heery as Chair of our new PWI Climate Change and Decarbonisation panel will be updating us on developments.

Image 1: Network Rail SF06-UK milling machine from Linsinger Austria

Image 2: Skyrailer remotely operated mobile elevated working platform

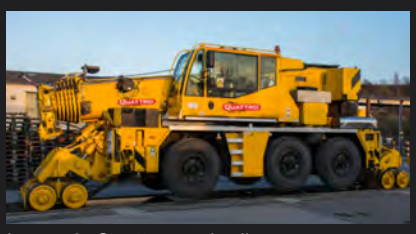

Image 3: Quattro road rail crane

Image 4: Eastleigh derailment 28 January 2020 - The broken fastenings

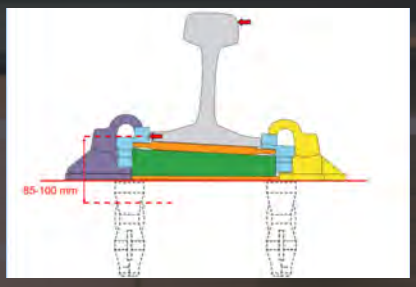


Image 5: Eastleigh derailment 28 January 2020 - The design drawing

Image 6: Eastleigh derailment 28 January 2020 - The sheared pandrol housing

Image 7: Resilience - February snow challenges in Scotland (photo: Network Rail)

Brian Counter

# Looking back, and now forwards

**Stephen Barber**
CEO
Permanent Way Institution

LOOKING BACK

As the dust has settled on 2020 it's clear that the Permanent Way Institution has emerged into 2021 in much better condition than we once feared. As the 2020 accounts reveal, and thanks to the generosity and continuing support of corporate and individual members, the Institution made a (very) small profit in the year: significantly improving on the Covid-19-driven year-end loss we anticipated back in Summer 2020. The PWI's experience looks to have been mirrored in the wider railway infrastructure sector. Whilst activity levels have undoubtedly dipped, it has been reassuring to see routine maintenance and renewal work continuing, and large multidisciplinary projects taking advantage of some easing of constraints on engineering access (a consequence of low passenger demand) to forge ahead. Physically at least, the UK railway remains in good shape.

- AND FORWARDS...

As I write in mid March there is some cause for optimism. Pandemic infection rates are falling, and the vaccination programme has been a resounding success: the latter due at least in part to railway engineers, including PWI members, drafted into the NHS to provide logistics advice and support. Government is talking cautiously and sensibly of easing lockdown restrictions on travel and meetings if current trends are maintained. I didn't foresee that the Swindon venue for our face-to-face seminar on railway engineering plant and equipment would become a temporary vaccination centre: as a result we've had to move this event (still in face-to-face format) back into November – but I'm sure it'll be worth the wait! No such fate befell the Quinton Rail Technology Centre and the PWI will be there at Rail Live in June – I'm very much looking forward to meeting members again at this outdoor event.

Subject to continued control of the pandemic, Summer and Autumn will see the PWI deliver a programme of activities close to "business as usual". Our July Electrification seminar in Glasgow, in advance of that city hosting the COP26 international climate change conference, will be followed by two Practical Trackwork Challenge events in October, and then November's Hit the North event in Manchester. Much to look forward to - and we're still considering options to expand our programme!

Undoubtedly, 2021 brings challenges and uncertainties, both to the Institution and to the wider railway infrastructure industry. In forcibly moving business and social activity online the pandemic has certainly changed travel patterns and behaviours: notably it appears unlikely that the number of traditional Monday to Friday commuters (and the associated revenues) will ever return to pre-pandemic levels. Against that, and more optimistically, can be placed rail's energy-efficient and low-carbon credentials (key attributes in a world struggling to decarbonise), and a basic human predisposition to travel. In any event, it will be some time before the industry and government properly understand the long-term impact of the pandemic on our industry's revenues. We can only hope that financial stringency doesn't drive rash decisions that damage our capability to play a leading role in longer term decarbonisation.

DECARBONISATION & CLIMATE CHANGE

Whatever the short-term uncertainties over industry revenues, there is little doubt that the world is set on a long-term path of decarbonisation and climate change adaptation. As previewed in January's Journal, the PWI has established its own advisory committee in this field chaired by Past President Joan Heery. Joan has assembled an impressive team to help the Institution decide how it can best work, on its own and with other bodies, to support decarbonisation. I welcome the committee members and very much look forward to their input. Whilst recognising the completion of Brexit, the UK rail sector retains strong relationships with continental rail companies and it is good to see 2021 designated as European Year of Rail. Though politically divorced, it's clear that the promotion of sustainable rail travel will help both the EU 27 and the UK meet their shared "green" goal of reducing carbon emissions.

PWI ONLINE

In the first half of 2020, Covid-19 restrictions caused the PWI to move virtually all its activities at very short notice from the face-to-face environment to online platforms. That change has allowed the Institution to remain connected with its membership and, arguably, to establish many new communication channels.

The PWI has long recognised the importance of its online presence and the events of 2020 only highlight the need to continue to strengthen that. So, I'm looking forward to the imminent launch of the Institution's new website. Whilst (thanks largely to Covid-19) a little later than envisaged, this major enhancement delivers another part of the Institution's 2019 strategy.

One of the many advances made is that our in-house team can now author and edit changes to our website structure and content directly, rather than having to specify and commission (and pay for) those changes from a website provider. The website carries the PWI's new branding and brings our operation firmly up to date, using the latest web and back-office functionality to offer members a wider range of information, services, and support, and to streamline our administrative processes.

Complementing the new website, changes to email and support applications will provide the PWI with an integrated virtual office, enhancing our capability to communicate with members and vice versa, and reducing the administrative burden on Section officers.

With our IT contractor, the PWI operations and marketing teams have worked tirelessly since the Autumn to bring the new site into existence and I take this opportunity to thank them publicly for their efforts.

STRATEGIC REVIEW 2021 - 2024

In January, the Board carried out a review of progress made against its 2019 five-year strategic agenda (last covered in the January 2020 Journal). The three priority items identified in 2019 (establishing the executive team; strengthening the Institution's relationships with its corporate members; and upgrading the PWI website and its online presence) are now substantively complete and the Board also noted the 2020 work to limit the impact of the pandemic on its activities. Looking forward, the Board decided to continue work on the remaining areas identified in 2019 (principally a training and development strategy, and competence management framework), and to incorporate into its strategic agenda work on decarbonisation, diversity and inclusion, and furthering employee safety.

There's no doubt in my mind that the PWI's strategic agenda 2021 - 2024 remains highly relevant to our industry and that its delivery will further enhance our Institution and the service it provides to its members.

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# A unique year full of opportunities and challenges

**John Edgley**
PRESIDENT
Permanent Way Institution

My year as President is drawing to a close and in July, I shall hand over the honour of supporting the PWI as the President to Nick Millington. The time has flown by with my term undoubtedly being shaped by the legacy of Covid which I found to be a period of great pride and some frustration.

Regarding frustration, it has impinged on our ability to meet face-to-face in our regular Section and committee meetings and my own ability to visit each of the PWI Sections to meet members. However, I see that soon, perhaps in a matter of months, we will be able to restart our face-to-face meetings and personally I remain committed to visit each Section over the coming year as soon as we return to a more normal environment.

Regarding pride, I have been hugely impressed by the spirit and commitment of our community during Covid. We have risen to the challenges that Covid-19 has brought, and we have kept the railway network running safely and efficiently. This was no easy task, with many individuals and teams continuing to work directly on the front line across the country during lockdown whilst the rest of the country worked from home. This period has seen some of the best from our industry as we have innovated, developed solutions and new working practices to keep ourselves and our passengers safe and to keep trains running. For instance, within the PWI we have seen a seamless transition from face-to-face Section meetings to online, these having an enormous demand with over 100 participants at many, and the recorded material having extremely high view rates. This has not been without its own small challenges with some speakers having recently commented to me that now the meetings are recorded and saved online they have needed to create new material for presentations at other Sections rather than recycling some of their favourite old presentations!

On Covid it is clear there will be a legacy. In the UK with the advent of inoculations we can reasonably expect to return to a 'new normal' over the coming months. That normal is unlikely to be the same as before Covid and as I commented in the January Journal, we can reasonably expect that the recovery of passenger numbers to take several years. Industry information shows that currently passenger footfall at major stations across the country is down by 83 % compared to February 2020 and the implications for our industry are clear. Across the industry we must assume and be ready for a financial challenge; we need to take stock to make sure we are investing our funds wisely, increase our pace of innovation, increase our pace of take up and embedding innovation, and maximise value for money: all while delivering quality, performance and of course safety. Rather than be concerned over this I consider it an opportunity for our industry to evolve and become stronger. The railway is after all the best and most efficient way to transport goods across the country, to manage chronic vehicle congestion in our urban centres, and to support the UKs response to the challenge of climate change.

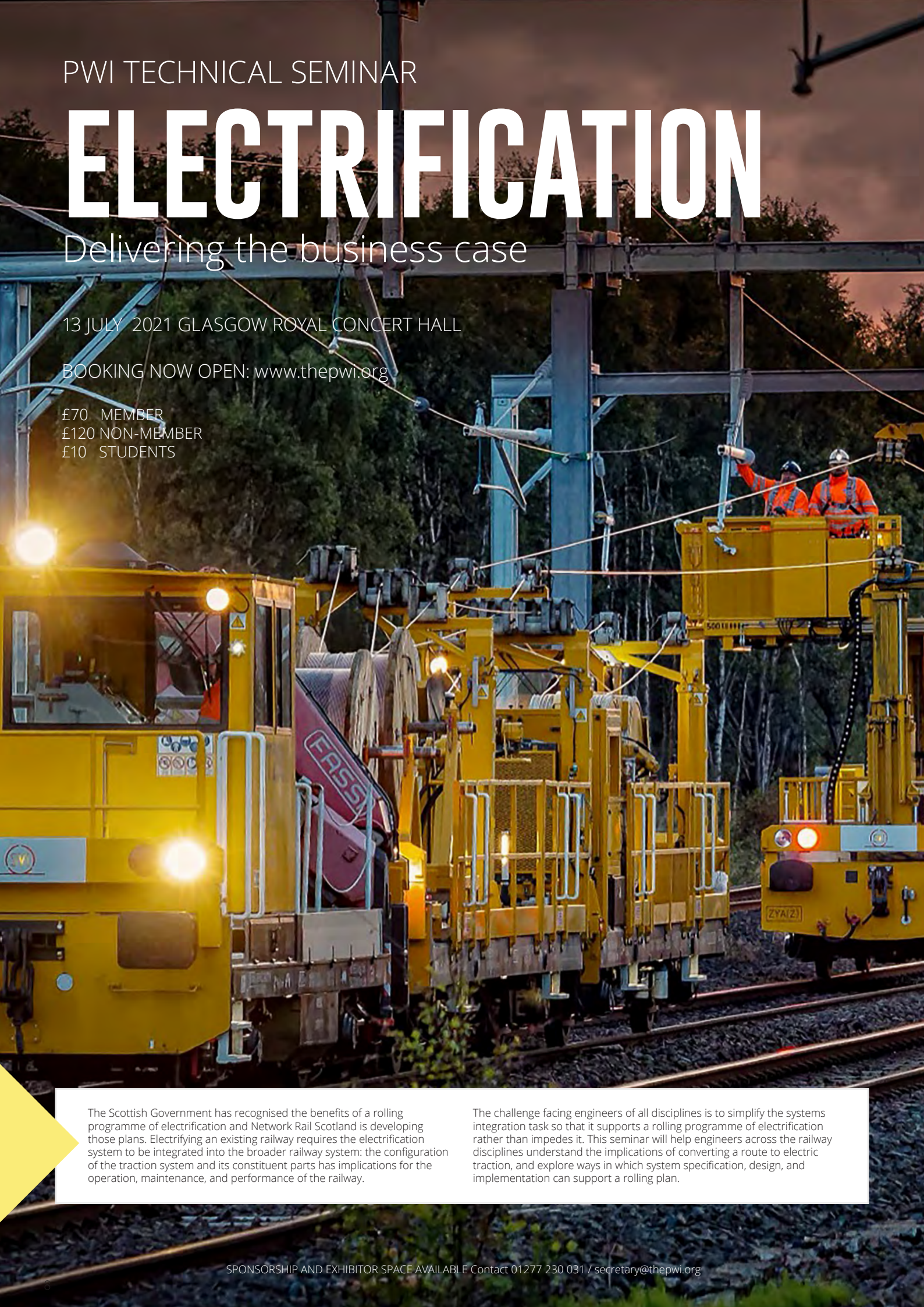
It is also with great sadness I recognise that our industry's recent safety record has been damaged with staff members having lost their lives as well as members of the public being injured with one also passing away at Carmont. In the last 12 months at Eastleigh in December 2020 at Network Rail's long welded rail facility a member of Network Rail was injured and passed away during machine maintenance activity. At Surbiton in February 2021 a member of Network Rail's inspection team was struck by a train during site inspection activities. And at Carmont in August 2020 a passenger train hit a landslip following severe rain. Of the nine people aboard this train three were killed, two members of railway staff and one passenger, and six passengers were also injured. Whilst the causes are under investigation it is clear to me that we all need to shift perspective on how we view safety matters and as a community become more aware of, and have less acceptance of risk, particularly the risk to each other and our colleagues working in a live railway environment. So, it's clear that as an industry we need to do more and I'm delighted that Nick Millington with his passion for safety, as our next President and also as the leader of Network Rail's Safety Taskforce is really well placed to support our industry drive in this direction.

As my Presidential term comes to a close, I'm pleased to report that the initiative that I have championed, that of the development of a national professional competence framework, has progressed very pleasingly, steadily and robustly. I see that this massively important and transformative work will be instrumental in helping our industry meet the challenges I've mentioned of safety improvement and value for money. The initiative makes this possible by supporting improved alignment and cross industry transparency of our people's skills, and by enabling better support of upskilling aligned to industry needs.

In January, the shape of the framework was agreed by the PWI Technical Board. It will be formed of seven competence groups with 40 specific competencies. Working groups are set up to develop and agree the scope of these areas, including the development of definitions of levels of competence within each. The work is on track to fully define the framework by the middle of this year, providing one model within which PWI Corporate Members (and other companies in our industry) can align their individual professional competence frameworks. Following this I will be asking member companies to work with me through my Past Presidential term to adopt and roll out the framework and align existing company schemes.

It has been a unique year full of opportunities and challenges and to finish as I started this article, it is a great privilege to be your President. I am full of pride over the efforts you have made to help us navigate the turbulent period of Covid and I'm looking forward to our transition toward our 'new normal' (read more on page 60). There are plenty of opportunities for us to develop, learn and innovate. And it is clear the railway industry and whole of the UK needs us to do so, and we cannot let them down.

*This period has seen some of the best from our industry as we have innovated, developed solutions and new working practices to keep ourselves and our passengers safe and to keep trains running.*



PWI TECHNICAL SEMINAR

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# Safety leader, every one of us!

## DESIGNERS, CONSTRUCTORS, MAINTAINERS & INNOVATORS

AUTHOR: Nick Millington

Nick joined the railway industry 30 years ago, aged 16, as an apprentice. He has undertaken a number of front line and leadership roles in maintenance, asset management, renewals and enhancements. Nick has perpetually carried on his learning journey and is currently a Chartered Civil Engineer, a Chartered Project Manager and a Fellow of the Institution of Civil Engineers. He also acts as a Supervising Engineer, and, like other people that helped him in his career, spends a good proportion of his time mentoring and developing tomorrow's engineering leaders. Nick is currently the Leader of the Network Rail Safety Task Force.

Some of you will know me, many of you may not. I am Nick Millington and from July this year it will be my absolutely pleasure to become the President of The Permanent Way Institution, your President.

I am a career railway engineer and I have undertaken a number of frontline senior delivery roles delivering efficiency, modernisation and improvements in train service delivery at scale. My passion, however, is safety.

As an institution together, we have a huge collective intellect. We undertake roles in a number of industry organisations (design, construction, maintenance, etc) and have many more relationships with others. The focus through my presidency will be to further harness this intellect, along all of your relationships, in order to significantly multiply the awareness, effectiveness and the moral imperative to reduce safety risk across our profession. Every member has a role to play and you can all multiply the effect that you make.

Many of you will know that you do not need to be a career Safety Professional to make a positive difference. You need a keen eye for risk and then be able to apply the very simple principles of risk reduction: Eliminate, Reduce, Isolate and Control – our friend, ERIC. And we must do this in a proactive and preventative way.

It goes without saying that the ten 'Life Saving Rules' provide a good lens to look through when you are considering risk. For example: the risk of being struck by train, electrocution, falling from height, being crushed by machinery and more… Our Institution must strive to make continual risk reductions and it can achieve more to keep more colleagues and customers even safer.

**DESIGNERS** have a great opportunity – the assets that you bring to life will be around for a long time. I am sure you put yourselves in the minds of those that have to maintain and operate that infrastructure for the many years ahead, but have you really considered all the risks and done everything to create that lasting safe impact? I have recently been the Head of Maintenance for one of Network Rail's routes and I would love to have been able to have the opportunity to travel back in time and talk to those designers that created the infrastructure. Hindsight gave me the opportunity to suggest how planned or reactive interventions could have been reduced over the assets' life, inspections could have been done remotely, access to the railway could have been made quicker (especially isolations) and safer (physical access and walkways). And providing additional operational flexibility for train routing or electrical feed arrangements would have meant I could have undertaken more of the essential maintenance tasks without having an inbuilt conflict with operations – a natural tension that always exists.

**CONSTRUCTORS** have made many improvements in construction safety over the last 15 years and long may this trend continue. But we still observe issues in possessions (that are often close to the open railway adjacent) and the delivery of isolations that facilitate railway construction. I recently visited a site that was trialling modern equipment to keep construction plant apart from each other and warn track staff – good to see. I am sure there is more that we can do to have injury-free construction and the PWI can help surface and deploy solutions. Again, putting my Head of Maintenance specs on, the quality of completed construction needs to be assured – front line maintenance staff can Ill afford repeat failures or unfinished snags. Another favourite of mine is site tidiness – a basic necessity. I have a fixation on sites that have been safely prepared, remain clean and tidy during construction and are completely clear of scrap and material when work have been completed, with safe lineside walkways restored. A number of very serious train incidents have occurred when small items / materials have been placed, disingenuously, on running lines – google West Ealing 1989 derailment, or Inverkeilor 2012 derailment, and it will show you where, as an industry, we were very lucky indeed.

**MAINTAINERS** keep our railway compliant and operational, perpetually. But how do we more progressively challenge and disrupt familiarity and the complacency that sometimes follows? I have been guilty of this myself: a healthy relationship with risk can fade through repeated exposure, but we must not slip. Maintainers see the railway every day, you know the risks that you inherently have to deal with so please generate a much more vocal 'ask' on what can be done to eliminate or reduce the risks that you perpetually deal with. Use the Institution as a platform to lobby designers, constructors, innovators and leaders for improvements – and those designers, constructors and innovators please listen; put your thinking caps on and act.

*I also look forward to continuing the good work of the Institution on upskilling and creating professional development pathways for more of our people.*

**INNOVATORS**, and we have many, what solutions can you bring to the table now? In my 30 years in the industry, I have seen radical changes, as I am sure you all have. I have seen solutions to problems that we didn't even know we had! When you consider the risks that I refer to above, what more can we do to harness technology, complex or simple, to reduce risk? How can we reduce hours on track? How can we ensure separation between people, trains, plant and high voltage electricity? How can we remotely monitor more assets and in more ways? How can we further use machine learning and artificial intelligence to create more effective designs, improve the science of asset management and, ultimately, provide a perpetually safer and more reliable railway for track staff and customers alike?

**LEADERS**, and we are all leaders in this space, consider the shadow that you cast, the habits you and your teams have and the proportion of time you spend focussing on the 'right' things – is safety leadership a prominent theme amongst these things? What more can you do, as leaders, to further energise and enable your teams to have a keener eye for safety risk, have more confidence to challenge and show more determination to take active steps to reduce safety risk? Every one of us can multiply our effectiveness through the examples that we set and through enabling other leaders, managers, supervisors and team members to be safety leaders in their own right. On multiple occasions, I have observed and overseen journeys in organisations from 'safety frustration' to 'the safest performance'. In the examples I have in my mind, financial performance, environmental performance and delivery performance all improved simultaneously.

Strong businesses are safe businesses and safe businesses do not happen through luck. It takes a greater focus, relentless effort and the ability to multiply the safety habits of an organisation, but it is rewarding, and it is worth it. To be successful in the rail industry, it is not enough to be just a 'good engineer', financial efficiency, environmental performance and continually improving a strong safety culture are essential attributes. These challenges are real, and they are raw - as I sit and write this article:

1. We are an industry with virtually no revenue (due to Covid), our trains are empty and we are locked down;
2. We have to rise to the challenge of decarbonisation quickly (the railway line along the Dawlish sea wall is shut whilst I am typing this message due to sea conditions);
3. And, sadly, a 30-year-old railway patroller has been struck and killed whilst inspecting an S&C layout on Tuesday of this week whilst working on an open railway with unassisted lookout warnings. In a little over 2 years, 5 colleagues have been struck by trains and killed working on our railway.

I look forward to leading the Permanent Way Institution, creating a stronger platform to debate these issues, enabling progressive challenge amongst each other in the industry and more importantly, driving, amongst other things, the safety agenda harder. I also look forward to continuing the good work of the Institution on upskilling and creating professional development pathways for more of our people. Learning and creating the strongest safety habits is the most powerful legacy we can all leave behind.


Covid has presented many challenges throughout this year. The safety of our teams has been of paramount importance, whilst delivering the planned inspection, maintenance and construction works on our railway. I visited an enhancement site in December where brand new tampers were being used to parallel tamp a new higher speed S&C layout to perfection (geometrically). The work was done to a high quality and the staff were diligent with mask wearing and social distance protocols.

The sad events of Margam and Surbiton very clearly highlight the risks of working on open railways. But through a greater focus on planning, many opportunities have been realised by the Safety Task Force to ensure separation between our front line teams and moving trains. I visited a site in November where maintenance works had been very well planned during daylight hours in planned line blockages, and additional protection had been applied to protect the line blockage. The key to identifying these safer opportunities is continued dialogue between work deliverers, railway planners, signalling colleagues and our passenger and freight customers.

*Our Institution must strive to make continual risk reductions and it can achieve more to keep more colleagues and customers even safer*

RAILWAY SYSTEMS

# HIGH SPEED

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# An Engineering Partnership

## The Royal Academy of Engineering's National Engineering Policy Centre

AUTHOR: Dr Nick Starkey, Policy Director at the National Engineering Policy Centre

Nick is Director of Policy at the Royal Academy of Engineering. He leads the Academy's policy work spanning all areas of engineering from Net Zero to data through to construction and infrastructure. He directs the Academy's leadership of the National Engineering Policy Centre and also leads the Academy's International Partnerships. Nick joined the Academy in January 2018 from the Department of Business, Energy and Industrial Strategy Skills, and has previously worked for Cabinet Office, Defra, the National Farmers' Union, and the British Red Cross.

INTRODUCTION by Stephen Barber, PWI CEO

PWI members often ask me how the Institution can use its collective expertise to influence government and other policy making bodies, so that their decisions and actions, particularly in the field of transportation, are informed by solid engineering advice. The PWI isn't the only one of the UK's 40 professional engineering institutions (PEIs) to have pondered that question and, as the technological world has become ever more complex, government has found itself facing a range of sources offering uncoordinated and potentially conflicting information and advice: a situation not conducive to effective decision making!

Under the wing of the Royal Academy of Engineering, the UK PEIs have come together to help provide government and other policy makers with a clear source of coordinated policy advice and support across the broad field of engineering. Established in 2018, the National Engineering Policy Centre now speaks with a single voice on engineering policy matters, representing and calling on expertise and advice from all UK PEIs. It is now through the NEPC that the PWI seeks to exercise influence and I've invited Dr Nick Starkey, the NEPC's Policy Director to tell PWI members a bit more about the Centre's work.

As we move forward and are inevitably faced with more policy dilemmas, I trust expert PWI members will support Nick's team and other PEI experts to ensure UK policy decisions are based on the best available engineering advice.

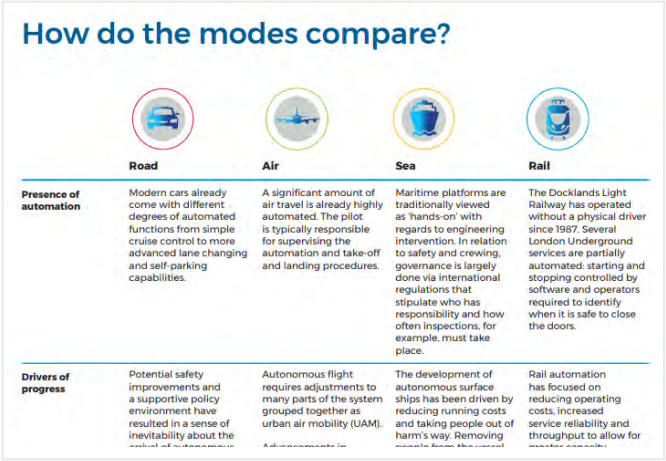
AN ENGINEERING PARTNERSHIP by Nick Starkey

Stephen Barber noted to me in a recent email that the current strategic policy agenda is bulging at the seams. With the adjustment after Brexit, the physical and economic impacts of Covid-19 and the potential for future pandemics, COP26*, decarbonisation and climate adaption and more, he is certainly right!

What is sometimes underappreciated is the role that engineers are playing not only tackling those issues on the ground, but also advising policy makers as they grapple with the governance challenges these issues bring. Whilst we have heard much about 'following the science' during Covid-19, the importance of government receiving good engineering advice has not always been fully appreciated in a Whitehall civil service environment where economists and statisticians have historically been more likely to have the Permanent Secretary's ear. In part, the engineering profession's impressive range of specialisms has been both a strength and a weakness here. The expertise held within an institution such as the PWI is deeply valuable, but a profession of 40 such institutions is hard to navigate, and time-poor officials often struggle to engage. That is why we established the National Engineering Policy Centre. Led by the Royal Academy of Engineering, it is a partnership between the Academy and the 40 professional engineering institutions, plus Engineering UK and the Engineering Council. The Centre connects policy makers with critical engineering expertise to inform and respond to policy issues of national importance.

Our recent spending review document was signed by every one of those 43 organisations, the PWI among them, and demand from senior levels of government for our advice has been increasing exponentially since the Centre was established.

Working together through the Centre also enables us to give better advice. By working across and beyond different engineering specialisms, we have been able to bring a cross-disciplinary approach to our study of the safety and ethics of autonomous systems and I've provided an extract (Figure 1) from that work to illustrate the Centre's output. Working together we can take a systems approach to complex issues such as decarbonisation; our programme Net Zero: A Systems Approach to the Climate Challenge has seen us engage with Cabinet Office, No.10 Downing Street and multiple government departments as we build up to COP26.



**How do the modes compare?**

| | Road | Air | Sea | Rail |
|---|---|---|---|---|
| **Presence of automation** | Modern cars already come with different degrees of automated functions from simple cruise control to more advanced lane changing and self-parking capabilities. | A significant amount of air travel is already highly automated. The pilot is typically responsible for supervising the automation and take-off and landing procedures. | Maritime platforms are traditionally viewed as 'hands-on' with regards to engineering intervention. In relation to safety and crewing, governance is largely done via international regulations that stipulate who has responsibility and how often inspections, for example, must take place. | The Docklands Light Railway has operated without a physical driver since 1987. Several London Underground services are partially automated: starting and stopping controlled by software and operators required to identify when it is safe to close the doors. |
| **Drivers of progress** | Potential safety improvements and a supportive policy environment have resulted in a sense of inevitability about the | Autonomous flight requires adjustments to many parts of the system grouped together as urban air mobility (UAM). | The development of autonomous surface ships has been driven by reducing running costs and taking people out of harm's way. Removing | Rail automation has focused on reducing operating costs, increased service reliability and throughput to allow for |

Figure 1: Extract from NEPC document graphic: Automation - How do the modes compare?

Transport is a recurrent theme in our work. We have worked with the Department for Transport to map and better understand the potential uses of hydrogen across the future transport system and have offered advice to government during the pandemic on issues from restarting transport after pandemic lockdowns to engineering controls to reduce virus transmission on transport. The Policy Centre is reliant upon the expertise in the engineering community and forms a vehicle through which specialist engineering advice from institutions such as the PWI can inform decisions at the highest level. Gathering policy advice that has weight and is based on evidence and expert judgment takes resource and organisation, and Stephen's article in the January 2021 edition of the Journal set out some of the things the Institution is doing internally to bring your expertise to the issue of climate change. We are certainly far more influential together than apart and I am always grateful for the Institution's continued engagement in the Policy Centre and its work.

*COP26 is the 2021 United Nations Climate Change Conference scheduled to be held in Glasgow between 1 and 12 November.

# Impacts of Automatic Train Operation on track & infrastructure

AUTHOR: Andy Vickerstaff

Andy Vickerstaff is the Principal Engineer: Components & Configuration in the Permanent Way engineering team at Transport for London, as well as being the technical lead for the wheel-rail interface and railhead profile management. Andy joined Metronet Rail in 2008 as a graduate trainee before being transferred to London Underground where upon completion of his training joined the track maintenance engineering team in 2010, before starting a specialist wheel-rail interface team in 2012. His work is focussed on assessing the impact of vehicle track interaction on assets through the entire lifecycle to reduce whole life cost through better understanding of the failure modes.

## INTRODUCTION

The world's first Automatic Train Operation (ATO) railway was the Victoria line when it opened in 1969 as part of London Underground (LUL) and following its subsequent upgrade in 2009 it is now capable of delivering a 36 train per hour service with headways of 100 seconds. Linking major terminal stations at Victoria, Euston and Kings Cross makes it one of the most critical points of failure within the overall integrated transport system, which is the responsibility of Transport for London (TfL).

Attempting to meet the demand for public transport has been the major challenge for TfL, and its forerunners, since the population of London began to increase again in the 1980s following its gradual decline since the Second World War. Chronic underinvestment in the system led to the failed Public Private Partnership (PPP) of the 2000s, which aimed to deliver the increases in reliability and capacity which were required to prevent the city grinding to a halt daily. The number of daily journeys across the network continued to climb steadily until March 2020.

Ridership across the tube was as low as 5% during the first Covid-19 lockdown, only ever rising to around 30% when restrictions were at their loosest during the summer of 2020, but hopefully as you read this in April 2021 there are signs of normality returning. The impacts of the global pandemic on ridership numbers will not become clear for months or even years, but as ever 'the prosperity of London and the health of its public transport system are inseparable'[1].

The challenges which ATO has brought to the maintenance of the Permanent Way, as well as all the other systems which make up the railway, are particularly acute on a system as old as LUL where many of the challenges are in-built. This article is written from the perspective of the Permanent Way engineer who is responsible for managing the interface between rolling stock, track and signals. The 'system of systems' which makes up an operational railway requires all engineers to take a holistic view; my experience means I do this even more than others. However, I am not an expert in signalling, automatic train control, traction or braking, merely an interested party!

## THE CAPACITY CONUNDRUM

Increasing capacity on railways can be achieved in several different ways. Running bigger trains, such as double decker versions widely used on the continent, is an obvious first option but even on the mainline UK network the inherent gauge limitations of the infrastructure prohibit this, and this is an even more acute challenge for LUL. Since the construction of tunnels switched to the 'deep tube' method in the 1890s, rather than the 'cut and cover' method used for the first sections of the underground from 1863, which was enabled by the change from steam to electric trains, the maximum gauge of 'tube' trains has been severely limited (Figure 1).

