

KT-Box

bridging the knowledge transfer gap in services

Final Report

**Improving the
competitiveness of
UK service providers
through applying
academic research**

KT-Box was the £2.2 million EPSRC Knowledge Transfer Account, which developed and applied recent academic research in complex services, to the benefit of the UK economy and society.

- **A collaboration of seven major UK higher education institutions and four of the UK's leading technical service providers. It developed the research from ten major EPSRC research projects, to develop 30 tools, which were applied 81 times in 48 different organisations. To enhance the impact of academic research to help UK industry create and improved complex services.**
- **It supported four knowledge transfer partnerships and secondments of researchers into industry, AND provided web based tools to help organisations assess their ability to provide services.**
- **It applied manufacturing research in the public and not-for profit sectors and supported the development of the first international supply chain risk index for purchasing and supply professionals.**

Many of the tools are available, free of charge, via the website www.kt-box.com. Special arrangements apply for access to the tools by the organisations who participated in KT-Box. Please contact Chris Pearson (cp349@cam.ac.uk) for further information.





Professor Andy Neely
Royal Academy of Engineering
Professor of Complex Service Systems
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Introduction

Like many of its international competitors, the UK has seen dramatic growth in its service sector. Employment in services now accounts for 75 per cent of the workforce in the UK and the US, and more than 50 per cent in Brazil, Russia, Japan and Germany. Within organisations the relationships between products and services are changing rapidly. Service industries and public services are underpinned by ever more complex technology. Companies are increasingly wrapping services around products in order to provide better value. This transition can be extremely beneficial for organisations, securing their competitive position, offering long-term stable revenues and opening up new market opportunities. Equally, it can be high risk and extremely costly.

The leading companies and organisations who have collaborated with KT-Box all seek to maximise value from increasingly high-tech services. In key areas for British manufacturing – such as defence, power generation and transportation – the products are very expensive and stay in service a long time. The cost of maintaining these assets can be as high, or higher, than the purchase cost. And a wide range of highly skilled people are needed for such service operations. Reducing cost or risk is an imperative whatever the sector - whether the asset is an RAF aeroplane or an NHS CAT scanner or, indeed, social housing in a rural area.

Many other services are highly dependent on technology – web-based services relying on computer servers, for example, or supply networks that must respond to changes in demand at short notice. In contrast to outsourcing, the service owner often retains overall responsibility towards the customer, so new ways of working across the whole supply and delivery chain are required, with a focus on relationships and information flow and use.

As you will see in the pages of this report, KT-Box has produced significant value for the UK economy in addressing such challenges. Its unique contribution lies in the particular ways in which the gap between academia and industry has been bridged. KT-Box has enabled the academic team to develop their ideas further than research funding usually allows, spending more time with organisations to better understand their needs, engaging with users who do not normally collaborate with universities. The practical tools developed by the programme embody research knowledge in software or workshop processes, enabling users to apply them with little or no input from the research team. In supporting the use of these tools across many sectors KT-Box demonstrates how high-quality academic research can be applied well beyond the application originally envisaged.

It remains therefore to give warmest thanks to all the KT-box collaborators: to the EPSRC for funding this challenging programme, giving us the opportunity to increase the value and relevance of our research; to the academics at Bath, Cambridge, Cranfield, Exeter, Nottingham and Warwick; to the industrial stakeholders BAE Systems, Bombardier, IBM and Rolls-Royce, to Prof. Sir Mike Gregory for leading the programme in its early stages and finally, to the Chairman, Paul Tasker, for balancing the needs and skills of all involved.



Professor Paul Tasker
Chairman of KT-Box programme, Royal Academy of Engineering Visiting Professor of Integrated System Design at Cranfield University and the University of Kent

Chairman's Foreword

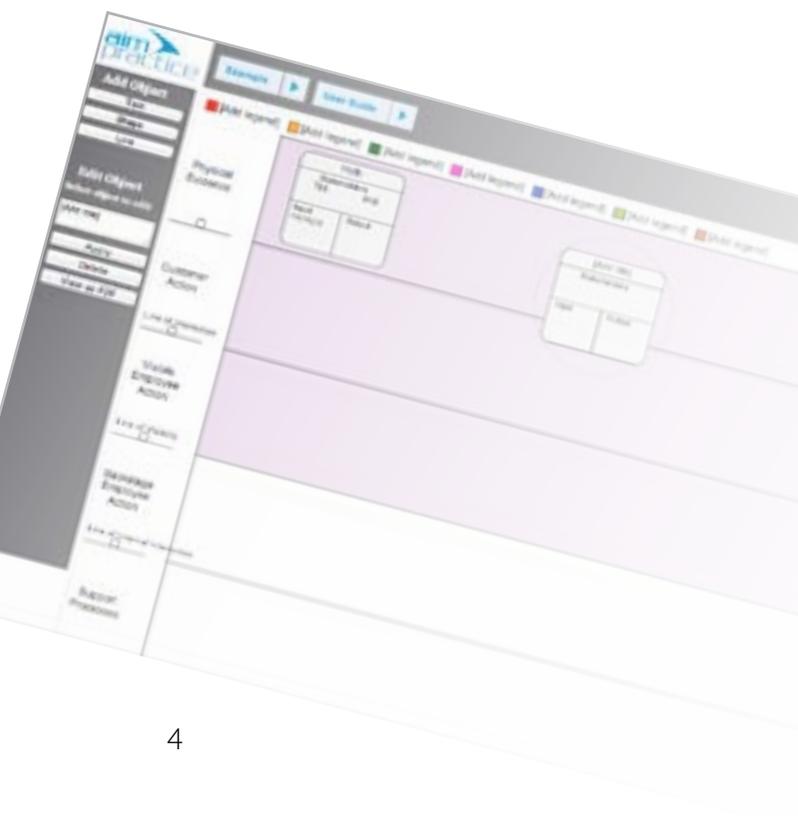
The origins of KT-Box lie in a research programme I directed called 'Support Service Solutions: Strategy and Transition' (S4T) that looked at how high-technology engineering companies such as BAE Systems, which had jointly funded the programme alongside EPSRC, could transform themselves to offer integrated services and products to their customers. S4T produced a huge range of research relevant to service; much of it long-term, but some of it almost ready for application. Yet still not quite mature enough for companies to pick up and use.

What was also clear was that it was not just large manufacturing companies that might benefit from this new knowledge; it was applicable to a wide range of UK users. We were proved right – research from S4T and other EPSRC programmes has been applied through KT-Box in a huge range of organisations, and the work is relevant not just to international companies like Rolls-Royce and Bombardier but also their specialist suppliers such as Dytechna, and to NHS trusts, housing associations and smaller manufacturing companies.

With funding from the EPSRC and the time and attention generously given by a number of participating firms and organisations, we were able with KT-Box to mature leading service research into practical applications producing generic tools now available to industry to improve their service operations.

