A National Strategy for Engineering Services

Delivering UK Economic Growth by Making Things Work Better for Longer

June 2016
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Introduction

We in the UK have been leading innovators in manufacturing since the Industrial Revolution. This remains true today as we work into the ‘fourth epoch’ of manufacturing, based on digital innovation and the Internet of Things (IoT). New technology and new business models – new ways of satisfying customers’ demand for value – are increasingly enabling manufacturing innovation.

The developing trend to ‘servitized manufacturing’ is a specific example of UK innovation that has allowed early adopters to develop successful differentiated offerings in the global market. Services within manufacturing, and indeed other sectors, are increasingly becoming a pre-requisite for success. But experience tells us that the transformation is difficult and there is a strong argument that UK capability needs to be built more quickly, across a broader front, in order to maintain and develop our lead.

The market influence for engineering services, manufacturing and technology where new methods and business models are applicable is huge. This has been assessed for this study by Professor Alan Hughes (University of Cambridge Judge Business School) and BIS and is of the order of 16% UK Gross Value Added (GVA), and to have very significant export potential.

This strategy provides a framework for this cooperative capability development across all relevant industrial sectors that rely on, or provide ‘complex engineering assets’. Much progress has been made in UK manufacturing in recent years through a focus on high-added-value production, but the sector remains challenging and highly competitive. Increasingly, leading UK companies are turning to service provision to differentiate themselves in the global market. The High Value Manufacturing Catapult, sponsored by BIS and Innovate UK is accelerating development in this area. Rolls-Royce continues to pioneer engineering for service: selling ‘power by the hour’ to airlines and aircraft lessors.

Leading manufacturing companies and those in many other sectors – from construction to transport to energy – recognise the imperative to provide services as a pre-requisite for success: to ‘servitize’. Through-life engineering services (TES) for high-value manufacturers and owners or operators of complex assets and infrastructure are increasingly critical to productivity and growth. Our UK capability in this area is, and must continue to be, a real differentiator in the global market.
There remains a significant challenge, which this strategy addresses:

- It is very difficult to add engineering services to conventional manufacture: to change from project delivery to the collaborative long-term outcomes characteristic of service
- There is not sufficient strength in depth in the UK to support our global market leaders let alone the export ambitions of new adopters and SMEs
- We need an agenda of cooperative capability development, aligning UK manufacturing and our ‘engineering plc’ with business model innovation across all industrial sectors that rely on, or provide ‘complex engineering assets’.

At present the ‘wheel’ is being continuously re-invented and the early practitioners, such as Rolls-Royce, BAE Systems, Bombardier Transportation, Siemens and Babcock International, all seek to increase the strength and capacity of their ‘TES-enabled’ domestic supply networks. Other sectors such as built environment, healthcare, renewable energy, machinery and industrial biotechnology recognise the issues but use a different language, inhibiting cross-sector learning and development. The early practitioners propose this strategy as a means to accelerate capability development in the UK in these important fields of engineering, manufacturing and technology. This will benefit traditional manufacturing as well as the other and emerging industries that use products sensitive to improvements in TES capability.

The proposition is that a nationally coordinated approach to capability development in through-life engineering services, supported by government, will significantly improve productivity and competitiveness at firm and national level. The industrial sponsors of the strategy commit to forming a cross-sector national ‘TES Council’ to inspire UK industry, lead delivery of these benefits and seek government support for this venture.
Overview

16.8% of UK annual GVA is critically dependent on the creation or use of high-value, long-life assets: making things work better for longer. Assets that work generate value, those that do not generate cost. This strategy’s goal is to achieve a 20% reduction in cost with a 20% improvement in asset availability across more than £20bn of UK economic output: a 20:20 vision. This would be a significant transformation of national productivity and global competitiveness. The time to do this is now. The world is shifting to a service economy, demanding increased manufacturing flexibility and closeness to customers. Customers are increasingly buying use, not ownership, of assets: manufacturing is service.

