White Paper

Making Things Work
Engineering for life – developing a strategic vision

Briefing the thinking from a cross-sector industry conference held in London on 13th May 2015 to consider the case for a National Strategy in Through-life Engineering Services

30th June 2015
Contents

Overview

Part 1: Strategic Context

Part 2: The Through-life Engineering Service (TES) Market

Part 3: Opportunities and Challenges

Part 4: Delivering Priority Capabilities

Conclusion
Overview

This paper briefs the thinking from a cross-sector industry conference held in London on 13th May 2015 to consider the case for a National Strategy in Through-life Engineering Services (TES). The conference was hosted by the industrial sponsors of the EPSRC Centre for Innovative Manufacturing in Through-life Engineering Services, and facilitated by Cranfield University.

The UK has a national strength in innovative engineering and some of the world’s most complex, long-life product and infrastructure to maintain but there is little focus on “engineering systems for life” or “through-life engineering services”. A national focus on through-life engineering services (TES) will transform the way we manufacture and deliver sustainable products for future generations enabling access to a considerable global market whilst improving public value from our long-life complex assets such as railways.

• Part 1: Strategic Context
  A context for TES – what is it, and why is it important for manufacturing?

• Part 2: The TES Market
  The current market, and market projections for engineering services

• Part 3: Opportunities and Challenges
  What these are, and how they can be realised or overcome

• Part 4: Delivering Priority Capabilities
  Industry, government and academia’s role in delivering key capabilities

• Conclusions

1 Engineering and Physical Sciences Research Council
Part 1: Strategic Context

Through-life Engineering Services are the technical services necessary to guarantee the required and predictable performance of a complex engineering system throughout its expected operational life with the optimum whole-life cost, taking account of design, manufacture, maintenance, repair, overhaul and disposal or re-use.

They (TES) will be key to manufacturing productivity and high value jobs in the circular economy of the future.

With increasing interest in the circular economy and the need to get more from ageing infrastructure, taking an "end-to-end" perspective on design, manufacture, maintenance, repair, overhaul and disposal, enabled by TES, will be a critical discriminator in very large global market for engineering support and services - approaching £1 trillion in 2025. Despite having leading capabilities in the field the UK currently enjoys only about 5% of the current global market and this will decline if no action is taken. Nevertheless, TES is significant to the UK with around 6000 companies employing over 107,000 people in engineering support and services with an average wage of £42,000 as compared to an overall industrial average of £27,000, demonstrating the "high-value" nature of TES employment. There are many strengths in the UK industry and with the right focus and execution the share of the global market can reach 7 to 8% by 2025.

TES are the vital, but currently missing, link for sustainable manufacture and infrastructure, and for the circular economy. It is vital to enable the transformation from “open-loop” linear, transactional or “throw-away” business models to circular, “closed-loop” alternatives integrating engineering with other business functions. In the future customers will only buy services: product-only providers will not exist in many technically complex fields leading to a polarization of manufacturing between the “throw-away” and circular economies.

In this vision of the future economy nobody and no company will ever buy major assets again: they will simply pay for some kind of service or functionality and will not think about products and services being separated. The Internet of Things and “incomplete products” where the product or asset, no matter how complex, is configured for and remains an integral part of the service delivery will drive this service economy. In this economy there will be two types of players:

• Service providers who will dominate profit recovery, sharing this with the service supply chain who are able to understand the operating context and make a value-add contribution to managing the assured performance of the underlying assets through-life, and

• “Traditional” manufacturers providing products and parts without an ability to support or understand the service supply chain and whose profits will be marginalised through global competition: competing in a race to the bottom – driven there by customers who understand TES and therefore get real value for money for the in-service support of their assets.

The UK can be at the forefront of these evolving business models and technologies for productivity in high-value manufacturing focused on customer value and the circular economy. World-class TES can drive infrastructure investment and the re-skilling of the engineering and manufacturing workforce creating new high-value jobs within the economy: increasing productivity and building the brand of UK manufacturing.

A National Strategy for TES will help by developing the ‘high gearing’ national capabilities, such as collaboration across sectors, necessary to deliver this transformation, at pace.
Such a strategy will focus the critical TES contribution to a number of the UK’s industrial strategies and highlight those from which it is worryingly absent.

Collaboration is a key high gearing function that will be enabled by a National Strategy encouraging the cross-fertilization of experience between industrial sectors, and how intellectual property (IP) is shared in a regulated and controlled way. The National Strategy will differentiate the UK’s capabilities in a high-value global market.
The TES Centre has produced a report on the UK and global market for engineering support and services\(^2\) that has initially considered data across eight sectors.

