Original Equipment Manufacturers in the Age of Smart Systems

Part 2: Critical Success Factors

Machine builders and equipment manufacturers need to address the true potential of connectivity and information-driven innovation. By integrating service and support automation directly into the fabric of machine solutions, new asset management platform technologies can help OEMs leverage the continuously evolving relationship between connected machines, smart services and customer value creation. This paper and supporting research highlights the productivity impacts and customer responsiveness gains new smart systems and digital platforms inform.

smart systems design | Harbor Research

Virtually all equipment and machines now contain a wealth of information about their status, usage, and performance. Until recently, this information has gone largely unharvested and unleveraged, even though it can offer extraordinary business advantage to the companies that manufacture and service those machines, especially in terms of customer relationships. The new world driven by networked services is one in which every connected machine turns manufacturers, and in many cases others along the value chain, into a new kind of "smart service" business. It bends the traditional linear value chain into a "feedback loop" through which data rich heartbeats and insights will continually flow back through the complex business alliances that create, distribute, and service those systems. Unfortunately, while most "product-centric" businesses are now embracing the concept of growth-creating services, many are not developing new business models and not investing in new digital systems to realize the true strategic potential and value. These businesses are thinking services, but they're not thinking "smart services." Leaders are creating unprecedented performance and unique barriers to competition by combining a fundamental understanding of the role of after market support and its inherently unique business and operating requirements with an acute understanding of the strategic impact of intelligent machines, data management and analytics.

TABLE OF CONTENTS

EXHIBITS

In Part 1 of this white paper, we covered potential areas for OEM growth and innovation. What is clear, however, is that this innovation and growth will not come from the "status quo," traditional modes of business centered around products and simple support services. A fundamental shift is required in how OEMs approach growth and innovation in the age of Smart Systems and Services, and this paper highlights some alternative approaches, implications and success factors for OEMs.

OEM BUSINESS MODELS are UNDERGOING MASSIVE CHANGE

Fundamental changes to business models will accompany every organization's decision to utilize and act on the data flowing from its connected machines and equipment.

While looking for and identifying the tools available to product-centric businesses shifting to services, it is vitally important that businesses consider whether or not the opportunity is one that can be seized alone or in conjunction with another or even with many others.

Simply put, the overall smart systems, assets and services opportunity is one a company can seize alone, a partner-driven opportunity, which will in one way or another be an opportunity that is shared with others, or an open collaborative opportunity.

» **Solo:** Where most of the elements of the opportunity are attached directly to a product's life cycle such that they are designed to be deployed by the product player alone;

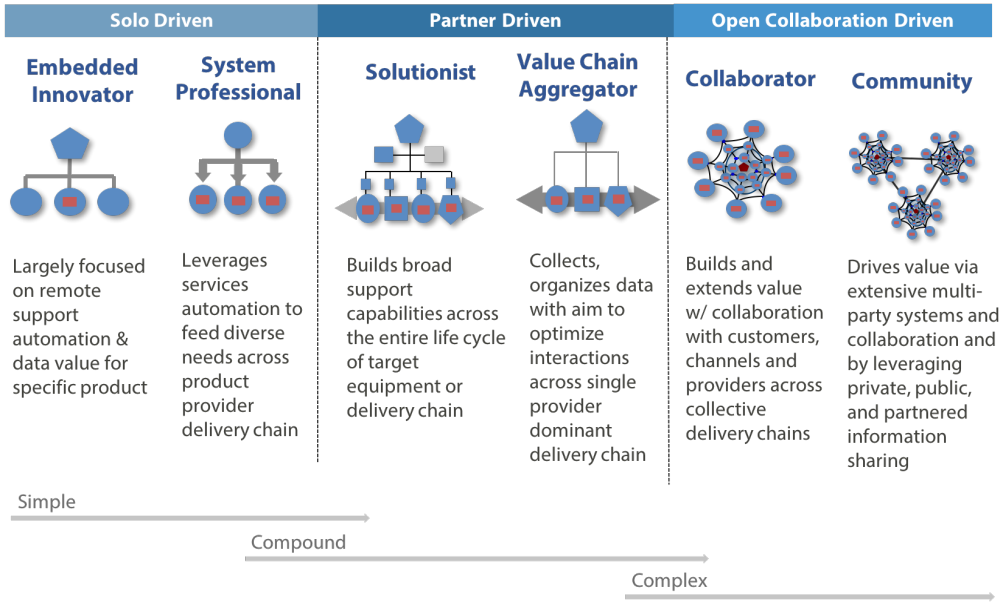
» **Partner-Driven:** Where the opportunities require multiple value adding partners working in a closely coupled fashion and are designed with partnerships in mind; and,

» **Open Collaboration:** Where the opportunity is forged around a platform model that provides for and enables extensive third party collaboration and contributions and clearly addresses a broader scope of the customer's operations systems than any single equipment manufacturer would address alone.