As an early adopter of engineering services, the UK is uniquely positioned to profit from this change. Achieving the bold goals of the 20:20 vision will require significant changes in behaviours, the adoption of new business and economic models, and exploitation of new and emerging technology. Through-life engineering services – TES – encompass the design, creation and in-service sustainment of complex engineering products with a focus on their entire life cycle, using high-quality information to maximize their availability, predictability and reliability at the lowest possible through-life cost.¹

TES integrate manufacturing, engineering and technology with new service-based business models such as leasing and benefit sharing, to ensure that the manufacturer and/or maintainer is incentivized to provide greater user value. TES have broad scope, embracing a range of technologies and business models that have application across many manufacturing sectors. Any industry that produces complex engineering products and where suppliers have the opportunity to consider their whole life cycle is, to some extent, one in which TES principles and associated business models may apply. Likewise, any industry that uses complex engineering products and where buyers of those products have the opportunity to consider their whole life cycle is, also, to some extent, one in which TES principles and associated business models may apply. In daily life, TES models have become increasingly familiar from such examples as automotive leasing in place of new buy, and a ‘through-life support’ approach for rented housing (both social housing and top end of the market). Leading-edge industrial case studies include – from civil aviation – Rolls-Royce TotalCare, Boeing

GoldCare, and Airbus FMS\textsuperscript{2}. Such examples merely scratch the surface of the potential value of TES products.

Currently, the UK places insufficient focus on TES – on what we might term an ‘engineering for life’ approach. Concerted support for TES across the range of applicable sectors would highlight the benefits of adoption and increase the chances of realizing the economic potential identified as achievable by 2025. Strategic action by industry, academia and government to support the rapid development of capability in TES would improve UK competitiveness in a large global market and improve productivity while providing high-value employment.

This strategy is the product of an extensive process of consultation and research from spring 2015 to spring 2016. It draws on the following sources:

- Four strategy development workshops attended by approximately 150 representatives from a range of industrial sectors – including automotive, aerospace, defence, marine, energy, nuclear, electronics, and logistics – and from manufacturing trade associations, government agencies and academia
- A market and data review\textsuperscript{3}
- Sector perspective discussions, with sector leads in the Department for Business, Innovation and Skills (BIS), selected industrialists and in some cases literature review\textsuperscript{4}. Output from the discussions fed into the market and data review.

Strategy development has been driven by a steering group whose members include senior leaders from the aerospace, defence, rail and machinery sectors, government and government agencies, academia and industry associations.\textsuperscript{5} Steering group members are listed on page 24.

\textsuperscript{2} See annex 1 for further detail of current examples.
\textsuperscript{3} Through-life Engineering Services (TES) Market and Data Review, Alan Hughes and Jonathan Hughes, Cranfield University 2016 \url{http://www.through-life-engineering-services.org/strategy}
\textsuperscript{4} See A National Strategy for Engineering Services – Sector Report, Cranfield University 2016 \url{http://www.through-life-engineering-services.org/strategy}
\textsuperscript{5} Outline implementation options discussed by the steering group in the light of the consultation are also reported: these are identified as such in the text.
1. The Case for a TES Strategy

UK companies already lead globally where the service model is replacing ownership across a number of sectors of manufacturing industry. This has driven productivity and exports. But leading practice is limited to a few early and successful adopters of ‘servitized manufacturing’ and TES. These companies, predominantly from aerospace, defence, rail and ICT (information and communications technologies) say they lack strength in depth, and breadth, in their supply chains. They are also well placed to help build capability across other relevant sectors including healthcare, renewable energy, industrial infrastructure and biotechnology as well as emerging sectors such as bio-renewables. Both these opportunities are supported by the programme of cooperative capability development, outlined in this strategy, which aligns UK manufacturing and our ‘engineering plc’ with business model innovation across all industrial sectors that rely on, or provide ‘complex engineering assets’.