Another option is to run longer trains with more carriages, however longer trains require longer platforms to allow that capacity to be effectively utilised, especially when dwell times are so short in order to keep throughput high. Extending platforms in deep tube stations is enormously expensive as it would require significant tunnelling to increase the size of the wider station boxes (Figure 2).

The final method that does not involve construction of new routes to increase capacity is to increase the maximum train speeds and hence reduce the journey time between stations, allowing more trains to be run. This is an option available to increase capacity on LUL, especially on the longer inter-station runs which are typically found the further from the centre of London, but is of limited value when inter-station runs are routinely as short as 500m, and 261m in the case of the shortest between Covent Garden and Leicester Square where it would be quicker to walk!

A much greater reduction in journey times for these shorter sections can be achieved by increasing the acceleration and braking rates, rather than by increasing the maximum achievable speed (MAS). The maximum achievable speed is inherently limited by the geometry of the tunnels, which prior to the construction of the Victoria line, were required to run parallel to the streets above them due to the cheaper land values, even once the deep tube tunnel construction method did not require the road to be dug up in order to build them. This has resulted in some unique geometries such as the Caxton curve located between Shepherds Bush and White City on the Central line where the radius is as tight as 70m.

Indeed, the iconic need to 'Mind the Gap' is a result of some of the extremely challenging curvatures through the platforms, such as Bank on the Central or Paddington on the Bakerloo (Figure 2), which result in some extremely non-compliant platform stepping distances. Approximately 36% of the entire track on LUL consists of curvatures tighter than 900m, 17% of it below 400m and this results in enormous challenges managing the wheel-rail interface, many of which are exacerbated by the implementation of ATO.

Therefore, the only method available to LUL to increase capacity has been to run more trains, closer together using a variety of different signalling systems under ATO. Most of the systems on LUL have achieved this by moving from fixed block to moving block systems. Fixed block systems maintain separation by limiting a train's authority to move based on the physical separation of trains using distance; moving block can change a train's authority to move based on its relative position to the train in front using the speeds from both. This allows trains to be run safely closer together as they are no longer having to assume the position of other trains relative to itself.

TONNAGES

The introduction of ATO across most lines has resulted in an increase in the number of trains per hour (TPH) significantly, if not across the whole line then through the busiest central sections. Figure 3 shows the changes in Million Gross Tonnes (MGT) from 2011 for 3 lines where ATO has been implemented: Victoria (Green Park to Victoria), Jubilee (Baker St to St Johns Wood) and Northern (Bank to London Bridge), and the final example where the current switch to ATO is being commissioned on the Sub Surface (Farringdon to Barbican). This shows an even greater increase than the deep tube lines despite the similar TPH because the S-Stock has an approximate axle load of 8.5 tonnes, compared to nearer 5 tonnes for tube gauge stocks.

Any notion that LUL should still be considered as a light rail system has definitively been removed by the implementation of ATO. The method of accumulating tonnage may be very different to mixed traffic, or dedicated freight networks, but as the majority of the defects which are dealt with are based on an accumulation of fatigue then running lots of trains, even with relatively light axle loads, is a very effective way of reducing asset life. Track maintenance has become much more risk based in the last decade and many activities are defined in MGT intervals rather than time, which allows much more informed decision making when the impact of changes in the system are being assessed.

Track is not the only area which has had to move from time-based maintenance. Some fleets had biannual planned wheel turning prior to a wide-ranging study redefining these intervals based on the predominant failure modes[2]. On one line, as train frequencies were increased with the implementation of ATO to allow a 34tph service, two years was no longer the same in terms of wheel wear when individual train paths on a daily basis could be as different as 400 km. Asset management systems also had to be adapted to allow maintenance intervals to become mileage based, especially in the context of other systems on the train which do not necessarily degrade in a linear fashion like wheel wear.

The next generation of tube train which will be delivered under the Deep Tube Upgrade Programme (DTUP) should deliver significant improvements in the ability to steer through tight curves and reduce forces in the contact patch through fundamental changes to the bogie concept design. However, they will have an increased axle load which even prior to the introduction of ATO will have major impacts on the single biggest cause of rail breaks on LUL, fishplated bullhead joints[3] which equates to approximately 40% of the network. The lessons learnt from the Victoria and Northern line upgrades, where individual axle loads were not significantly increased, is that this inherently weaker rail section is completely unsuitable for running at 40MGT per annum. Therefore, changing the rail section through flat bottom conversions has been prioritised over full track reconstruction as its rate of delivery is much quicker and the costs much lower. This is not an ideal solution but will enable the biggest safety risk to be removed much quicker ahead of DTUP, as well as reducing the number of maintenance inspections.

THE ADHESION CHALLENGE

There have been enormous amounts of research into low adhesion at the WRI in the last few years and our understanding of this area has much improved. LUL has to manage adhesion at both the low (55% of the network is above ground) and high ends of the scale. Leaf fall plans for each line are implemented every Autumn which involve combinations of vegetation management, rail adhesion trains (RAT) and increased wheel turning capacities to cope with flats.

In most upgrade projects ATO has normally been implemented alongside a new train introduction, and this has almost always led to a change from DC to AC traction. This has normally come with much improved Wheel Slip Protection (WSP) systems which allow much better control of braking in low adhesion conditions. These systems have been very successful in reducing the amount of wheel flats suffered, although Autumn timetables are still implemented based on weather conditions which require reduced braking rates.

However, following the introduction of ATO on lines with modern AC traction systems and WSP, an entirely new rail defect emerged: the squat type defect. These started to appear on the Central, Northern and Jubilee lines in prodigious numbers from around 2010 and ultrasonically appear no different from mechanically induced conventional squats. Initial metallurgical analysis identified the presence of martensite above the cracks indicating thermal transformation of the steel[4] had taken place which would require temperatures in excess of 727°C. Further modelling of the traction package of a 92TS (Central) demonstrated that this was possible during low speed slip recovery in damp (as opposed to contaminated with leaves) conditions[5].

This explained why these defects are predominant around major junctions where under ATO train speeds are reduced, without necessarily coming to a stop, to regulate the service in the event of traffic disruptions yet are extremely rare in platforms, and only in open sections where nature creates far more low adhesion events than the occasional artificial ones created in the tunnels.

Figure 1: Deep tube concrete (left) and sub surface ballast (right) track-forms

Figure 2: Paddington Southbound platform on the Bakerloo line

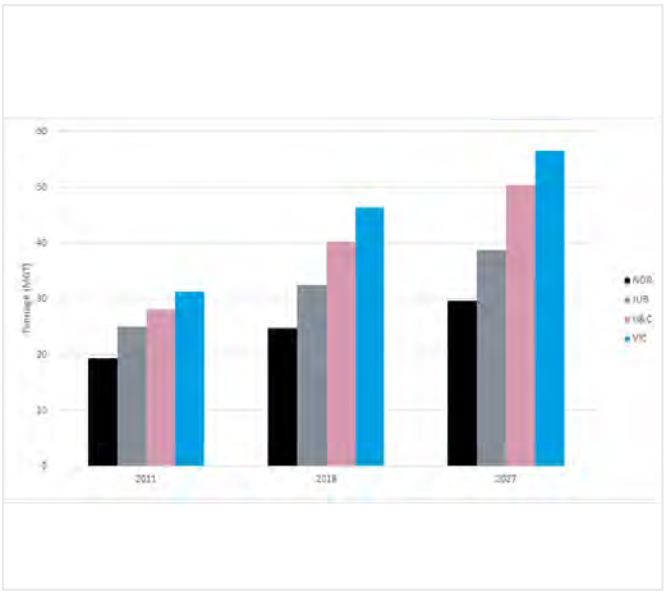



Figure 3: Tonnage forecasts (pre Covid-19)

Occurrences under 'damp' rather than 'contaminated' conditions also fits with much anecdotal evidence provided by train operators on manually driven lines that controlling accelerating and braking when rails are moist from dew or drizzle is far more difficult than in soaking wet saturated conditions. Defensive driving techniques in manual operation may be good at protecting assets but reductions in braking and acceleration rates result in lower tph, the conundrum which the whole industry has battled with for many years in the Autumn.

The solution is to modify the WSP system to change the algorithms in managing low adhesion, and indeed we are currently awaiting software changes to S-Stock which will allow this, and the first unit of 92TS with a new traction package is ready for dynamic testing on the Central line in 2021. This unfortunately involves physical changes of the motors (which also suffer from major reliability issues) rather than software so will take a lot longer for the benefits to be realised.

The short-term solution combined changes to the standards based on monitoring several defects which were left in the track, as well as the implementation of a preventative grinding programme. The initial studies which were conducted demonstrated that the cracks below the martensite rarely propagated to any significant length or depth and were very low risk of leading to broken rails. Therefore, they can be categorised as 3M (no Emergency Actions and monitored in line with the normal ultrasonic testing frequencies). Should they start to propagate, they can be removed through a head wash weld repair process, or because they tend to occur in clusters then the longer timescales afforded to the maintainer can make it more economical to carry out re-railing to remove a number of defects.

Grinding was implemented as a preventative measure on the hypothesis that each individual activation of WSP was not necessarily resulting in a squat type defect every time but that repeated activations were forming a layer of martensite in the railhead, which being inherently more brittle was more likely to result in crack formation. Alternatively, the grinding is removing defects which are so shallow they have not even been detected ultrasonically (the grinding is never intended to remove defects which have already been identified).

This is the only kind of grinding on LUL which I categorise as preventative because the martensite layer is shallow enough that minimal material removal is required (target is 0.3mm). The limited gauge of deep tube tunnels means the grinders which LUL utilise have only 8 stones, requiring multiple passes of the same machine for significant material removal, and whilst the sections which are ground for squat type defects are in open sections, we use the same machines as the programme is not flexible enough to allow different machines in different locations.

The preventative grinding approach has been successful at reducing the number of squat type defects (normalised by line per open km of track) as can be seen in Figure 4 and is now proving even better value for money since closures have been granted for maintenance activities. Grinding in closures for squat type defects has reduced the costs to around £3/m from approximately £40/m in engineering hours; this is mainly due to many of the costs per shift being fixed whether the working window is 52 hours or 3 hours (which normally results in a maximum of 1 hour of actual 'spark time'). The Victoria and Waterloo and City lines do not suffer from thermally induced squats as the passenger running parts of the lines are all in tunnels.

Squat type defects are a result of low adhesion, however two of the other major rail defects suffered by LUL are affected by high adhesion between wheel and rail, and are exacerbated by ATO: rolling contact fatigue (RCF) and corrugation. The relationship between steel wheels and rails can be analysed in infinitesimal detail (necessarily so) and it is beyond the scope of this article to do so but some of the basic principles are required to understand why ATO has such an impact.

A way of thinking about adhesion between wheel and rail is to consider another contact patch which many of us are familiar with; that between your car tyres and the road. If you are sat in your stationary car on a dry tarmac road then you can put your foot on the accelerator as hard as you like and you will move away smoothly and accelerate. If you now place your car on an icy road and put your foot hard on the accelerator, then you are likely to start the wheels spinning and you will not be able to move.

However, it is possible to drive on ice, but you need to very gently apply the accelerator because the lower friction between the surfaces means there is less adhesion available to support demand from the wheels to accelerate. It is possible to drive at the same speed on the dry and icy roads, up to a point where all the adhesion has been used up, but to do so in the icy situation more of the contact patch will be slipping than in the dry situation.

In railway wheel-rail interface terms we describe this as the creep-creepage relationship where some of the contact patch remains in stick, and some of it is in slip as illustrated conceptually by Figure 5.

The maximum amount of creep (T) that can be supported at the interface is related to the normal load of the wheelsets (N) multiplied by the friction between the two: $T = \mu N$

A simple rearrangement of this formula gives the traction ratio (T/N) where the maximum amount of creep force that can be supported is limited by the friction between the two surfaces, with the amount of creepage between them increasing to accommodate this, often referred to as creep saturation.

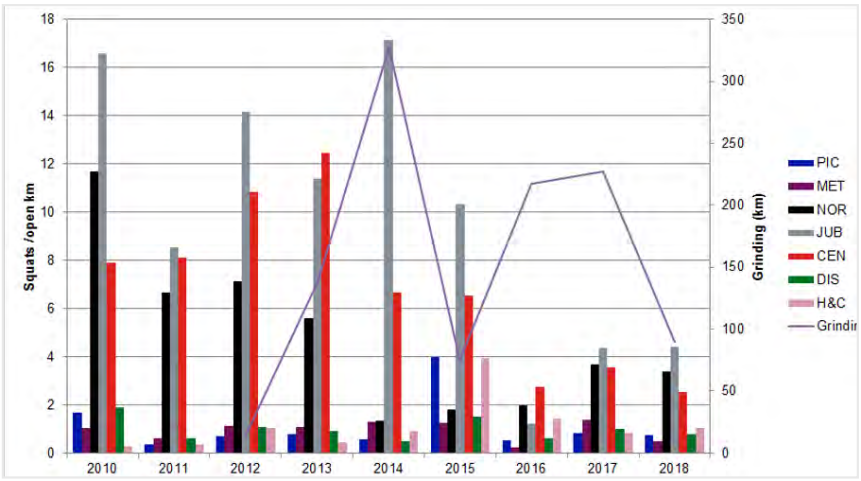



Figure 4: Squats per open km and grinding volumes per annum

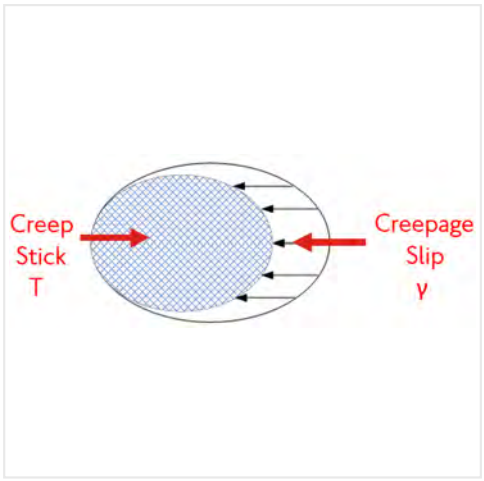



Figure 5: Relationship between creep and creepage

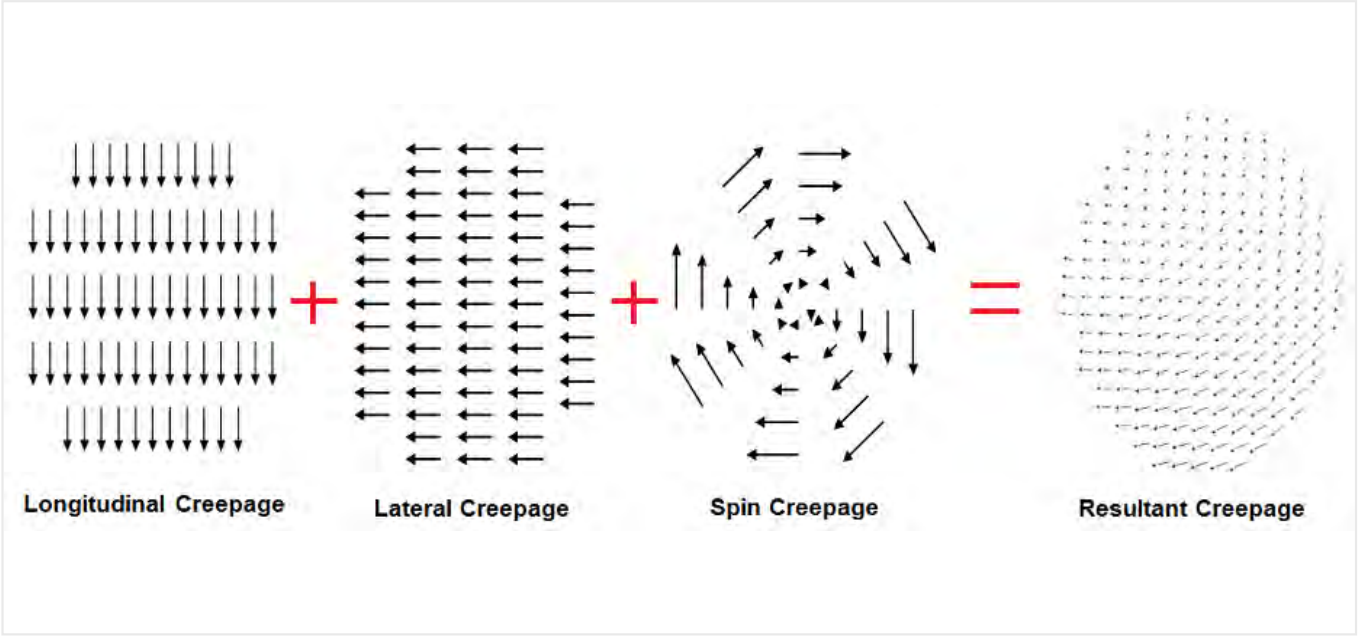



Figure 6: Resultant creepage in curving

Figure 7: Short wavelength corrugation on LUL

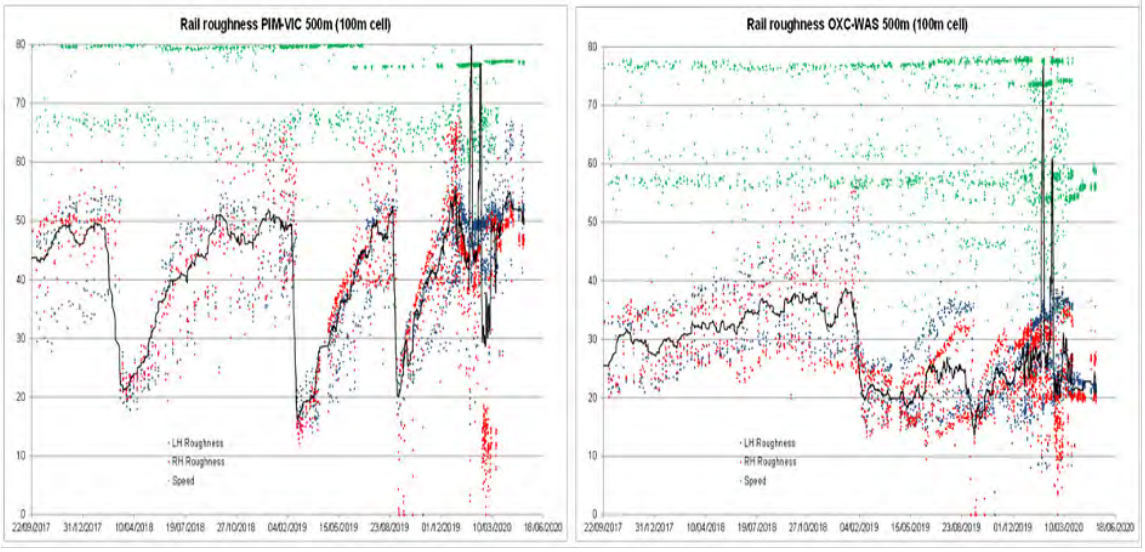



Figure 8: Rail roughness growth Pimlico to Victoria (left) and Oxford Circus to Warren St (right)

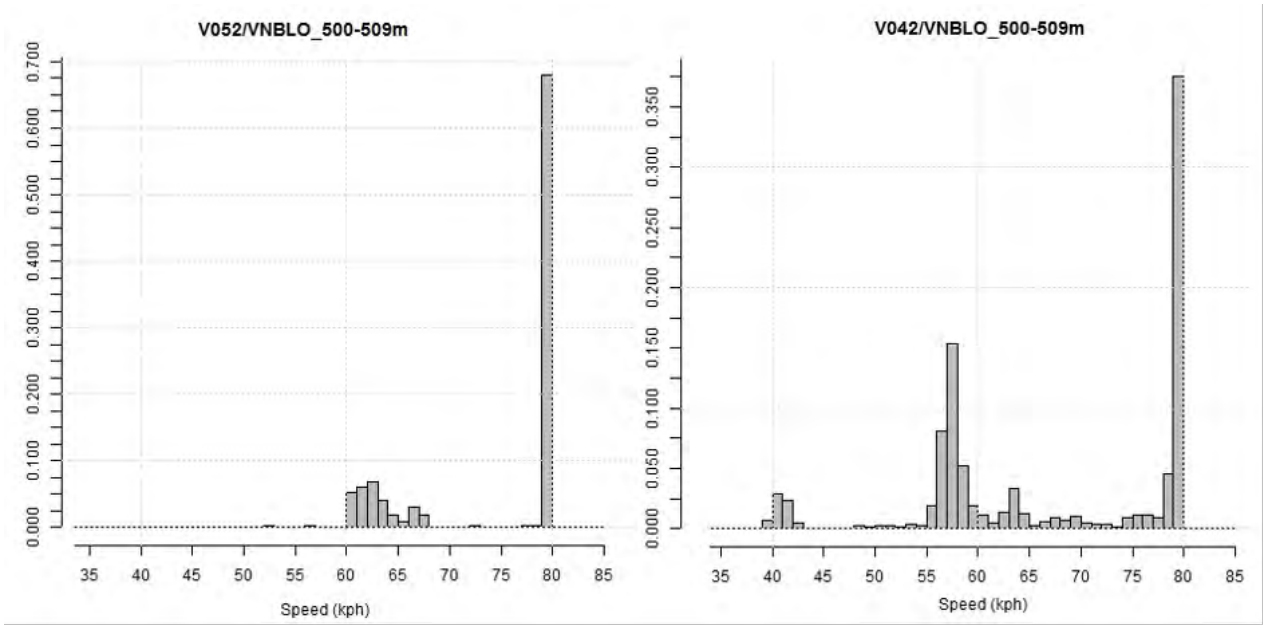



Figure 9: Speed distributions Pimlico to Victoria (left) and Oxford Circus to Warren St (right)

The tighter the curve, the more lateral creepage the wheels and rails have to accommodate increasing the demand for the available adhesion. If this is combined with increased tractive demand from power being applied at the wheelsets then more of the available adhesion is consumed, in even more simplistic terms 'traction destroys curving'.

Creep saturation may also be thought of as the point at which wheelsets are no longer able to steer around curves without the flange of the wheel contacting the gauge corner of the rail. There are numerous factors which affect this including the primary yaw stiffness of the bogie, the wheel and rail profiles and the cant deficiency to name a few which would need a whole other article to cover in enough detail.

I have previously described much of our work into our understanding of RCF on LUL in this Journal[3], and further work is currently ongoing within an RSSB funded cross-industry study. One of the initial hypotheses is to explore the effects of applied traction on the overall $T_\gamma$, the product of the creep force (T) and the creepage (γ) which is one of the underlying inputs used in the Whole Life Rail Model[6].

CORRUGATION

The impact of ATO is even more acute on another major rail defect which occurs on LUL; that of rail corrugation which has been the focus of much work since the introduction of Night Tube in 2016 when residential and commercial noise complaints increased in response to the longer running hours. Rail corrugation is a constant frequency phenomenon which requires a wavelength fixing mechanism from the dynamic behaviour of the vehicle/track system[7]. Excitation of this frequency results in vertical movement of elements of this system and a rippled effect on the vertical longitudinal profile of the rail (Figure 7). All types of corrugation which LUL suffers from are driven by wear when the limits of adhesion are approached[8].

However, so far, we have only considered the relationship between creep-creepage in the longitudinal direction but as soon as we start attempting to curve there is also demand on the contact patch to support lateral creepage, as well as a much smaller spin element due to the relative rotation of the surfaces (Figure 6).

The majority of ground-borne noise complaints related to rail corrugation were initially found to be related to a particular type of deep tube track-form which was installed across LUL from the mid-1990s. This consists of an NTF415 concrete sleeper with built-in baseplates cast directly into a concrete track slab, giving major advantages because this arrangement takes up very little of the vertical clearance available in the tunnels. The consequence of this is that there is very little resilience built into the system, other than the small rail pad which can be fitted between the rail and direct cast baseplate.

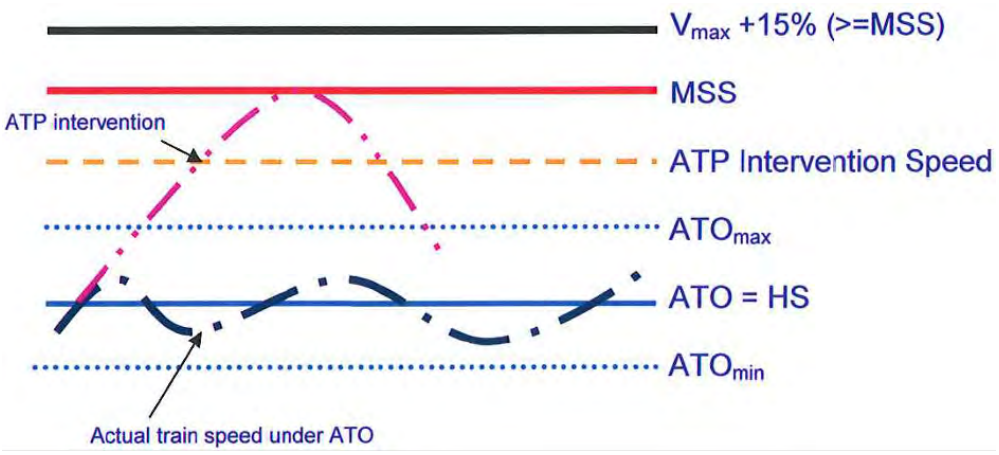



Figure 10: Conceptual relationships for ATO on Central Line

Figure 11: Stock rail fitted enDAQ Sensor

The initial response to many of these noise complaints was to install a retrofit version of the Pandrol Vanguard system, which suspends the rail from the baseplates in a rubber mounting, and results in a very vertically soft track which does not transmit the rail vibration from corrugation into the ground. The original configuration (left) and retrofit Vanguard (right) can be seen in Figure 7. However, this was installed without understanding the root cause of the corrugation and whilst it was successful in reducing ground-borne vibration, since the corrugation was still being developed it resulted in this vibration becoming airborne noise in tunnels.

The constant frequency of corrugation means that the wavelength developed on the rails (λ), when combined with the train speed (v) allows the frequency (Hz) to be derived:

$$f = \frac{v}{\lambda}$$

The frequency enables the root cause of the corrugation to be identified and across LUL this appears to fall into one of three categories: pinned-pinned, track-form specific and rutting[8]. Unfortunately, Pandrol Vanguard was developed to reduce the vertical track stiffness associated with a different form of corrugation, that of P2 Resonance[8] which is mostly related to the unsprung mass of the wheelset and has a frequency range of 50-100Hz (some of which does exist on LUL), whereas the predominant types in the NTF415 sites are pinned-pinned (450-1220Hz), and trackform specific (300-500Hz)[9].

There are two very distinct impacts from ATO on corrugation: the repeatability of train speeds that comes from automation and the way that the signalling system maintains that speed. When considering that it is a constant frequency phenomenon, and one of the major inputs into corrugation development is the speed (v) of the train to develop a wavelength (λ), then the more consistent this is the quicker the growth rate of corrugation will be.

One of the assumptions of the implementation of ATO is that every train will accelerate and brake in the same place, leading to very localised degradation of track assets. However, on the Victoria line this has been shown to not necessarily always be true. Two trains on the Victoria line are fitted with the Automated Track Monitoring System (ATMS), which allows constant monitoring of various track geometry outputs, such as speed and rail roughness, and information from this system has revealed why two very similar sites on the Victoria line show such different growth rates.

The two sites in question both consist of c.500m radius curves with a speed limit of 80kph, an annual 40MGT and consist of Pandrol Vanguard retrofit on NTF415 sleepers. They have both been identified as suffering from pinned-pinned corrugation by the wavelength of 50mm equating to a frequency of 441Hz, the sleeper spacing being approximately 1m in both sites. However, as can be seen in Figure 8, corrugation growth rates are vastly different; the blue and red dots indicate roughness on the left and right rails, with the black line a rolling average (there were some issues with the ATMS equipment towards the end of the period analysed). The grinding interventions (three times at the first site Pimlico to Victoria and once at Oxford Circus to Warren St) also clearly shows how effective it is at reducing rail roughness.

The green dots also seen in Figure 8 give the speed of the train when the measurements were taken, and this was further analysed across the two ATMS units for a period of 2 months to give a speed distribution. The results from this for each of the sites can be seen in Figure 9, which shows the distribution of speeds at 500m where for the quickest corrugation growth site nearly 70% of trains reach 80kph, whereas in the lower growth site this is only around 35% of trains (the y-scale is unfortunately different due to the graphs being automatically generated).

The second issue which exacerbates corrugation growth in ATO systems is the way in which the system controls the speed of trains. As previously described the more demand there is in the contact patch for the available adhesion, laterally through curving or longitudinally in traction or braking, then the more likely that creep saturation will be achieved leading to corrugation.

Therefore, in areas where we are accelerating or braking (utilising rheostatic rather than any friction braking) and we are attempting to curve, then the more likely we are to develop corrugation. In LUL we are far more susceptible to this due to having numerous curved platforms and approaches, and short interstation sections where tractive effort will always be high. However, in some ATO systems the way that constant speed is achieved is by the train either accelerating or braking, as there is no 'coasting' element built

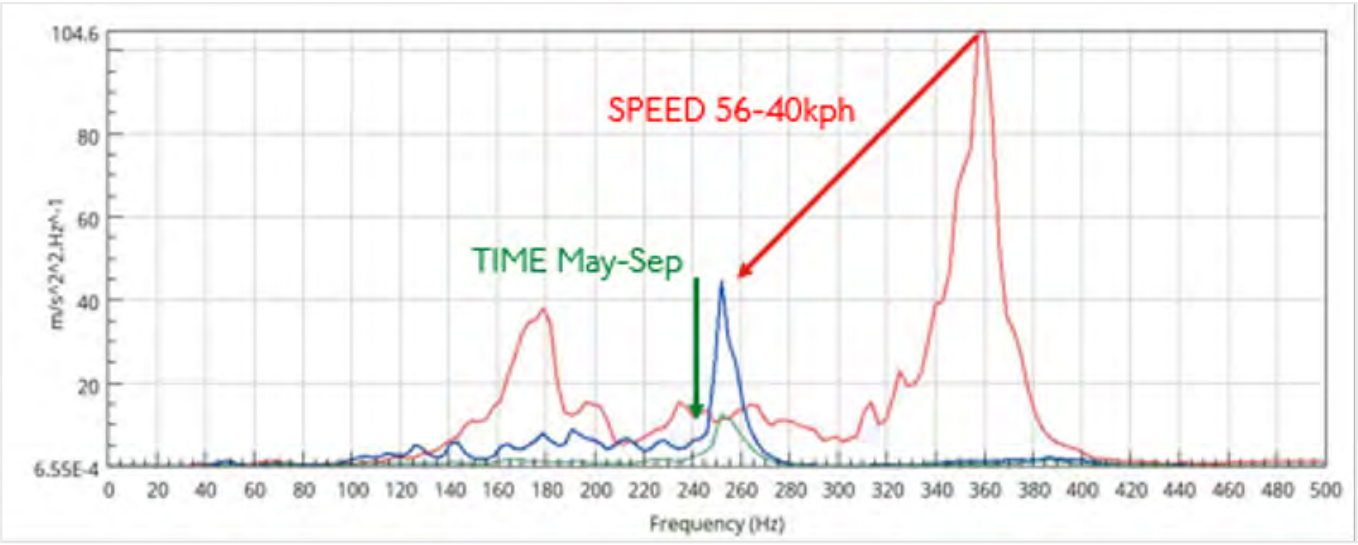



Figure 12: Impact on frequency of speed and time

in as conceptually shown in Figure 10 by the black line to achieve the Headway Speed (HS). Therefore, even in areas where constant speed is achieved, we can still be making even more demands on the adhesion available to achieve it.