The direction a company takes will help determine the kind of business model it should adopt. For players that go at it alone, it may be what we call an "embedded innovator" or "system professional." Examples of solo models include remote services for office equipment or other types of machines.

If you partner with others, it may be as a "solutionist" or "value chain aggregator." Examples of these models include construction and agricultural equipment from players like Deere and Caterpillar where the value chain is integrated with equipment dealers and other adjacent value added services suppliers. But if your

Exhibit 1: Smart Systems and Services Business Models



goal is to leverage a more open participative model, it is what we would call a "collaborator" or a "community builder."

Moving beyond simple applications for connected products requires broader collaboration across multi-party ecosystems that drive numerous interactions between and among people, systems and devices.

These models are progressive where the value increases with the integration of each additional player's equipment and systems and the increased resulting interactions. These "complex" applications and the significant increase in interaction value they inform, inevitably require open information flows and shared data across the ecosystem and participants.

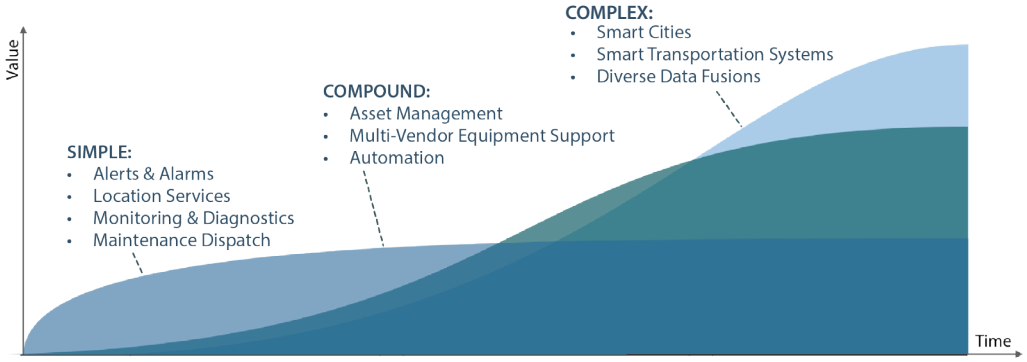
To achieve real compound value in smart systems and asset applications, equipment players and value adders will need to think and act differently. A renewed focus on developing ecosystems and the critical relationships that will drive value are key to success.

ASSET SYSTEMS REQUIRE NEW DATA and PLATFORM INNOVATIONS

When it comes to preparing for the digital global information economy of the 21st century, most people assume that the "technologists" or the "IT department" are taking care of it. They take it on faith that the best possible designs for the future of connected assets, people, systems and information will emerge from traditional functions. But

those are big, unfounded assumptions. In fact, most of today's machine builders and OEMs have shown little appetite for radical departures from current practice. Yet current practice and current asset management systems will not serve the needs of a genuinely connected world. What are the major obstacles that need to be overcome?

Exhibit 2: Simple, Compound and Complex Application Values Driven From Data



End Customer Evolution	• Simple asset monitoring to increase uptime and OEE • Increased plant floor visibility • Basic preventative maintenance offerings	• Predictive maintenance leveraging advanced data management and machine learning technologies • Visibility across full ecosystem, and integration of plant floor data into multiple operations and enterprise systems	• New levels of ecosystem collaboration through integration of data from operations with multiple partners, including OEMs, suppliers and value added services providers
OEM Evolution	• Provide classic "remote service and aftermarket support" offerings, only focusing on the OEM's own assets/systems and service delivery	• Increasing service scope and value is provided to the customer through: system enhancement and optimization, installed base data management, predictive analytics	• Offering entirely new services that create value through collaboration between/amongst parties across a complex, multi-brand, multi-business system

» **Optimizing All Assets - Tangible And Intangible:** New software technologies and applications need to help organizations address the key challenge of optimizing the value of their balance sheets, allowing them to move beyond just financial assets and liabilities to their physical assets and liabilities (like factories, electric grids or hospitals) and then to their intangible assets and liabilities (like a skilled workforce). The task of optimizing the value of financial assets, physical assets and people assets requires new technologies that will integrate diverse asset information in unprecedented ways to solve more complex business problems.

