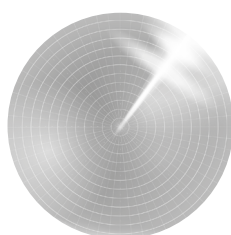




ENGINEERING & MANUFACTURING 2025+ **BUILDING THE WORLD**

A DHL perspective on future
Engineering & Manufacturing Supply Chains

2015



Powered by DHL Trend Research

PUBLISHER

DHL Customer Solutions & Innovation
Represented by Matthias Heutger
Senior Vice President
DHL Customer Solutions & Innovation
Junkersring 55, 53844 Troisdorf/Spich, Germany

PROJECT MANAGEMENT AND EDITORIAL OFFICE

Dr. Klaus Dohrmann

Vice President Strategy and Development
Engineering & Manufacturing Sector
DHL Customer Solutions & Innovation
Phone: +49 228 182 93821
Email: Klaus.Dohrmann@dhl.com

Lorraine Bent

Marketing Director
Engineering & Manufacturing Sector
DHL Customer Solutions & Innovation
Phone: +49 228 182 30205
Email: Lorraine.Bent@dhl.com

IN COOPERATION WITH:

 **z punkt** The Foresight Company

- Johannes Mahn (mahn@z-punkt.de)
- Holger Glockner (glockner@z-punkt.de)

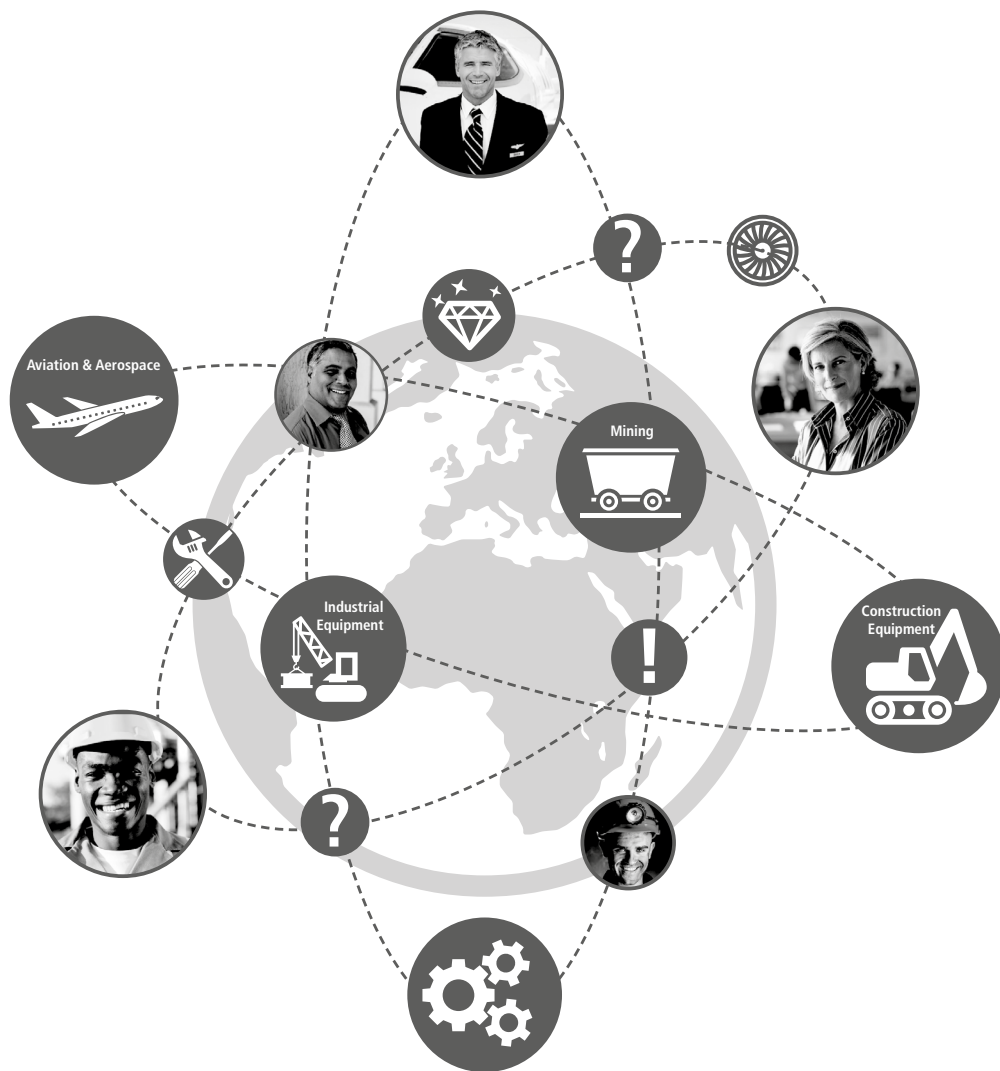
“We are pleased to share quotations from our key contributors, given during their interviews for this White Paper – **enjoy!**”

KEY CONTRIBUTORS / INTERVIEW PARTNERS

- **Kenneth Bjerregaard**, Vice President Global Logistics Services, Danfoss Distribution Services
- **Jon Boyle**, Global Managing Partner, Transportation & Logistics Practice, Heidrick & Struggels
- **Simon Cotterell**, Worldwide Purchasing Manager for Transport, Saint-Gobain
- **Greg Fromknecht**, Vice President of Global Logistics, Emerson
- **Pierre Guyot**, Vice President Worldwide Logistics, Deere & Co.
- **Randy Jayne**, Managing Partner, Heidrick & Struggels
- **Uwe Schmitt**, Logistics Manager Europe, Deere & Co.
- **Zoltan Janos Szabo**, Director Corporate Logistics, Grundfos

DHL TEAM

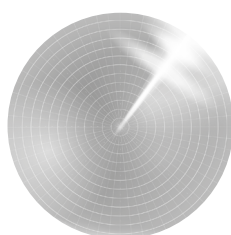
- **Mark Bradley**, Regional E&M Sector Head EMEA, DHL Global Forwarding
- **Mark Gieben**, Vice President, Global Customer Manager E&M, DHL Customer Solutions & Innovation
- **Dries van Hoeymissen**, Senior Director Business Development E&M MLEMEA, DHL Supply Chain
- **Reg Kenney**, Sector President E&M, DHL Customer Solutions & Innovation
- **Martyn Lawns**, Head of Mining Sector, Industrial Projects Group, DHL Global Forwarding
- **Eamon McMahon**, Vice President E&M EMEA, DHL Customer Solutions & Innovation
- **Darren Plested**, Vice President E&M Asia Pacific, DHL Customer Solutions and Innovation
- **Andy Ramsden**, Vice President Global Sector Development Automotive, E&M, DHL Supply Chain
- **Gio Theunissen**, Vice President E&M Aerospace, DHL Freight
- **Boris Tranberg**, Global Customer Manager E&M, DHL Customer Solutions & Innovation
- **Marja-Liisa Turtiainen**, Vice President Aerospace & Aviation, DHL Customer Solutions & Innovation



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EXECUTIVE SUMMARY

The Engineering & Manufacturing (E&M¹) sector is on the brink of change. The trends we identify and describe in this paper confirm that E&M companies are getting ready for fundamentally new and competitive market conditions over the next 10-20 years.

Many organizations have begun to actively re-engineer their production and business models to prepare for these changes. Their objective is to become more customer-centric and competitive. **We at DHL believe that supply chain management will be a key enabler and driver to achieve this.**

However, our research shows that supply chain managers will have to deal with an even higher level of complexity in the future. A broader and more customized product portfolio, more different parts, more suppliers, more interfaces along the value chain and the individual requirements of new markets including compliance.

Based on this we anticipate a number of implications for future supply chains:

Speed to market and the ability to react promptly to changes in customer demand will require a global network of more regionalized supply chains closer to markets and customers.

To deal with volatility and exogenous threats, future supply chains must be both resilient and compliant. E&M companies will be forced to constantly re-examine the trade-off between efficiency and redundancy and contingency planning will become imperative. At the same time, supply chain managers will be increasingly challenged to understand new and ever-changing compliance specifications, adapt processes accordingly, and make sure all requests are met.

Customer demand, regulatory pressure, and economic necessity will be the drivers for more sustainable supply chains of the future.

Environmental performance or proximity will gain importance in procurement decisions. Capabilities for reverse logistics – including repair services, return solutions for disused products, and recycling – will be essential.

E&M KEY TRENDS



Shifting Markets: focus towards emerging countries, intensified global competition, re- and nearshoring



Customization and Convergence of B2B and B2C: increasing complexity and customer-centricity through customized products, solutions, and processes inspired by B2C markets



Compliance and Sustainability: focusing on stakeholder value and avoiding non-compliance



Volatility and Exogenous Threats: more uncertainty and less predictability in planning and decision-making



Labor Shortage: lack of qualified people threatening the realization of business plans



New Technologies: intelligent products and big data opportunities

¹ As per DHL's definition the E&M sector consists of the four sub-sectors: industrial equipment, aviation & aerospace, non- energy mining and construction equipment.

New technologies will build the basis for **highly integrated supply chains in the future**, connected end-to-end and in real time. This will significantly increase supply chain visibility and the anticipatory capacity of the whole system, enabling higher service levels.

And ultimately, to cope with smaller batches of customized products, shorter product lifecycles, and unpredictable variations in demand, **future supply chains will have to be more agile and responsive**. Build-to-order production will become the norm as E&M companies learn to deal with an uncertain future.

For all of these supply chain implications there are already **best-practice cases in the E&M sector today**. For future success it will be key to apply and further improve these best practices across the E&M sector. At the same time **expertise from other sectors** can be leverage. **This is especially the case for well-established concepts from the Automotive sector as the maturity level of E&M supply chains is well below this sector.**

E&M SECTOR RESPONSES



Intelligent Manufacturing:
create decentralized, modular, and flexible 'smart factories'



Sustainable Manufacturing:
apply energy-efficient, circular cradle-to-cradle concepts



New Business Models:
increase customer centricity with 'servitization' and 'to-order'



New Collaboration Models: commit to manufacturing clusters and open innovation

E&M SUPPLY CHAIN IMPLICATIONS



Regionalized Supply Chains – global economic activity shifts, supply chains of the future must adapt accordingly.