Corrugation has also been the root cause of several issues for signalling components mounted on the track. One such issue was on a set of points on the Jubilee line extension which has historic issues with developing corrugation and where several failures occurred on KLM clips associated with the points resulting in costly delays. Initial monitoring was carried out using an enDAQ sensor (Figure 11) which is a tri-axial accelerometer which can be simply attached to the rails, or point operating equipment, and records a number of train passes to identify the Power Spectral Density (PSD) of the vibration. This is a method used to identify the relative power of the signal (in this case the acceleration of the vibration) against the frequency (rather than time) which enabled us to establish if the corrugation was causing the damage.

The initial monitoring carried out in February 2020 identified that the frequency of vibration with the greatest power at the stock rail was 355Hz. The speed through this particular trailing set of points is 56kph, which equates to a wavelength of 44mm which tied up pretty accurately with measurements taken on site during maintenance. As they say in politics 'don't waste a good crisis' and given the ridership at this point was so low, operations were consulted as to whether putting a speed restriction on would be acceptable. A 40kph speed restriction across the points was agreed (approximately a seven second increase in journey time) and implemented with the intention of trying to wear out the corrugation which had developed, a result which had previously been achieved using this method on the Victoria line[10].

Figure 12 shows that the speed restriction had an immediate impact, in both reducing the power of vibration being experienced (y-axis) and a change in the frequency (x-axis) from 56kph (red) to 40kph (blue) as the speed restriction was applied between these two sets of measurements on the same day in May 2020. The speed restriction then remained in place until the next set of measurments in September 2020 (green) which shows the reduction in power, but the frequency remains constant.

The initial change in frequency is achieved by the new train speed running over already corrugated rails (40kph @ 44mm = 253Hz), the reduction in the power of the vibration was achieved over time due to the constant frequency nature of corrugation. The root cause of the corrugation, in this case most likely a trackform specific issue due to the lateral track stiffness, remains the same at 355Hz but now we are running at 40kph the wavelength it is trying to generate is 31mm and hence it starts to wear out the 44mm.

The results from September 2020 indicate that we may have nearly worn out the 44mm wavelength, but we are now expecting to see the 355Hz increasing as the 31mm is being generated.

The next phase will be to remove the speed restriction and return to 56kph, and once again change the wavelength which is being generated. We have effectively tried to recreate some of the variability of manual driving, into an ATO system, but if the number of passengers starts to return in 2021 then it is unlikely that implementing speed restrictions will be tolerated.

## CONCLUSIONS

The impacts of ATO on track and infrastructure on LUL have been significant, from a new type of rail defect which had to be understood and managed, the overall increases in tonnage which reduce asset life, and the repeatability of train speeds on a constant frequency driven defect. The improvement to the overall condition of the track assets on LUL through renewals has both solved and created problems, some of which have been exacerbated by the implementation of ATO.

The removal of jointed bullhead track has enormously reduced the number of broken rails by increasing the time available between detection and failure, however this has essentially been achieved by increasing the stiffness of track both laterally and vertically, through both the rail section and underlying componentry. Modern tube track aims to balance the increased stiffness by building resilience into the baseplates, which should reduce some of the impacts vertically but laterally this is more difficult to achieve the tighter the curvature.

Whilst the majority of corrugation on LUL which falls into the pinned-pinned or track-form frequency ranges affects curves in the 400-600m radius, once 200m is approached then rutting corrugation develops (50-150Hz)[9] as can be seen in Figure 13, and at sub-100m radius curves corrugation becomes less of an issue but often results in low rail wheel squeal, causing airborne noise issues.

The most demonstrably successful solution to both these issues is managing the adhesion at the top of rail through friction modifiers to prevent stick-slip[7, 11] which has been used with some success on LUL but is more limited by the ability to deliver the material to the interface and distribute it through the curves. However, more recent work has started to look at the role of stiffness in the generation of wheel-squeal[12] and the experience on LUL certainly supports this, as sites which have historically never suffered from wheel-squeal in bullhead, almost inevitably do in flat bottom 100m radius curves.

Figure 10 demonstrates another area in which much better understanding of the relationship between ATO and ATP (Automatic Train Protection) will allow track design to be better optimised for whole life cost. During the Northern line upgrade new track installations were designed using the principle that the ATP intervention speed would result in a maximum of 8kph over the HS, yet there was no statistical analysis carried out which would give a risk of this occurring, indeed the examples in Figure 9 show that the actual speeds through a section may even be lower in some cases.

Whilst the speed limits are mostly driven by the curving rules governed by the Permanent Way engineer through cant, cant deficiency and potentially more importantly the rates of change of these elements, when ATO is implemented, the computer rather than the human controls the likelihood of over speed events occurring.

The Maximum Safe Speed (MSS) which is used to govern the relationships between these systems is set much lower than that at which an overturn derailment becomes a risk, and whilst the risk of other types of derailment needs to be considered in deriving limits, the risks involved can be controlled. This is the approach that was used by LUL to determine where check rails need to be installed[13] and will be applied in rewriting these rules to be based on relative, rather than absolute risk.

The tools we have at our disposal to both monitor and model the effects of low and high adhesion are a world away from when the world's first automatic railway opened in 1969, and we also have the benefit of hindsight which allows us to be in a much better position to receive the next generation of ATO systems within the many limitations of the infrastructure bestowed upon us by also being the world's first underground railway.

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Figure 13: Rutting corrugation on modern track-form

# Japanese knotweed: A deep-rooted problem

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Japanese knotweed (see Figure 1) is present in almost every square kilometre of England. An estimated £166 million per year was spent on remediation in 2010 – since which time the industry has grown significantly. In response to a freedom of information request by the Times newspaper, it was reported in 2019 that the UK's largest rail infrastructure owner (Network Rail) had received over 11,000 complaints about Japanese knotweed since 2011 with over 6,000 of these about infestations moving onto private property.

So how did we get here? The short answer is through the naïve and misguided industry of a single man, Philipp Von Siebold, a German botanist who brought 12,000 plant specimens from Japan (Figure 2) and disseminated them across Europe. Japanese knotweed was embraced by landscape architects for its ability to establish quickly, provide dense cover and survive in poor soil and inclement conditions.

In springtime, Japanese knotweed sends up green and/or red asparagus-like shoots, which grow up to 3cm per day, developing into thick (but soft) bamboo-like canes with hand-sized, shield-shaped leaves (Figure 3) and characteristic zig-zagging branches (Figure 4). During summer, the plant can reach a height of three metres, with dense, bright-green foliage and clusters of small cream-coloured flowers emerging late in summer. The stems drop their leaves around the end of October and no further leaves will grow from these dead stems – new shoots will emerge the following spring. The canes often remain standing, forming dense thickets of deep reddish-brown colour which may turn to a cream colour over winter as they dry out. Older infestations will form raised "crowns" at ground level where shoots are clumped together, and the underground rhizome "root system" is extensive (Figure 5). Live rhizomes are orange in the centre and will normally snap rather than bend.

Japanese knotweed is frequently described in extreme (and sometimes over-the-top) terms. However, the plant is almost uniquely suited to thrive as an invasive species. A lack of predators in the UK mean it flourishes unchecked by pests and diseases, growing bigger and spreading more quickly in the UK than in its native range. Parts of the plant, particularly the root system (rhizome) can grow into new plants from extremely small pieces. Rhizome fragments weighing less than 1g can regrow and, given that larger remediation projects can remove tonnes of rhizome from a single site, poor management or inadequate works as well as landscaping, gardening and fly tipping can (and do) result in widespread cross-contamination. The viability of such small sections of rhizome means that herbicide treatment is not a quick or simple process and that flooding, movement by animals and transport networks are all contamination pathways. The only silver lining is that all known Japanese knotweed plants in the UK have come from a single female clone and do not spread by seed (although closely related plants do).

Japanese knotweed and railways have a long history, with the plant being used to stabilise railway embankments due to its persistent and quick-spreading root system. While a number of measures can be taken directly on rail land, including targeted herbicide application using handheld equipment (see Figure 6) and blanket spray by "spray trains", a joined-up approach is required to manage infestations across land boundaries and particularly on engineering projects – where the plant has potential to compromise infrastructure or spread to safety-critical areas. In these cases, specialist remediation is strongly recommended, with management of the rhizome being critical. Rhizomes generally extend around four metres from surface growth at a depth of around 500mm, with the roots under the surface growth extending up to 1,500mm downward. Previous studies have found rhizomes extending further than this, but these results are now generally accepted as outliers and the "7m EA zone" is seen as an upper limit, where it was once viewed as a rule of thumb.

Mechanical removal, sometimes involving separation of the rhizome from the soils, is often the optimum approach. Arisings can be sent to landfill or relocated on site, sometimes to specially created burial cells, through the use of specialist membranes known as "root barriers".

Root barriers (Figure 7) can also be used to protect areas or infrastructure where the full extent of the rhizome cannot be removed. In such cases, and where infestations extend off-site, follow-up monitoring and ongoing herbicide treatment are often required to achieve full eradication.

Because few other species share the characteristics of Japanese knotweed's rhizome, for other problem species, particularly buddleia (which causes problems due to its ability to root in building mortar and interfere with overhead power lines) but also rhododendron, giant hogweed and others, remediation tends to rely more on herbicide application or cutting and stump treatment, although excavation can be appropriate in certain cases.

One development that has occurred in the Japanese knotweed industry over recent years is the development of a long-term non-herbicidal remediation method using MeshTech (Figure 8), a product developed in the UK by Dr Eric Donnelly and Japanese Knotweed Solutions Ltd. The product is a grid that is securely fixed over the top of a 'cut back' infestation during the winter period when there is no growth occurring. In springtime, the plant pushes its shoots up through the grid and as they grow further and expand, they constrict and cut themselves off. As the plant tries to send out further shoots, they suffer the same fate and the plant gradually exhausts itself of the carbohydrate store it needs to maintain in its rhizome to enable year-on-year survival and after a period of a few years, will eventually die completely. The method is simple, passive, and environmentally friendly, although obviously it takes some time

Figure 1: A Japanese knotweed infestation

Figure 2: Japanese knotweed in its native range

Figure 3: Japanese knotweed leaf

Figure 5: A Japanese knotweed rhizome system


Figure 6: Hand-held spraying of Japanese knotweed

Figure 7: A root barrier installation

Figure 4: Zig zagging branch of the Japanese knotweed

before the desired result is obtained. Other regulatory, legal and financial measures have developed over the years that are helping to contain the problem. These include the restriction of bank lending against properties affected by Japanese knotweed and the introduction of insurance-backed guarantees to assuage this, the involvement of trade bodies INNSA and Property Care Association (PCA), and the recent court case where Network Rail was found liable for damages for allowing Japanese knotweed to impact neighbouring property.

The key advice for dealing with invasive plant species is to engage an expert at the earliest stages of the process, when effective planning can integrate management into the project from the start, prevent breaches of the law and significantly reduce costs and delays.

*BASIS is an independent organisation committed to raising professional standards across land management and food production. It supports people and businesses with industrial qualifications, professional registers and auditing schemes.

The INNSA Code of Practice – Managing Japanese Knotweed is available online: https://www.innsa.org/wp-content/uploads/2019/06/INNSA-Code-of-Practice.pdf

INNSA – the Invasive Non-Native Specialists Association is a dedicated trade association for the invasive species industry: www.innsa.org

PCA – the Property Care Association operates an Invasive Weed Control Group: https://www.property-care.org/homeowners/invasive-weed-control/

Chris is happy to provide sources if required – email chris.oliver@sltd.co.uk

Figure 8: The MeshTech solution

# An introduction to the overhead electric traction system


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## INTRODUCTION

In the last few years, the PWI has moved to strongly encourage those of the electrification discipline to become members of the Institution. As the PWI welcomes increasingly more members from that community, it is the intention that articles presented in this Journal will in future explore technical and specialist detail of the electrical and mechanical engineering of the traction system.

There are many forms of overhead electric traction. The development and evolution of the technology has been ongoing since the later years of the 19th century. Today variations of the basic system can be seen around the world powering trams, urban metro systems, high speed railways and heavy haul freight across continents. Electrical systems vary, there are examples of direct and alternating current systems with many different voltages. In the 1950s/60s British Rail adopted the 25kV OLE system as the standard for UK main lines.

Network Rail has published plans to meet the challenges of decarbonisation towards the net zero target of 2050 and that proposes a near doubling of the electrified network. The plan also heralds a modal shift of freight traffic from road to rail. Over the next 30 years it is therefore all but inevitable that many more in the industry engaged in maintaining and renewing the railway, especially those from the PWI's more track and civils biased member base, will want to understand how the electric traction system is configured and how it works. This article has two purposes; first to offer some explanation of the building blocks of an electric traction system, second is to provoke interest in seeking more detail which future papers and articles will present.

## THE ELECTRIFICATION SYSTEM

The electrification system consists of many constituent elements to enable electrical power to be transferred from where it is generated to the trains. Much of the electrical system adopts standard industrial practices but there are some features of railways that require special attention.

For main line railways in the UK a 25kV single phase 50 Hz alternating current (AC) overhead line system has been the preferred system for more than 60 years. Adopting 50 Hz AC enables connections to be made directly to public supplies without the need to change frequency (16.7Hz is a common system in some countries) or rectify to a direct current (DC - as required for lower voltage third rail and tram systems). The electricity supply industry (National Grid and Distribution Network Operators) use three phase systems from the highest 400kV transmission networks to 400V local substations and industrial premises (most domestic properties then have a single phase 230V supply). Although there have been attempts to use three phases on railways, it is impractical to have three conductors above every track, hence the railway adopting a single phase for power distribution between the supply network and trains.

Simple electrical theory dictates that the higher the voltage, the lower the losses due to the resistance in the wires. Hence the relatively high voltage of 25kV was adopted as standard for many railways worldwide, including in the UK.

The simplest connections between the railway and the supply are made by connecting the primary side of a supply transformer between two of the three phase conductors at 132kV, 275kV or 400kV and the secondary side to the railway feeder station at 25kV (see Figure 1). The traction system is not therefore balanced from a three-phase distribution perspective.

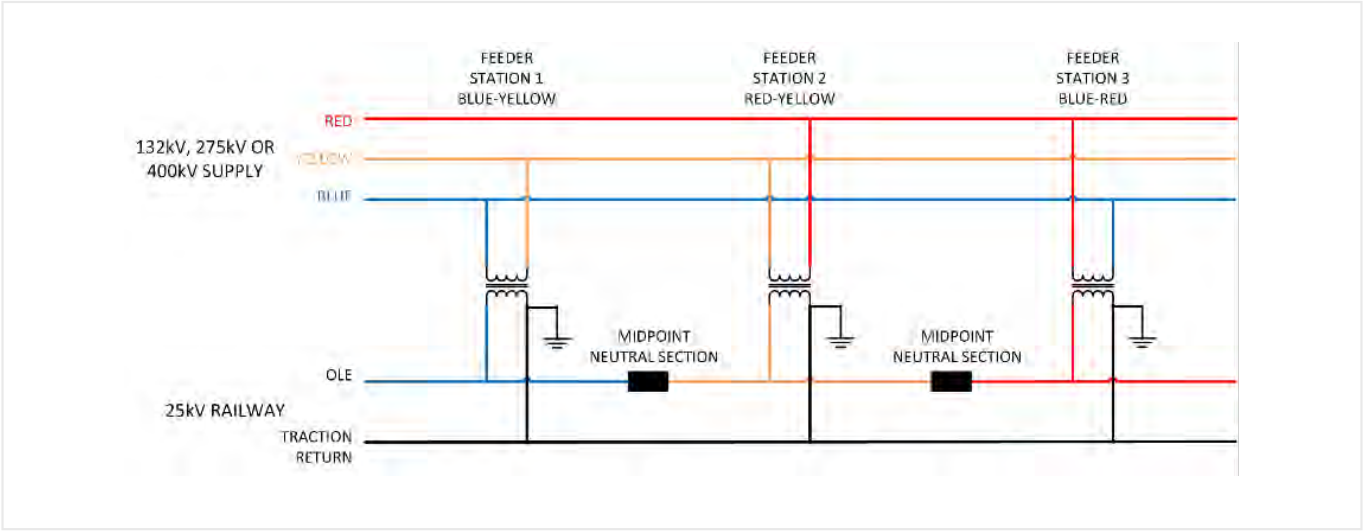


Figure 1: Simple representation of three phase supply providing single phase railway

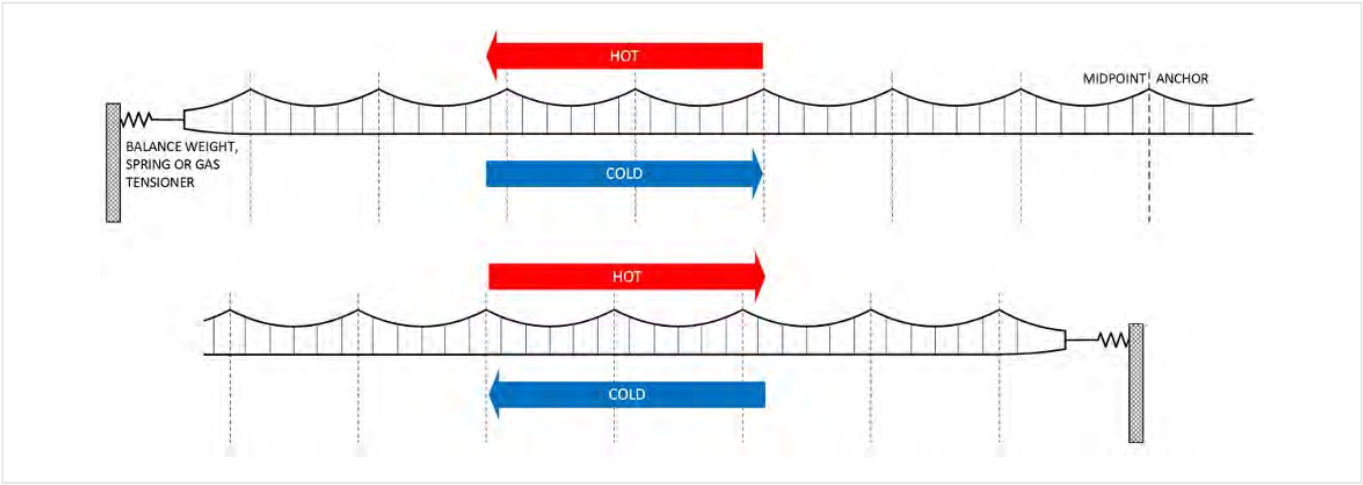


Figure 2: Auto tensioned OLE

As the railway can be a significant load on the high voltage electrical supply, additional equipment or special transformers are sometimes provided to reduce the imbalance which, if significant in magnitude, can cause disruption to other customers of the electricity supply companies. Supplies around the country are taken from different phase pairs to provide some balance. It is necessary to keep these supplies separate so insulated sections are provided in the overhead line between supplies, known as Neutral Sections.

Relatively recent developments in the UK have resulted in distribution of power on some main line routes at 50kV, known as autotransformer or AT systems, allowing higher loads over longer distances, with no effect on train systems as only 25kV is “seen” by the train. Semiconductor switchgear can also be used to take a balanced three phase supply and convert it to the required single phase for the railway (although in the UK they are 50Hz systems, they were developed for 16.7Hz so are called Static Frequency Converters (SFCs)). However, these are not currently widely used in the UK, with the first installation only recently commissioned at Potteric Carr near Doncaster.

Having transformed the supply voltage to the single-phase railway voltage it is now necessary to distribute it to the trains. At the supply point “feeder station” substations are provided. These contain electrical switchgear to enable each line to be separately supplied. For a “classic” 25kV system, one terminal of the secondary side of the supply transformer is connected through a “circuit breaker” to a busbar. This busbar is then connected to each track through individual circuit breakers and overhead line switches. In simple terms this is like the consumer unit in a domestic property with the main circuit breaker and then separate circuit breakers for each electrical circuit typically; upstairs and downstairs lights, upstairs and downstairs sockets and other equipment ie electric oven.

The line side overhead line switches could be compared to the socket or light switches. The second terminal of the supply transformer is connected to a “return current busbar”. This in turn is connected to the running rails and provides the return circuit from the trains to complete the electrical circuit. As this is connected to earth there is no additional switching provided in this part of the circuit.

Additional electrical substations are provided between feeder stations along the railway to provide additional switching and facilitate redistributing power when sections are isolated (“alternate feeding”). These substations are similar to feeder stations but without the incoming supply transformer. In addition to the circuit breakers in the substation, additional equipment is provided for protection and control purposes. This equipment enables the circuit breakers to be opened in the case of a fault or when required for an isolation of the overhead line and are remotely controlled from the Electrical Control Room (ECR). There are also sensors on the equipment to enable the Electrical Control Operator (ECO) to observe the status of the equipment. This is known as the SCADA system (Supervisory Control And Data Acquisition). Modern SCADA systems include complex telecommunications technology that enable significant automation of the traction infrastructure speeding up the isolation of faults, minimising the extent of disruption due to a fault, identifying accurately where a fault has occurred and potentially reducing the time for taking isolations.

## OVERHEAD LINE EQUIPMENT

The primary purpose of the Overhead Line Equipment (OLE) is to conduct the electrical supply to the pantograph of the trains. In electrical engineering terms it is a power distribution system, but it is also an electrical commutator, allowing solid and continuous

electrical supply between the fixed OLE and the moving pantograph. The mass and upward pressure of the pantograph and the reaction of the wire as the pantograph passes create a complex mechanical interface, so whilst the electrical functions of the OLE are relatively straightforward, the mechanical design is quite the opposite.

## TENSIONING ARRANGEMENTS

Typically, the OLE consists of a contact wire suspended from a catenary wire, though some slow speed systems may consist of a contact wire alone. These wires are supported from lineside structures at regular intervals and tensioned to maintain the contact wire height along the span between supports to provide continuous current collection by the pantograph. Contact wire tensions run from 8kN for slow speed systems up to around 30kN for high-speed systems.

The tensioning arrangements must take account of the expansion and contraction of the wires with varying temperature. A complete length of OLE (with a wire run typically 1500m to 1700m long) will expand and contract as much as 1.5 metres over a typical range. This has a significant effect on tensioning arrangements.

The standard system for medium and high speeds is the Auto Tensioned (AT) system. Here the catenary is fixed only in the centre of the wire run at the midpoint anchor; the whole system is free to move around this fixed point (see Figure 2). Constant tension is provided by a tensioning device – traditionally by a set of balance weights attached to the catenary and contact wire.

A mechanical advantage of 3:1 or 5:1 is provided via pulleys or drum-wheels. The weights travel up and down the mast as the system expands and contracts. A single set of weights can tension both contact wire and catenary, but modern mainline and highspeed systems typically have independent tensioning of the two wires.

Balance weights are simple and robust, but for mainline railways they suffer from a number of disadvantages. A recent development is the use of spring tensioners instead of balance weights (see Figure 3). These maintain a constant tension by using a spiral torsion spring. The tensioners are often placed over the track for ease of maintenance access using rail-mounted plant.
Whatever tensioning device is used, along track movement is provided for at intermediate structures by pulleys, flexible links or pivoted cantilevers.

## TENSION LENGTHS AND OVERLAPS

The length of a wire run is limited due to frictional drag (at all the moving components and hinges at the registration supports) and stagger change (due to the angular movement of the registration assemblies, the arc described by that movement resulting in the contact wire moving further from the track centre line), as well as practical considerations of maximum wire length on a drum. OLE is therefore split into tension lengths. Turnouts and crossovers are provided with their own wiring, and due to the shorter length of OLE needed are often provided with a half tension length comprising a tensioner at one end, a fixed anchor at the other, and no midpoint anchor.

At the end of each tension length, arrangements must be made to transfer the pantograph from one tension length to the next. This transfer arrangement is known as an overlap (see Figure 4). At its simplest, an overlap is a purely mechanical arrangement. However, it can also be a convenient place to create an electrical break in the OLE for sectioning purposes.

The standard arrangement is a single span overlap, so-called because it has a single span of parallel running. The pantograph is transferred gradually from one wire run to the other; within the parallel running section, it is in contact with both (see Figure 5).

## OLE GEOMETRY

The requirement for continuous contact between the OLE and the pantograph means that the geometry of the system must be kept within strict limits. It is important to ensure that the OLE geometry is matched to the pantograph head width and operational performance of the train suspension. Failure to do so will compromise the reliability – and potentially safety – of the system.

The contact wire geometry is defined in terms of height and stagger of the contact wire at each structure. The height is measured parallel to the track centreline, perpendicular to the plane of the rails; the stagger as the offset perpendicular to the track centreline (see Figure 6).

The vertical range is limited by the pantograph operating range. Therefore, each system has both a minimum and maximum contact wire height. The requirement for height variation arises from the need to achieve minimum safe clearance for road and pedestrian traffic at level crossings, and to operate through low overbridges. The pantograph has a maximum rate of rise and fall per second, above which it will not be able to follow the wire (see Figure 7).

Therefore, the maximum permissible contact wire gradient is generally set to be in proportion to the line-speed – a useful rule of thumb for good current collection is:

$G_{max} \leq 1$ in (5v) where v is measured in mph.

The contact wire is installed so that its position does not dwell in one place on the carbon collector strips of the pantograph. This is known in the UK as stagger (perhaps more descriptively in Europe it is

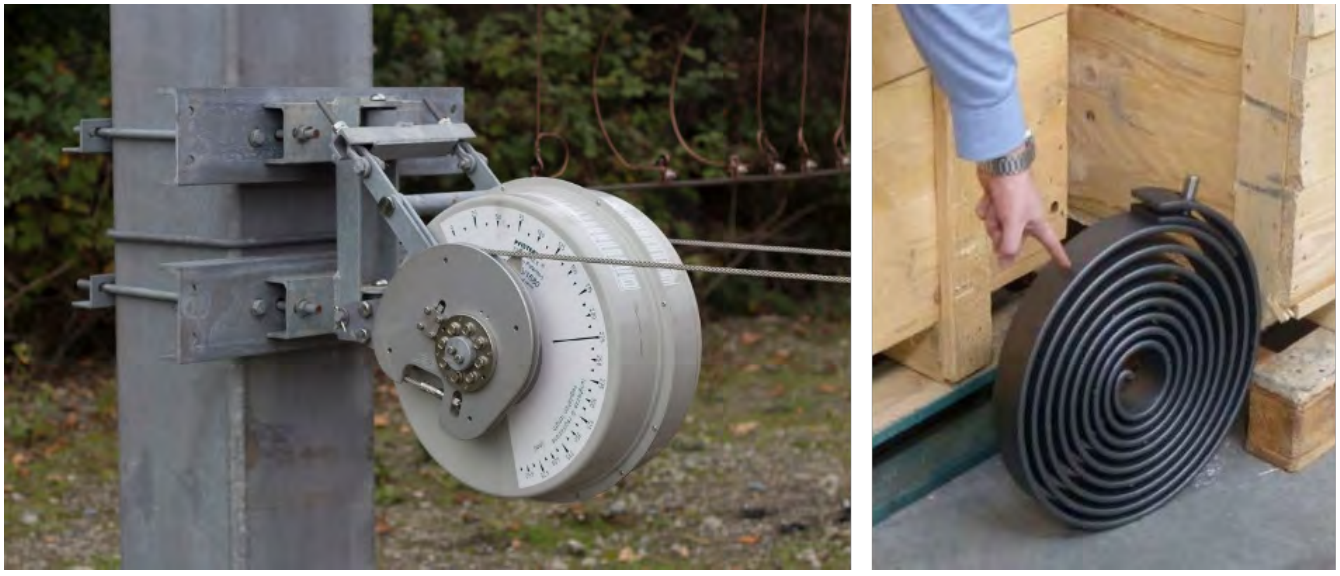

Figure 3: Pfisterer Tensorex C+ spiral torsion spring tensioner, and Tensorex spring

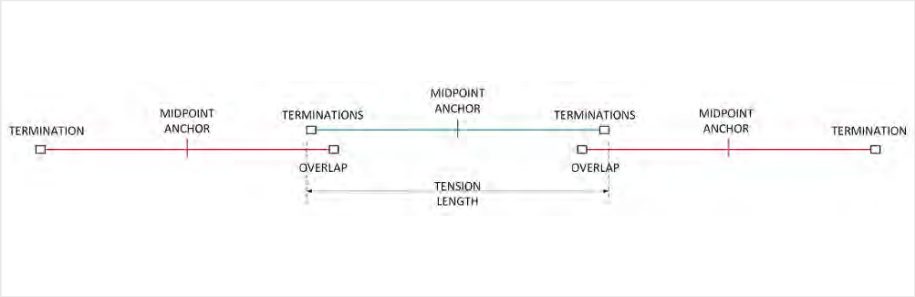


Figure 4: Tension lengths, overlaps and midpoint anchors

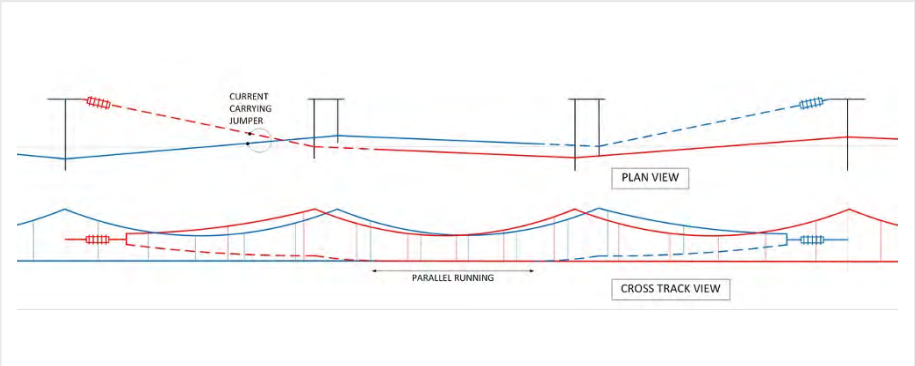


Figure 5: Uninsulated single span overlap

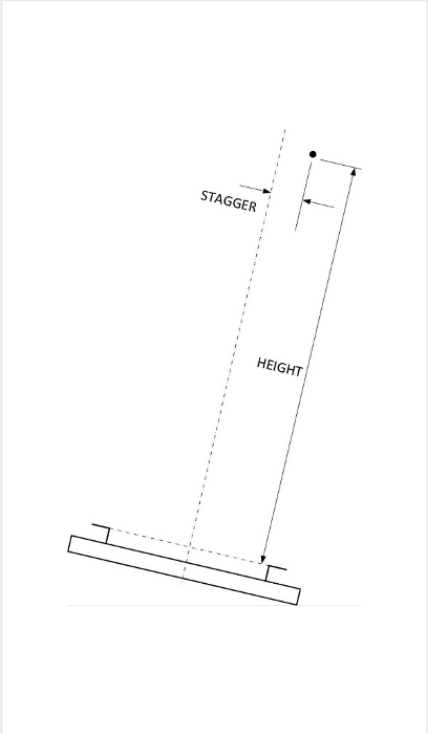


Figure 6: Height and stagger

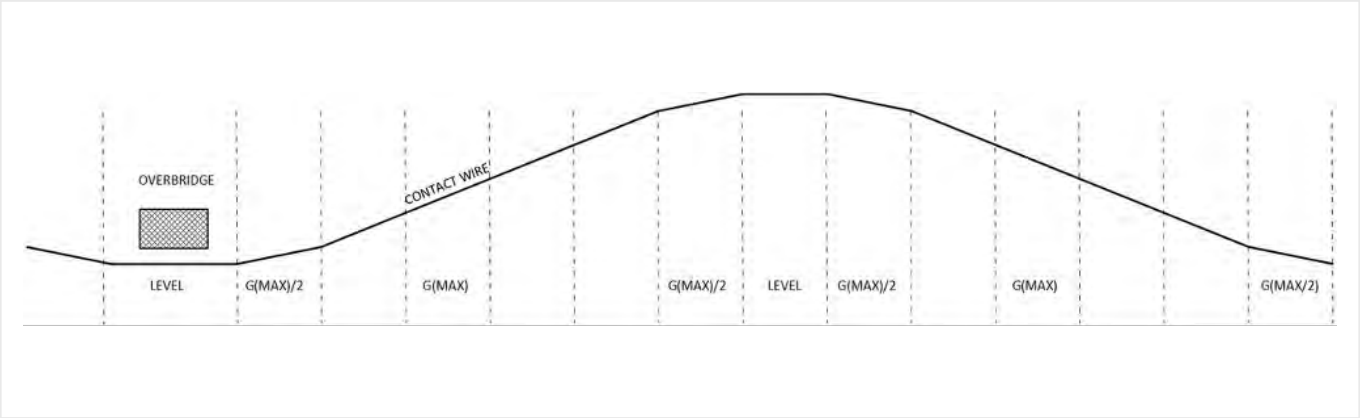


Figure 7: Typical contact wire profile (y axis exaggerated)

Figure 8: Contact wire stagger (zigzag) on tangent track; East Boldon, UK

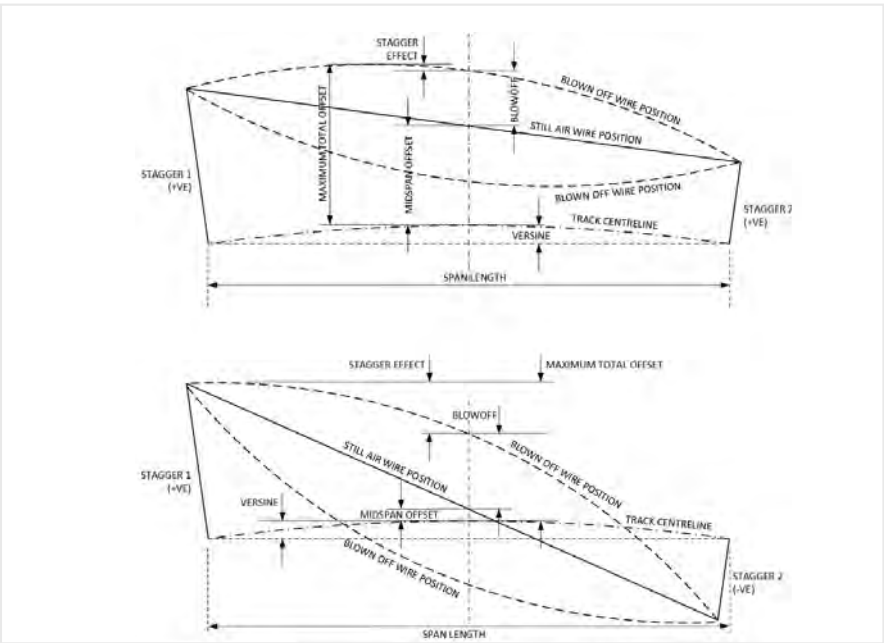


Figure 9: Midspan offset and blowoff illustrating in case two how a midspan offset can allow wire to be biased into the prevailing wind to improve reliability

more commonly known as zigzag – see Figure 8) and the horizontal stagger range is limited by the width of the pantograph. In operation, the horizontal operating range is most at risk at the midspan between the structures. This is because wind forces cause blowoff of the contact wire from its still air position. Designers must focus on minimising midspan contact wire offset, bringing the still-air position of the wire as close to zero as possible by adjusting stagger at the ends of the span accordingly. Midspan offset is a function of the stagger at either end of the span and the track versine (see Figure 9). Smaller structure spacings are needed on small radius curves to keep midspan offset within limits.

