McKinsey&Company

Huge value pool shifts ahead – how rolling stock manufacturers can lay track for profitable growth

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Contents

Key insights

The global rolling stock industry is on the verge of fundamental shifts. Over the last 12 months McKinsey has conducted in-depth research, including more than 50 interviews with industry experts ranging from rolling stock manufacturers and suppliers to rail operators as well as scientific institutions. We have used the findings from this to create a comprehensive picture of the current and future state of the industry, and to sketch a strategic road map for rolling stock OEMs.

Our findings are that nine key trends will significantly shape the future of the global rolling stock industry within the next decade, along the three dimensions of industry conduct, customer landscape, and technological change:

Shifts in industry and competitive landscape. The global rolling stock industry is under consolidation pressure given the large overcapacity issues that it has long been plagued by. The recently created Chinese manufacturer CRRC has emerged as the dominant market player across most segments and provides global products and services at a highly competitive price level. Moreover, the value chain contribution of suppliers is also gaining in importance.

Changes in demand and customer landscape. In the future, the key area of market growth will be urban transport, particularly in emerging markets. However, we foresee only moderate overall real-term growth in new vehicle sales. In parallel, the traditional customer landscape is shifting towards more cost-/return-oriented customers, such as financial investors, and the financial health of rolling stock OEMs will become a decisive factor in bidding successfully for large-scale and complex rolling stock projects in the future.

Technology-driven disruption and growth opportunities. New offerings from the digital space and data analytics are increasingly available and enable traditional OEMs to tap into the service business with scalable and targeted solutions. In addition, energy efficiency considerations are challenging OEMs to upgrade their technologies consistently and offer refurbishment solutions. Autonomous rail operation is just around the corner as well and OEMs need to prepare their portfolio and product platforms for its arrival.

In an industry where a large share of value chain activities are covered by parties other than OEMs, it is important to look specifically at the OEM value pool as opposed to a more general focus on the overall revenue pool. We define the OEM value pool as the total revenue pool less goods and services purchased by OEMs.

We expect the global rolling stock OEM value pool to grow in total size:

- The OEM value pool in new vehicles is anticipated to remain relatively constant in absolute terms through to 2025, leveling off at EUR 19 billion p.a. (own value pool, while total revenues are EUR 50 to 60 billion p.a.).

- The OEM value pool in the after-sales and service segment is predicted to grow by around 40 to 50 percent to EUR 19 billion. This shift in the OEM value pool towards the after-sales and service segment will mostly be driven by new business models and solutions from the digital space and service data analytics, such as predictive maintenance and real-time monitoring.

The character of the global rolling stock business is therefore changing for OEMs. The business is shifting from a largely product-only business towards a lifecycle business. The value pool share for OEMs in this lifecycle business will no longer mostly come from selling new vehicles, but will essentially be split between selling the product on the one hand and servicing and maintaining it over its full lifecycle on the other hand. More importantly, this shift in the OEM value pool can contribute to sustaining long-term profitability for OEMs, which can traditionally earn higher margins in the service business than in the asset-intense and complex new vehicles business. The growth in profits may thus even outperform the value pool increase.

Despite moderate real-term market growth, the OEMs' core segment of new vehicles will remain under pressure from various sources. Suppliers are expected to bite into the OEM share of the value chain, and price erosion in the mid term is likely due to significant global overcapacity and increasing international competition.

There is certainly no standardized approach to adapting the current business model of OEMs so that they can capture the new growth potential effectively. However, our observations of players in the rolling stock industry – and in adjacent industries that have successfully adapted their business model to tap into new value pools, particularly in the service business – reveal a set of approaches and perspectives that have proven effective, and that aspiring OEMs might adopt. In particular, we recommend that they consider the following four areas:

- Strengthen their service business. To capture the growth potential, rolling stock OEMs need to increasingly focus on strengthening their service offerings, including big data and advanced analytics solutions, to gain market shares in service from rail operators.

- Tailor sales activities to the new customer landscape. Rolling stock OEMs need to tailor sales to a more heterogeneous customer landscape, including the growing base of financial investors, leasing companies, and private rail players.

- Focus on cost efficiency. Established OEMs need to produce at lower cost in order to be price competitive – especially in growing emerging markets.

- Leverage partnerships. OEMs should evaluate opportunities for further cooperation across and beyond the industry in order to form scalable ecosystems and profitable alliances.

Introduction

Today's industries are changing dramatically, triggered by developments in emerging markets, the accelerated rise of new technologies, regulation, and shifts in customer structure and preferences. The rolling stock industry marks no exception.

Most industry players and experts agree that the triggers mentioned above will reinforce and accelerate one another. Yet although there is widespread agreement that game-changing disruption is already on the horizon, there is still no integrated perspective on what the rolling stock industry will look like in the near future as a result of these trends.

This publication aims to shed light on the imminent changes, make them more tangible, and provide answers to questions that are looming large in the industry:

- What forces are shaping the current industry structure for rolling stock?
- How will the customer landscape in the rolling stock industry evolve over the next decade, and what implications will this have for OEMs?
- How will the business model and value pool of OEMs be impacted by new technology, digitization, and big data solutions?

In discussing the sector's recent, current, and imminent key trends, we draw upon proprietary analyses, our industry expertise, and insights from client discussions.

We will also quantify the implications of these trends and highlight the shifts they will lead to in the value pools for manufacturers and suppliers over the upcoming decade. Based on the expected shifts, we identify associated key challenges and growth opportunities for rolling stock OEMs in the fields of new vehicles as well as after-sales and services.

This paper concludes with a set of pragmatic recommendations on how rolling stock manufacturers can best capture the new growth potential and prepare their business models for future success.

