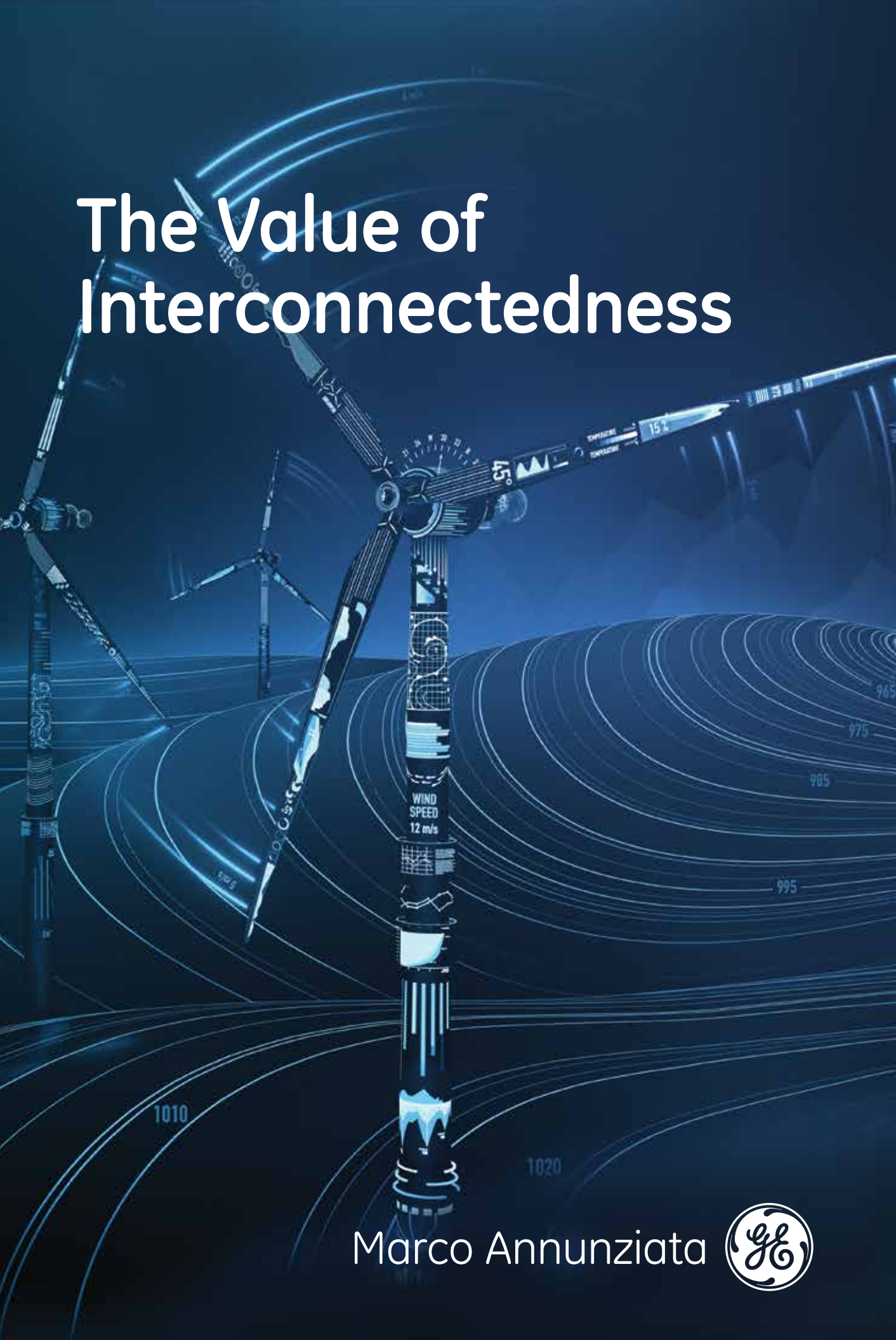
The Value of Interconnectedness



Marco Annunziata

The Value of Interconnectedness: Toward a new kind of industrial company

The convergence of the digital and the physical in the industrial world is a profound transformation that is far from fully appreciated. A connected device or machine becomes something entirely new. A smart phone, for example, still performs its original function; it allows you to make and receive telephone calls. But interconnectedness has rendered this a secondary function. The smart phone has new ways to make us more connected and informed (video chat, social networks, e-reader, and news and weather alerts). It is our concierge (restaurant reviews and bookings, taxi caller, online shopper). It is our entertainment system (music, TV, and games). It controls our thermostats, alarm systems, cars and more. A smart phone today is a fundamentally different object.

Cars are undergoing a similar transformation. Self-driving cars are already a reality. They can guide us on the most efficient route through web-enabled navigation systems and find the nearest gas station or restaurant; thanks to sensors, they can watch out for us, warning us if we stray from our lane, if we are about to turn when someone is in our blind spot, if we are at risk of hitting a pedestrian. In a Tesla, some technical problems can be fixed remotely by a technician at a computer hundreds of miles away. A car today is a fundamentally different object.

In a similar way, a company producing interconnected industrial devices becomes a fundamentally different company.

We have argued in previous work that the Industrial Internet and Advanced Manufacturing are not only transforming individual machines and systems, but they are also changing the nature of economies of scale, transforming the economic landscape and blurring the lines between manufacturing and services. In a similar way, industrial companies that combine the digital and the physical open entirely new dimensions in the way they operate and in the value they can provide to customers and shareholders.

Connecting the digital world of research, design, engineering and manufacturing enables a company to drastically reduce the time to introduce new products, leading to faster responses to customer needs and higher engineering productivity. Translating real-time factory and supply chain data into insights makes those factories and supply chains able to respond much faster to shifts in customer needs and external shocks. Linking engineering, supply chain operations, and services data through the cloud means operators can optimize factories and products in real time and continuously improve them throughout their lifecycle. As a result, machine uptime, throughput, and inventory turnovers increase. Higher responsiveness leads to higher sales.

Combining deep expertise in both digital technology and industrial machines is not easy. Both fields require complex and sophisticated domain expertise, and are experiencing fast-paced innovation. To be successful, a digital-industrial company must keep ahead of the curve on both fronts and be able to merge them seamlessly

[1]Marco Annunziata and Peter Evans, "Industrial Internet: Pushing the Boundaries of Minds and Machines" ; and Marco Annunziata and Stephan Biller, "The Future of Work".

in a way that maximizes value. Just like innovation, design and manufacturing need to be closely intertwined to learn from each other and adapt to each other, so digital technologies and industrial manufacturing need to be melded to learn from each other and spur each other to reach higher levels of performance. Software development must be guided by the industrial machines' purpose, potential and limitations—and vice versa.

GE has achieved this combination by establishing a new Software Center of Excellence (COE) in San Ramon, Calif. With an investment of $1 billion in software and analytics over three years, GE has become one of the major software companies in the world with the San Ramon Center and regional software centers in Europe and China. GE now employs 14,000 software engineers.

More than 1,000 of these software and data science experts are concentrated in the San Ramon COE, working seamlessly with their counterparts in the company's industrial divisions from Oil & Gas to Transportation, from Aviation to Healthcare. Combining the software skills of the COE's experts with the sectoral experience of data scientists and data engineers in the industrial businesses is essential—both to maximize the joint value of digital and physical as well as to ensure the compatibility and adaptability of software solutions across industries.

Creating value: The platform and Industrial Internet solutions

Platforms

Platforms are essential to enable and monetize the value of interconnectedness. Interconnectedness is all about communication, collaboration and compatibility, including for big industrial equipment, and it all starts with platforms. The power of platforms has been abundantly demonstrated in the digital world; just think of the burgeoning range of increasingly powerful apps on our smartphones. A powerful platform can facilitate the compatibility of applications, delivering a number of benefits:

i. collecting and analyzing data from a larger set of different industrial assets, creating a deeper and more informative information set that delivers more effective insights;

ii. enabling the interoperability of a wider range of assets within an industrial operation or system, boosting operations optimization;

iii. allowing applications to be adapted and adopted across different industrial sectors;

iv. making it easier for developers, engineers and data scientists to collaborate on a wider range of industrial solutions, leveraging the Global Brain to the maximum effect.

Most engineering and manufacturing system design tools, as well as factories and supply chains, have a plethora of data sources that are often neither connected nor integrated. To unleash the power of data integration and **systems-level** analytics and optimization in manufacturing, it is critical to ensure interoperability between data sources.

Much effort has recently been expended in integrating the data of design, product engineering, and manufacturing engineering through product lifecycle management (PLM) tools. But we have yet to reach the stage where a change in design automatically propagates through all virtual validation tools, such as robot and controls emulation, throughput and process simulation, and productibility and model-based manufacturing tools.

In factories and supply chains, it is not uncommon to find **20 or more separate data collection systems,** from Enterprise Resource Planning (ERP) to Manufacturing Execution Systems (MES) to energy management and homegrown quality systems. In fact, from a data collection perspective, every machine or controller might generate megabytes of data that often are not used to their fullest extent.

Integrating and fusing those data into one interoperable platform allows engineering, factory and supply chain leaders to gain visibility over their functions and to understand the system-level trade-offs of their decisions. Furthermore, the interoperability platform enables the development and implementation of generic engineering, factory, and supply chain tools that require only minor customization for different businesses and plants. These tools will unleash the power of analytics, simulation, and optimization providing leaders with (1) visualization of key performance integrators, (2) real-time decision support, and in some cases, (3) optimization and automation of decisions allowing them to focus on strategy and 'exception management' rather than day-to-day operations.

Platforms will play a key role in accelerating the growth and unleashing the value of the Industrial Internet, and the Future of Work more broadly. GE has developed Predix, our proprietary software platform for the Industrial Internet. Predix is designed specifically to meet the requirements and characteristics of industrial systems: it guarantees data security as well as mobility, it is optimized for machine-to-machine communication, and it supports distributed computing and big data analytics. Predix will support the rapid development of a growing number of applications for asset and operations optimization for a wide range of industrial sectors.

GE's Industrial Internet solutions

In previous papers we highlighted how the Industrial Internet can increase efficiency and productivity, eliminating unplanned downtime of machines like power turbines and locomotives.[2] Industrial Internet solutions are now being developed and applied in a range of industrial sectors, including those that play a pivotal role in driving economic growth. In this section we provide selected examples of GE's Predictivity services—productivity-enhancing solutions developed across different sectors—to give a fuller sense of the range of potential applications.

Transportation

The transportation network is the backbone of the economy, and inefficiencies in transportation translate to higher costs for business and ultimately in slower growth in output and incomes at the national level. In the railways sector, efficiency and productivity can be increased by raising the velocity at which the railway network operates, and by reducing the "yard dwell time" that trains spend idle in a railway yard. Dwell time is closely and inversely linked to operating margins.

To improve performance, GE has developed the RailConnect 360 solution, which provides comprehensive support to rail mechanical and transportation departments on locomotive health, maintenance and repairs. The system collects and analyzes performance data during locomotive operations, provides automating diagnostics and root cause analysis. This allows railway managers and technicians to schedule preventive, conditioned-based maintenance and repairs, maximizing reliability and availability. Software modeling can guide an optimal reconfiguration of network and yard operations—along the logic of the digital thread in advanced manufacturing. Similarly, it enables advanced planning of resources and materials.

GE's Movement Planner software has already achieved 10 to 20% increases in velocity and a 50% reduction in the need to change crews, substantially improving asset productivity. Similarly, our Trip Optimizer solution for railways has already delivered a 10% reduction in fuel consumption.

Aviation

The top priorities in aviation are clear: maximizing safety and minimizing delays, limiting cancellations and reducing fuel consumption. Intelligent Operations services, developed by the Taleris joint venture between GE & Accenture, use proprietary algorithms to monitor data collected from aircraft equipment and airline systems to predict, prevent, and recover from operational disruptions. The system has already proved capable of spotting and flagging issues not detected by traditional diagnostics, preventing operational disruption and lost revenue. For an average U.S. domestic airline (14 million passengers, 85,000 flights per year), Intelligent Operations services could prevent 1,000 delayed departures and flight cancellations each year, helping more than 165,000 passengers get to their destinations on time.

Another Predictivity solution, Flight Efficiency Services (FES), collects real-time data generated by an aircraft and applies proprietary techniques that provide business intelligence and actionable insights to significantly improve an airline's overall efficiency. FES uses smart software tools and analytics algorithms to help airlines achieve higher levels of efficiency in four areas: fuel management; flight analytics; navigation services; and fleet synchronization.

[2]See "Industrial Internet: Pushing the Boundaries of Minds and Machines" and "The Future of Work"

Health Care

Health care touches everyone, and the value of improving the quality and speed of health care outcomes is readily apparent. But health care also has enormous economic significance: better health care translates into higher economic growth , and cost effectiveness in health care services is an increasingly pressing priority in both advanced and emerging economies.

GE has developed a range of Industrial Internet solutions for health care. Centricity 360™ is a secure and reliable cloud-based platform that helps teams of physicians and caregivers work together in a clinical community—where they can quickly confer on patient cases, simultaneously access images and reports, and collaborate on diagnoses and treatment plans. It helps reduce duplicate tests and patient transfers, while yielding improvements in imaging costs and system maintenance.

Hospital Operations Management (HOM) integrates bed assignment, departmental workflow, patient flow, and equipment management to reduce wait times, optimize utilization of equipment and beds, and enable more efficient quality care to be delivered throughout a patient's stay, from admissions to discharge. It reduces bed turnaround time and patient wait times.

DoseWatch gives hospitals a Web-based radiation dose monitoring system that tracks a patient's exposure to radiation from any imaging device. This means clinicians can reduce the cumulative radiation dose produced by a series of imaging procedures, while still delivering the high image quality needed to diagnose and treat cancerous diseases.

Energy

Maximizing efficiency in power generation and distribution is essential not just to enable economic growth, but to do so in a way that improves environmental sustainability, especially as global growth raises standards of living—and desired energy consumption levels—across emerging markets. There are a number of Industrial Internet applications that are helping raise efficiency in this sector.

Wind PowerUp is a perfect example of the combined joint power of software and hardware. The software analytics allow wind farm operators to optimize the performance of the turbines, based on environmental conditions. Raising the turbines' efficiency can increase the wind farm's annual energy output by up to 5%, which translates in a 20% increase in profitability. Wind PowerUp is already in operation on nearly 500 wind turbines, delivering an additional 86GWhr in annual power generation.

GE has developed a similar blend of software and hardware solutions for gas-power generation: the FlexEfficiency Advantage Advanced Gas Path solution (AGP). AGP combines sophisticated software with an upgraded hardware design enabled by the use of new materials. Based on 100 million hours of real-world operating data already, the flexibility of this system allows power generation plants to prioritize increased output, more efficient load responsiveness, reduced emissions, more robust start ups

[3]See for example David E. Bloom, David Canning and Jaypee Sevilla (2001), "The effect of health on economic growth: Theory and evidence", NBER Working Paper n. 8587.

or lower turndown capability. Thanks to this flexibility, plant operators can quickly react to changing market conditions by maximizing output or reducing operating costs, and to possible changes in emissions and power grid regulations. On one combined-cycle power generation plant with a net output of 525.2 MW, these solutions can reduce annual carbon dioxide emissions in an amount equivalent to that of 2,200 cars.

Lighting

You don't need to be as large as a jet engine or a gas turbine to be brilliant. GE has developed a smart LED light bulb as well. It is an interconnected light bulb, which allows you to connect your home's lighting system from any location, and can sync with other connected devices thanks to the "Wink" application. This solution helps reduce energy consumption, resulting in cost savings at the individual home level, and corresponding sustainability benefits at the macro level. The system is flexible and easy to install and use—requiring only the Wink app, the light bulbs and a base station, without any additional infrastructure.

The benefits of interconnected lighting, however, will be even more powerful at the commercial level, and herald a profound transformation in cities as ecosystems. Once interconnected, lighting becomes a city's nervous system. It is intrinsically linked and crucial to the functioning of every element of a city, from a major infrastructure like highways, subways and power grids to parking lots, streets and public buildings. Once interconnected, it becomes a platform that can make cities truly smarter, and enormously more efficient.