## TURNOUT AND CROSSOVER WIRING

Special arrangements are required where tracks diverge, converge or cross, to ensure continuity of current collection and to minimise dewirement risk. A second wire run is required to service the crossover, and introducing this additional contact wire brings with it the risk of hookover, where the contact wire enters the space at the end of the pantograph, and then gets underneath the pantograph head with catastrophic results (see Figure 10).

## TURNOUT CONTROL STRUCTURE

At the core of the turnout arrangement is the control structure; an OLE structure placed at a specific point in relation to the turnout (see Figure 11). The control structure is carefully positioned to hold the wire at a fixed stagger relative to the switch toe opening. UK OLE systems have evolved over time; there are a variety of rules applicable to individual OLE types, but all sit within a range of toe opening positions between 200mm and 350mm.

One method used to minimise the hook-over risk at higher speeds is to use a cross contact arrangement. In this case the two wire runs cross, and a cross contact bar is provided at the contact wire crossing point (see Figure 12), which is set inboard of the control structure by careful staggering. The cross contact bar ties the two wires together while allowing for along-track movement.

The cross contact system has been used extensively in UK heavy rail - although the cross contact bar can cause high dynamic forces between the wire and pantograph if poorly designed, leading to fatigue of the bar, and the bolts for the bar have a tendency to loosen and fail. For this reason, use in the UK is now limited to speeds below 160km/h or where there is no practical alternative.

## TANGENTIAL METHOD

The latest UK designs instead favour a tangential arrangement with the crossover wire running parallel with the main line wire in the span before the control structure, and a different form of droppering around the turnout (see Figure 13).

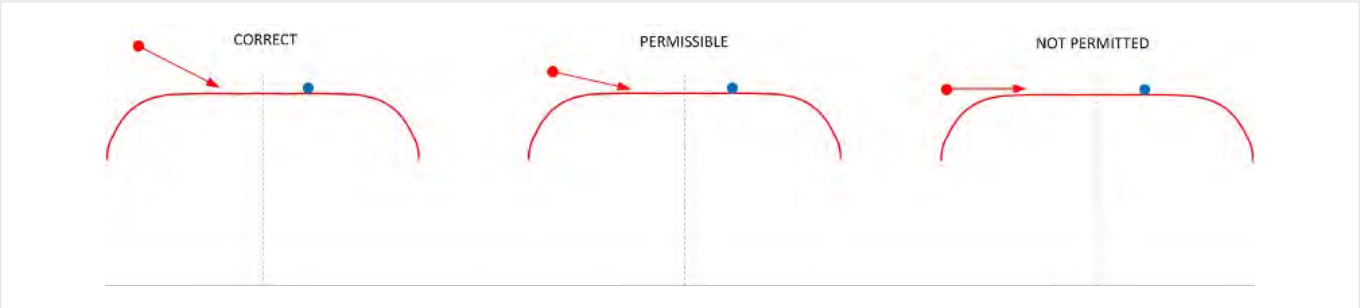


Figure 10: Hook-over risk for different wire/pantograph interactions

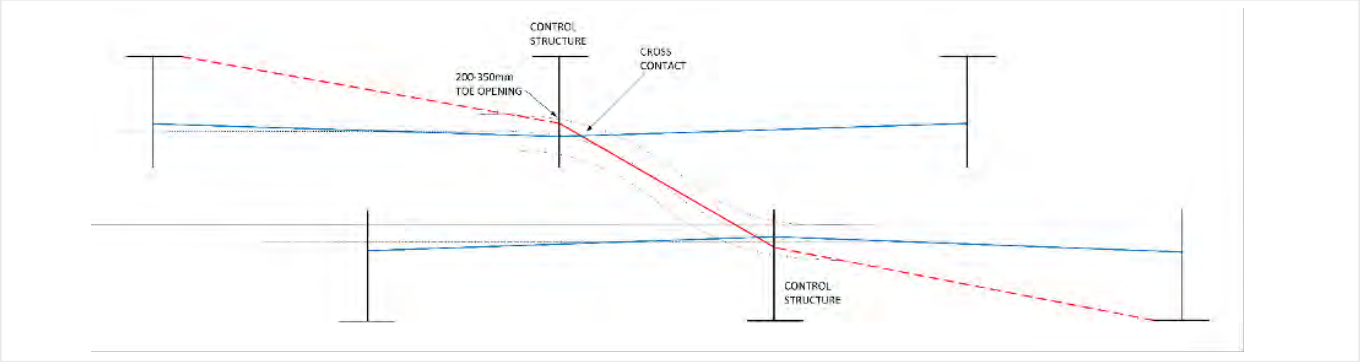


Figure 11: Traditional cross contact crossover wiring with mast anchors

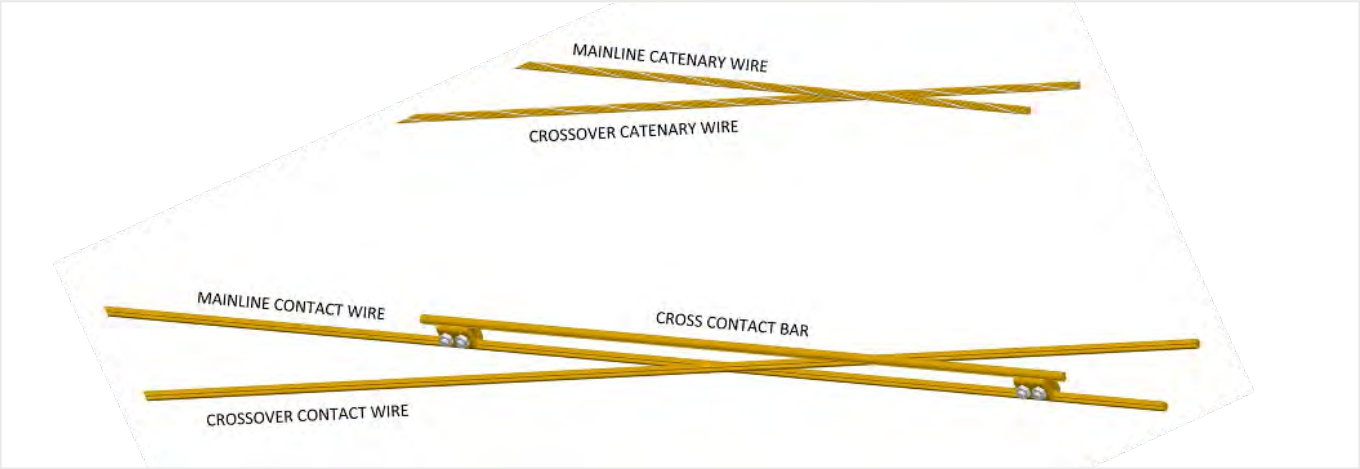


Figure 12: Traditional cross contact bar general arrangement

SECTION INSULATORS

Although overlaps are used wherever possible to create electrical section breaks, there are times when additional breaks are required. At these locations, a Section Insulator (SI) is used. This is a set of insulators spliced into the contact wire and catenary, while allowing the pantograph to pass directly in contact with the SI assembly. A standard insulator is used in the catenary, and an arrangement of insulators and skids are placed in the contact wire (see Figure 14); this allows the pantograph to pass over it without loss of current collection.

SIs introduce significant mass into the OLE which can result in high dynamic forces on the fragile pantograph carbon strip head assembly. Their use is generally restricted to crossovers, sidings and station areas where speeds are lower. SI installation design and set up are critical to achieve reliable performance.

NEUTRAL SECTIONS

An electrical section break is required wherever different supply phases meet at feeder stations and midpoint sectioning locations, or where there is a change of system voltage, as occurs at many European national borders; or where an earthed section of operational OLE is to be provided at a location where sufficient electrical clearance cannot be provided. At these locations a neutral section is used. This is a section of earthed OLE placed between the two electrical supplies (see Figure 15). This gives a high level of security against a short circuit between the two supplies.

The train must not draw power through the neutral section. The train power is automatically disconnected by a trackside Automatic Power Control (APC) magnet (see Figure 16), which signals the on-train APC equipment to open the circuit breaker on the train.

When the train has cleared the neutral section, the circuit breaker is closed by a second APC magnet. Care must be taken to place signals and neutral sections relative to each other to avoid the risk of a train becoming stranded in the neutral section.

There are two types of neutral section; the inline type, and the overlap or carrier wire (CWNS) type. The inline type consists of insulator rods cut into the contact wire and over the surface of which the pantograph runs. Sacrificial arcing horns are often provided to protect the delicate insulating rods in the event that a train draws an arc as it moves across the neutral section (see Figure 17).

The carrier wire type consists of two or more overlaps in quick succession; the first transfers the pantograph from the live wire at the entry to the neutral section where the pantograph transitions to an electrically floating wire run – the carrier wire; the second overlap transfers the pantograph back onto the live wire at the exit from the neutral section. As described previously APC systems automatically disconnect train power. In the UK, four overlaps are normally employed allowing an earthed section at the centre of the neutral section.

Carrier wire types can give better dynamic performance and reliability than the inline type but require a more complex OLE arrangement and take up much more space. This can make it harder to find a location away from bridges, stations, junctions and signals, but still close to the switching site.

TRACTION RETURN, EARTHING AND BONDING

These aspects of the electrification system are not the most exciting to look at visually, but they are a crucially important aspect of the system. The components, cables, connecting cable lugs, cable clips and fittings used for installation of the traction return system and for the earthing and bonding of the system seem to all look the same to the untrained eye and even to the trained eye, without careful reflection, the difference is not always obvious. Bonding cables can have a role both in traction return and in earthing. Any cable installed for these purposes is referred to generically as a “bond”.

TRACTION RETURN

As described elsewhere the train pantograph collects the 25kV supply current from the OLE. On the train, this is used to power the traction motors, run the air compressor for braking and provide lighting, heating and other domestic services. Also, on modern trains, it is used to power increasingly sophisticated control systems. Like all electrical power systems electric traction requires a circuit to function. Mains wiring in your home has a live and neutral conductor; the traction system equivalents are the OLE (live) and rail (neutral). In the simplest form an electrification system uses only the rails to complete the circuit back to the supply point. The rails must be electrically continuous, at places where that is not the case such as rail joints or around switches and crossings, then a bond, a bolted cable connection is placed across the electrical discontinuity. The cable must be sized to carry the current associated with the electrical load and the cross section of these bonds can be large. Steel conducts electricity, though it is a relatively poor conductor

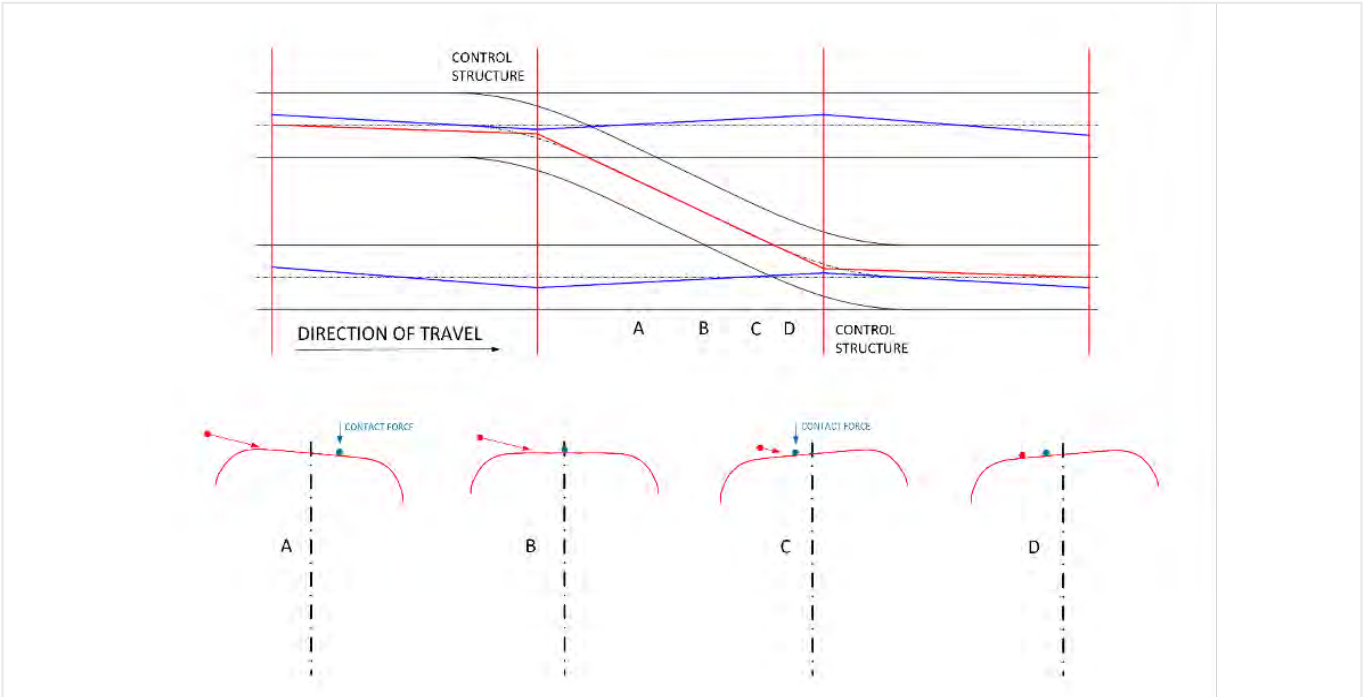


Figure 13: Pantograph approaching a turnout in the trailing direction, with hook-over risk controlled by careful staggering (head angle exaggerated)

having high unit resistance. A conductor made of steel presents just over 5 and a half times as much resistance as a copper conductor of the same physical dimensions. The resistance of the conductors in a distribution circuit limits the distance over which power can be distributed. That limitation is the result of the voltage lost in the conductors. Ohms law tells us that voltage loss is the numerical product of current (amps) times resistance (ohms). Rails have a large cross section compared to the OLE conductors, but the steel of the rails is part of the return circuit, so it follows that any steps to minimise the effect of the rail resistance will improve the overall efficiency of distribution. A significant contribution to securing best efficiency is by connecting all the rails on multi track railways together. At intervals of around 400m along the line “cross bonds” are installed which create a mesh connection of all the rails, placing them all in parallel electrically.

Alternating current (AC) for electric traction has the great advantage that higher voltage (25kV) can be used. The higher voltage means that lower currents are needed, making it possible to use lighter conductors. However, with that benefit comes an increased need to tackle electro-magnetic interference. OLE conductors produce a magnetic field and this will induce currents into any metal within the field; an effect called inductive coupling. Inductive coupling is most significant in its effect on cables running parallel with the OLE conductors. Induced currents can interfere with the function of signalling and telecommunications circuits on the railway, and non-railway electrical services beyond the railway boundary. Railway systems such as the signalling must be “immunised” on electrified routes. Immunisation measures for the railway systems entail some detail changes within the circuits and components of those systems. More conspicuous are the arrangements to supress the magnetic field at source. All magnets have a polar orientation. In radiated interference from conductors this orientation is linked to the direction of the current in the conductor. Placing the flow and return conductors in an electrical circuit in proximity has the consequence that the two magnetic fields, each equal to the other, but with opposite polar orientation, sum to zero, cancelling each other out. For an electric traction system this law of physics is exploited by the installation of an additional aerial return current conductor along the outside of the OLE structures above the cess. This is connected to the rails at the cross bonds described above. Some return traction current will therefore flow out of the rails and along the return current conductors, the proximity of which to the OLE will provide some significant suppression at source.

## EARTHING

The electric traction system brings the risk of electrical injury to public, passengers and people. The exposed high voltage OLE conductors and assemblies are installed with clearances and associated guidance and rules to bring an acceptable balance of those risks. However, at ground level and in accessible areas the installation must always remain safe to touch.

Other electrical systems such as installations at stations and at the line side will bring electrical enclosures, lighting columns etc. into the same accessible zone. Furthermore, planet Earth itself is conductive, but the connection to that planetary conductor is variable due to topsoil qualities and water content. Without some attention, the OLE structures, the rails, lighting columns, metal bridges and structures and the planetary conductor would all settle at their independent voltage levels. Instantaneous changes in the relative levels of those voltages would result from the electrical load on the systems and from electrical storms. Electric shocks would be common, injury frequent and death a regular result. Thankfully, the elimination of that risk is simple.

The way in which connections to the planetary conductor (which we all refer to as “earthing”) is a matter of providing an electrical connection deeper into the ground. In most electrical installations copper covered steel earth rods are driven through the soils. For a railway traction system, the OLE foundations do the job. Each foundation on its own would not provide a good enough connection, but all the foundations are connected together, bonds connect the foundations to the rails and through the steel OLE structures to the return current conductors. All those connected parts form a bonding “mesh” which can be regarded as the traction earthing system. Bonds are added to connect the traction earth to the exposed parts of any other electrical system at stations and at the lineside, and to major metallic structures such as bridges, utility pipe crossings and station buildings.

## RED BONDS

The interconnected traction return and earthing and bonding mesh includes one specific class of bond, the red bond. All bonds have the potential if they are disconnected to cause arcing and under short circuit to give rise to electric shock. Some equipment installed as part of and fed from the traction system such as protection

Figure 14: Arthur Flury section insulator; Rugby, UK

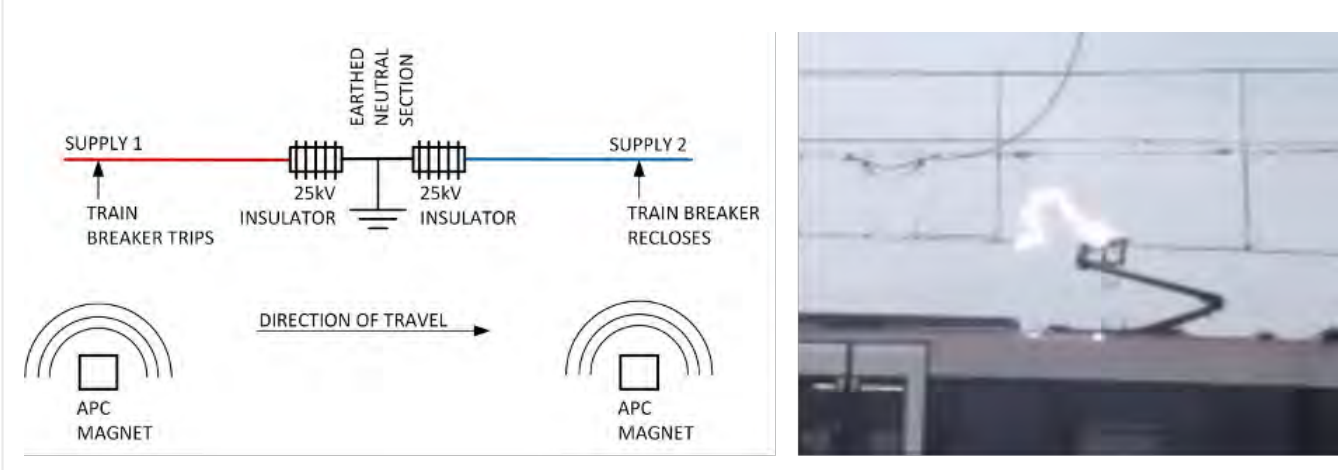


Figure 15: Hook-over risk for different wire/pantograph interactions

measurement and ancillary supply transformers make their return current connections through bonds that are sleeved or painted red. If, for any reason, these become disconnected under normal operation, dangerous voltages are exposed. Any red bond found cut, broken or not connected should never be approached or handled. It should be reported immediately to the Electrical Control Operator.

SUMMARY

This article describes the main electrical and mechanical system components of OLE electrification. The authors have tried to present wide coverage of a big subject area, necessarily avoiding the temptation to dive too deeply into technical detail to provide interest for those unfamiliar with or new to electrification.

We hope this will feed an appetite for more in-depth articles and technical papers which we intend will follow. Also, the PWI will, over the next few months, conclude the preparation of modules for a new training course as part of an electrification diploma, giving further opportunity to learn more.

This article and others which follow should prove essential reading for all, whether that is out of general interest, or to aid understanding towards formal qualification.

Figure 16: APC magnets

Figure 17: Arthur Flury type inline neutral section; Drayton Park, UK. Note the uninsulated cantilever at the neutral point

# Object detection at level crossings using deep learning techniques

## THE PWI YOUNG ACHIEVER AWARD

This article is an updated version of a paper that was awarded "Highly Commended" status by the judges of the PWI 2020 Young Achiever Award (YAA) competition.

This award is open to all involved in rail infrastructure engineering projects; engineers, project & maintenance staff, graduates, apprentices etc. See page 59 for details of the 2021 award.


AUTHOR: Muhammad A B Fayyaz

Muhammad has recently submitted his PhD thesis, which considers how to integrate Artificial Intelligence (AI) into existing sensing systems at level crossings, thereby improving their Safety Integrity Levels (SILs). Muhammad is a PWI Ambassador. He has a mechanical engineering background and expertise in different fields of AI. He is enthusiastic about learning and sharing his expertise using different platforms such as YouTube and Kaggle. He is currently exploring Computer Vision applications within the rail industry.



AUTHOR: Dr. Christopher Johnson

Dr Christopher Johnson is a Systems Engineering Team Leader at Park Signalling. Previously he operated as a programme manager in Industry 4.0 at Manchester Metropolitan University and has a distinguished track record in delivering impact through industrial partnerships as a recognised project manager (APM-PMQ, SCQF Level 7). Working closely with the rail supply industry, Dr Johnson's background work has included synergistic, adaptive prognostic monitoring of rail assets, bespoke image analysis techniques in the classification of surface born rail defects and pioneering the use of adaptive learning techniques in the analysis of rail vehicle and track components.



## ABSTRACT

Level crossings pose a significant risk, and their use or misuse can lead to serious accidents between railway vehicles and road and footpath users who may sometimes behave unpredictably. Currently, Great Britain has 7,500 level crossings and the Rail Safety and Standards Board (RSSB) reported 3 fatalities and 385 near misses in the year 2015-16. The Office of Rail and Road (ORR) and RSSB have recommended the upgrading of the automated technologies used at level crossings. For this purpose, automated safety systems remain a key area for investigation for inclusion in interlocking systems at level crossings. In this study, we propose a solution to automate the operational cycle at level crossings using deep learning technologies. The proposed solution will add another layer of resilience to the safety system without the use of manual operators at level crossings and ensure an interlocking system with a safety integrity level (SIL) of 3-4.

The paper discusses the current technologies utilised at level crossings along with the algorithms required for post-processing the data. The proposed model integrates deep learning technology with the current vision system, CCTV, to detect and localise an object at a level crossing. Two approaches are discussed to train the neural network: from scratch or using transfer learning techniques. Neural networks along with their associated accuracy, which represent the percentage of true predictions on the test dataset is mentioned as well. Classification, detection and segmentation models are used to classify, detect and localise objects like vehicles, bicycles and pedestrians at level crossings. Neural networks trained from scratch achieved an accuracy of 75%, networks trained for object detection using transfer learning techniques achieved an accuracy from 58 to 82%, and the image segmentation model, Mask RCNN, achieved an accuracy of 95% on test data. Finally, this paper discusses some future work to improve the network's accuracy and another application of convolutional neural networks (CNN) using radar sensing.


## INTRODUCTION

Railway level crossings represent some critical safety issues for the railway industry and are therefore of great interest to authorities charged with improving safety eg RSSB, Network Rail and Office of Rail and Road (ORR) (Office for Rail and Road, 2017)[1]. Level crossings account for nearly half of the potentially higher risk incidents on British railways, with misuse from road users accounting for nearly 90% of the risk at level crossings over the last five years. For Great Britain, there were three fatalities and 385 near misses at level crossings in 2015–2016. Furthermore, in its annual safety report, the Rail Safety and Standards Board (RSSB) (TSSA 2014)[2] highlighted the risk of incidents at level crossings during 2016/17 with a further six fatalities at level crossings including four pedestrians and two road vehicles (Office for Rail and Road, 2016)[3].

Traditional intrusive sensors are installed either inside or on rail lines (Darlington, 2017)[4]. Intrusive sensors are costly and disrupt the rail system during their installation and maintenance, which further increases the cost and shortens the product lifecycle (Petrov, 2011; Darlington, 2017)[5,4]. Intrusive sensors were replaced with non-intrusive sensors (Ohta, 2005; Valera and A. Velastin, 2005; Kim et al., 2012; Govoni et al., 2015; Horne et al., 2016; Leddar, 2018) [6,7,8,9,10,11] which are installed outside rail lines and do not affect the rail system during installation and maintenance. Therefore, the product is comparatively cheap with a longer product-lifecycle. Some post-processing techniques are required to process the information acquired from any of the above-mentioned sensors to analyse and differentiate between obstacles present at the level crossings. Most of these traditional algorithms detect the foreground by comparing pixel values with background pixels. However, the environment at level crossings is complex and dynamic with growing vegetation and the presence of many harmless objects.

Traditional algorithms cannot detect complex texture, adapt to a dynamic background or avoid detection of unnecessary harmless objects. To avoid these problems, the proposed work utilises "deep learning" technology (LeCun, Bengio and Hinton, 2015)[12] integrated with the proposed vision system; CCTV. Deep learning technology can learn representations from labelled pixels; hence it does not depend on background pixels. Deep learning technology can classify, detect and localise objects in the level crossing area. It can classify and differentiate between a child and a small inanimate object, which was impossible with traditional algorithms. The system can detect an object regardless of its position, orientation and scale without any additional training because it learns representation from the data and not rely on background pixels. In the proposed system, deep learning technology is integrated with the existing vision system installed at level crossings, hence implementation cost is significantly reduced as well.

This paper provides a summary of existing sensing systems and algorithms used at level crossings before discussing deep learning technology and its integration at level crossings with the video sensing system. The paper uses different models, which are trained using deep learning technology; from scratch and transfer learning techniques along with their accuracy and results at real-site deployment. Finally, the paper gives some concluding remarks and suggestions for future work.

## METHODOLOGY

To select the most appropriate sensing system, a summary of sensors is presented in Table 1, which are currently used or have the potential for their applicability at level crossings. The work in (Fayyaz et al., 2020)[13] discusses the limitations and preferability of each sensor. Table 1 strongly advocates the preferability of CCTV for its application at level crossings because of its low cost and maintenance.