Resilient and Compliant Supply Chains – to mitigate rising volatility and uncertainty in the business environment E&M business will have to become more resilient.



Sustainable Supply Chains – environmental legislation, product design, and consumer behavior will impact supply chains.



Connected and Integrated Supply Chains – new technologies to manage the entire supply chain, to eliminate delays and improve service levels.



Agile and Responsive Supply Chains – fast and efficient supply chains will enable E&M business to produce more customized products, deal with variations in demand, and respond quickly to disruption.



INTRODUCTION

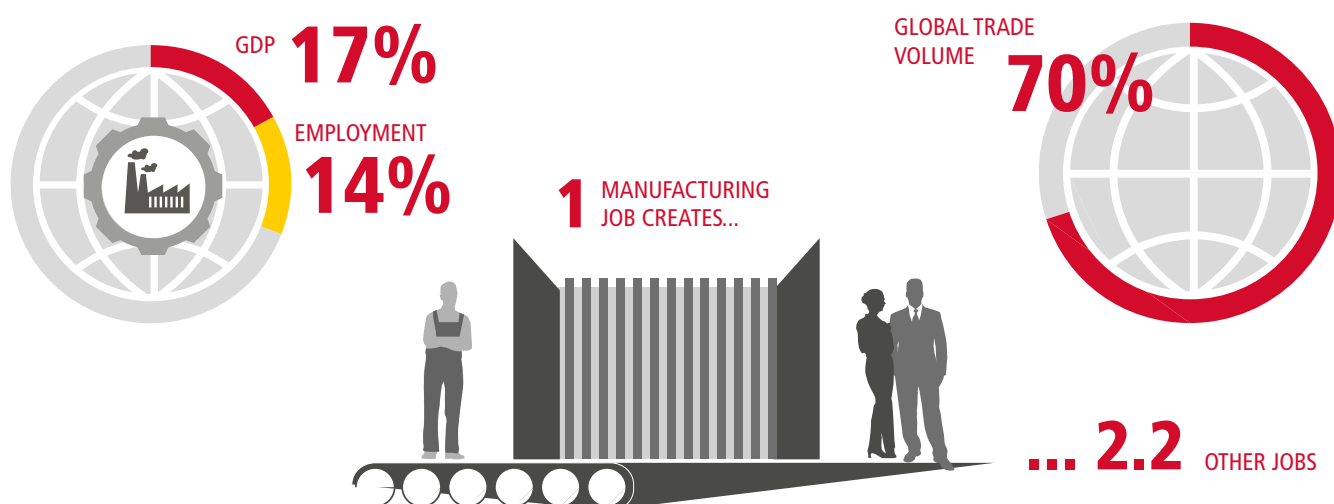
Since the dawn of the industrial revolution nearly three hundred years ago, industrial production has been a key driver of job creation and rising standards of living. Also today its importance for growth and prosperity persists. Globally manufacturing accounts for approximately 17% of GDP and 14% of employment (McKinsey 2012). Each job in manufacturing creates an additional 2.2 jobs in other sectors, and 70% of the entire global trade volume is due to manufacturing companies. Each GDP dollar in manufacturing generates 1.4 US dollars in GDP for other sectors of the economy (Siemens 2015a). In recent times of economic struggle, and the observation that economies with a stronger manufacturing base have struggled less, the calls for resurgence in this sector have become louder in many countries. In the UK, for example, 85% of voters want the next government to promote the country's manufacturers as they believe it will give the country more economic stability (The Guardian 2014). And in the United States, president Obama actively promotes his vision to rebuild manufacturing 'Made in America'.

The E&M sector is highly diverse, as it includes companies that produce jet engines and drilling rigs as well as those that manufacture less complex fasteners and filters. But the entire sector is more or less driven and likely to be affected by the same future changes and trends. However, today we do see different maturity levels of supply chains within the E&M sector with more traditional setups as well as innovative supply chain concepts e.g. in Aviation & Aerospace.

“It is impossible to predict the future but also dangerous not to try.”

Henri Deterding,
Founder Royal Dutch Shell

ENGINEERING & MANUFACTURING AS KEY GROWTH DRIVER



As a first step we systematically identify the most important trends affecting E&M companies. In addition we describe new manufacturing concepts (sector responses) that are partly implemented already today and have significant impacts on supply chains. Based on these trends and sector responses we finally highlight the E&M supply chain implications and action areas in order to manage the resulting challenges and to stay competitive. **Our research shows that supply chains are and will be even more in the future a key enabler for value creation of E&M companies.**

At DHL we are experts in supply chain management and aim to understand our customers’ businesses and markets. That said, we are convinced that customers are also our most important source of information. We therefore asked a number of key customers and experts to contribute to this white paper by providing their views and opinions. The interviews that we conducted have yielded valuable insights. In addition, of course, we leveraged DHL experience and knowledge, bringing together sector and operational experts across all DHL divisions, key account managers as well as our innovation team to collectively outline for our valued customers, potential action points for their supply chain strategies.

1. E&M ENVIRONMENT /TRENDS



1.1
Shifting
Markets



1.2
Customization
and Convergence
of B2B and B2C



1.3
Compliance
and
Sustainability



1.4
Volatility and
Exogenous Threats



1.5
Labor
Shortage



1.6
New
Technologies

2. E&M SECTOR RESPONSES

- 2.1 Intelligent Manufacturing
- 2.2 Sustainable Manufacturing
- 2.3 New Business Models
- 2.4 New Collaboration Models



3. E&M SUPPLY CHAIN IMPLICATIONS

3.1 Regional Supply Chains	3.2 Resilient and Compliant Supply Chains	3.3 Sustainable Supply Chains	3.4 Connected and Integrated Supply Chains	3.5 Agile and Responsive Supply Chains
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1. E&M ENVIRONMENT /TRENDS

We have identified six major changes impacting the E&M business environment. They reflect widely different aspects – ecology, economy, environment, politics, society, and technology.

1.1 Shifting Markets

We anticipate that the global E&M market landscape of the future will look different from today, as the center of economic gravity will continue to shift to the East, mainly fueled by the growth of China's and India's economies. Many E&M companies from the USA and Europe have already moved large parts of their production eastwards to profit from lower wages and lower production costs in general.

More importantly, emerging countries will also become more relevant as sales regions. The Chinese economy, for example, already overtook the US economy in purchasing power parity terms (PPP) in 2014, and is projected to surpass the US also in market exchange rate (MER) terms by 2028 (PwC 2015). And with the large majority of China's urban consumers expected to earn between USD 9,000 and USD 34,000 per year in 2022 (McKinsey 2013), a large portion of future growth will be the result of China's domestic consumption.

India follows suit as third largest economy based on GDP at PPP in 2014 and should become the third largest global economy at MER by 2030, moving all the way up from position ten in 2014, overtaking countries such as France, Japan, and Germany in the process (PwC 2015).

Generally speaking, E&M companies assume that the BRIC countries will, by and large, remain at the center of their attention, even though prospects for growth in Brazil and especially Russia are somewhat uncertain at the moment.

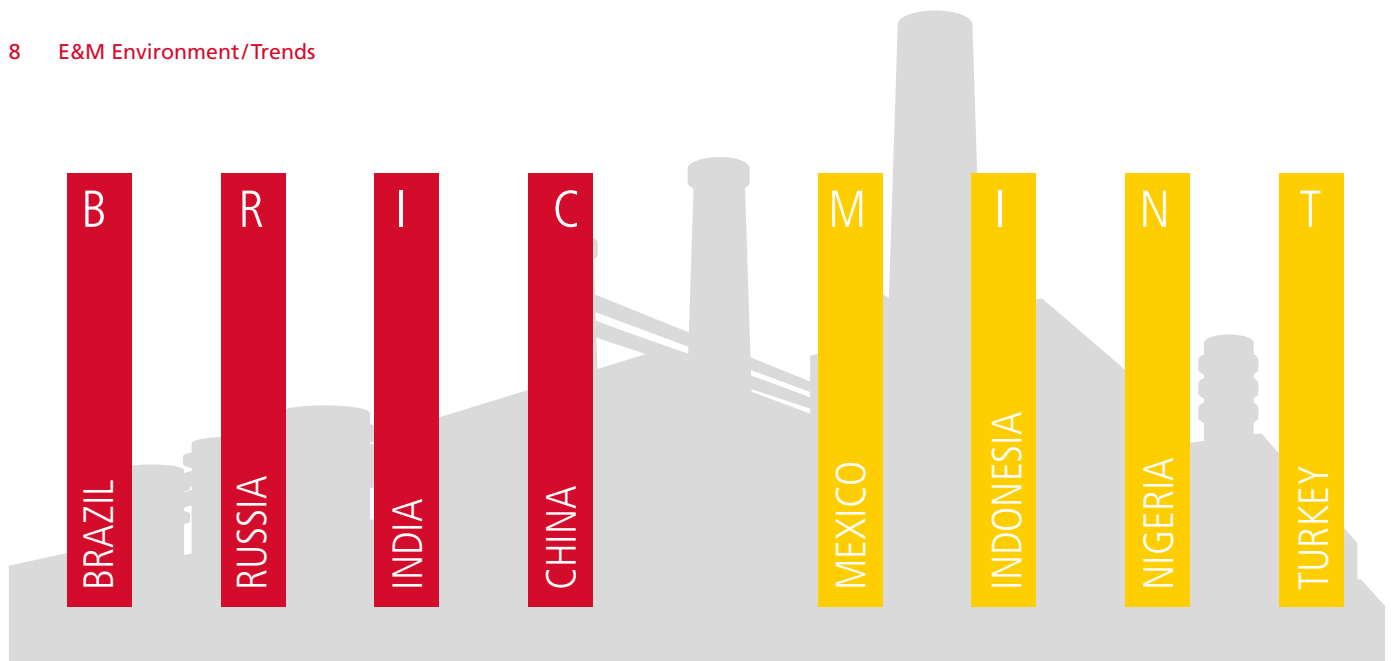
As we learnt from the interviews, our **E&M customers are also starting to look beyond BRIC**. Emerging countries such as Mexico, Indonesia, Nigeria, Turkey (the so-called MINT countries) and ASEAN members are expected to perform well in the future and become attractive markets.