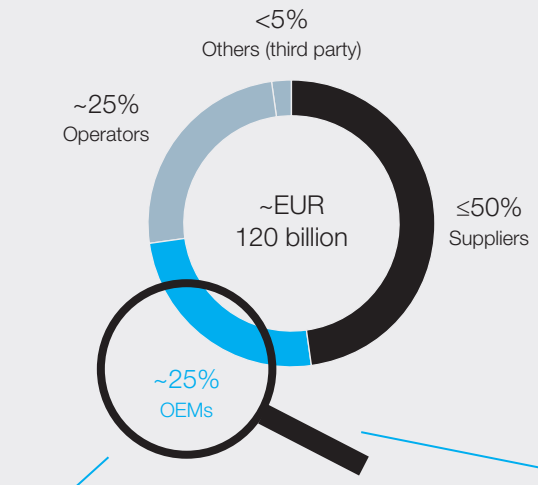
I. Status of the industry

The global rolling stock industry for new vehicles and after-sales, including services, currently generates revenues of around EUR 120 billion per year (Exhibit 1). The major players are the vehicle OEMs and suppliers of components and parts. In addition, railway operators and third-party service shops are predominantly responsible for maintenance of the vehicles.

OEMs are currently capturing roughly a quarter (approx. EUR 30 billion annually) of the global rolling stock value pool, while suppliers tap almost half the value. The remaining quarter is mostly under the control of rail operators and some third parties who perform maintenance.

Exhibit 1: Total rolling stock market size

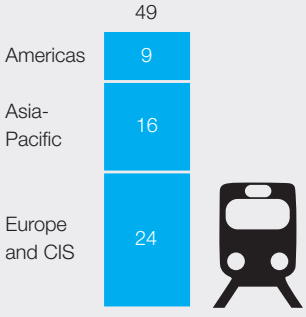
Revenues and value pool by player (new business and after-sales, including services)



New business
EUR 50-60 billion
OEMs: EUR 15-25 billion
Suppliers: EUR 30-40 billion

After-sales, including services
EUR 60-70 billion
OEMs: EUR 10-15 billion
Suppliers: EUR 15-25 billion
Operators: EUR 25-35 billion

Geographical split
No. of OEMs (>EUR 50 million revenue)



OEM employees globally
(excluding employees at suppliers, rail operators, etc.)

>400,000

Source: SCI; UNIFE; company information; McKinsey

The OEMs' vehicle portfolio is large. Besides the general classification as shown in Exhibit 2, very complex local requirements and certification standards often result in small product series, sometimes with fewer than 100 vehicles in the same series.

This often leads to high complexity in the production process as well as to challenges for maintenance in terms of always having the right capabilities and spare parts at hand. Additionally, product data management remains an ongoing challenge because of the high degree of individuality of each vehicle.

Exhibit 2: Rolling stock is a complex product space

Source: McKinsey

II. Overview of trends in the global rolling stock industry

To provide insights into the changes ahead and how they will affect OEMs, the industry landscape, and the overall value chain, we have identified nine trends along three key dimensions:

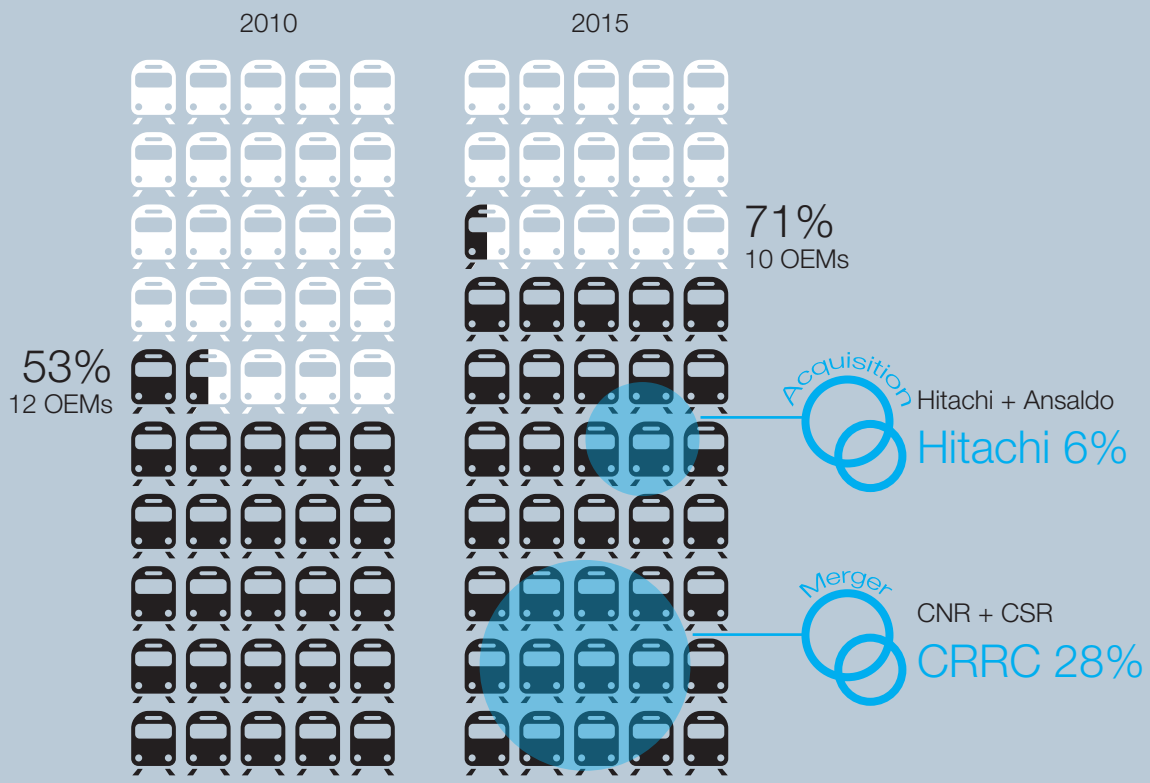
A: Shifts in industry and competitive landscape (A1 to A3)

B: Changes in demand and customer landscape (B1 to B3)

C: Technology-driven disruption and growth opportunities (C1 to C3)