KT-Box has benefitted hugely from the opportunity the programme gave to bring together the project management and application discipline from industry with the culture of creative exploration from some of the UK's leading universities. The following pages show something of what can be achieved when two cultures co-operate closely. My particular thanks go to the key industrial collaborators BAE Systems, Bombardier Transportation, IBM and Rolls-Royce, who provided the time of experienced practitioners and managers who could work with the researchers; exchanging ideas, challenging assumptions and, at all times, making sure that the needs of real users were more important than good ideas and hypothetical future opportunities. Their knowledge of current industry practice strengthened the researchers, and the programme.

So, one legacy of the programme has been researchers with a greater understanding of users' needs. The programme has generated Knowledge Transfer Partnerships and secondments to continue embedding this learning and has given the participants some clear insights about improving the joint ability of industry and academia to adopt leading edge research into practical use. Of course the more specific KT-Box legacy is its suite of tools to enable users to introduce or improve services, and the support available to help them use these tools. The legacy is the stronger for the series of events we held to introduce potential users to the tools and a system of 'KT-Box vouchers' to enable researchers, users and independent consultants to apply the tools repeatedly.



Bringing research to fruition

High quality academic research often has impact beyond that originally envisaged, but it takes time - five years or more is common - and impact can be difficult to identify and measure, particularly where new applications are concerned. When the knowledge can't be protected by patenting, companies are reluctant to make their successes widely known.

KT-Box created the conditions for research to have a bigger impact, sooner. EPSRC support allowed researchers to develop knowledge further than traditional academic funding allowed, and apply it in real situations. KT-Box enabled research to be applied with multiple users simultaneously, in different business sectors. It encouraged some organisations to invest resources in knowledge too immature to underpin a conventional business case, and enabled others to engage with universities for the first time.

The following two applications typify KT-Box, applying recent EPSRC research with UK organisations, leaders in their fields, in ways that would otherwise not be possible.

Designing out uncertainty: Rolls-Royce, Cranfield University and the attribute trading tool

When Rolls-Royce runs its annual bidding process to select the best research ideas for improving its aerospace engines, it faces a problem familiar to many design teams. Optimal design is a trade-off between different elements. But with many attributes contributing to overall engine performance, efficient assessment of the overall impact of a change in one of those attributes can be difficult.

KT-Box brought Rolls-Royce and Cranfield University together to tackle this challenge. The resulting Attribute Trading tool benefits not only Rolls-Royce, but anyone involved in the design of complex products and systems.

There are a number of factors to consider when improving the design of an aerospace engine, such as maintenance costs, weight, and fuel consumption. "Invariably what you change has an impact on a range of different product attributes and cost drivers," says Andy Harrison, Associate Fellow in life-cycle engineering at Rolls-Royce.

Rolls-Royce already had robust decision-making processes, but was, in Harrison's words, "searching for the final five per cent of efficiency" to make the right decisions first time. This meant finding a way to "inject the expert opinion at the start" rather than rely on methods such as reviews of decisions partly enacted.

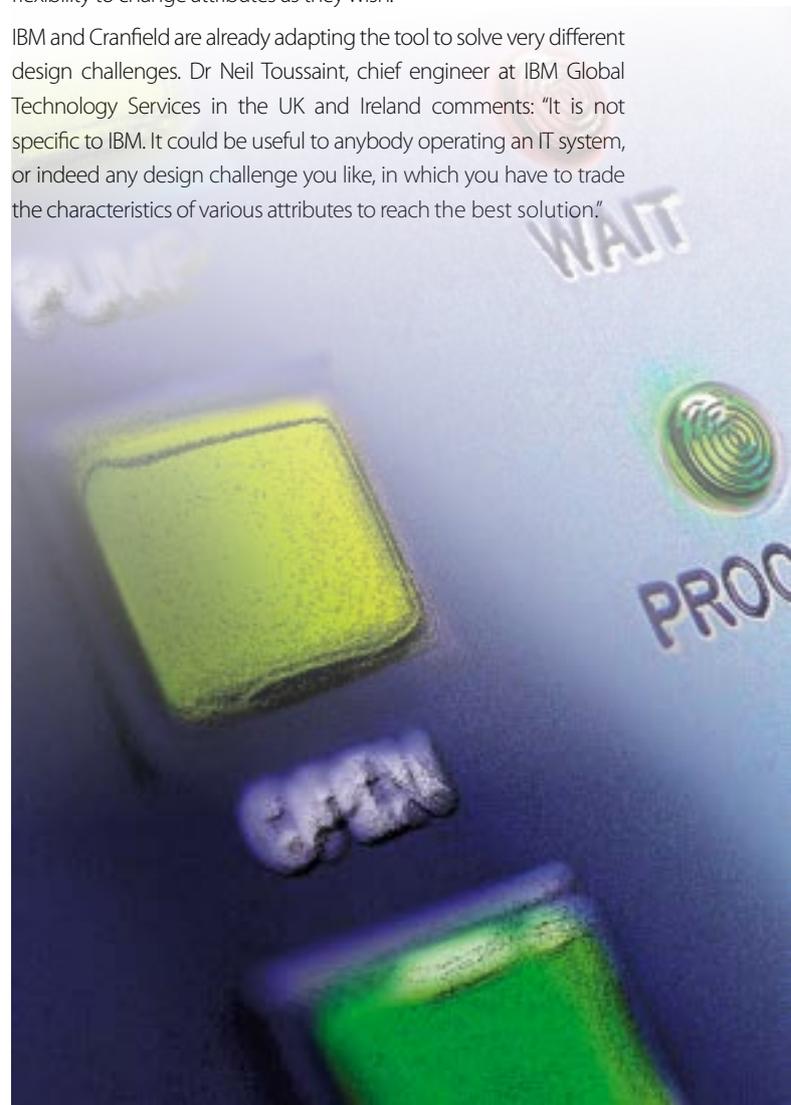
Rolls-Royce worked with John Ahmet Erkoyuncu, a service modelling engineer at Cranfield University with software tool development experience. The aim was to develop a standard template that would make the research bidding process easier and facilitate speedier proposal analysis by allowing a normalised assessment of each proposal's contribution to the overall engine design.

Erkoyuncu spent several months at Rolls-Royce mapping out a framework for a solution based on some 40 hours of interviews with key stakeholders. Back at Cranfield, he developed the software, together with a second, data harvesting tool. "It takes the data from the first tool, brings it together and presents it as a ranking," he says. "This enables someone to look at 100 bids, for example, and select the best..."

Rolls-Royce was very pleased with the project's outcomes for the company - and beyond. Its input, and that of other KT-Box industrial partners has helped improve the tool and ensure its transferability

to other sectors. The tool uses a 'hub and spoke' approach, with each attribute relating to a central 'common currency', giving users flexibility to change attributes as they wish.

