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THE FUTURE OF SERVITIZATION:
Technologies that will make a difference

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Acknowledgements

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Executive summary

This executive briefing provides an invaluable guide to the technologies that are likely to play a pivotal role in the future of servitization. In doing so it offers integrated product–service providers some insights into how they can maintain or gain competitive advantage in their markets.

The phenomenon of manufacturers shifting their business models to add a services dimension to their product offering is a widespread phenomenon. Servitization has allowed manufacturers to maintain their competitive advantage in the face of competitive pressures arising from globalisation, and at the same time create greater value for customers.

However, maintaining this advantage is a challenge, and requires an innovative and progressive approach to servitization. The adoption of technologies that allow the improvement of existing, and the development of new, integrated product–services offers a route to sustaining competiveness. The question is: which technologies are and will be the most important?

The existing literature offers limited insight into the game-changing technologies of the future in a servitization context. Our research rectifies this significant knowledge gap.

By consulting panels of practitioners and academic experts we identify 85 technologies that the experts believe are the most important technologies for servitization. Furthermore, the research combines rankings of the technologies by both academics and Capital Equipment Manufacturing (CEM) experts to prioritise the technologies and identify the top10.

Five of the ten top technologies selected by both CEMs and academics are identical:

- Predictive analytics to predict specific failure modes.
- Remote communications to adjust/fix products remotely.
- Consumption monitoring to create customer-specific service offerings.
- Pushing information to employees or customers via mobile platforms.
- Mobile platforms to access the ERP system remotely for maintenance techniques, product details, etc.

Given that many of the academics are engaged in, or aware of, early stage research on technologies that may be useful in servitization, the academic rankings outside the top technologies also provide crucial insights into key technologies for the more distant future.

As well as highlighting important technologies, the research also indicates 22 drivers motivating the adoption of the technologies identified by the panels. The five key drivers from the industrial perspective of the CEMs are:

- Generating new revenue streams.
- Improving maintenance efficiency and effectiveness.
- Improving product performance.
- Increasing data gathering (volume, quality, data types, etc.).
- Increasing/improving access to information.

Overall there are several messages for integrated product–service providers that emerge from the research.

It is incumbent upon manufacturing managers to assess the individual value of the technologies highlighted in this executive briefing, as a service system component, in order to ensure medium-term service competitiveness. This assessment is particularly important as the adoption of many technologies is dependent on lengthy organisational transformation.

In addition, organisational change, the internal mindset and culture, risk, and organisational infrastructure must be aligned to allow for the full employment of a single technology. Organisations need to align their products, technologies, operations and supply chain to provide a new service. This takes time and so it is therefore essential to identify the right technologies, and incorporate these early in the service design process, in order to progress towards the provision of more advanced services■

Introduction

Globalisation has created many opportunities for Western firms. Globalising has allowed firms to improve their competitive position by offshoring elements of the value chain, and provided new markets and customers. At the same time, however, the emergence of corporations from developing markets operating globally, coupled with an erosion of cost differentials, means that many Western firms are under pressure to innovate in order to maintain any competitive advantage they possess.

Product manufacturers are certainly not exempt from this competitive challenge. In recent years, for example, many capital equipment manufacturers have adapted their business model to include an element of service provision. This has sparked a servitization revolution that has transformed both the way that customers use their products and how value is created for everyone in the servitization ecosystem. Yet, in today's fast-paced business world, any advantage tends to be fleeting and so it is proving with servitization as foreign manufacturers increase their service portfolio.

Now, as before, capital equipment manufacturers involved in servitization must search for ways to maintain any competitive advantage that they have managed to secure. One possible solution lies in identifying and utilising technologies that facilitate innovative services, service scalability and improved margins. If firms on the servitization journey can identify and deploy technologies that will help them refine and develop their servitization operations to create and deliver greater value to customers, more efficiently and effectively, then they may be able to stay ahead of the market.

Surprisingly, though, while technology plays an intrinsic role in the development of the servitization business model, and is recognised as a major service science research priority, fewer than half of UK manufacturers who provide services perform formal evaluations to gauge the potential of adopting specific technologies. This despite that fact that it is ever more challenging to keep pace with the emerging opportunities arising from advanced technological development.

It seems obvious that firms should stay informed about emerging technological developments. However, little research exists on the topic, accompanied by few other sources of information to help. This executive briefing, based on the paper "Future Technologies in Servitization: Facilitators in Capital Equipment Manufacturing", goes some way to rectifying that. Drawing on the experience of Capital Equipment Manufacturers and academic experts it identifies some of the most important technologies related to servitization, both in the short term, but also over a mid- to long-term timeframe.

The question we set out to answer was: "Which technologies do academics and experts in the capital equipment manufacturing industry perceive to be key in facilitating servitization in the future?"