Top OEMs' market share has clearly increased

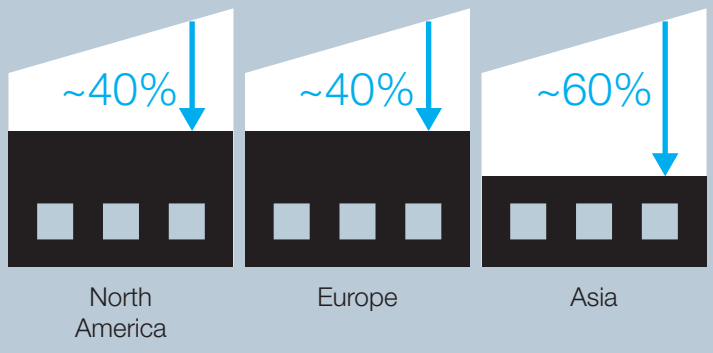
New vehicles business



Source: SCI; UNIFE; McKinsey

Dramatic overcapacity in all geographies

Estimated utilization gap of rolling stock factories



Source: McKinsey

A1 The rolling stock industry is facing heavy consolidation pressure due to large global overcapacity

Over the last five years, today's top 10 OEMs increased their market share from 53 percent in 2010 to 71 percent in 2015. Key industry players are increasingly engaging in M&A transactions and growing in size.

- The 2015 merger of the two Chinese rolling stock OEMs, CNR and CSR, created CRRC. The new company is the market leader across almost all market segments, and will thus play an important role in the industry in the years ahead (also see trend A2).

- Hitachi acquired Italian rolling stock manufacturer Ansaldo Breda, strengthening its footprint especially in Europe.

This phase of significant consolidation includes both horizontal as well as vertical integration moves. Small and medium-sized incumbents face increasing pressure and are often either taken over or exit the market. A takeover example is the sale of Vossloh's tram and heavy diesel locomotive business to Stadler in 2015. The remaining business of smaller diesel locomotives based in Germany is currently for sale, with a deal expected to be closed by 2017. As an example for a market exit, Voith stopped manufacturing locomotives in 2014, only a few years after entering the market.

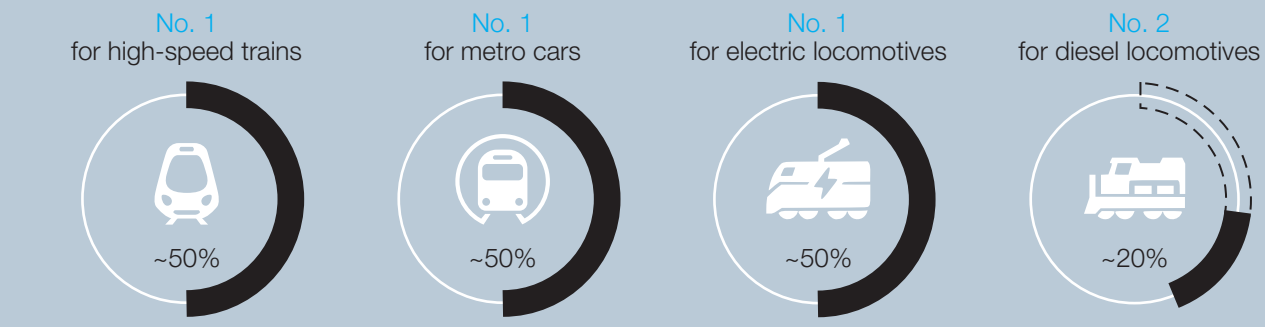
The underutilization of production facilities in all geographies may force additional action, with an estimated unused capacity of around 40 percent in factories in North America, 40 percent in Europe, and 60 percent in Asia. Further consolidation among the top players is seen as a likely scenario. In an analysis of Chinese outbound activities, McKinsey identified several approaches to foreign M&A and their clear characteristics, including the following:

- China M&A is at a historic high. Within Asia, China represents around half of the deal volume – higher than the next three countries combined.

- The typical integration approach is "light touch," i.e., leaving management in place, avoiding disruption to the acquired business, seeking selective synergies, and avoiding broad-based integration.

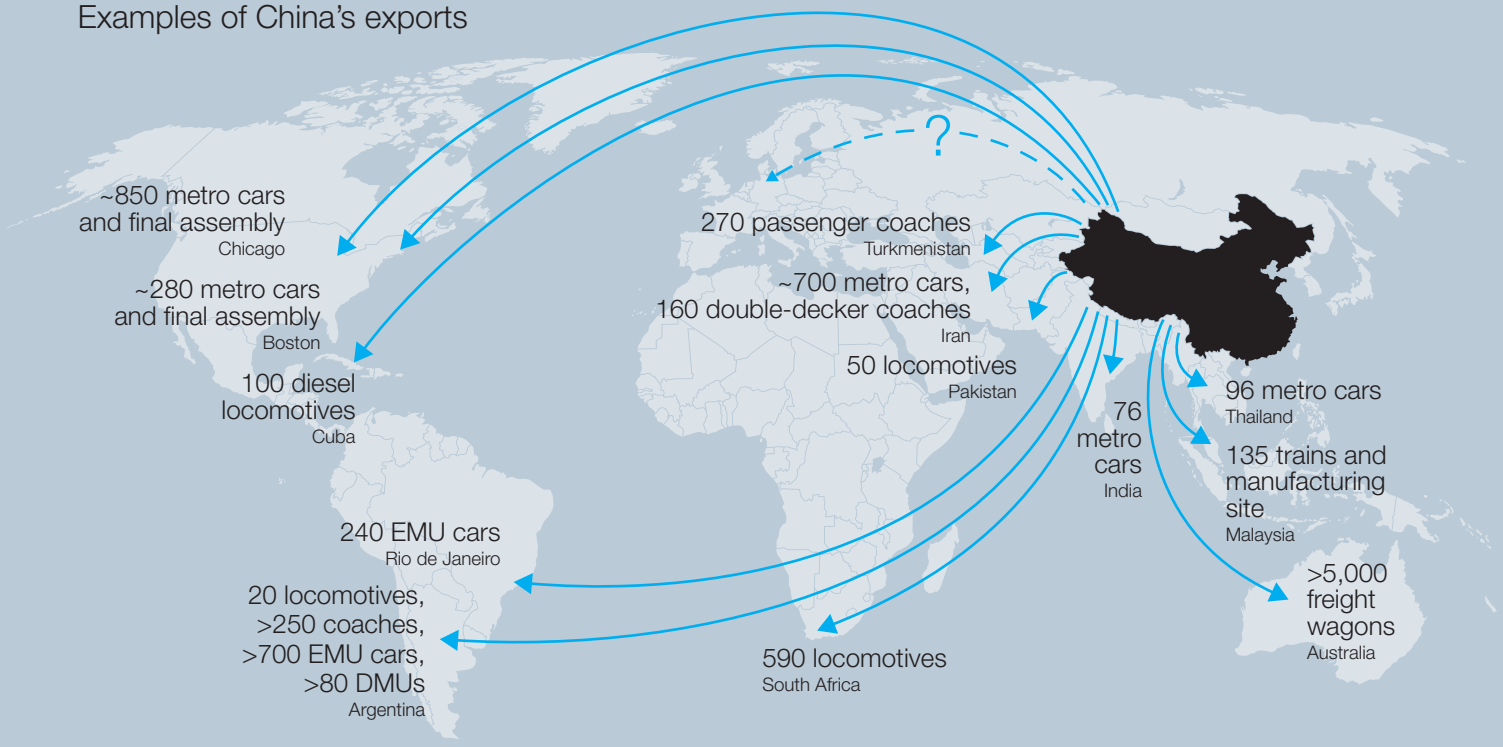
- Chinese companies are reluctant to make "buy-to-fix" acquisitions, as few are likely to have sufficient managerial resources to turn around a struggling asset in a foreign market.