IBM and Cranfield are already adapting the tool to solve very different design challenges. Dr Neil Toussaint, chief engineer at IBM Global Technology Services in the UK and Ireland comments: "It is not specific to IBM. It could be useful to anybody operating an IT system, or indeed any design challenge you like, in which you have to trade the characteristics of various attributes to reach the best solution."



The complete property service: United Welsh Housing Association

KT-Box has transferred learning from the servitization of large industrial companies to tackle challenges in the social housing sector – generating potential savings for one housing association of £450,000 per annum, while increasing tenant satisfaction.

In 2008, Nigel Caldwell, then based at the University of Bath's School of Management, began work on the EPSRC/BAE Systems funded research project 'Support service solutions: strategy and transition' (S4T). In 2010, as part of KT-Box, Caldwell was looking to transpose learning from S4T, and noticed in social housing interesting servicing and support parallels with some of KT-Box's larger industrial partners.

Small housing associations usually have to maintain their assets – the stock of housing – over a widely distributed area. The critical competence of property maintenance involves weighing up factors such as number of visits, amount of work to do each visit, whether to replace or repair, and whether to do preventive work or take a reactive approach.

Caldwell and colleague Nick Rich eventually teamed with Luke Mitchell and his team at United Welsh Housing Association in South Wales, where challenges centred on achieving service levels while managing administration costs. Existing processes, involving 14,000 unplanned repair requests annually, clearly wasted resources.

For several months, Caldwell attended fortnightly meetings with the Association's maintenance team, helping them adopt a more operation management and lean management oriented approach. His regular presence was important for building trust and confidence: legitimising the new ideas; providing independent and academic challenge to existing processes; and contributing new insights.

Gradually a service solution emerged: to move from a reactive approach to a planned maintenance model, centred on a property auditing inspection tied to the annual gas servicing visit. In parallel, the team developed an activity voucher system to incentivise tenants not to call in unnecessarily, and only report actual emergencies.

Mitchell and Caldwell found the value added by KT-Box core industrial stakeholders particularly useful. At a KT-Box seminar, Mitchell spent "hours discussing the project with people from IBM, BAE Systems and other companies", while Caldwell commented on Rolls-Royce and Bombardier support and experience in prioritising service challenges.

When United Welsh piloted the new process, it both reduced the number of visits and brought down substantially the average repair cost figure. According to Mitchell, "The newly badged Complete Property Service neatly addresses both the customer satisfaction and cost issues. The work done so far is being used to inform a price per property model price negotiation with contractors during the maintenance procurement process."

Many other tenants stand to benefit. A knowledge-sharing event in Wales kicked off the dissemination process: presentations and an explanatory leaflet will spread the word to housing associations further afield. With four million tenants in the UK's social housing sector, the potential for positive impact on living conditions is huge.



The KT-Box contribution

The need

Service is a growing part of the UK economy and service delivery capability has become a more important factor for many organisations. Many challenges require investigation within the new research field of 'complex service provision'. Collaboration between a range of academic disciplines – such as operations management, engineering, logistics/supply chain management, marketing, psychology – is needed.

Developing academic research outcomes further so that they have real impact for businesses and other organisations is rarely straightforward. Often there is a funding gap between 'research' and 'development'. Taking research further with external partners is beyond the parameters of public funding for pre-competitive research. But often that research is not ready for industrial investment either: too immature to apply in real cases, technically too risky.

A unique approach

KT-Box was different. KT-Box engaged with UK users to take recent academic research, develop it further and use it in initial applications. The EPSRC (Engineering and Physical Sciences Research Council) enabled this approach by funding each development project within KT-Box in whole or in part. Crucially, funding was available to:

- embed researchers within user organisations, developing, testing and supporting implementation of the applications
- enable consultants to engage with the researchers and end users.

KT-Box also impacted on an unusually wide range of sectors. Its funding stemmed from EPSRC's remit to support research to improve competitiveness of UK manufacturing. Yet in KT-Box, work that began in a manufacturing or engineering services environment was further developed in contexts such as social housing or mental health, with providers who do not normally engage with manufacturing-related research.

This was made possible also by industrial stakeholders' willingness to:

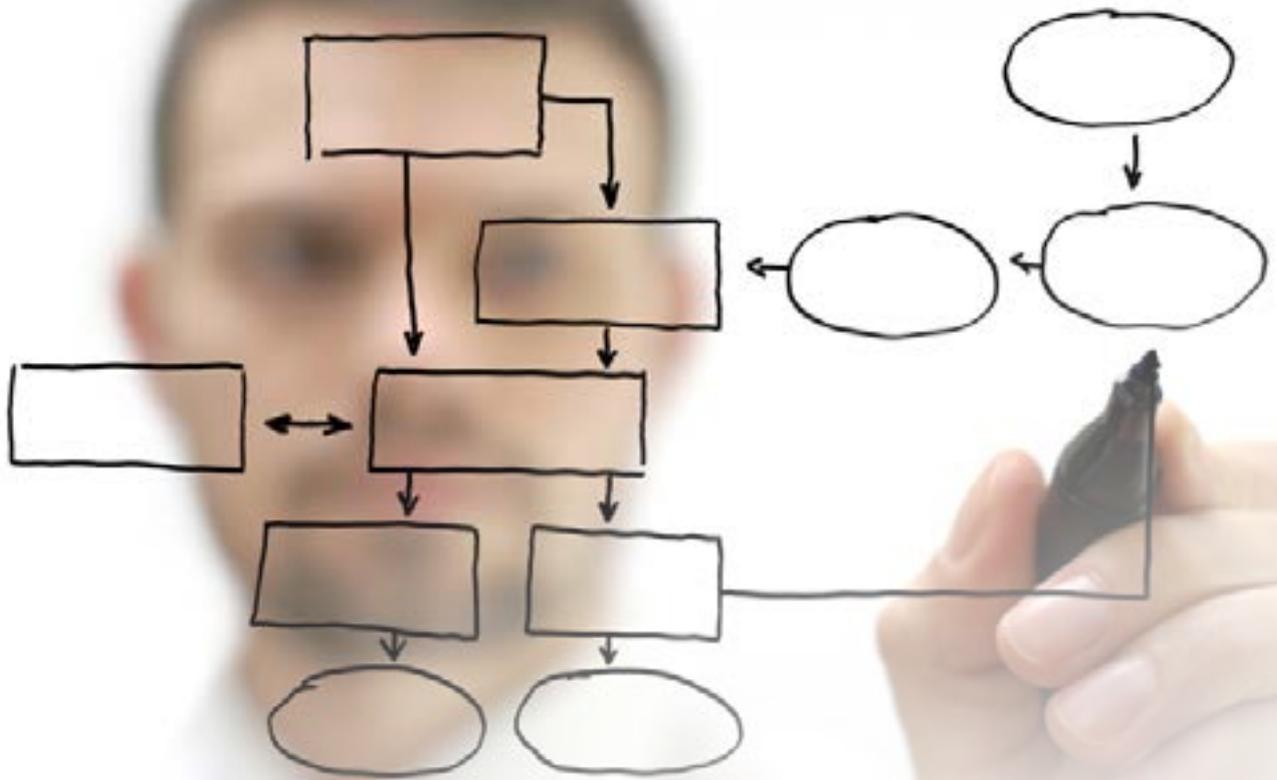
- contribute their expertise: a management board combining academic and industry representatives supervised operations;
- act as reviewers and 'critical friends' to researchers, providing new ideas and challenging assumptions
- share project outcomes for the broader benefit of the UK economy and society while also meeting their corporate goals.