“We will operate in geographies we do not operate in today. I fully believe that Africa and Central Asia are the next places for farming. And Africa might also be the next big thing for construction.”

ACTUAL AND PROJECTED TOP 20 ECONOMIES RANKED BASED ON GDP IN PPP TERMS

	2014		2030		2050	
PPP rank	Country	GDP at PPP (2014 US\$bn)	Country	Projected GDP at PPP (2014 US\$bn)	Country	Projected GDP at PPP (2014 US\$bn)
1	China	17,632	China	36,112	China	61,079
2	United States	17,416	United States	25,451	India	42,205
3	India	7,277	India	17,138	USA	41,384
4	Japan	4,788	Japan	6,006	Indonesia	12,210
5	Germany	3,621	Indonesia	5,486	Brazil	9,164
6	Russia	3,559	Brazil	4,996	Mexico	8,014
7	Brazil	3,073	Russia	4,854	Japan	7,914
8	France	2,587	Germany	4,590	Russia	7,575
9	Indonesia	2,554	Mexico	3,985	Nigeria	7,345
10	United Kingdom	2,435	United Kingdom	3,586	Germany	6,338
11	Mexico	2,143	France	3,418	United Kingdom	5,744
12	Italy	2,066	Saudi Arabia	3,212	Saudi Arabia	5,488
13	South Korea	1,790	South Korea	2,818	France	5,207
14	Saudi Arabia	1,652	Turkey	2,714	Turkey	5,102
15	Canada	1,579	Italy	2,591	Pakistan	4,253
16	Spain	1,534	Nigeria	2,566	Egypt	4,239
17	Turkey	1,512	Canada	2,219	South Korea	4,142
18	Iran	1,284	Spain	2,175	Italy	3,617
19	Australia	1,100	Iran	1,914	Canada	3,583
20	Nigeria	1,058	Egypt	1,854	Philippines	3,516

Source: IMF WEO database (October 2014), PwC projections for 2030 and 2050



Most E&M companies are planning to supply those new markets mainly from their facilities in China and other emerging countries, as there are strong similarities (e.g., in terms of requested product qualities and market structures). Setting up local production is currently assessed as unlikely within the next 10-15 years. Among other reasons, this is due to the persistent threat of political instability in many countries and the lack of basic industries such as steel production.

“Competitors from emerging countries are catching up in terms of technical and quality levels. They are also starting to target the premium segments. Just look at the car industry. First companies from emerging markets were producing for their own markets and quality was rather bad. Then they emerged as international players with good quality.”

Consequently, future demand for E&M products will be much more geographically fragmented as the number of markets and sub-markets grows. In order to be successful in those markets and meet local needs, it will be increasingly important to have access to local R&D, production, and assembling facilities, and to establish regional supply chains – a trend that is referred to as near-shoring.

In parallel with this trend, re-shoring activities are also experiencing an upswing. The combination of declining energy costs in the USA, rising wages in many emerging countries as well as improving automation and robotics mean **more and more US companies consider it an attractive alternative to re-shore manufacturing processes back home.** In 2014, about 60,000 manufacturing jobs were brought back to the USA. Ten years back in 2003, the USA lost more than 140,000 jobs annually to offshoring (Industry Week 2015).

Newly emerging markets also mean intensified competition, especially for the established players in the USA and Europe. In many E&M industries, companies from emerging markets are catching up in terms of know-how and quality, and are targeting international markets. For example, the state-owned Commercial Aircraft Corp of China (Comac) could become a serious threat for the Airbus and Boeing duopoly in the commercial aerospace market. And the ownership of companies is becoming more global as indicated by an increase in inter-regional investments and increasing foreign direct investments (FDI).

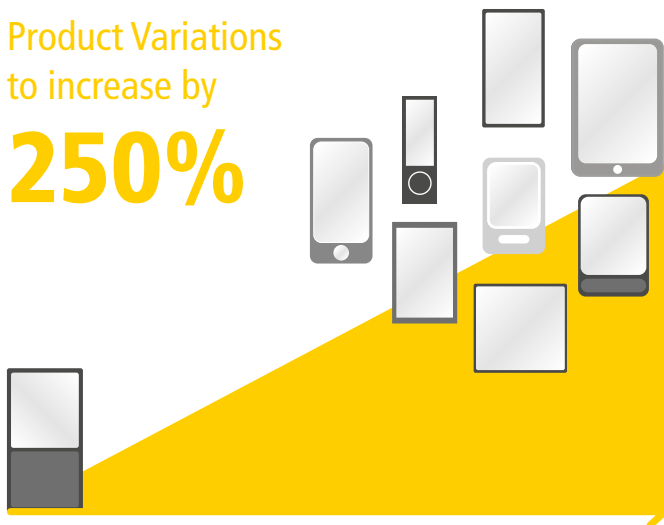
1.2 Customization and Convergence of B2B and B2C

Across all E&M sub-sectors, customers more and more ask for customization and personalization.

Customized products have already turned into a mega-trend in many consumer industries and in the automotive industry. Driven by the desire for individualization that also finds its expression in more personalized consumption preferences, more and more companies are allowing their customers to modify products according to their wishes. In 2014, globally nearly 1,000 companies offered a web-based online product configurator, up from 600 in 2007 (Blazek et al. 2015).

Consequently, the number of product variations has increased substantially; according to Siemens by 250% during the past 10 years for items produced on an industrial scale (VDC Research 2014).

Product Variations
to increase by
250%



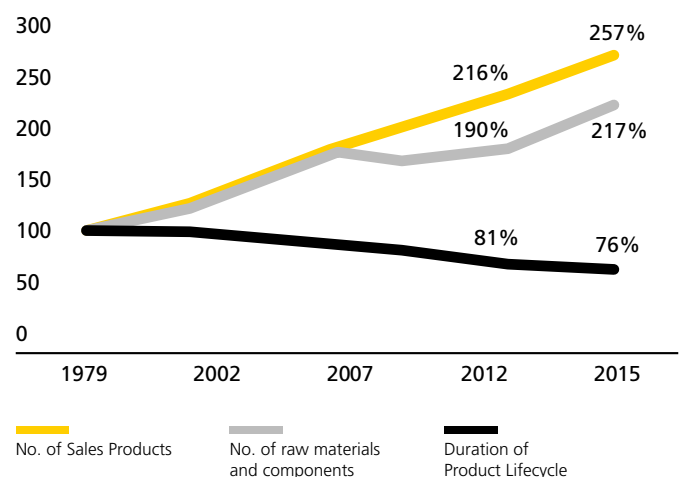
We believe that this diversity will increase further, as mass customization will emerge beyond luxury products and expand to mid-markets, and – even more importantly – as it becomes more relevant for B2B products as well.

In a survey by the German Engineering Association (VDMA), 74% of the surveyed engineering companies expect that customized system solutions will gain in relevance within their industries (VDMA 2014). The ability to meet specific customer demands will become more important than having sufficient manufacturing capacities or economies of scale, as companies will increasingly contract their suppliers for capability rather than capacity. Even without direct contact with the end user, E&M companies will have to respond.

“I see that there will be an increased focus on differentiation from our customers. They need specific solutions in order to develop their business. We will have to move away from the same-to-all approach.”

“Over the past 10 years, the number of components we have to manage grew exponentially. That will continue because the demand and level of customization we want to achieve is growing.”

INCREASE OF PRODUCT VARIETY IN %



Source: Roland Berger, http://www.rolandberger.us/media/pdf/Roland_Berger_Mastering-Product-Complexity_20121107.pdf

Another driver of customization is the convergence of B2B and B2C. Despite the unique nature of B2B activities, customer expectations of B2B companies are becoming increasingly similar to those in consumer markets.

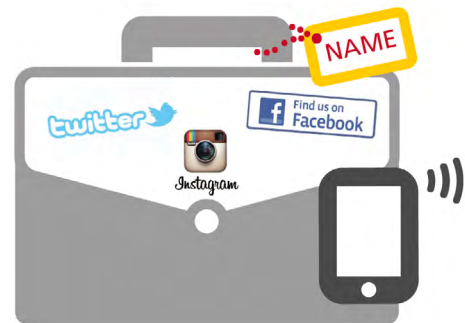
Customer experiences in B2C commerce, such as the availability of product configurators and personalized offers, are being transferred to (and expected in) the B2B world.

As a result, we see a continuing acceleration of product and market cycles. In a survey by Capgemini, 76% of respondents expected a shortening of the product lifecycle of at least 10% by 2020, and some 24% anticipated even 50% (Capgemini, 2012). Although these numbers may not be directly transferable to E&M, the general trend of acceleration is certainly true – as many of our interview partners confirmed.