Collaborative development of national capability in TES will deliver productivity and global differentiation in a future where the service model has replaced ownership and where attention to the circular economy and environmental sustainability becomes critical. Although focused on the integration of manufacturing, engineering and technology with new business models, the programme must also address market and customer needs, cultural change and communication, financial and economic models, skills, standards and regulation.

The size in terms of GVA of the sectors capable of being transformed by TES means that the market opportunity is huge. It is, however difficult to estimate precisely. TES cuts across many manufacturing and other sectors, including those consuming TES (User sectors) and those providing TES (Maker sectors) and those which do both, in particular, energy, and electronics and ICT. There is inevitable uncertainty about the extent to which the production and use of TES is technically feasible across these sectors and about the extent to which the use of TES methods will diffuse across businesses in them.

To tackle these uncertainties an initial assessment has been generating a very broad range set of upper and lower bound estimates. This pilot assessment exercise utilizes expert opinions gathered through interviews and literature assessments. It looks at the market opportunity and has indicated that around 16.8% or £275.2bn of the UK economy is attributable to sectors that could be influenced
by TES methods. Of this at least 2.0% or £31.6bn is potentially associated with the creation or application of through-life engineering services.⁶

From a Maker perspective the upper bound estimates suggest that £64.0bn (billion) of GVA could be generated from TES-based outputs, amounting to around 3.9% of total UK GVA. From a User sector perspective an upper bound GVA of around £120bn or over 7.3% of UK GVA could be associated with the use of TES. Lower bound estimates suggest that TES Users account for at least around £16.2bn or 1.0% of total UK GVA, while TES Makers account for at least around £15.4bn or 1.0% of total UK GVA.⁷

A TES approach involves delivering lifetime value for products, assets and infrastructures to make businesses grow. The figure below shows the desired relationship between cost and value throughout the expected operational life of a product or system, a life cycle which encompasses R&D, design, production, marketing, logistics, in-service (maintenance, repair), upgrade, overhaul and disposal, or re-use. In a TES transaction, the customer pays for a service or functionality rather than an asset, and does not think of products and services as separate. It is the focus on desired functionality which enables the switch of emphasis from ownership of a product or system to delivery of a service. Maximizing the service value throughout the expected operational life of the product or system, while minimizing cost, become the central drivers. ‘Value-in-use’ becomes the touchstone by which a product or system is judged. Such a cultural shift requires considerable change in the business environment (ecosystem).

⁷ These figures exclude SIC 33 covering ‘repair, installation and maintenance’ which is clearly TES related and which represents 0.5% of UK GVA (£7.3bn).
In the following figure:

- **Service value** indicates monetizing customer and supplier needs for performance and safety throughout the lifecycle, delivering *value-in-use*
- **Cost** represents the resources required to deliver value *throughout the lifecycle*
- **Create** means to design and establish so as to maximize value vs cost potential across the lifecycle
- **Use** represents maximizing *actual* customer value vs cost in service
- **Refresh** completes maximization of actual customer value vs cost through maintenance, upgrade and disposal/recycle
- **Ecosystem** represents the need to optimize culture, environment and resources of the network of suppliers and stakeholders essential for delivery of value-in-use.
Although there are areas of excellence unique to the UK, the opportunity for TES-based business models is presently underestimated. Whilst practised (though not in name), TES are not well understood across the national economy and the market is immature. Information sharing is constrained by a number of factors, not least IP concerns, but also commercial trust issues which limit ability to exploit the opportunities presented. Notwithstanding that world-leading examples of TES exist in the aerospace, defence, rail and – as isolated examples – in a number of other sectors, overall in the UK short-term, profit-and-loss-based financial drivers dominate. Investment decisions are made on the basis of cost rather than value, which leads to a disconnect between capital and through-life considerations. A commitment to service is seen as high risk, leading to aversion to investment and innovation in the field.