In doing so we examined the existing literature on the topic to see what insight it provided into future technologies in servitization, and enlisted the help of industry practitioners and academic experts to identify and rank the most important technologies and their drivers. The findings describe the evolving technological landscape and prioritise viable technologies for manufacturing services■

Servitization – what we know already

The existing literature provides us with some information on the general concepts of servitization – its meaning, some of the challenges and benefits, and the process. It also categorises different servitized offerings.

So, for example, servitization has been defined as the process of creating value by adding services to products. It involves offering "fuller market packages or 'bundles' of customer focused combinations of goods, services, support, self-service and knowledge in order to add value to core product offerings".

There are numerous potential benefits from adopting a servitization approach. The service providers gain increased revenues and better margins, over a longer time span, which reduces competition. Customers can maximise equipment performance and lower the total cost of ownership. Consumers get better products and services that meet their needs more precisely. Society benefits from better sustainability and environmental performance.

Naturally, challenges accompany the transitioning to a servitization approach. The servitization paradox, for example, describes difficulties associated with an expanded focus on service, which increases costs without generating a commensurate increase in returns. Some of the main obstacles to the effective implementation of value-creating servitization concern service design, organisational strategy and organisational transformation.

For example, services must be designed with both economies of scale and scope. In terms of strategy, servitization presents a new challenge in evaluating the risk-return relationship. At the same time organisational transformation is required to communicate the value proposition to customers, and to generate the correct internal culture and mindset. Here, technology can provide assistance in overcoming these obstacles and avoiding the servitization paradox.

There is no one definitive version of servitization. Instead, there are many levels of servitization, ranging along a continuum from the addition of relatively peripheral services with limited, mainly transactional, interaction with the customer, all the way to total product–service solutions that are customised and co-designed by the service provider and customer.

Moving along the servitization continuum involves a shift from a product-centric to a customer-centric approach, to connecting and collaborating with other firms, and building strong front-end customer-facing functions – which support a move from product- to process-oriented services, and from transaction- to relationship-based interactions. This usually entails organisational transformation. Manufacturers need to acquire new structures, capabilities and

processes in order to create advanced services.

The different combinations of products and services have been defined and classified in the 2012 publication 'Toward integration of products and services: Taxonomy and typology', published in the *Journal of Engineering and Technology Management*, by the academics Yongtae Park, Youngjung Geum and Hakyeon Lee. The different types of integrated services and products share a number of common characteristics: they all integrate services and products; consider the service components in the design phase; and focus on the sale of functions and not products. They differ in that they can be divided into market-oriented IPS that aim to differentiate products and promote sales, and engineering-oriented IPS, which integrate products and services in order to provide the outcomes that customers want.

Integrated products and services	
Market-oriented IPS	**Engineering-oriented IPS**
Bundling	Solution
System selling	Integrated solution
Full service	Eco-efficient producer solution
Service package	Functional sales
Installed base	Functional product
	Integrated product and service offering

Table 1: Integrated product-services (IPS) classification[1]

Technology and servitization

Increasingly, technology plays an important role in enabling services and servitization – in the development of services, in product – service integration and in service delivery. Take the situation where technology acts as an interface between products and services, a common example of technology's role in a servitization context.

Some attempts at servitization technology classification have been made. It has been suggested, for example, that technologies involved in servitization can be classified depending on the level at which the technology is involved. Thus technology providing the direct means of integration, without which the product–service integration could

1 Park, Y., Geum, Y. & Lee, H., 2012. 'Toward integration of products and services: Taxonomy and typology'. *Journal of Engineering and Technology Management*, 29(4), pp.528–545.

not be achieved, might be termed enabling technology. Technology applied to the product or the service before integration occurs would be mediating technology. And facilitating technology would provide additional help to bring the product closer to the service, or vice versa.

Beyond its integration role, technology is important with respect to the customisation of offerings, the administration of products and effective customer service delivery through communication channels.

A thorough search through the existing literature on the topic of servitization did reveal some technologies linked to servitization, they ranged across sectors and many had a digital theme. However, most descriptions of servitization-associated technology in the existing literature tend to have a historical or current focus. The literature fails to tell us what is likely to be important in the future, and therefore limits its value in allowing firms to get or stay ahead of the servitization curve■

METHODOLOGY - WHAT WE DID

We used a structured communication method, the Delphi method, to obtain consensus about future technologies between two panels of experts. One panel represented capital equipment manufacturers (CEM), manufacturers of plant or equipment with lifespans of over one year. They were selected from across 13 organisations, which operate in a variety of capital equipment segments ranging from construction equipment, rail, power generation, and defence, to industrial machinery.

