ENGINEERING: ALL CHANGE?

Institution of MECHANICAL ENGINEERS

Carolyn Griffiths FREng FIMechE
Presidential Address 2017

Improving the world through engineering

OUR INSTITUTION AND OUR VOLUNTEERS

I would like to particularly recognise and personally thank all the volunteers throughout the world who give hundreds of thousands of hours freely to lead and support this Institution in delivering our mission to improve the world through engineering. It is, after all, their expertise, influence and knowledge that working alongside the Institution's staff are key to what we do and how well we do it, and which will be essential to this organisation's ongoing success.

Carolyn Griffiths FREng FIMechE

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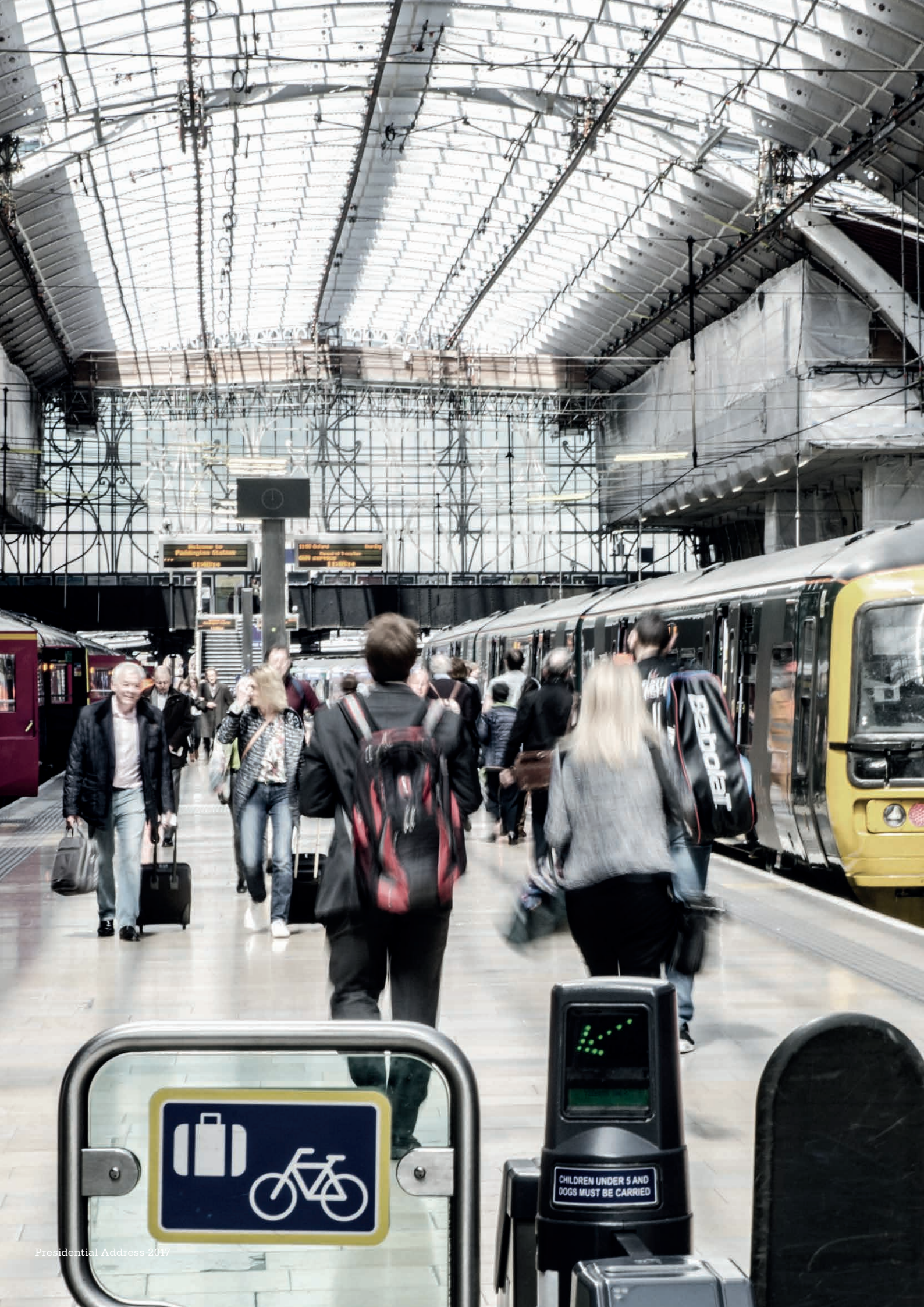
CHILDREN UNDER 5 AND
DOGS MUST BE CARRIED

FOREWORD

I am a career railway woman, and the title of this Address is a play on the announcement used to encourage customers to disembark a terminating train, 'All Change'.

I will use the past 40 years, from when I was in secondary school until now, as my reference period to review how the engineering profession has changed, and what I believe, after all this time, still needs to change. Specifically, I will examine issues that still stubbornly exist relating to education, employment and the gender agenda.

I have mixed feelings in acknowledging that, in very broad terms, these issues have been referred to by past Presidents of this Institution, and indeed other institutions. On the positive side, this confirms we have broadly shared views and a shared agenda. However, on the negative side it does raise questions on why are these issues are still of concern, and what is limiting our progress.

While this Address does not provide all the answers to what appear to be intractable issues, I will share some personal observations in the hope that it might engage you, provoke some new thoughts or reactions, or establish common ground.