If we consider the present prevailing ‘ownership’ model, however, the risks are high, particularly as regards obsolescence and technology lag. The underlying economics of TES models are not well understood. Suppliers and procurers think in terms of products, not their function throughout life: through-life support is not a primary driver for OEM designs to tailored requirements where cost, schedule and performance are the focus. In general, service is seen as an add-on to equipment sales and often a significant source of income, even though high service costs present a potential source of customer dissatisfaction. A national shift to business based on TES would strengthen the UK economy in multiple ways. A world in which TES principles prevail would be one which favours UK flexibility and adaptability and strong R&D base. In particular, it would:

- Build international competitive advantage and exports
- Improve productivity whilst also creating more skilled jobs
- Drive the transformation of supply chains necessary for the circular economy and sustainable manufacturing of the future
- Enable emerging industries to grow and establish world-leading positions
- Equip innovative and early adopting small and medium-sized businesses (SME) and original equipment manufacturers (OEM) for new market opportunities.

Business based on TES offers potential for economic transformation to new, highly flexible business models, with suppliers ever closer to the customer and increasingly efficient use of potentially scarce resources. The UK has an opportunity to lead the world if the appropriate actions are taken to enable and accelerate collaborative capability development and cross-sector learning. Without such action, it is likely that our leading companies and the UK as a whole will become increasingly
challenged in the global marketplace. The UK Government has an opportunity to lead the way by applying TES principles to public procurement and enabling a new policy framework for IPR sharing. The broad outline of the current situation, future vision and journey to achieve the vision are outlined in the chart below.

<table>
<thead>
<tr>
<th>Current State</th>
<th>TES Journey</th>
<th>Vision 2025</th>
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| - Opportunity is underestimated | - Developing TES-related capabilities:  
  - Market knowledge, to ‘market with’ a deep understanding of user and customer needs  
  - Innovation and innovating integrated business, economic, operational and technical models  
  - Lifecycle ‘end-to-end’ technology innovation and analytics, design for service and degradation  
  - Integrated management of cooperative customer and supply networks  
| - There are islands of excellence | - Enablers:  
  - Transferable skills with a ‘TES-focus’ and service culture through cross-institutional engagement  
  - Transformation of organization culture and communication style to ‘service-led’  
  - Development of common integrated framework (or behavioural) process and technical standards  
  - Establishing a financial environment where life-cycle costing and value assessment is the norm  |
| - Minimal cross-sector learning, poor collaboration on the world stage. Collaboration inhibited by concerns over IP | - Skills and capabilities enjoy robust institutional support  
| - Lack of collaborative standards | - Risk management and cost efficiency not inhibited by IP ownership  
| - Business models and culture driven by acquisition cost | - Financial models reward long-term value creation  
| - Difficult to cost long-term service or balance risk and opportunity in service provision | | - UK leads in a competitive world market where the service model has replaced ownership across many HVM sectors  
| - All solutions are bespoke with no economy of scale | | - Business models and financing are aligned to long-term value creation by the service enterprise |

The following sections present the strategy in terms of vision, development of TES-related capabilities and enablers including the roles of industry, academia and government, likely benefits and possible success measures and strategic actions. Our consultation process has identified a number of initiatives necessary to promote TES. These encompass:

1. Leading innovation in new TES-related business models  
2. Developing the necessary communications and standards infrastructure  
3. Building knowledge, common language, mindsets and enthusiasm for the necessary new ways of thinking across all high value manufacturing sectors of the UK  
4. Developing the necessary scale, funding and resources of support activities.

The consultation shows strong support for the creation of an industry-led body to drive such initiatives.
2. Vision Statement

Our vision for the future is that the service model has replaced asset ownership, and attention to the circular economy and environmental sustainability are critical differentiators. Business and financial models are aligned to capture long-term value in use. The ability of the UK to provide global leadership in this future is enabled by TES.