We have already developed monitoring and control management systems which allow for real-time visibility of efficiency levels of individual fixtures as well as fault alerts. This enables cities to optimize the management of their lighting systems, maximizing energy efficiency, optimizing asset management, and yielding maintenance costs savings. San Diego, California, the first city to adopt GE's Lightgrid Outdoor Wireless Control System, estimates it will save more than 250,000 dollars each year with this GE technology. As cities adopt these systems at scale, the energy savings will be substantial, and interconnected lighting could translate into a precious boost to local authorities' budget and a strong improvement in their eco-sustainability.

Even more importantly, interconnected lighting can become the platform linking together different aspects of the life and functioning of a city - exactly like the nervous system in a human body. Interconnected lighting could link together a city's transportation system, helping optimize traffic flow; it could collect data on air quality and meteorological conditions, noise levels and foot traffic; and link to portable interconnected devices to collect and distribute information. The benefits could extend from adapting lighting intensity to traffic conditions on streets and in shopping areas to helping schedule preventive maintenance on city infrastructures in a way that minimizes disruptions - improving the quality of city life at lower cost.

Commercial and industrial systems also stand to benefit greatly from interconnected lighting. Commercial establishments will leverage the interconnected lighting infrastructure to improve customer experience while reducing costs; and in

industry, interconnected lighting will be an integrant part of the digital thread that improves communication, workflow and efficiency on factory floors as well as through supply and distribution networks. Again, the benefits in terms of lower costs and greater sustainability will be substantial.

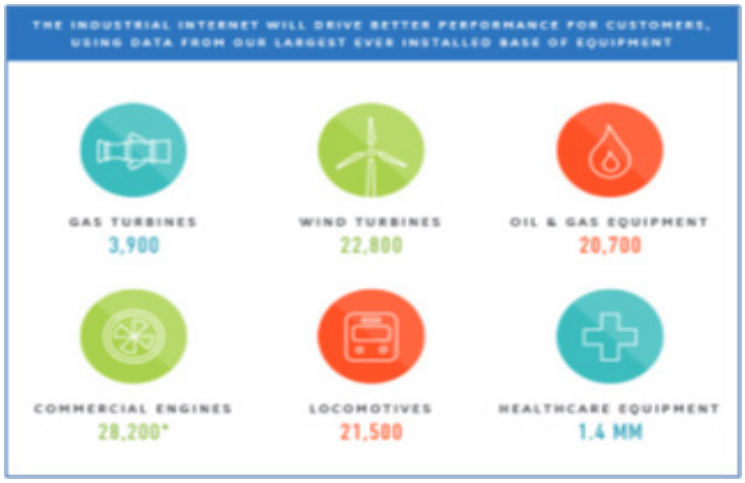
The Industrial Internet is making lighting truly brilliant.

A closer relationship

The examples above represent not just the new value that a digital-industrial company can provide, but also how this transforms the relationship between a solutions-provider and its customers. These solutions are developed through a much closer relationship with customers, which lead to a much deeper understanding of their needs, priorities and constraints. Developing these solutions, in fact, requires internalizing the customers' own objectives and value propositions. This requires a more intimate understanding of the customers' relationship with their customers, which, in turn, could be transformed as the reach of the Industrial Internet extends directly to the consumer—think of the relationship between utilities and households, and the additional role that Wink plays in it.

Installed base: the importance of industrial scale

Just as a powerful platform is essential to unleash the power of Industrial Internet solutions, so the software platform itself needs to be deployed across a large hardware base to quickly deliver benefits and rapidly trigger network effects. Given GE's position as a leading industrial hardware manufacturer, the solutions described above can be scaled across a global industrial system, reaching a massive installed base of industrial assets: more than 28,000 commercial jet engines; 21,500 locomotives; nearly 23,000 wind turbines; 3,900 gas turbines and 20,700 units of oil and gas equipment; and 1.4 million pieces of health care equipment.



This is only a portion of the universe of industrial assets that will be impacted by the Industrial Internet revolution. These numbers summarize GE's footprint in the key industrial sectors where the company operates, but the Industrial Internet will affect all key assets and equipment across all industrial sectors. These numbers, however, already give a powerful sense of the scale of this transformation.

They also underscore the point raised at the beginning of this paper: that a company producing interconnected devices—in this case interconnected industrial assets—

becomes a fundamentally different company. In particular, **the simultaneous development of interconnected hardware and an enabling software platform under the same roof redefines the very nature of a company, transforming it from a traditional industrial equipment producer to a full-range customer solutions provider, able to maximize customer outcomes and profitability.**

Valuing interconnectedness: Financial impact

The Industrial Internet solutions described above have started to deliver greater efficiency and productivity, higher "uptime" of assets, and reduced energy and water consumption to companies operating in aviation, energy, transportation, mining and other sectors, as well as to cities and hospitals. **What are the implications for the new breed of industrial companies that can deliver these solutions?**

While we are still in the early phases of the Industrial Internet, Predictivity solutions are already beginning to show a meaningful impact on GE's top line: For 2014, GE is on track to record more than $1 billion in revenues from Predictivity solutions. **While the process is just at the very beginning, there are several reasons to believe that this area will be characterized by especially fast revenue growth.**

- **First, the merging of the digital and the physical brings the benefits of Moore's Law to the industrial world.** Physical machines are subject to physical laws, and will therefore not enjoy the full exponential improvement in cost-adjusted performance typical of software. But as the digital becomes closely interlinked with the physical, it will accelerate the pace of performance improvement in a way that has hitherto not been possible.

- **Second, as the Industrial Internet platform takes hold, it will trigger network effects** that will allow more companies and individuals to participate in the Industrial Internet innovation process and will accelerate both the pace of such innovation and the speed at which additional benefits can accrue.

- **Third, the economic incentive to adopt efficiency-enhancing Industrial Internet solutions is extremely strong across all industrial sectors.** This is due in some cases to external pressures, such as the need to contain costs growth in the healthcare industry or improve margins in the mining industry given weaker commodity price dynamics. But it is also driven by competitive pressures, as the efficiency gains that Industrial Internet solutions can deliver could quickly change the competitive landscape. For companies in sectors impacted by the Industrial Internet, the cost of doing nothing is simply too high.

It is worth noting that software and other mature tech companies are able to achieve operating margins well in excess of 30% given the near zero marginal cost of incremental sales of digital products and solutions. This compares high-teens operating margins for best-in-class traditional industrial equipment manufacturers.

[4]Data based on publicly listed companies on the major world stock markets.

Market valuations currently indicate strong investor confidence in the ability that software-driven companies have to create value, especially when compared with traditional industrial companies. Price to sales multiples are in a relatively tight 1-1.5x range for traditional companies such as industrial conglomerates (1.1x), industrial machinery (1.3x), oil and gas equipment and services (1.5x), electrical components and equipment (1.3x) and aerospace and defense (1.1x). Only health care equipment fares better, with 3.0x.

By contrast, multiples for software-driven industries average around 5x, with internet software and services (5.7x) and healthcare technology (5.0x) at the top, followed by application software (4.5x), systems software (4.3x), data processing and outsourced services (3.2x), life sciences (3.1x); biotechnology is the outperformer with 10.5x. The Operating Margin for the second group is more than double that of traditional industries (24% vs 11%); and these new industries combined have a nearly identical market cap to that of traditional industries, even though their sales are only one quarter of the traditional group.

The higher multiple is a testimony to market expectations of faster growth, higher margins and greater capital efficiency in the new, digital-driven industries. **Companies that position themselves at the intersection of digital and physical within industry should see their valuations move closer to those of software-driven companies,** as the additional value and greater growth potential of Industrial Internet solutions becomes apparent. As argued above, the intrinsic limitations of physical machinery could cap the pace of improvement in the industrial world compared to the full power of Moore's law; on the other hand, the huge installed base of industrial assets provides an enormous base of economic value that can be leveraged and boosted by the merger of the digital and the physical.

An example of this trend can be seen in Tesla, a car maker that trades at a price-to-sales multiple of 13.0x, well above that of even established digital players such as Google (6.2x) and Apple (3.4x). Markets are clearly looking at Tesla as a fundamentally different kind of car maker: a company that produces interconnected cars. And this is in an industry where digital services are (at this stage) limited to the new cars it produces; they cannot be applied to a new car company's existing installed base of assets, as is the case for other industrial sectors. Yet the example of Tesla suggests that it is possible in principle that "new generation industrial companies" that leverage the merger of digital and physical could attract even stronger market interest and valuation than segments of the digital industry.

Conclusion

The marriage of the digital and physical world brought by the Industrial Internet and augmented by advanced manufacturing and the global brain is bringing a profound transformation to industry. At the same time, it is redefining the nature of industrial companies. Those that position themselves at the intersection of digital and physical become fundamentally different from traditional industrial companies—just like interconnected devices are fundamentally different from their non-connected versions.

Industrial Internet solutions are beginning to deliver substantial benefits to companies operating in aviation, energy, transportation and other industrial sectors, as well as

[5]Multiples as of 02 October 2014.

to cities and hospitals. While we are still at the beginning of this process, Industrial Internet solutions are already having a meaningful impact in terms of revenue generation for a company like GE. Revenue and margin growth in these services should be considerably higher than in traditional industrial solutions, thanks to the accelerating power of digital technologies, network effects, and powerful economic incentives for adoption. For companies, the cost of doing nothing is simply too high.

As these benefits unfold, "new generation industrial companies" will also be seen by markets as fundamentally different, with a revenue growth and margin potential closer to that of software-driven companies than traditional industrial companies. This should translate in the strengthening of key market valuation metrics.

Compared to software-driven companies, these "hybrid" industrial companies have one disadvantage: the physical limitations of hardware will cap the exponential improvement potential of the embodied digital technologies. However, they have the comparative advantage of a large installed base of industrial assets, which enables the new Industrial Internet solutions to be readily leveraged across a huge range of economic activities to maximize their overall value-creating potential.

Platforms will play a crucial role in accelerating the growth of the Industrial Internet, and in allowing companies to monetize the resulting benefits. Developing a platform establishes a keystone position within the Industrial Internet ecosystem: the company that owns the platform can leverage a broader and deeper pool of distributed expertise, and capture a share of the value that third parties create on the platform. Capitalizing on this role as an ecosystem hub requires the ability to move fast, keeping ahead of the curve, and rapidly adapting to the faster market changes spurred by the digital-industrial innovation.

As communication and collaboration accelerates, the industry will need supportive common standards and communication protocols, as well as continuous strengthening of cyber security safeguards. To this end, GE is a founding member of the Industrial Internet Consortium, a partnership of industry, government and academia aimed at sharing best practices and shaping global development standards to accelerate the growth of the Industrial Internet in the most efficient and open way possible.

The new wave of innovation spurred by the Industrial Internet is bringing about an unprecedented transformation. As software-driven performance improvement reverberates through the world's massive installed base of industrial machinery and gets embodied in new investment, it will reshape industry, reshuffling the competitive landscape. Mastering both the digital and the physical is the key to accelerating value creation in this new industrial world.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According to new research from GE and Accenture, executives across the Industrial and Healthcare sectors see the enormous opportunities of the Industrial Internet and in many cases are deploying the first generation of solutions. The vast majority believe that Big Data analytics has the power to dramatically alter the competitive landscape of industries within just the next year and are investing accordingly. Yet challenges around security, data silos and systems integration issues between organizations threaten to delay Industrial Internet solutions that could offer distinctive operational, strategic and competitive advantages. Spurred on by board-level direction, surveyed executives feel a sense of urgency in moving more briskly toward the Industrial Internet future.

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Introduction

How big is the economic power of the Industrial Internet? Consider one analysis that places a conservative estimate of worldwide spending at $500 billion by 2020, and which then points to more optimistic forecasts ranging as high as $15 trillion of global GDP by 2030.[1]

The Industrial Internet—the combination of Big Data analytics with the Internet of Things (see sidebar)—is producing huge opportunities for companies in all industries, but especially in areas such as Aviation, Oil and Gas, Transportation, Power Generation and Distribution, Manufacturing, Healthcare and Mining. Why? Because, as one recent analysis has it, "Not all Big Data is created equal." According to the authors, "data created by industrial equipment such as wind turbines, jet engines and MRI machines … holds more potential business value on a size-adjusted basis than other types of Big Data associated with the social Web, consumer Internet and other sources."[2]

1. David Floyer, "Defining and Sizing the Industrial Internet," Wikibon, June 27, 2013; Peter C. Evans and Marco Annunziata, "General Electric: Industrial Internet, Pushing the Boundaries of Minds and Machines," November 2012.

2. http://wikibon.org/wiki/v/The_Industrial_Internet_and_Big_Data_Analytics:_Opportunities_and_Challenges.

Tapping the potential value

Executives of industrial companies are well aware of the potential power and source of value of the Industrial Internet, according to new research from GE and Accenture. (See "About the research.") For example, according to our survey, 73 percent of companies are already investing more than 20 percent of their overall technology budget on Big Data analytics—and more than two in 10 are investing more than 30 percent. Moreover, three-fourths of executives expect that spending level to increase just in the next year. (See Figure 1.)

Across the industries surveyed, 80 to 90 percent of companies indicated that Big Data analytics is either the top priority for the company or in the top three. This finding is especially strong in the Aviation industry, where 61 percent of those surveyed noted that analytics is their top-ranked priority; this number drops to about 30 percent or less for industries such as Power Distribution (28 percent), Power Generation (31 percent), Oil and Gas (31 percent) and Mining (24 percent). (See Figure 2.)

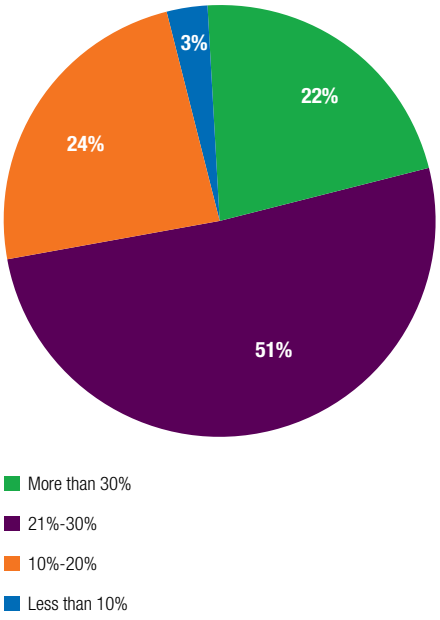
This prioritization of spending becomes clearer when we look at who is supporting Big Data initiatives. Simply put, it's no longer the usual suspects such as the CIO or COO. Indeed, 53 percent of all survey respondents indicated that their Board of Directors is the primary influencer of their Big Data adoption strategy—more than those citing the CEO (47 percent), the CIO (37 percent) or a business line P&L executive (15 percent). (See Figure 3.)

This board-level influence particularly stood out in several industries such as Mining, where the Board is the top influencer for 73 percent of those surveyed. Strong board-level support can also be seen in industries such as Manufacturing (67 percent noted the Board as the primary influencer), Aviation (61 percent) and Rail (60 percent).

Across the industries surveyed, 80 to 90 percent of companies indicated that Big Data analytics is either the top priority for the company or in the top three.

Figure 1: Investments in Big Data analytics are strong

1. What portion of your overall technology expenditure is made in Big Data analytics?



2. Do you expect this to increase, stay the same or decrease over the next year?

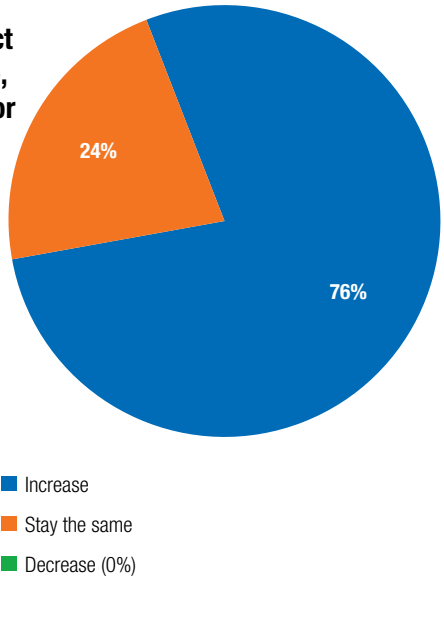


Figure 2: Big Data analytics is one of the top corporate priorities

How important is Big Data analytics relative to other priorities in your company?