The other panel represented academic experts chosen from nine institutions based on their involvement in the service science and/or technology domain.

The three-step process began with telephone or face-to-face interviews, followed by standardised questionnaires. Participants were asked to name and give brief qualitative descriptions of each technology. Once similar responses were combined, 200 initial answers were reduced to 85 individual technologies.

Phase two used a questionnaire to sort all technologies by importance, with participants using a five-point scale from 0-Not Important to 4-Significantly Important. The voting in phase two was used to select the top 10 technologies prior to the start of phase three.

Phase three generated consensus on the rank of the top 10 technologies. Participants submitted a rank from 1 to 10 for each item on each list, allowing a final ranked list of technologies to be created.

	Panels	Phase 1	Phase 2	Phase 3
A	**Academics**	**Process**	**Process**	**Process**
	Service science and/or technology from 9 institutions	Face-to-face or phone interviews	A digital questionnaire asked participants to rank the 85 individual technologies from phase 1 from 'not important' to 'significantly important'	Participants ranked the top 10 technologies relative to one another
		Interviewees were asked to list key technologies and give brief descriptions		
B	**Capital Equipment Manufacturers**	**Output**	**Output**	**Output**
	Experts from 13 manufactures across construction, raise, power and defence	200 responses combined into a long list of 85 technologies	Identification of top 10 technologies per panel	Ranked list of key technologies per panel
				Degree of consensus between and among panel

What we discovered: key servitization technologies – now and in the future

The leading technologies examined

To begin with, the participants, capital equipment manufacturers (CEMs) and academics identified 85 technologies that they believe are important in a servitization context. Next, the list of technologies was given to the two panels – the CEMs and the academics – to rank all results relative to one another. Finally, the panels ranked their top 10 technologies.

There was a good deal of overlap between the two lists of top technologies, with five technologies appearing in both lists: predictive analysis; remote communications; consumption monitoring; and two aspects of mobile communication platforms.

Although there was agreement between the top ten technologies on the two lists, there was a significant difference in the level of consensus attained over the ranking of technologies by the respective panels. While the CEMs achieved a high level of consensus over their top 10 ranking, there was considerable disagreement among the academics.

This disagreement highlights an important aspect of the findings. Part of the reason for the diverse opinions over ranking the top 10 was to do with the particular area of expertise and research interests and objectives of the academics. However, another significant reason for the divergence of opinion is that the academics often

listed technologies that were likely to have an impact further into the future, rather than in the relatively predictable short- to mid-term.

These technologies included genetics, nanotechnology and cognitive systems, for example. Given the longer time frames involved, it is not surprising that there was less agreement over the future significance of these technologies for servitization. However, it also suggests, despite a lack of consensus, these are technologies that may well have an industry-transforming impact on servitization over the longer term and as such merit some attention. The agreement on short-term technologies among the CEM panel shows that industrial participants lacked some breadth in their exposure to future technological developments compared to their academic counterparts.

The top five technologies
Predictive analytics

Three related forms of analytics were listed during the technology identification exercise: descriptive, predictive and prescriptive analytics.

Predictive analytics – using a combination of hardware and software technologies to predict the future state of a product – was ranked by both CEMs and academics as the most important of all

Rank	% in Top Five	Capital Equipment Manufacturers Panel	Rank	% in Top Five	Academic Panel
1	100%	**Predictive Analytics** used to predict specific failure modes.	1	77%	**Predictive Analytics** used to predict specific failure modes.
2	92%	Increasing **analysis of existing data sets** used to find causality and patterns of failures, instead of simply tracking trends.	2	46%	**Remote communications** used to remotely adjust, fix, or send software updates to Machines/Products.
3	83%	**Remote communications** used to remotely adjust, fix, or send software updates to Machines/Products.	3	62%	**GPS or Geo-spatial technologies** used to track Machines/Products, People, or Components.
4	67%	**Dash boarding technologies** used to provide KPIs to make services more tangible and visible.	4	69%	**Consumption Monitoring** used to create consumption driven supply chains for consumer specific offerings.
5	58%	**Case Based Reasoning** (using historic data) in failure pattern recognition, frequent failure pattern analysis.	5	54%	**Mobile** Phones (or other mobile platforms) used to receive internal data or customer information in real time. E.g. control system data or information pushed to customers.

Table 2: Ranked List of Top 5 Technologies

the technologies identified. In particular, the use of prognostic technology to predict the specific failure modes of equipment or machinery.

Prescriptive analytics – providing decision support and making recommendations based on predictive analytics – and descriptive analytics – using diagnostic technology to identify the current state of a product, as in engine monitoring and asset management, for example – were ranked fifteenth and twentieth by the CEMs.