The traditional algorithms rely on calculating the background pixel values to model the background, which then confirms the presence of the foreground using a predefined threshold value. This method does not depend on the object features or recognise

| | Equipment cost | Maintenance | Product life cycle | False positive | Impact on weather |
|---|---|---|---|---|---|
| Inductive Loops | 5 | 5 | 4 | 4 | 4 |
| Strain Gauge/Piezometers | 5 | 5 | 4 | 4 | 3 |
| CCTV | 2 | 3 | 2 | 3 | 3 |
| Stereo Camera | 3 | 4 | 2 | 3 | 3 |
| Thermal Camera | 4 | 2 | 2 | 2 | 2 |
| SONAR | 2 | 4 | 3 | 3 | 2 |
| Millimeter-Wavelength Beam Interference | 4 | 4 | 1 | 3 | 4 |
| Laser Range Finder Beam (LRBF) | 3 | 4 | 2 | 5 | 4 |
| Light Detection and Ranging (LiDAR) | 5 | 4 | 2 | 2 | 2 |
| Radar | 3 | 2 | 1 | 1 | 2 |

Table 1: A brief comparison of different sensors available at level crossings, where five represents the worst choice and one represents the best choice for the given parameter

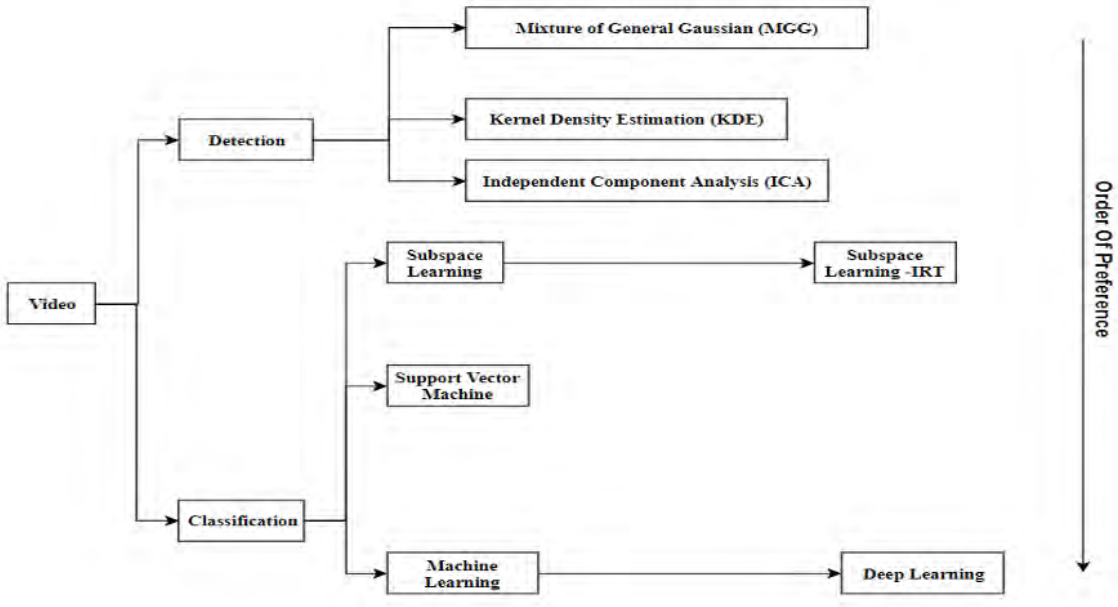


Figure 1: A decision tree to demonstrate which sensor is prefered for its applicability at level crossings

objects from their specific properties, rather on the variation within the background scene. This further suggests that any variation in background scene due to change in lighting conditions or dynamic environment eg, growing or moving vegetation would give false positives. These false positives would pose a significant threat to road or rail users. Also, the recovery time for most of these mentioned algorithms is slow, which means more chances of failure, which is undesirable for use at level crossings. To overcome these problems, the work in (LeCun, Bengio and Hinton, 2015)[12] proposed the use of the deep learning technique. Deep learning is a subset of machine learning, which can automatically learn the representation from the images and classify the given categories without any supervision. It consists of multiple processing layers and can learn representation using backpropagation algorithms. With enough representations, very complex functions are learned and used for different applications such as classification and detection. The deep learning model learns features for the general-purpose avoiding the need for human engineering, for example, the classification model learns small features like edges, orientation and location to more complex representations such as motifs or parts of objects with assembled features. From such learned models, it can detect and classify objects very effectively.

The model does not require any supervision or regular increment of data to update the existing system. Another advantage of deep learning is its ability to integrate with other existing sensing systems eg a video system. A decision tree in Figure 1 is used to demonstrate the preferability of these sensors for its applicability at level crossings.

This paper aims to use deep learning technology, which is integrated with the vision sensing system at a level crossing to classify and detect an obstacle. The objects that may pose a threat to a train or other users at a level crossing are vehicles, pedestrians (adult and child) and bicycles, hence the model is trained to detect and classify these particular objects during the operation cycle at a level crossing. Convolutional neural networks (CNN), which are used for image classification (Krizhevsky and Hinton, 2012)[14], detection (Karpathy and Leung, 2014)[15] and segmentation (Huang, Pedoeem and Chen, no date; Redmon et al., 2016)[16,17] are trained using two different methods; from scratch and using transfer learning techniques. Images are obtained for each required category from an open source eg ImageNet and split into training and validation. The training set of images are required to train the model, whereas the validation dataset is used for evaluation of the model before its deployment at the real site.

A traditional neural network is used as a base model for image classification when training the network from scratch, where different depths of convolutional neural network and regularisation techniques are used to improve the accuracy of the model. To better understand the effect of the convolution layer, often the visualisation of such representations during the training process is used. Afterwards, the transfer learning technique is used to train different pre-trained neural networks along with their associated weights to retrain the model on new datasets and its application at level crossings. The pretrained neural network used are RetinaNet (Lin, Ai and Doll, 2018)[18], YOLO (Redmon et al., 2016)[17], tiny-YOLO (Huang, Pedoeem and Chen, no date)[16] and Mask-RCNN (Ren, He and Girshick, 2015)[19].

| Trail # | Change | Network's Summary | Accuracy |
|---|---|---|---|
| 1 | Traditional Neural Network (base) | 1 Flatten Layer<br>2 Dense Layer | 55% |
| 2 | Add Convolution Layers | 2 Convolution Layer<br>2 Max. Pooling Layer<br>2 Dense Layer | 68% |
| 3 | Add Regularisation | 4 Convolution Layer<br>4 Max Pooling Layer<br>2 Dense Layer<br>1 Dropout Layer | 75% |

Table 2: Details of CNN's architecture used to train the model for classification using a traditional neural network and a network with convolution layers

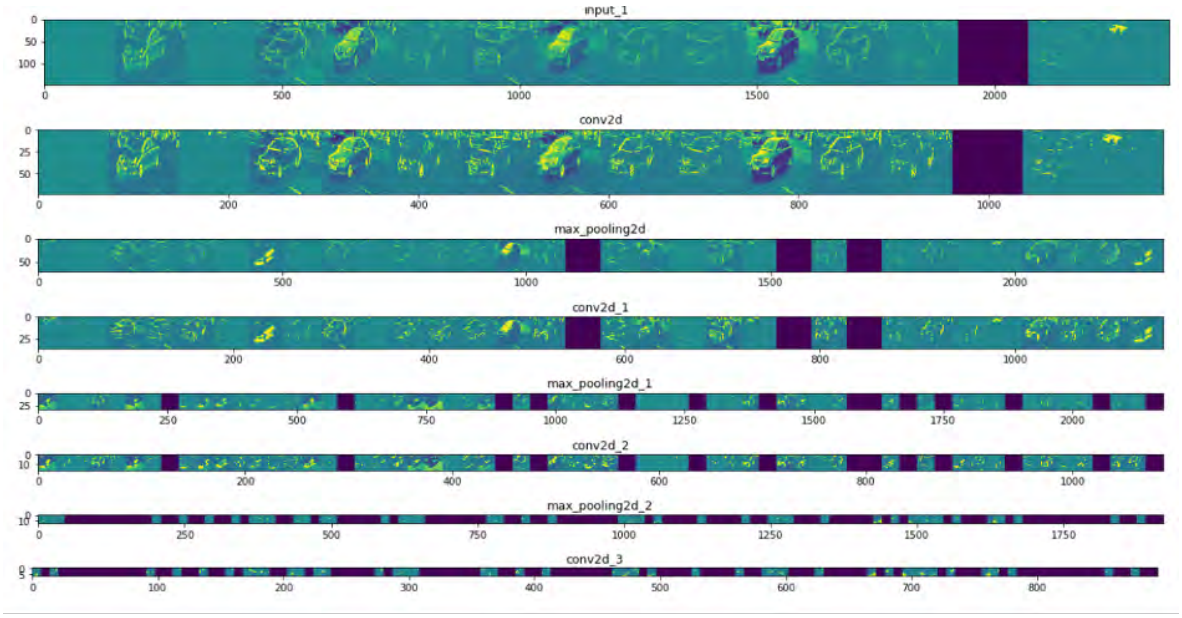


Figure 2: Visual representation of a car at level crossing site. This visual above represents the features learned from successive convolution layers within a neural network

## RESULTS

### CONVOLUTIONAL NEURAL NETWORK TRAINED FROM SCRATCH

A public dataset from ImageNet is used to train and evaluate the CNN model. To understand the effect of the convolution layer (Dumoulin and Visin, 2016; Karpathy, 2018) [20,15] a traditional neural network with only Flatten and dense layer is trained on the given dataset, which achieved an accuracy of about 55%. With the addition of two convolution layers and two max pooling layers (Ricco, 2017)[21] the accuracy increased from 55% to 68%. Where different regularisation techniques are also used, an increase in the model's accuracy to 75% is obtained. The accuracy metrics represent the percentage of true predictions on the test-dataset. The details of these models along with their architecture and accuracy metrics are summarised in Table 2.

To understand the convolution layer, a common practice is to visualise the representations learned during the training process. An image of a vehicle (car) present in the dynamic environment of a level crossing is fed to the network and representation from each subsequent layer is visualised as shown in Figure 2.

In the first layer, as shown in Figure 2, the activation from the neural network has retained all the information from the given image (eg car). It contains some edges or collection of apparent edges that is interpretable by human eyes as well. The activations or representations become more complex in deeper layers of the neural network. They are more abstract and less interpretable. These complex features correspond to the specific class rather than a visual interpretation of the generic object. The black boxes in the subsequent layers of the neural network demonstrate the sparsity of the network. These black boxes represent that the pattern encoded by the particular filter is not found in this particular location. As the convolution neural network is fed with raw data containing specific objects, the subsequent layers within the CNN learn relevant information specific to the class and leaves irrelevant information eg the visual appearance of the image. For this reason, any object similar to the given object in the image regardless of its orientation and size will be predicted accurately. The whole idea of retaining generic information in the subsequent layers gave rise to "transfer learning" techniques, where a notable model trained on millions of images is used. The generic pattern learned on these models will be used along with specific features learned from a small dataset fed to the CNN.

### CONVOLUTIONAL NEURAL NETWORK TRAINED USING TRANSFER LEARNING TECHNIQUES

Neural networks, which are trained on millions of images, are used to retrain the network on custom classes or images for a specific problem. Transfer learning is achieved in three possible scenarios; freeze all the layers except the last final layer, freeze first few layers and retrain the remaining one and retrain the whole network with new weight initialisation.

A common practice is to use notable models, which are trained on millions of images and achieve state-of-the-art results and to feed them with a custom dataset for specific classes. Table 3 shows two notable models along with the summary of its parameters and achieved accuracy. The accuracy achieved on a new custom dataset using transfer learning is mentioned as well.

Many different data augmentations and regularisation techniques could be used to further improve the accuracy of the networks. However, accuracy beyond 75% is acceptable to validate and test the new data for its application at a level crossing. The models can predict at a rate of 15 frames per second (fps) with low computational power, which suggests the efficiency and reliability of these models for real-time application. The natural progression from the classification is the localisation and detection of these objects at level crossings. A summary of the models used for transfer learning is mentioned in Table 4.

Once trained, the model is deployed at a real site for real-time predictions. The results as shown in Figure 3 demonstrate the effectiveness and reliability of these models for its applicability at level crossings.

The accuracy and confidence of the YOLO network is higher than that of the RetinaNet, which is roughly 82% ± 10% but it did not classify every single object, whereas the RetinaNet can predict all objects within two distinct environments with an accuracy of 70% ± 8%. Other networks eg, Mask-RCNN can detect and localise the objects to the pixel-level precision compared with the bounding boxes. Pixel-wise detection is called image segmentation. The accuracy of Mask RCNN eg, 95% ± 7% is highest compared to all other networks used for its application at a level crossing as shown in Figure 3.

## CONCLUSION

This paper addresses the safety issue at level crossings and requires an automated system for classification and detection to automate the operational cycle. A brief introduction to sensors, which are used or have the potential to be used at a level crossing is mentioned along with some associated algorithms used for post-processing the data acquired for real-time detection.

The paper demonstrates the effect of convolution layers on traditional neural network and the representations learned during the training of the network. The accuracy achieved from a CNN trained from scratch is further increased using transfer learning techniques. Particularly, the YOLO and Mask-RCNN can precisely classify and localise objects in a dynamic background environment.

The network can correctly classify and predict objects in real-time, which demonstrates its effectiveness and accessibility to replace the manual operator at level crossings increasing the resilience of the safety system. Furthermore, the model could be used for objective risk analysis. The classification from the network is useful data to analyse which particular objects frequently misuse the level crossings and cause the greatest threat. Such information will allow authorities to perform risk assessments more effectively. For example, the real-world classification for level crossings demonstrates that cyclists more frequently misuse level crossings, posing a threat to themselves and the train driver. From the data, the authorities can take precautionary measures and actions to avoid such incidents and improve the safety of bicycle users.

The proposed network should be trained on a larger dataset gathered from the same distribution (sites which strongly represent the site of deployment). This will ensure that the network is not overfitting (a state where a model precisely learns on training examples but does not perform well on the new dataset). The dataset will need to be from Great Britain only because other countries deploy different technologies at level crossings or do not use them, particularly in underdeveloped countries. The dataset from different locations from within Great Britain will allow the user to gather a large variance of images to avoid our network's bias towards one particular ethnicity.

As an alternative to using CCTV sensors (as described in this paper), CNN could also be trained on images obtained from radar. Radar imaging is a diverse application, which provides sufficient information for CNN layers to learn representation and classify objects. One such application is to use micro-Doppler signatures from radar to train a new CNN model.

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| Name | Summary | Accuracy |
|---|---|---|
| InceptionV3 | The network achieves 21.2% top-1 and 5.6% top-5 error for single frame evaluation with a computational cost of 5 billion multiply-adds per inference and with using less than 25 million parameters (Inception, 2019). | 76% |
| MobileNet | Same pre-processing as Inception with an accuracy 66.51% top-1 and 87.09% top-5 on ImageNet-2012 Validation dataset. The network has about 3.3 million parameters (MobileNet, 2019). | 82% |

Table 3: Some notable models along with their summary and achieved accuracy on a new custom dataset using transfer learning

| Name | Summary | Accuracy % (based on test data) |
|---|---|---|
| RetinaNet | • ResNet + FPN as backbone for feature extraction.<br>• Two task-specific subnetworks for classification and bounding box regression (Lin, Ai and Doll, 2018). | 70 |
| Yolo | • A Neural Network is applied to the whole image.<br>• The Image is divided into grids for predicting bounding boxes and probabilities.<br>• These predictions and probabilities are weighted to give final output (Redmon et al., 2016). | 82 |
| Tiny-Yolo | • A smaller version of YOLO network<br>• Design for computers with no GPUs (Huang, Pedoeem and Chen, no date). | 58 |
| Mask RCNN | • Trained on CocoDataset<br>• Extends Faster R-CNN by adding a branch for predicting an object mask in parallel with an existing branch of bounding box prediction (Ren, He and Girshick, 2015). | 95 |

Table 4: Models used for detection and classification using transfer learning techniques. The model's summary and results are mentioned as well

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Figure 3: Predictions from: A) Yolo | B) RetinaNet | C) Mask-RCNN at two distinct environments

ONLINE SEMINAR

# On track for a safer railway

AUTHOR: Chris Parker

Chris is a Chartered Civil Engineer, and a Fellow of the PWI and ICE. He has worked in the rail industry since 1972 retiring in 2004. His experience covered track and structures, design and maintenance and infrastructure management. After retiring Chris has remained active as a technical writer as well as writing reports for the PWI Journal and other organisations.

The seminar was held online, as has become the norm under the Covid-19 pandemic. The event was co-sponsored by Volker Rail and Tracksure; thanks are due to both organisations for this.

## WELCOME

JOAN HEERY - (CHAIR), PWI PAST PRESIDENT

Joan welcomed everyone to the seminar and spoke of the importance of safety within the rail industry. Very sadly, this message was reinforced for us all by the recent news that a colleague from the industry had suffered fatal injuries at Eastleigh the previous day. Our thoughts were with the family and colleagues of the person concerned.

Joan introduced each speaker with a brief resume of their railway career, beginning with Nick Millington of Network Rail (NR).

## REDUCING RISK TO TRACK WORKERS

NICK MILLINGTON - PWI DEPUTY PRESIDENT
SAFETY TASK FORCE LEADER, NETWORK RAIL

Nick explained that his taskforce had been introduced after the tragic loss of the lives of two colleagues at Margham in South Wales in July 2019. The need for this had been further confirmed by a further death of a colleague, at Roade, in April 2020*.

The ORR served two enforcement notices upon NR after the Margham deaths. These notices were wide-ranging, with a total of 12 compliance criteria between them. A compliance date of July 2022 was set, meaning that there is real time pressure.

Nick explained how NR is approaching this challenge, with him and his team at the head of the action. His presentation was detailed and comprehensive, and it is recommended that anyone in the industry with safety responsibilities should review the full record of it. This will be available via the PWI website, along with all of the other presentations made at the seminar. The following account is only a high-level summary to give a taste of the presentation.

Data is key to understanding safety, to allow identification of where there is risk. “Tangible facts are crucial to correct decisions” Nick rightly said. He and his colleagues are working to improve the availability of data, for example, seeking to reduce the number of reported close calls and incidents where the cause is not properly identified.

Nick spoke of some of the statistical evidence available, such as the importance of incident timing, showing statistics relating to time of the week and time of day. Work with unassisted lookouts accounts for 53% of reported near misses. In track maintenance some 28 million tasks have been identified.

The two Notices relate to “planning” and “technology” respectively. NR has five main workstreams dealing with the different aspects of these, and Nick described them. One significant element involves eliminating the need for some of the 28 million maintenance tasks that have been identified, since elimination is the most effective way of managing out the risks associated with anything.

To assist the Routes to manage their part in all of this, a specification document has been developed. This work has been carried out collaboratively, meaning that the current version at the time of the presentation was the third iteration, and has been signed off by all of the Routes.

To go with the specification, there is a tracking and reporting system to keep everyone aware of the progress made to date.

Nick described some of the biggest opportunities, of which the elimination of working under unassisted lookout protection is the most important. This has been reduced by 53% since July 2019, but that still leaves around 850,000 unfulfilled work orders that propose using lookouts. Critically, eliminating these has to be done without transferring risk to the infrastructure in the process.

Other workstreams are looking at the workload of signalers, track safety equipment, new technologies to keep boots off the ballast and improvements in planning safe working practice.

Last, but definitely not least, is a workstream managing frontline engagement, all of the Routes and Regions working with their teams to lead change from the front. Without the hearts and minds of all colleagues, none of this work will be fully effective. Senior people are therefore getting out amongst the frontline activities, talking to people, observing, advising and also learning for themselves.

Nick ended with a rapid summary of what is being done, what has been achieved to date and what comes next. He showed statistics that demonstrate a fall in the numbers of near misses and an increase in the average time between these and described how progress is monitored through Route based dashboards and metrics for the NR Board.

Leaving a lasting legacy is an important ambition for Nick and the project, for example, by upskilling frontline safety leaders.

## ASSETS, SYSTEMS AND SAFETY - A BROAD PERSPECTIVE

STEPHEN BARBER - CEO, PWI

After offering a brief history of his career form British Rail through privatisation to TfL and finally the PWI, Stephen launched into his theme. This concerned the vital importance of corporate memory and the need to remember past safety incidents and the lessons that were learned from them.

Six railway incidents and a couple from outside the industry exemplify this theme:

- Clapham, December 1988: collisions between three passenger trains caused 35 fatalities and circa 500 injuries. The Hidden Inquiry found that the causes ranged very widely, from dangerous working practices to poor communications.
- Hatfield, October 2000: about 35m of rail disintegrated under a highspeed passenger train causing four fatalities and about 170 injuries. The causes found were again very wide ranging, from non-compliances with standards to cultural failings and work backlogs.
- Potters Bar, May 2002: the failure of a set of switches beneath a Networker Express train caused the loss of seven lives and around 70 injuries. Once again, a similarly extensive range of underlying causes were identified subsequently.
- Grayrigg, February 2007: like Potters Bar, this train crash occurred due to the failure of a set of switches under a train, this time one fatality and around 58 injuries resulted. Underlying causes identified were again many; a significant one was the failure to carry out the planned inspections of the switches because of track access constraints.
- Earls Court: track became “wide to gauge” when rail fastening systems failed undetected. Fortunately, in this case no injuries resulted, but there was very considerable disruption on the network. It was found, inter alia, that track faults had not been correctly identified, or were wrongly recorded/classified.
- Wimbledon: four minor injuries resulted again because of track gauge failure. The fundamental cause here was a complete failure of the track inspection regime, as a result of a misunderstanding of the boundary of responsibilities between NR and TfL. Neither organisation, it transpired, had inspected the relevant section of track for eight years or more.

The two non-rail incidents identified by Stephen were:

- Grenfell Tower, June 2017: we are probably all familiar with the awful fire and the loss of life involved in this incident in which 72 people are believed to have died. Lessons we can learn from it revolve around non-compliance, failures of regulation and guidance, poor change controls and QA, and the risks implicit in failure to clearly define roles and responsibilities.
- Boeing 737 Max: two air crashes on different dates involved aircraft of the same type, killing 346 people in all. The whole fleet of these planes was grounded, worldwide, for a significant period. It seems that a hidden, automated flight control system caused unsafe conditions in certain circumstances, and that the pilots were not able to correct the situation on either of the fatal flights. It appears that the plane manufacturer attempted to modify the systems after the first crash, but flaws in this, in its implementation and in the training and advice offered to flight crew and airlines allowed the second crash.

Stephen’s concluding thoughts and questions were these:

Asset risk is well understood
- we have most, if not all, data (it’s out there somewhere!)
- why do we still tolerate in-service failure?

New railways can deploy effective engineering and safety management from the outset

But legacy assets and systems pervade existing networks
- do we fully understand their failure modes and criticality?

Defect identification and work management processes and systems remain absolutely critical to infrastructure management
- all currently rely on human input and interaction (to a greater or lesser extent)
- do we confirm they are robust - and how (HAZOP/FEMECA)?
- do we understand their performance in QRA terms and how do we improve it?

Will data quality ever reach the standard required for autonomous operation?

How is “wrong culture/wrong ethics” to be countered?

Finally, Stephen advised “always act on concerns, don’t brush them under the carpet”.

## 25kV OVERHEAD LINE SAFETY UPDATE

ROB SHERRIN - MD, LEEPS LTD.

Rob commenced by discussing the lessons to be learned from past major AC electrical incidents, displaying a chart showing the history from 1998 to 2019. Between 2014 and 2019 there were no incidents, but in December 2019 this record was sadly broken when a linesman contacted live OLE.

Risks arise when there are late changes of plan. OLE staff are at greatest risk by some margin, followed by rolling stock and depot staff, with track workers next. A key issue is that it’s impossible to tell live assets from dead ones just by looking. The big risk for track workers comes from work on top of vehicles under OLE. Rob continued by looking at the typical distribution of outcomes from incidents, using the Heinrich/Bird Accident Triangle. This suggests that for every fatality there are likely to be ten major injuries, 100 minor ones, 1000 near misses and 10,000 unsafe acts or conditions. This model suggests that if we tackle the unsafe acts and near misses, there will be a proportional reduction in events all the way up the triangle, leading to fewer injuries and deaths. He then showed that this triangular distribution does not apply in the case of 25kV incidents. In this instance the accident severity model is totally different. For every fatality experienced there will be around 22 major injuries recorded, no minor ones, and only about ten near misses/close calls. Little information is available about unsafe acts and conditions. This renders conventional risk management completely inapplicable.

Rob described the strategy being implemented to manage this situation. It involves the development of a testing culture “test before touch” through the lifesaving rules. Electrical risk assessment is being improved, and safety standards are being modified to support modern OLE and the lifesaving rules. Keeping talking about it is also vital.

New processes include the single approach to isolations (SAI) and key messages are being driven forward about the life saving rules, SAI, the importance of avoiding last minute changes to plans, and the fact that there will not be warnings from near misses or minor incidents.

* Regretfully, it is acknowledged that very sadly, since this seminar took place a further fatality occurred at Surbiton during February 2021

## IMPROVING CONTRACTOR WORKFORCE SAFETY

STUART WEBSTER-SPRIGGS - HSQE DIRECTOR, VOLKERRAIL

VolkerRail is one of the corporate members of the Institution, and also kindly sponsored this seminar, helping to make it available to all. Stuart described how VolkerRail approaches the safety management of its staff using the “Safety II” approach. He began with a diagram showing work as described, work done, work as prescribed and work disclosed as four different, overlapping zones. There is probably only a small area, in reality, where all four overlap.

The objective has to be to enlarge that small area as much as possible. The consequences of getting things wrong can be very serious. He described the VolkerRail HSQES plan, its goals and objectives and some of its actions, including the use of QR codes for hazard and close-call reporting, the use of HAVWEAR technology for the reduction of hand/arm vibration injury. He also talked about the investigation of accidents, incidents and close calls.

Also covered were the company’s award scheme, the monthly AIM Awards, and the response of the company to Covid-19. Stuart concluded by reminding us of the vital need for industry collaboration as well as action by individual companies/organisations.

## INNOVATING FOR A SAFER RAILWAY

GERHARD DODL - TRACKSURE

Tracksure kindly sponsored this seminar, helping to make it available to all. Gerhard began with a brief look at the safety challenges facing the rail industry, saying that in Europe there are typically 50 - 100 fatalities pa. To address this, the industry is focusing on getting boots off the ballast. Every intervention on the track carries a risk. One very significant driver of such interventions is the failure or loosening of fastenings, very often bolted ones. Gerhard showed a short video clip that demonstrated how readily a conventional nut and bolt fastening can be loosened by vibrations, a commonplace phenomenon in the railway environment.

Tracksure market a simple means of overcoming this problem, a fail-safe nut locking system. It employs modified bolts, each having a short extension on which there is a lefthanded thread. Once the main nut has been tightened to the specified extent, it is locked in place by means of a lefthanded locknut secured on the bolt extension. This locknut is tightened against the main nut, then the two nuts are locked together by fitting a stainless-steel cap over them. Gerhard described how this has two advantages: not only does the system prevent the loosening of the main nut, eliminating the requirement to inspect and, when necessary, retighten it, but it also ensures that the correct tension is maintained in the bolt. This is not necessarily the case when a loose bolt is retightened, even if the torque applied is correctly checked as this is done. He showed how corrosion, incorrect lubrication and other influences can easily result in bolts having an incorrect tension after retightening, even when the nut is correctly torqued. They may be left with too little tension, with the result that the fastening system malfunctions, and also that the nut is liable to easily work even looser. Alternatively, they might be overtightened in some circumstances, with the consequent risk of the bolts failing.

Gerhard pointed out how many applications there are for bolted fastenings in the track, from rail fastenings to joints, breather switches and S&C. Every track intervention eliminated equals a safer railway.

## MACHINE SAFETY BY DESIGN

MICK JAMES, SENIOR APPROVALS ENGINEER, PLASSER UK

Mick said that it is patently obvious that any machine or tool has to be used safely. However, that requires that the equipment to be inherently capable of being safely used. He continued to describe how that is ensured, through legislation, standards, design, maintenance and more. An on-track machine is capable of operating in three possible states:

- Running: in traffic, whether under its own power or towed in a train
- Travelling: moving under its own power between areas of work
- Working: doing its job on the railway

Mick described how the Interoperability Directive sets requirements with which an on-track machine must comply to be used in Europe. The Machinery Directive applies to a machine when it is in working or travelling modes, and the Railway Safety Directive applies to the running and travelling modes. He detailed the standards (EN) which apply as a result, and the three different parts of the EN applicable.

In addition, the Infrastructure Manager of the railway in question will require Product Acceptance of the machine before permitting its operation on their railway. Any machine should have the appropriate certification covering all of the foregoing requirements. Mick described the decision tree applicable to any machine with the capability of rail travel, which determines the ENs applicable to it. He finally looked in some more detail at the questions of braking and stability that are of vital importance.

## ASSET INTEGRITY - HOW CIRAS CAN HELP

KERRY DOLAN - MEMBERSHIP MANAGER, CIRAS

www.CIRAS.co.uk / enquiries@CIRAS.co.uk

Kerry explained that CIRAS is an independent, not for profit, confidential reporting service. It is, she said, an easy to use safety net. She saw it fitting into the Bird Accident Triangle towards the bottom, in the zone of unsafe acts and conditions or that of near misses. CIRAS aims to reduce the risks associated with assets. Safety is about people as well as documentation, and reporting by people (staff) is critical, whether they report through internal processes or otherwise. Reports missed by internal systems for any reason may be crucial, and if CIRAS gathers in these missed details, this has to be beneficial to everyone. CIRAS has some 1,900 members and can help to improve reporting of vital issues for them.

Kerry spoke about the intelligence that comes from reports made to her organisation, giving examples, and described the kinds of improvement that reporters seek. Most commonly, people are looking for improved health and wellbeing, with the desire to be able to more effectively carry out their work the next most common. She spoke about a case study that involved malfunctioning driver-only operation (DOO) CCTV screens on a station platform. Internal reporting by train-crew had not been effective in resolving this problem, but reports to CIRAS resulted in the repairs being made, and in plans to further improve the infrastructure.

Any genuine health and safety concern may be reported through CIRAS. All are input to a database that is used to learn more about underlying issues. The organisation issues a regular newsletter which is freely available, “Frontline Matters” and is worthwhile reading for all in the industry.

## ACCIDENT INVESTIGATION AND TRACK-WORKER SAFETY

JONATHAN GRAHAM - INSPECTOR, RAIB

Jonathan is the RAIB's track specialist and their liaison contact with the PWI. The Rail Investigation Branch was established following the Ladbroke Grove rail crash that occurred in October 1999 and resulted in 31 deaths and over 400 injured. It was set up to be an independent investigator for railways. Its role is to inform government, the industry and the public. It is independent of all other parties and establishes neither blame nor liability. It does not seek to prosecute. The RAIB covers all main line, metro and light railways, heritage railways and the UK half of the Channel Tunnel. There are about 20 staff in all, and there are always at least five on call, one duty coordinator, and two at each of the organisation's sites in Derby and Farnborough. Moving to the subject of track-worker safety, Jonathan described the progress made since the late 1960s, when a BR report described how typically some 30 civil engineering staff deaths occurred each year. Recent statistics are considerably better, he said, with no fatalities between 2015 and 2017. Unfortunately, things are far from perfect, however, and in the last three years the RAIB had been involved in investigating 21 incidents, with five deaths among them, up to the time of preparation of his presentation. He particularly mentioned the Margham incident that others had referred to earlier in the seminar. The RAIB report on this, Report 11/2020, had recently been released, and Jonathan recommended that everyone should read it.

He discussed some of the key details from the Margham investigation, the key findings and the underlying factors identified. He similarly looked at a number of other investigated incidents, including South Hampstead and Egmanton. Staff behaviours were of critical importance in these kinds of incidents, both the behaviours of the teams and those of individual key players, such as COSS/PICs and other key safety leaders. Tradition, pressure to get the job done, unofficial working practices and the willingness or otherwise to challenge unsafe behaviours; all these feature amongst the team behaviour issues. Issues relevant to key safety leaders include their perceptions of risk, and how these change with time. The non-technical skills of such leaders are critical, and so the selection, training, development and retention of these people are of paramount importance.

Jonathan came to the question of unassisted lookouts, saying that around half of RAIB's investigations involve these. The move away from reliance upon them will be a huge cultural shift, he said. However, it is vital, and he was heartened by Nick's presentation with its suggestion of progress.

He briefly described the eleven recommendations in the Margham report, nine directed at NR, one to NR and the Railway Development Group (RDG) and the last aimed at the industry as a whole. He saw this last, which concerns the balance between operational railway needs and the need for infrastructure maintenance, as particularly important. Finally, Jonathan asked everyone to sign up to RAIB email alerts through the website www.RAIB.gov.uk and keep themselves up to date with the latest information.