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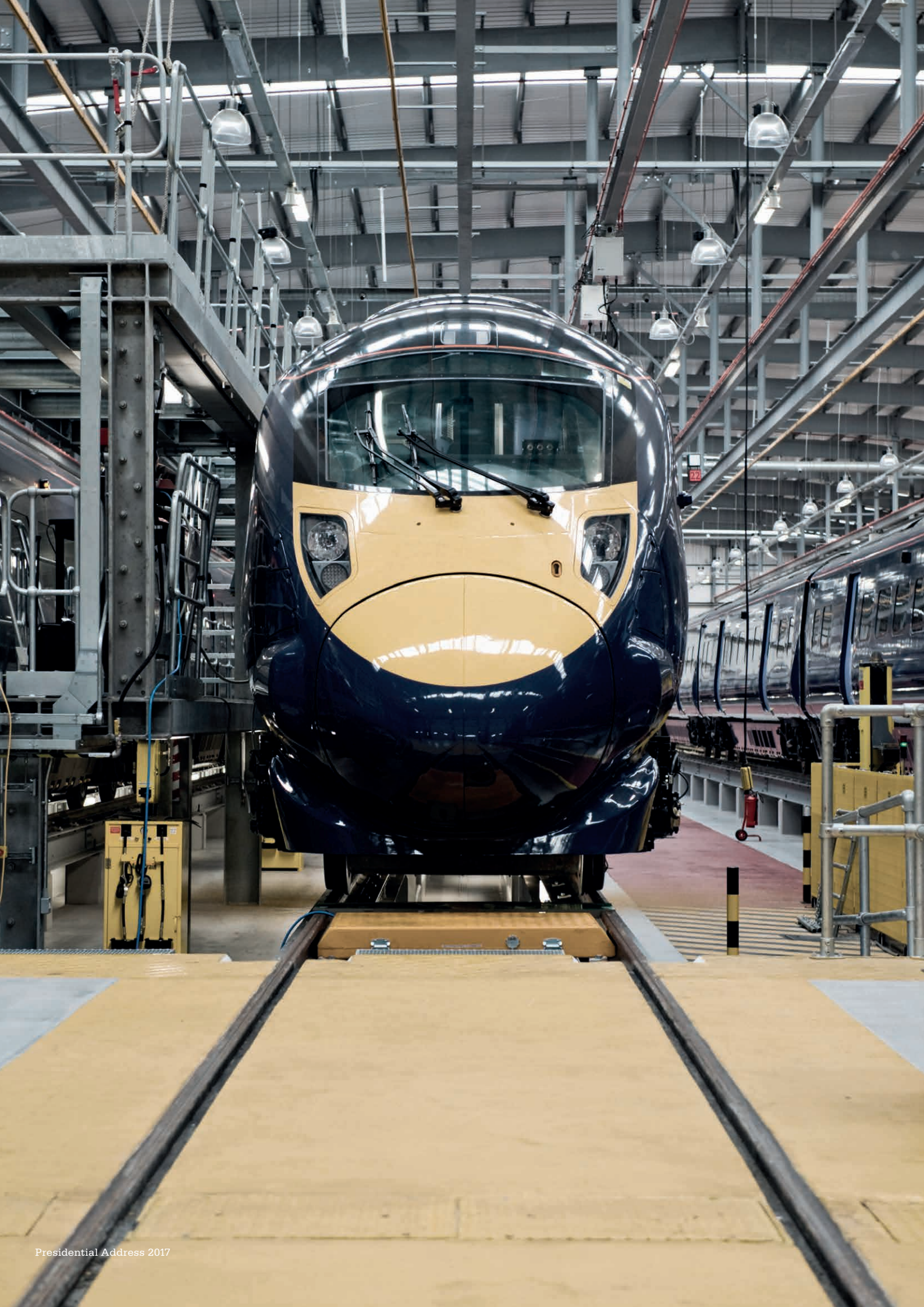


CHANGES IN THE ENGINEERING PROFESSION

Are we moving with the times?

It is difficult to measure the rate of change in the world of engineering. Engineering is such a diverse activity and it is not clear what unit we would use to measure it. Most agree that the rate of technological change is increasing rapidly, profoundly changing society and the way we work and learn.

Many of today's young people will work in jobs that you and I have not heard of before. They will work in ways vastly different from the ways we work today, with new technology, and in a digital environment. Additionally, over the last couple of decades we have talked about inter-disciplinary project teams and systems integration, usually referring to different engineering disciplines. However, the high-performing project teams of today, and in the future, are equally likely to include professionals from the disciplines that interface with engineering, such as architects, experts in human factors, medicine.

Advances in communications, the internet and much more accessible international travel, have enabled technical developments and innovation to be quickly promulgated worldwide, creating new norms and promoting horizontal innovation, where ideas from one sector are capitalised on by another. However, the popular perception of the rail industry is that not much has changed. It is still characterised by steel wheels on steel rails, and much of our vast infrastructure has not changed for decades. However, the railway industry has experienced significant technological changes over the years, which have changed the way it works today, and will continue to in the future. On such example is the way in which inspections are undertaken on the trains and tracks. Until relatively recently, supervision of track conditions was primarily dependent on persons patrolling the track to observe and measure its condition. Because this is best done in daylight, this means staff working on a running railway, with the inherent risks of human error to their safety.

For those who work in the railway sector, the New Measurement Train and Network Rail's other infrastructure measurement and recording machines are not new. All carry out measurement of the track from on-board a train. The Measurement Fleet is the most advanced in the world and can run at up to 125mph in among normal traffic, hugely increasing the quality of asset supervision. The vehicles measure dynamic track geometry in real time, record overhead line equipment, the rail head profile and the condition of track fasteners and the track profile including ballast shoulders. The analysis of the data collected by the laser-based and advanced imaging technologies is currently carried out off-train and image recognition techniques are used to identify areas that require further investigation.

Network Rail is also introducing further train-borne technology in the form of Eddy current testing to detect the depth of surface cracks in rails; this will replace the 'first line' visual inspection by patrollers and measurement of surface length of the crack, which of course has some inherent limitations.

Train maintenance staff routinely inspect the equipment on vehicle underframes and roofs to carry out tests and confirm the condition and security of components. This means trains have to be berthed in a depot over a pit or adjacent to roof-level gantry, so staff can physically carry out the inspection, and in my time sometimes in filthy conditions. Today's trains are designed with the capability to supervise the condition and performance of their own equipment thus enabling greater levels of accurate information to be readily available. Some maintenance locations have further introduced Automatic Visual Inspection facilities at some of their sites, meaning checks of physical equipment can be made remotely and in less time via images captured by track-mounted or roof-height cameras.

So these are examples of relatively new technology changing the way we work today, but what is the role of new technology in the industry's future?

Our railway transports 1.65 billion passengers and 503 million tonnes of freight each year. Since 1997/8 the number of trains on our network has doubled and the demand for rail transport is expected to continue to grow. The conventional engineering and operational solutions of today will struggle to meet future demand. So the industry is looking to harness new technology to deliver more services, easier access, greater passenger choice and better connectivity. The Rail Capability Delivery Plan (CDP) published early this year, builds on the Rail Technical Strategy which was published in 2012. The CDP identified 12 key capabilities the industry needs to develop in order to meet the industry and customer needs in a safe, sustainable and affordable way.

The aim of the plan is to halve unit costs, double the network capacity and halve carbon emissions, at the same time as significantly transforming the experience of customers. To achieve this will require development of new technologies, or new applications of existing technology. For instance, autonomous train control, exact real-time tracking of vehicle location and speed to optimise traffic control, and systems and designs that allow more flexible train working such that additional vehicles might join a trainset or the train might split into two separate trains dynamically during transit.

These are examples of changes in the railway sector. But every sector of engineering is undergoing similarly massive technology-driven change. The question is whether the profession is keeping up with the rate of changes, or might the profession ultimately become the limitation of our possibilities?