This was possibly because CEMs consider descriptive analytics to be well established, while the widespread use of robust prescriptive analytics is some way off.

Research suggests that while monitoring and diagnostic analysis are adopted in roughly a quarter of organisations using similar technologies, prognostic and decision-support technologies are adopted in only 13 and 11 per cent of cases respectively. This shows that there is considerable scope for improvement in this area – and consequently for firms to gain competitive advantage.

A related technology, likely to become more significant in the longer term, is the self-ordering of spare parts by machines themselves. At present this automated process is too complex and immature for the CEMs and academics to reach consensus on, yet academics still ranked the technology as #30. This finding is congruent with the service automation driver identified as one of the top 10 in this research.

Remote communications

CEMs and academics expressed similar views on the importance of remote communications, with CEMs ranking these third in the top 10 technologies, while academics placed them second. The particular interest was in technologies where the ability to receive, store and transmit data remotely would enable someone to "remotely adjust, fix, or send software updates to machines/products". This would support greater autonomy of machines, and also provide an opportunity for the creation of new services.

The CEMs anticipated a future that would allow remote control of the customer's production line, based on sensor feedback and analytics. Indeed, "remote control used to automatically change the physical behaviour of machines/products to give better operational performance. For example, a remote change to settings based on suggestion driven by analytics" was one of the 85 technologies identified originally, and ranked twenty-first by the CEMs.

Mobile platforms – customer communication and data access

A number of different uses of mobile communication technologies were considered important. Both the CEMs and academics listed the use of mobile platforms "to communicate with customers and to access data for enterprise resource planning purposes" as top 10 technologies. In the servitization context, for example, this might involve sending real-time data via smart phones.

Thus, mobile platforms can extend the value generated by other technologies, for example, by pushing diagnostic messages to customers – something that is already common for capital assets using GSM technology.

On the data access side, a good example is Toyota Materials Handling Europe, which has employed a mobile business system and hand-held computers to access customer information, fleet data and spare parts information since 2002. More recently Toyota expanded the system to collect data from the machines wirelessly and allow for process analysis and consulting.

One participating CEM detailed organisational plans to allow business reporting on tablets, and operational control systems governing large assets to be made accessible from mobile phones within the next 10 years.

A third use of mobile platforms "to feed machine/product, process, or other operational data into central data server remotely," – focusing on data input, facilitating efficient mobile data entry – was listed by CEMs in their top 10 technologies, but not by academics. As one panel member pointed out, allowing operators to use private mobile devices enhances operations by providing engagement, as well as richness and confidence in data.

One CEM explained that the use of mobile communications supported the implementation of the early stages of servitization by their organisation, through practices such as the booking of spare parts from client sites by service staff using iPads.

Consumption monitoring

Another technology ranked in the top 10 technologies by both CEMs and academics was consumption monitoring. When CEMs have a better understanding of how their customers use the machines and products, it is easier for them to offer personalised service offerings, tailoring servitization to the needs of the customer,
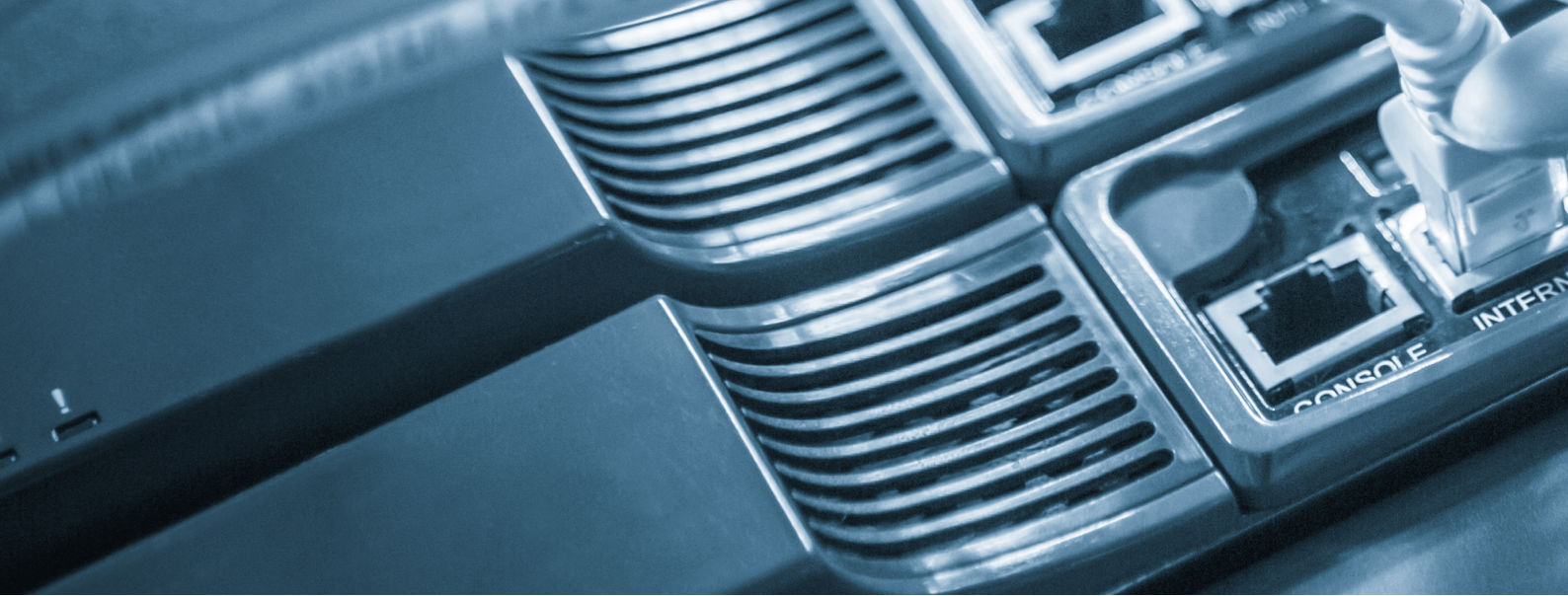
and to co-create value with customers. This in turn creates a competitive advantage.