» **Flexible, Scalable Systems:** IT professionals rarely talk these days about the need for ever-evolving information services that can be made available anywhere, anytime, for any kind of information. Instead, they talk about web services,

enterprise applications and now cloud computing. The Web stores information in one of two basic ways: utterly unstructured, or far too rigidly structured. The unstructured way gives us typical static Web pages, blog postings, etc., in which the basic unit of information is large, free-form, and lacking any fundamental identity. The overly structured way involves the use of relational database tables that impose rigid, preordained schema's on stored information. These schema's, designed by database administrators in advance, are not at all agile or easily extensible. Making even trivial changes to these schema's is a cumbersome, expensive process that affects all the data inside them. Just as importantly, they make deep, inflexible assumptions about the meaning and context of the data they store. Both of these approaches to data-structure enforce severe limitations on the functions you want most in industrial pervasive-era information system: scalability, interoperability and seamless integration of real-time or event-driven data. The client-server model underlying today's systems greatly compounds the problem.

OEM Case: Acquiring to Innovate

A water test, treatment and transport equipment manufacturer with a digital innovation agenda that is top priority has made a number of acquisitions to add important technology and development skills to its business. It has centralized those skills in a single, self-sufficient organization with relative autonomy to leverage existing capabilities and build new solutions to increase the OEMs value-add to the customer.

» **Automated Development:** When telephones first came into existence, all calls were routed through switchboards and had to be connected by a live operator. It was long ago forecast that if telephone traffic continued to grow in this way, soon everybody in the world would have to be a switchboard operator. Of course that has not happened, because automation was built into the systems to handle common tasks like connecting calls. We are quickly approaching analogous circumstances with the proliferation of smart connected devices. Each new device requires too much customization and maintenance just to perform the same basic tasks. We must develop software and methods to automate development and facilitate re-use, or risk constraining the growth of this market.

» **Leveraging Collective Intelligence:** For all its sophistication, many of today's so-called asset management systems and platforms are a direct descendant of very traditional computerized maintenance management systems where each machine on a network acts in a "hub and spoke" mode. The inability of today's popular asset management systems to inter-operate and perform well with distributed heterogeneous machine and equipment environments is a significant obstacle. The many "nodes" of a network may not be very "smart" in themselves, but if they are networked in a way that allows them to connect effortlessly and inter-operate seamlessly, they begin to give rise to complex, system-wide behavior. This allows an entirely new order of intelligence to emerge from the system as a whole—an intelligence that could not have been predicted by looking at any of the nodes

individually. What's required is to shift the focus from simple device monitoring to a model where device data is aggregated into new applications to achieve true systems intelligence.

Because it is impractical to deploy human beings to gather and analyze the real-time field intelligence required, connected services depend on "machine intelligence" and device data as a fundamental building block.

THE COMMON CURRENCIES of ASSET SYSTEMS and the IIoT

Financial economies that lack an abstracted, liquid currency are barter systems. You can accomplish rudimentary trade in such a system, but not sophisticated, ever-evolving exchange that transcends the inherent meaning of traded objects such as silk or grain or livestock. The idea of a liquid currency was a paradigm-shifting innovation in running an economic system.

The common "currencies" of the bit, the byte, and the packet made massive and rapid evolution possible in computing and networking. What is the common currency of the Web world? Is it HTML? XML? The Web "page"? The relational database table? The hard truth is that the Web has no common currency for information or information objects and devices. As a platform for the world's information, be it information from traditional IT systems or from OT systems, the Web and legacy asset management solutions resemble a comparatively primitive barter system of "apples and oranges," not a sophisticated economy.