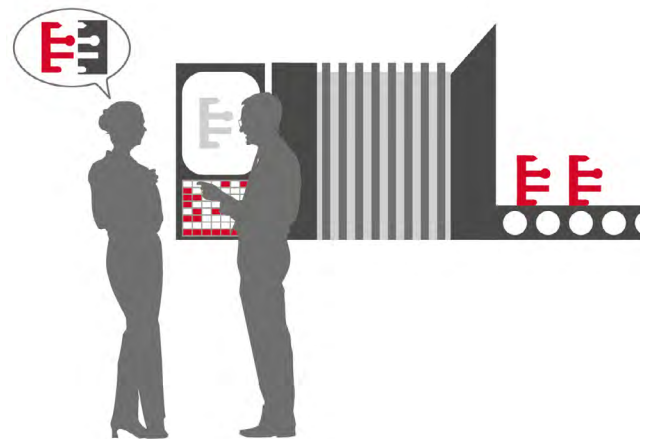
This will have tremendous future implications for E&M companies. Gone will be the era of long-term 'cash cows', where products remained more or less unchanged in portfolios over many years, often decades, providing their companies with a constant flow of revenue without the need to invest heavily in R&D. We see changes starting already. In many industries, products released over the past three years now account for half of annual revenues (Horn 2015). Between 1997 and 2012, the average product lifecycle – the time from market entry to withdrawal – within the automotive, chemical, engineering, and pharmaceutical industries has decreased by about a quarter, while the number of product variations has increased by 220% (Roland Berger 2012).

The B2B-B2C convergence is not only impacting products, but also other business aspects such as speed of delivery, the traceability of products, and customer interaction. The use of smartphones and tablets as well as social media platforms (e.g., for order placement) will no longer be a characteristic of B2C markets alone; it is starting to become commonplace in B2B as well. Business customers are also asking to be more involved in product design and production processes, even though this is currently at a lower level than in B2C.

B2C TO B2B CONVERGENCE



INVOLVING CUSTOMER ACTIVELY IN THE DESIGN-PROCESS



“There is a lot of change in the business. It has been a very classic manufacturer-wholesaler relation. In the future we will use more different sales channels. Internet sales are also coming up. We are starting to have direct contact with our industrial customers. But this also creates a lot of challenges in terms of order flow and order execution.”

1.3 Compliance and Sustainability Requirements

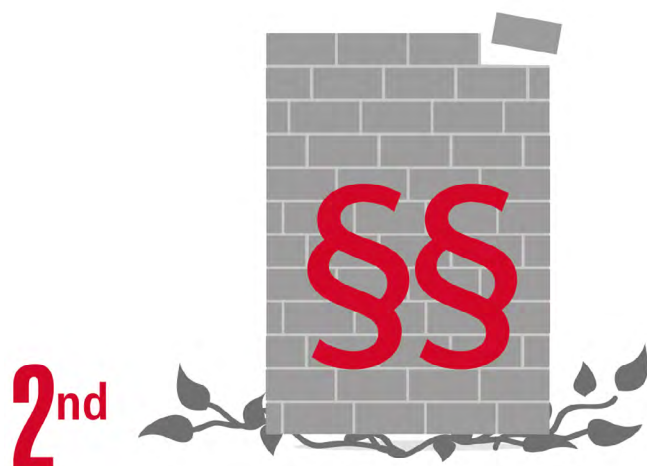
“I can clearly see that compliance and security requirements are becoming more and more an issue and more difficult.”

Besides changes in the market environment and customer behaviour, our E&M customers are also facing increasing requests in terms of compliance and sustainability.

The risk of non-compliance and regulatory failure has been a very real challenge for E&M companies in recent years. Companies are already increasing their expenditures in this area to ultimately keep their license to operate. Oklahoma Gas and Electric for example is spending approximately \$1.1 billion for their environmental compliance plan.

With E&M companies expanding their geographic footprint across countries, regions, and jurisdictions, these challenges and cost multiply. We expect regulatory and compliance regimes to further mature globally in all different areas, such as trade-related requirements, ecological, security and industry standards, and corporate policies. This is especially true for emerging countries.

INCREASING REGULATION



2nd most important barrier to growth

According to a PwC survey, increasing legislative and regulatory pressures will be the second most important barrier to growth in the near-term future, surpassed only by lack of demand (PwC 2014a).

Companies are increasingly being asked to substantiate adherence to compliance, e.g., by documenting and retaining an audit trail for a range of technical and procedural decisions, including designs, design reviews, engineering change orders (ECOs), manufacturing processes, work instructions, and much more. Interestingly, though, compliance budgets in manufacturing are increasing at a much slower pace than in other sectors.

Growing complexity of regulations and standards is not only a problem for larger OEMs as they expect their suppliers, no matter how small, to demonstrate the same levels of diligence, too.

Sustainability is the other major focus topic in this respect. The large majority of our E&M customers regard sustainability as key to future business operations and success.

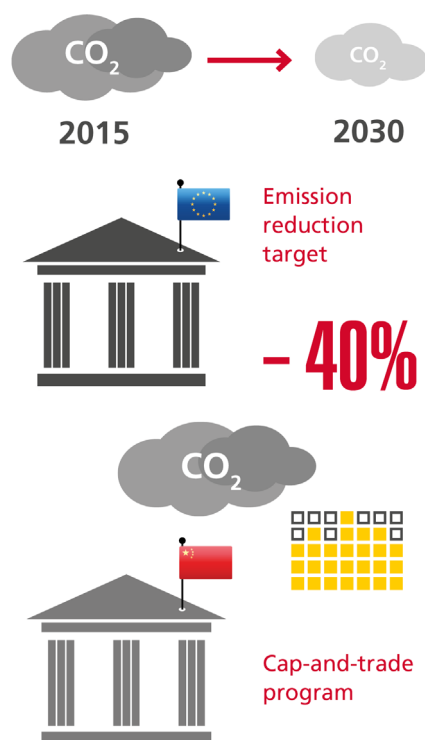
With global warming reaching previously unseen levels, virtually all stakeholders are putting increasing pressure on E&M companies to become 'greener'. Customers are asking for energy-efficient products and a lower carbon footprint in production and delivery processes. Shareholders expect resource efficiency to drive down cost and reduce the dependency on fossil fuels. Governments, pushed by their constituents, are having to introduce emission reduction strategies and clamp down on pollution.

In this respect emerging countries have lagged behind for some time, but awareness and pressures are increasing. While the EU agreed to a binding emissions reduction target of 40% by 2030 (European Commission 2014), China has announced the introduction of mandatory cap-and-trade programs for emissions, including plans for a national system as early as 2016, forcing manufacturers and suppliers to improve emissions reduction and reporting.

According to the E&M leaders we spoke with, sustainable management will see its role increase from being simply a matter of compliance to being a source of competitive advantage.

In light of growing energy and resource demand – for example, the demand for steel is expected to increase by about 30% from 1.5bn tons in 2014 to 2,0bn tons in 2030 (WSA 2015) – manufacturers that increase their efficiency along the whole value chain and align their activities on the concept of eco-efficiency will gain a significant competitive edge.

EMISSION REDUCTION CHALLENGES FOR E&M COMPANIES



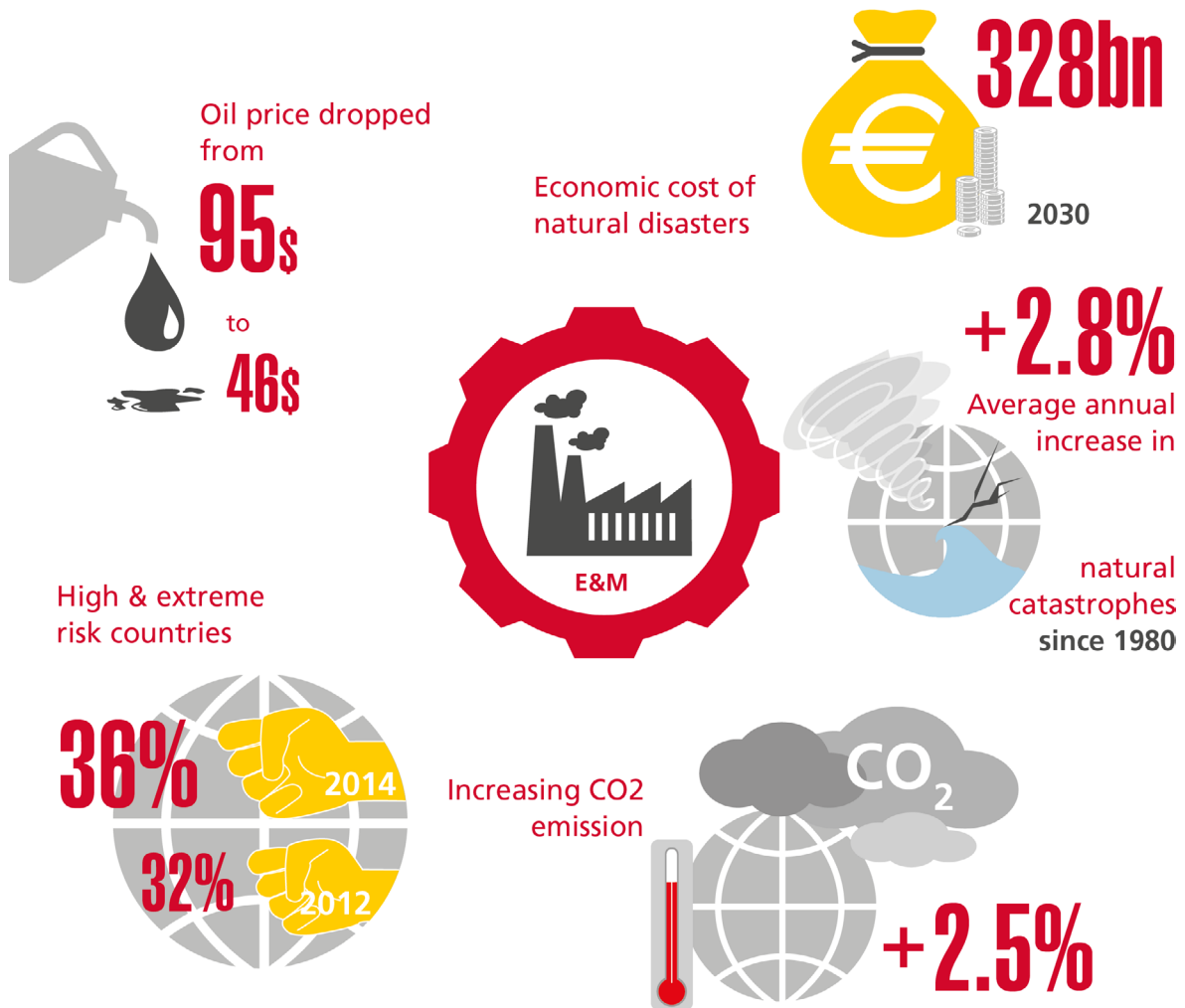
1.4 Volatility and Exogenous Threats

E&M companies expect that higher commodity price volatility, greater political instability, and an increased risk of being hit by natural disasters will characterize the business environment of the sector in the future. All of this will result in more uncertainty and less predictability in planning and decision-making processes.