Vision summary

UK companies lead globally where the service model has replaced ownership across many high value manufacturing (HVM) sectors, driving productivity and exports. The prime driver for adoption of TES is demand from users across HVM sectors, building from aerospace, rail, defence and ICT to other sectors, for example, healthcare, renewable energy, and industrial biotechnology. Space may be considered a sector already fully employing TES principles and growing very rapidly. The supply chain, including SMEs, is fully engaged in jointly developing and delivering these new service models. Emerging products are getting to market faster, including biopharmaceuticals, bio renewables and micro and small nuclear reactors. Enterprises throughout the supply chain think globally and sustainably, giving fair value in a 'circular economy', and ensuring knowledge and information is transferable: supply chain transformation is driven by broad acceptance of TES principles throughout UK society. Market and customer needs drive TES requirements. New business models for service value creation and risk sharing are supported by trusted and secure data and information. The UK is recognized as a global leader in innovation, including in support of TES.

Culture change and communication are key enablers of TES. Skills required to support TES capabilities are broadly available with a ‘TES module’ in every STEM course, both academic and vocational. Institutional and regulatory arrangements and priorities support appropriate standards, professional registration and IP protection. Financial models reward long-term value creation through common understanding of and long-term approach to risk management and profit in the TES arena. Government procures extensively on a ‘through-life’ basis and treasury models favour and promote TES.

The following section sets out each part of the vision in detail.

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*Source: TES strategy workshops November 2015–January 2016 and BIS and government agency interviews April–May 2016*
Vision

Global leadership

The UK, original equipment manufacturers (OEMs) and SMEs are truly competitive in the global market. Across sectors, ownership is seen as ineffective and is replaced worldwide by a service model: TES are seen as unquestionably better than ownership. The UK has a strategic advantage globally in the industrial market and is consistently best in class, with a reputation as a global lead in terms of TES quality and capability. There is a strong insight into the needs and dynamics of target markets, including emerging markets and industries. Many UK sectors have a significant proportion of value added through the finest, most technologically advanced TES offer in the global market. In addition, UK companies are offering TES on goods made outside the UK.

Exports and productivity

There is a common framework within which to operate across countries targeted for export, with ‘Team UK TES’ explicitly supported through government policies. The UK leads on international standards development (to fill gaps and maintain safety) adopted by the World Trade Organization. Product-only providers are under intense pressure in many technically complex fields, leading to a polarization of manufacturing between low-cost products that may be regarded as disposable and higher value products which are upgraded regularly through life and re-purposed or recycled at the end of life.

Sector adoption

TES support competitive new customer propositions across all of the HVM sectors considered. Sectors where TES are presently extensively practised have seen strengthening of competitiveness, including in aerospace; rail; defence and ICT. The space sector employs TES principles in practice if not in name: capital equipment, while dominating the balance sheet of most companies is invisible to the user of the services provided. New sectors are benefiting from TES principles, including: healthcare; renewable energy and industrial biotechnology.

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9 Source: TES strategy workshops November 2015–January 2016 unless otherwise stated
10 Source: BIS and government agency interviews April–May 2016
Supply chain

The supply chain, including SMEs, is fully engaged in jointly developing and delivering these new service models. Emerging products are getting to market faster, including, for example, Pharmaceuticals, biopharmaceuticals and bio renewables. Enterprises throughout the supply chain think globally and sustainably, sharing value and ensuring knowledge and information is transferable: supply chain transformation is driven by broad acceptance of TES principles throughout UK society. Standard models are used throughout the industry, such as ARINC\textsuperscript{11} and other supply chain integration models.

Market and customer needs

Market and customer needs drive TES requirements. UK suppliers understand their customers better than anyone else, understand potential new markets at home and identify and exploit cross-over markets, and there is a deep understanding of what customers really want as the service from their complex assets. Consumer behaviour is focused on lifetime cost:

- In a significant segment of global markets, ownership is seen as ineffective, and TES is seen as unquestionably better. These customers will only buy services
- Consumers value long-life products that are upgradeable rather than replacing them and recognize the value of solutions that are optimized through-life
- Risks and incentives are shared along with skills and education to create trust and a through-life culture
- Cost of ownership will be readily predictable through-life
- Decision makers’ specifications emphasize total lifecycle cost (TLC) and upgradeability.