The management board's 'hands-on' approach was notable: industrial board members collaborated directly with researchers, on projects large and small.

Outcomes

The KT-Box toolkit is the outcome of over 30 separate development projects. Each resulted in a 'tool' which can be applied by different users to a specific problem area. Project activity was all about application. The underpinning research had to be complete (and, usually, published). New research was limited to filling in specific, small gaps. Academic publications were encouraged, but not funded.





Beyond the toolkit development projects KT-Box produced a Knowledge Transfer Partnership with Rolls-Royce and three further partnerships and researcher secondments with successful specialist high-tech firms Dytecnica, OSys and Supacat.

Success factors

‘This is the only academic project I’ve worked on where industrial engagement strengthened as the project progressed.’

Dr Nigel Caldwell, University of Bath and Heriot-Watt University

Funding mechanisms encouraged ‘user pull’

- Significant funding was triggered only when the academic team achieved end-user support for a specific application
- Funding was withdrawn if industrial need diminished
- Funding was phased; users had to demonstrate increasing commitment to use the work as each development progressed
- Additional funding could be provided quickly to support the organisation to apply the resulting tool if strong user need was demonstrated.

In all, one quarter of the development projects originally commissioned were discontinued because ‘user pull’ receded.

Engagement of appropriate technical staff in industry

Most industry representatives were senior technical staff. Importantly, they could judge both technical progress and evolving business needs. Other extended team members included recently appointed staff with postgraduate degrees. They were able to work closely with academics, leading to better academic outputs.

Impact across the supply chain

Some research was partially paid for by industrial partners, such as BAE Systems, with KT-Box developing it further for a customer (e.g. Ministry of Defence) or smaller suppliers (e.g. Dytecnica) to increase the benefit to the UK economy.

Depth and continuity of academic expertise

KT-Box assembled and retained an established team of academics from a range of disciplines, together contributing a large body of high-quality research:

- All universities had worked together on the precursor to the KT-Box initiative S4T (Service Support Solutions: Strategy and Transition), a programme jointly funded by BAE Systems and EPSRC
- KT-Box maintained relations with researchers who moved to new universities during the project, and built links with other researchers within participating universities.

Addressing user's needs

KT-Box began by identifying gaps in current practice, which existing research supported by the EPSRC could address. Using their existing networks, researchers engaged with potential users and development partners who needed help with existing challenges. This 'bottom up' approach ensured that every tool would be used, but left unanswered the question of how to reach out to other potential users across the UK.

As the toolkit developed, it became clear that new users needed help to find the relevant tools to address their own problems. An online guide was developed to help orientate potential users when they first encounter KT-Box, directing them towards the help they need. It also helps companies think about how they might introduce new services.

KT-Box helps an organisation improve the services it offers by guiding users to three key areas for service system improvement:

- Improving the organisation's business model.
- Understanding the market that the organisation operates in.
- Improving specific aspects of the service delivery, such as organisation, information, technology and risk

Each tool addresses one or (more typically) a combination of these areas. The online guide incorporates a tool selector to help users identify needs and the steps they need to take to improve their service. Some tools can then be applied by the organisation on their own; others require, or may benefit from, the support of consultants or facilitators.

Understanding your business model



There are three parts to an organisation's business model

Value proposition: what is offered to your customers, that they will value and be prepared to pay for.

Value creation: the organisation's strategy to deliver the product or service to the customer.

Value capture: ensuring that your organisation takes its share of the profit or its contribution is recognised in other ways.

Example

With the help of facilitators, 30 smaller manufacturing companies were able to assess their capability to introduce new services. In a session lasting less than a day, the facilitators – who are experienced manufacturing practitioners but with no previous experience of research in services – were able to work with a company and help them apply latest thinking to their situation.

Recent work with SMEs demonstrates that the KT-Box tools are accessible, replicable and time-efficient; enabling companies to identify solutions to potential opportunities and challenges.

IfM Education and Consultancy Services (IfM ECS) is the University of Cambridge's technology transfer company specialising in manufacturing.

The SME team within IfM ECS worked closely with KT-Box academics to identify those tools that were appropriate for smaller companies with little experience of providing or monetising services.

SME team facilitators have worked with over 300 smaller manufacturing companies in recent years, but never before on "servitization". They engaged 30 smaller manufacturers in the North West, Midlands and East Anglia who were considering increasing the range and quality of services they provide to customers. (Often, smaller companies already provide services to their customers, but, far from profiting from this work, they are incurring significant costs aimed at securing the product sale.)

Working with SMEs individually, facilitators used some KT-Box "micro-tools": those designed to provide a quick assessment. In most cases they started with the Service Capability Maturity tool, based on University of Cambridge research on new business models, to assess the company's readiness to innovate in the service field. Another tool commonly applied was the Ecosystem Mapping tool – a simple way of identifying the relationships between key organisations in a company's business environment; suppliers, customers, competitors and regulators.

In just a few hours the facilitators helped the companies identify specific areas and priorities for improvement in their existing operations and new competencies required.

Development and impact of KT-Box tools

The following pages illustrate the development and impact of KT-Box tools addressing the four aspects of service delivery: risk, technology, information and organisation

Risk

Risk is all pervading in service provision. To some degree all KT-Box tools help practitioners to better manage risk. Most tools include a focus on sharing the risks that arise when responsibilities are shared across a network of organisations.

However some of the tools focus exclusively on risk management and are designed for use by experts. Two of these are described below.

TOMCAT and FORCE: Tools for proactive obsolescence management

KT-Box has enabled researchers at Cranfield University, together with the MOD and its industrial partners, to develop two tools that support proactive obsolescence management strategies. These allow organisations to avoid much of the significant cost associated with obsolescence.

Obsolescence risk

Obsolescence is a burgeoning problem in defence and a significant issue in any complex, long-life equipment such as trains, planes and production plant.

Components become obsolete for many reasons. The supplier may have changed its proprietary design, for example, or gone out of business. "If a component fails, or needs to be replaced, but is no longer available and has become obsolete, there is usually a significant cost involved in either designing out the obsolescence or remanufacturing the obsolete component," says Paul Tasker, Independent Chair, KT-Box Programme. "For complex, long life programmes, this can be excessively expensive."