China Railway Rolling Stock Corp. (CRRC) is the no. 1 player in many new vehicle segments



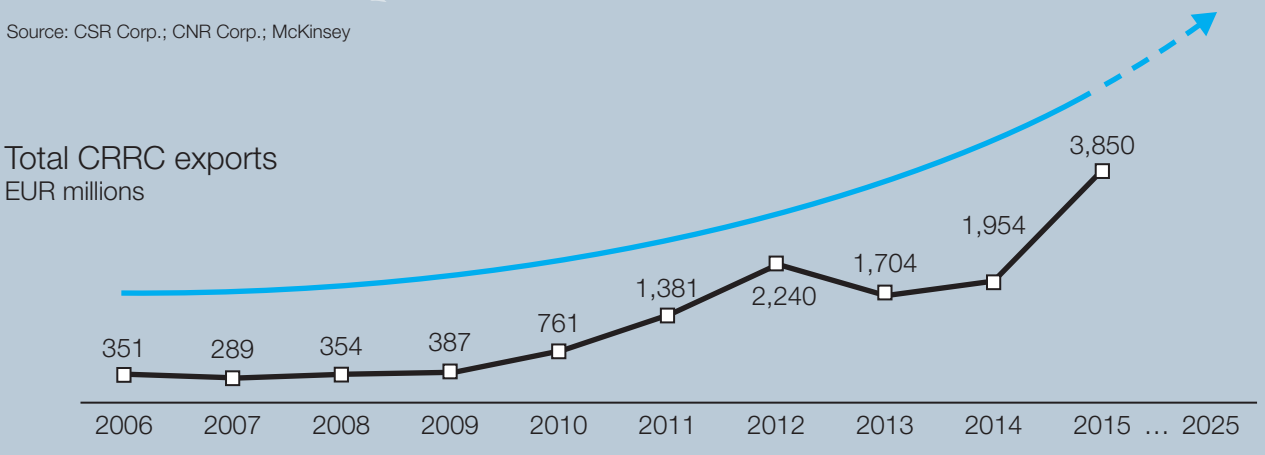
Source: SCI; UNIFE; McKinsey

Examples of China's exports



Source: CSR Corp.; CNR Corp.; McKinsey

Total CRRC exports
EUR millions



Source: Annual reports

A2 The Chinese industry leader is tackling export markets with rolling stock and beyond, resulting in great price pressure

The consolidation move between CNR and CSR leaves the new combined company China Railway Rolling Stock Corp (CRRC) as the undisputed industry leader, with revenues of around EUR 30 billion in 2015. CRRC's dominance is evident on multiple fronts: CRRC is at least twice as large as its biggest global competitor, and the company is no. 1 for high-speed trains, electric locomotives, and metro cars, and no. 2 for diesel locomotives. Currently CRRC focuses mostly on new vehicle business and has a limited after-sales business.

With an expected decrease in openings of dedicated, high-speed passenger lines from approx. 10,000 km in 2013 down to only approx. 3,000 km in 2020, the Chinese market for high-speed trains, their past growth segment, is becoming increasingly saturated. CRRC's capacities, however, are designed to serve historic peak demand levels. The company will therefore need to actively seek out business opportunities beyond the Chinese domestic market to improve its utilization levels, which are currently below 50 percent in many segments.

CRRC will clearly strive to tackle further export markets across the globe, most likely entering at a highly competitive price point (press reports suggested that recent tender offers were around 15 to 25 percent below the price of the nearest competitor). China's political environment has strongly supported the export ambitions of CRRC. Powered by this backing, the manufacturer has defined a strategy termed "High-speed rail going out," which according to CSR's 2014 annual report "(…) plays a strong role in promoting the export of high-speed trains and even high-end rail transport equipment. (…)." Together with very generous financing agreements backed by the Chinese government, several nations have shown interest in projects. But there have also been setbacks. For example, after winning a large high-speed rail contract in Mexico in 2014, the agreement was withdrawn in 2015.