\textsuperscript{11} A technical standard for avionics data
New business models

New business models for service value creation and risk-sharing are supported by trusted and secure data and information. Industry predominantly buys capability rather than products. Business models support and sustain the life of a specific ‘product’ or service through cycles of maintenance, upgrade and re-purposing whilst ensuring risk is shared in an effective and economic fashion. Through such models:

- Data, information and innovation have recognized value to both customers and suppliers
- High-performance systems are autonomous, adaptive, secure and accurate
- Immediate data collection and analytics are capable of cross communication, and support decision-making based on assured data

Innovation in technology and analytics

The UK is a global leader in production methods, with cutting-edge manufacturing processes. Intelligent components within viable systems give true autonomous maintenance and data sharing becomes the norm.

Culture change and communication

Culture change and communication are key enablers of TES. The UK is recognized as an exemplar and leader in this area, which is seen as a prime enabler of change – welcoming disruptive innovation and developing and exploiting technology. Indeed, there is broad acceptance of TES principles throughout UK society. There is a clear rationale for industry to change, with a compelling case for increased value-add for all:

- An innovation-centric culture and practice embraces the service economy throughout high value manufacturing
- Inclusive thinking and development is the norm
- An overarching lifecycle assessment process and its execution, which drives a change in culture.
Skills

The UK’s skills and experience gap has been radically transformed. A sustaining and thriving knowledge base has developed, where simple is good and IP is not seen as a barrier or risk. The knowledge base is characterized by:

- Leadership from a registered professional body with recognized qualifications, standards and regulations
- Collective understanding of the engineering skills required to meet market demands
- An embedded culture of TES through the workforce with skills and competency sets at all levels to support the necessary capabilities
- A ‘TES module’ in every STEM course (at a minimum), both academic and vocational.

Institutions and regulation

Institutional and regulatory arrangements and priorities support appropriate standards, professional registration and IP protection. The UK leads international standards development to fill all gaps in capability, maintain safety and be adopted by the World Trade Organization. A registered professional body offers recognized qualifications, standards and inputs to the development of regulations. Intellectual property rules promote data sharing as the norm, supported by appropriate protocols for IP protection.

Finance

Financial models reward long-term value creation through a common understanding of and long-term approach to risk management and profit in the TES arena.

Government procurement

Government procures extensively on a ‘through-life’ basis and treasury models favour and promote TES.
3. Developing TES-related Capabilities

Value propositions
Because TES enables reduced total cost in assets, it not only offers better value for money but also supports increased sustainability and value-add in the economy, in both the public and private sector. With suppliers ‘closer’ to their customers there are optimized design incentives, improved availability of asset or service and better risk management. Exploitation of key UK strengths in IP, R&D, and innovation as well as sensitivity to cultural traditions can create first-rate services. These value propositions are described more fully below.

Value for money
Better value for money comes from extending the life of assets, increasing their availability, reducing and assuring costs, and making more effective use of the key finance, skills and environmental resources. This will lead to increased productivity in major public and private assets, which will increase the sustainability of the economy and increase GVA. The use of complementary skills and the understanding that we are ‘better together’ will create long-term solutions which reduce overall levels of risk in areas such as healthcare, energy, infrastructure and transport. Whole-life revenue will be greater than up-front sales revenue and costs will be reduced. Long-term business models will be based on return on investment. Analytics with high integrity/confidence levels will demonstrate widely the value of new technology.

Customer intimacy
Linking the culture of the provider to the customer enables the creation of optimized design incentives, improved availability of the asset or service and better risk management. Diverse businesses talk the same ‘TES language’ and link together all elements of the customer requirement – improving visibility and manageability, and knowledge and information to share and minimize risk. An effective long-term balance is struck between supply and demand throughout the supply chain.