Organisations' various strategies for mitigating obsolescence are often reactive and time consuming, with equipment potentially becoming unavailable while resolutions are found.

Tool development

At Cranfield University's EPSRC/Industry funded Innovative Manufacturing Research Centre, researchers were investigating more proactive approaches to managing obsolescence risk. Francisco Romero Rojo, in his PhD, and subsequently as project manager of the MOD funded Obsolescence Management Improvement (OMI) project, was principal in developing the research. He collaborated with the MOD, the Defence Equipment and Support organisation, and industrial members of the MOD's Joint Obsolescence Management Working Group, which supplied broad representation across the UK defence industry.

"Initially there was no way of measuring the maturity of a project's approach to obsolescence management. Industry would give the MOD project team the plan of what they were proposing to manage obsolescence and overcome any issues arising, and that was all we had – a statement in their plan with no means of assessing its effectiveness, efficiency or cost," says Paul Crimmins, Obsolescence Management Lead with the MOD's Defence Equipment and Support organisation.

So, working with the MOD, the KT-Box initiative helped Romero Rojo translate the initial research into two specific tools to help improve obsolescence management: the Total Obsolescence Management Capability Assessment Tool (TOMCAT), and the Framework for Obsolescence Resolution Cost Estimation tool (FORCE).

TOMCAT and FORCE

TOMCAT enables a project team to assess how capable its suppliers or internal partners are at managing obsolescence. It allows the company to obtain some measure of the effectiveness of the processes and management activity being undertaken to ensure that the costs of components becoming obsolete through a piece of equipment's life is minimised. Not only for 'top-down' application by a project team, TOMCAT is also designed for use throughout the supply chain, so a partner can employ it within their scope of work, as can individual suppliers.

TOMCAT benefits from being devised across industry partners. All of the Joint Obsolescence Management Working Group had an input – BAE Systems piloted the tool, for example. The research team, including the MOD, held several workshops with industry to identify and validate the metrics most important for obsolescence, in order to provide a rigorous scientific basis for the tool.

FORCE, developed in parallel, is designed to meet the challenge of estimating costs of managing obsolescence in service delivery (for example when bidding to develop new products or systems). Provided with enough detailed information – which can include the overall TOMCAT 'score' – it will produce the estimated cost of obsolescence over a period of time.

Crimmins concludes: "We now have a common standard which we can apply to all obsolescence management plans and obsolescence management providers," and praises KT-Box's involvement for helping ensure that the tools are not solely MOD ones: "What we have now in TOMCAT is a workable, easily understood tool that everybody can use."

Supply chain risk assessment and monitoring (SCRAM)

Supply chain disruptions have a major impact on the bottom line, but most businesses are underprepared for disruptions. Managing supply chain risk becomes particularly complex for the many companies with extensive, often international, supply networks.

This combination of high financial penalties and a lack of industry readiness inspires the work of Dr Brian Squire, from the School of Management at the University of Bath. One result is SCRAM: a tool that enables companies – from a wide range of industries – to systematically identify, analyse and monitor risks within their supply chains.

The tool was co-developed with three large companies: Zurich Financial, Meggitt Aircraft Braking Systems and BAE Systems Submarines. It was iteratively applied to different categories of purchasers' spend over several time periods. The tool combines user input with web scraping (data extracted from the web) to deliver analysis and insight into the changing levels of risk within supply bases. Metrics from its automatic web scraping provide insight into risks such as exchange rate fluctuations, shipping rate changes, material pricing and suppliers' positions.

The next stage saw the development of software tools aimed at suppliers and for smaller companies, helping them become proactive at monitoring and hence managing the risks inherent in their own supply chain.

First the team developed a network tool designed to take input from suppliers and feed into the main tool. This benefits both supplier and buyer: reducing the burden on buyer organisations to update risk data and potentially increasing the timeliness and accuracy of information.

Using the insights generated during SCRAM's development, Squire then developed a micro tool which analyses and trends user-based information regarding levels of risk within the supply base. Designed with SMEs in mind, this tool is being made freely available to all 65,000 members of the Chartered Institute of Purchasing and Supply.



Technology

A defining characteristic of complex services is the use of technology. New technology can both enable new service offerings, and improve the efficiency of existing ones.

KT-Box supported the application of EPSRC research by organisations large and small, to help make better use of the UK armed forces' equipment.

KT Box: predicting the future

Prognostics for hardware is a field with major challenges but huge potential. If service providers could predict when equipment supplied and maintained was likely to break down, maintenance could be managed, and service provision continued, without unplanned, usually very costly, interruptions.

Using cutting-edge mathematics and with KT-Box funding, Adam Zagorecki and colleagues Ken McNaught and Chris Hockley from Cranfield University's School of Defence and Security at Shrivenham have worked with the defence industry to make prognostic maintenance a reality.

Zagorecki's PhD in the US on intelligent diagnostic systems used Bayesian network modelling techniques to diagnose the causes of hardware failure. (Bayesian networks are a type of statistical model representing the dependencies between random variables.) Moving to Cranfield, Zagorecki continued his research as part of the EPSRC/BAE Systems co-funded S4T project.

Complex hardware has ample capacity to measure usage and record faults. However, both data overload and 'unknown unknowns' make reliable prognostics hard to achieve. In practice it is not cost effective to provide prognostics for a whole complex system. Zagorecki's proposed solution focuses on component failures that cause the highest costs.

The additional challenge that Zagorecki's team identified in S4T, and applied to solve with KT-Box support, was developing prognostics for new hardware – where there is little or no monitoring data to construct a predictive model. The T45 destroyer was a new vessel with a cutting-edge Health and Usage Monitoring System (HUMS). As there was no useful historical data the team proposed a generic approach to the problem, based on Bayesian network modelling.

KT-funded tool development was key to ensuring that this promising technology will be available to organisations both large and small, rather than proprietary technology of a single corporation: "Before going to industry we proposed two tools, the Predictive Maintenance Probabilistic Decision Support (PMPDS) tool, and the Failure And Degradation Elicitation Support (FADES) software tool," explains Zagorecki.