EDUCATION, EMPLOYMENT, SKILLS AND PRODUCTIVITY

Attracting the next generation

It has been known since the 1960s that the number entering the engineering profession was declining. Indeed, since the 1970s, it was recognised that when the so-called 'baby boomers' began to retire, the UK would start experiencing significant skills shortages. This challenge has been highlighted in Engineering UK's report 'State of Engineering' for many years.

These shortages could have major implications for the UK's economy. The engineering sector accounts for 20% of the UK's current Gross Added Value and 48% of our exports. The turnover of UK's engineering enterprises is £1.2 trillion, ie 25% of the UK's total turnover. For every new job that is created in engineering there are two further jobs created elsewhere in the UK in reaction. Already 64% of UK engineering employers say a shortage of engineers in the UK is a threat to their business. This does not take into account any impact of the eventual education and employment policies that might emerge from Brexit. And to make more it difficult, it is predicted the number of 21-year-olds in 2022 will be 14% less than in 2012.

The engineering community of industry, academia, the Professional Engineering Institutions and Government have for decades tried to address these issues, but with limited success. The number of young people pursing engineering as a career has remained broadly flat for the last ten years. This is despite, according to a recent report by the Royal Academy of Engineering, over 600 largely uncoordinated schools outreach initiatives, all aiming to engage the 23,500 schools and 8.5 million students in the UK.

For years, organisations within the engineering community have called unsuccessfully for a fundamental overhaul of our education system, at both primary and secondary levels, placing science and engineering at its core.

It is doubtful that the Government will ever make the radical changes to our curriculum to make it STEM-focused. This would be unpopular with large parts of the education system, costly, highly disruptive and would probably be met with resistance from almost all other disciplines. Here there seems little prospect of change.

Therefore, maybe an alternative approach would be to embed science and engineering throughout the curriculum, instead of in one or two niche areas, so a greater proportion of students are given 'access' to the 'manufactured' world and the related creativity and problem solving. So for example, students would hear about engineering in geography, history and economics, and not just maths and physics. This is also one of the main conclusions of the Institution's work with the Royal Academy of Engineering in 2016 entitled 'Big Ideas in Engineering Education'.

Furthermore, the Institution's own 'Five Tribes' report, published in 2015, examined the values and beliefs, attitudes and preferences of 1,500 students aged from 11–19. The results showed that there were five broad categories (tribes) of students, with STEM Devotees, who account for about 29% of students, expressing high levels of enjoyment for STEM subjects, and who were interested in STEM-related careers. However, the overall efforts of the engineering community were not overtly tuned to attract the remaining 71% of students who are not STEM Devotees.

To engage with these students, each distinct Tribe should be engaged in a way that appeals to their values and beliefs, so they can understand why and how they could become an engineer or scientist. For example, the Social Artists tribe are creative people who are more attuned to helping others or improving the environment in which we live. Therefore, designing their learning to include some focus on related activities will be more attractive to their core beliefs, and expose them to aspects of the engineering professions which they may find engaging.

Finally, compounding this problem is the continuing poor provision of careers advice and guidance provided for students, not only for science and engineering but also for the vast majority of professions. Following recent changes in education policy, Ofsted now considers it is 'sufficient' for schools to direct students to a careers web-portal; but does not necessarily recognise the quality of advice that should be made available nor the need for some form of navigation among the plethora of sites that exist. How can this be right when a young person's choices concerning work and education is so vital not only to him or her, but also collectively to our economy?

Skills development beyond school

In 2014, the UK spent £5.1bn less on training in real terms, at today's prices, than a decade ago. The European Commission reports that UK employers spend half the amount per employee of the EU average for continued vocational education.

In April 2017, the new Institute for Apprenticeships was established. Its mission is to promote the return of high-quality and valued apprenticeship schemes throughout our economy.

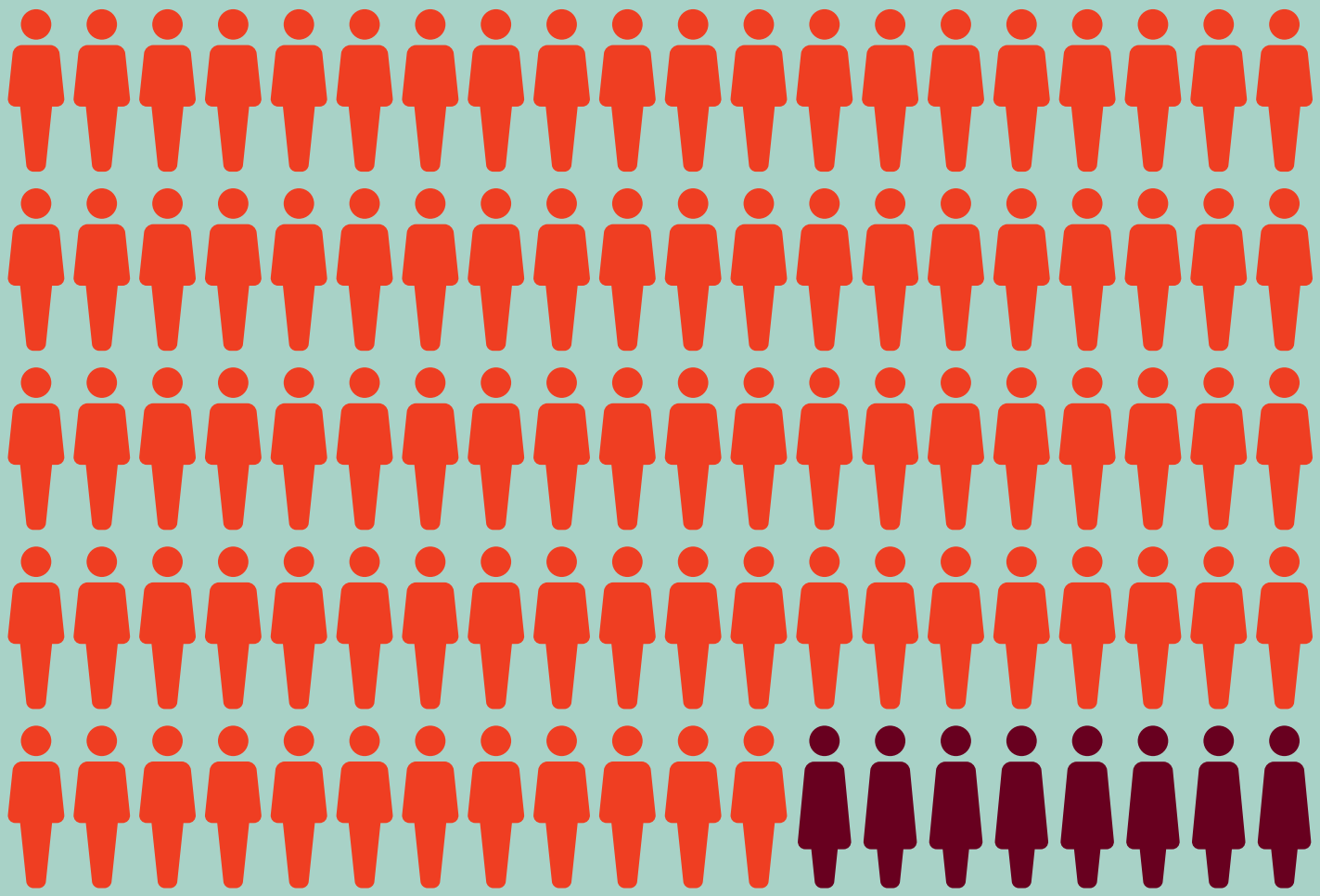
The re-emergence of high-quality apprenticeship schemes has been welcomed in principle by many, especially in the science and engineering community, who have over the past decades created some of the best apprenticeships schemes in the country.