UK strengths
The UK has a long history of service innovation. R&D and associated intellectual property development are cornerstones of UK value-add.
Capability development

Supporting new through-life business models needs enhanced real-time data capture, integration and analysis and management, exploiting ICT developments such as the IoT. In this way, product knowledge is fed back from the customer to the provider through a reactive and flexible infrastructure and acted on to improve value and keep the provider engaged for longer. These new skills and behaviours combine with TES application of ‘traditional’ engineering approaches including systems engineering and condition-based maintenance, and a strong national standards base in BSI.

Multi-disciplined, resilient people are needed to build on practical experience with international commercial, legal and business skills to manage, sell and promote TES. Upskilling should provide ‘market-ready’ students who can untangle and manage complex relationships as part of a reactive and flexible workforce. TES therefore creates and requires multi-functional, high-value jobs requiring new skills and collaborative behaviours.

Technology development

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. Process and tools necessary for TES include those which support better understanding of science and technology developments, and a common ICT infrastructure for research and innovation, cross-cultural collaboration and training. Research and development priorities may include ubiquitous sensing and information systems and analytics to support collaborative working environments.
4. Enablers: Linking Industry, Academia and Government

Industry, government and academia have equally important roles to play in delivering these capabilities. An industry-led but joint body or forum involving government, academia and industry is proposed, to implement the plan to deliver the strategy. The plan is focused on achieving a 20:20 vision: a 20% reduction in cost with a 20% improvement in asset availability across more than £20bn of UK economic output by 2025.\(^\text{12}\) This will be achieved by influencing:

- Industrial strategies for sectors that either use, or provide TES-applicable products – initially telling these sectors about TES and the TES Strategy and then influencing sector strategies themselves to recognize TES
- Technology programmes in research, development and application of new and related underpinning technologies – particularly regarding measurement and analytics, and degradation, preservation and self-repair
- Customers and users of TES-applicable products, particularly government, to highlight the benefits of demanding a whole-life perspective and to change their procurement and maintenance policies
- Education and training bodies, including professional institutions and the general public to ensure an awareness of TES and whole-life management as important elements of engineering, manufacture, procurement and project management.

With government support, the firms that have led development of this strategy intend to cooperate to deliver the strategic plan. This will involve establishing working relationships with all the groups and organizations currently or potentially engaged in TES-based activity, including servitized manufacture.

Initial action will establish a national ‘TES Council’ mirroring the example of other areas. This may then oversee other initiatives such as the establishment of a TES Catapult or other facility to scale and demonstrate technology and business capability: providing an incubation space for business model and technology innovation and a showcase for learning and capability development across large and small firms and academia.

\(^\text{12}\) Goal based on lower bound estimates of 2.0% or £31.6bn of economic output directly addressable for performance improvement through the application of through-life engineering services (User sectors and Maker sectors not including SIC code 33, see pp. 7–8).
The consultation identified the following specific needs:

- Carry out funded R&D projects/demonstrators to show the case for change
- Link to existing programmes in, for example, in aerospace/automotive/marine sectors
- Engage with the Engineering Council (and other institutions)
- Conduct international benchmarking to ensure the UK remains competitive
- Develop collaborative IP agreements and codes of practice
- Fund and support the national strategy implementation
- Co-ordinate a multi-year, industrially funded rolling research programme which links multiple scientific and social science disciplines.

**Role of academia**
The consultation highlighted multiple roles for academia:

- Verifying the techniques and goals of TES and confirming the economic value of an extended lifecycle
- Developing TES aspects of sustainability, bio-economy, autonomy and big data, IoT, sensors, and data security
- Building the science better to understand degradation mechanisms
- Developing and sharing new business and economic models
- Providing ‘market-ready’ students.

**Role of industry**
Industry has two main areas of responsibility – first, to promote engagement with 'TES thinking', encompassing information exchange, SME integration, business change, financial change, and education-system intervention; and second, to drive and agree appropriate standards for information exchange across industry and supply chains.