Consumption monitoring used to "create consumption driven supply chains for consumer specific offerings" was ranked the sixth most important technology by the CEM panel, and among the top five technologies by 69 per cent of academics.

Interestingly, the use of advanced customer relationship management (CRM) tools, in conjunction with consumption monitoring and analysis, helps to facilitate the development of personalised services. As a technology, advanced CRM tools (to combine collected data and target customers with tailored service offerings to reduce the cost and increase the effectiveness of service provision) were ranked sixteenth overall by CEMs.

Other top ranked technologies

A number of other technologies – including the use of mobile platforms for data input, as already mentioned – were rated top 10 technologies by either academics or CEMs, but not by both panels. For the CEMs these technologies were: the analysis of existing data sets; dashboarding; case-based reasoning; and inventory management.

The technologies rated by academics included: position tracking; RFID and 3D barcodes; sensor network integration; customer behaviour monitoring; and additive manufacturing.

Ranked highly by CEMs

Analysis of existing data sets

CEMs ranked the analysis of existing data sets, and in particular its use "to find causality and patterns of failures, instead of simple trend tracking" as the second most important technology. This technology is closely linked to sensor technology – sensors featured in 11 of the 85 technologies identified.

The integration of existing sensor networks and use of smart networking sensors were seen by CEMs as more important priorities than incremental gains in sensor technology. The integration of sensor networks and their data, and the use of advanced databases, and real-time data management, allows more complicated analysis

and sophisticated business intelligence applications.

Dashboarding

The use of dashboarding technologies to "provide KPIs to make services more tangible and visible" was the fourth most highly ranked technology by the CEMs and fifteenth by the academics.

For example, CEMs highlight the ability to develop and use KPIs to dashboard service performance, demonstrating that an agreed-upon service was delivered, thus "ROI-proofing" services.

One CEM described how their organisation specified the dimensions of service benchmarking based on internal and external KPIs. Financial measures and order handling dimensions, such as first-time fix rate, and time to offer a service, were observed internally, versus uptime as an external customer KPI. It is worth noting that uptime monitoring, in particular, is impacted by other technologies mentioned in the study, including cloud and data-handling technologies, for example, which support a move to real-time KPIs and virtual reporting.

In the future dashboarding will become an important component in the provision of cloud-based business intelligence. Dashboards will highlight issues, provide possible strategies to address problems, and, as one expert interviewee pointed out, could represent an intermediate step to the 20-year future of cognitive systems to support human decision-making in service systems.

However, while it may seem likely that outcome-based contracts would be significantly enabled by ICTs, one academic sounded a note of caution. They argued that KPIs may become incapable of their envisaged use in helping to structure contracts in the face of increasingly complex and intangible services. In such a future risk sharing will be integrated into relationship-based contracts.

Case-based reasoning

Using past experiences to find solutions and insights to existing and new problems is known as case-based reasoning. As a technology used specifically for "failure pattern recognition, and frequent failure pattern analysis" case-based reasoning was ranked in fifth place by the CEMs, but only thirty-sixth by the academics.

Many of the technologies that were ranked highly complement one another. This is the case with case-based reasoning, predictive analytics, and the analysis of existing data sets, for example. The ranking of these three in the top five technologies by CEMs emphasises the importance of finding ways to capture operational data, analyse that data, and take actions based on that analysis.