Business leaders today are confronted with a situation of increasingly unpredictable resource supply. Market prices for key resources such as oil or iron ore are less related to supply and demand. In reality, factors such as speculation, trading activities, geopolitical interests, and the weather have a greater influence and this is likely to continue into the future. The result is higher volatility in commodity prices, as demonstrated recently by the oil price, which dropped from USD 95 in June 2014 to USD 46 per barrel only eight months later.

In addition, global E&M companies are increasingly exposed to ecological risks. Continued climate change is resulting in more frequent and more intense natural catastrophes such as flooding, storms, and droughts. In the last 20 years, 1.3 million people lost their lives due to natural disasters. This also caused major economic losses, especially in the most vulnerable regions of South Asia, Sub-Saharan Africa, and Southeast Asia (CRED 2015). By 2030, it is estimated that annual economic costs related to natural disasters could reach €328bn (IFRC 2014) with the root causes for this (particularly greenhouse gas emissions) being expected to increase even further, although at a slower pace.

GEOPOLITICAL AND GEOLOGICAL RISKS



Globally active E&M companies also report that they are increasingly having to deal with the risk of geopolitical disruptions such as political instability, protectionism, armed conflicts, and piracy. According to Maplecroft's research, the number of countries categorized at 'extreme' and 'high' risk has increased from 32% in 2012 to 36% in 2014 (Marsh-Maplecroft Political Risk Map 2013). While the overall number of armed conflicts has declined during the past decades, larger events that have previously been assessed as unlikely (such as the Ukraine Crisis or the war in Yemen) seem to occur more often as we go forward, making reliable planning more complex.



1.5 Labor Shortage

Many of the interviewed E&M leaders expressed concern that they may not realize all planned new business ideas, or even maintain current activity levels, because of a shortage of skilled labor.

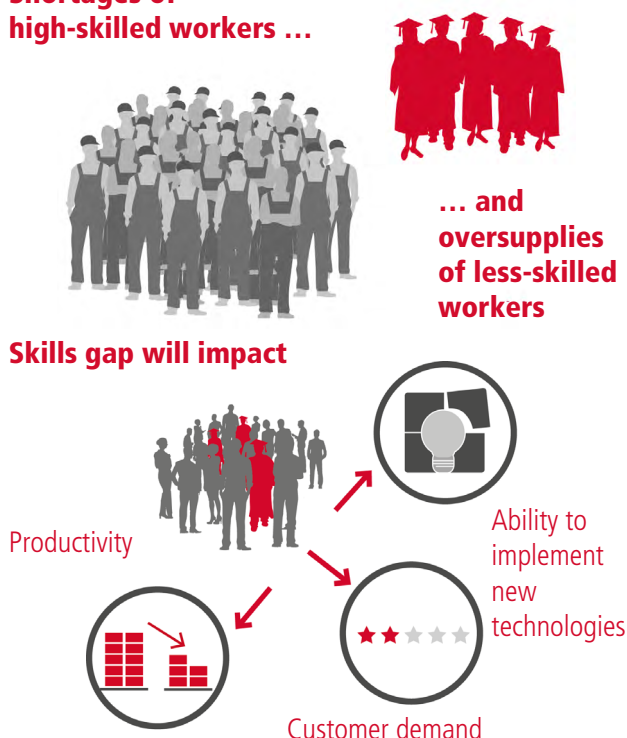
Today over a third of global companies across all industries report difficulty filling jobs due to a lack of available talent. In one of five cases, this is having a direct limiting impact on the organization's ability to meet client needs (Manpower Group 2013).

Looking ahead, Deloitte estimates that just in the US nearly 3.5 million manufacturing jobs will become vacant over the next decade. Of these, 2 million are expected to stay unfilled (Deloitte 2015).

Added to this, many companies will have difficulty replacing their retiring workforce, especially as the populations of industrialized countries are ageing quickly. Due to low birth rates and, simultaneously, the retirement of baby boomers, working populations (aged between 15 and 65) have started to shrink already this decade. Germany's working population, for instance, is expected to decrease by about 8 million people until 2030 – a loss of almost 15% (United Nations 2012).

LABOR SHORTAGE

Shortages of high-skilled workers ...



Many emerging countries will also be affected. Between 2020 and 2030, China's workforce will start to decrease by a staggering 16 million people until 2030 (United Nations 2012).

But the sheer size of the working age population is not the only significant factor companies should look at carefully. It is also the quality. Despite huge and growing working populations, countries such as Brazil, India, and Turkey rank among those countries from which the most acute shortages are reported (Manpower Group 2013). The same is true for Africa, where 83% of surveyed CEOs are especially worried about the availability of skilled labor, making this their most important concern (PWC 2014b). New expertise will be required in many E&M companies. With the increased use of robotics and automated processes, for instance, the nature of manufacturing work is changing and demanding ever-higher technological skills from workers.

Additionally an entirely new skill set will be needed – knowledge of 'me-chem-tronics', a combination of mechanical, chemical, and electronic systems. In light of a decreasing proficiency in math and sciences, with fewer people pursuing STEM education (science, technology, engineering, and mathematics), these skill sets will be harder to find. By 2020, McKinsey projects shortages of highly skilled workers around the world and an overpopulation of less-skilled workers (MGI 2012)².

“I think there is a danger. There is a lot of decline in manufacturing skill in the medium term in the Western world. The ability of manufacturing industries to attract really bright, talented young people into it has also somewhat eroded.”

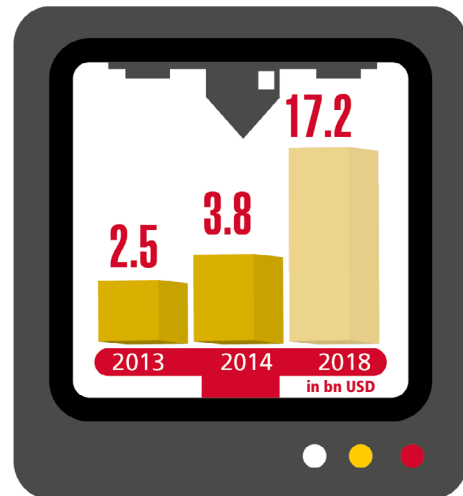
² For further details on the looming talent shortage within the supply chain, please also see DHL's study 'Solving the talent crisis: Five alternatives every supply chain executive must consider'. Online at: http://www.dhl.com/en/logistics/industry_sector_solutions/automotive_logistics/automotive_talent_whitepaper.html

With concurrent progress in the field of artificial intelligence (AI) and algorithms, and in combination with cloud computing, it will become possible to process and utilize ever-increasing amounts of data in real time and access it anytime and from anywhere. This will enable completely new business models for E&M companies (see chapter 2.3). AI will also play a key role in the development of advanced autonomous systems, such as robots and cars⁵.

Another emerging and potentially disruptive technology is 3D printing. Market numbers indicate that this technology is progressing rapidly, with an exponential increase in the range and quality of materials that can be processed. The global market grew from USD 2.5bn in 2013 to USD 3.8bn in 2014 (+58%) and, with an estimated CAGR of 45.7% until 2018, growth prospects remain strong (Canalys 2014).

Added to this, findings in the fields of nano- and biotechnology indicate a growing range of adaptive materials that can autonomously adjust their properties in response to external stimuli, such as thermal or chemical changes. Shape-memory alloys, for instance, can assume their original shape after a deformation, while composites will also gain in importance.

3D PRINTING MARKET IS GROWING



⁵ See also DHL's study on Self-Driving Vehicles: http://www.dhl.com/en/about_us/logistics_insights/dhl_trend_research/self_driving_vehicles.html

2. E&M SECTOR RESPONSES

E&M companies are already reacting to the trends outlined before and already proactively reshaping their industry. On the following pages, we describe the four major industry transformations anticipated in E&M over the next 10 to 15 years.

2.1 Intelligent Manufacturing

As outlined in chapter one, the conditions under which E&M companies produce and operate are subject to significant change. Shorter product lifecycles, changing customer demands, and growing product varieties require that production processes become more intelligent.

Enabled by technological progress, a fourth industrial revolution is about to take place⁶ – either labelled as Industry 4.0 (Germany) or the Industrial Internet of Things (USA). And even though many companies in the classic E&M industries produce small quantities of highly complex industrial equipment and will probably never have the same levels of automation as the automotive industry, the basic principles of a more intelligent production paradigm will become relevant in E&M.

It is expected that only in the German manufacturing sector, industry 4.0 can drive productivity by 5-8% within the next ten years, creating an additional 390.000 jobs and increasing manufacturing investments by €250bn. Moreover, according to a study by the Manufacturing Leadership Council and Frost & Sullivan, more than 50% of participants across all different industries expect that design and production processes will be fully digitized in the next five to ten years (Frost & Sullivan 2014).

The centrepiece of the intelligent production paradigm of the future is the smart factory. Here products will be finding their way independently through the production process. Equipped with cyber-physical-systems, machines and products will monitor physical processes, create a virtual copy of the physical world, and make decentralized autonomous decisions. Connected machines, work pieces, and systems will create intelligent networks along the entire value chain that can control each other autonomously.

“I anticipate that manufacturing processes will get faster, leaner and IT-rich, with really synchronized, automated parts and with equipment communicating.”