Smart Systems, Assets, Pervasive Computing and the Industrial Internet of Things implies a true global information economy where we understand that and data access, usage and interoperability are essential requirements—remarkably simple foundations for intense complexity that remains comprehensible and useful at any scale. The key point is that making very few assumptions about the data and about the devices connecting to the network to send and receive data. It is this extensible, technology-neutral information architecture that will allow new applications and services to scale dramatically (and gracefully), with minimal central administration.

Demand for interoperability is growing, and as designers of information systems to manage OT systems and assets work to provide it, they will be laying the foundation for an information system far vaster than the existing World Wide Web.

This is the fundamental reason that new asset management and OT systems will require new data and information architectures to enable the integration of senors, actuators, machines, equipment, systems and people. The next generation of asset management systems and technologies are opening a whole new realm of business process innovation, including:

» **Multi-Vendor Service Provisioning and Handling:** Monitoring and managing machines in the field as well as keeping track of service resolution routines and alternatives relative to machines and equipment systems from multiple vendors is a significant feature. This allows a value based approach based on factors such as the timing, the nature of and the technical personnel involvement for a given service activity provided, but orchestrated across the reality of these systems configured and installed; well beyond a single equipment vendors scope of coverage.

» **Systems & Software Management:** Software based services have the potential for constant improvement once incorporated into an asset management program. In order to deliver this value, machines in the field must be able to be updated remotely. This set of capabilities can deliver and track such updates, and also maintain records for compliance or billing purposes.

» **Usage & Performance:** Usage monitoring and performance tracking are required functions for this type of value delivery. Partners can step up to higher levels of impact on the customer.

» **Decision Support Extends Customer Relationship:** Providing users and customers with valuable information that helps them run their own businesses more efficiently will extend the relationship between the machine builder and end customer well beyond the initial product sale, helping to build a "mutual, shared understanding of customer systems allows knowledge gained on either side to be continuously leveraged."

OEM Case: Partnering to Drive Higher-Value Solutions

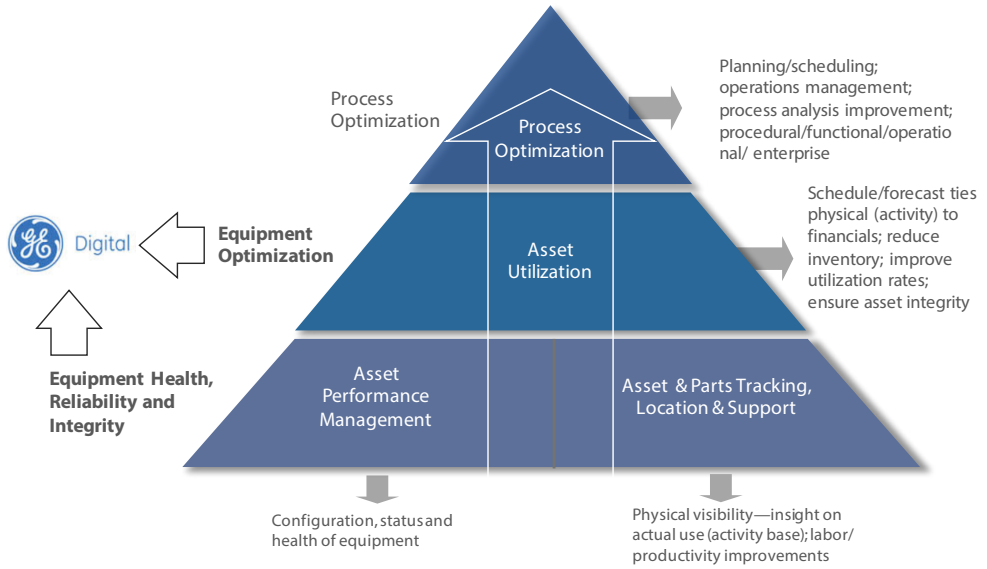
A forklift manufacturer had acquired telematics capabilities to support simple monitoring and tracking of its equipment in customer environments. Unrequited by the lack of further internal development of these capabilities and the ability to offer higher value applications by combining disparate data, it has begun to look externally to industrial-focused third-party solution providers to partner with and enhance the value of its solutions and services.

Beyond the immediate benefits that are visible to equipment OEMs today, networked machines will become portals into other network resources in which users will gain utility not only from the machines themselves, but from a variety of adjacent value added processes and services. This new knowledge becomes extremely valuable when combined with other information, allowing the creation of new service value.