One CEM, for example, explained how they had co-developed a software platform with a large enterprise software corporation in order to analyse and find patterns in internal data. The intention was to use this platform to help integrate analysis functions within their ERP system, allowing them to order spare parts and engineers based on a remote analysis.

Inventory management

CEMs and academics did not simply identify cutting-edge emerging technologies. They also highlighted the importance of some well-established technologies. Although well established, these technologies often need to be adapted to meet the demands of servitization.

A good example of this is inventory management, ranked in tenth place by CEMs, but some way down the list in forty-fourth place by academics. CEMs were focused on the use of inventory management to price spare parts based on demand. Thus one CEM described a recent project in which spare part categories were significantly simplified to improve pricing as a component of new service contract types. Indeed, the dynamic pricing of spare parts is likely to become commonplace.

Ranked highly by academics
Position tracking

GPS or Geo-spatial technologies used for "tracking machines/products, people or components" were placed in the top five technologies for academics, and just outside the top ten at #11 for CEMs. This despite the fact that 44 per cent of the CEM panel was composed of manufacturers of stationary equipment, who clearly obtain fewer benefits from tracking technologies.

Among mobile-CEMs, however, 66 per cent believed that the technology was "significantly important" for the future of

servitization (compared to only 14 per cent of stationary CEMs). The use of GPS is well established in servitization, and is likely to play a greater role in the future, in areas such as autonomous vehicles and service robots, for example, both of which are emerging servitization technologies ranked eightieth and eighty-first by the CEM panel.

The adoption of GPS technology is driven by a number of factors. It creates opportunities for CEMs to create new services and revenue streams and impacts maintenance efficiency by allowing for improved delivery of repair and spare parts to mobile assets.

Customer behaviour monitoring

As well as consumption mentoring, academics also ranked another customer-related technology in their top 10 – customer behaviour monitoring – and, at #13, this was only just outside the CEMs top 10.

The use of consumer behaviour monitoring impacts services in a number of ways. One academic, for example, described the ability to tailor supermarket offerings instantly in real time facilitated by big data analysis of previous purchasing behaviour mixed with customer video monitoring data. Some CEMs explained how product utilisation report packages might allow manufacturers to create more proactive, high-quality maintenance and operational services through the collection of more product usage data, wirelessly and in real time.

However, there are challenges involved in the successful implementation of this technology, not least being able to understand how behavioural data actually predicts future needs and then how to link the data with innovation and customer relationship management.

RFID and 3D barcodes

Another example of a well-established technology playing an important role in servitization is RFID and 3D barcode technology and its use in the "storing of information throughout the supply chain".

While RFID and 3D barcode technology was ranked in the top 10 technologies by the academics, it was ranked just forty-fourth by CEMs. The technology was mentioned in several of the interviews with academic and CEM panellists, but there were few new uses

associated with it. When discussing the benefits arising from the use of RFID and 3D barcode technology, the focus was on logistics and gradual improvements to materials handling procedures and traceability. While some interviewees mentioned increased maintenance efficiency due to the rapid identification of parts, or the stored maintenance information about parts, it was not in the context of a fully developed cyber-physical system.

Sensor network integration

Linked to a number of other technologies, sensor network integration technology is fundamental to the establishment and growth of servitization. Its use in "facilitating big data analytics" was ranked in the top 10 technologies by the academics and in eighteenth place by the CEMs.

Initially, sensor technology tended to involve the use of static sensors; however, advances in mobile communications technology mean that a variety of sensing capabilities – GPS, compass, proximity sensors, for example – are prevalent in mobile devices. The ability to sense and monitor information in the environment dynamically presents new challenges in the context of servitization.

These are real challenges for CEMs, who, in their research interviews, highlighted the need to integrate existing diagnostic sensors into a single system, and combine data currently in isolation, to create a big data environment supportive of data analysis. If CEMs are to be able to provide predictive analytics for a customer's entire production line, for example, connecting machines from a variety of manufacturers, then progress will need to be made on standardisation. At present, a lack of standardisation is a barrier to sensor data sharing and integration between OEMs and, as a result, to remote monitoring.

Additive manufacturing

The last of the top 10 ranked technologies was additive manufacturing, when used in combination with predictive analytics to create spare parts on customers' sites just in time. This technology

was ranked in the top 10 by academics, but only sixty-eighth by CEMs. At the same time, academics ranked the use of additive manufacturing to create spare parts at #25 and to refurbish parts at #51. CEMs were less impressed, placing the three uses of additive manufacturing sixty-ninth, seventieth and seventy-first.

The difference in perception between the academics and CEMs over the merits of additive manufacturing suggest that the technology and its various uses are likely to have an impact on servitization at some time in the mid- to long-term. One CEM outlined the advantages of additive manufacturing technologies as their ability to "…reduce inventory carrying requirements, deliver parts more quickly [...][and] shorten the spares supply chain".