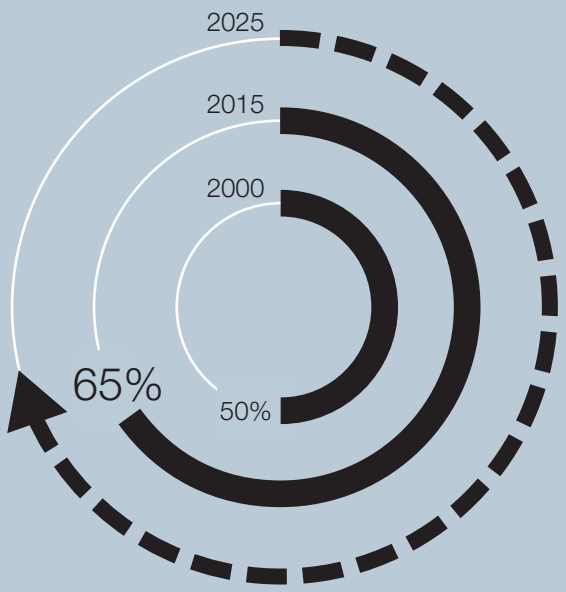
International partnerships have also helped the Chinese OEM to close the technological backlog in recent years, making their products competitive in international markets. Since 2005, Chinese players have consistently built up their export reputation and realized more than 70 large projects – primarily in emerging markets such as Asia-Pacific, South America, and Africa, but also in developed markets such as the US (the Boston and Chicago metro fleet renewal programs, for example).

CRRC's latest stretch of successful international bids includes being awarded the contract to provide at least 850 metro cars for the Chicago Transport Authority. CRRC won with a price advantage of approx. 15 percent according to press reports. The deal is valued at approx. USD 1.3 billion, and includes setting up a local final assembly plant in Chicago.

CRRC's large market share challenges other OEMs in their current positions. Expectations are therefore that its competitors will increasingly concentrate on cost efficiency and continue moving production to low-cost countries so as to remain capable of competing at an attractive price level and securing profitability.

Suppliers are gaining importance due to their increasing share in the value chain

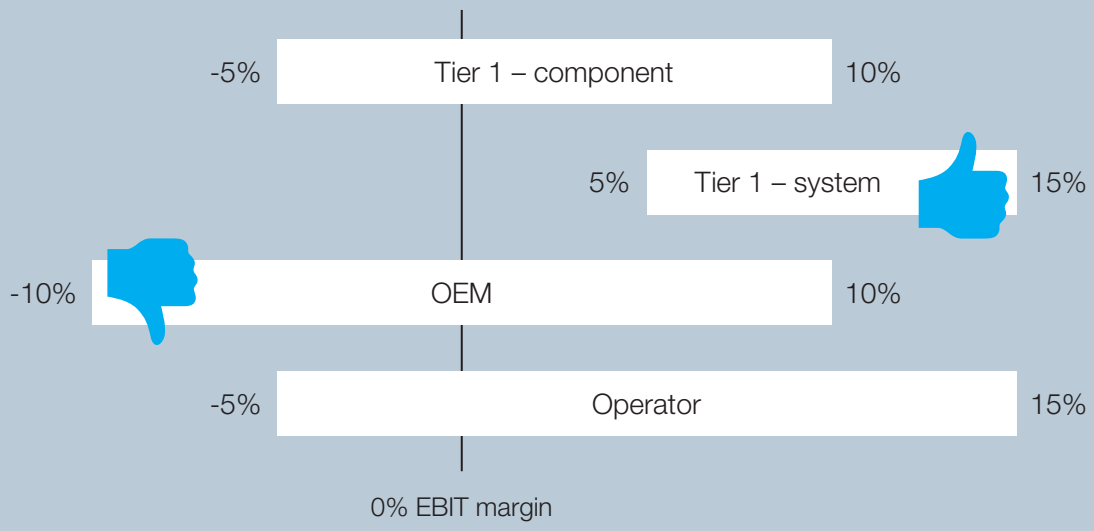
Share of suppliers' value chain activities in the rail industry



Source: Expert interviews; McKinsey

Tier-1 suppliers take the lion's share of value chain profits

Typical range of EBIT margins



Source: Amadeus; McKinsey

A3 Tier-1 suppliers are capturing an increasing share of the value chain and profits due to limited competition in core components

Tier-1 suppliers are capturing the lion's share of the rolling stock value chain: currently around 65 percent of the value chain in the new vehicles business is covered by suppliers. This trend has grown over recent years.

Suppliers are often able to achieve profit levels of 10 percent EBIT margin and above, while OEMs struggle to earn significant profits (with an average EBIT margin level of some 3 to 4 percent). First of all, this is due to suppliers' clear USP and limited competition among suppliers resulting from the fact that there are only a few specialized players in each subsystem (e.g., braking systems). Moreover, high R&D expenditure is required to sustain a fast development pace in high technology.

High-level decomposition analysis suggests that some components will likely remain OEM in-house parts: control, diagnosis, safety, and propulsion systems, for example, as well as core engineering. While some components are already largely outsourced today, such as wheel sets, braking systems, and the interior, suppliers are likely to increasingly take on additional components such as the body, connectivity systems, and potentially application engineering.

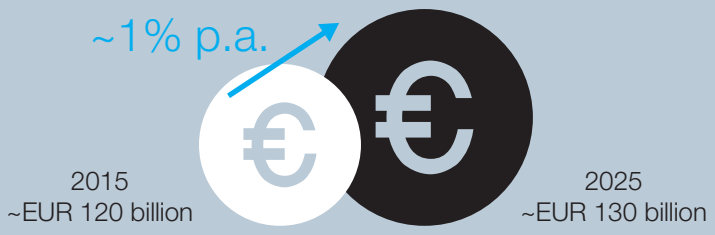
Suppliers have limited attractiveness as M&A targets for OEMs. This is based on the hypothesis that other OEMs would preferentially buy from other suppliers rather than from a competitor, which would result in a heavy decline in revenues and profits for the acquired supplier.

A potential move for OEMs could thus be stronger collaboration on some systems. There have been several examples in the automotive industry, such as the joint acquisition of Nokia Here map data by Audi, BMW, and Daimler, or even collaboration on engines. PSA (Peugeot/Citroen) and Ford have, for example, jointly developed a new diesel engine.