## CLOSING COMMENTS / Q&A

JOAN HEERY - (CHAIR), PWI PAST PRESIDENT

Joan thanked all of the speakers and sponsors for their invaluable support, and to the PWI London Section and the PWI Operations Team for the planning and logistics for the event, and reminded all that a recording of the event and electronic copies of the presentations will be available to attendees and PWI members.

# Making tracks for the network

AUTHOR: Peter Heubeck

Peter Heubeck joined British Rail in 1979. After roles in frontline operations, freight projects and infrastructure planning, he project managed Railtrack NE, before becoming Zone Commercial Manager in Manchester.

After negotiating and implementing the first Schedule 4 regime, he played a leading role in centralising and modernising engineering trains and track materials supply. He later established Trackwork Moll as a major sleeper manufacturer and now works as a consultant.

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Manufacturing track products is specialised work, which goes largely unseen. Who are the companies, what are their challenges, how have products changed and how stable is this supply chain? Peter Heubeck reviews the sector's work supplying Network Rail and offers some thoughts on the lessons that can be drawn from its 25-year evolution since the privatisation of the UK's national rail system.

## RAIL

After the closure of rolling mills at Cargo Fleet on Teesside and Glengarnock in Ayrshire, the British Steel Corporation (BSC) plant at Workington was, by 1985, the UK's only rolling mill dedicated to volume rail production. Skilled staff produced high-quality products for the UK market and BSC also had strong export sales. However, problems loomed. Having ceased making its own steel in 1974, the Workington plant relied on the costly transport of steel blooms from Teesside. The constrained site limited rail rolling to 120 feet and prevented upgrading to make the longer rolled lengths that track engineers wanted (even high-quality factory welds form undesirable discontinuities in the rail). The plant's relative remoteness increased distribution costs.

To solve these problems, and as part of a new contract with NR, new owner Corus in 2006 converted the Medium Section Mill at Scunthorpe steelworks to roll rails up to 120 metres long, with a new high-tech rail finishing centre built alongside (Figures 1,2 3 and 4). NR could then buy rail in 216 metre "strings", incorporating only one weld. From Scunthorpe, rail-carrying trains easily access NR's distribution network via its Doncaster hub. This complex project involved both heavy investment and a major culture change at Scunthorpe, which had not previously made such high-specification products. Although tough for Workington, and despite teething problems during which some rail profiles were unavailable, this was a major advance in UK rail manufacturing and showed NR's ability to use its buying power creatively.

Unfortunately, the story has since been marred by instability in the UK steel sector. The Scunthorpe plant, now operated by British Steel and owned by the Jingye Group of China, has had four owners in 12 years. To guard against disrupted supply, NR has invested in higher stocks of rail, has given commercial guarantees to British Steel and has taken deliveries of rail from Voestalpine in Austria and Arcelor Mittal in Spain. It has even offered to purchase the Scunthorpe rail finishing centre. This offer was declined, though it is understood that it remains "on the table". In spite of these prudent steps, a threat to rail production at Scunthorpe is a major risk for the UK rail industry. Regardless of price, the few European mills capable of producing high quality long rails may not have the spare capacity to replace Scunthorpe's large output. NR represents around 6.5% of the European rail network. If demand from the large buyers (Germany, France and Italy) was increasing, NR would struggle to source rail reliably from foreign mills. Even if sufficient tonnage could be secured, establishing reliable logistics for high volumes of rail over such long distances would be difficult, costly and could not be done quickly. We must hope that British Steel, and their new owner Jingye Group, are successful and bring stability to this vital facility.

## PRE-STRESSED CONCRETE SLEEPERS

Pre-stressed concrete sleepers were a vital enabler of the continuously welded rail (CWR) revolution of the 1960s and 70s. Concrete sleepers had been experimented with for many years, but the breakthrough came with tensioning steel strand running through the length of the casting mould, prior to casting the sleeper. DowMac and Costain built seven factories to meet soaring demand as British Rail (BR) modernised its track. Costain almost secured a monopoly in 1988 when it acquired DowMac, but an enterprising ex-DowMac manager persuaded RMC to invest in a new factory at Washwood Heath in Birmingham, so a new duopoly emerged.

Demand for concrete sleepers declined during the 1980's, because those installed over the preceding 20 years were very durable and due to reduced funds for track renewals. By the mid-90s, only the Tallington (now Tarmac owned) and Washwood Heath factories were operational. RMC was acquired by the Mexican multinational Cemex in 2005 and a new factory in Doncaster, operated by Anglo-German newcomer Trackwork Moll, later replaced Tarmac's factory at Tallington. The Doncaster factory can produce around 400,000 sleepers each year and uses a modernised form of the reliable long-line casting process. This factory is novel in that the land and building are owned by NR, who wanted the logistical benefits of locating the factory at one of its distribution hubs, without granting a permanent presence to a particular manufacturer. The hub location eliminated costly daily "trip" trains to and from Tallington, out and back cycle times to worksites were reduced, specialised sleeper-carrying wagons could be used more intensively, and peak supply capability was increased.

The G44 sleeper (introduced in 1991) and the shallower EG47 now meet almost all NR's needs and are a triumph of ingenious design, balancing immense strength, resilience, durability and ease of mechanised handling. When made in large numbers in a well-configured factory, sleeper production is very cost-effective. Ironically, shallow depth sleepers cost more to make than the heavier G44, because they use more of the expensive, high-specification pre-tensioning strand to compensate for their reduced depth. Sleeper manufacturers must closely control the quality of inbound raw materials, the concrete mix, the accuracy of strand tensioning and the temperature gain during the curing process. Sleepers must meet fine dimensional tolerances, which requires the use of expensive, high quality casting moulds. With careful maintenance, these can give a long life, in spite of abrasion caused by the concrete aggregate. The high cost of new moulds can require contract variations if the client changes sleeper designs. NR has sensibly removed "legacy" sleeper types from supply contracts, enabling manufacturers to optimise production of standard designs. Sleeper factories are equipped with on-site laboratories (Figure 5) for testing dimensional accuracy, concrete strength and the positive and negative bending strength of the sleeper. Quality tests are also carried out on raw materials.

Figures 1-4 Scunthorpe rail manufacturing:

Figure 1: Passing through the finishing mill

Figure 2: On the cooling bank

Figure 3: Digital imaging inspection

Figure 4: Pre-dispatch stock

As well as good train loading arrangements, a large stockyard is needed to act as a buffer between steady factory output and fluctuating despatches. Since the advent of High Output renewals, sleeper factories also need space to unload and sort used sleepers returning from worksites. A significant recent change has been the addition of under-sleeper pads, which assist engagement with the ballast and prolong ballast life through reduced abrasion. Sleepers are cast upside down, so the pads bond with the underside of the sleeper by being placed on the newly cast sleeper.

In 2009, HS2 chose Washwood Heath as its preferred site for a train servicing depot. This choice was eventually confirmed, and Compulsory Purchase Order (CPO) powers were included in the HS2 Act. Building a replacement for the Cemex factory required the security of a major supply contract, so NR needed to issue a new Invitation to Tender (ITT). Unfortunately, this was slow to emerge, and the tender was then heavily amended after bidders had submitted their proposals for a range of sites. In its revised form, and to the dismay of bidders, NR mandated the use of a cramped site at the west end of Bescot down yard which was adjacent to residential properties. As one of NR's key logistics hubs, Bescot was a logical choice, but the nominated site was constrained and the planning risks very high. NR awarded the sleeper supply contract to RailOne of Germany but as some feared, and in spite of a changed site layout, the scheme failed to gain planning consent and the project was abandoned. To prevent sleeper shortages after the Washwood Heath factory had closed, NR spent circa £50M building up large stockpiles of around a million new sleepers at Carlisle Kingmoor and Tyne Yard. Such resolute action to maintain supply is commendable, but this very costly exercise would not have been necessary if one of the initial bids for a less risky site had been accepted. The Washwood Heath factory has now closed and the industry awaits the outcome of an "emergency" ITT issued by NR.

STEEL SLEEPERS

By the late 1980s, many secondary routes faced an unaffordable backlog of track renewals. Although not routinely used on high speed or high tonnage routes, steel sleepers have been the saviour of many regional lines. They do not require the deep ballast necessary for concrete sleepers, so if ballast conditions are satisfactory (a key requirement), very cost-effective renewals are possible by scarifying the existing ballast and using light, mobile plant to lay the new sleepers. Even if new ballast is required, they offer savings compared to concrete sleepers. Steel sleepers also offer valuable height savings when vertical clearances are an issue. David Ventry (Head of Track Engineering at Railtrack at the turn of the 20th Century) was a notable pioneer of the use of steel sleepers on routes in the north-west of England. Trackwork of Doncaster acquired the successful steel sleeper manufacturer GMT in 2016 and production continues at their Wallasey plant on the Wirral. British Steel at Scunthorpe also produce steel sleepers.

FASTENINGS

In 1957 Norwegian engineer Per Pande-Rolfsen designed what would become the world-beating Pandrol rail fastening. In an epic blunder, the Norwegian State Railways rejected the design and the global rights were promptly snapped up by the British Elastic Rail Spike company. After some refinement, this brilliantly simple and

Figure 5: Rt Hon Patrick McLoughlin in December 2013, when he was Secretary of State for Transport is shown laboratory testing of sleepers at the Doncaster factory

effective design was adopted as BR's standard in 1965/6. The initial PR1 clip later evolved into the e-clip, which in 1993 was superseded by the Fastclip, which aids mechanised installation and removal. This family of clips has been a global success. Pandrol was acquired by the French Delachaux group in 2003. Manufacturing still takes place in Worksop, although components are also imported. Despite superb product capability, it appears that relations between NR and Pandrol have fluctuated, with NR sometimes looking uncomfortable with Pandrol's dominant position.

## BALLAST

Good track needs good ballast, so compliance with the ballast specification requires strong, wear-resistant rock. The specification has, quite correctly, become more demanding over time. A requirement for improved resistance to attrition when wet effectively eliminated the use of cheaper limestone. Most hard rock is found in the west and north of Britain, where the rail network is sparse. Fortunately, the granite deposits of the Charnwood Forest north-west of Leicester are a notable exception. This area's central location explains why so much of NR's ballast comes from Tarmac's Mountsorrel quarry (Figure 6) and Midland Quarry Products' nearby quarry at Cliffe Hill. Both of these huge quarries are rail connected, but with Mountsorrel's railhead at Barrow on Soar connecting onto the fast lines of the Midland main line and with Cliffe Hill being accessed via the single-track Knighton Junction to Bagworth Junction line, train working requires careful planning. Both quarries despatch large quantities of other aggregate by rail and with loading "slots" in short supply, the quarries need NR to use their allocated slots efficiently. Another solution to the geographical imbalance of supply and demand has been using Aggregate Industries' depot on the Isle of Grain in north Kent, which is supplied by ship from Glensanda quarry on the west coast of Scotland.

NR's annual ballast demand peaked at a mighty 3 million tonnes during the height of the West Coast Mainline (WCML) Upgrade but is now much lower. The passing of this peak was followed by cuts to NR's track renewals programme, leading NR to concentrate supply on a few large quarries. HS2's decision to use slab track (which the PORR / Aggregate Industries consortium plans to manufacture at a limestone quarry in the Mendips) has avoided a potential shortage of track ballast.

Key to successful quarrying is being able to sell all of the rock sizes produced by the crushing and screening process. This works best at quarries which are close to markets for a wide range of aggregate products. This is true of the East Midlands quarries, which can offer NR volume-discounted rates in the knowledge that they won't be left with unsaleable by-products. This is a problem at remote quarries, such as the formerly railway-owned site at Meldon on Dartmoor, where huge quantities of material were simply dumped, (although Meldon "dust" was used for blanketing and other railway work). NR only uses compliant sources, but some rock deposits exceed the specified performance and make exceptionally durable ballast. Good examples are the hornfels from Breedon's Shap Blue quarry in Cumbria and the reddish-pink micro-granite quarried by Cloburn near Carstairs. NR's procurement is currently based on simple spec-compliance but could usefully assess whole life costs.

## SWITCHES AND CROSSINGS

S&C is the most complex track form. The specification, design and manufacturing of junction layouts is highly skilled work. Doing it well requires years of experience, as does developing new products and design standards. Even the simple task of ordering the right replacement item for track maintenance can be complicated by the huge variety of S&C in the network.

Figure 6: Tarmac's huge granite quarry at Mountsorrel. The primary crusher is visible on the far rim, beyond which are the secondary crusher, storage bins and the long conveyor to the Barrow on Soar railhead

Manufacturing new junctions is also complicated. In theory, the manufacturer is given a final, approved design by the client in time to meet project timescales. This can happen, but it is not the norm. Designs can go through many iterations, which challenge project timescales. Detailed activity scheduling is vital for the S&C manufacturer because a wide range of specialist long lead components, many of which are specially made, must be ordered for the complete layout to be carefully assembled, tested and inspected at the manufacturer's layout ground prior to despatch to site (Figures 7 and 8). Precise activity scheduling is all the more vital due to the peaking of S&C installation work at Christmas, New Year and Bank Holiday weekends. Sometimes it is possible to flatten workload peaks by manufacturing layouts in advance, but late finalisation of designs often prevents this. S&C layouts are not designed in theoretical isolation. Both modular and conventional layouts are designed and manufactured to suit specific installation methods and the careful sequencing of activities on congested worksites. This requires close collaboration between the designer, the manufacturer and the installation team. Complex road and rail transport plans are needed to ensure that the many elements of new layouts arrive correctly grouped, sequenced, aligned and right on time.

After adopting the heavier and stiffer CEN60 rail in 1991, Railtrack initiated a general redesign of S&C, which greatly improved ride and wear rates when passing through junctions in the facing direction. Less desirable consequences of the redesign were high wear rates for trailing movements and the high cost of modifying OLE to match the new footprint (neatly illustrating the interconnectedness of railway systems). A further complication was that the four S&C manufacturers were invited to use their own subsidiary designs for supporting the track, within the confines of the new geometry. This proliferation of fixing systems caused unwanted complexity for renewals and maintenance teams. Subsequent design revisions and standardisation by NR have largely overcome these problems. Cast manganese crossings are complex products and are impressive demonstrations of the steel-makers craft. They are subject to high impact forces and can crack or break. NR has issued a new specification for cast crossings and is working with manufacturers to develop more advanced designs to minimise these risks.

In most developed countries, the S&C market is dominated by the two international giants, Voestalpine of Austria and Vossloh of Germany. Historically, these companies have had only a limited share of the UK market. Balfour Beatty became a key player in 1989 with its acquisition of Henry Boot Railway Engineering. Other manufacturers at this time were Edgar Allen in Sheffield and Corus Cogifer (formerly Grant Lyon Eagre) at Scunthorpe. Voestalpine entered the UK market when they acquired the BR S&C works at Baileyfield in Edinburgh. Balfour Beatty became the dominant supplier in 2006 when it acquired Edgar Allen, whose immense skill with complex junction layouts and cast crossings was the stuff of legends. Vossloh subsequently became the sole owner at Scunthorpe, while Trackwork entered the market with its acquisition of Hall Rail. Progress Rail, a Caterpillar subsidiary, acquired Balfour Beatty's S&C business in 2011, which by then included an advanced new foundry near Edinburgh.

Believing there was excess capacity in the supply chain, NR issued an ITT in early 2019 which aimed to reduce its suppliers of S&C products (junction layouts, cast crossings, full and shallow depth switches, insulated block joints etc). After a protracted tender process, NR advised bidders of its proposed contract awards in late 2020. To most observers' amazement, Progress Rail, previously the largest supplier, had won no contracts. New junction layouts were to be shared between Trackwork and Vossloh, most cast crossings were to be supplied by Voestalpine, and Trackwork had won most other maintenance products. NR constituted such a large proportion of Progress Rail's business that the company placed its S&C manufacturing staff under notice of redundancy and mounted a High Court legal challenge against the contract awards. This halted the contract awards but compounded the uncertainty for all concerned while the legal process ground slowly on. In February 2021, two years after the ITT had been issued, NR finally advised bidders that it would not be awarding the new contracts and a new tender would be issued in due course.

## CONCRETE BEARERS

Concrete S&C bearers developed much later than concrete sleepers, with both S&C manufacturers and renewals teams valuing the flexibility and relative ease of drilling and handling hardwood bearers, which were readily available. The first concrete installation was at Finchley Road in 1967 and small numbers of trial layouts continued until the early 1980's, after which production began in earnest. Tarmac at Tallington perfected the "cast-in" method, which was very reliable, but required the manufacturer to invest in a large stock of expensive moulds to match the wide variety of bearers required. RMC made concrete bearers at their Washwood Heath plant from 1991, although this work was later moved to a non-rail connected site at Somercotes in Derbyshire to release space for increased sleeper production at Washwood Heath. Somercotes developed the alternative "drill and glue" method which was faster and did not require a large stock of moulds. Over time, concerns developed that bearers produced by this ingenious method had a greater propensity to develop faults around the post-casting drill holes. After Tarmac failed to secure a new long term sleeper contract, its plant at Tallington also ceased making bearers. Vossloh Cogifer at Scunthorpe subsequently invested in its own in-house bearer manufacturing capacity, an initiative that experienced significant teething problems. NR allocates bearer output from Cemex and Vossloh Cogifer to the S&C manufacturers.

On mainland Europe, modular S&C units have been conveyed to worksites on specialist tilting-bed wagons for many years. In spite of the more restrictive UK loading gauge, this technology was adopted by NR as part of the "7-day Railway" programme. It invested heavily in a fleet of tilting wagons and cranes. A key aspect of the project was the design of the connecting bearer joint. Rather than adopt a proven European design, NR chose a new design which tried to achieve complete rigidity between linked bearers, (whereas European best practice favoured a flexible joint). The performance of the rigid joint has proved problematic, causing cracked bearers and significant maintenance problems. These difficulties have unfortunately made some track engineers wary of modular S&C, which is a concept with great potential. Persistence is a virtue! A move to flexible bearer joints may now be in the offing.

## SUSTAINABILITY

Railway departments have always sought to extend the life of, and find secondary uses for, track materials. Originally the motivation was financial, whereas sustainability is now a policy objective in its own right. Although used ballast recycling had taken place previously, Railtrack introduced this on an organised, national basis when it took charge of ballast procurement and organising engineering trains. This has been successful, although at times of low demand for aggregates, it can be difficult to sell recycled material in competition with discounted virgin aggregate. NR operates track recycling depots at Crewe, Westbury and Whitemoor (which also specialises in used S&C). NR also sells used concrete sleepers from High Output track renewals which return to the Doncaster sleeper factory (the best being reused by NR). Concrete sleepers are difficult to crush and recycle since the concrete adheres to the steel strand, which itself distorts into awkward shapes. Fortunately, there is steady demand for them as a complete item.

Unusable rail is sold to steelworks, either to charge blast furnaces or for melting in electric arc furnaces, such as those at Aldwarke, near Rotherham. NR has produced "second hand" long rail by cutting and welding recovered rail at its Eastleigh rail depot. The most efficient form of rail reuse is when it is moved directly from site to site without being handled at a depot, but this takes a lot of organising and the buy-in of asset owners.

## CENTRALISED PROCUREMENT

Following BR privatisation and Railtrack's decision to leave material procurement largely with its contractors, long-welded rail was the only centrally procured track material. Uncoordinated ordering of materials by contractors was seen to lead to delays, over-subscribed manufacturers, inefficient logistics and a lack of forward visibility of demand. Following the cross-industry 1997 Engineering Haulage Review, Railtrack quickly centralised the ordering of ballast and

engineering trains. Realising this approach could be cheaper and could increase supply capacity, sleepers and S&C soon followed. Costs were reduced, supply reliability and product quality improved and distribution logistics were modernised. The new procurement and logistics team collaborated closely with Track Engineering over the adoption of CEN60 rail and the relocation of rail manufacturing to Scunthorpe. In addition to meeting routine demand, they worked closely with projects colleagues to resource major blockades, the WCML Upgrade and High Output track renewals. Indeed, the reforms stemming from the 1997 Engineering Haulage Review were a vital enabler of these critical projects.

From the outset, the new procurement and logistics team included managers with practical experience of the supply chains they were managing. Although tensions could still arise, serious efforts were made to tackle underlying problems between the end customer, Track Engineering, the procurement team and the manufacturer. These closer links were weakened as a result of NR's troubled reorganisation of its headquarter (HQ) departments and physical relocation of staff to Milton Keynes in 2009/10. Links were weakened again following the retirement of Martin Elwood, the railway manager who had developed the team over 13 years and who knew all key suppliers personally.

## SOME CONCLUSIONS

Having worked in and observed procurement and supply chains over the last 25 years or so, what are the lessons of history and of experience? Important questions remain and face those now in charge of the rail industry's procurement, supply, and engineering functions. The conclusions below are offered to stimulate discussion on how those questions can be answered as our industry faces yet more challenge and uncertainty.

## PROCUREMENT

The procurement regulations with which public sector purchasers must comply are onerous and complex. NR works hard to state clear requirements in their tenders, which include detailed scoring criteria. This means the ITT must be "right" before it is issued, since with mechanistic scoring systems and little open dialogue with bidders, the purchaser effectively loses control of the outcome after this point and can become a prisoner of its own process. An ITT which is inadequately thought through can lead to unpredictable and potentially damaging outcomes. NR is such a dominant client that suppliers may understandably be reluctant to protest when they believe NR is making a mistake. A culture of silence which stifles debate and allows mistakes to go unchallenged would be unhealthy and must be avoided.

## WHAT PRICE KNOWLEDGE?

Periodic Reviews have created relentless pressure on staff costs, especially on those not in front line roles. The vital role of backroom track engineering has been undervalued. Repeated reorganisations tend to deplete an organisation's knowledge base and leave engineers wrestling with conflicting priorities. Ownership changes, and the cumulative effect of competitive tendering - which usually undervalues product quality and product development capabilities - tend to eat away at company engineering resources. Such pressures are inevitable and fall on all producers and procurers, but they must be acknowledged, understood, and well-managed.

## COST, VALUE, QUALITY AND CULTURE

How does one measure value for money? What is the "right" price for safety-critical track products which must perform reliably for long periods with minimal maintenance? A simplistic answer is to say that competitive tendering will fix the price and suppliers must

Figure 7: S&C assembly needs space! VAE's 18,000 square metre layout ground at Harworth near Doncaster

manufacture products in compliance with the standards and designs which form the basis of tenders and supply contracts. Of course they should, but real life is rarely this tidy. How do you value exceptionally durable, longer lasting ballast, when all bidders appear to comply with the ballast specification? How do you value the work of the S&C supplier who always goes “the extra mile” to manufacture on time following late changes by the client, or who consistently has the least faults on layouts at the pre-despatch client inspection? Is it best to secure the lowest price, even if this means the manufacturer can’t justify the cost of technical support or product development resources? These are not simple issues to resolve. Purchasers must declare their tender evaluation process and scoring criteria to bidders for contracts. Scoring must be based on objective facts and evidence. With NR tenders having the power to make or break companies, bidders can be tempted to make rash promises and offer unsustainably low prices, simply to win a contract. Whether driven by desperation or cynicism, this approach has a horrible logic to it, because once a major contract is awarded, power subtly transfers from the client to the supplier, especially if competitors have been driven from the market.

Procurement teams must, of course, achieve excellent value for money. To achieve this the tender evaluation process must be clever enough to measure value in all its forms and give the right weighting to critical measures of quality. Similarly, supply contracts need to reward excellent performance and penalise “bad” behaviour or substandard products. This requires both suppliers and purchasers to invest in, and really own, effective quality management systems. Although there are many shining examples of good practice, poorly constructed tenders, erratic product quality and ineffective contract management are not unknown. Behaviour matters, and nobody has a monopoly on good or bad behaviour. NR has occasionally behaved unfairly towards manufacturers. To suppliers, NR can seem aloof or unaccountable. Suppliers on the other hand can become complacent, even arrogant, neglecting their customer’s interests or seeking to exploit contractual loopholes. Collaboration based on mutual respect, aligned objectives, honest endeavour and “one version of the truth” is always more productive.

## WAYS FORWARD

Modern track is a superbly engineered system. Its long and brilliantly successful evolution has depended on close collaboration between informed users and skilled manufacturers. Even if post-Covid train frequencies are reduced, we shall still have an intensively-used, mixed traffic railway network, with limited possession opportunities, severe cost pressures and a need for very reliable assets. Success in this challenging environment requires very close links between maintainers, renewals teams, procurement, Track Engineering and manufacturers. The information, knowledge, products and commitment are all potentially there, but can be better harnessed. Compliance with procurement legislation is essential, but closer collaboration, based on the real needs of end users, is vital if our industry is to meet its challenges. Space must be found for creative dialogue.

NR has built a formidable procurement machine and has great logistics capabilities. Centralised procurement can be very efficient, but real damage can be caused if a major tender goes “wrong”, with serious impacts on internal customers, other clients and the supply chain itself. NR needs to use its dominant position wisely; understand the supply chains it depends on and make great efforts to listen to suppliers. Its procurement processes should be as simple and as fast as possible, and it should be less resistant to buying patented products when they are the best solution to a problem. Manufacturers, meanwhile, must be utterly focused on meeting customer needs, must deliver on commitments and should support clients rather than exploit their vulnerabilities. Manufacturers must have the confidence to engage with clients in new ways and to speak out to prevent things going awry or important opportunities being missed.

IMAGES COURTESY OF:

Figure 1-4 British Steel / Figure 5 Network Rail / Figure 6 Tarmac
Figure 7-8 voestalpine Turnout Technology UK

Figure 8: Battersea Pier junction assembled for NR inspection at VAE’s Harworth site prior to installation, Christmas 2018

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# ANDY²

We Andys will soon have been PWI Technical Content Managers for two years and we hope the content we've been bringing you so far has been interesting and engaging. We thought that this Journal's "Andy Squared" would be a good opportunity to take stock and let you know more about the content and activity we are responsible for, and how we would really like you to engage with and contribute to this. We'll cover the different types of technical content and activity we look after with one at a time:

## JOURNAL ARTICLES

Journal technical articles are a mainstay of the PWI's published content. You will have noticed that over the last year or so that the Journal has been evolving and we are now in the position where the primary function of the Journal is to publish articles that we hope members will find technically interesting and stimulating. The Journal sets out to cover technical subjects, activities and innovations of interest to practitioners in the contracting, client, consultant, academic, standards setting and products and services communities. We want to provide "bridges of understanding" between these communities that lead to useful development of knowledge and its application. Through these articles, we aim to tackle the requirements and problems experienced by practitioners and how they are solved by innovators, researchers or by people who can pass on their experiences.

We would really like to encourage readers to contribute articles for publication in future Journals! Doing this meets key objectives for personal development and CPD, sharing your knowledge with others and letting them share with you. So, wherever you are in your career, please think about writing and submitting an article for a future Journal and get in touch if you want any help or advice about how to do this. Articles could (for instance) be about the delivery of a project, approaches to maintenance, how you have developed or applied new tools and technologies, research and innovation, meeting the challenges of climate change and sustainability or how you have overcome difficult engineering problems – the list is endless!

We typically look for articles to be between 2,000 and 4,000 words long (although we often publish papers outside these boundaries) illustrated with interesting tables, diagrams and (safety compliant!) photos. Go on - give it a go!!

## TEXTBOOKS

The PWI has published and sells a number of really useful textbooks including "Understanding Track Engineering", "Understanding Rails and Rail welding", "Switch and Crossing Maintenance", "Design of Switches and Crossings" to name a few. These can be ordered from the PWI website shop.

We are currently putting together a strategic plan for reviewing and revising these books to make sure they are up to date and relevant to the tools, technologies and practices of today. We very much want to include willing PWI members to play a role in this, so if you want to volunteer to review, revise or author sections of our textbooks of the future, please let us know – we will be very grateful. Again, this sort of involvement really boosts your personal development and the quality of your CPD!

## THE PWI'S KNOWLEDGE HUB

The Knowledge Hub on the PWI's website is your portal to treasured technical knowledge curated by the PWI! From here, you are able to search for relevant Journal articles, seminar presentations, handbooks, track guides and video content such as recorded PWI section meetings. Some of these generic resources are discussed below with a call for you to be involved with refreshing them or adding to their volume.

## TRACK GUIDES & INDUSTRY HANDBOOKS

A wide range of Track Guides and Handbooks have been created over the years and can be accessed through the PWI website. For example, the "Guide to Track Stiffness" produced as a result of a Track Stiffness Working Group Initiative and edited by track experts from the University of Southampton was published in 2016 and can be downloaded if you are a PWI member. More recently, the "Geocells Technical Guide" has been written by Network Rail and peer reviewed by experts from the PWI, consultancies, international universities and from Network Rail itself. This valuable new guide will soon be available through the Knowledge Hub on the PWI website.

As for best practice handbooks, a dozen or so of these excellent little documents were written and published in the earlier 2000s by collaborating railway contracting and client organisations operating back then. These publications reflected best practice at the time they were published and whilst this may now sometimes have moved on, they remain valuable resources to refer to.

Many of these are available through the PWI's Knowledge Hub and plans are afoot to refresh them or at least provide accompanying statements that describe key changes in practice since they were written. Please get in touch if you would like to play a part in this process.

## PWI CONFERENCE, SEMINAR & SECTION MEETING PRESENTATIONS

Under "normal" circumstances, the PWI holds at least three national conferences or seminars each year and the presentations given at these as well as presentations from the great many Section meetings held each year form a hugely valuable set of resources. Many of these presentations can be searched for and downloaded from the Knowledge Hub as PDF or PowerPoint documents. Increasingly there are also videos of Section meeting presentations that you can view on YouTube, accessing them via the PWI Knowledge Hub.

## THE PRACTICAL TRACKWORK CHALLENGE

Andy Steele is taking the lead in organising the Practical Trackwork Challenge (PTC) that, Covid-19 permitting, will finally take place in October 2021. The PTC is one of our most popular events where we as a community of track infrastructure engineers help a heritage railway with a track renewal, whilst sharing our skills with our Corporate Members who can send delegates to the event who have little or no experience of track renewals work. We are always looking for help at this event in the way of skilled demonstrators and trainers, in particular land surveyors, small tools and plant operators and track supervisors. This event also provides an opportunity to demonstrate new technology and innovative methods of working. Andy Steele is currently putting a five-year plan together touring this event all over the UK. Please get in touch if you think you can contribute in any way to the PWI Practical Trackwork Challenge.

We hope this summary gives you an idea of what the PWI makes available for you to access, engage with and use to expand your technical knowledge and horizon. We also hope that you will consider contributing to making these resources even better in the future, by using your unique input to produce new content or to improve and update existing content for sharing with and expanding the knowledge of fellow PWI members.

*Get in touch to see how you can engage with the PWI: andy.packham@thepwi.org | andy.steele@thepwi.org*

# PROFESSIONAL REGISTRATION

Professional Registration is an important step in pursuing a career in engineering and it lends itself to a ready-made career path, progressing through the grades as your experience broadens and deepens.

Putting those letters after your name (EngTech, IEng or CEng) instantly tells employers, clients and wider society that your competence and understanding of engineering principles has been independently assessed, that you have the knowledge, skills and professional attitude they value, and that you are committed to developing and enhancing your competence. It sets you apart from your non-registered colleagues.

The right professional registration title for you is based on your academic and professional competence: here's a general guide…

## EngTech

Engineering Technicians apply proven techniques and procedures to the solution of practical engineering problems.

They hold Level 3 engineering/technology qualifications and 2-3 years industry experience, OR 3-5 years industry experience.

## IEng

Incorporated Engineers maintain and manage applications of current and developing technology, and may undertake engineering design, development, manufacture, construction and operation.