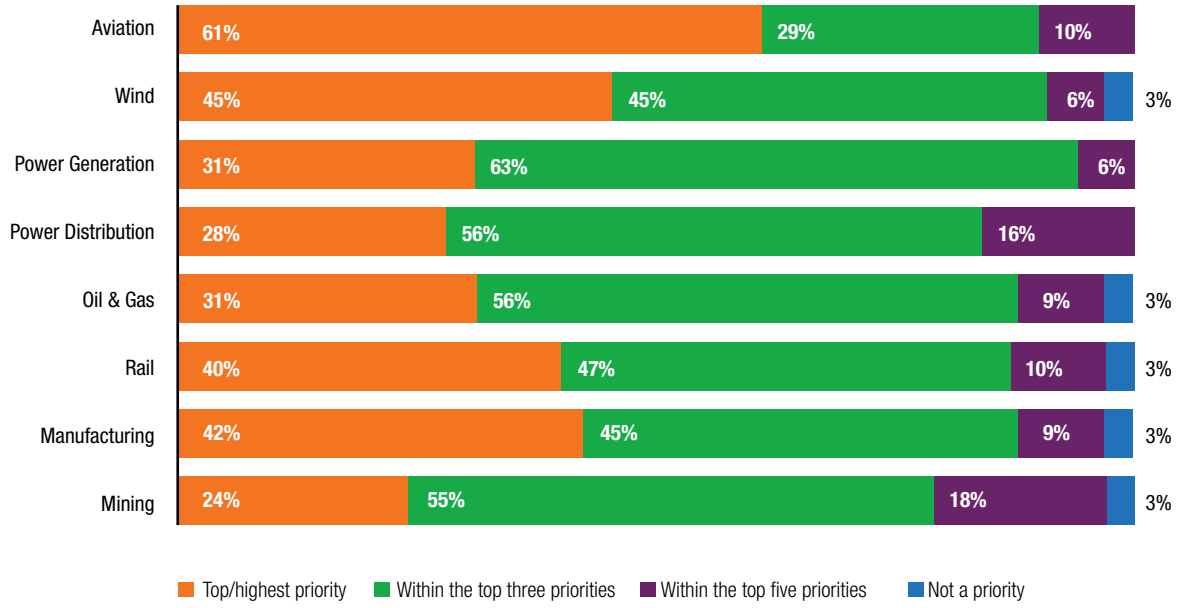
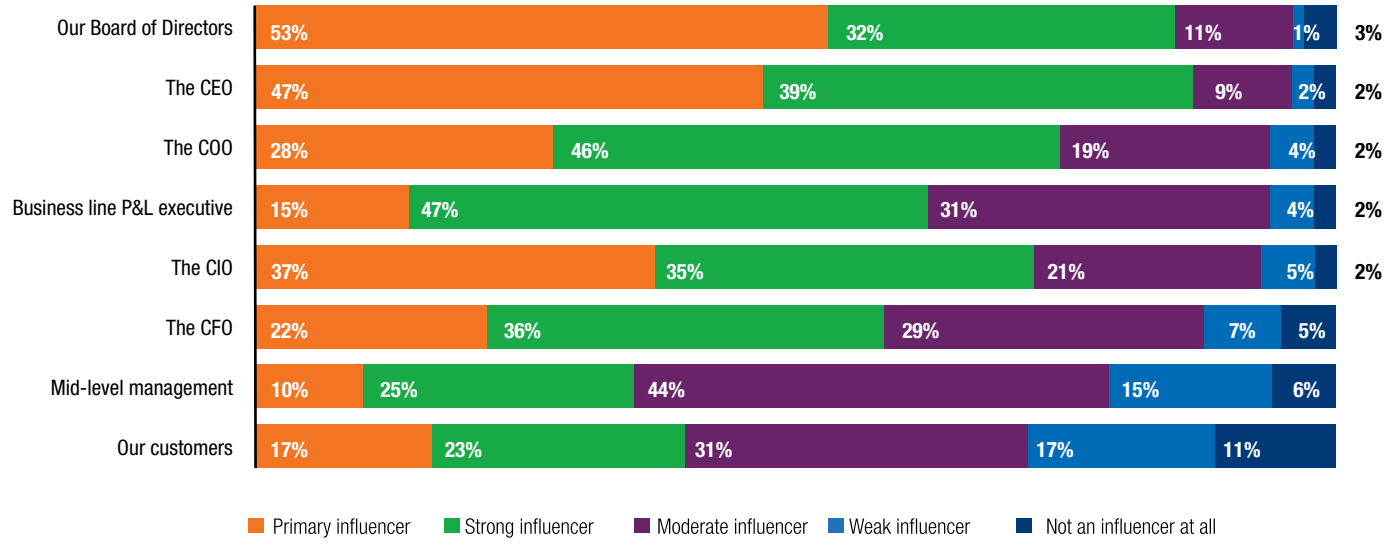


Figure 3: Support for Big Data analytics initiatives is coming from the top of the organization

Please rate the level of influence of each of the following in setting the strategy for Big Data analytics adoption in your company.



The formula for the Industrial Internet

The Industrial Internet can be described as a source of both operational efficiency and innovation that is the outcome of a compelling recipe of technology developments:

- Take the exponential growth in data volumes—that is, "Big Data"— available to companies in almost every industrial sector, primarily the ability to add sensors and data collection mechanisms to industrial equipment.
- Add to that the Internet of Things, which provides even more data—in this case about equipment, products, factories, supply chains, hospital equipment and much more. (Cisco predicts that by 2020 there will be 50 billion "things" connected to the Internet, up from 25 billion in 2015.[3]) With new technologies such as data lakes, the ability to capture and process such data is now a reality.
- Then add the growing technology capabilities in the area of analytics—the ability to mine and analyze data for insights into the status of equipment as part of Asset Performance Management (APM), or the delivery of healthcare, and then even to predict breakdowns or other kinds of occurrences.
- Finally, add in the context of industries where equipment itself or patient outcomes are at the heart of the business—where the ability to monitor equipment or monitor patient services can have significant economic impact and in some cases literally save lives.

The resulting sum of those parts gives you the Industrial Internet—the tight integration of the physical and digital worlds. The Industrial Internet enables companies to use sensors, software, machine-to-machine learning and other technologies to gather and analyze data from physical objects or other large data streams—and then use those analyses to manage operations and in some cases to offer new, value-added services.

3. "The Internet of Things," Cisco, http://share.cisco.com/internet-of-things.html.

A sense of urgency

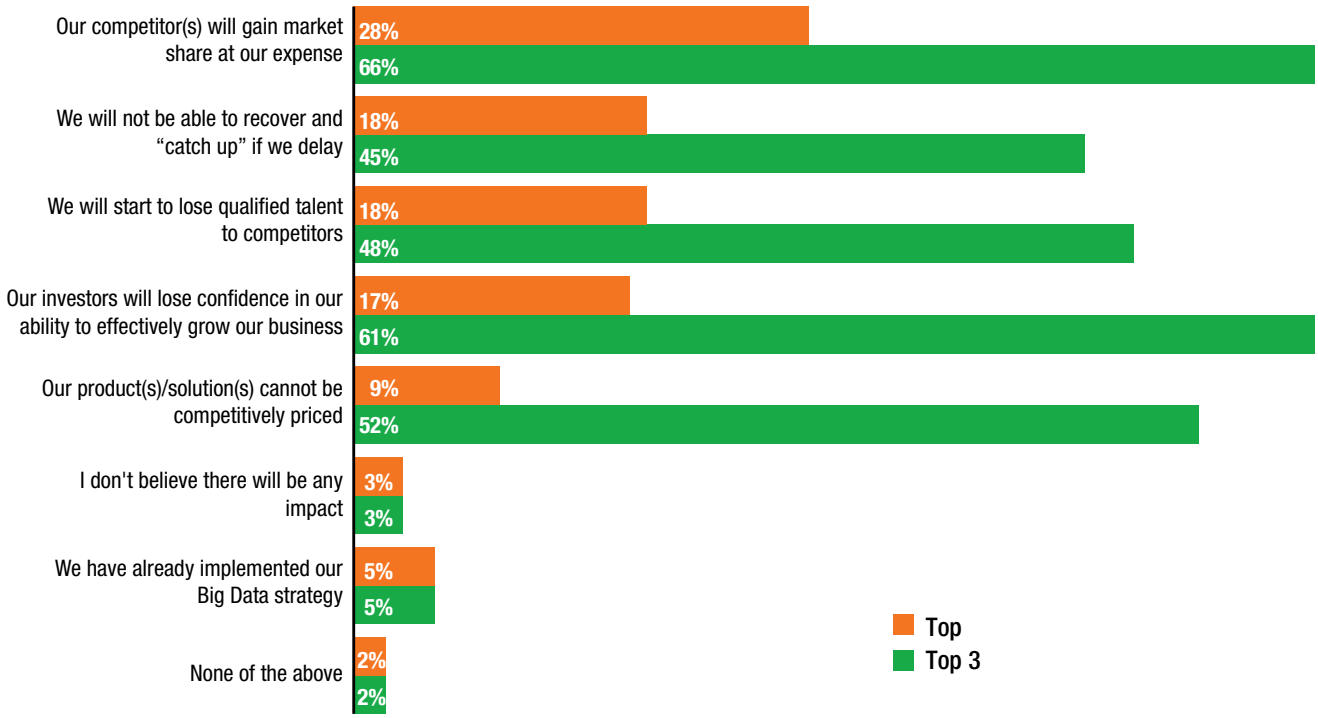
A striking finding from our survey was the sense of urgency felt by respondents in implementing Industrial Internet solutions. This is driven in part by the impact being felt at an industry level as well as the competitor level. For example, 84 percent of those surveyed indicated that the use of Big Data analytics "has the power to shift the competitive landscape for my industry" within just the next year. A full 87 percent believed it will have that power within three years. Eighty-nine percent say that companies that do not adopt a Big Data analytics strategy in the next year risk losing market share and momentum.

Executives are looking over their shoulders at competitors as well. Seventy-four percent said that their main competitors are leveraging Big Data analytics proficiencies to differentiate their capabilities with clients, investors and the media. New entrants are also coming into their industries, according to 93 percent of respondents, and these newer entrants are leveraging Big Data analytics as a key differentiation strategy.

There is risk in not taking action now, according to surveyed executives. Asked to name their top three fears if they are unable to implement a Big Data strategy in the next few years, the number one answer was, "Our competitors will gain market share at our expense." The second top answer was the concern that investors will lose confidence in their company's ability to grow. (See Figure 4.)

Figure 4: Companies are aware of the risks of not implementing a Big Data strategy soon

If we are unable to implement our Big Data strategy in the next one to three years, my top three fears are:



About the research

Recognizing that Big Data analytics is the foundation of the Industrial Internet, GE and Accenture fielded a survey in China, France, Germany, India, South Africa, the UK and the United States that explored the state of Big Data analytics and how it is being viewed across eight industries. Sectors surveyed were Aviation, Wind, Power Generation, Power Distribution, Oil and Gas, Rail, Manufacturing, and Mining. A similar survey was conducted for the US Healthcare industry and results are integrated into this report. Companies represented had revenues in excess of $150 million, with more than half of them having revenues of $1 billion or more. More than half of the respondents were CEOs, CFOs, COOs, CIOs and CTOs, and the sample also included vice presidents and directors from information technology, finance, operations and other cross-functional management areas.

This study adds to the growing portfolio of thinking and reports on this topic–one of those being the recent Accenture report, Driving Unconventional Growth through the Industrial Internet of Things (IIoT), which explored the opportunity the IIoT represents and implications for the workforce. The report also outlines seven steps companies can take to overcome challenges they may encounter as they prepare to use and analyze the vast amount of data they have at their disposal to generate new revenue-producing products and services. The report is available at http://www.accenture.com/us-en/technology/technology-labs/Pages/insight-industrial-internet-of-things.aspx.

Moving to growth and value creation

Industrial companies are at varying stages of adoption of Big Data analytics and, as with all new technologies, a maturity curve is emerging that delineates the early adopters from those who are at a more foundational level. One of the first stages in that maturity curve is connecting operating assets and performing monitoring and problem diagnosis. Industrial companies are focused on moving from this type of asset monitoring to areas of higher operational benefits. By introducing analytics and more flexible production techniques, manufacturers, for instance, could boost their productivity by as much as 30 percent.[4]

Industrial companies are addressing their needs for better efficiency and profitability in two major categories: asset and operations optimization. In the area of assets, it's clear that Industrial companies are progressing in creating financial value by gathering and analyzing vast volumes of machine sensor data. Additionally, some companies are progressing to leverage insights from machine asset data to create efficiencies in operations and drive market advantages with greater confidence.

Predictive maintenance of assets is one such area of focus, saving up to 12 percent over scheduled repairs, reducing overall maintenance costs up to 30 percent, and eliminating breakdowns up to 70 percent.[5] For example, Thames Water Utilities Limited, the largest provider of water and wastewater services in the UK, is using sensors, analytics and real-time data to help the utility respond more quickly to critical situations such as leaks or adverse weather events.[6]

Another example comes from the Oil and Gas industry, where one of America's premier regulated energy providers, Columbia Pipeline Group, has placed a particular focus on pipeline operations and safety. Using existing asset data integrated with digital visualizations, analytics and shared situational intelligence, pipeline operators can respond to potential events even faster. This helps prioritize maintenance tasks, resource allocation and capital spend more effectively based on risk assessment.

The movement toward more sophisticated use of analytics is also exemplified by fuel consumption solutions in the airline industry. Fuel is typically the largest operating expense for an airline; over the past 10 years, fuel costs have risen an average of 19 percent per year. The ability to reduce flight time by using full flight data, "tip to tail," as well as using performance analytics to combine an aircraft's flight data, weather, navigation, risk data and fuel operation, can result in direct bottom-line savings.

Smart buildings are another prevalent type of Industrial Internet solution. The city of Seattle, for example, is applying analytics to building management data to optimize equipment and related processes for energy reduction and comfort requirements. The software identifies equipment and system inefficiencies, and alerts building managers to areas of wasted energy. Elements in each room of a building—such as lighting, temperature and the position of window shades—can then be adjusted, depending on data readings, to maximize efficiency.[7]

Although improving existing operations through Big Data analytics is highly valuable, it is, relatively speaking, low-hanging fruit. Moving up the maturity curve are solutions that go beyond being proactive to being predictive. For example, a petrochemical producer can rely on predictive maintenance to avoid unnecessary shutdowns and keep products flowing. Apache Corporation, an oil and gas exploration and production company, is using this approach to predict onshore and offshore oil pump failures to help minimize lost production. Executives

Determine how your company compares with others in your industry along the Industrial Internet maturity curve by engaging with the Industrial Internet Evaluator* (gesoftware.com/IIEvaluator). See how others in your field are leveraging Big Data analytics for connecting assets, monitoring, analyzing, predicting and optimizing for business success.

* Note: Use of the Industrial Internet Evaluator is subject to the terms at the website referenced here.

4. "Industry 4.0: Huge potential for value creation waiting to be tapped," Deutsche Bank Research, May 23, 2014.

5. G. P. Sullivan, R. Pugh, A. P. Melendez and W. D. Hunt, "Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency, Release 3.0," Pacific Northwest National Laboratory, US Department of Energy, August 2010.