Centralized planning of all production steps in advance will become more or less obsolete. Intelligent industrial production machinery will no longer simply process products as programmed but must be able to gather and process information about orders and production in real time and adjust parameters such as compressive force and even complete production plans accordingly. And instead of being completely shut down for maintenance, production lines will be modularly organized using a ‘plug-and-produce’ principle.

As components will have a certain degree of self-awareness, they will also be able to self-optimize and to provide much more detailed information about factory status. All together, the vision is that production will be much more flexible – allowing the production of smaller quantities at reasonable costs – and will run almost completely autonomously.

Manual work processes will also be increasingly supported by technology. Augmented reality (AR)⁷ applications in particular are seen as likely to increase efficiency and re-design entire production chains. Moreover, AR will enable lower-skilled workers to perform more complex tasks. At Boeing, for example, mechanics have recently been equipped with special tablets to test the future feasibility of AR on the assembly line. Looking through a tablet, each mechanic can see the real-world torque box unit they are assembling enriched with digital parts, arrows, and instructions to supplement the real-world view (informationweek.com 2015).

⁶ 1st revolution (end of 18th century): introduction of water and steam-powered mechanical manufacturing facilities - 2nd revolution (start of 20th century): introduction of electrically powered mass production - 3rd revolution (start of 1970s): automation by use of electronics and IT (Source: Acatech 2013)

⁷ See also: DHL's study on Augmented Reality in Logistics (http://www.dhl.com/en/about_us/logistics_insights/dhl_trend_research/augmented_reality.html)

2.2 Sustainable Manufacturing

Many E&M businesses are responding to increasing sustainability requests and have already started to take important steps towards cleaner and greener manufacturing. Looking ahead to 2025, we anticipate a more widespread use of these approaches in the E&M sector.

The list of aspects within sustainable manufacturing is long, ranging from green product design and product lifecycle management to eco-efficient processes, fuel-efficient machines and vehicles, green purchasing, and a sustainable organization culture.⁸ Some of the most forward-looking initiatives for E&M companies are the use of renewable energies, energy efficiency, and sustainable products, as well as the introduction of new concepts such as cradle-to-cradle.⁹

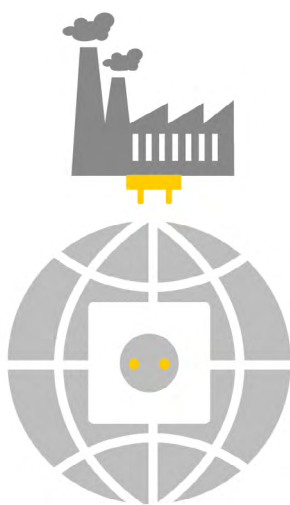
Industrial production alone is responsible for about 30% of the world's total energy consumption (IEA 2014). Most of this energy is provided by fossil fuels. At this stage, retailers are particularly at the forefront of installing renewables but manufacturers are about to join them. Until 2030, the renewable energy share in manufacturing could increase from 11% in 2010 to at least 15%. If further options for deployment are realized, it could jump to as high as 26% (IRENA 2014).

WORLD TOTAL ENERGY CONSUMPTION

Industrial
production
responsible for

30%

of world's
total energy
consumption



Another important aspect of sustainable manufacturing is energy efficiency. In recent years, especially since the high oil price era, many manufacturers have started to implement measures to reduce waste and energy use, such as replacing fixed drives in electric motors with variable ones. But larger savings potential remains untapped.

Globally, it is estimated that energy efficiency could reduce industrial energy use by 26 Exajoules per year by 2030 (IEA 2015), the equivalent of today's annual electricity consumption of the USA and China combined. The effect would be not only reduced emissions but also substantial cost savings. According to our E&M customers, consumers are driving this development as they increasingly select products according to sustainability performance criteria.

One E&M customer reported that fuel consumption has become more important than horsepower for his business customers. Added to this, early in the development process product designers are now considering waste reduction and planning for the future recycling of their products. For the longer-term future we expect a shift from end-of-pipe solutions to a stronger focus on product lifecycles and integrated environmental strategies. Also increased efforts will be made to create closed loop circular production systems and explore ways to withdraw products towards the end of their lifecycle in order to reuse valuable raw materials. Siemens, for example, has developed a product take-back program for its healthcare segment. In the USA alone, the amount of recoverable plastic, steel, glass, aluminium, and paper waste sent to landfills annually is estimated to be valued at \$11.4 billion (GreenBiz 2015), representing a significant loss of feedstock for new products.

⁸ For a complete list see, for example: Rehman & Shrivastava 2013.

⁹ Invented by Walter R. Stahel in the 1970s and popularized by William McDonough and Michael Braungart in their 2002 book of the same name, it describes production techniques that are not just efficient but are essentially waste free. In cradle-to-cradle production, all material inputs and outputs circulate in a perpetual cycle of production.

2.3 New Business Models

Today E&M companies are changing their business models as customers demand more value-add (contracting for capability), core markets become increasingly saturated, and product margins are under pressure.

We see a clear “Servitization”-trend towards more service-oriented business models (e.g., ‘power-by-the-hour’ programs in aerospace and aviation). Today, service-type activities already make up 30 to 55% of manufacturing employment (McKinsey 2012). More and more companies are offering after-market services or complete solutions that are closely coupled to the manufacturer’s products – examples include local customer services, development contracts, and the provision of spare parts or maintenance.

In many cases, the development of new service offerings is regarded as less risky and less costly than the development of new products. Demand for services is highest in capital goods industries. In aerospace and aviation, for example, maintenance can make up 50% of total revenues. Across the E&M sector, first and foremost in construction equipment, leasing and rental offers will gain in importance as customers are forced to reduce capital intensity. In India, one of the major future markets for construction equipment, demand for leasing could grow by more than 30% annually over the next few years (Project Vendor.com 2014).

Technology and smart data will also be key enablers for many new, service-oriented E&M business models. Smart product concepts such as predictive maintenance will become much more widely available. Siemens, for example, is testing a new service model for its power and gas customers in which service and payment are based on the most flexible and efficient use of a gas turbine (Siemens 2015b). And Caterpillar recently joined forces with Uptake, a provider of a dynamic analytics and insight platform, to develop an end-to-end platform for predictive diagnostics to its customers which monitors and optimizes fleets more effectively (PRNewswire 2015).

In general, E&M companies will slowly be shifting their business models from a B2B (business-to-business) to a B2B2C (business-to-business-to-consumer) model. Traditionally, manufacturers have focused on manufacturing and managing capacity.

In the future, we will see E&M companies expanding their business models along the value chain, focusing more on capabilities than capacity. This will bring manufacturers even closer to their customers, making intermediaries such as wholesalers, distributors, and retailers partly obsolete.

The combination of direct access to users, user data, and orders as well as new technological possibilities will allow E&M companies to move their business models from ‘to-stock’ to ‘to-order’, whether they are in the business of assembling, making, or engineering. Up until recently, manufacturing practices were mostly built around a to-stock model. According to a study by the Manufacturing Leadership Council and Frost & Sullivan, to-stock production continues to decline precipitously while to-order is regarded as the production model of the future (Frost & Sullivan 2013).

“*I think we will remain a manufacturing company at core. But probably what we will see in the near future is that the emphasis goes also into how to serve our customers so that we will be much more into the supply chain solutions, much more into the service business.*”

2.4 New Collaboration Models

Given the changing E&M environment, we expect E&M companies to rethink their relationships along the value chain, leading to more collaboration with suppliers and service providers.

Best practices can be found in the automotive sector which, during discussions with our E&M customers, was often quoted as the blueprint for the future of manufacturing. It seems that the E&M sector is perceived to be 10-15 years behind the automotive industry in many respects.

Yet E&M companies are now starting to apply a concept that the automotive industry already applies successfully: the formation of manufacturing clusters in key regions (KPMG 2014). In the aerospace and aviation industry, for example, clusters can be found in Poland, Mexico, and Canada already.

By concentrating business activities close to key suppliers, research institutes, universities, trade associations, and others in a single geographic area, all involved parties can aim to improve efficiency, effectiveness, innovation, and flexibility. The idea is to benefit from physical proximity by jointly using infrastructure, knowledge, and a shared pool of skilled labor.

The cluster trend also fits well with changes that are happening in innovation. Historically, internal R&D departments have been the main source of innovation. But there has been a shift away from this 'closed innovation' approach to a more open and interactive one. This is because it is increasingly complex to innovate, requiring collaboration with many different stakeholders such as suppliers, customers, and even competitors. And often it will be insufficient to look for partners only within the same industry.

The importance of cross-industry cooperation to combine complementary competences will play a leading role on the innovation stage of the future (BDI/Z_punkt 2011). Going forward, innovations will more often result from collaboration between two unrelated industries, such as IT and manufacturing.

A good example of this transformation in E&M is agricultural equipment, which is evolving from mechanical machines that can plough, seed, or harvest into precision high-tech farm machinery. Manufacturers such as Deere & Company have now teamed up with partners from the ICT industry to exploit new data analytics, software, and sensor technology.

MANUFACTURING CLUSTERS



3. SUPPLY CHAIN IMPLICATIONS & ACTION AREAS

Changes in the E&M business environment as well as the sector's responses have significant implications for the supply chain. The E&M supply chain status quo is increasingly being tested.

Typical performance indicators such as total cost, efficiency, quality, and delivery performance will remain important, of course. On top of this, business leaders will have to consider additional requirements to stay competitive.

3.1 Regional Supply Chains

As the gravity of global economic activity shifts, the supply chains of the future for E&M companies must adapt accordingly.

Doing business in emerging markets is not new for most E&M companies. Almost all E&M companies have, over the course of the past decades, moved at least part of their production to emerging countries as well as established capabilities to export there. But the export-centered approach has one significant drawback: long lead times.

As product lifecycles continue to shorten, demand from emerging markets grows, and local competition increases rapidly, time-to-market has already become a crucial success factor. This is why production will have to move closer to the actual customer, and future supply chain concepts must adapt accordingly.