When data from new equipment is lacking there is still much useful knowledge within the organisation. FADES helps capture

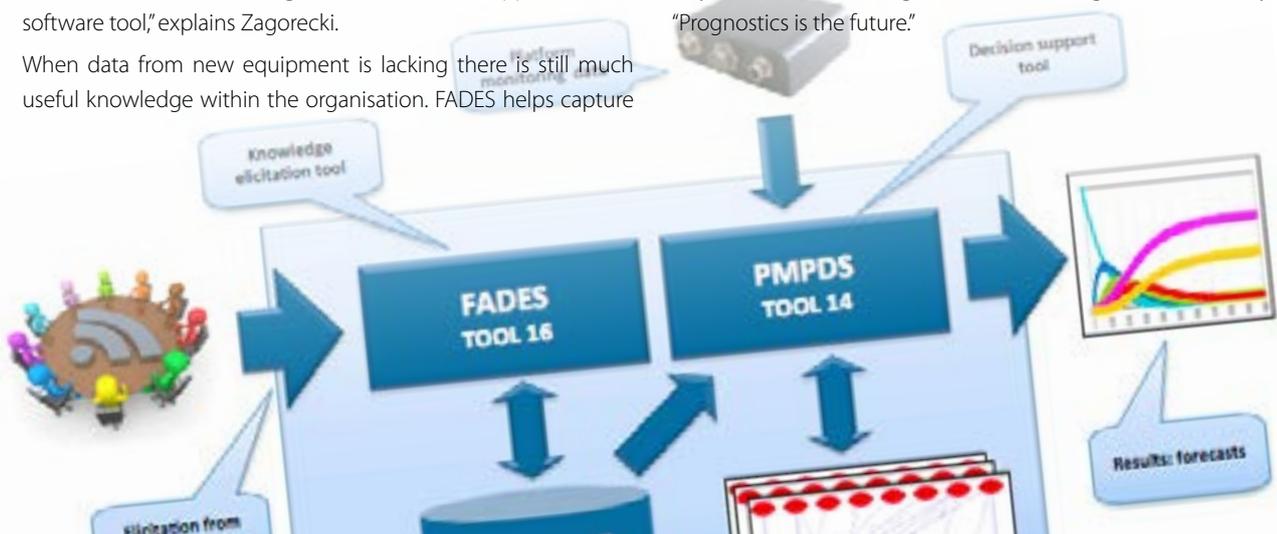
knowledge from maintenance personnel, engineers, and designers. PMPDS is a cost-effective tool for semi-automated model building. It takes data, including data from FADES, in a prescribed form to create Bayesian network models for prognostics.

Engineering and technology company Dytecna hopes to exploit this exciting technology. "Essentially our product is a Vehicle Monitoring Unit (VMU), although it is not confined to use on vehicles," says James Hudson, senior engineer at Dytecna. "We use it for capturing HUMS data. Currently our main customers are defence related. So we have it on a number of vehicles - armoured personnel carriers, for example."

At present the HUMS data is used to optimise maintenance schedules based on previous use and as a diagnostic tool. But Dytecna would like to do much more, using FADES as a key enabler. "With the FADES tool, the customer's organisation can identify what is worth pursuing for prognostics," says Zagorecki. Once that key factor information is captured, Dytecna can use it to configure its technology to focus on collecting data from the equipment-critical areas, and present it in a way that can be used for prognostics, with PMPDS.

First, though, the two technologies - FADES and Dytecna's VMU – needed to be able to "talk" to each other. This was achieved as part of a KT-Box mini-KTP.

More generally, Zagorecki sees FADES as an enabling tool to start people seriously thinking about using prognostics for competitive advantage. For many organisations involved in complex service agreements this will also mean addressing issues of data sharing and usage. Nevertheless, the major benefits obtainable from using FADES and PMPDS indicate that stakeholders will find ways to solve the data governance challenge. As Hudson says: "Prognostics is the future."



Information

Good use of information is essential to provide services based on expensive capital equipment, but there are considerable obstacles to achieving this:

- Equipment-based services require equipment users, owners and maintainers to share information – leading to issues of information quality, data access and trust
- Planning becomes more difficult: such equipment must be used more of the time, leaving less time available for maintenance and repairs.

KT-Box developed the tools to help make better use of information: identifying what data should be managed; setting priorities for data quality; helping managers visualise and hence use the vast amount of data already at their disposal.

Information Quality Risk Assessment

In 2012, Allan MacMaster, asset strategy inventory manager at Scottish Water, wanted the company to invest in new geographic data management resources. Making a well-reasoned business case for investment was a challenge though, because of the difficulty in quantifying what difference the data made to business performance

Many service providers collect massive amounts of data as they go about their everyday business. Some of this data is key to optimising the services provided, and maximising value for stakeholders.

Alexander Borek, a doctoral researcher at the Institute for Manufacturing, University of Cambridge, had developed a management process to address the consequences of not having good information for a particular business process. KT-Box funding enabled a critical next step. According to Borek, "There was significant value added. The management process itself is not feasible without a good software tool that complements it."

The Information Quality Risk Assessment software tool allows users to understand and model the business impact of poor quality information, by assigning probabilities to consequences and estimating the financial impact on the business.

MacMaster became aware of Borek's work during a knowledge partnership meeting at the University. Once familiar with Borek's research MacMaster agreed to use the tool on a project at Scottish Water.

"We were looking at either upgrading or replacing our Geographical Information Systems (GIS)... where we store all our asset information about our water mains and sewers," says MacMaster. The significant investment involved meant there had to be good business justification.

With Borek's assistance MacMaster's team used the tool to understand the impact of GIS data quality on specific performance drivers. They were able to analyse potential consequences relating to data quality, identify ways of mitigating the risk of those consequences occurring, and estimate the cost benefits and risks associated with that mitigation. As a result it was possible to recommend what measures to implement.



Managing information through the life of a service

When companies struggle to design and deliver service offerings, information gaps may be the root of their difficulties.

KT-Box enabled Rachel Cuthbert, a researcher at the University of Cambridge, to develop wider applications for work with large companies as part of the EPSRC/BAE Systems S4T project. The aim: a tool for companies to gain a complete overview of information needed to design and deliver a profitable service offering, especially for long-term contracts.

The Through-Life Service Information tool enables a company to weigh up key decisions and information required for different

business, operational and technical areas. Known informally as the 'twelve-box' tool, because it examines twelve distinct stages in the life of a service, the tool assesses the criticality of decisions and the associated availability of information.

Having tested the tool's transferability to companies, including SMEs, in different sectors, Cuthbert developed guides so that users and facilitators can use the tool without the support of service experts.

Fleet Management Tool

Keeping a large naval fleet performing optimally over many years is a considerable challenge. It is one faced by Lt Cdr Mark James, responsible for Type 23 Duke class frigates – which are slated for service until 2035.

Clive Kerr and Simon Ford from Cambridge University's Centre for Technology Management (CTM) worked with the MoD to produce a software tool to address this challenge.

Kerr's work on service capability enhancement – part of the EPSRC/BAE Systems S4T project – and some of CTM's technology road-mapping research showed especial potential. KT-Box funding allowed Kerr to work with the MoD to productise the generic framework and principles, and thus meet James's requirement for "an effective long-term planning tool, which easily represents the interdependencies between projects and ships"

James is now conducting a stakeholder consultation prior to operational use. Potentially the tool could be deployed in any organisation with a combination of a complex product service system, and assets of high value and long life.



Organisation

New types of service demand new organisational structures and ways of working. Often they require a huge range of specialist skills, use of other scarce resources, and the active involvement of the customer.

Closer working with others is essential – not only with the

customer and the organisation's own suppliers, but also collaborating with the customer's other suppliers.