Successful engineering companies made the switch to service-centric business models from the mid-1990s to early 2000s and now derive between 50% and 60% of their revenue from these activities with margins much greater than that from selling the product alone. There are many instances where the service and support revenue has sustained companies through periods of low demand for new product, such as during the recession.

Companies that have made a success of support and service have identified a clear vision, focus and execution of their transformation to being a service provider. They have designed and implemented a service supply chain, managed divestments, mergers and acquisitions and made strategic alliances to grow in market and win long term business. They have also employed capital to improve facilities and infrastructure, and invested between 5% and 8% of total revenue in focussed research and development.

In financial year 2014-15 the UK Support and Service industry generated revenue of over £23bn (£23,000 million) comprising £11bn within the UK and over £12bn in global exports to a world market of around £500bn. More than 50% of UK companies’ revenue comes from exports representing approximately a 5% share of the global market. On current trends, in 2025 the value to the UK will be over £35bn with exports accounting for 65% but representing a diminishing share of a greatly expanded global market of over £700bn. A national focus on TES will enable this forecast to be exceeded significantly.

Around 6000 companies employ over 107,000 people with an average wage of £42,000 as compared to an overall industrial average of £27,000\(^3\), demonstrating the “high-value” nature of TES employment.

We are scratching the surface. As well as improving the value of engineering employment it is clear a focus on TES, through establishment of a National Strategy will support access to a greater proportion of a very large global market.

Although circumstantial evidence from early adopters of engineering services such as Rolls-Royce, BAE Systems and Bombardier suggest that the UK is in a world leading position in understanding TES, there is clearly an opportunity to do much more at a national and global scale and, indeed, to more effectively sustain our own ageing infrastructure. Conversely, if we don’t take a lead on this our industries are at risk of being taken over by others. We need to be able to further differentiate the UK’s capabilities in this high value global market.

**Enabling other UK Industrial Strategies**

Development of TES capability is clearly necessary to support a number of current UK industrial strategies but is addressed explicitly only rarely. A National Strategy in TES will ensure that those industrial strategies that require it are properly supported whilst highlighting the needs of those in which TES is worryingly absent. At least four of the sectors considered in the market analysis illustrate this concern:

- Rail
- Nuclear
- Marine
- Aerospace
The development of a National Strategy for TES could be instantiated for each of the above industry sectors, along with others, and could provide a framework for collaboration between industries such that TES capability and capacity could be developed on common principles, and potentially, with economy of cost and effort.

2 UK Support and Service Industry as a High Value Employer and Net Exporter, Raj Mehta, TES Centre, Cranfield University 2015
3 Source ONS data from December 2014 SIC Division 33
Part 3: Opportunities and Challenges

The UK leads today. TES is mission critical for long-term growth and export in high-value manufacturing – if we don’t continue to lead we will lose out.

Opportunities
• Continue to lead, through differentiating UK capabilities
• Focus on UK engineering innovation and technology: “export reliability and availability”

Challenges
• Commoditization of the service element continues – need to develop skills and behaviours that break free of goods-dominant thinking in manufacturing
• There is presently no clear national TES focus without which we will lose sight of the opportunities
• Long-term thinking is a missing piece in UK productivity – can this be supported by better incentives?
• Engineering institutions (and other institutional stakeholders) and many initiatives such as the Catapults and industrial strategies are fragmented and stove piped

TES provides an essential link to, and enabler for new business models critical to the realization of the circular economy.

Opportunities
• Provide a global lead for the manufacturing transition to the circular economy
• Develop TES technologies and standards to drive “circular economy” thinking, and leverage relevant EU legislation
• Share learning and scarce resources to accelerate development and support the aspiration to be world leaders
• Add value to the economy based on skills and cooperation

Challenges
• Move from closed-loop to open-loop business models and thinking (beyond engineering, enabled by TES skills, technologies and standards)
• How is this driven into the rest of the business (‘closing the loop’)?
Government contracts, especially those for infrastructure, energy and transport are critical and could provide a game changer for TES and competitiveness in the future.

**Opportunities**
- Government can lead by being a service customer, improving value for money in government contracting

**Challenges**
- How to get Government to act as a service customer?

Transactional, lowest tendered price competition for manufactured goods and infrastructure is driving a “race to the bottom” where the UK is increasingly unable to compete against the rest of the world resulting in weakening margins and negative growth. Those early adopters of servitized manufacturing and TES have demonstrated the ability to grow by providing better value to customers and shareholders, as well as higher value jobs. Government and industry leaders can strongly influence and support rolling out the approach across the service supply chain and SMEs in particular.
Part 4: Delivering Priority Capabilities

There are four clear thematic areas where “TES-based” capabilities can make a real difference to UK productivity, leadership and competitiveness in high-value manufacturing and the global circular economy: Technology, Standards, Supply Chain and Skills.