The next great step in IT and OT development—completely fluid information and fully inter-operating devices, people and systems—requires a new generation of data and application integration platform technology that will make information itself truly portable in both physical and information space, and among any conceivable smart information devices and machines.

Technology advancements need to engender new system elements and new services. Correctly balanced, technology and new service delivery modes can help customers

Exhibit 3: GE's Value Proposition Lies in its Platform Modularity and Ease-of-Use



reach their goals of increased operating efficiency, reduced costs, automated system upgrades, and more efficient operations. Achieving this critical balance is the challenge that GE Digital's Predix platform is aimed squarely at solving.

GE's platform is intended to reduce a significant percentage of the complexities of application development, systems management and application delivery. The challenges of networking smart devices, developing connected product applications, integrating complex IT systems and unifying services delivery in a coherent and cost-effective manner have been big hurdles to adoption that new platform technologies are finally addressing.

THE IMPORTANCE of ORGANIZATION, RELATIONSHIPS and SKILLS

From an organizational and relationship perspective, many new capabilities will be needed: new technology capabilities and assets, new skills and talent sourcing, new and expanded ecosystems, value delivery networks and partnerships, new cost structure/s and investment priorities and new performance measures. Management teams will need to evolve their own skills, shifting from traditional management modes to nurturing and coaching, adding value through enabling new roles, relationships and the free movement of information and knowledge.

Diverse collaborative networks of individual and team contributors will be self-organized by people who are motivated to explore and develop ideas they care deeply about. Business

innovation will extend beyond ideas about new products and services to the very manner in which business is conducted. There is no "right way" organizational model for developing new smart systems growth opportunities. The best companies we have worked with have not just embraced the importance of leveraging smart systems technologies but have articulated a higher purpose mission around how they will serve customers. This is a central element in their business, culture and people strategies.

OEM Case: Chief Growth Officer

A packaging machine and material manufacturer combined the responsibilities of its CIO with a new role, Chief Growth Officer, to attack new smart services growth opportunities. This role is now able to drive technology and ecosystem development from one place, which has led to a number of new software and service capabilities for the OEM.

Having defined a clear mission, an OEM can then identify the skills and roles that are most critical to delivering it. We call these roles and people the "critical enablers." This is a very significant shift from the era of professional management where organizations viewed professional managers as central to a company's performance. The organizational goal was to advance the best performers into management—to take expert "functional" roles and staff and make them managers of other functional or specialist skills staff.

Rewards and recognition flowed accordingly. In the coming era, the priority will be to create communities of expertise within the firm or within its ecosystem—think guilds of bricklayers— to reorient investment around the key roles that deliver the customer mission and to place the best talent in these roles. The payoff can be significant, as top talent can dramatically outperform average talent in these kinds of roles

In the end, it's also about doing things differently and driving new smart systems and services innovation by abandoning traditional protocols and, ultimately, finding the right mix of skills, capabilities and organizational relationships.

EVOLVING SUCCESS FACTORS and GROWTH THEMES for OEMs

Building new ventures for Smart Systems and the Internet of Things requires new and very different modes of design and development – organizations will need to push the boundaries of collaboration to include many new and unfamiliar participants.

As much as we would like to say there is a simple "linear" process and recipe to drive new smart systems innovation, the nature and complexity of the Internet of Things makes that impossible. There is no one best way to move through an innovation process to design new systems. There are useful starting points and milestones along the way, but the innovation continuum for smart systems is best thought of as a group of overlapping stages of innovation rather than a sequence of orderly steps. The reason for the iterative, nonlinear nature of the process is not that business innovation is undisciplined but that the process overall is one of exploration and discovery; done right, the process should lead

OEM Case: Re-focusing On What Matters

A focused diversified OEM of mining, construction and industrial equipment has restructured by spinning off various business segments to refocus each on their dedicated industries. This has allowed the individual businesses to be more agile in their development of new smart systems and services capabilities and more closely support customers in their digital endeavors.

to unexpected concepts and ideas and it would be foolish not to explore where they lead. Often projects can loop back and repeat steps more than once as a team refines its concepts and ideas.