KT-Box supported the development of a range of tools to help organisations make the changes they need to provide the complex services that customers demand.

Towards effective collaboration: the Service Transformation Toolkit

In the new world of outcome-based service contracts, the ability to deliver a promised outcome is bound up in the relationship between the parties involved collaborating to deliver that outcome.

Given the emphasis on collaboration, maximising the performance of an outcome-based contract requires new tools to analyse the relationships and activities involved, identify strengths and weaknesses, and suggest actions accordingly. Together, Irene Ng from the Warwick Manufacturing Group, Warwick University, and the MoD, with the assistance of BAE Systems and Rolls-Royce, developed and tested the Service Transformation Tool.

"That level of collaboration is not easy. It requires a very close knit relationship between the provider and customer," explains Ng. She drew on cybernetics-based Viable Systems theory to analyse the activities and relationships underpinning the delivery of an outcome. With KT Box's assistance the tool emerged from S4T research on value co-creation undertaken when Ng was based at the University of Exeter.

The tool examines the collaborative delivery of a service outcome

from single contract level to the entire customer-provider relationship. Initially, there is an information capture element. Data from this process is input into a visualisation model, enabling users to visualise their collaboration system and where there are gaps and deficiencies in the cooperative capabilities. There is also a high-level workshop mapping out the boundaries and scope of the viable system of collaboration. A manual for consultants using the tool details the workshop methods.

Appropriately, for a tool that analyses collaboration, the tool was co-created with the MoD. The MoD saw the toolkit as a systematic way to understand and compare co-capability across platforms, one partnership relationship against another, despite being different contracts. Having piloted the tool, the MoD also notes its value in addressing partnered working in a non-threatening way: with its focus on systems not individuals the tool "gets away from the personalities".

Mindsets in partnerships

Many services rely on partnered working. Yet each member of the project team is held to account by a different 'constituency'. And the needs of the partner constituencies never completely coincide.

Combining research from the S4T programme and work by Anne O'Brien at the University of Exeter's Centre for Leadership studies, KT-Box supported the development of a process tool to help team members understand the needs and aspirations of partners' constituencies.

Mindsets in Partnership is a facilitated workshop where partnership

members generate a common framework and language to assess the situation and learn how to think collectively without losing the diversity within the partnership.

Using an independent consultant, Mindsets in Partnership has been used successfully by the Environment Agency and its partners on the Upper Mole flood alleviation scheme, and by the UK Met Office.

Seeing the big picture of service operations

One major service delivery challenge in large organisations is understanding how all the elements that produce an effective service fit together to create value.

Typically, the tools available for managers to deal with this issue have been too specialist, or too detailed. Enterprise Imaging, however, is a recently developed, powerful technique that allows managers to construct a visual representation of the different parties that combine in organisations to produce a particular service. Developed to help manage complex services in the defence industry, it has found use elsewhere.

Glenn Parry, an Associate Professor at the University of the West of England, used Enterprise Imaging to assess service provision. He

found the person to help him in Trevor Mapondera, then a senior manager in the NHS and now operations director of a healthcare firm, who has developed the approach in new contexts. Mapondera shared Parry's aim of maximising the technique's impact in the broader economy. At Mapondera's suggestion, and with his ongoing support providing an invaluable user perspective, Parry created both a practitioner-friendly web-based tool and a detailed user guide.

The KT-Box organisation

Programme leadership

Andy Neely Cambridge (from September 2011)

Mike Gregory Cambridge (to September 2011)

Paul Tasker Chairman, S3 Engineering, and Visiting Professor at Cranfield and Kent universities

Partners & Members	Themes	
<p>Academic partners</p> <p>University of Bath School of Management</p> <p>University of Cambridge, Institute for Manufacturing</p> <p>Cranfield University, School of Applied Sciences</p> <p>Cranfield Defence and Security</p> <p>Exeter Business School, University of Exeter</p> <p>Warwick Manufacturing Group</p> <p>University of Nottingham, Precision Manufacturing Centre</p> <p>Other academic institutions</p> <p>Heriot-Watt University</p> <p>University of the West of England</p> <p>Major Industrial Members</p> <p>BAE Systems (Stewart Leinster-Evans, Karen Cosgrove). Britain's biggest manufacturer and a leader in services to the UK's Ministry of Defence.</p> <p>IBM (Steve Street, Neil Toussaint). Leading supplier of information and consultancy services, and global leader in promoting service science as an academic discipline.</p> <p>Bombardier (Jeremy Lovell, Rob Cowling). A major provider of equipment and services to the railway industry worldwide.</p> <p>Rolls-Royce (Andy Harrison, Steve Marlowe) a world-leading provider of power systems and services for use on land, at sea and in the air.</p>	<p>Organisation design and improvement</p> <p>Providing the tools organisations need to work more effectively in partnership - not just as suppliers or customers of services</p> <p>Anne O'Brien (Exeter)</p> <p>Glenn Parry (University of West of England, formerly Bath)</p> <p>Tomas Harrington (University lead, Cambridge)</p>	<p>Integrated Vehicle Health Management</p> <p>Enhancing cost-effective, guaranteed availability and operation of equipment</p> <p>Chris Hockley (Cranfield Defence & Security)</p> <p>Svetan Ratchev (Nottingham)</p> <p>Emma Kelly (Nottingham)</p> <p>Ken McNaught (Cranfield Defence & Security)</p> <p>Adam Zagorecki (Cranfield Defence & Security)</p> <p>Kathryn Wand (Cranfield Defence & Security)</p> <p>Andy Duncan (Cranfield Defence & Security)</p>
	<p>Supply chain monitoring and improvement</p> <p>Improving service provision and providing new ways to monitor the risk of disruption</p> <p>Nigel Caldwell (Bath, now Heriot-Watt)</p> <p>Brian Squire (Bath)</p> <p>Adam Joinson (Bath)</p> <p>Tomas Harrington (Cambridge)</p>	<p>Cost engineering and obsolescence management</p> <p>Enabling suppliers and customers to understand and manage costs to guarantee services for many years</p> <p>Rajkumar Roy (Cranfield)</p> <p>Paul Baguley (Cranfield)</p> <p>Fran Romero-Rojo (Cranfield)</p> <p>Alex Motta (Cranfield Defence and Security)</p>



Information management and strategy

New approaches to sharing knowledge across organisations for effective through-life service delivery

Rachel Cuthbert (Cambridge)

Phil Woodall (Cambridge)

Alex Borek (Cambridge)

Tariq Masood (Cranfield)

Visual strategy

Helping managers visualise complex services for enhanced operations management

Clive Kerr (Cambridge)

Simon Ford (Cambridge)

Service transformation

Finding new governance and management structures and ways of relating to the customer to ensure service efficiency

Irene Ng (Warwick, formerly Exeter)

Laura Smith (Exeter)

Susan Wakenshaw (Warwick)

Product-service design integration

Making better design decisions by weighing up the impacts of attributes throughout the life of a product

Rajkumar Roy (Cranfield)

John Erkoyuncu (Cranfield)

Support to smaller manufacturers

Using KT-Box to help smaller manufacturers understand the opportunities services offer for business growth.