Technology (and analytics)

Better tools and techniques are needed for data integration and analysis, performance prediction and maintenance that work “end-to-end” across the product life cycle and across the service supply chain. These should support the transformation from “open-loop” to “closed-loop” business models with multi-functional management and collaborative behaviours.

In particular there is a need for better through-life cost and risk models, and better condition management and fault analysis capabilities. These will improve performance assurance (predictability) with automation and self-repair technologies to reduce system downtime for essential maintenance interventions. Without such models there will be little chance of building in sustainability or maintainability to complex assets. Effective cost and risk models are particularly important to allow the trade-off necessary across research, design, operations and overhaul, and recycling needed to support an optimum cost service within the future circular economy.

Technology developments to facilitate management, transfer, integration and analysis of contextual data, with no technology limit to the “mash-ups” available for meaningful operational performance analysis, allowing knowledge transfer and development whilst helping to manage intellectual property, will be key enablers for TES – “data is going to do it for us”.

Standards

Formal standards, and regulation, will be key enablers for innovation in TES, for knowledge transfer and behavioural alignment across the service supply chain and knowledge transfer across industries to accelerate capability development.

A TES “standards strategy” will build on the success of ISO 55000 (Asset Management) and other recent standards to work (such as BS 11000 Collaborative Business Relationships, IEC 60300 Dependability and BS 8887 MADE⁴) and, of course ISO 9001, towards an integrated set of behavioural, process and technical standards, many of which already exist, to codify emerging best practice in TES. It will represent a wider perspective on the economics of design, manufacture, commissioning, maintenance, upgrade, and decommission / re-use of complex physical assets than that taken by previous standards and ISO 55000 in particular: whereas ISO 55000 provides a generic process standard for managing the main asset groups that contribute to business objectives, TES seeks to address how these assets are effectively integrated across a wider enterprise so that the "through-life" management of complex, physical or capital assets remains optimised for value creation.

Supply Chain

The supply chain needs revolutionary change to adapt to the circular economy. The future service supply chain must embrace service and TES-thinking and behaviour or otherwise compete in the race to the bottom.
TES, or engineering service supply chains of the future will need to be very different: they will be highly collaborative comprising suppliers who are able to understand the operating context and make a value-add contribution to managing the assured performance of the underlying assets.

Whilst those firms that have been pioneers of engineering services – for example “availability contracting” – have made progress towards understanding the issues, technologies and behavioural changes needed, the supply chain has not generally been engaged in this “new thinking”. Customers – governments and service operators – and the associated service providers have an obligation to broaden the engagement of the supply chain in TES thinking to accelerate TES capability development, particularly in SMEs.

Skills

TES create multi-functional, high-value jobs requiring new skills and collaborative behaviours but have not been recognised as an attractive or interesting area of work resulting in particular difficulties in developing the workforce.

As with engineering as a whole there is a skills shortage. TES requires a skilled workforce and is amenable to inclusive employment. It creates multi-functional, high-value jobs with average wages in engineering services 1.5 times those of engineering as a whole, yet is not seen as an attractive or interesting “mainstream” area of engineering. This is not an argument to create yet another professional specialization but rather mobilize interest across the engineering and associated professions and institutions. This will provide a joined-up narrative that engages interest and develops consistent capabilities across each of the contributory disciplines.

A TES skills programme is needed to generate interest and expertise, but also to promote the major change in attitude and behaviour to support the new sharing and collaborative operation of service supply chains. “Generation Z” are well disposed to these behaviours but need to have their interest in engineering and TES in particular engaged. TES, and operating within the service supply chain, is not a case of just winning a new contract type, it fundamentally spins the business on its head with a significant “soft side” to the change. Companies, and their people need to fundamentally change their thinking to capture value from TES.

What can we do about it?

Industry, government and academia all have potential roles to play in delivering these capabilities through new initiatives or leveraging the “TES dimension” of other industrial strategies.

Industry leaders can do more to develop “TES-thinking” and share knowledge in TES to accelerate capability development in the supply chain and within SMEs in particular.

All these groups need to fundamentally change their thinking to capture value from TES, and can do more to enable a focus on the importance of TES and the needs for new technology, skills and collaboration or knowledge sharing. Industry and the early adopters of TES in particular, will need to lead on this new thinking, improvements in knowledge sharing and the acceleration of capability development in SMEs and their inclusion within the service supply chain. Industry, with academic support, can work with the engineering and professional
institutions to ensure that an appropriate “through-life” or TES perspective is taken in education and the requirements for institutional membership.