6. Press release, "Accenture to Help Thames Water Prove the Benefits of Smart Monitoring Capabilities," March 6, 2014.

7. "Accenture Analytics and Smart Building Solutions are helping Seattle boost energy efficiency downtown," Accenture, http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture-Analytics-and-Smart-Building-Solutions.pdf.

"We'd like to take a more holistic approach to asset maintenance—to look at an asset from the point at which it went into service across the entire lifecycle, leveraging analytics to improve operations."

Matt Fahnestock, Vice President IT Service Delivery, NiSource Inc., Columbia Pipeline Group

"If you generate a small savings on each flight, it translates to big savings at the end of the year. Even a 1 percent savings can translate into millions of dollars."

Jonathan Sanjay, Regional Fuel Efficiency Manager, Air Asia Berhad

"Using Big Data analytics can be powerful. It moves us beyond being reactive and allows industries to predict and prevent. There are challenges with disparate data sources and varying levels of quality. At Johnson Controls, we are building an infrastructure to standardize and manage information. Ultimately, we want to be able to leverage predictive analytics to prevent and solve problems, while continuously improving processes."

Craig Williams, Vice President, Quality, Johnson Controls Power Solutions

at Apache claim that if the global Oil and Gas industry improved pump performance by even 1 percent, it would increase oil production by half a million barrels a day and earn the industry an additional $19 billion a year.[8]

The Healthcare industry provides another example. Technology tools are enabling providers to collect health data in real time and then use advanced predictive analytics techniques to help uncover what will likely happen next. By proactively measuring, monitoring and managing this data, providers can improve care management and address risk factors and symptoms of chronic disease early and provide positive reinforcement in new and more effective ways.

One leading US health system's work in infection, or sepsis, management is an example of the power of predictive analytics to improve clinical delivery. Recognizing that sepsis is a leading driver of in-hospital mortality, the medical center defined early leading indicators of sepsis and used technology tools to monitor patients to drive earlier diagnosis and intervention. The new initiative saved hundreds of lives and has saved millions of dollars for the health system.[9]

In another case, a leading Florida-based hospital and medical center used real-time tracking and analytics to optimize patient flow, cutting emergency department (ED) wait times by 68 percent. Upon admission, an ED patient receives a tag. A dashboard then begins monitoring the patient's journey, combining patient Real-Time-Location System (RTLS), interfaces and bed placement timestamps to evaluate and display real-time patient throughput metrics. The hospital was able to achieve shorter lag time between discharge and patient pickup, with most ambulatory patients on their way in about 30 minutes. These achievements are all the more impressive given that the hospital's census continues to rise: the average patient age is 74 years, and 85 percent of admissions come through the ED.[10]

As companies master these higher-level capabilities they can also move into innovative, revenue-generating services. For example, a global energy company is leveraging analytics to analyze tens of thousands of data points in a wind farm every second. With this data, the company can use data science to direct a set of performance dials and levers (speed, torque, pitch, yaw, aerodynamics and turbine controls) to fine-tune a wind turbine's operation and help enhance its energy production. By having this level of control with a single turbine and leveraging this technology across a farm, energy providers can gain up to 5 percent improvement on power output. With an integrated approach to providing fuel-powered energy as well as renewable-produced energy, analytics can contribute directly to new revenue streams with positive bottom-line impact.

Intelligence-based services are likely to be the answer to "What's next?" in the realm of information technology and the Industrial Internet. One of the executives we surveyed as part of our research offered an insight behind the urgency to implement more innovative kinds of Industrial Internet solutions based on Big Data analytics: information technology needs to move from the era of automation-based savings alone to an era of intelligence and value creation.

But are companies up for the challenge?

Are companies ready for more predictive and innovative kinds of value-creating solutions? The answer here is mostly "Not yet," but they are actively positioning themselves for such solutions. Asked to describe their current capabilities in Big Data analytics, almost two-thirds of respondents (65 percent) are focusing on monitoring—the ability to monitor assets to identify operating issues for more proactive maintenance. Fifty-eight percent have capabilities such as connecting equipment to collect operating data and analyzing the data to produce insights. However, only 40 percent can predict based on existing data, and fewer still (36 percent) can optimize operations from that data. (See Figure 5.)

This finding is validated by other responses. When asked about their progress in managing business operations, only one-fourth said they had predictive capabilities and only 17 percent indicated the ability to optimize. In a separate query, when asked about capabilities on the analytics spectrum from connect to monitor to analyze to predict to optimize, answers were primarily on the lower end of that spectrum. Only 13 percent indicated the ability to optimize, and 16 percent said they did not fall on the spectrum at all. (See Figure 6.) However, connecting, monitoring and analyzing are necessary precursors to development of predictive models and optimization capabilities, so the advancement of industrial companies along the maturity curve positions them to take advantage of more sophisticated Big Data analytics.

8. Scott MacDonald and Whitney Rockley, "The Industrial Internet of Things," McRock Capital.

9. "Better Than a Crystal Ball: The Power of Prediction in Clinical Transformation," Accenture, http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture-Cystal-Ball-Power-Clinical-Transformation.pdf.

10. "Losing the Wait," GE Healthcare.

Figure 5: Current Big Data analytics capabilities are stronger in the areas of monitoring and connecting equipment than in predicting issues and optimizing operations

In my company, our current capabilities around Big Data analytics include the ability to (multiple responses):

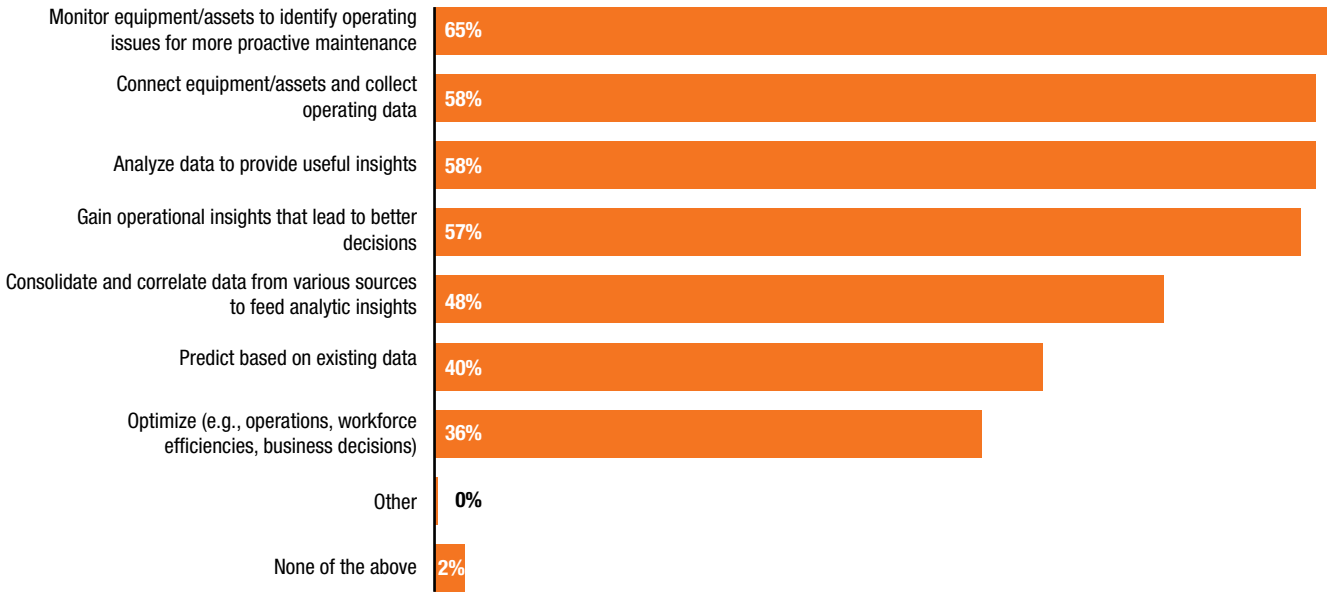
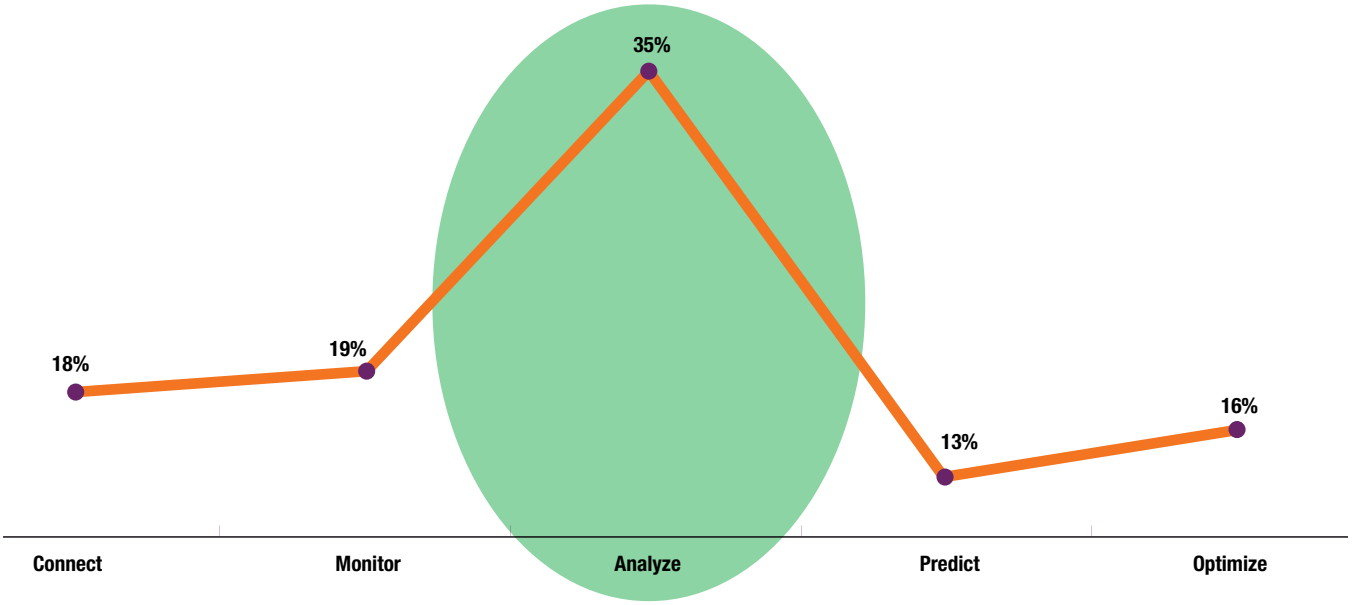


Figure 6: Companies' Big Data capabilities are strongest in the area of analysis

On average across the company, where do your company's Big Data analytics capabilities fall on the spectrum below?



Moving from today's implementation to tomorrow's strategies

What does the roadmap of surveyed companies look like in the next one to three years? Understandably, initial investments are focused in areas representing the connection and monitoring of assets for improving the ability to react and repair and move toward zero unplanned downtime.

However, when asked about future plans, respondents stated their priorities in more ambitious plans for analytics: increasing profitability (60 percent), gaining a competitive advantage (57 percent) and improving environmental safety and emissions (55 percent) represent more pervasive, cross-functional and sophisticated use of analytics.

Breaking this out by business line, individual strategies emerge for particular industries. As shown in Figure 7, survey respondents were asked what their top three priorities were for the next one to three years. The shaded areas indicate the highest-ranked priorities, by industry.

Figure 7: Top business priorities, by industry

☐ Highest-ranked priorities

Priorities: 1-3 years	Aviation	Wind	Power Generation	Power Distribution	Oil & Gas	Rail	Manufacturing	Mining
Increase profitability through improved resource management	61%	71%	56%	59%	56%	67%	58%	55%
Gain a competitive edge	58%	55%	53%	69%	50%	50%	76%	48%
Improve environmental safety and emissions	39%	61%	50%	75%	59%	43%	52%	58%
Gain insights into customer behaviors, preferences and trends	58%	61%	47%	56%	38%	60%	70%	39%
Gain insights into equipment health for improved maintenance	55%	48%	34%	56%	47%	73%	67%	39%
Drive operational improvements and workforce efficiencies	42%	48%	41%	72%	44%	53%	55%	64%
Create new business opportunities with new revenue streams	45%	61%	34%	53%	47%	40%	52%	58%
Meet or exceed regulatory compliance	32%	39%	41%	63%	50%	33%	39%	39%

“In the ’60s through the ’90s, railroads focused on manpower reduction by automating processes. But we have greatly exhausted that. Now the focus is on better, more informed and intelligent decisions. This is coming from several directions, but top down more so than bottom up.”

Fred Ehlers, Vice President - Information Technology, Norfolk Southern Corporation

The impact of unplanned downtime on industrial companies is real and significant. See how unplanned downtime impacts industries from Aviation, to Oil and Gas, to others. Learn more. (gesoftware.com/the-power-of-ge-predictivity)

Big Data analytics in the healthcare industry: A diagnosis

Among the healthcare organizations we surveyed as part of our Industrial Internet research, an overwhelming majority acknowledged the critical role of analytics in driving improved clinical, financial and operational outcomes. These organizations feel that analytics will have the power to dramatically improve patient outcomes, even in the next year. However, challenges around system barriers between departments, budgetary constraints and organizational obstacles are impeding implementation of their analytics initiatives.

"In the past, decision-making was more straightforward—doctors simply made a decision based on knowledge of the domain, personal experience, and evaluation of the patient's physical signs and symptoms plus relevant diagnostic laboratory data. Now there is much more data available to the clinician that requires additional expertise and having the right people with the right skills to interpret the data—biostatistics, epidemiology, health informaticists, other health professional clinicians, and so forth. Caring for patients is now a team activity, and learning to work in teams is an important skill for physicians to acquire."

Christopher C. Colenda, MD, MPH
President and Chief Executive Officer,
West Virginia United Health System

Positive outcomes

More than half of the healthcare executives surveyed believe that analytics can drive a variety of positive outcomes for their organizations, including improved diagnostic speed and confidence (named by 54 percent of respondents); reduction in patient wait times and length of stay (56 percent); and better clinical outcomes and patient satisfaction scores (59 percent). Fifty-seven percent of respondents overall—and 66 percent of operations-focused respondents—named improved healthcare system profitability as an important business impact of analytics.