To serve these needs, supply chain models of the future will reflect a global network of more regionalized supply chains, as the majority of products will be produced or finally assembled and sold in the same geographic region. Supply chains will have to be increasingly differentiated by region, and it will be critical to success to both leverage global reach and size, and meet local requirements.

“Local sourcing is becoming an issue. Over time we are going to stop the nonsense of building a component in China and then putting it onto an airplane with heavy fuel burn to fly it around the globe. It is environmentally a nonsense. It is economically a nonsense.”

DRIVERS



Shifting Markets



Customization & Convergence
of B2B and B2C



Compliance and Sustainability
Requirements



Volatility and Exogenous Threats



Lack of Skilled Labour



Sustainable Manufacturing

REGIONAL SUPPLY CHAINS



For each region (or even country), E&M companies will have to come up with tailored supply chain solutions and decide on issues such as who should build and own the logistics infrastructure, and whether implementation should be done in-house or with the support of a logistics service.

“We are already active in Africa, but we have to accelerate there. Our supply chain has to grow everywhere around the world.”

These new supply chain concepts not only help to overcome the time-to-market challenge but also ensure a high level of flexibility to deal with changes in regulatory requirements and demand patterns. They also offer substantial environmental benefits, as they significantly reduce emissions.

ACTION POINTS FOR E&M COMPANIES



Align future business and production strategy with supply chain strategy



Revisit supply chain setup (undertake a supply chain health check)



Develop strategies for supply chains per region / markets



Assess options, then make or buy logistics services for every region / market



3.2 Resilient and Compliant Supply Chains

There is a simple answer for future E&M supply chains to rising volatility and uncertainty in the business environment – resilience. The big challenge, though, is how to achieve this.

In the past, supply chains have often been designed with the ultimate goal of minimizing costs while maximizing customer benefits. We expect that to change. Future supply chains have to be more resilient and must be built around risk management. If they don't, companies could encounter significant losses in brand value, profits, and share price. Research shows that larger disruptions to the supply chain impact company share price by 7 % on average (World Economic Forum 2013).

Resilience includes supply chain planning and operations, as well as management. It should be based on maximum visibility, process alignment, and cooperation between all supply chain partners, facilitated by a risk management culture and based on clear performance requirements.

“Supply chains will have to be much more resilient. We have to be able to react quickly to the increasing volatility.”

The consideration of potential supply chain risks should start as early as the R&D process for a new product and, later on, must continue for production planning and supply chain design and management. For existing supply chain networks, contingency plans will become imperative and it will be essential for supply chain managers to understand and map critical paths or pinch points within the supply network, reaching as far as suppliers and their suppliers as well as to downstream customers.

E&M companies will be increasingly forced to re-examine the efficiency versus redundancy trade-off. The current design paradigm of longer and leaner supply chains, often in combination with single sourcing, could prove to be a hindrance in the future. From a resilience perspective, it is preferable to have multiple suppliers and alternatives at hand, as well as the strategic disposition of additional capacity and/or inventory.

DRIVERS

	Shifting Markets
	Compliance and Sustainability Requirements
	Volatility and Exogenous Threats
	Intelligent Manufacturing
	New Collaboration Models

A changing risk landscape might even influence the choice of location for manufacturing sites. Stable and low-risk environments might gain in relevance, even trumping those with lower wages but higher risks. And as many supply chains are evolving into digital supply chains, companies will also need to focus on digital resilience to cyber-attacks.

To manage supply chain disruptions in a timely manner, it will be crucial to have early access to all relevant information. If you know, for example, that a particular road is blocked following an earthquake, you will be able to reroute, avoiding transportation disruption and potentially moving ahead of a competitor. The same is true for early information on potential strikes

ACTION POINTS FOR E&M COMPANIES

	Risk assessment of existing supply chains
	Implement an incident monitoring tool
	Improve supply chain visibility end-to-end (consider control tower concepts)
	Ensure agility, appropriate redundancy, and contingent capacity
	Improve inventory management to avoid higher security stock
	Assess collaboration options with all parties involved in the supply chain

3.3 Sustainable Supply Chains

“Sustainability will more and more impact our sourcing criteria. Today it might be less than 5%. Maybe in five years it's 20% or 25%.”

Making supply chains more sustainable must become a major focus for E&M companies in the years ahead.

In a survey by Accenture, 88% of interviewed CEOs of global companies mentioned the supply chain as an area of specific importance in their sustainability strategy (Accenture 2012).

One major aspect of sustainability in the supply chain is sourcing and purchasing. Companies will increasingly select their suppliers based on their environmental performance, with a direct impact on supply chain design, structure, and planning. Unfortunately, many manufacturers have hit a major roadblock in this area in recent years, as they only have direct control over a fraction of the sourcing. In many cases more than 50% of a product's carbon footprint comes from suppliers ('Scope 3 emissions') (Accenture 2012).

Many E&M companies don't have enough visibility of their actual supply chain carbon emissions, with almost 50% of companies surveyed by KPMG having only sufficient knowledge about their immediate Tier 1 suppliers and almost no information about Tier 2 and beyond (KPMG 2013). In future, E&M companies will be forced to increase this visibility along the supply chain in order to improve environmental impact.

DRIVERS



Shifting Markets



Compliance and Sustainability



Customization and Convergence
of B2B and B2C



Sustainable Manufacturing



“The green agenda might become more important than the lead time. It could be that we move to rail solutions and move away from air shipments, even though there will be an impact on lead time to customers.”

Transportation-related activities are a big lever, too, as between 5 and 15% of a product's carbon emissions are related to either inbound or outbound moves. Supply chain managers will have to look at their supplier network and chose by proximity in order to reduce transportation distances. This will further facilitate the trend towards local sourcing and consolidation of production. And it will be crucial to consider environmental aspects of transportation modes to become more eco-efficient.

Changes in environmental legislation, product design, and consumer behaviour will also impact supply chains. Manufacturers are increasingly asked to recycle their products, for instance due to the WEEE directive¹⁰, or to aim at re-using products or raw materials. With this, reverse logistics gains in importance. The expansion of repair services also increases the demand for return solutions. And changes in material selection (e.g., the use of more biodegradable plastics) may require entirely new supply chains to be established.

ACTION POINTS FOR E&M COMPANIES



Establish carbon reporting end-to-end along the supply chain (including your suppliers' suppliers)



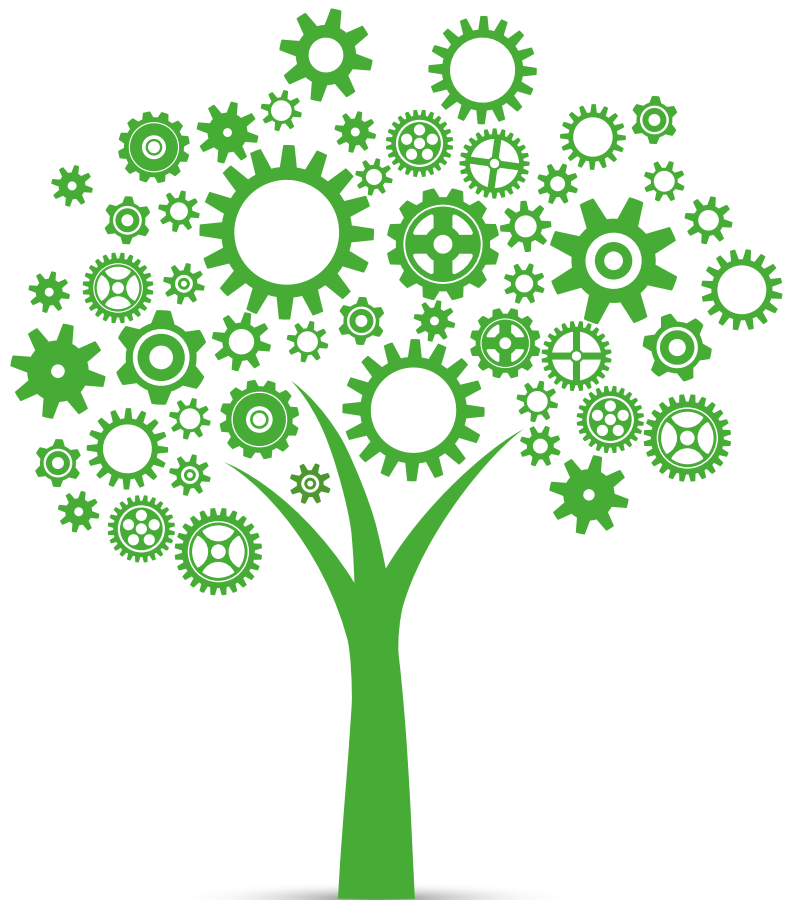
Identify levers to improve supply chain eco-efficiency



Assess options for transportation mode shifts such as intermodal transportation and new modes (e.g., China-Europe rail transportation, multi-modal)



Establish strategy for reverse and waste logistics



¹⁰ The WEEE Directive is the European Community directive on waste electrical and electronic equipment that aims to decrease electrical waste and increase its environmentally friendly disposal.

3.4 Connected and Integrated Supply Chains

Vertical integration of E&M companies will lead to highly integrated supply chains end-to-end –including the very attractive but complex after-market supply chain-, and new technologies will build the basis for managing these models in real time.

With increased deployment of cyber-physical systems in logistics and production contexts (such as RFID-tagged production equipment, work pieces, and parcels), E&M companies will generate data about basically everything in real time – from the position of single items to overall equipment performance and the status of customer- specific configurations.

Omnipresent connectivity and transparency will not be restricted to company-internal processes. All steps of the future supply chain will be integrated, from inbound- to- manufacturing and in-house production flows to

“I believe that data, data management, the cloud and all that will enable a fully integrated end-to-end supply chain much faster than we think. People are saying that already. But we are in an infant stage.”