**Role of government**
The consultation emphasized that government should continue to fund associated primary science research, and establish or facilitate the establishment of structures which encourage technology pull-through and best-practice sharing between sectors in TES. Sectors that practise TES today will drive further improvements in practice which can, through this facilitated exchange, be shared with new adopters and also with new emerging and growing sectors. As the largest but probably the most diverse user of 'TES-applicable' products, government has a key role in leading the change in procurement practice and financial modeling.
5. Benefits and Success Measures

Benefits
Basing government investment decisions on TES principles will offer significant improvements in value for money in national infrastructure investments, and control of IP by companies and providers will protect key UK industries. The UK can use TES to compete in the global marketplace, yielding faster economic growth and driving innovation in emerging sectors. TES long-term solutions increase the availability of expensive complex assets and so make more effective use of resources – supporting the sustainability agenda and the circular economy, by providing economic measures and controls for optimization of asset utilization.

Through the creation of a joint body or forum for TES, a single voice will not only help promote sustainability: cross-fertilization of ideas will lead to more efficient innovation and a more vibrant tier 2+ supply chain; and best practice lessons will be transferred more quickly from sector to sector.

Key performance indicators (KPI)
Following discussion of the consultation’s initial findings, it was proposed that a small management group monitor delivery of the implementation plan to agreed KPIs based on agreed levels of investment. It is anticipated that this independent management group will report regularly to stakeholders and provide an annual public progress report. Target review periods would thus be aligned to the implementation plan. Waymark checks would be linked to key milestones in the plan, designed to enable amendments to programme priorities. KPIs for the strategy will include:

- Sector and national GVA improvement
- UK productivity
- TES-related exports
- Cross-sector/institution common approach to ‘through-life’ standards, competencies and education
- Proportion of long-life asset acquisitions based on through-life considerations and financing
- Intangible investment in TES-related activity
- Profitability and order-book for participating firms

13 Working out and maintaining that data would require some resource allocation, that is, a ‘programme office’ or ‘digital manufacturing institute’ as part of the proposed investment programme.
This data would also provide information on percentage take-up by sector. Some element of surveying would be required to establish this data and so it would be reliant for credibility on sample size.
6. Strategic Actions

The consultation process highlighted three priority areas for action:

1. The creation of a cross sector UK National TES centre of excellence/Council with industry lead to:
   - Develop and promote ‘TES thinking’, broadening engagement across industrial sectors, sharing knowledge to develop supply chain capability and influencing sector strategies to encompass TES
   - Nurture innovation and improvement and associated investment and measure performance against the strategic KPIs
   - Provide a support network
   - Drive the TES educational agenda (including a TES module in every STEM course)
   - Direct the focus of research funding
   - Coordinate the development of future technologies to ensure the ‘TES dimension’ is not overlooked
   - Integrate government, industry and academia with the global scene
   - Drive the development of formal standards.

2. Government departments should change their procurement policy by putting emphasis on through-life costs.

3. A new government policy framework for IPR sharing should be developed, with open book services and a technology framework which covers IP law and improves protection.

Industry and markets will increasingly take up TES, especially where driven by changes in customer needs. The focus of these strategic actions is to ensure that the UK environment is such that UK companies are best placed to exploit these new needs and capture value at home and in export markets.

Annex 2 summarizes the workshop outputs from which these priorities are derived, and Annex 3 lists workshop participants and consultees. Membership of the steering group is shown below.
# National Strategy Development Steering Group

<table>
<thead>
<tr>
<th>Name</th>
<th>Surname</th>
<th>Company</th>
<th>Role</th>
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<tr>
<td>Dave</td>
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<td>Meir</td>
<td>BAE Systems</td>
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<td>Alan</td>
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<td>Roy</td>
<td>Cranfield University</td>
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<tr>
<td>James</td>
<td>Selka</td>
<td>Manufacturing Technologies</td>
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<tr>
<td>Rob</td>
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<td>Bombardier Transportation</td>
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<td>Siemens</td>
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<td>Babcock International</td>
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<td>White</td>
<td>Member of Parliament</td>
<td>Advisor</td>
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Acknowledgements

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