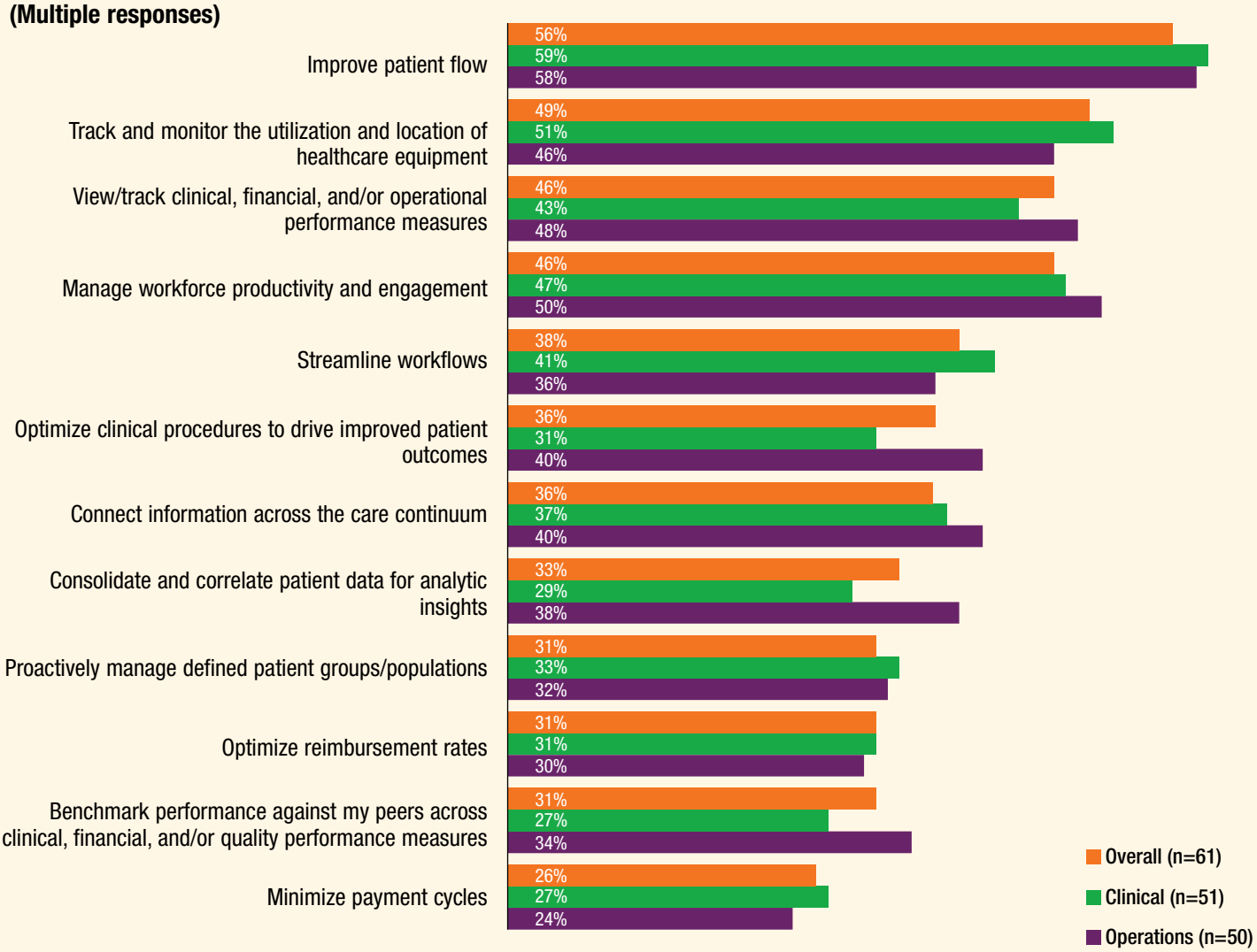
In the next one to three years, these healthcare organizations see Big Data analytics driving several kinds of positive results in particular. The top outcome named (by 44 percent of respondents) was the ability of analytics to integrate a view of clinical, financial and operational data—data that is currently spread across multiple disparate systems. The second outcome cited was the ability to provide unified patient records (38 percent). Perhaps not surprisingly, 34 percent of operations-focused respondents (compared with 25 percent of clinical-focused respondents) looked to the outcome of predictive analytics that provides actionable insights into opportunities for operational improvements.

Asked to name their best current capabilities around analytics, top answers focused on improving patient flow (56 percent); tracking and monitoring the utilization of healthcare equipment (49 percent); tracking clinical, financial and operational measures (46 percent); and managing workforce productivity and engagement (46 percent). (See Figure 8.)

Figure 8: Healthcare companies' strongest capabilities in Big Data analytics

In my organization, our current capabilities around analytics include the ability to:

(Multiple responses)



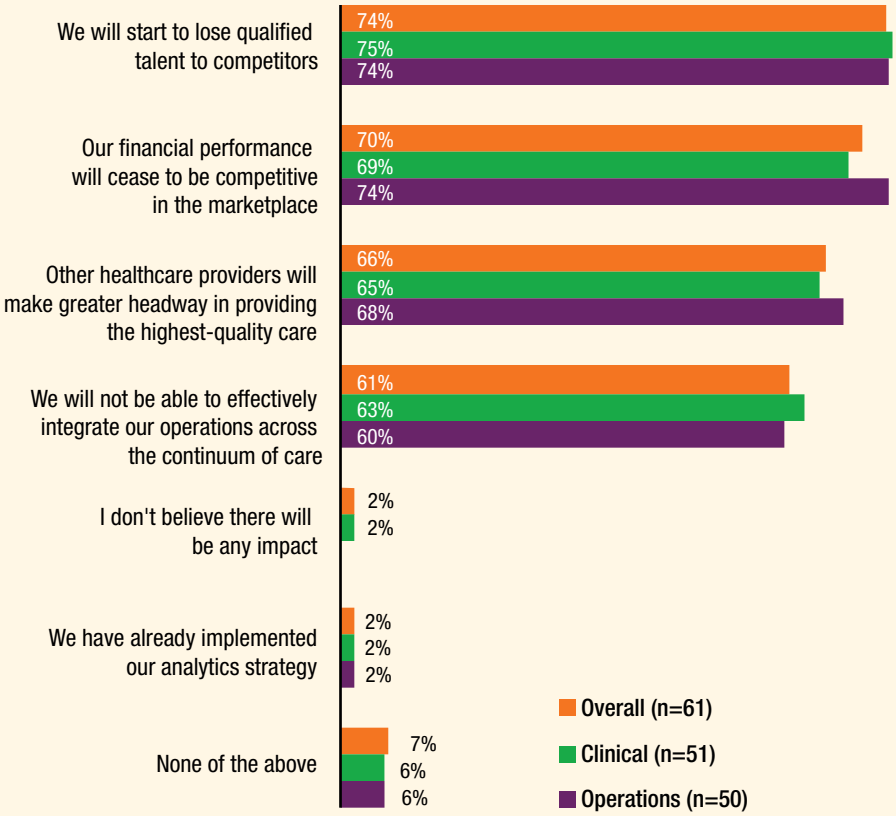
Shaking up the healthcare space

Big Data analytics is both a promise and a threat to healthcare organizations. Three-fourths of those surveyed believe that the use of analytics has the power to drive a productivity transformation in Healthcare in the next year, and 87 percent believe it will do so over the next three years.

Eighty-four percent of respondents agree that healthcare providers who adopt an analytics strategy in the next one to three years will outpace their peers in the marketplace. And 74 percent have seen competitors leveraging analytics as a key strategy over the past two to three years.

The threat of analytics-based competition is on the minds of healthcare executives, especially if they are unable to integrate analytics into clinical and operating processes in the coming years. Seventy-four percent of respondents named "losing qualified talent to competitors" as one of their three greatest fears; another 70 percent were concerned that their financial performance would cease to be competitive in the marketplace; two-thirds feared that other healthcare providers would make greater headway in providing the highest-quality care. (See Figure 9.)

Figure 9: Top concerns of companies if they are unable to effectively integrate analytics capabilities



Expectations are high and driven by the Board

Overwhelming percentages of healthcare respondents are already seeing positive outcomes from their analytics investments. Ninety percent or more of healthcare organizations lay claim to having successfully implemented analytics related to improving patient outcomes and to driving improvements in operational efficiency.

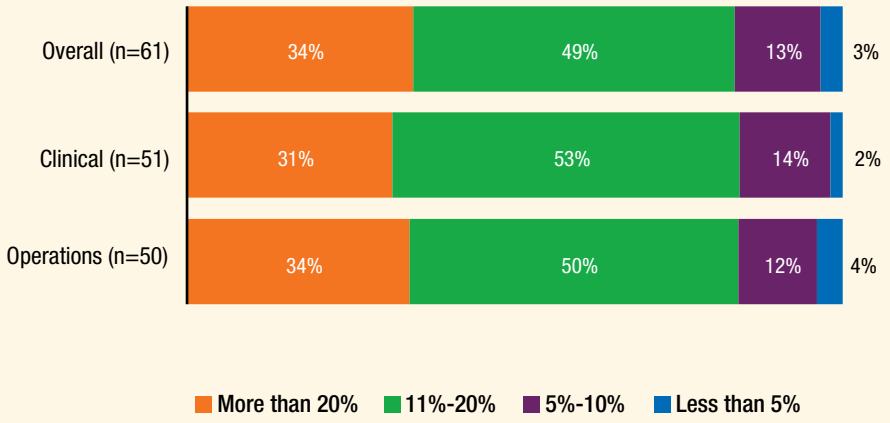
Relative to their competitors, about one-third of healthcare organizations (31 percent) claim that they are significantly ahead of the game in the area of analytics, with another 39 percent saying they are at least somewhat ahead of the competition. Only 2 percent of those surveyed claim to be lagging behind competitors in this area.

A look at investment levels reveals that healthcare companies are not investing to the same level as industrial companies, but percentage of budget is still significant. About half of all healthcare organizations surveyed (clinical, 53 percent; operations, 50 percent) are investing from 11 to 20 percent of their overall technology budget on Big Data analytics. About one-third are investing more than 20 percent; by contrast, 73 percent of industrial companies are investing at that level. (See Figure 10.) Asked to name their top three challenges in implementing analytics solutions, the number one response was "budget constraints are slowing our analytics initiatives."

Even if investment is not at the same levels as industrial companies, executive commitment is strong: Big Data analytics strategies are being driven from the very top of these organizations. Eighty-two percent of respondents said their Board of Directors is either a primary or strong influencer of the analytics adoption strategy at their company. Almost as many (77 percent) named the CEO as a driving force. By contrast, just 43 percent named the CIO as the strong or primary influencer and 52 percent named the COO.

Figure 10: Percentage of technology spend on analytics initiatives

What portion of your overall technology expenditure is made in analytics initiatives?



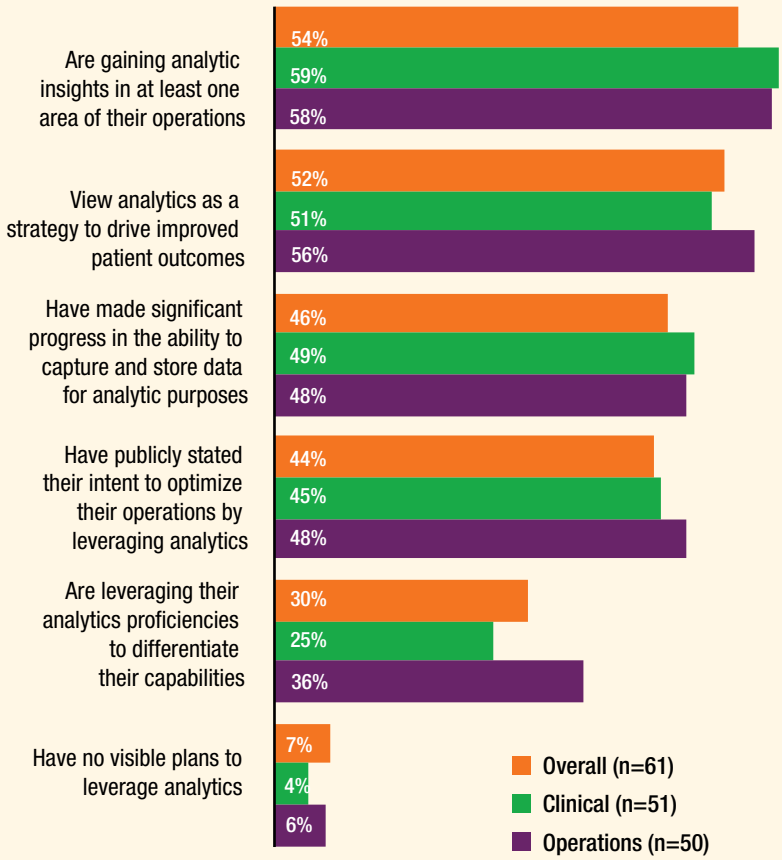
An urgency to deliver improved patient outcomes

Healthcare organizations, unlike their industrial counterparts, have a greater focus on how analytics can drive better patient care rather than as a means to achieve competitive advantage. For example, the perceived threat level posed by analytics-based competition appears to be lower than among the industrial companies surveyed. There, recall, 74 percent said that their main competitors are leveraging Big Data analytics proficiencies to differentiate their capabilities. Only 30 percent of healthcare executives had that fear.

Instead, the power of analytics to improve patient outcomes was a greater concern for respondents. Over half (54 percent) stated that their competitors were already gaining analytic insights in operations and 52 percent thought their competitors viewed analytics as a strategy to drive patient outcomes. (See Figure 11.)

Figure 11: Perceptions of competitors' analytics capabilities

My understanding of other healthcare providers with analytics capabilities is that they: (Multiple responses)



The top three capabilities targeted for development in the next three years indicate that healthcare organizations are planning on building out the infrastructure required for leveraging analytics. Forty-four percent said they are planning to build an integrated data source for patient information; 43 percent noted plans to create an analytics platform for managing large volumes of data; and 41 percent claimed to be developing analytics capabilities that drive improvements in clinical performance. (See Figure 12.)

Talent issues

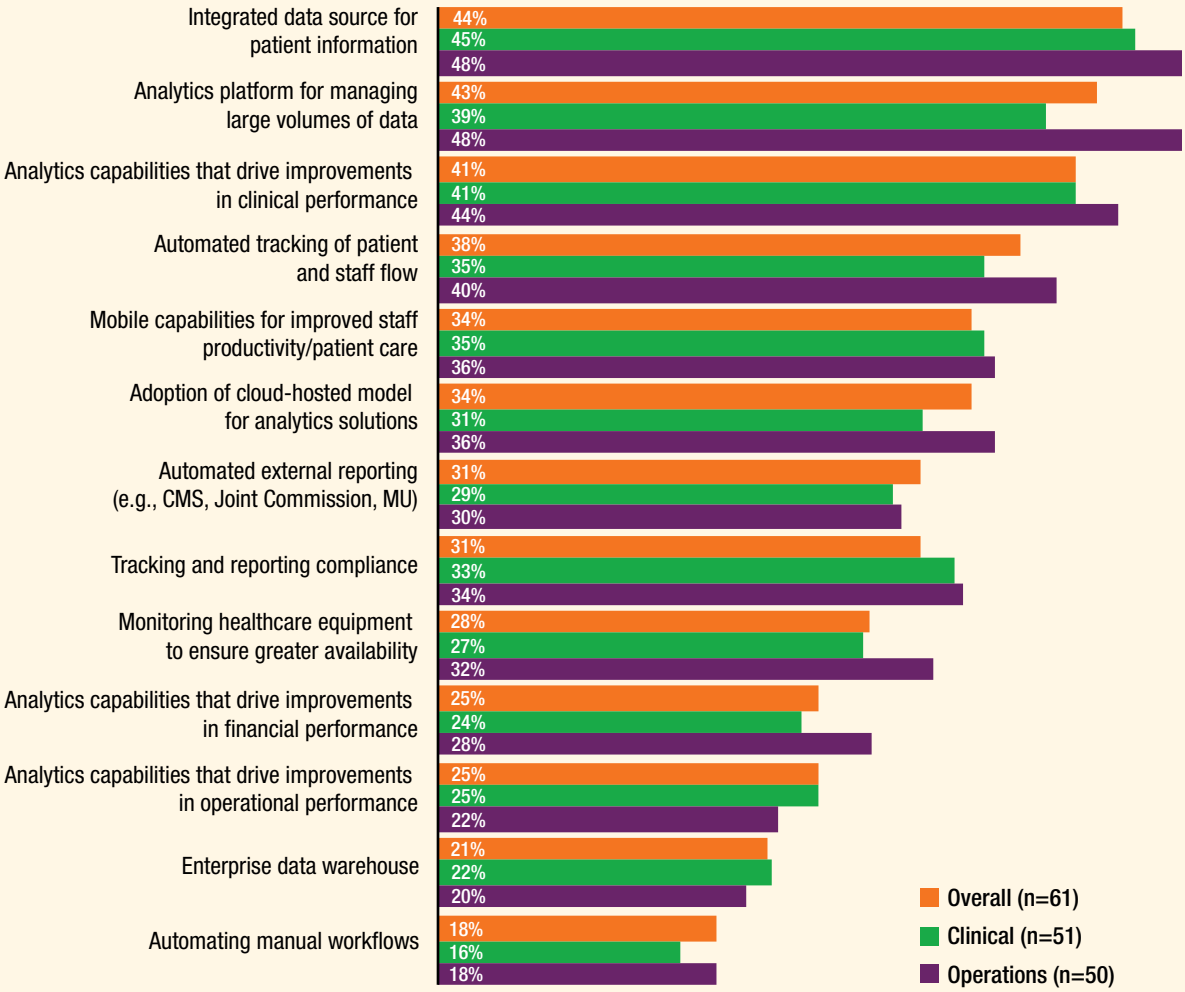
What kinds of talent and competencies will be needed in the analytics area in the coming years to help healthcare organizations succeed? Two-thirds of respondents named patient-care analytics as the most important competency; 51 percent cited software development/ engineering. Far fewer (38 percent) cited the need for data scientists.