The business environment for OEMs has entered a new chapter with new challenges and unfamiliar technologies impacting virtually all of the diverse players and segments across the OEM arena. Because of its breadth and diversity, it's difficult to generalize how players in specific segments should think about and respond to new unpredictable forces in the market. Even though the journey forward will differ from company to company, we believe leadership teams in OEMs should be focusing on the following growth themes:

» **New Non-Traditional Growth Opportunities:** sources of new growth are shifting away from just growing with the market or taking market share from peer players. For many OEMs, growth is rapidly shifting beyond their core business to broader product/system/solutions offerings, integrating new embedded digital capabilities or expanding vertical integration, particularly leveraging new services and value-added customer support.

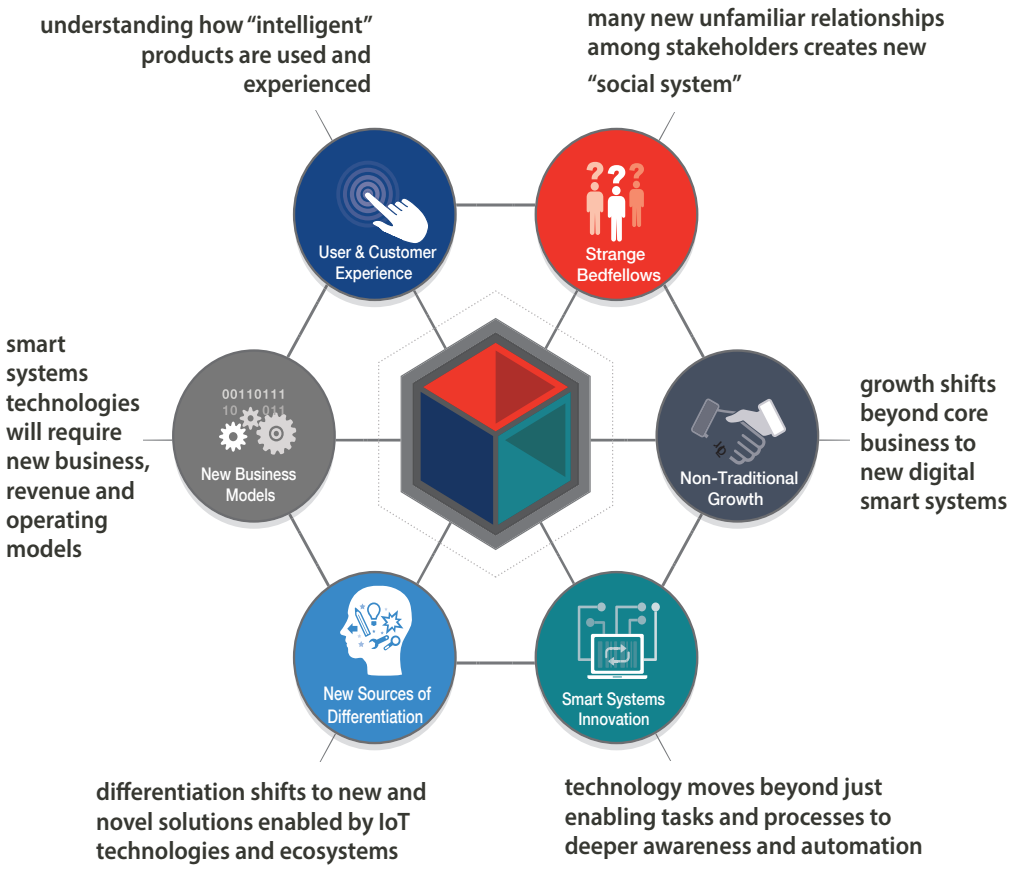
» **Changing Sources of Competitive Differentiation:** we believe competitive differentiation will shift away from traditional sources such as product/brand position, scale and available capital, low cost manufacturing, product portfolio, channel or customer support capabilities towards a new focus aimed at areas such as IoT enabled product innovations as well as partner and ecosystem development.

» **User and Customer Experience:** IoT and connected product technologies are enabling radically new user and customer experiences and informing equally disruptive business models (think of Apple, Amazon, Uber, etc.). Understanding user and customer preferences, behaviors, interactions and the technologies that can inform unique user experiences can create new differentiated offerings. This will drive a shift toward understanding how 'intelligent' products are experienced and how 'networked' products foster diverse interactions between and among manufacturers, users, application developers, technology sourcing partners and channel participants in a networked context.