“With Industry 4.0 we will see much more synchronized delivery and small packing. Suppliers will have to be much more agile, flexible and nimble.”

distribution to the customer. Tracking and controlling the end-to-end flow of materials (from suppliers, into the factory, and out to customers) will significantly increase supply chain visibility and will become critically important in the context of Industry 4.0. This will become possible only with complete transparency of flows and the seamless integration and automation of physical processes along the whole value chain.

The virtualization of the supply chain will also significantly increase the anticipatory capacity of the whole system. Alerting tools, analytic tools, and algorithms will make it possible to quantify and predict changes in the system (e.g., demand fluctuations, machine breakdowns, and supply bottlenecks) earlier and more accurately.

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Shifting Markets



Customization and Convergence of B2B and B2C



Volatility and Exogenous Threats



Intelligent Manufacturing



New Collaboration Models



New Technologies

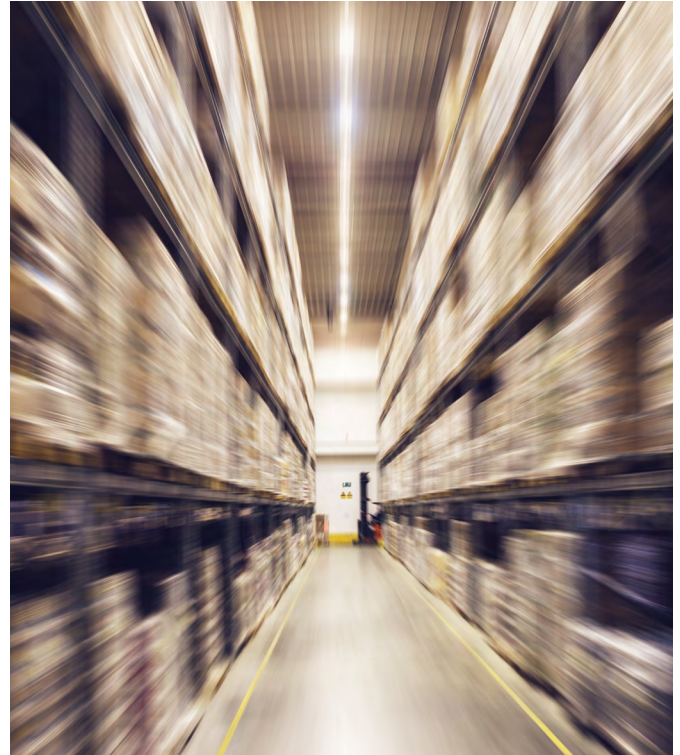


New Business Models

“What we are starting to work on, and that may develop, is to integrate our tier 2 suppliers into our network. How could our suppliers’ suppliers play a role in our global freight? We started that in Brazil and we see significant improvements in terms of costs and everything.”

The digitalization of the supply chain is increasingly becoming a business necessity for E&M companies. As outlined above, B2B and B2C business practices are converging and at the same time business partners and suppliers now expect digital services such as order management, traceability, and product configurators. Supply chain leaders will make increasing use of technologies such as cloud computing to manage orders, shipments, and inventory across the entire supply chain, aiming to further eliminate delays and improve service levels.

But we are not there yet. Achieving this high level of transparency will be critical for more collaboration, better planning, improved efficiency, and shorter response times. To realize a connected and integrated supply chain architecture, more and more manufacturers are commissioning a lead logistics service provider (LLP) to orchestrate the supply chain via a control tower concept. Within the supply chain tower concept, and acting as a guide, the LLP has access to all information and constantly monitors and assesses the condition and performance of the entire supply chain. Once again, the automotive industry can serve as a useful role model for E&M companies in this respect.



ACTION POINTS FOR E&M COMPANIES



Assess options to improve supply chain visibility end-to-end



Drive collaboration along the supply chain, including suppliers and customers



Review or create after-market supply chain setups



Assess control tower and LLP concepts

3.5 Agile and Responsive Supply Chains

Future supply chains must be designed to be agile, fast, and efficient, enabling the profitable production of smaller batches of customized products, dealing with unpredictable variations in demand, and being able to respond more quickly to disruptions.

The growing demand for customization is regarded as a challenge for supply chains and significantly increases the demand for greater flexibility. Allowing customers to customize products effectively means that manufacturers will have to handle a greater number and variety of assembly steps with more different parts. From a supply chain perspective, this means more suppliers, higher inventory levels, and in general greater complexity.

In addition, with the switch in approach from build-to-stock to build-to-order in the E&M sector, supply chains will have to adapt quickly to changes in demand to deal with unsteady flows.

“LLP solutions will increase as warehouse operations will change. Some parts of the manufacturing process will take place at the warehouse, as part of a late-postponement strategy to be able to react to increasing customization demands.”

Leading manufacturers are increasingly applying an anticipatory support model, managed by a lead logistics provider (LLP) to deal with these requirements. In this model, the LLP provides flexible capability in maintaining inventory stock levels, has the visibility and data to anticipate what will be moving when and where, and has sufficient logistics capacity to do so.

Warehouses will no longer be about managing stock alone. Final assembly could be done here or in the distribution center with in-house or logistics service providers enabling product customization late in the production process. 3D printing could also increase the agility and responsiveness of supply chains. In particular, infrequently used spare parts could be produced on-demand and on-site in future, driving shorter lead times and lower inventory levels.

DRIVERS



Shifting Markets



Volatility and Exogenous Threats



Intelligent Manufacturing



New Collaboration Models

ACTION POINTS FOR E&M COMPANIES



Assess control tower and LLP concepts



Investigate postponement strategies and 3D printing options



Improve inventory management to avoid higher security stock



Consider inbound-to-manufacturing concepts

CONCLUSION & OUTLOOK

The trends and sector responses highlighted in this white paper underscore the need for E&M supply chain concepts to be adapted and even redesigned in the future.

Going forward, we believe supply chains will play an even more important role in the E&M sector – they will become a key value driver for E&M companies. New supply chain concepts will enable E&M companies to differentiate themselves in the market and stay competitive. Flexibility and agility will increase customer satisfaction, enable more service-oriented business models, and ensure resilience. Connected and integrated supply chains will drive efficiency and increase stakeholder value. The sustainability requirements of different stakeholder will be satisfied, too.

At the same time, numerous trends and sector responses put pressure on supply chains as they increase complexity. A broader and more customized product portfolio implies more parts, more suppliers, and the challenge of higher inventory levels. Closer collaboration along the E&M value chain leads to more interfaces. And a modularized manufacturing setup requires even more flexibility and agility in the supply chain. Added to this, entering new markets creates new supply chain challenges in terms of setup, compliance and resilience.

In these conditions, the diversity of the E&M sector represents an opportunity. Many E&M companies are already successfully applying new supply chain concepts, and these can be leveraged across the entire E&M sector. More than this, well-established concepts from other sectors are ripe for application in E&M, especially concepts from the automotive and technology industries.

Engaging with experienced logistics companies such as DHL that are active in multiple sectors can provide the support required to successfully transfer knowledge within and across sectors.



To watch our DHL White Paper insight videos, please visit our White Paper website at: www.dhl.com/emtrends_whitepaper

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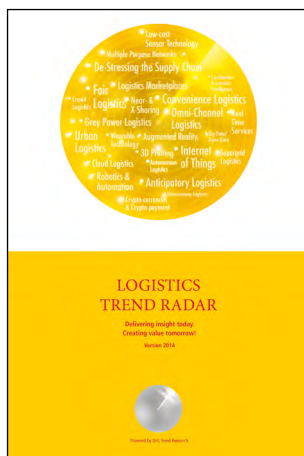
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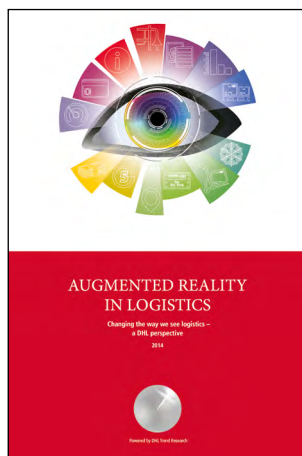
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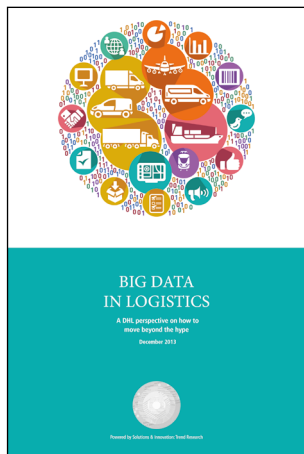
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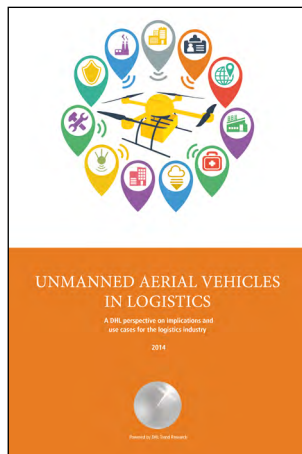
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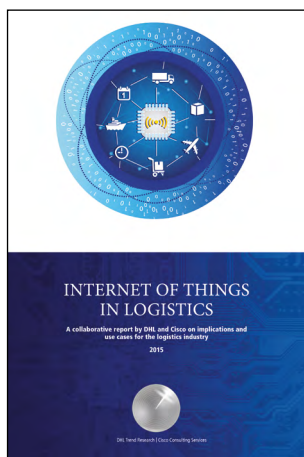
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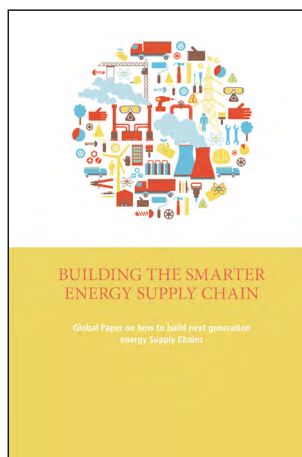
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