The surveyed executives seemed relatively unconcerned about talent shortfalls. Asked to rank their top three challenges, only 23 percent named "Talent acquisition is impacting our ability to understand and realize the potential from our collected data."

Perhaps related to this last point is the fact that healthcare executives are more open than their industrial peers to using external analytics providers. Sixty-one percent intend to pursue relationships with providers who are experts in their industry and who can quickly translate their needs into analytics solutions.

Figure 12: Top analytics capabilities targeted for development

Which of the following are you planning to build or grow over the next three years? (Multiple responses)



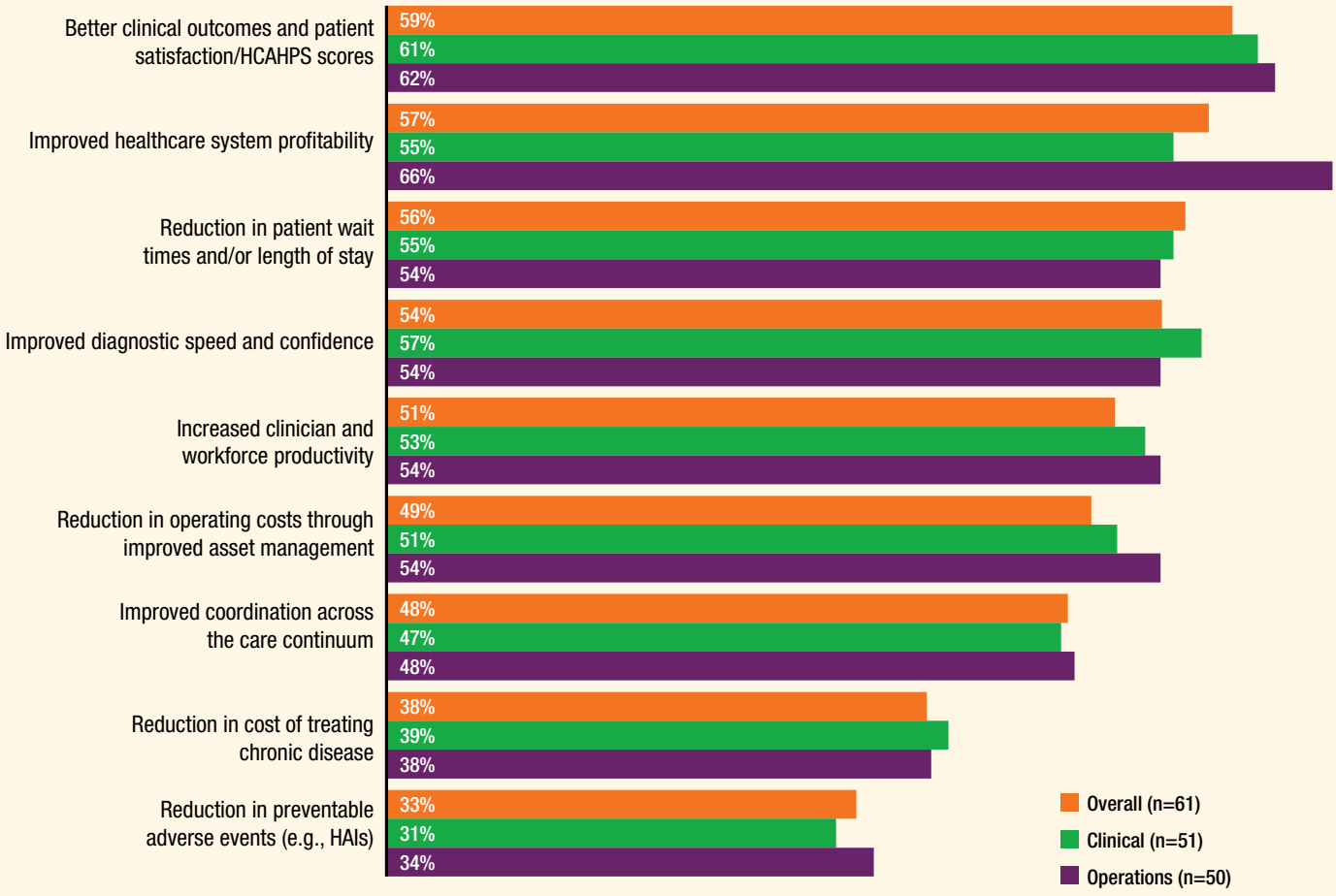
Driving better patient outcomes

Healthcare organizations clearly understand the potential of analytics to drive better patient outcomes and operational efficiencies. With board-level support, will they be able to translate that commitment to budgetary support to build the right infrastructure, overcome system barriers and attract the talent needed to realize their vision? With outcomes such as better clinical results, improved profitability and improved diagnostic confidence (see Figure 13), it is unlikely that any provider will wish to lag in realizing the wide range of benefits that analytics can deliver.

> "Being successful at Big Data requires putting the foundational elements in place—allocation of strategy, capital and mindshare."
>
> **David Hefner, CEO (retired), Georgia Regents Medical Center**

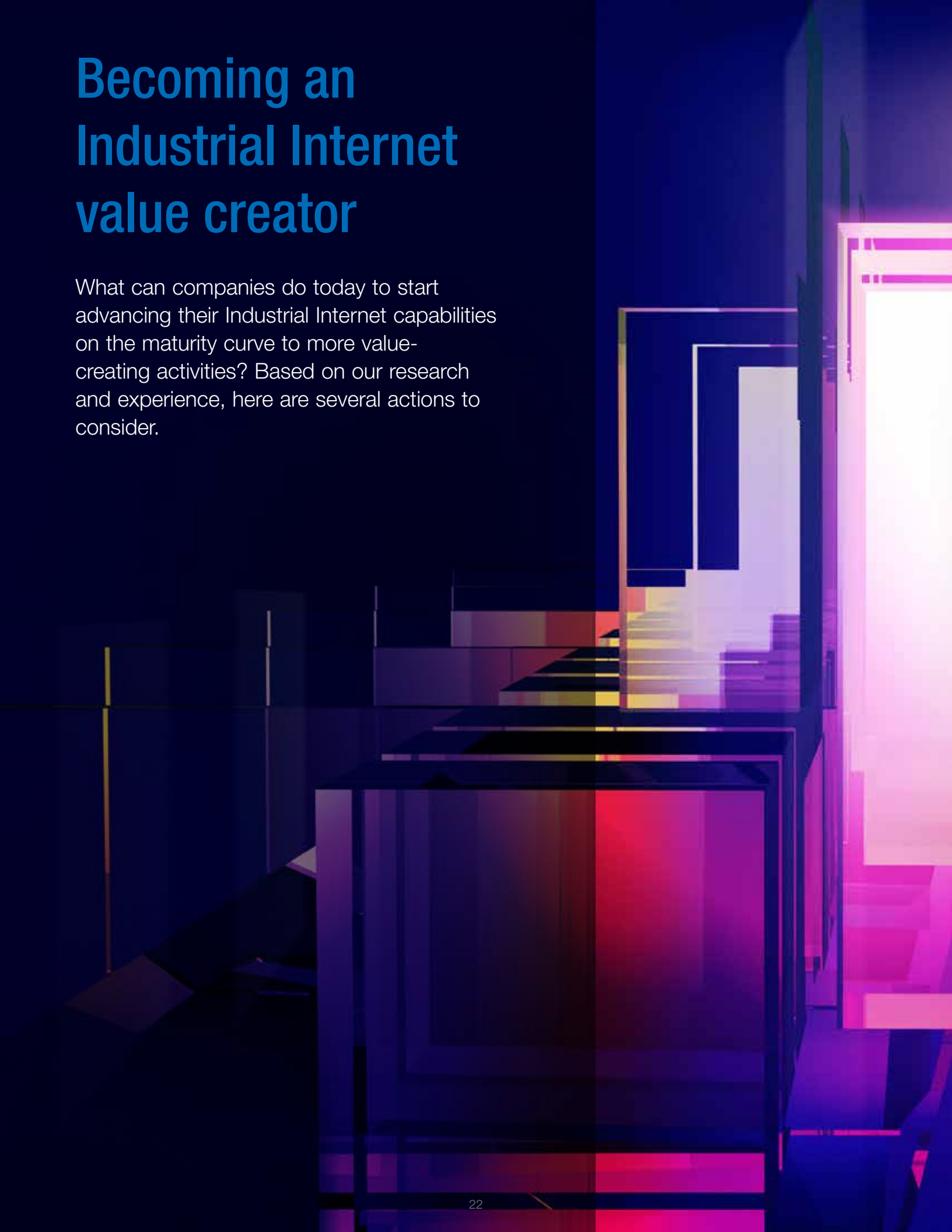
Figure 13: Likely outcomes delivered by analytics capabilities

Outcomes most likely to be impacted by analytics in our organization include: (Multiple responses)



Becoming an Industrial Internet value creator

What can companies do today to start advancing their Industrial Internet capabilities on the maturity curve to more value-creating activities? Based on our research and experience, here are several actions to consider.



Invest in end-to-end security

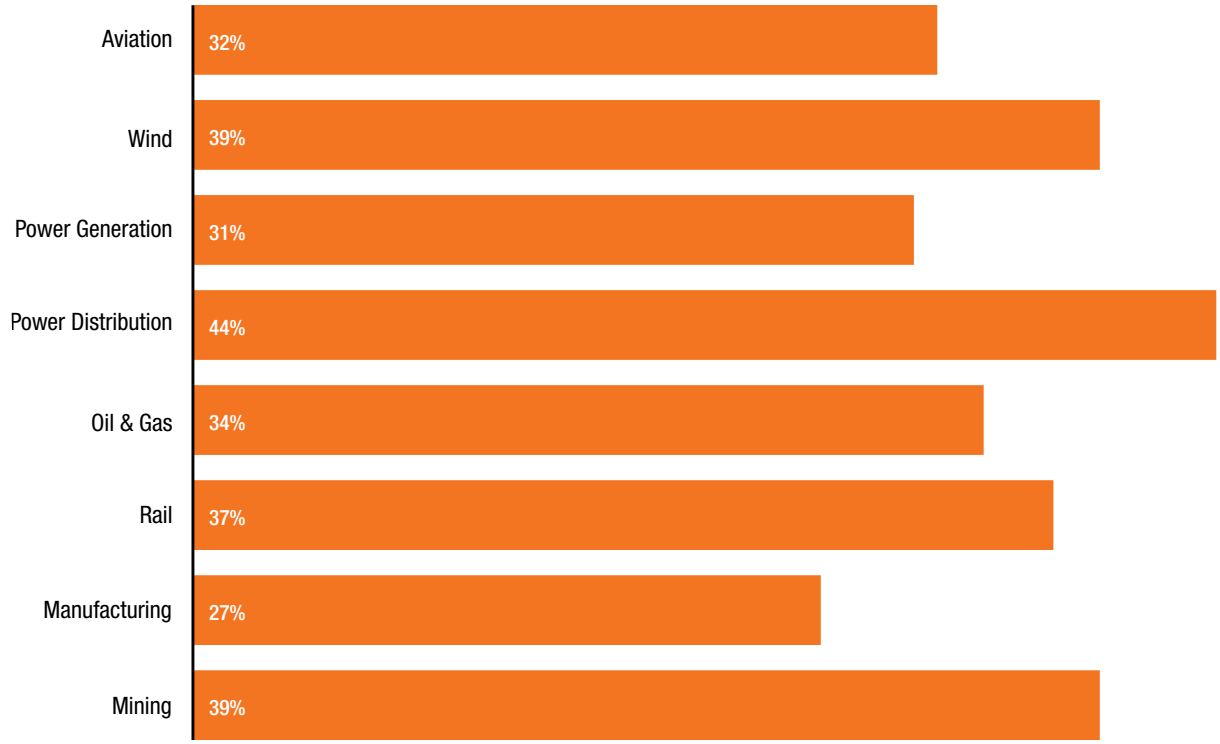
The value of the Industrial Internet is being brought to bear due to the confluence of a multitude of technology enablers such as cloud, mobility, Big Data and analytics. These technologies, while innovative and even game-changing, nevertheless can expose a company to security risks. Indeed, the survey found that one of the top three challenges to deliver on the promise of the Industrial Internet is security (35 percent). Security is of special concern in the Power Generation sector. (See Figure 14.)

Although these results are not surprising, what is concerning is that less than half (44 percent) feel they have end-to-end security in place against cyber-attacks and data leaks. This has enterprise-wide implications. The tools and technologies leveraged to protect company-wide assets would be appropriate in the operational technology (OT) environment as well. IT and OT leaders responsible for security policies related to the Industrial Internet should consider the following best practices:

- **Assess the risks and consequences.** Use experts to evaluate and fully understand vulnerabilities and regulations to prioritize the security budget and plan.
- **Develop objectives and goals.** Set the plan to address the most important systems with the biggest, most impactful and immediate risks.
- **Enforce security throughout the supply chain.** Incorporate robustness testing, and require security certifications in the procurement process to ensure vendor alignment.
- **Utilize mitigation devices designed specifically for Industrial Control Systems (ICS).** Use the same effort given to the IT side to ensure ICS-specific protections against industrial vulnerabilities and exploits on the OT side.
- **Establish strong corporate buy-in and governance.** Gather internal champions, technical experts, decision-makers and C-level executives to ensure funding and execution of industrial security best practices.

Figure 14: Percentage of companies, by industry, that named security as a top three challenge

Security concerns are impacting our ability to implement a wide-scale Big Data initiative



Break down the barriers to data integration

Asked to name the top three challenges faced in implementing Big Data analytics initiatives, the answer most frequently appearing (36 percent) was "System barriers between departments prevent collection and correlation of data for maximum impact." In addition, for 29 percent of executives, a top-three challenge was in the consolidation of disparate data and being able to use the resulting data store. (See Figure 15.)

All in all, only about one-third of companies (36 percent) have adopted Big Data analytics across the enterprise. More prevalent are initiatives in a single operations area (16 percent) or in multiple but disparate areas (47 percent).