Derek Ford (IfM ECS Ltd)

Alan Cousens (IfM ECS Ltd)

Nicky Athanassopoulou (IfM ECS Ltd)

Programme management

Chris Pearson (Cambridge)

Andy Shaw (to July 2011) (Cambridge)

Angela Walters (Cambridge)



Impact summary

List of tools

Tools to understand and enhance your business model

Co-creation capability assessment

Irene.Ng@warwick.ac.uk

Analysing an organisation's capability to co-create outcomes and benefits for your customers (Warwick).

Service transformation tool

Irene.Ng@warwick.ac.uk

A framework to develop an improvement plan for an organisation to improve its ability to co-create value (Warwick).

Design attribute trading

j.a.erkoyuncu@cranfield.ac.uk

A visual modelling tool showing the implications of design changes on products and services (Cranfield).

Privacy dictionary

a.joinson@bath.ac.uk

Helping organisations to visualise the effect of sharing personal information with customers and organisations (Bath).

Social housing supply chain reconfiguration

n.d.caldwell@hw.ac.uk

Helping social housing providers manage the maintenance of their housing stock (Bath & Heriot-Watt).

Multi-Organisational Network Capability Assessment

tsh32@cam.ac.uk

Assessing the capabilities of networks to collaboratively deliver integrated services (Cambridge).

Multi-organisational Network Configuration

tsh32@cam.ac.uk

Helping manufacturers design networks to support long lifecycle products (Cambridge).

Service Capability Audit

www.aimpractice.com

Identifying a company's readiness to introduce new services. (Cambridge).

Tools to assess your market context

Ecosystem mapping

iv231@cam.ac.uk

Helping companies understand their position within the ecosystem in which they operate (Cambridge).

Reframing the partnering context

Jamie@stewart-associates.co.uk

Increasing the efficiency of partnered working by better understanding the roles of those involved (Exeter).

Tools for managing key service enablers

Fleet management support

civk2@cam.ac.uk

Providing visualisation to support the scheduling of equipment maintenance and enhancement (Cambridge).

Through life service information assessment

Rc443@cam.ac.uk

Helping practitioners assess information provision for existing and new services (Cambridge).

Information quality risk assessment

aknp2@cam.ac.uk

Enabling organisations identify quality problems with the information they need to manage their physical assets (Cambridge).

Predictive maintenance probabilistic decision support

A.zagorecki@cranfield.ac.uk

Supporting predictive maintenance planning (Cranfield Defence & Security).

Failure and Degradation Elicitation Support

A.zagorecki@cranfield.ac.uk

Helping to collect expert knowledge to support maintenance planning. (Cranfield Defence & Security).

Obsolescence cost estimation

p.baguley@cranfield.ac.uk

A tool to predict the cost impact of component obsolescence for long duration services (Cranfield).

Obsolescence management capability assessment

p.baguley@cranfield.ac.uk

Helping companies assess their ability to manage obsolescence issues (Cranfield).

HUMS Cost benefit analysis

k.r.mcnaught@cranfield.ac.uk

Quantifying the benefits of fitting Health and Usage Monitoring Systems to small equipment fleets (Cranfield Defence & Security).

Mindsets in partnership

Jamie@stewart-associates.co.uk

A tool for diagnosing managerial 'mindsets' in partnered services (Exeter).

Supply Chain Risk Assessment and Monitoring (SCRAM)

b.c.squire@bath.ac.uk

A tool to help organisations track and monitor levels of risk in their supply chains (Bath).

Sustainability led service blueprint

www.aimpractice.com

Helping smaller companies increase the sustainability of their service offerings (Cranfield).

Multi-Organisational Network Organisation (MON-ORG)

tsh32@cam.ac.uk

Enabling organisations to identify what to do and where to locate the essential elements of service delivery (Cambridge).

Multi-Organisational Network Metrics (MON-MET)

tsh32@cam.ac.uk

Quantifying the performance of service delivery across organisations (Cambridge).

Multi-Organisational Network Resilience (MON-RES)

tsh32@cam.ac.uk

Identifying the risks inherent in service delivery networks (Cambridge).

Service system complexity

www.aimpractice.com

Helping managers understand the complexity of the services they deliver (Cambridge).

Supply chain risk assessment and monitoring for smaller companies

b.c.squire@bath.ac.uk

Helping smaller firms identify the risks in their supply chains (Bath).

Supply chain risk assessment and monitoring for extended supply networks

b.c.squire@bath.ac.uk

Giving companies knowledge of the risks they face from their extended supply chain (Bath).

Supply chain efficiency mapping

f.j.charnley@cranfield.ac.uk

Enhancing the efficiency of service processes, across extended supply chains (Cranfield).

Agent based modelling of service operations

b.Tjahjono@cranfield.ac.uk

Supporting computer simulation of complex service systems (Cranfield)

Process problem solving tool

R.Hussain@cranfield.ac.uk

To analyse and improve service delivery processes

KTPs and secondments

Rolls-Royce

Developed a Service Knowledge Backbone (SKB) prototype to support the design of products for service delivery. (Cranfield)

Dytecna

Supported the specification of the next generation of health usage monitoring systems to support prognostic maintenance. (Cranfield Defence and Security)

OSys

Investigating further opportunities to apply Bayesian techniques in service provision. (Cranfield Defence and Security)

Supacat

Preparation of a business case to retrofit health usage monitoring systems to the Army's Jackal vehicles, currently in use in Afghanistan.

Summary of applications in the UK:

Application sector	Number of applications by University					Total
	Bath	Cambridge	Cranfield	Warwick/Exeter	Cranfield Defence & Security	
Utilities		1				1
Financial and Professional services		5	1	1		7
Defence (MoD)		1		4	5	10
Environmental Services		4				4
Digital Media	1	2				3
Health/Medical/Pharmaceutical		2				2
Manufacturing/Aerospace and Defence	2	2	8		3	17
Manufacturing/Other	3	17	1			21
Manufacturing/Construction		3	1			4
Manufacturing/Instrumentation	1	2				3
Transportation		1	3	1		5
Public and Third Sector	1			3		4
Grand Total	8	40	16	9	8	81

Raising awareness

KT-Box organised two open events specifically for consultants and practitioners to raise awareness of the tools. KT-Box was represented at twelve further specialist events and conferences, with contact made with over 200 individuals from 80 organisations.

The KT-Box website (www.kt-box.com) provides guidance to users to identify and use the tools. Five kt-box tools have been e-enabled, allowing users to try simplified versions of the tool over the internet. These tools are available to all, via AIM Practice (www.aimpractice.com).





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Research Council



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