Another CEM interviewee mentioned the value of additive manufacturing in the context of facilitating zero-trip maintenance. Maintenance of an asset typically required two trips, one to diagnose problems and one to effect repairs, but descriptive and predictive analytics will enable a single repair trip in the mid-term. In the longer term customers will be able to fit their own spare parts created in a just-in-time additive manufacturing device based on a predictive analytical input. This transforms the role of the OEM from value creation to design and IP.

This section has detailed specific technologies that will drive the future of servitization for CEMs. These technologies ranged from predictive analytics to additive manufacturing. From an academic perspective the top technologies will impact servitization in a medium-term time frame and these have been supplemented with some important long-term views ∎

The technology drivers

At the same time as investigating which technologies were considered most important by the two panels of experts, we also identified the drivers for the adoption of those technologies.

Interview responses were used to match the 85 research technologies with one, or multiple, individual drivers. Similar responses were combined to leave a final list of 22 thematically clustered drivers. In addition, a targeted list of the drivers among the top 30 technologies for CEMs was compiled.

The results of this list are, perhaps, the more significant. While the drivers may seem obvious, they provide an insight into the main trends driving

technology adoption by CEMs, and thus servitization itself. The full list is shown in Figure 1 below.

The top five are: generating new revenue streams; improving maintenance efficiency and effectiveness; improving product performance; increasing data gathering; and increasing/improving access to information.

Figure 1: Average Prevalence of Drivers in all 85 compared to prevalence in top 27 technologies

Driver	To 30 CEM Technologies	All 85 Technologies	Top 30 CEM Technologies over 20%
Improve Service Resource Efficiency and Effectiveness	20%	25%	
Increase Data Gathering (volume, quality, data type, etc.)	22%		23%
Improving Maintenance Efficiency and Effectiveness	22%		30%
Increased/Improved Access to Information (internal and external)	21%		23%
Generate new Revenue Source	18%		40%
Provide more Services	17%	15%	
Provide Ability to Analyse/Manipulate Data	17%	15%	
Improving Product Performance (e.g. reliability)	14%		23%
Improve Service Quality	20%	14%	
Increase Degree of Service Automation (automated delivery, analysis, maintenance ordering, etc.)	3%	12%	
Systems or Data Integration	20%	11%	
Support Customers, or Relationships with Customers	13%	9%	
Reduce Costs	7%	9%	
Providing more Functionality	13%	9%	
Improve Spare Parts Supply Chain Structure/Performance (cost, speed of delivery, etc.)	10%	9%	
Supports Product or Service Customisation/Personalisation	10%	8%	
Supports Risk Management	10%	5%	
Measure, Benchmark, or make Services Tangible	10%	4%	

Legend: ▪ To 30 CEM Technologies ▪ All 85 Technologies ▪ Top 30 CEM Technologies over 20%

Generate new revenue streams

Perhaps unsurprisingly the most significant driver for the adoption of the CEMs' top 30 technologies was the generation of new revenue. Technologies motivated by this driver appeared twice as frequently in the top 30, as across all technologies, with 40 per cent motivated by generating new revenue streams.

Evidence suggests that many of the most important technologies do provide opportunities for new revenue generation. For example, a 2011 paper by Cranfield University academic Tonci Grubic, 'The adoption and use of diagnostic and prognostic technology within UK-based manufacturers', revealed that diagnostic and prognostic technologies generated increased and sustained revenues for 70 per cent of companies that adopted them.

Improve maintenance efficiency and effectiveness

The adoption of technology by CEMs enables more efficient maintenance processes – the second most important driver for CEMs' top 30 technologies. Remote ICTs, for example, reduce the cost of communicating maintenance needs and requirements. Technologies motivated by this driver included the top ranked technology, predictive analytics, as well as GPS, and supply chain analytics.

Improving product performance

For CEMs this is one of the top five drivers for technology implementation. Technologies that were motivated by this driver included inter-machine communication for optimised performance, remote control and digital integration of the production line. Remote monitoring, for example, is one research technology that allows for enhanced product productivity and reliability, and for future product designs.

The importance of this driver also highlights a major challenge facing CEMs who are focused on servitization. During the CEMs' phase one interviews an internal product-centric mindset was described as a major hurdle in the transition to services. Yet CEMs still focus on technologies that they hope will improve product performance. As one CEM reflected "the focus has still been on product development and not so much on revenue from the aftermarket business".

Increase data gathering (volume, quality, data types, etc.)

Another of the top five drivers for the CEMs' top 30 technologies, specific technologies motivated by the desire to increase data gathering include mobile phones, GPS and smart sensors with networking capabilities.