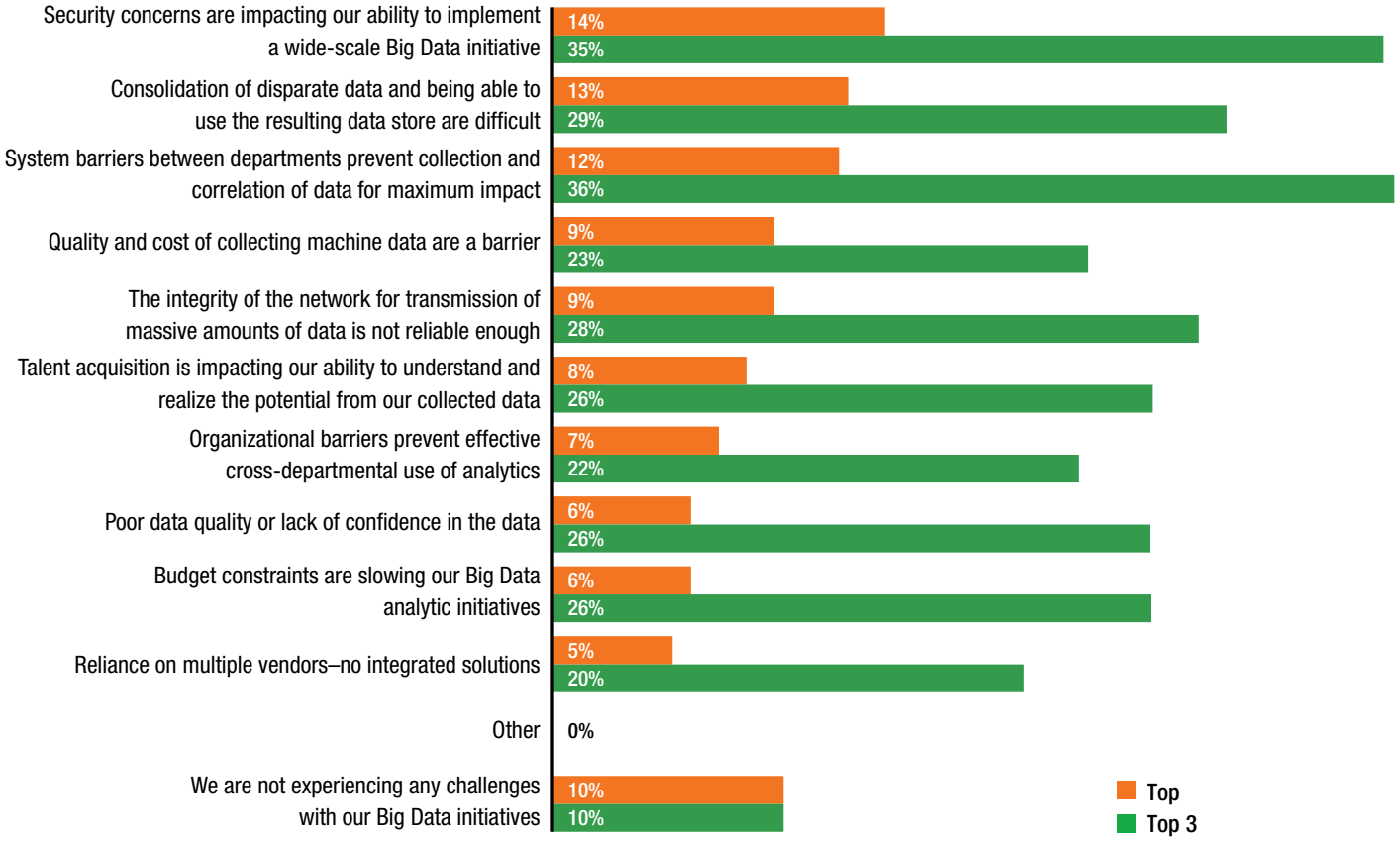
The lack of an enterprise-wide analytics vision and operating model often results in pockets of unconnected analytics capabilities, redundant initiatives and, perhaps most important, limited returns on analytics investments. New technologies such as data lakes, combined with Industrial Internet capabilities, enable operators to funnel sensor data from various networked machines onto a single platform. From there, massively parallel processing capabilities analyze the data as a unified whole rather than as a billion separate bits of information, each with its own individual file path.[11]

Data management itself will be a core skill set. Industrial companies report that a vast amount of the time is consumed by accessing, cleansing, manipulating and consolidating machine data before data scientists can examine the resulting datasets to create predictive models. Breaking down organizational, data and system silos will be both a requirement and an outcome of companies implementing their Big Data strategies—at least the ones that hope to generate the greatest benefits from their efforts.

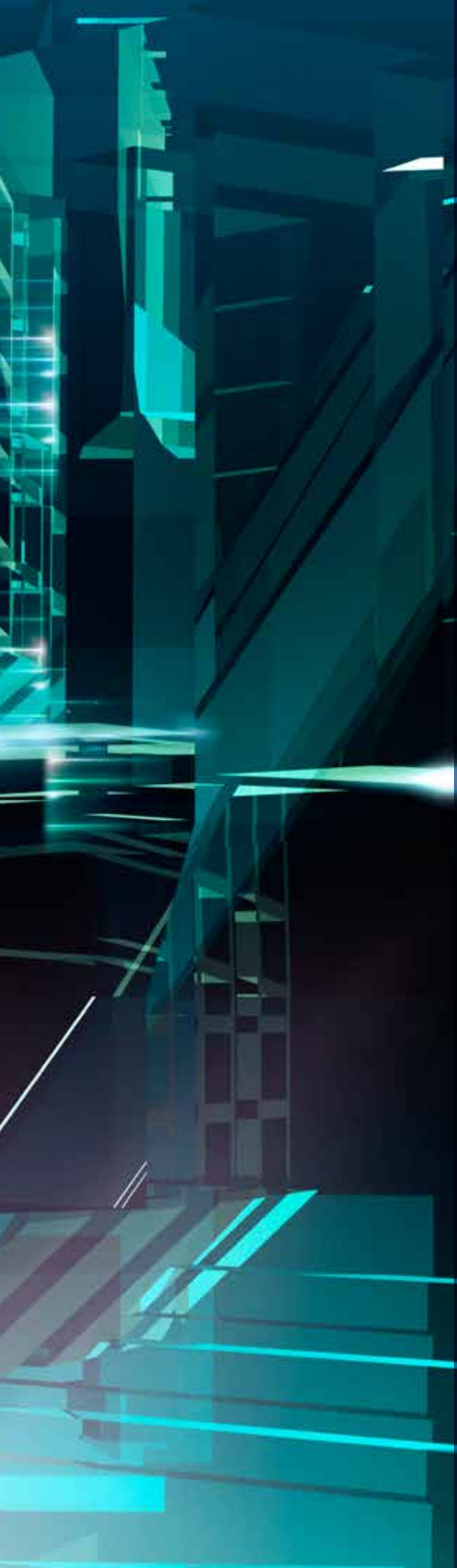
Given these findings about data silos, it is not surprising that our survey data shows a move toward centralization of the analytics function in one way or another. For 50 percent of executives surveyed, their companies are moving toward either an overall

Figure 15: Top challenges in implementing Big Data initiatives, overall

Please rank the top three challenges your organization faces in implementing Big Data initiatives:



11. Ideas Lab, "Trawling for Big Insight in the 'Industrial Data Lake,'" GE Ideas Lab Staff, August 15, 2014.



"We aren't planning to just aggregate Big Data. We are gearing up to re-engineer the business around this capability."

Matt Fahnestock, Vice President, IT Service Delivery, NiSource Inc., Columbia Pipeline Group

"The biggest challenge was the data itself—to get it to the right system and to the right person. It seems so easy for data to be transferred, but it's not—it's much more difficult than people realize."

Jonathan Sanjay, Regional Fuel Efficiency Manager, Air Asia

"We had more data than we could actually use; it was good to have this information, but you need resources to analyze the data, derive best practices and generate new flight plans. There were not enough resources to interpret the data."

Jonathan Sanjay, Regional Fuel Efficiency Manager, Air Asia

"Once standards and practices are established, it becomes easier and more manageable to carry out higher and higher levels of IT/OT integration that go beyond time and costs savings to value creation via data visibility and agile availability of data."

IT and Operational Technology Alignment Innovation Key Initiative Overview, Kristian Steenstrup, Vice President and Gartner Fellow, Gartner Research, 26 March 2014

centralized group to manage Big Data analytics initiatives or a coordinating group within the IT function. Half of these companies (49 percent) also intend to appoint a Chief Analytics Officer responsible for business and implementation strategies concerning analytics. (See Figure 16.)

Bringing the OT and IT divisions together to deliver on the value of the Industrial Internet will be key to driving maximum benefits. Only 26 percent are considering merging the IT and OT organizations to deliver analytic solutions. IT/OT convergence is an important objective because:

- Two of the top three challenges as discovered in the survey—system barriers between departments (36 percent) and disparate data (29 percent)—would be greatly mitigated by being addressed by jointly held OT/IT responsibility. The OT executives would have clear visibility of operational processes, data stores and usage, while the IT executives would have the line of sight to new technologies that would help mitigate the data integration issues.
- As other organizations leverage asset data outside of the Operations arena, such as in Finance for capital management purposes, the need for consolidation and business-focused analytics to derive valuable insights will drive the OT/IT convergence.

Focus on talent acquisition and development

Executives surveyed are aware of their own talent shortfalls in the area of Big Data analytics and the critical nature of sourcing and developing the talent needed to succeed in these areas. About half of those surveyed note that they have talent gaps in several critical areas including analyzing data, interpreting results, and gathering and consolidating disparate data. (See Figure 17.)

Hiring talent with the expertise needed is the most obvious remedy to the talent gap issue, named by 63 percent of survey respondents. Yet the fact is that there won't be enough experienced talent to go around in this burgeoning area of Big Data analytics. Indeed, shortages in the number of data scientists are projected, as well as the number of managers capable of using Big Data analyses to make good decisions. Another option favored by 55 percent of executives is to partner with organizations such as universities to groom the talent needed. This is an option being used at one of the aviation companies surveyed.

The use of skilled external talent—experts in an industry who can quickly translate business needs into analytics solutions—is also an option favored by more than half of respondents (54 percent). (See Figure 18.)

When it comes to retaining talent for augmenting internal skills, industry knowledge is key to success (30 percent), exceeding analytics talent alone (24 percent). However, it is those who hold both industry knowledge and analytics skills who would be preferred by most industrial companies (43 percent). (See Figure 19.)

Figure 16: Anticipated organizational changes to implement Big Data analytics

Which of the following organizational changes have occurred or do you expect will occur to support your company's use of analytics? (Multiple responses)

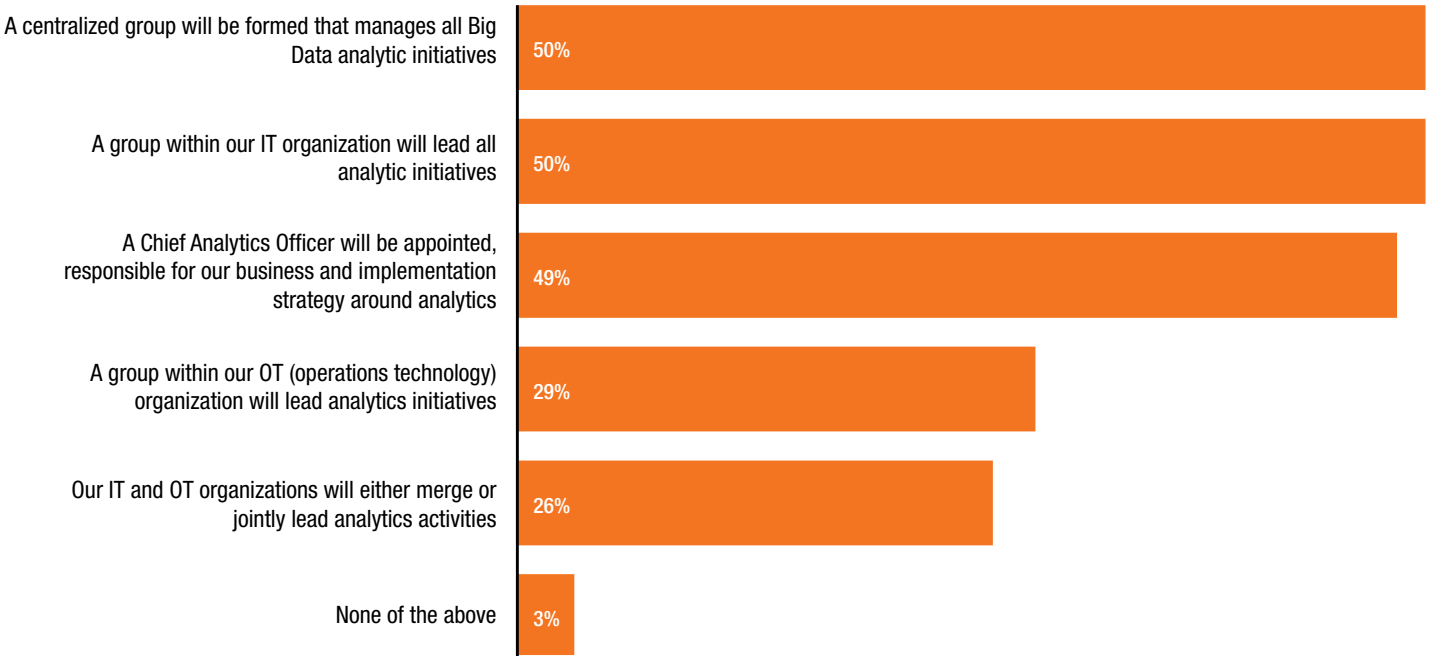


Figure 17: Talent gaps in the area of Big Data analytics

In which of the following areas do you have gaps in your talent? (Multiple responses)

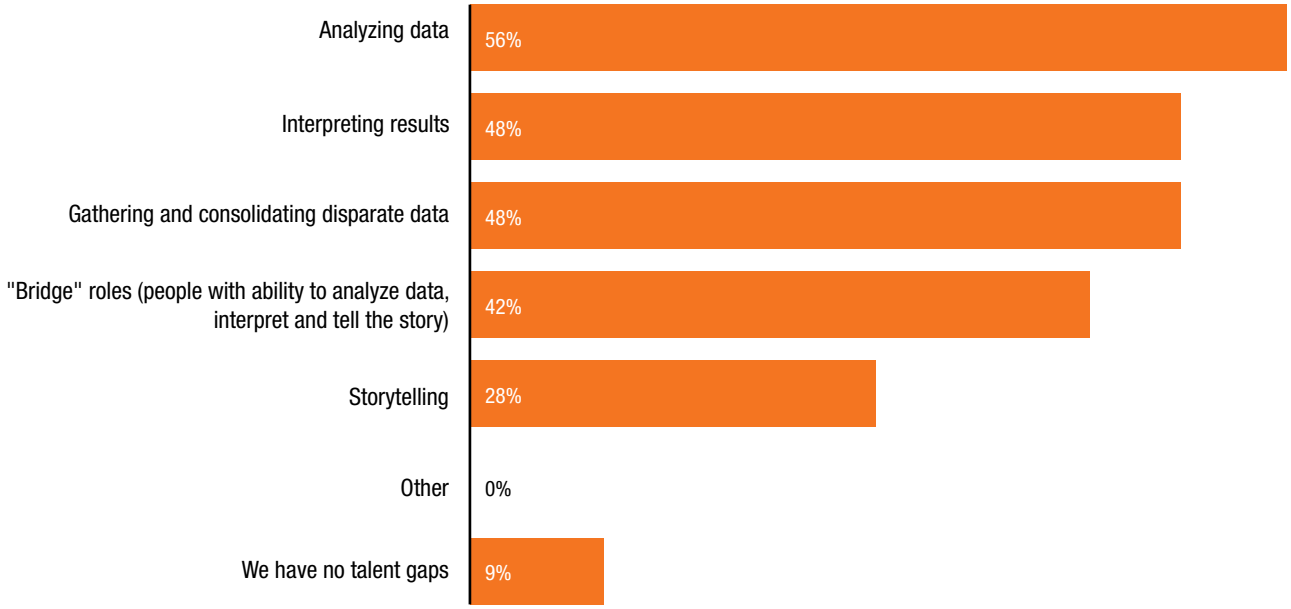


Figure 18: Strategies to fill talent gaps in Big Data analytics

Which of the following will your company pursue to ensure you have the talent needed to fulfill your Big Data analytics strategy?