They hold Level 6 (Bachelors) engineering/technology qualifications and 3-5 years industry experience, OR 5-10 years industry experience.

## CEng

Chartered Engineers develop solutions to complex engineering problems using new or existing technologies, and through innovation, creativity and technical analysis.

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I started my CEng application to celebrate and recognise my engineering achievements from my early years as an apprentice to my current role as Senior Design Engineer.

Making a start on the application felt overwhelming at the beginning but I took the opportunity from the Covid-19 Lockdown and the spare time it brought to focus on the application and crack-on with it.

It was a satisfying feeling when I finally completed the report and the opportunity to describe my engineering experiences through a range of projects I had led, and the lessons learnt. The competency framework enabled me to capture and align my achievements through the key requirements of the application which included demonstrating my consideration to the safety and wellbeing of others.

The entire process enabled me to reflect on my career and the amazing people I have met along the way. It highlighted the importance of not only what I did but how I did it and the significance of having a network of people and organisations to help make it happen. This is reflected in my CPD which for me is a journal of contacts and information I can continue to refer to as part of my professional development plan as the journey continues, having achieved the honour of becoming a Chartered Engineer.

Errol Maginley CEng MPWI

Senior Design Engineer: Track Alignment
Network Rail Design Delivery

We reached 212 PWI registered engineers last month, with 123 Engineering Technicians, 34 Incorporated Engineers and 55 Chartered Engineers. I am pleased to report that the virtual PWI Professional Review interviews in December were a great success with an exceptional pass rate in all areas. There were two special achievements of note, a Technical Report route Chartered Engineer result for an ex-Network Rail Apprentice and an Experiential Learning CEng for someone with nonstandard qualifications. I offer my sincere congratulations to both and look forward to plotting their enhanced careers. These results are a great tribute to our dedicated mentors and sponsors.

We are working hard to get more early career rail engineers qualified at EngTech level. The target area is those on training schemes, apprenticeships and graduate schemes who can qualify with between 1-2 years' good railway experience. This will be a major focus for us now as we have over 500 student members from amongst those doing HNC's and BEng degree apprentice schemes. The important thing is to get qualified as soon as you can and get on that ladder! I keep saying that having the letters after your name "EngTech MPWI" opens doors and gives you choices.

Proposals are also being developed for a HNC to Incorporated Engineer route by a combination of courses and railway experience. Our Professional Development Officers are working well to promote industry links through more workshops offered to Corporate Members.

Finally, the PWI Reviewers, believe it or not, enjoy passing people! 30 of our great band of volunteer PWI Reviewers attended the annual forum recently and also had refresher training. There were many good suggestions for improvement, mostly related to improved mentoring and benchmarking of levels for each grade.

It is good to see that in the PWI, people can progress right up the higher professional levels and I get great pleasure in seeing them achieve what sometimes seem impossible goals. Determination pays off and help and support from PWI members pays dividends.

**Brian Counter**
TECHNICAL DIRECTOR
Permanent Way Institution
technicaldirector@thepwi.org

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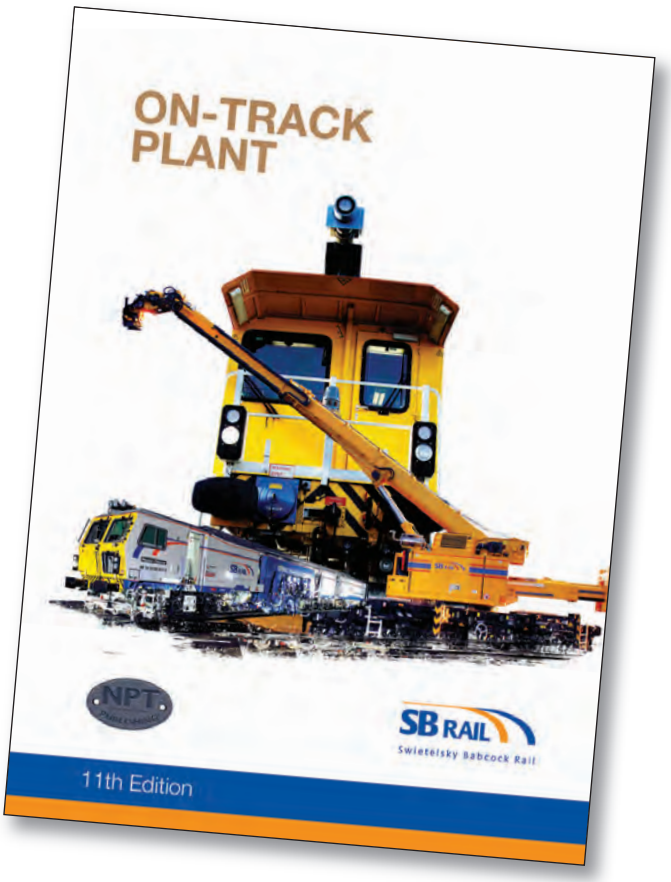


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# TECHNICAL TRAINING TO SUIT YOU


## COURSES DELIVERED BY INDUSTRY EXPERTS

PWI training started over 100 years ago and has been providing high level technical training for engineers and professionals operating at all levels ever since. Our courses are designed to develop skills and knowledge in all aspects of track repairs, renewals and projects - and can help you on your journey to professional registration.

Join us in person or in our virtual classroom from your home or office as we deliver our industry revered, first class training directly to you. All PWI courses use the most up to date content and standards; both attendance options provide the same high quality materials, tutorials, group discussions, interactive working examples and access to tutors in a 1-to-1 environment to answer queries or recap areas of uncertainty. A printed course book, personal workbook and PWI textbooks will be made available in class, or posted to your home address ahead of your start date for virtual candidates.

Awards are made by the PWI upon successful completion of written or online assessments. These comprise Certificates and a Diploma, which has been professionally validated at university level.

"I recently attended the final module of the PWI Track Engineering Diploma course, and want to say I found the three modules thoroughly enjoyable and valuable in developing my understanding of railway maintenance and its interdependencies. Thank you for putting together a brilliant course which was well presented. I am now interested in becoming an Incorporated Engineer.

**Chris Fuller**
Senior Engineer: Track, Switches & Crossing
Network Rail

# NEW ELECTRIFICATION ENGINEERING COURSE

We are delighted to launch the new PWI Electrification Engineering Course for 2021, following continued interest in this invaluable industry topic.

MODULE 1: 28 June - 1 July 2021

The aim of the programme is to give delegates an understanding of the principles of the theory and practice of electrification engineering in the UK.

Gain an understanding of the theory and practice of overhead electrification engineering in the UK, including history and context, interfaces, inspection and maintenance.

Further modules are under development and will include design, construction, asset management, 3rd/4th rail and side contact systems. These will lead to a qualification which is mapped to HE Level 6 and provides further learning from HNC, HND and Foundation Degree towards IEng level.

Course cost: £645 Accommodation cost: £245 See www.thepwi.org for full details

Image: **Lawrence McEwan MPWI Principal Construction Manager - Network Rail**

## PWI S&C REFURBISHMENT TRAINING COURSE

28 September - 01 October 2021 Derby

Delegates on this course will gain comprehensive detailed knowledge of S&C and how to undertake refurbishment safely, efficiently and to the required engineering quality. The course will cover both the track assemblies and the trackbed under S&C.

Participants will undertake detailed analysis and inspection of layouts so that they can scope and specify work correctly to provide the necessary life extension of the layout. The course will then ensure that delegates understand the various maintenance interventions suitable for S&C and its components and can plan those required in the correct sequence. Modules include: S&C Components Design and Analysis / Site Survey and Measurement / Scoping and Planning.

Delegates will have to pass a formal assessment at the end of the course and will be awarded a PWI Certificate in S&C Refurbishment on successful completion.

Course cost: £895  Accommodation cost: £325

See www.thepwi.org for full details

## PWI TRACK ENGINEERING DIPLOMA

Top-up qualification to IEng for HND / Foundation Degree Holders

The aim of the programme is to give delegates an understanding of the principles, theory and practice of track engineering in the UK. It is comprised of three modules and involves 100 hours of taught study all mapped to HE Level 6. Upon successful completion of all three modular assessments, candidates will be awarded the PWI Diploma in Track Engineering.

This course is aimed both at newly qualified and experienced engineers, and will give delegates the knowledge and skills needed for professionals in track engineering.

### MODULE 1: TRACK MAINTENANCE

7 - 10 June 2021 Derby
6 - 9 September 2021 Virtual Training Classroom

Gives a basic understanding of track engineering and its theory and context. Develops a knowledge of track types and features, its interfaces with other rail infrastructure including earthworks, structures and clearances, and track maintenance including ballast, drainage, stressing, grinding and welding.

### MODULE 2: TRACK DESIGN

21 - 24 June 2021 Virtual Training Classroom
20 - 23 September 2021 Derby
25 - 28 October 2021 Virtual Training Classroom

Focuses upon track design for projects and enhancements. Through design case studies and exercises, develop skills in track design of plain line and switches and crossings, component knowledge and configurations, layouts, innovations and life extension, route evaluation and trackbed design.

### MODULE 3: ADVANCED TRACK ASSET ENGINEERING AND RENEWALS

17 - 20 May 2021 Derby
19 - 22 July 2021 Virtual Training Classroom
8 - 11 November 2021 Derby
6 - 9 December 2021 Virtual Training Classroom

The study becomes more strategic and delivery oriented with advanced asset management techniques and applications. Gain a deep understanding of UK track renewal planning, plain line, S&C, existing and future methods, rail renewal scenarios and optioneering, and learning from accidents. Understand advanced technical rail management issues, rail sustainability and strategic track asset management.

Module cost: £645 (Virtual or Derby)  Accommodation cost: £245

See www.thepwi.org for full details

COVID-19

We are monitoring our plans to deliver our training courses and are working very hard to ensure learning with us is not interrupted. We are committed to delivering first class technical training, developed and delivered by experienced rail infrastructure engineers. Please check the website for the most up to date information or contact us: secretary@thepwi.org 01277 230031 (option 1)

We have done our final review of 2020 and despite Covid-19 we delivered fifteen courses, eleven virtually and four at Derby with over 250 trainees. It was an interesting change of take up with many “new” people liking the opportunity to do virtual courses because it suits them both in the UK and abroad. Ong Chin How from Malaysia found it fine, even though it was in the late evening! We are conscious of the problems of sitting behind a screen for hours and that is why our model is 2½ hours in the morning and 2 hours in the afternoon with self-study, usually Monday to Thursday. There were those who deferred their plans as they wanted the face-to-face experience and we have respected their views. They will be welcome at Derby when we start again in May and we are all looking forward to those railway chats in the evenings!

The plan for 2021 is 24 courses, including a new model for S&C Refurbishment for a Monday to Friday course with site visit. When you read this, we will have already delivered a split course; the first part being virtual as we did not want to defer it knowing the demand is high. Also, Network Rail graduates again figure highly into our plans with 81 being trained virtually over two weeks.

Finally, the great news is that we will start on electrification training in June 2021 with Module 1 of a new award - PWI Electrification Engineering Diploma. I am very pleased by the help given to me by Glen Wiles, Alan Derbie and Garry Keenor and the book that will be used on the course is available for free download from: www.ocs4rail.com/downloads

**Brian Counter**
Technical Director
Permanent Way Institution
technicaldirector@thepwi.org

In-person courses held at the Derby Conference Centre in Derby.

These courses include all training materials and lunch. Accommodation at the venue includes evening meal, single room and breakfast.

All prices are exclusive of VAT.

FOR FURTHER INFORMATION AND BOOKING VISIT THE WEBSITE

WWW.THEPWI.ORG

secretary@thepwi.org
01277 230031 option 1
technicaldirector@thepwi.org

PWI TECHNICAL SEMINAR

# HIT THE NORTH

## Insight into upcoming railway infrastructure developments in the North

5 OCTOBER 2021 MANCHESTER CONFERENCE CENTRE

BOOKING NOW OPEN: www.thepwi.org

£85 MEMBER
£150 NON-MEMBER

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David Woods
Chair, PWI Manchester and Liverpool Section

"The UK government has recently invested £589m to kickstart rail upgrades as part of the Transpennine Route Upgrade programme driving rail improvements across the North of England. The seminar will review the upcoming multi-billion pound rail programmes including Trans-Pennine Route Upgrade, Northern Powerhouse Rail and High Speed 2 which will Hit the North over the forthcoming decade and beyond, providing generational change and legacy benefits of capacity and connectivity to supporting growth of the economy.

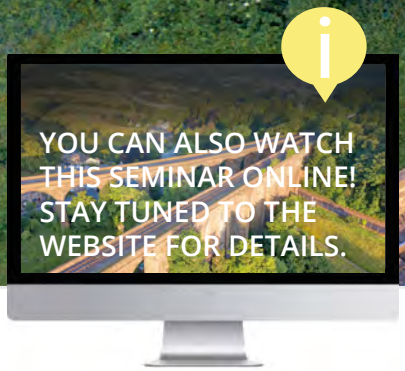
Delegates will hear about latest developments, collaboration and integration of these programmes which will provide insight into the future workload pipelines, highlighting the skills and resources needed.

The seminar will explore how the latest innovation and technology advances in the rail industry are being used to support these programmes to provide value for money, cost effective solutions whilst also addressing the traction decarbonisation climate change challenge. Lessons learnt will be shared from previous programmes that are applicable to all upcoming rail works.

Guest speakers from across the rail industry; Transport for the North, High Speed 2, Transpennine Route Upgrade, Network Rail, Tensar and Northern Rail will cover multifaceted aspects of rail engineering which are developing at pace.

Speakers include:

- Keynote Speaker: Tim Wood, Transport for the North, Director
- Howard Mitchell, High Speed 2, Head of Innovations
- Neil Kerry, Transpennine Route Upgrade, Technical Design Authority Systems Lead

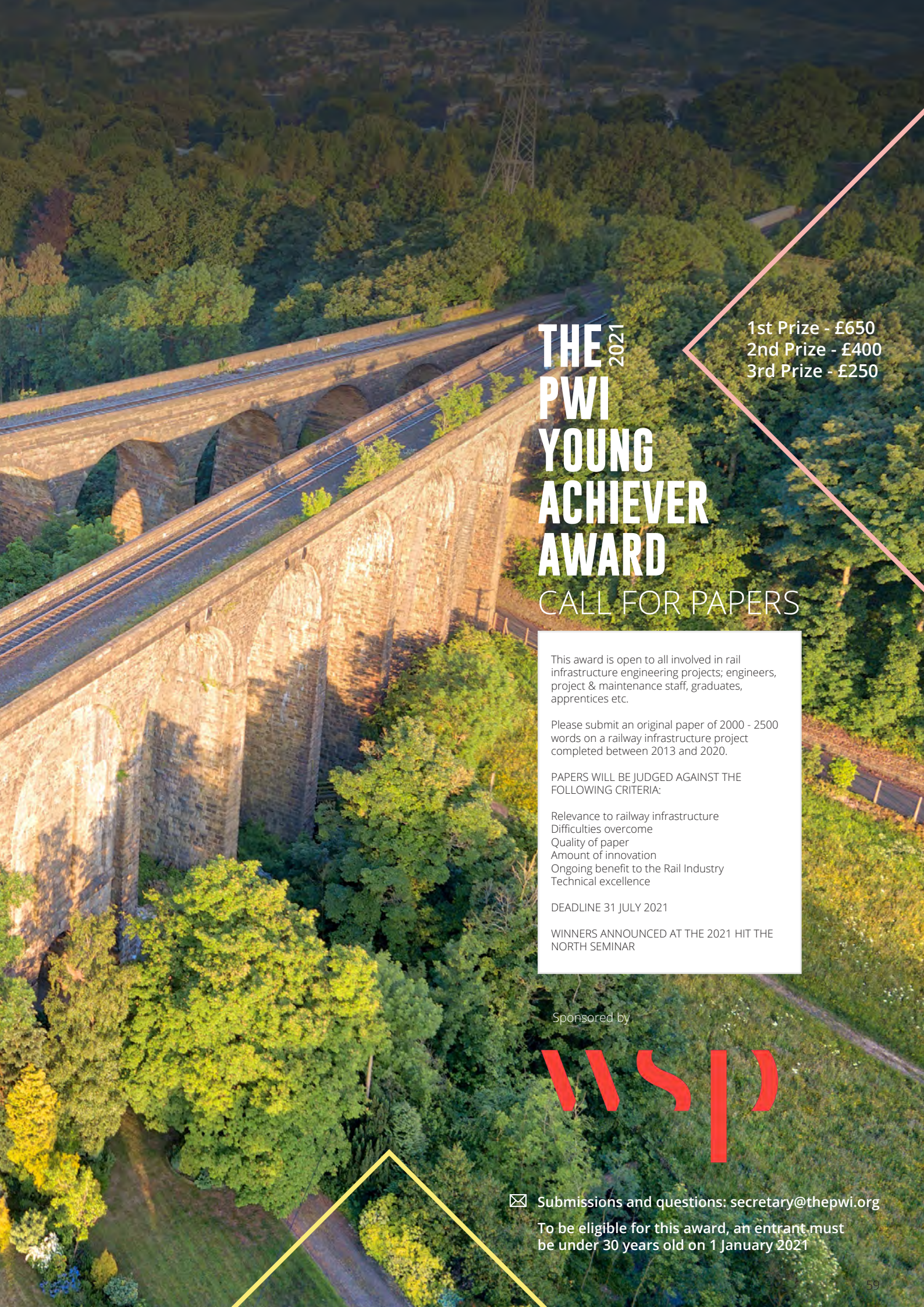



The 2021 North West Technical Seminar will review the proposed upcoming developments in the North of the UK and the latest innovation and technology advances in the rail industry to support these programmes.

Delegates will hear from leaders across the rail industry on:

- The latest updates from major programmes including Trans- Pennine Route Upgrade, Northern Powerhouse Rail and High Speed 2
- Safety considerations
- Climate change challenges
- Latest innovation and technology advances in rail

SPONSORSHIP AND EXHIBITOR SPACE AVAILABLE Contact 01277 230 031 / secretary@thepwi.org



# THE PWI YOUNG ACHIEVER AWARD 2021

## CALL FOR PAPERS

**1st Prize - £650**
**2nd Prize - £400**
**3rd Prize - £250**

This award is open to all involved in rail infrastructure engineering projects; engineers, project & maintenance staff, graduates, apprentices etc.

Please submit an original paper of 2000 - 2500 words on a railway infrastructure project completed between 2013 and 2020.

PAPERS WILL BE JUDGED AGAINST THE FOLLOWING CRITERIA:

Relevance to railway infrastructure
Difficulties overcome
Quality of paper
Amount of innovation
Ongoing benefit to the Rail Industry
Technical excellence

DEADLINE 31 JULY 2021

WINNERS ANNOUNCED AT THE 2021 HIT THE NORTH SEMINAR

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✉ **Submissions and questions: secretary@thepwi.org**

**To be eligible for this award, an entrant must be under 30 years old on 1 January 2021**

# THE NEW NEW NORMAL

## HOW THE PWI CAN HELP YOU TRANSITION INTO THE POST-LOCKDOWN WORLD

Here's hoping we're not jumping the gun with this article in hedging our bets that the UK is not going to curveball into further lockdowns. Presuming this is the case, many of us are now facing the challenge of the transition to this new "new normal" as places of work reopen, deferred physical operations resume, and all with social distancing and anti-Covid measures still in place. It is perfectly natural to feel a level of anxiety and apprehension over this next phase, especially given the amount of time we've been living under the constraints of "lockdown normal". So, as the UK starts to embark on the journey out of lockdown, what does "new normal" look like and how can the PWI support you?

### KNOWLEDGE RESOURCES

The greatest asset we can take from the last twelve months and apply going forward is knowledge. The PWI knowledge community has been immensely productive throughout the pandemic. Our adoption of online tools has enabled us to deliver more talks and presentations to a wider audience than ever before. Some of these industry talks have been directly focussed on Covid-19, such as the SPOLKS (Special Online Knowledge Shares) series, with experts explaining how rail operations have had to adapt quickly and safely. As a PWI member, through our online Knowledge Hub you have access to all this captured knowledge in the form of videos, articles and presentations. Please tap into this unique library of data and use the search facility to find material relevant to you.

### SUSTAINABLE RAIL

It's no coincidence that the European Commission has named 2021 as the "year of rail" with a continent-wide drive to promote rail as the sustainable transport of choice, as the world refocuses on the twin challenges of decarbonisation and adapting to climate change. Only time will tell how far use of road and rail will recover towards their pre-Covid levels, but we do know that companies everywhere are now set up for remote working. That means the demand for office space will fall - and so will the numbers of those who routinely commute.

Here in the UK, and within the PWI community, we are playing our part in the effort to reduce carbon emissions by arguing for the expansion of railway electrification, by seeking the active encouragement of modal shift to rail, and by understanding how the emissions associated with engineering work can be eliminated or reduced. How can you get involved? You could volunteer as a PWI Ambassador (focussing on sustainability); or you could find out what your company and other companies you work with are doing to reduce $CO_2$ emissions and to cope with more extreme weather events. We'd love to hear about what you and your colleagues are doing in this area. With a legal target of net zero $CO_2$ emissions by 2050, sustainability is set to be the "hot topic" for decades to come.

### PERSONAL DEVELOPMENT

While the rail industry may not have suffered Covid-induced displacement to quite the same degree as the hospitality and retail sectors, it is evident that the constraints imposed by the pandemic and lockdown have caused some in the industry to put their personal development on hold. Employment concerns, home schooling, and loss of support networks have taken their toll but as UK society moves towards something resembling pre-Covid functionality, the PWI is keen to help members pick up the threads and keep track of developments and opportunities in the world of railway infrastructure engineering.

The Institution has set out to deliver a full programme of training courses in 2021 – in a mixture of online and face-to-face formats. We're planning to deliver a normal sized programme of seminars running between July and November and we'll be on the ground offering help on development - and textbooks - at Rail Live in June, and at Infrarail in September. Online Section meetings continue and at least some are likely to move to in-person format from September. Our professional registration manager is always happy to supplement the advice on formal Engineering Council registration provided on our website.

We're always on the lookout for interesting Journal articles. If the topics you're working on interest you, they're likely to interest many of our other members too, so why not write one of them up as a potential Journal article? Authorship is a very effective way of getting noticed! Finally, our website hosts an array of useful development tools, including My CPD for recording what you've experienced and achieved in a structured way, and guidance on CV writing and interview techniques.

## COMMUNITY SUPPORT

One of the biggest challenges the pandemic has inflicted on us all is the physical disconnection of communities. Yes, online tools helped to alleviate this, both socially and professionally, but living physically isolated from others has felt unnatural and unsettling for many. And worrying reports on the state of the nation's mental health have appeared several times over the last year. Now, we face meeting in person once more, whether at social or professional events or just back in the workplace. Regardless of the setting and the numbers involved, it is only human to face this change with a mixture of excitement and trepidation. So, how can we help?

Firstly, for those feeling a bit lonely and bereft of company, you can join any of our Section meetings online, and then pop along to local face-to-face Section meetings once they resume. Most, if not all, online Section meetings are open around 15 minutes before formal start time, which allows additional socialising. Some meetings include a similar period after the formal meeting has concluded.

Secondly, if you are experiencing unusual stress or significant levels of fear or concern over an impending transition back into a physical work environment, please consider talking to your GP, or a friend, colleague, manager that you trust, or a confidential support service. Many employers including Network Rail and Transport for London provide confidential support and there are a number of charitable organisations who also offer advice and trained counselling. Network Rail's Safety Central website has relevant advice and is available to all in the industry at: https://safety.networkrail.co.uk/healthandwellbeing/living-with-mental-health/

The site also carries the contact details for sources of confidential support: https://safety.networkrail.co.uk/wp-content/uploads/2016/06/Mental-Health-support-group-contacts.pdf

Lastly, TfL advice for employees is provided on their private intranet, however general advice on dealing with stress or mental health concerns, together with contact details for sources of confidential support are freely available at: https://tfl.gov.uk/info-for/taxis-and-private-hire/licensing/health-and-wellbeing

## HEALTH AND SAFETY

The rail industry responded very quickly and efficiently to the health and safety challenges raised by Covid-19. We had to – because putting the safety of staff and passengers first is fundamental to our industry's successful operation. As we move out of lockdown and particularly as those who've been working at home start to work at office and site locations, is it imperative that all understand and take account of changes in the safe working regime that have been implemented in the lockdown period. Nick Millington's article on page 10 of this Journal is a great place to start for an insight into the major changes that have been made affecting how and when we work on railway infrastructure.

If you're returning to working in an office or site environment after a prolonged period of working from home, make sure that you're fully up to date with any changes in processes, procedures, and standards that have occurred while you were at home. If you're at all unsure, ask your supervisor or manager to bring you up to date.

We know that lack of familiarity with workplace settings can increase the risk of accident and industrial illness. If you've been away from a particular working environment for several months, recognise that you're likely to be at least a little unfamiliar with it, and take extra care to confirm that you've got the measure of all the hazards present and are applying all the risk controls necessary to stay safe and healthy. Keep an eye out for others too: teams are safest when each member is monitoring their teammates safety as well as their own. Finally, it's helpful to remember that companies working on railway infrastructure operate "worksafe" procedures, so if you're in any doubt about your own or others' safety, stop and raise your concern with the person in charge of the work: always better safe than sorry…

We really hope this article helps in any post-Covid transitions that you are facing, and we would love to hear your stories going forward.

# Our people

## NEW MEMBERS

We're honoured to have you on board and are thoroughly looking forward to working with you. We'll keep you updated on news and events via our monthly newsletter as we don't want you to miss a thing. We have a thriving social media network and we'd love to see you get involved! We're here to help, so if you have any questions, then shout out!

**ASHFORD:** Mathew Rippin, Daniel Sears, Joshua Hammond **BENGALURU:** Utkarsh Singh, Kishore Gudepu **BIRMINGHAM:** Ranga Pabathi, Matthew Evans, Philip Hough, Ellie Yuruker, Ana Skarova **Cheshire & North Wales:**Richard Daly, Daniel Duff, James MacLellan, Oliver Homer **Croydon & Brighton:** Ben Cooke, Mikael Kauzeni **Edinburgh:** Callum Kay **Glasgow:** Colin Deuchars, Johncolin Rowe, Leon Ballin, Khurram Arshad, Hannah Thomson **International:** Wing Hung Wong, Christopher Alexander, Jaymee King, Aran van Belkom, Nicholas Meredith **Irish:** Niall Mellon **Lancaster, Barrow & Carlisle:** Douglas Morton **London:** Frankie Regan, Fahad Munir, Richard Rowell, Thomas Concannon, Mohammed Usama, Matangi Tarmier, Lee Clifton, Richard Stengel, Ian Gregory, Temi Osomo, Majken Zimmermann, Jessica Hulme, Duncan Weir, Andrew McQueen, Dominic Kisz, Matthew O'Connell, Mathew Lucas, Mateusz Krzemien, Mariyan Petrov, Paolo Raddi, Irin Tiwana, Philip Chay, Asa Sibley, Veer Narayan, Alexander Flockhart, Billy Kamanda, Gavin Brown, Peter Connolly, Aqueel Zaman, Marvin Tulloch, Francesco Lazzara, Ashley Ankrah, Mumin Malik **Manchester & Liverpool:** Ian Spibey, John (Alex) Peake, Michael Edgar, Paul Cross **Milton Keynes:** Anthony Roache, Isaac Astley, Josh Stapleton, Sophie Wood, Anthony Poncia, Dr. Brian Haddock, Karl Kiernan, Alistair Grice **North East:** James Moore, Christopher-James Green, Natalija Faraja **Nottingham & Derby:** Daniel Welsby, Jim Davies, Telma Neto, Matthew Stone, David Horne, Raymond Lewis, Nayab Siddique, Matthew Smith **South & West Wales:** Karl Gilmore, Colin Berry, Cameron Llewellyn, Derek McNeill, Ajaz Hussain, David Paddison, David Whatley, Owen Dyckhoff, Katherine Fiford, Alex Butler, Arron Silva, Allan Weeks, Chris Hussey **Thames Valley:** Paul Milnes, Thomas Rayfield **West of England:** Rob Mashford, Joshua Monks **York:** Bilal Jahangir, Daniel Wright, Deborah Quick, Ryan Hughes, Ben Abram, Heather Dougan

## OBITUARIES

We're always saddened to hear of the passing of PWI Members and Fellows. Our thoughts go out to their families, friends and colleagues. Full obituaries can be found on the PWI website and a special testimonial of all those members who have passed away in the last 12 months will be included in the October Journal.

**Albert (Albie) Gray**
North East Section

"Thank you Albie from all your colleagues for some great times and great memories, whether it was deep inside an industrial mining, steel or chemical complex, or out on a rural branch line somewhere. May you now forever rest in peace."

Read Albies full obituary on the PWI website.

**Michael Chorley**
Lancaster, Barrow & Carlisle Section.

"Mike passed away on 18 February 2021 after a period of deteriorating health. His enthusiasm for all things railway related will live on by all that knew him. Due to Covid restrictions his funeral was only attended by family members, but many tributes to him arrived by post."

Read Michael's full obituary on the PWI website.

## FELLOWSHIPS

Srinagesh Rao - Bengaluru
Dr Ian Coleman - Milton Keynes
Christopher Newton - Thames Valley
Daniel Molloy - Milton Keynes
Karl Gilmore - South & West Wales
Duncan Weir - London
Andrew McQueen - London
Colin Deuchars - Glasgow
David Paddison - South & West Wales
Richard Bonney - Nottingham & Derby
Phil Harrison - West of England

## PROFESSIONAL TITLE

A huge well done to our members who have gained a professional title since the last Journal. This is an amazing achievement.

Andrew Jones - Engineering Technician
Yeong (Samuel) Liau - Engineering Technician
Richard Tilley - Engineering Technician
Anthony Shotton - Engineering Technician
Daniel Mahoney - Engineering Technician
Paul Makosz - Incorporated Engineer
Louise Walley - Chartered Engineer (Additional)
Daniel Molloy - Chartered Engineer
Philip Seymour - Chartered Engineer
Mark Walker - Chartered Engineer
David Woods - Chartered Engineer
Errol Maginley - Chartered Engineer

## PWI TRACK ENGINEERING DIPLOMA

Kavitha Nagalingam, Nick Kelly

READ ABOUT OUR ELECTRIFICATION SEMINAR ON PAGE 8

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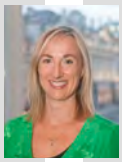

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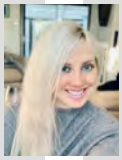

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journaleditor@thepwi.org

THE PWI TEAM

*Here to help*

## TECH TALK

Tech Talk is a private forum where members can discuss, debate and share views on all things related to rail technology. Members can ask questions and make comments about the technical articles that are published in the PWI Journal, as well as react to our technical seminars, Boards and relevant news.

We encourage healthy debate and differences of opinion, but ask that contributions remain friendly and respectful at all times. Simply request to join!

www.linkedin.com/groups/8862498/

## YOUNG ENGINEERS SECTION

This virtual Section has been formed on LinkedIn and provides a central location for all the younger members of the rail community to engage whilst remaining a member of your regional home Section.

The Young Engineers Section is a place to exchange thoughts, ideas, views and challenges you may be experiencing in your role as a young person working in the rail industry. It's a place to gain and offer support, to meet likeminded individuals, and to participate in social activities as the group becomes more defined. Simply request to join!

www.linkedin.com/groups/8865220/

## AMBASSADORS

This forum connects PWI Ambassadors to discuss ideas, suggest collaborations and to receive updates and announcements from the central team.