This return has been down to many factors, including the introduction of higher education fees as well as the desire of some to simply earn while they learn. However, we are left to address the importance of equivalence of apprenticeships and degrees as both being essential to our future.

The challenge to industry is to provide graduates and apprentices with the mentors to point out accrediting training opportunities to develop their skills beyond initial training. Many of the larger companies have well-established graduate schemes, many of which are accredited by the Institution, and are developing excellent and high-quality apprenticeship programmes. However, noting that over 90% of all companies are SMEs and below, there remains an obvious gap for companies which lack the resources, financial and personnel, to create, run and manage graduate or apprenticeship schemes. Many talk about supply chain skills development. Again, where this is happening, and if the head of the chain can offer training provision, the benefits are spread throughout the chain. However, what is being done to help individual companies within a local area or region who lack the knowledge, network and ability to create schemes but have the potential to employ future graduates and apprentices?

Finally, skills development is not just a graduate scheme or apprenticeship scheme, but is an ongoing commitment to all employees. For companies, a skilled modern workforce helps them keep at the forefront of industry and is a valuable tool for attracting and retaining necessary talent.

The professional engineering institutions have enjoyed a privileged and highly respected place in our society for many years. However, does their role need to change in this ever-changing world? Do the institutions have the knowledge, network and influence to facilitate regional training hubs with the prestige and promise of high-quality initial and ongoing skills development, as well as internationally respected Professional Registration?



As I have discussed previously, the UK needs to encourage more young people to become engineers. However, the most obvious solution would be if engineering were equally attractive to women as to men. The number of engineers would likely double.

But that would not be the only advantage. Research by McKinsey has shown that companies are 15% more likely to perform better if they are gender-diverse. Other recent research concerning corporate diversity reported that talent leaders agreed that 'A diverse and inclusive workforce is crucial to encouraging different perspectives and ideas that drive innovation'.

I have been the first woman in all nine of my jobs. In all but two organisations, there were no other women engineers.

I chose a career in engineering simply because that's what appealed to me. I certainly did not join the industry to campaign for women, or to prove a point. I had to work hard to be accepted as a credible and successful professional, and this in my time would not have been helped by me raising gender issues. It would likely have been seen as self-serving as there was no other female engineer on site. Rather, my contribution to the gender agenda has been to make sure I left a positive mark in the hope that my work might make it easier, or at least no harder, for the next female engineer. But several decades later it's very clear to me that more needs to be done.

Being President of this Institution and now a senior engineer, I feel I should not, and hope I will not, be judged for talking about the gender agenda, and sharing some surprising findings of research and some personal observations.

Over the last 20 years, the number of women working in technology and engineering has doubled. However, the UK is still the worst performing country in Europe for gender diversity in engineering. Only 8% of engineers are women, and in my own industry, its only 4%. Compare this with the figures from medical schools which show that while the number of men entering medicine has doubled in the past four decades, female recruits have risen ten-fold.

The Research Centre for Women forecast we will not achieve equal representation in the engineering sector this century. Yet in professions such as medicine and law this is already the case.

So what is happening here? It's nothing to do with capability. We know that women can and do succeed as an engineers. And there is compelling current and historic evidence that women can excel as engineering technicians; thousands of women worked as engineering technicians during the war years; but this fell into decline once a male workforce became more available.

At every stage the percentage of women decreases. And if that isn't depressing enough, research indicates that for every 100 women graduating in engineering, only 55 will become engineers and only 37 of those will work in industry. Based on international studies, 22 of those are likely to leave over the first five years of their careers. The UK's Public Policy Research Unit indicates two thirds of those who leave will not return.

Do the below statistics concerning young people at school indicate the prospect of studying Physics at A-level limits the number of women going into engineering? Or have girls by this stage decided engineering is not for them and so do not take physics. Or is it both?

From a study of 1,000 students

	Male	Female	Male as % of sample	Female as % of sample
Sample total 1,000 assumed equal males:females	500	500	50	50
Achieved A–C grades in physics	111	101	50	50
Achieved A-level physics or equivalent	44	13	8	2.6
Studied engineering/technology-related degree at university	21	3	4	0.6
Predicted number who will secured employment in engineering and technology	14	1 or 2	2.8	0.3

Hypothesis one: Lone females studying physics at A-level

Research published in 2012 by the Institute of Physics, revealed that in 49% of UK co-educational state schools, no female students chose to study A-level physics. In fact the research indicates only a relatively small number of students study physics A-level and of these, only 6,400 are girls. Physics A-level is regarded by many employers and higher education establishments as a key requirement for a career in engineering.

It was, in my opinion, no coincidence that the two women who studied mechanical engineering with me at Birmingham University came from all-girls schools. And, in my opinion, this and the research by the Institute of Physics suggest being the lone female in a class of boys is in itself a deterrent. At the age of 15 or 16 self-image and peer approval are as important to young women now as they have ever been. In tackling the gender agenda, is this issue really recognised?

One solution is to recruit more female physics teachers. Undoubtedly this would be a good thing but there is an overall shortage of teachers who are qualified at degree level in physics, so this does not present a solution for now.

So could the requirements for entry to an engineering degree be changed? How essential is physics to an engineering degree anyway?

In 2006, an engineering department in University College London changed their entry requirements. About 10% of the students accepted onto courses did not have maths or physics A-levels. The university maintains these students are doing as well, if not better, than their peers. In 2006, 21% of the department were women. Today this has increased to 29%, in part due to the change in intake requirements. Furthermore, the new Dyson Institute of Engineering and Technology, which will offer a four-year BEng degree, does not require A-level physics from its applicants. It reports that 25% of its applicants are women, a higher percentage than it would be for a traditional university.