Successful companies have pushed the need for “design for TES” into the engineering culture and supply chain. Whilst this is the start of a journey for these early adopters, the approach and expertise can provide a pathway for others to follow.

**Industry and Government** can work together to shape future technologies, standards and skills, ensuring that the “TES-dimension” of other initiatives and Industrial strategies are coordinated.

Collaboration in the development of new and existing formal standards will in particular enable cross-sector skills sharing and inclusion of all parts of the service supply chain.

The initiative for new formal standards might, for example, take the form of a national TES Standards Institution set up as a collaboration between BSI, the High Value Manufacturing Catapult and industry on a similar basis to the Smart Cities Standards Institution. Within such an initiative, government and industry might usefully collaborate on the development of standard role and capability definitions for TES to enable broader participation and accelerate skills development.

**Government** can support development of TES practices through effective commercial leadership: by setting aspirational targets for public infrastructure and assets.

Government can do more to encourage development of TES practices by defining alternative commercial policies to be followed for TES based service contracts, establishing the data and performance models for setting realistic aspirations for value for money and continuous improvement, and by understanding and developing the management skills to deliver these contracts. Aspirational targets could be set for public infrastructure by exercising leadership in contracting for service and availability of high value manufactured products and infrastructure, and in integration of capability development across current initiatives with a balanced public investment in research and development for TES technologies and skills.

These measures could allow government to lead practice development by ensuring it acts as a “service” customer wherever possible: particularly with the renewal and regeneration requirements in defence, infrastructure (including utilities), energy and transport. Government could also look at European Union legislation to open up and drive the circular economy towards servicing products.

**Government and Academia** can ensure that current and future manufacturing initiatives, including research, are better integrated with TES elements being developed consistently.

More can be made of taking a “transverse” view of TES needs and capabilities across current industry strategies and research initiatives. This should be the primary responsibility of government and academia, with the support of industry, to ensure that current and future manufacturing initiatives are better integrated and that the TES elements are developed consistently.

---

4 **Manufacture, Assembly, Disassembly and End-of-life processing**
Conclusion

Innovation in TES and the development of these capabilities across the UK supply chain will contribute significantly to manufacturing productivity and the development of high-value employment across the UK manufacturing sector. Development of TES capabilities will also provide improved competitive access to a significant global market in engineering support and services. But industry and government need to do more to change their thinking to capture value from TES.

TES are the vital, but currently missing, link for sustainable manufacture, infrastructure, and the circular economy. It is vital to enable the transformation from “open-loop” linear, transactional or “throw-away” business models to circular, “closed-loop” alternatives integrating engineering with other business functions.

A National Strategy for TES will help by developing the ‘high gearing’ national capabilities, such as collaboration across sectors, necessary to deliver this transformation, at pace. It will ensure development of the enabling technology and standards so that the leading practitioners engage productively with all levels of the supply chain, particularly SMEs, with confidence that appropriate skills will be developed for the future. It will furthermore promote access for UK firms to a very substantial global export market.

The National Strategy will build on the opportunities, and mitigate the challenges associated with what is currently a leading position in building manufacturing productivity and high-value employment during the transformation to a global circular economy. Developing capability in TES is key to future growth in high value manufacturing and manufacturing productivity.
# List of Attendees