Suppliers themselves are also ambitiously pursuing goals to establish a strong position in the data management space by 2025. Some have already entered the market with comprehensive data solutions in areas such as automated early diagnostics systems, vehicle control, and fleet management support. Going forward, holistic solutions in the data management space will further increase suppliers' share of the value chain and put OEMs under pressure.

The rolling stock global market is expected to grow

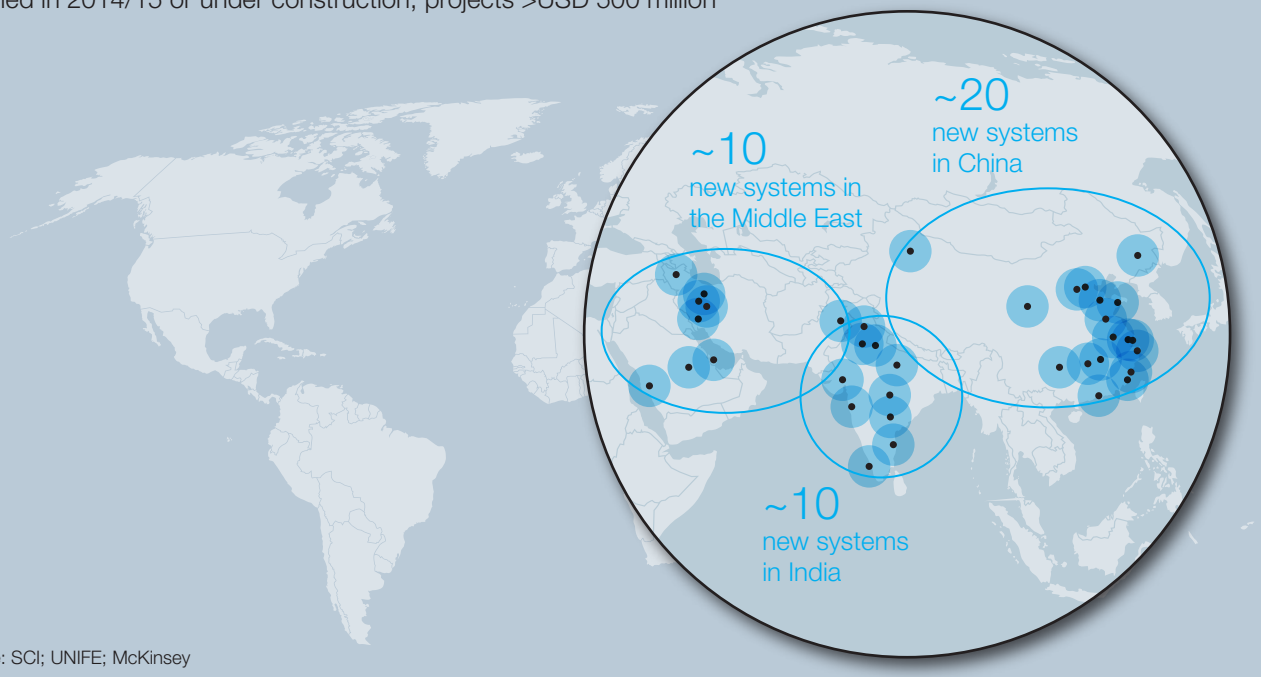
Revenues of new business and after-sales services, adjusted for inflation



Source: McKinsey

New urban metro systems in the Middle East and Asia on the rise

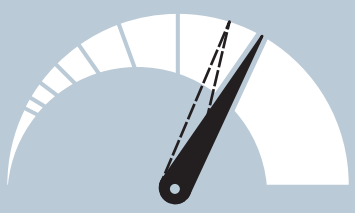
Opened in 2014/15 or under construction, projects >USD 500 million



Source: SCI; UNIFE; McKinsey

Train speed changes and estimated demand for locomotives in the US

+2 km/h
Increase in average
train speed ...



... reduces locomotive demand by
~1,000 locomotives

Source: AAR; STB; Railinc; McKinsey

B1 Market growth is driven by urbanization especially in emerging countries, resulting in a value-driven footprint/ localization

The overall annual global rolling stock market is expected to grow in real terms from approx. EUR 120 billion today to around EUR 130 billion in 2025. The primary driver of this growth is the urban transit segment, especially in emerging economies. This postulates a shift in historic growth drivers away from (high-speed) mainline connections, induced by ever increasing urbanization. Hence, ample opportunities will open up for OEMs to address new customers.

Overall, the market for the new vehicles and after-sales business in rolling stock is projected to increase by around 1 percent p.a. in real terms through to 2025. We project a real-term increase of around 2 percent p.a. in the new vehicles business, fueled by growth in emerging markets and particularly the urban transit segment. Also, we assume a relatively flat development (again in real terms) for the after-sales and service segment as new technology used in the maintenance segment substantially improves performance and availability, and thus reduces maintenance requirements.