Hypothesis two: focussed communication and engagement to overcome strong stereotypes

The second hypothesis is that there are so few women studying A-level physics because they have made career choices that do not require this qualification, ie they are not interested in engineering. As mentioned earlier in this Address, we need to more effectively communicate to students, and indeed to their parents and teachers, the value and importance of engineering. Appropriate communication is even more important for girls, as it must overcome current misconceptions and stereotypes and counter the challenge of being a minority in the workplace. We have also seen earlier that different young people are receptive to different aspects of engineering. Research undertaken by the University of the South West of England suggests that women are more drawn to roles which improve society and which intrinsically require people skills. While we know this aligns well with engineering and our own vision of ‘Improving the world through engineering’, it is a far cry from the popular stereotype of engineering.

The workplace and its culture

If we were to succeed in attracting more young women into studying engineering, we would need to understand that this could be undermined by the culture of the workplace, which might deter them from staying.

There have been significant changes in the workplace over the last four decades. In the past, some engineering companies would have had no female toilets or wash rooms, inappropriate images of women on the walls, occasional offensive language and some inappropriate behaviour.

Changes in technology, general expectations, legislation and health & safety have also improved the working environment for all. However, could the UK’s poor performance in attracting women into engineering compared with other countries be because of our heritage, and decades of acceptance that engineering was a male occupation? This is a stereotype that may not be so strongly rooted in newer economies.

But because of the pervading gender disparity in engineering, it can be no surprise that bias is evident today. Even in the most enlightened organisations, the culture is almost certainly going to be different from an organisation where there is greater equality of the sexes. A forthcoming 2017 report by IMechE, points to simple and unintended issues which contribute to such a culture, for example social activities connected with work not always being welcoming to women.

Introducing measures to change culture

Until there is more of a representative number of women in the industry, specific measures need to be engaged to counter negative culture. Here are some examples which I believe warrant very serious consideration.

1. **Are we taking sufficient steps to counter unconscious bias?**

   I applaud training in unconscious bias. This was compulsory in my last job but unheard of 38 years ago. I expect most companies now have such training, but is this enough? There are both pros but also significant cons concerning quotas. However, if we take a step back and look at the recruitment and promotion processes, organisations could add in objective checkpoints that ensure the female applicants have not been subject of conscious or unconscious bias. So, for example, an independent person could scrutinise, and where appropriate challenge, why female candidates did not make the short-list. But importantly, all candidates would remain subject to the same selection criteria.

2. **Objective assessment and benchmarking of an organisation's maturity in managing equality and diversity to drive improvements. This should become a norm if we are serious about this issue.**

   In my last job I became aware of methods of measuring safety management maturity. It defines the characteristics you would expect to see in an organisation as it develops towards a level of excellence. This way it enables you to measure where your organisation is, to benchmark against others, and to see what needs to change. This has been used with some success in the UK's rail industry. Similar tools have been developed to measure and promote arrangements and behaviours that encourage equality and diversity.

3. **Radical measures… or is it so radical, that the taking of paternity and maternity should be 'levelled'?**

   It is undeniable that the prospect of an employee taking maternity leave can, despite legislation, still influence recruitment and promotion. In 2015, new legislation in the UK heralded Scandinavian-style shared parental leave of up to 50 weeks. But the difference is that in Scandinavia there are generous payments for new parents. This is not the case in the UK and most men in the UK still don't take significant paternity leave. This is not just a matter of pay. According to a report commissioned by the Guardian, many choose not take the leave, as they fear it may impact their career prospects. That's why Finland, Norway, Sweden and Germany have chosen to break this self-perpetuating culture and make it mandatory for men to take a number of weeks' leave. If they don't, their family isn't eligible for the full amount.

Once the stigma is removed, and men start taking more leave, more follows, as has been proven to be the case, for example in Germany and in Quebec, Canada. This is a powerful way to make corporate culture friendlier towards women. A study in Sweden showed that for every month a father took for parental leave, the mother's future earnings increased by 7% and workplace flexibility becomes an issue for fathers and stops being a 'women's issue'.

Recently, research was conducted by the Association of Women in Science in the United States, where 100 academic organisations were asked to assess the suitability of a candidate for the role of laboratory manager. Two résumés were sent out, identical except in one important detail: one had a female name, the other was male. The female 'candidate' was perceived as less competent by both male and female assessors and they were less willing to mentor her or hire her. They also recommended paying her on average 13% less than the male 'candidate'. The research concluded 'gender bias' is often an outcome where stereotypes shape our judgements, regardless of our intentions.

ALL CHANGE?

So if there is a need to 'All Change', where do we go from here?

No-one can argue that, over the last four decades, there hasn't been significant change in engineering and technology, which has profoundly changed the way we live, work and learn.

But astonishingly, as we have seen, in other related areas there is nowhere near enough change, even though many reports have been commissioned and recommendations made.

This Address cannot possibly present a comprehensive solution to these intractable problems, but I have shared with you some of my thoughts about what we might yet still try to bring about change. And for the purposes of this paper I will summarise the top-line issues.

Education and engaging understanding and interest

- We clearly need to unify our messaging and outreach activity to inspire the next generation. Not only will this undoubtedly save resources in time and money, it will also allow us to approach Government with a more unified and agreed position.
- We need to establish whether we commonly believe the integration of engineering and technology into the existing schools curriculum is feasible.
- We need to expand our promotion of engineering beyond the 29% STEM Devotees. This will be by rephrasing how we speak to other groups of students, offering them example and insight more attuned to their beliefs and attitudes.

The Gender agenda

- We need to consider what can be done to alleviate the apparent deterrents to girls of their being in a minority in A-level physics classes; and for physics in co-educational schools to be seen as not solely a subject for boys.
- Since A-level physics appears to be a barrier and because universities recap to some extent what is covered by A-level physics, they may consider the route taken by University College London and the Dyson Institute of Technology, which have dropped A-level physics as a requirement.
- The institutions should promote the use of an equality and diversity management maturity tool, and the adoption of a related 'kitemark' for improvement. Should there be incentives for organisations to do better on the gender agenda? Medical schools for example are required to demonstrate standards of equality or else find themselves not eligible for parts of funding from the National Institute for Medical Research.
- We should understand why we have not adopted the Scandinavian model to encourage men to take paternity leave, in particular the use it or lose it approach, and encourage its adoption here in the UK.

But it is my over-riding belief we need a catalyst, without which we will likely continue to struggle to make meaningful change. It concerns me how we will go about change.

The catalyst needed to make changes happen

One of the most recently published reports is by John Uff QC which looks at our preparedness for the 21st century. The report made 20 recommendations and the Institution of Engineering and Technology, Institution of Civil Engineers and this Institution have agreed to work on five. These cover joint policy work, aligning of interventions in schools, a shared information service, joint accreditation, and a new initiative to engage what Uff calls the 'missing 3 million'.