The panellists agreed that object connectivity enables manufacturers to transform into service and solutions providers. However, some were focused on obtaining analytical capabilities, some wanted access to adequately rich databases, while others stressed how significant further data collection was for their servitization process.

So, for example, one organisation revealed the need to capture more data, and to connect existing data together to create a "whole greater than the sum of the parts". Another CEM described lacking data analysis infrastructure as the primary cause for not having sensors on their equipment. The firm will need to focus on integrating existing sensor technology into its equipment as it is currently co-developing a data-analysis module to find patterns in its existing data in order to enable advanced services.

Increased/improved access to information

Another of the top five drivers of technologies that CEMs ranked highest, the desire to increase/improve access to information, is linked to technologies such as comprehensive online customer portals and the cloud, as well as digital knowledge-sharing technologies.

The cloud, in particular, facilitates this access to information through low-cost storage, remote access to data, record tracking and analysis, and the ability to serve manuals, videos and other media, in a consistent and manageable way. Another technology likely to have an impact on information access in the future, wearable technologies, will provide real-time efficient data access and, increasingly, context-aware answers.

Others

There are also other drivers that, although not in the top five drivers for the technologies ranked highest by CEMs, were still considered important across all 85 technologies. These included: improving service resource efficiency and effectiveness (associated technologies included mobile phones, autonomous maintenance robots); providing more services (software-as-a-service [in the cloud], apps to allow customer co-design of services, GPS); providing the ability to analyse/manipulate data (the hub, the cloud); improving service quality (customer behaviour monitoring, cognitive systems to support humans, and service ecosystem simulations); and increasing the degree of service automation (remote control of machinery, automated data analysis)■

Conclusion

It is clear from the research that technology is central to both effective and efficient servitization, and innovation in servitization to create greater value for the stakeholders in the servitization ecosystem. As such it offers a potential route to competitive advantage for manufacturers engaged in the provision of integrated product–services.

At the same time, the research both identifies the broad technological themes that underpin the development of servitization today, as well as providing a glimpse into the future, by detailing the key technologies for the future of servitization, as identified by practitioner and academic experts.

While the academics do not agree on the relative importance of the key technologies, there is agreement between academics and CEM experts over the five most important technologies in the future of servitization.

- Predictive analytics to predict specific failure modes.

- Remote communications to adjust/fix products remotely.

- Consumption monitoring to create customer-specific service offerings.

- Pushing information to employees or customers via mobile platforms.

- Mobile Platforms to access the ERP system remotely for maintenance techniques, product details, etc.

It is incumbent upon manufacturing managers to assess the individual value of these technologies, and other highly ranked technologies, as a service system component, to ensure medium-term service competitiveness. This assessment is particularly important, as the adoption of many technologies is dependent on lengthy organisational transformations.

The research findings also suggest that such an evaluation may be challenging for many organisations, as there is strong evidence that CEMs lag in their adoption of technologies.

Interestingly, the research revealed the primary drivers motivating technology adoption. New and increased revenue is a primary objective for CEMs, even outweighing the motivation to employ technologies to create cost reductions. Beyond generating revenues, however, there was a desire to improve contract design and generate business models to support service revenues.

Thus, for example, the benchmarking of processes was described as one such facilitator in improving service contract design. Measuring and benchmarking of services to support tangibility is over twice as important among the top 30 technologies as among all 85. Dashboarding was voted into the top 10 technologies by CEMs, yet dashboarding is hardly a new academic concept or technology and has been available for some time now.

The capital equipment manufacturing industry lags in the adoption of integrated product–service technology, both because it struggles to identify relevant future technologies and it suffers from slow internal adoption of technologies.

Another important message from the study is that successful business transformation is essential. Organisational change, the internal mindset and culture, risk and organisational infrastructure must be aligned to allow for the full employment of a technology. Organisations need to align their products, technologies, operations, and supply chain to provide a new service. It is this alignment process that is likely to cause a lag in the adoption of technology.

It seems sensible therefore to incorporate technologies at an early point in the service design process. A possible barrier to early integration, though, may be reputational risk. As one CEM pointed out there is greater risk of damaging the reputation of a service provider with the increased adoption of unrefined technologies. Risk aversion may lead CEMs to hold out on integrating underdeveloped technologies into their integrated product–service offerings.

For this reason the findings outlined in this executive brief are particularly useful. They help organisations identify the right enabling technologies, and so help them to reduce the potential risk to reputation inherent in adopting relatively novel technologies. In particular the research assists manufacturers in designing competitive integrated product–services more effectively by assessing long-term technologies such as automated production control, nanotechnology or service automation, which are identified as technologies likely to play an important role in servitization in the future.∎