» **Smart Systems Innovation and Optimization:** new digital and IoT technologies will drive a multi-year wave of growth based on the convergence of innovations in embedded software, machine intelligence and data and information architectures integrated with more powerful sensors, actuators and client devices connected to higher performance personal, local and wide-area networks. These technologies will work

together in unprecedented ways to solve more complex business problems than previous generations of automation, control and computing technologies. These new capabilities will revolve around real-time situational awareness and automated analysis of "states" and operations. As a result, technology moves beyond just proposing task solutions — such as executing a work order or a sales order — to sensing what is happening in the world around it, analyzing that new information for risks and alternatives, and taking actions.

Exhibit 4: Evolving OEM Growth Themes



» **Go-To-Market and Value Delivery Networks Drive Strange Bedfellows:** As the complexity of these systems continues to increase, the number and diversity of stakeholders, users, sellers and supporters interacting with these systems will also rise in a way that creates a "social system" comprised of new unfamiliar relationships - a phenomenon we call "strange bedfellows." Leveraging new digital data value inherent in connected products and systems will require new infrastructure and enabling technologies that will, in turn, inform the formation of new and different market relationships and alliance networks comprised of complementary equipment and device OEMs as well as third party application developers and services providers. We

believe that within this solution delivery social system [or ecosystem] OEMs will need to understand new value adding "roles," but also make conscious decisions about their evolving position in market delivery alliances and networks.

» **New Business Models, Skills and Organization Designs:** The technical innovation driven by digital and IoT technologies coupled with diverse and changing relationships between and among complementary players will likely lead to changes in market structure, shifts in the sources of profit and value creation and thus, new business and operating models. Identifying and designing new business models along with developing the new skills, capabilities, systems and organizational relationships they require will be critical to success.

ENDPOINTS

The first fact about a networked product, which is so obvious that no one needs to be told, is that it will capture and convey valuable data. The second fact, not quite so obvious, is that these new data become a core asset. The third fact, an obscure leap for many managers, is that information as an asset makes for fundamental changes in a company's business. The fourth fact, which makes things simple but by no means easy, is that most changes brought about when information becomes central have the effect of moving a company toward an entirely new service business model.

We say this is simple but not easy, because while the fact that service moves to the fore is not hard to grasp, in practice service is a paradigm so foreign to manufacturers that they cannot understand, let alone implement, the changes necessary to make the shift successfully.

Many companies have already seen some of the challenges inherent in shifting to a services-driven business. In fact, the phrase "shift to services-driven business," though accurate, can be dangerously misleading as it can make the required corporate culture and business model changes sound almost tame. They aren't. The era of near perfect, real-time information about physical assets and customer behaviors is looming like a tanker coming out of the fog. Any degree of complacency – even from those who consider themselves "advanced" – will be deadly.

The next great step in IT and OT development—completely fluid information and fully inter-operating devices, people and systems—requires a new generation of data and application integration platform technology that will make information itself truly portable in both the physical and information spaces, and among any conceivable smart information devices and machines.

Technology advancements need to engender new system elements and new services.

Correctly balanced, technology and new service delivery modes can help customers reach their goals of increased operating efficiency, reduced costs, automated system upgrades, and more efficient operations. Achieving this critical balance is the challenge that most OEMs smart services developments must focus on solving.

New business model innovation needs to reduce a significant percentage of the complexities that customers and users face with connected platform development, systems management and application delivery. The challenges of networking smart devices, developing connected product applications, integrating complex IT systems and unifying services delivery in a coherent and cost-effective manner have been big hurdles to adoption that OEMs businesses need to address.

Radical new thinking about connected product technology must begin at the most basic levels. OEM business development teams need to future proof their innovations by making the fewest possible assumptions about the nature of networked objects and the data they produce, carry or process - the company needs to take a much broader, all-encompassing view of device data and information. Ultimately, these types of solutions will radically alter how new applications are realized and customers supported.

ABOUT HARBOR RESEARCH

Founded in 1984, Harbor Research Inc. has more than thirty years of experience in providing strategic consulting and research services that enable our clients to understand and capitalize on emergent and disruptive opportunities driven by information and communications technology. The firm has established a unique competence in developing business models and strategy for the convergence of pervasive computing, global networking and smart systems.