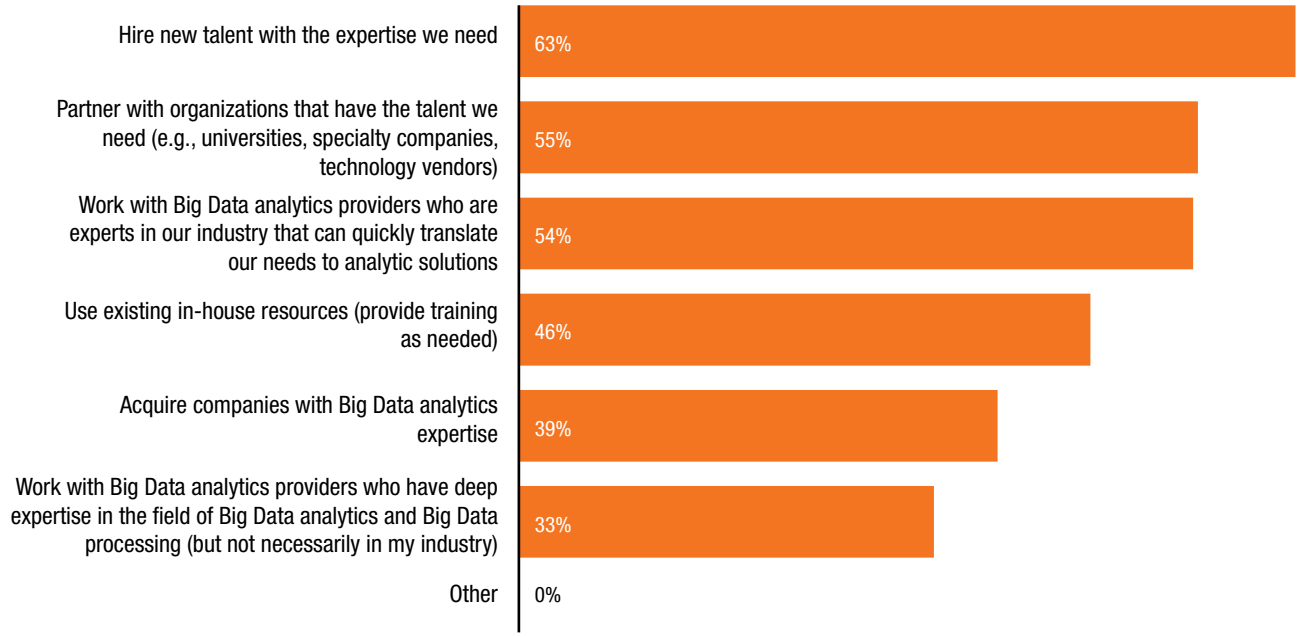
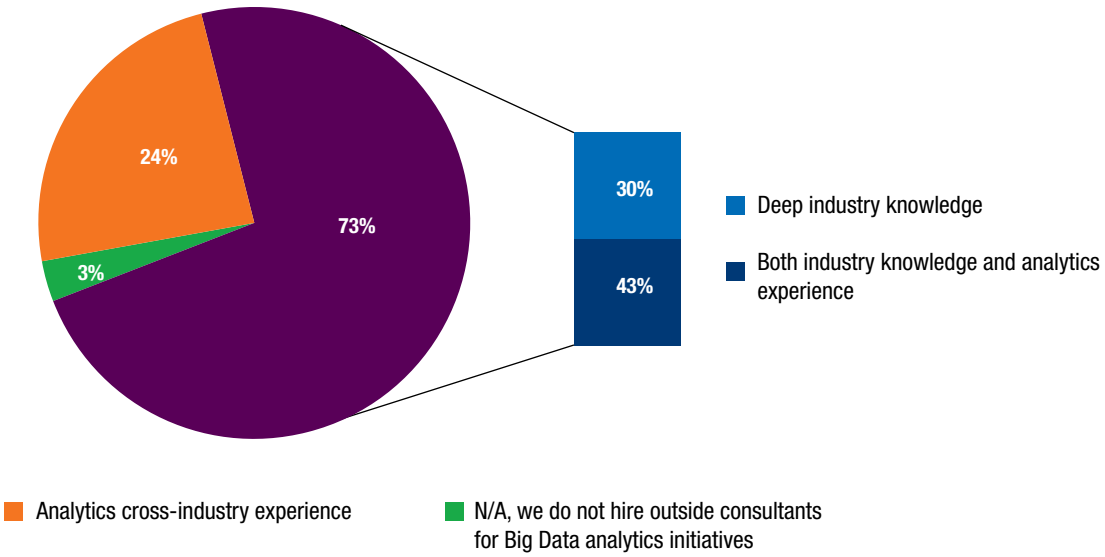
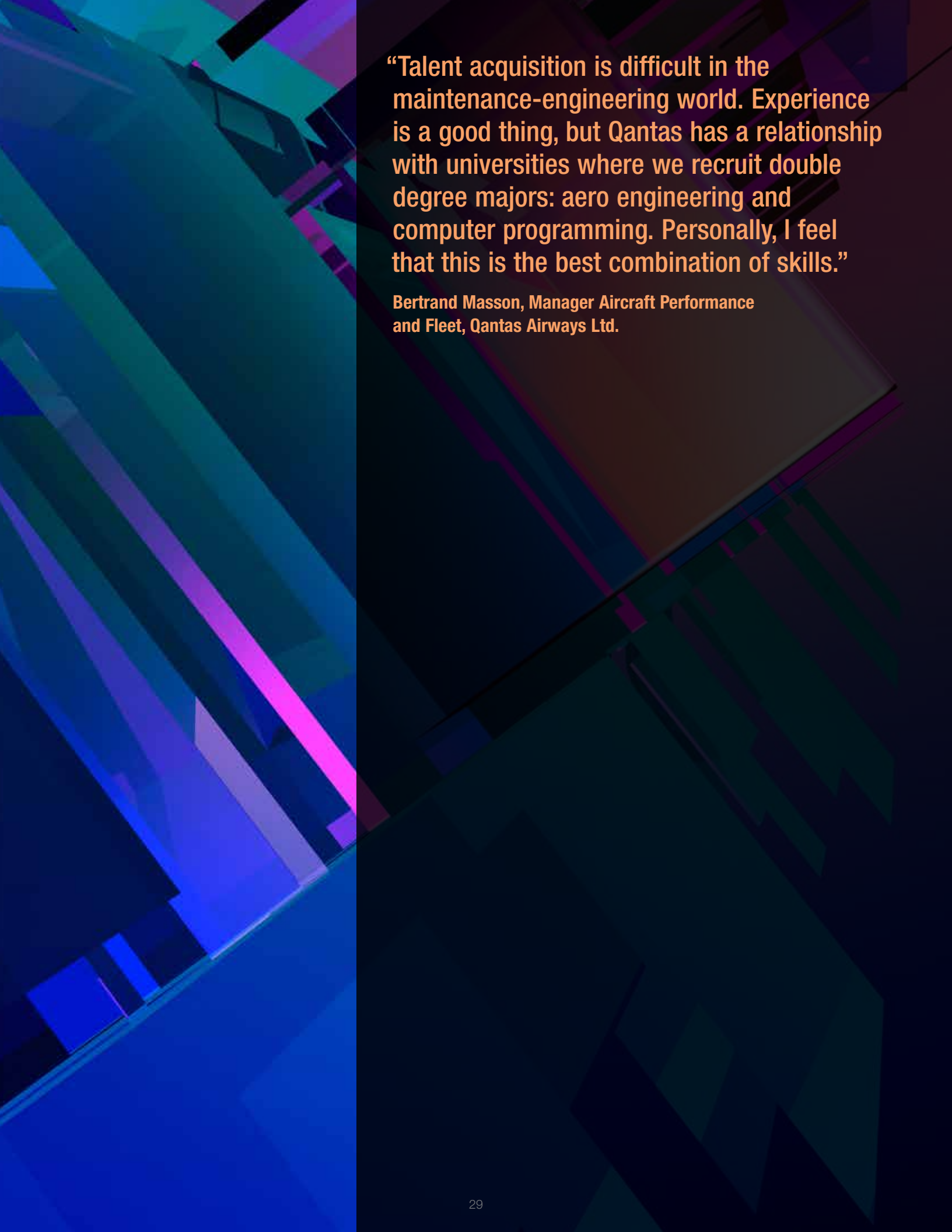


Figure 19: Desired qualities in outside consultants in Big Data analytics

When choosing an outside consultant for a Big Data analytics initiative, I would choose someone with:





"Talent acquisition is difficult in the maintenance-engineering world. Experience is a good thing, but Qantas has a relationship with universities where we recruit double degree majors: aero engineering and computer programming. Personally, I feel that this is the best combination of skills."

Bertrand Masson, Manager Aircraft Performance and Fleet, Qantas Airways Ltd.

"When it comes to incident response, our regulators are requesting that we review and plan with so much more information than before. It's now in one data mart; all of the information is available and will play a large role in saving us time and money in the whole regulatory process."

Matt Fahnestock, Vice President, IT Service Delivery, NiSource Inc., Columbia Pipeline Group

Consider new business models needed to be successful with the Industrial Internet

To begin moving up the maturity curve of Industrial Internet solutions, it is important to think boldly about the new business models needed. As noted earlier, digital services based on Big Data analytics capabilities represent an important evolution of the Industrial Internet. Some companies are already converting products into product-service hybrids—intelligent physical goods capable of producing data for use in digital services. These services enable companies to create hybrid business models, combining the benefits of operational efficiency with recurring income streams from digital services. These digital services will also enable firms in resource-extracting and process industries to make better decisions, enjoy better visibility along the value chain and improve productivity in other ways.

Begin by asking: "What product-service hybrids beyond remote monitoring and predictive asset maintenance resonate with our customers and our customers' customers? What product, service and value can we deliver to clients? How prepared are we to accelerate our move toward a services-and-solutions business model? How do we develop and add the talent we need to be successful?"

Focus on rapidly progressing to predictive analytics and optimization capabilities to derive the greatest value from operational insights.
Asset Performance Management (APM), at its baseline level, delivers value to industrial companies by monitoring availability and performance of assets across the entire enterprise. However, predicting equipment outages for proactive action, before a catastrophic event can occur, results in significantly greater value with increased overall productivity. Taking it to the next level–optimization–will allow for greater insights that can be used for business trade-offs. For example, with complete visibility into output from a fleet of power generation plants, an energy trader can execute optimal transactions in the market, leading to greater profitability.

It is also important to think about tomorrow's partner ecosystem. Companies will work with partners and suppliers to create and deliver services as well as reach potential new customers. Think of the partnering taking place among farm equipment, fertilizer and seed companies, and weather services, and the suppliers needed to provide IT, telecom, sensors, analytics and other products and services. Ask: "Which companies are also trying to reach my customers and my customers' customers? What other products and services will talk to mine, and who will make, operate and service them? What capabilities and information does my company have that they need? How can we use this ecosystem to extend the reach and scope of our products and services through the Industrial Internet?"

Actively manage regulatory risk

A full 55 percent of industrial companies surveyed indicated that improving environmental safety or emissions was part of their data strategy over the next one to three years. Additionally, 42 percent of industrial companies reported that meeting or exceeding regulatory compliance was part of their company's strategy in that same time period.

Industrial companies experience myriad regulatory requirements around safer operations, better emissions controls and more effective use of resources such as water. Companies can leverage the capabilities of Big Data to help actively manage their operating environment and risk profile. Ways that Big Data analytics can assist include:

- Predictive maintenance that identifies equipment issues for early and proactive action, creating better operating equipment that lowers overall emissions.
- Wide-reaching monitoring and diagnostics systems that can identify an equipment failure early, before it becomes a catastrophic event.
- Monitoring and managing the processing of water within an operating plant, reducing overall water use and, in some cases, enabling the use of recycled water.
- Leveraging the historical records that machine data provides to be used when an audit question arises.

Leverage mobile technology to deliver analytic insights

The research revealed that less than 50 percent of survey respondents currently have integrated user experience capabilities. Yet, industrial workers do their jobs in physically challenging circumstances that give them limited ability to interact with software and devices while they work. Traditional user interfaces and interaction paradigms that were created to be suitable for desk-based enterprise environments are not always appropriate for people working in places like locomotive yards, power plants and offshore drilling platforms. This means there is a substantial unmet need to deliver information to Industrial Internet users in a manner that is aligned with how they work day to day. New user experience approaches should be developed to support the following:

- **Hands-free (and sometimes eyes-free) interactions.** Industrial workers typically work with their hands, which means that interacting with screens and buttons requires them to put down tools and disengage from the task at hand.
- **Meaningful integration of data and tools.** Current industrial software is siloed and requires users to interact with numerous systems and screens to accomplish even basic tasks. This creates sizeable time inefficiencies and requires workers to dedicate mental resources to memorizing how to operate complex software rather than performing core job responsibilities.
- **Data-driven, collaborative workflows.** Analytics and collaboration tools hold huge promise to improve the effectiveness of industrial workers, but will require changing how people work from reactive, standardized workflows to anticipatory and adaptive ones.

"Mobility comes into play for our industry. A guy in the field can now, in real time, provide information about assets and status. Before, he used to have to get in his car, drive home, wait till the next day… and then enter the data."

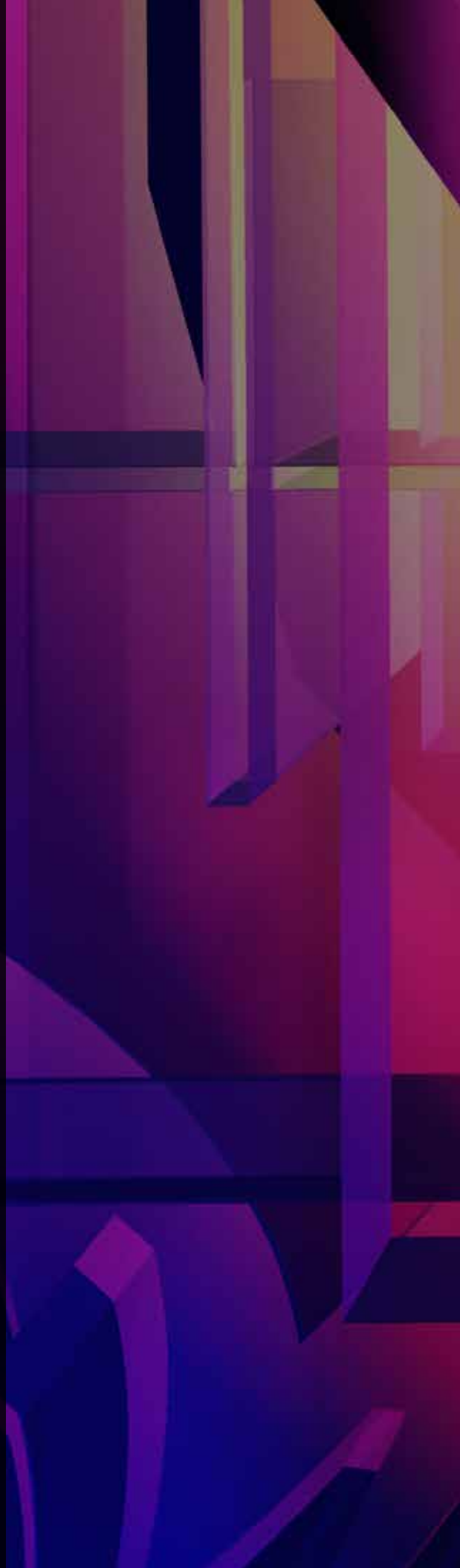
Matt Fahnestock, Vice President, IT Service Delivery, NiSource Inc., Columbia Pipeline Group

"For Big Data initiatives, we do it ourselves and rely on vendors. We look for systems integrators and partners who both understand operations and bring analytics resources to bear."

Fred Ehlers, Vice President - Information Technology, Norfolk Southern Corporation

Conclusion

Industrial companies are rapidly implementing programs to realize financial gains from the Industrial Internet, motivated by the potential for high-order benefits and the threat of competitor advancement. While current implementations consist of asset monitoring, diagnostics and fundamental analysis, the lure of game-changing market shifts and the need for strong regulatory compliance are driving investments in predictive analytics and optimization for decision-making. Overcoming barriers such as data silos and lack of robust security will not be easy. However, it's clear the race is on with urgency across the executive team and with board-level focus.



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About GE and Accenture Alliance
GE and Accenture have formed a strategic global alliance to develop technology and analytics applications that help companies across a range of industries take advantage of the massive amounts of industrial strength big data that is generated through their business operations. The alliance expands on Accenture and GE's relationship announced in 2012 with the establishment of Taleris—a joint venture company between GE Aviation and Accenture dedicated to providing airlines and cargo carriers around the world with Intelligent Operations services to predict, prevent and recover from operational disruptions.