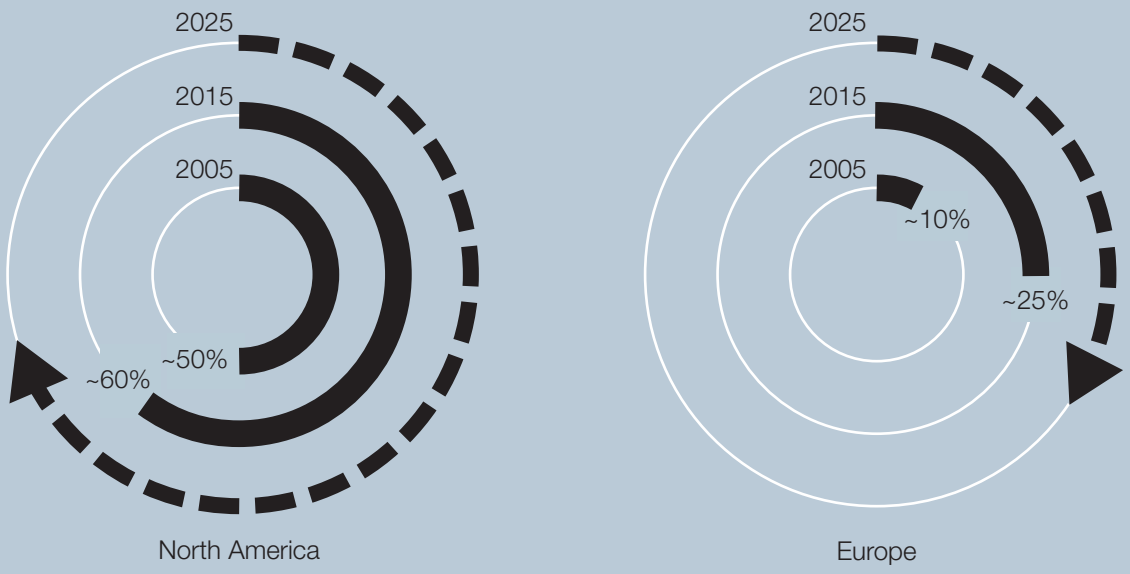
The major driver behind market growth will be the ever increasing urbanization – particularly in emerging markets – that is fueling demand for public transportation in the new vehicle business. All regions across the world are expected to see further urbanization in the decade to come, with 90 percent of the increase in urban life concentrated in the Middle East, Asia, and Africa. This opens up substantial business opportunities for rolling stock OEMs as a multitude of new urban metro systems are likely to emerge, primarily in China, India, Turkey, Iran, South-East Asia, and the Middle East.

Rolling stock OEMs will need to cater to these large-scale urban transit projects at an attractive price point. Traditional OEMs will thus be required to focus on cost efficiency and localization as both will be key to successfully competing in the demanding emerging markets space. Some North American and European OEMs may also need to rethink their current engineering and manufacturing footprint as a result – also given localization and partnering requirements.

In mature markets, infrastructure investments are driving higher asset utilization, such as double tracking, longer loops and yards to allow an increase in maximum train length and tonnage as well as velocity increases due to improved infrastructure and better transport scheduling. Even if the volumes transported grow globally, the demand for new rolling stock will therefore remain rather constant in these regions.

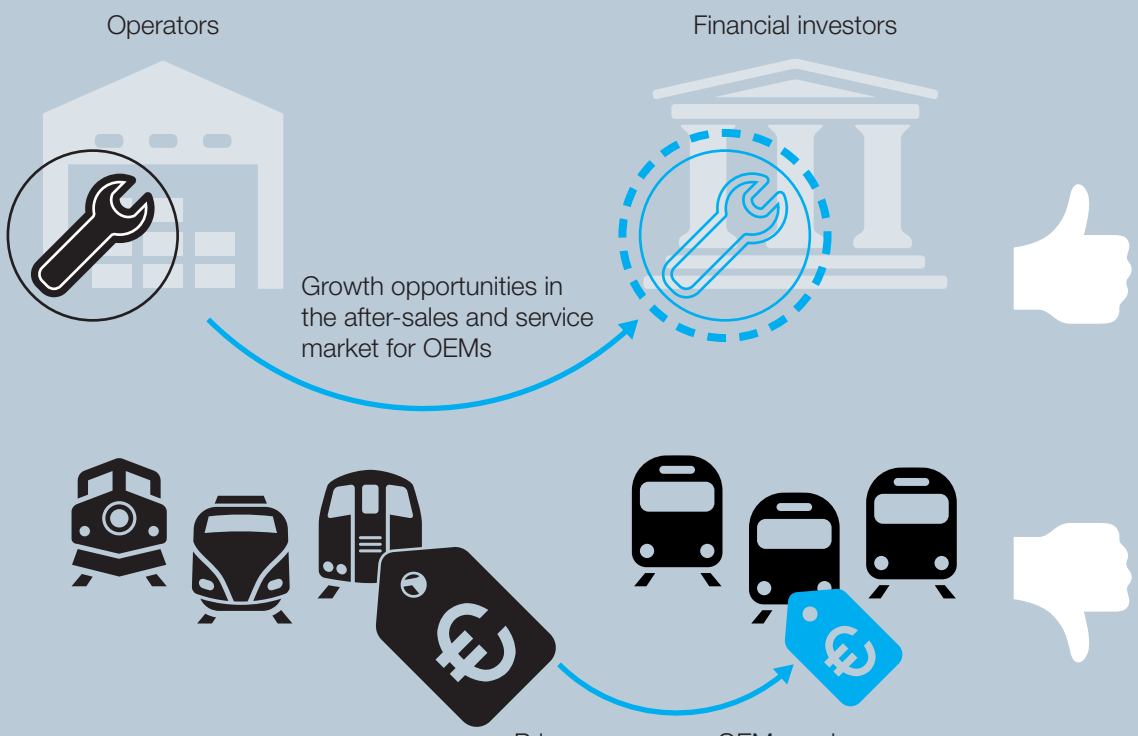
Leasing companies have increased their market share dramatically

Market share of freight wagon leasing companies



Source: SCI; GATX; IRG; McKinsey

The shift towards financial investors as customers has an upside and a downside for OEMs



Source: McKinsey

B2 Investments are increasingly being made by financial investors with a TCO perspective, demanding more standardized products

The customer landscape in the rolling stock industry is shifting. Over the last decade, leasing companies and financial investors have become important players in rolling stock, particularly in the freight market. They dominate the North American freight car market with a market share of 60 percent, and make up approx. 25 percent of the market in Europe today, up from approx. 10 percent in 2005. We expect this trend to continue.

Developments in liberalized passenger markets are similar, especially in Europe. In an environment where transport contracts typically run for 5 to 15 years there is an ownership risk for the operator as the lifetime of a train typically exceeds 25 years. As there are often no guarantees that the operator will win the subsequent contract or that authorities will offer to buy back vehicles at a reasonable price, leasing is an appropriate option. Leasing companies often balance supply and demand for rolling stock across various contracts and regions within countries, in some cases even internationally. So most nonincumbent railways rely on leased assets for their transport contracts.