PWI Ambassadors are free to post comments, ideas and suggestions to fellow Ambassadors or for the attention of the PWI central team. We continue to seek new Ambassadors and Young Ambassadors, and aim to appoint at least one Ambassador for every Corporate Member. If you wish to volunteer or nominate a colleague, please contact: michelle.lumiere@thepwi.org

www.linkedin.com/groups/8913254/

## PROFESSIONAL REGISTRATION

This group is for all those embarking on their Professional Registration journey, as well as those who have already completed the process. Connect with each other, raise questions, discuss challenges and gain support from your peers.

We encourage members to treat this as an alumni network for PWI Professional Registration, allowing you to make friends and stay engaged with others who have undertaken the same journey, and to offer your experiences and mentorship to others when possible. Simply request to join!

www.linkedin.com/groups/8976547/

# 200+ SECTION MEETINGS A YEAR!

PWI Section meetings are great places to learn about rail projects and new technical developments, and network with other rail professionals.

The Sections page on the website hosts useful meeting information such as locations, meeting details, and how to attend.

Simply continue to send your reports including presentation details and any photos to secretary@thepwi.org

## CENTRAL ENGLAND

VICE PRESIDENT Richard Quigley richard.quigley@networkrail.co.uk

BIRMINGHAM SECRETARY Richard Quigley 07715 132267 richard.quigley@networkrail.co.uk Venue: 2nd Floor, Network Rail, Baskerville House, B1 2ND

MILTON KEYNES SECRETARY Kevin Thurlow 07802 890299 kevin.thurlow@networkrail.co.uk Venue: Auditorium, The Quadrant, MK9 1EN

NOTTINGHAM & DERBY SECRETARY John Garlick 07532 071727 jgees01@btinternet.com Venue: Aston Court Hotel, DE1 2SL / Jury's Inn Hotel, NG2 3BJ

## IRELAND

VICE PRESIDENT Cathal Mangan cathal.mangan@irishrail.ie

IRELAND SECRETARY Joe Walsh 00 353 872075688 pwiirishsection@gmail.com Venue: Wynn's Hotel, Dublin 1, Ireland, D01 C9F8

## NORTH EAST ENGLAND

VICE PRESIDENT Phil Kirkland philkirkland@btinternet.com

NORTH EAST SECRETARY Phil Kirkland 07899 733276 philkirkland@btinternet.com Venue: Newcastle College Rail Academy, NE10 0JP

WEST YORKSHIRE SECRETARY Martin Wooff 07487 652622 pwi@railrace.co.uk Venue:The Cosmopolitan Hotel, LS1 4AE

YORK SECRETARY Gareth Dennis 07951 918236 york@thepwi.org Venue: Network Rail Meeting Rooms 0.1, George Stephenson House, YO1 6JT

## NORTH WEST ENGLAND & NORTH WALES

VICE PRESIDENT Roy Hickman royhickman@live.co.uk

CHESHIRE & NORTH WALES SECRETARY Lynne Garner cheshire@thepwi.org 07494 753652 Venue: Crewe Arms Hotel, CW2 6DN

LANCASTER, BARROW & CARLISLE SECRETARY Philip Benzie p.benzie@yahoo.co.uk 01704 896924 Venue: Station Hotel, PR1 8BN / Royal Station Hotel, LA5 9BT / Network Rail, CA28 6AX / Network Rail, CA1 2NP

MANCHESTER & LIVERPOOL SECRETARY Richard Wells richard.wells@tonygee.com 07817 302652 Venue: Manchester Metropolitan University, Room E0.05, M1 5GD

## SCOTLAND

VICE PRESIDENT Tom Wilson tom.wilson@wsp.com

EDINBURGH SECRETARY Mark Taylor marktaylor5@networkrail.co.uk 07710 959630 Venue: The Scots Guards Club, EH12 5DR

GLASGOW SECRETARY Jim Watson glasgow@thepwi.org 07590 929107 Venue: WSP Offices, 7th Floor, G1 3BX

## SOUTH CENTRAL ENGLAND

VICE PRESIDENT Paul Ebbutt paulebbutt1@gmail.com

LONDON SECRETARY Sean Tarrant seantarrant@tfl.gov.uk 07764429211 Venue: Transport for London, SE1 8NJ / Transport for London, E20 1JN

THAMES VALLEY SECRETARY Richard Antliff richard.antliff@gmail.com 07804 329497 Venue: Network Rail Offices, Davidson House Offices, RG1 3EU

WESSEX SECRETARY Kenneth Newell kenneth.newell@btinternet.com 07771 668044 Venue: The Rose and Crown, SE1 8DP / The Eastleigh Railway Institute, SO50 9FE / Network Rail Offices, Waterloo Station, SE1 8SW

## SOUTH EAST ENGLAND

VICE PRESIDENT Jonathan Bray Jonathan.bray@keolisameydlr.co.uk 07976 199011

ASHFORD SECRETARY Colin Burnikell colin.burnikell@hilti.com 07801 913562 Venue: Online until further notice

CROYDON & BRIGHTON SECRETARY Colin White c.white@chaucerrail.co.uk 07845 316042 Venue: Mott MacDonald House, CR0 2EE

LONDON SECRETARY Sean Tarrant seantarrant@tfl.gov.uk 07764429211 Venue: Transport for London, SE1 8NJ / Transport for London, E20 1JN

## SOUTH WEST ENGLAND & SOUTH WALES

VICE PRESIDENT Andy Franklin andy.franklin@networkrail.co.uk 07901512293

WEST OF ENGLAND SECRETARY Constantin Ciobanu western@thepwi.org 07549 319335 Venue: Engine Room, Atkins, SN1 1DW

EXETER SECRETARY Mark Woollacott Mark.woollacott@networkrail.co.uk 07920 509011 Venue: Mercure Exeter Rougemont Hotel, Queen Street, EX4 3SP

SOUTH & WEST WALES SECRETARY Andrew Wilson southandwestwales@thepwi.org 07974 809639 Venue: Network Rail Offices, CF10 5ZA

## INDIA

VICE PRESIDENT Tom Wilson tom.wilson@wsp.com

BENGALURU SECRETARY Srinagesh Rao sringagesh.rao@arcadis.com Venue: Arcadis Sez Office Bengaluru, Karnataka 560045, India

## INTERNATIONAL CONTACTS

MALAYSIA Mr K Sukumaran sukumaran@ktmb.com.my NEW SOUTH WALES Peter Boonstra secretary@pwinsw.org.au QUEENSLAND Robin Stevens robin.stevens@qr.com.au SOUTH AUSTRALIA Mark Pronk mark.pronk@sa.gov.au

PWI TECHNICAL SEMINAR

# PLANT AND MACHINERY

## to support rail infrastructure renewal and maintenance for the 2020s and beyond

24 NOVEMBER 2021 SWINDON STEAM MUSEUM

BOOKING NOW OPEN: www.thepwi.org

£85 MEMBER
£150 NON-MEMBER


Despite the recent falls in passenger traffic consequent on Covid-19, over the longer term the climate change and decarbonisation agendas remain set to drive growing volumes of freight and passenger traffic onto rail networks. As the demand for rail transport bounces back and as train services are added to the network to meet growing demand, access to carry out maintenance, renewal, and project work will remain at a premium.

The pressure to do more work in shorter possessions drives a requirement for more productive, mechanised, work delivery methods. Effective, safe, and highly productive plant is an essential component of this. Plant and the methods and strategies to deploy it that can together deliver high quality, durable infrastructure at lower unit costs is crucial to meeting industry challenges: along the way it must play its part in reducing rail sector carbon emissions and other environmental impacts, and in improving the performance and reputation of the railway.

This seminar will provide delegates and speakers with an opportunity to understand and debate the requirements for plant to meet these challenges, and the solutions that are being deployed and developed to deliver them.

Sponsored by

Plasser UK

SB RAIL
Swietelsky Babcock Rail

VolkerRail

SPONSORSHIP AND EXHIBITOR SPACE AVAILABLE Contact 01277 230 031 / secretary@thepwi.org

# From our sponsors...

## Plasser UK

Plasser UK, the agents for Plasser & Theurer and ROBEL, have been established in the UK since 1960. From our workshop at West Ealing, we facilitate the sale of new Plasser & Theurer and ROBEL on-track machines and ROBEL hand-guided tools, provide training and sell spare parts from our well-stocked warehouse and maintain, repair, overhaul, and upgrade older machines – ensuring decades long reliable service life from these high-quality machines.

In the past 5 years we have successfully introduced the latest generation 09-4x4/4S dynamic continuous action tamping machine with dynamic track stabilisation, 08-4x4/4S cyclic action tamping machine and GWS-75 in possession switch tamping machine; the ROBEL Crossrail Engineering train, the High Output Ballast Cleaning System 5 including RM900 + 09-CM ballast cleaner with integrated continuous action 2-sleeper tamping and stabilising, 09-3X – 3 sleeper continuous action tamping and stabilising machine, the USP5000 and USP6000 ballast regulating machines and the revolutionary ROBEL Mobile Maintenance Trains (MMT)

The Plasser & Theurer and ROBEL portfolio of machines cover all aspects of rail bound installation and maintenance. The new plant includes the URM700 S&C ballast machine, new generation TRM's and TRAMM's as well as fully automated Long Welded Rail delivery and recovery trains, plus the FUM OHLE installation and maintenance machine. This machine installs the wires under very precise constant mechanical tension ensuring that once installed on the night no return shift is required to re-register as the wires remain in their final installed position.

Plasser UK and Plasser & Theurer are proud supporters of the PWI.

## SB RAIL Swietelsky Babcock Rail

Swietelsky Babcock Rail was established in 2004. Our highly successful Joint Venture partnership now has the most capable and diversified fleet of on-track machines in the country and has built a strong reputation for innovation and for introducing first of type equipment.

We were the first in the UK to introduce the Unimat 09-4X4/4S Dynamic Tamper with integrated DTS in 2014, which is the latest generation continuous action S&C machine. By June 2021 SB Rail will be the largest operator of this type, with 6 machines operating across the UK taking our UK fleet size up to 27 machines. Some of our firsts include undertaking tandem tamping of S&C, 125mph hand-back after both plain line and S&C renewals and the first to introduce technologies such as Sprinter tamping, Curve Laser and Tandem Drive and the first to achieve a 100% track quality measure. Our entire fleet utilises 100% biodegradable oils thus reducing our impact on the environment.

Not only do we own and operate tampers and regulators we also own and operate four Kirow Multitasker 250 Rail Cranes across the UK which utilises our unique robot-arm technology which combines precision, speed of operation and the safest working methods.

Since 2014 we have invested over £35 million in cutting edge machinery to service the UK rail network covering geographical areas from the North London stations up to the North coast of Scotland.

As one of the first Corporate Members of the PWI we are proud to sponsor the Plant & Machinery seminar.

## VolkerRail

VolkerRail is one of the UK's leading multi-disciplinary railway infrastructure contractors, with a successful track record of delivering projects for a range of clients including Network Rail Transport for London and UK light rail operators. Our offering is diverse ranging from small contracts to joint venture and alliance projects in excess of £1bn.

Our detailed understanding of the industry comes from years of experience on heavy and light rail networks, and our skills range covers every aspect of track renewals, maintenance and construction, HV and LV power, signalling and electrification. This includes complete design and build capability, which can be delivered individually or as part of a fully integrated project; all of which are enhanced by our in house plant division.

Volkerrail is a market leader in rail plant supply, and one of the few contractors with a railway safety case to operate plant on the mainline railway. Our fleet includes: plain line and S & C tampers, ballast regulators, Kirow rail mounted cranes and a variety of On Track Plant including beaver lightweight tampers, MEWP's, 3600 excavator cranes, as well as an array of rail mounted support vehicles and an extensive range of small plant and equipment.

The reliability of our fleet is class leading as evidenced by client league tables, we employ a maintainer/operator system with highly trained personnel who are considered some of the best in the country. Our specialist plant team provide a fully integrated planning service including lift operations and route planning, route planning.

# Your Permanent Way Institution

## AGM Agenda

Friday 2 July 2021

16:00 - 17:30

Macdonald Burlington Hotel
Birmingham
B2 4JQ

The full agenda and accompanying papers will be published on the website in May 2021
www.thepwi.org

1. To receive apologies for absence
2. To celebrate the lives of members who passed away during 2020
3. To receive the roll call of the Sections
4. To receive and agree the minutes of the 2020 Annual General Meeting, held on Friday 3 July at 16.00hrs virtually, via GoToWebinar
5. To receive a report from the President
6. To receive a report from the Chief Executive Officer
7. To receive and adopt the Directors' Report and Accounts for the year ending 31 December 2020
8. To confirm Nick Millington as President
9. To elect officers of the Institution

Any member wishing to propose a candidate for any of the above posts must advise the Secretary in writing not less than 28 clear days in advance of the Annual General Meeting. Any candidate must meet the requirements of Clause 4(1) of the Articles of Association. Details of the person specification for each role are available from the Secretary.

A member entitled to attend and vote at the meeting, but who is not able to attend, is entitled to appoint a proxy to vote in his/her place. Proxy forms will be available on the PWI website or can be obtained from the Secretary and must be returned not less than 7 clear days in advance of the Annual General Meeting.

To increase the accessibility of the Annual General Meeting, and to mitigate against government restrictions that would prevent the meeting from taking place in a face-to-face environment, this year's AGM will also be streamed on the GoToWebinar platform. Any member joining virtually will have the opportunity to listen to the presentations and ask questions in real time. Voting over the GoToWebinar platform will not be possible and members joining the meeting virtually and wishing to vote must signify their voting intentions in advance via the submission of a proxy form. Full details of how to register to attend and vote by proxy will be published on the PWI website in May 2021.

# 2020 Accounts

The full version of the 2020 accounts is available. Please visit the PWI website, or contact the Membership Team: secretary@thepwi.org

**Permanent Way Institution (Incorporated)**

**Company Limited by Guarantee**

**Directors' Report**

**Year ended 31 December 2020**

The directors present their report and the financial statements of the company for the year ended 31 December 2020.

**Directors**

The directors who served the company during the year were as follows:

| | |
|---|---|
| Mr A J Cooper | |
| Mr S B Whitmore | |
| Mr J C Dutton | |
| Dr B J Counter | |
| Mr S J Barber | |
| Mrs K J Hatwell | |
| Miss J Heery | |
| Mr A Tappen | |
| Mr N J Millington | |
| Mr J R Edgley | |
| Mr J G Edwards | |
| Mr P Dearman | (Appointed 3 July 2020) |
| Ms M Nolan - McSweeney | (Appointed 3 July 2020) |
| Mr C J Wheeler | (Resigned 3 July 2020) |

## Permanent Way Institution (Incorporated)

### Company Limited by Guarantee

### Directors' Report *(continued)*

### Year ended 31 December 2020

**Statement from the Board of Directors.**

This statement complements the quarterly updates from the President and the CEO provided in each PWI Journal.

2020 has been an extraordinary year. The restrictions imposed due to the coronavirus pandemic (COVID-19) caused significant disruption to the business and operations of the Institution. Compliance with UK and devolved governments' guidance for social distancing created a range of challenges, opportunities, and successes in what is best described as an operationally challenging year.

Despite the challenging business and operational environment, the Institution has, through the dedication of the Executive, Section officers and volunteers, and Personal and Corporate Members been able to deliver a turnover level equivalent to 92.7% of 2019 and to produce a profit that results in members funds increasing by 2.0% in 2020. On 31st December 2020 we were supported by 3,358 Personal Members, representing 5.1% growth on 2019, and 51 Corporate Members, similar in number to 2019. We continue to see growth in our professionally registered membership which stood at 188 at the year end.

During 2020 the Board of Directors met four times. Due to COVID-19 restrictions the latter three meetings were held using an online platform and this approach was similarly applied to Section Meetings, the July AGM, and (after some outstanding work by the training and operational teams) the PWI Track Engineering Diploma and other training courses. Starting on March 25, 2020 saw 55 Section meetings held online, with an average attendance of 55. As the year progressed, meetings often had more than 100 attendees (a trend maintained through early 2021). Online and face-to-face PWI training courses registered total attendance of 270 in 2020, remarkably close to 2019's "normal year" figure of 300.

Innovative thinking overcame the many initial challenges to establish a "near normal" business operation. Coupled with the transition of training into the virtual world, this proved to be very efficient and effective in managing the day-to-day business of the Institution and provided the strongest of foundations from which to deliver our 2020 financial position. Extensive work in the latter half of 2020 saw the reshaping and rebranding of the quarterly Journal, as well as the creation of a new website and knowledge hub due to go live early in 2021. To comply with impending changes in tax regulations, the Institution became an employer in 2020 with a small number of our personnel becoming employees.

At the end of 2020, the Board reemphasised the Institution's commitment to equality, diversity, and inclusion by adopting the Royal Academy of Engineering's Diversity and Inclusion Framework. The Board of Directors has recognised that adopting that Framework will challenge the Institution to examine carefully what should, can and must be done to ensure PWI welcomes and treats all people equally. One metric offers encouragement: of our professionally registered members, 10.4% are women. That is an example of positive progress: actions and changes developed within the Framework will seek progress over time in all measures.

Work also started to determine how the PWI can most effectively respond to the challenges of climate change adaptation and decarbonisation. These actions complement ongoing initiatives on technical competency; workforce safety; education, training, and development; and growing the support offered to electrification engineers, technicians, and operatives. These workstreams will run through 2021 and into the years beyond.



## Permanent Way Institution (Incorporated)

### Company Limited by Guarantee

### Directors' Report *(continued)*

### Year ended 31 December 2020

**Statement from the Board of Directors, *(continued)***

As we focus on 2021, we anticipate that in some respects the year is likely to be more testing than 2020. Whilst the Institution's cashflow remains healthy, railway industry income has yet to recover from the collapse in passenger revenue resulting from corona virus and we expect corporate budgets to be under pressure. Depreciation of the investment made in our new website will start to flow into overhead costs. Recognising the importance of the social dimension of the Institution to existing and potential members, the PWI will reintroduce and attend face-to-face events. Traditional Section meetings will resume in early Summer and two Practical Trackwork Challenges are planned for the Autumn. Summer will also see the resumption of face-to-face national PWI seminars and professional reviews.

We shall continue to build on the achievements of 2020 but delivering all intended outputs whilst aiming for a financially positive outcome, as was achieved in 2020, will require the continued efforts of a dedicated, focused, and effective Executive, and the continued support of an enthusiastic membership.

**Directors' responsibilities statement**

The directors are responsible for preparing the directors' report and the financial statements in accordance with applicable law and regulations.

Company law requires the directors to prepare financial statements for each financial year. Under that law the directors have elected to prepare the financial statements in accordance with United Kingdom Generally Accepted Accounting Practice (United Kingdom Accounting Standards and applicable law). Under company law the directors must not approve the financial statements unless they are satisfied that they give a true and fair view of the state of affairs of the company and the profit or loss of the company for that period.

In preparing these financial statements, the directors are required to:

- select suitable accounting policies and then apply them consistently;
- make judgments and accounting estimates that are reasonable and prudent.

The directors are responsible for keeping adequate accounting records that are sufficient to show and explain the company's transactions and disclose with reasonable accuracy at any time the financial position of the company and enable them to ensure that the financial statements comply with the Companies Act 2006. They are also responsible for safeguarding the assets of the company and hence for taking reasonable steps for the prevention and detection of fraud and other irregularities.

**Auditor**

Each of the persons who is a director at the date of approval of this report confirms that:

- so far as they are aware, there is no relevant audit information of which the company's auditor is unaware; and
- they have taken all steps that they ought to have taken as a director to make themselves aware of any relevant audit information and to establish that the company's auditor is aware of that information.

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## Permanent Way Institution (Incorporated)

**Company Limited by Guarantee**

**Directors' Report** *(continued)*

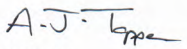
**Year ended 31 December 2020**

**Small company provisions**

This report has been prepared in accordance with the provisions applicable to companies entitled to the small companies exemption

This report was approved by the board of directors on 15/3/2021 and signed on behalf of the board by:

Mr A J Dutton
Director



Mr A Tappen
Director



## Permanent Way Institution (Incorporated)

**Company Limited by Guarantee**

**Independent Auditor's Report to the Members of Permanent Way Institution (Incorporated)**

**Year ended 31 December 2020**

**Opinion**

We have audited the financial statements of Permanent Way Institution (Incorporated) (the 'company') for the year ended 31 December 2020 which comprise the statement of comprehensive income, statement of financial position, statement of changes in equity and the related notes, including a summary of significant accounting policies. The financial reporting framework that has been applied in their preparation is applicable law and United Kingdom Accounting Standards, including FRS 102 The Financial Reporting Standard applicable in the UK and Republic of Ireland (United Kingdom Generally Accepted Accounting Practice).

In our opinion the financial statements:

- give a true and fair view of the state of the company's affairs as at 31 December 2020 and of its profit for the year then ended;
- have been properly prepared in accordance with United Kingdom Generally Accepted Accounting Practice;
- have been prepared in accordance with the requirements of the Companies Act 2006.

**Basis for opinion**

We conducted our audit in accordance with International Standards on Auditing (UK) (ISAs (UK)) and applicable law. Our responsibilities under those standards are further described in the auditor's responsibilities for the audit of the financial statements section of our report. We are independent of the company in accordance with the ethical requirements that are relevant to our audit of the financial statements in the UK, including the FRC's Ethical Standard, and we have fulfilled our other ethical responsibilities in accordance with these requirements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

**Conclusions relating to going concern**

We have nothing to report in respect of the following matters in relation to which the ISAs (UK) require us to report to you where:

- the directors' use of the going concern basis of accounting in the preparation of the financial statements is not appropriate; or
- the directors have not disclosed in the financial statements any identified material uncertainties that may cast significant doubt about the company's ability to continue to adopt the going concern basis of accounting for a period of at least twelve months from the date when the financial statements are authorised for issue.

## Permanent Way Institution (Incorporated)

### Company Limited by Guarantee

### Independent Auditor's Report to the Members of Permanent Way Institution (Incorporated) *(continued)*

### Year ended 31 December 2020

**Other information**

The other information comprises the information included in the annual report, other than the financial statements and our auditor's report thereon. The directors are responsible for the other information. Our opinion on the financial statements does not cover the other information and, except to the extent otherwise explicitly stated in our report, we do not express any form of assurance conclusion thereon.

In connection with our audit of the financial statements, our responsibility is to read the other information and, in doing so, consider whether the other information is materially inconsistent with the financial statements or our knowledge obtained in the audit or otherwise appears to be materially misstated. If we identify such material inconsistencies or apparent material misstatements, we are required to determine whether there is a material misstatement in the financial statements or a material misstatement of the other information. If, based on the work we have performed, we conclude that there is a material misstatement of this other information, we are required to report that fact.

We have nothing to report in this regard.

**Opinions on other matters prescribed by the Companies Act 2006**

In our opinion, based on the work undertaken in the course of the audit:

- the information given in the directors' report for the financial year for which the financial statements are prepared is consistent with the financial statements; and
- the directors' report has been prepared in accordance with applicable legal requirements.

**Matters on which we are required to report by exception**

In the light of the knowledge and understanding of the company and its environment obtained in the course of the audit, we have not identified material misstatements in the directors' report.

We have nothing to report in respect of the following matters in relation to which the Companies Act 2006 requires us to report to you if, in our opinion:

- adequate accounting records have not been kept, or returns adequate for our audit have not been received from branches not visited by us; or
- the financial statements are not in agreement with the accounting records and returns; or
- certain disclosures of directors' remuneration specified by law are not made; or
- we have not received all the information and explanations we require for our audit; or
- the directors were not entitled to prepare the financial statements in accordance with the small companies regime and take advantage of the small companies' exemptions in preparing the directors' report and from the requirement to prepare a strategic report.



## Permanent Way Institution (Incorporated)

### Company Limited by Guarantee

### Independent Auditor's Report to the Members of Permanent Way Institution (Incorporated) *(continued)*

### Year ended 31 December 2020

**Responsibilities of directors**

As explained more fully in the directors' responsibilities statement, the directors are responsible for the preparation of the financial statements and for being satisfied that they give a true and fair view, and for such internal control as the directors determine is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, the directors are responsible for assessing the company's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless the directors either intend to liquidate the company or to cease operations, or have no realistic alternative but to do so.

**Auditor's responsibilities for the audit of the financial statements**

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with ISAs (UK) will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

As part of an audit in accordance with ISAs (UK), we exercise professional judgment and maintain professional scepticism throughout the audit. We also:

- Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.
- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the internal control.
- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by the directors.
- Conclude on the appropriateness of the directors' use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the company's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the company to cease to continue as a going concern.
- Evaluate the overall presentation, structure and content of the financial statements, including the disclosures, and whether the financial statements represent the underlying transactions and events in a manner that achieves fair presentation.

## Permanent Way Institution (Incorporated)

### Company Limited by Guarantee

### Independent Auditor's Report to the Members of Permanent Way Institution (Incorporated) *(continued)*

### Year ended 31 December 2020

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

**Use of our report**

This report is made solely to the company's members, as a body, in accordance with chapter 3 of part 16 of the Companies Act 2006. Our audit work has been undertaken so that we might state to the company's members those matters we are required to state to them in an auditor's report and for no other purpose. To the fullest extent permitted by law, we do not accept or assume responsibility to anyone other than the company and the company's members as a body, for our audit work, for this report, or for the opinions we have formed.

Lee Elsworth (Senior Statutory Auditor)

For and on behalf of
Tiffin Green Limited
Chartered accountants & statutory auditor
Swan House
9 Queens Road
Brentwood
Essex
CM14 4HE

8/4/2021



## Permanent Way Institution (Incorporated)

### Company Limited by Guarantee

### Statement of Comprehensive Income

### Year ended 31 December 2020

| | Note | 2020 £ | 2019 £ |
|---|---|---|---|
| **Turnover** | | **631,609** | 681,716 |
| Cost of sales | | **222,662** | 318,351 |
| **Gross profit** | | **408,947** | 363,365 |
| Administrative expenses | | **408,915** | 357,191 |
| **Operating profit** | | **32** | 6,174 |
| Income from other fixed asset investments | | **1,657** | 10,798 |
| Other interest receivable and similar income | | **4,505** | 1,883 |
| **Profit before taxation** | 7 | **6,194** | 18,855 |
| Tax on profit | | **1,093** | 2,330 |
| **Profit for the financial year** | | **5,101** | 16,525 |
| Reclassification from revaluation reserve to profit and loss account | | **(1)** | – |
| **Total comprehensive income for the year** | | **5,100** | 16,525 |

All the activities of the company are from continuing operations.

**The notes on pages 13 to 19 form part of these financial statements.**

## Permanent Way Institution (Incorporated)

### Company Limited by Guarantee

### Statement of Financial Position

### 31 December 2020

| | Note | 2020 £ | £ | 2019 £ |
|---|---|---|---|---|
| **Fixed assets** | | | | |
| Intangible assets | 8 | | – | 15,688 |
| Tangible assets | 9 | | 25,656 | 9,178 |
| Investments | 10 | | 62,654 | 61,410 |
| | | | 88,310 | 86,276 |
| **Current assets** | | | | |
| Stocks | | 16,187 | | 23,409 |
| Debtors | 11 | 36,655 | | 68,621 |
| Cash at bank and in hand | | 343,558 | | 280,178 |
| | | 396,400 | | 372,208 |
| **Creditors: amounts falling due within one year** | 12 | 255,298 | | 234,409 |
| **Net current assets** | | | 141,102 | 137,799 |
| **Total assets less current liabilities** | | | 229,412 | 224,075 |
| **Provisions** | | | | |
| Taxation including deferred tax | | | 11,150 | 10,913 |
| **Net assets** | | | 218,262 | 213,162 |
| **Capital and reserves** | | | | |
| Fair value reserve | 13 | | 49,916 | 48,909 |
| Profit and loss account | 13 | | 168,346 | 164,253 |
| **Members funds** | | | 218,262 | 213,162 |

These financial statements have been prepared in accordance with the provisions applicable to companies subject to the small companies' regime and in accordance with Section 1A of FRS 102 'The Financial Reporting Standard applicable in the UK and Republic of Ireland'.

These financial statements were approved by the board of directors and authorised for issue on 15/3/2021, and are signed on behalf of the board by:

Mr JC Dutton
Director

A.J. Tappen

Mr A Tappen
Director

Company registration number: 00099838

**The notes on pages 13 to 19 form part of these financial statements.**



## Permanent Way Institution (Incorporated)

### Company Limited by Guarantee

### Statement of Changes in Equity

### Year ended 31 December 2020

| | Fair value reserve £ | Profit and loss account £ | Total £ |
|---|---|---|---|
| **At 1 January 2019** | 40,501 | 156,136 | 196,637 |
| Profit for the year | | 16,525 | 16,525 |
| Other comprehensive income for the year: | | | |
| Reclassification from revaluation reserve to profit and loss account | 8,408 | (8,408) | – |
| **Total comprehensive income for the year** | 8,408 | 8,117 | 16,525 |
| **At 31 December 2019** | 48,909 | 164,253 | **213,162** |
| Profit for the year | | 5,101 | **5,101** |
| Other comprehensive income for the year: | | | |
| Reclassification from revaluation reserve to profit and loss account | 1,007 | (1,008) | **(1)** |
| **Total comprehensive income for the year** | 1,007 | 4,093 | **5,100** |
| **At 31 December 2020** | 49,916 | 168,346 | **218,262** |

**The notes on pages 13 to 19 form part of these financial statements.**

# Our Corporate Members

Corporate Members are fully involved in the development of the PWI, ensuring that its products and services meet the needs of the rail industry for technical expertise.

## TECHNICAL BOARD Update

Now we have over 50 PWI Corporate Members, the quarterly meeting with them is something to look forward to, with great opportunities to network and meet new members from all kinds of companies.

The year started off well with our first meeting in February covering a good mixture of issues, starting with John Edgley who presented the new Great Britain and Ireland track competence framework.

This was well supported by companies and organisations, and the next step involves them volunteering to create and develop more detail. Paul Ebbutt then discussed professional development services from the PWI and CPD.

Lastly, we were delighted to be given a project update by Mark Howard, Chief Engineer of HS2. We were all amazed by the progress on tunnelling works to date, on which he detailed the machines used and the extent of the works. He was also particularly interested in HS2 joining our competency discussions.


For details of Corporate Membership please contact Kate Hatwell PWI Operations Director (kate.hatwell@thepwi.org)

# TECHNICAL SEMINARS

## PWI SEMINARS PROVIDE A UNIQUE PLATFORM FOR INCREDIBLE NETWORKING AND KNOWLEDGE EXCHANGE.

**ELECTRIFICATION:**
DELIVERING THE BUSINESS CASE

**13 JULY 2021**
09:00 - 16:30
GLASGOW ROYAL CONCERT HALL

£70 MEMBER
£120 NON-MEMBER
£10 STUDENT

**HIT THE NORTH:** INSIGHT INTO UPCOMING RAILWAY INFRASTRUCTURE DEVELOPMENTS IN THE NORTH

**5 OCTOBER 2021**
09:00 - 16:30
MANCHESTER CONFERENCE CENTRE

£85 MEMBER
£150 NON-MEMBER

**PLANT AND MACHINERY:**
SUPPORT TO RAIL INFRASTRUCTURE RENEWAL AND MAINTENANCE FOR THE 2020s AND BEYOND

**24 NOVEMBER 2021**
09:00-16:30
SWINDON STEAM MUSEUM

£85 MEMBER
£150 NON-MEMBER

SPONSORSHIP AND EXHIBITOR SPACE AVAILABLE FOR ALL SEMINARS Please contact 01277 230 031 (option 1) / secretary@thepwi.org