The report also calls unsurprisingly for more collaborative working across the profession; but this in itself is not new. That is not the change.

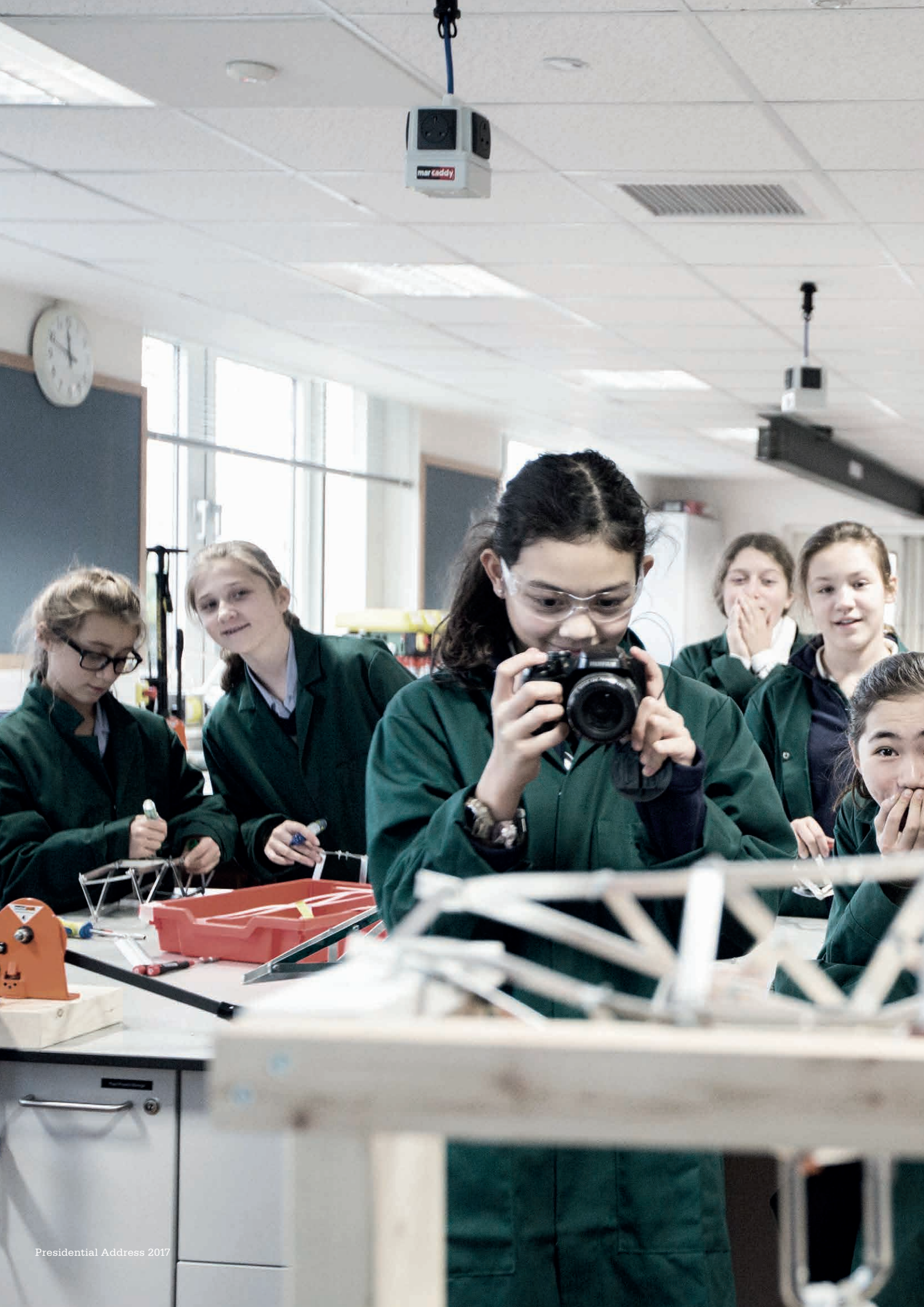
Engineers are good at diagnosis; so what has deterred or prevented us from doing this until now? Is it risk of loss of income or membership, a dilution of our brand, sharing what currently distinguishes us from the other institutions; a loss of specialism or a fear of loss of value to our current members?

Can we find a way to be more effective in identifying areas for collaboration by mutual consent that facilitates the negotiations, and recognises the motivations of and rewards for those involved?

I don't know all the details of how this might work, but I do believe it warrants examination. And I would like to do this with other institutions and also members with experience of organisational design.

In summary, what we have done in the past has achieved little. Unless we try something new, there is a real risk we will continue for the foreseeable future to have skills shortages, continue to have a lack of women in our profession, and continue to respond with multiple, but not necessarily connected, actions from our institutions. We may not be quite at a terminus, but surely it is time to change direction so that we can at least see progress to get us to where we all know we want to be?

Can we find an organisational framework which has an overarching and representative group whose purpose it is it help identify areas for collaboration, and to facilitate the negotiations which will recognise the motivations and rewards for those involved? Such a framework will retain the current institution structures for as long as they want, and the level of collaboration may differ between organisations.



APPENDIX: MY LIFE IN THE RAILWAY

My career has been and continues to be in the rail industry. The industry has given me more than enough freedom to do new things and to continue to learn. And this, for me, has been compelling.

British Railway: Trainee to Depot Manager

I joined the railway industry because British Rail had a graduate training programme which was, in my view, second to none. On the completion of the training scheme I, by choice, worked on the shop floor at Cardiff's Diesel Maintenance Depot, where I worked alongside apprentice-trained men, and where I was trained to undertake maintenance and heavy repairs on diesel locomotives.

From here I went to work in the maintenance depot in Stratford, in the heart of the East End of London. At the age of 24 I was running my own shift with a team of fitters and electricians, and with very significant technical, time and team management demands. Each shift was responsible for ensuring a sufficient number of locomotives and trains were repaired and serviced to safely and reliably run the busy passenger services out of Liverpool Street station and the timetabled commercial freight services.

After some years I was promoted to manage an electric traction depot at Selhurst, which maintained and repaired the trains for some of the busiest London arterial routes. Here I had a second task: to manage the team responsible for removing asbestos from trains and buildings throughout the South East; a peculiar job which saw me working in some unlikely locations such as the ceiling space of Waterloo station, and working night shifts and weekends in the heavy, cumbersome, protective clothing that working with asbestos requires.

My last port of call with British Rail was to become Manager of all operations at Brighton Depot, maintaining a large commuter fleet of about 850 trains running every 24 hours. I was on call managing a 24/7 response team, who investigated and recovered rail accidents and also supported civil works throughout the central South East.

Singapore Mass Rapid Transit: Senior Maintenance Engineer

In 1987 I decide to leave British Rail and was appointed Senior Maintenance Engineer for the then new Singapore Mass Rapid Transit (SMRT). This was a real game-changing move.