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neil Barnett</td>
<td>ADS Group Limited</td>
</tr>
<tr>
<td>John Duthie</td>
<td>AMEC</td>
</tr>
<tr>
<td>Sam Turner</td>
<td>AMRC with Boeing, University of Sheffield</td>
</tr>
<tr>
<td>Peter Stuttard</td>
<td>Aspîre Consulting Ltd</td>
</tr>
<tr>
<td>Mark Norris</td>
<td>Atkins Limited</td>
</tr>
<tr>
<td>Tim King</td>
<td>Babcock International</td>
</tr>
<tr>
<td>Stewart Leinster-Evans</td>
<td>BAE Systems</td>
</tr>
<tr>
<td>Ian Laurence</td>
<td>BAE Systems</td>
</tr>
<tr>
<td>Paul Thorley</td>
<td>BAE Systems</td>
</tr>
<tr>
<td>Rob Cowling</td>
<td>Bombardier Transportation UK Ltd</td>
</tr>
<tr>
<td>Ben Sheridan</td>
<td>British Standards Institution</td>
</tr>
<tr>
<td>Steve Wilson</td>
<td>British Standards Institution</td>
</tr>
<tr>
<td>Bill Bardo</td>
<td>Centre Advisory Board Chairman</td>
</tr>
<tr>
<td>Ian Blackman</td>
<td>COG UK</td>
</tr>
<tr>
<td>Raj Mehta</td>
<td>Consulting</td>
</tr>
<tr>
<td>Andrew Gill</td>
<td>Consulting Partnership</td>
</tr>
<tr>
<td>Eleanor Collins</td>
<td>Cranfield University</td>
</tr>
<tr>
<td>Jose Endrino</td>
<td>Cranfield University</td>
</tr>
<tr>
<td>John Erkoyuncu</td>
<td>Cranfield University</td>
</tr>
<tr>
<td>Jorn Mehnen</td>
<td>Cranfield University</td>
</tr>
<tr>
<td>Rajkumar Roy</td>
<td>Cranfield University</td>
</tr>
<tr>
<td>Andy Shaw</td>
<td>Cranfield University</td>
</tr>
<tr>
<td>Andrew Starr</td>
<td>Cranfield University</td>
</tr>
<tr>
<td>Paul Tasker</td>
<td>Cranfield University</td>
</tr>
<tr>
<td>Juan Matthews</td>
<td>Dalton Nuclear Institute University of Manchester</td>
</tr>
<tr>
<td>Yvonne Elsorougi</td>
<td>Department for Business Innovation &amp; Skills</td>
</tr>
<tr>
<td>Peter Brook</td>
<td>DLA Piper</td>
</tr>
<tr>
<td>Alan Purvis</td>
<td>Durham University</td>
</tr>
<tr>
<td>Nick Frank</td>
<td>Frank Partners</td>
</tr>
<tr>
<td>Geoff Hanson</td>
<td>GE Aviation</td>
</tr>
<tr>
<td>Chris Bell</td>
<td>GE Intelligent Platforms</td>
</tr>
<tr>
<td>Rachel Gollin</td>
<td>GKN Aerospace Services Limited</td>
</tr>
<tr>
<td>Russell Hargrave</td>
<td>Hitachi</td>
</tr>
<tr>
<td>Prasanna Gundi</td>
<td>HP Enterprise Services</td>
</tr>
<tr>
<td>Ian Collier</td>
<td>HVM Catapult</td>
</tr>
<tr>
<td>Victoria Abbott</td>
<td>Hydro GmbH</td>
</tr>
<tr>
<td>Jonathan Farndfield</td>
<td>Hydro GmbH</td>
</tr>
<tr>
<td>Derrick Dunkley</td>
<td>IAM</td>
</tr>
<tr>
<td>Phillipa Oldham</td>
<td>IMechE Management Group</td>
</tr>
</tbody>
</table>
Jeremy Lovell  Intelligent Energy
Richard Pitman  KTN
Alex Stallman  Labinal Power Systems
Chris Owen  Marshall Aerospace and Defence Growth Partnership
Richard Denning  MOD
Ken Young  MTC
David Hogan  Nuvia Limited
Mal Bruce  Pilotwise Internation Ltd
Rob Smith  Plexus Planning Limited
Dave Benbow  Rolls Royce
Steve Gregson  Rolls Royce
Andy Harrison  Rolls Royce
Roddy Beat  Segin Global
Steve Foxley  Siemens
Will Stirling  Stirling Menia
James Selka  The Manufacturing Technologies Association
Chris McDonald-Bradley  TRW Conekt
Paul Calver  UKTI
Bernard Molloy  Unipart Logistics
Dan Somers  Warwick Analytics
Pasquale Franiosa  Warwick University
Organised by the EPSRC Centre for innovative Manufacturing in Through-life Engineering Services

The national research centre is hosted by Cranfield (lead) and Durham Universities. Our core industrial partners are Rolls-Royce, Bombardier Transportation, BAE Systems, Babcock International and the UK MOD. We also have another eighteen industrial partners and continue to grow.

The mission of the Centre is to develop knowledge, technology and process demonstrators, novel methodologies, techniques and the associated toolsets to allow the concept design of high value engineering systems based on design and manufacturing for through-life engineering services. We aim to improve the availability, predictability and reliability of complex engineering products to deliver the lowest possible whole life cycle cost by developing technologies and processes to improve the design and manufacture of such systems.

Our vision is to provide thought leadership in through-life engineering services and be the first choice for UK manufacturing companies as a source of technological solutions, research and development capability, knowledge, skill and advice.

TES Centres website:  
www.through-life-engineering-services.org

TES Market Size Report - Full Paper:  