When I arrived in Singapore, there were only a few kilometres of operational track and two of the three depots I was to take charge of were still under construction. However, this railway was both literally and metaphorically thousands of miles from my experience in British Rail. It was then the most technically advanced in the world. My job was to develop and manage the maintenance arrangements of the new metro trains and support vehicles, to procure specialist on track equipment for the Civil Engineers Department, and to ensure my team would become self-sufficient when none had prior rail experience.

There was ample scope to influence this exciting project which was literally changing the face of the country. I enjoyed this even more because my team was truly multicultural: Chinese, Malaysian and Indian, and the main contractors were from Japan and Germany. By the end of 1991 the metro was fully open and working well. It was time to move on and new challenges awaited me back in the UK.

South Yorkshire Supertram: Engineering Director

I became Engineering Director for the new tram system in Sheffield. Again, I was to join a railway under construction; this time at a stage where I could influence the design. I was responsible for not only for the trams but also the signalling, track, power supply and structures. Some of the technology was new, but the most challenging aspect was establishing operational arrangements that were safe, competent and responsive, but importantly value for money and appropriate for a small railway that was to be privatised in three years' time. We were the first railway in the UK to wholesale outsource maintenance. The supply market was in its infancy (before the privatisation of the national rail system) and time was tight.

By 1994 the tram system was nearing full operation and British Rail was in the throes of privatisation. I decided to join the Office of the Rail Regulator (the ORR) as Technical Director and thus became a Civil Servant.

Office of the Rail Regulator: Technical Director

The privatisation of the rail industry was massively complex and politically charged. Regulation at that time was dominated by considerations of economics, competition and law. I advised the Regulator on railway technical and operational matters which would underpin the franchises for train and depot operations, and also the privatisation of Railtrack. For much of my time I was the only engineer in the organisation, which meant I was particularly challenged in respect of controls on how money would be spent on engineering assets once the contracts were let.

Adtranz: Director, New Products

Once all of British Rail's operations were in private hands, I decided to join a private sector company, Adtranz. I was appointed Director, New Products and moved to Sweden to manage the relationship between the UK and Swedish subsidiaries in the development of a traction and control system for a new train that was being built for the UK market. This was the Electrostar train which is now a staple train in the South East of England.

Adtranz: Senior Vice President

In 1999, I was invited by the Chairman of Adtranz to become the Senior Vice President for Business Processes and Quality at the corporate headquarters in Berlin. My role was to form an international team to homogenise the way in which the numerous subsidiaries worked from marketing though to after-sales to increase effectiveness and to reduce costs. I was given a very challenging time frame. We had established an optimised process and were in the early stages of trialling when Adtranz was acquired by Bombardier; I understand this process or at least a development of it is in use in the company today.

Chief Inspector: Rail Accident Investigation Branch

It was then I was recruited by the Secretary of State for Transport in the UK to establish and then manage the new Rail Accident Investigation Branch (RAIB). The RAIB is a no-blame organisation that investigates accidents and near-misses on the mainline railway, tramways, metros and heritage rail throughout the UK and also the Channel Tunnel.

There was much to do in establishing this new organisation, such as developing policy, establishing legislation, recruiting staff, and designing a bespoke training programme. Furthermore, we needed to develop and negotiate working arrangements with other organisations within the railway industry as well as police, coroners and regulators so that, among other things, the RAIB could have primacy in collecting evidence and interviewing witnesses.

But I had the freedom to set up operations the way I wanted. The team I recruited consisted of engineers specialising in rail vehicles, track, structures, signalling and geotechnics, as well as experts in operations, human factors and forensics.

The RAIB went fully operational in October 2005, an unknown quantity, yet another player in an already complex industry and one that would for the first time make its investigations into the industry's accidents public. By the time I left it had become highly respected and had brought and continues to bring change for good. The RAIB is now recognised as a world leader in this field of work and we were rated among the top-performing organisations in the Civil Service in terms of teamwork and motivation.

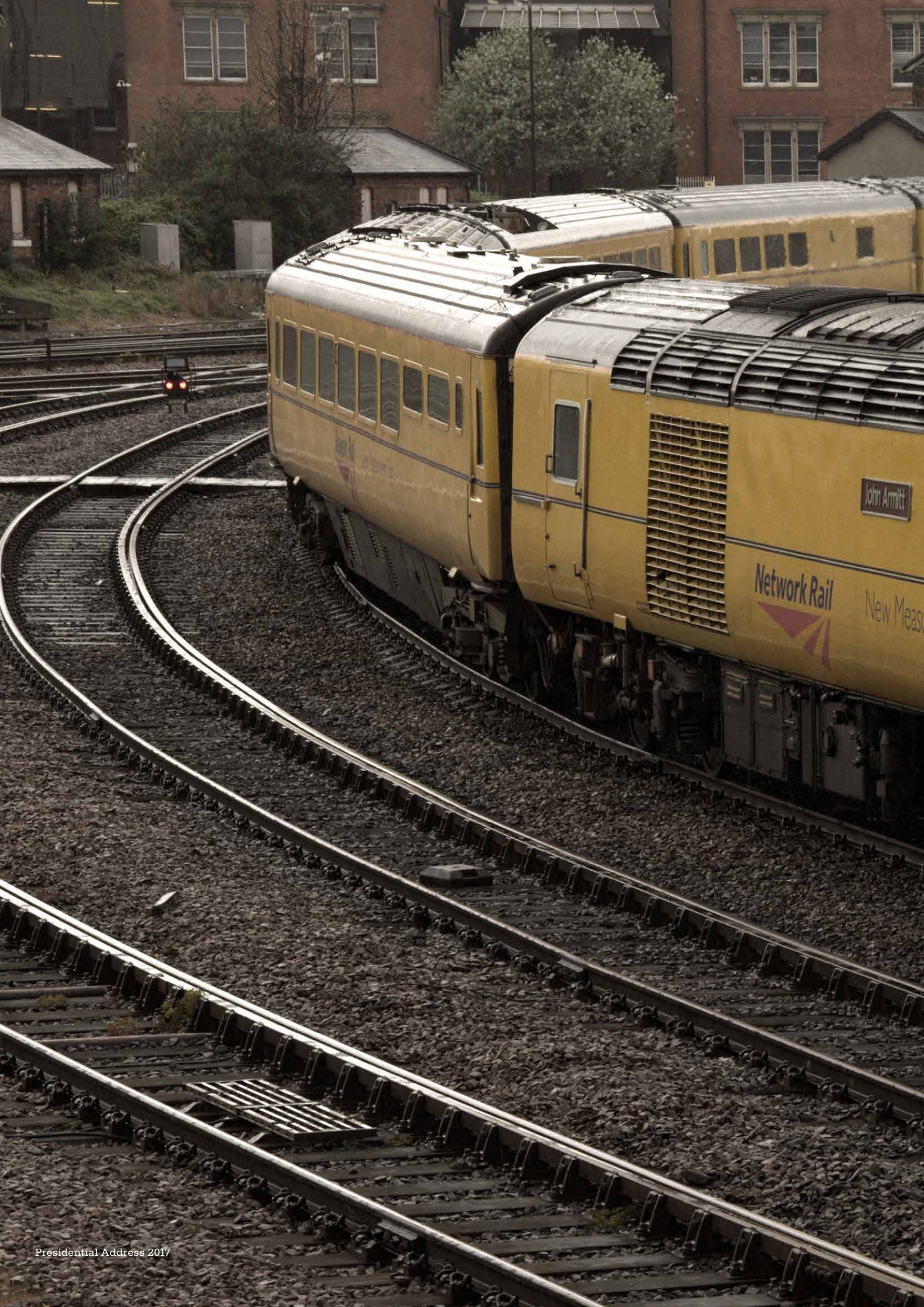
Even though the UK has the safest railway in Europe, we worked to full capacity conducting about 25 investigations a year. Among these we sadly had to investigate accidents resulting in fatal or life-changing injuries involving the passengers, the public at crossings or platforms, and workers on the track. Each of these investigations made on average five recommendations to the organisations, rail or otherwise, best suited to address the problems identified. About 95% of those recommendations were implemented, bringing real change to our railways.

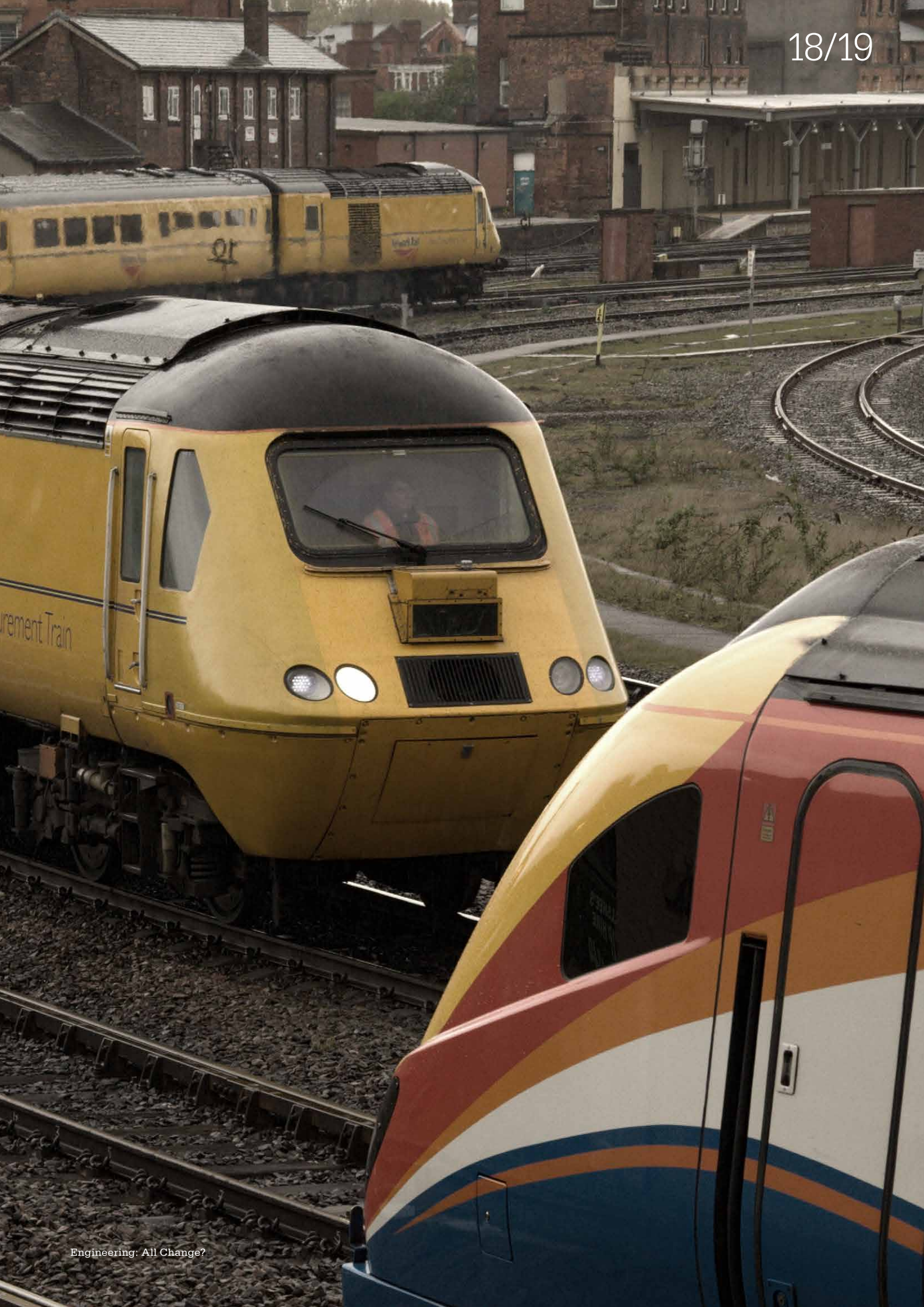
In 2015, I felt my job was done at the RAIB. I could not have immediately rejoined the industry that I been investigating until the day of my departure. I therefore took this opportunity to invest my energies into becoming more involved with work of the Engineering Council, our Institution and the Royal Academy of Engineering.

Irish Rail: Non-Executive Director

I am currently a Non-Executive Director of Irish Rail, appointed by the Minister for Transport, Tourism and Sport.

I am a Board member of Engineering Council, and a member of the Audit and Risk Committee of the Royal Academy of Engineering. I was formerly a Governor of Imperial College, London. In 2013 I was awarded an honorary doctorate by Cranfield University for my services to the rail industry.


John Armitt
Network Rail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Through this Institution and my employment I have met professional engineers whose inspiration and encouragement have played no small part in my working life from the outset until now. I want to acknowledge how immensely grateful I am to those people.

I would also like to thank the Rail Accident Investigation Branch, Network Rail, Bombardier, RSSB, Cheltenham Ladies' College, the Royal Academy of Engineering, and the Institution's Railway Division who have in particular helped me with materials for both this paper and my inaugural Presidential Address, and Colin Brown and Richard Campbell from the Institution for their support.

And last, but certainly not least, I owe Mikael my very special thanks for understanding why my professional and voluntary work is so important to me, for his encouragement and his support.

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