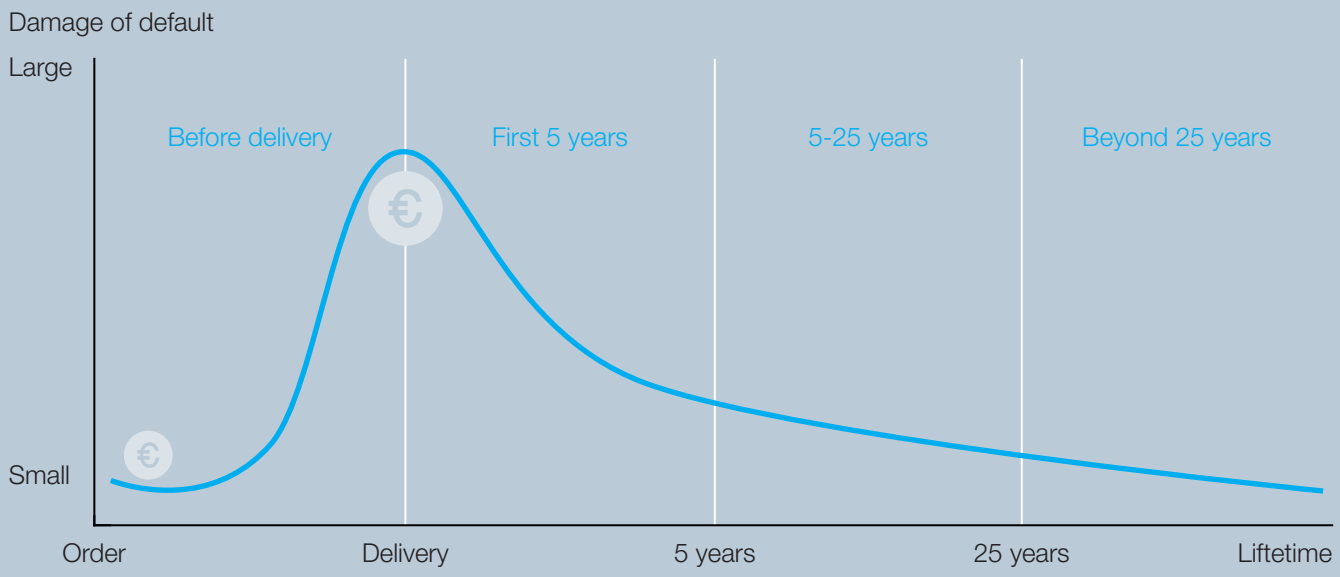
Financial investors as customers for the rolling stock industry can be characterized in three main ways:

- They have a high incentive to maintain their assets well in order to realize the full value over their lifetime, adopting a total cost of ownership (TCO) perspective.
- They lack in-house rolling stock capabilities (particularly maintenance operations), in contrast to incumbent rail operators.
- They will likely be looking for the best and most (cost-)efficient provider of these services.

This shift in the customer landscape towards more financial investors has an upside and a downside for OEMs. On the one hand this opens up growth opportunities in the after-sales and service market as most leasing companies and financial investors lack in-house maintenance operations and capabilities. Adopting a TCO perspective means they demand holistic solutions at the highest performance levels to ensure realization of the full value potential of their assets over their lifetime. On the other hand, leasing companies demand fewer tailor-made rail products and have a keen eye on positive financial returns, which puts greater price pressure on OEMs and suppliers. Even for incumbent operators there is the trend for less customization and more standardization. In the past, this demand for customization of products was typically profitable for OEMs.

If the OEM fails, the customer faces negative financial implications throughout the asset lifetime

Financial and reputational implications in the event of OEM default (illustrative)

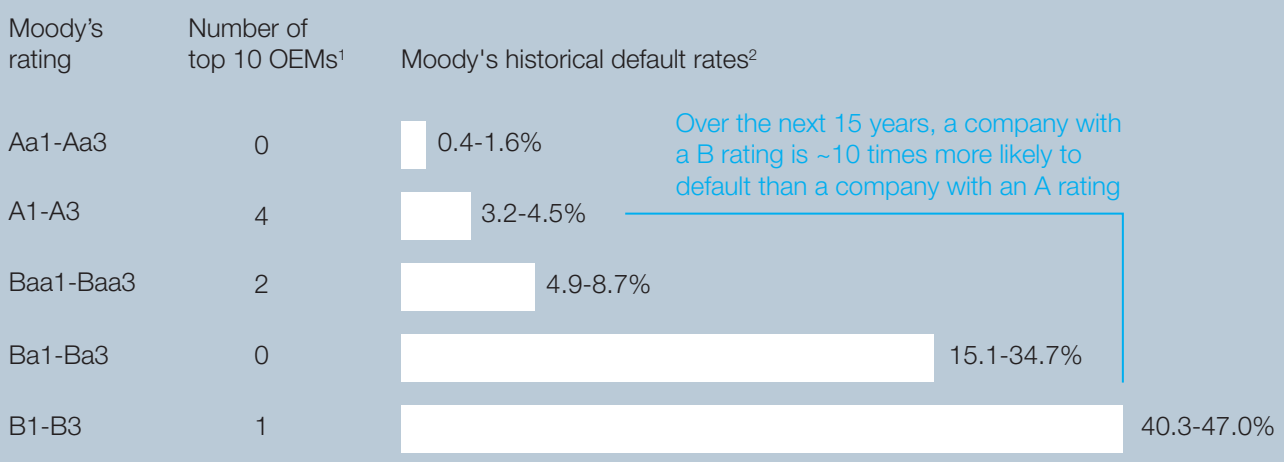


Major implications for customer

Before delivery	First 5 years	5-25 years	Beyond 25 years
Delay in delivery Lost advance payment Additional complexity due to retendering	Assets devalued Warranty contract useless Possible discontinuation of operations	Spare parts more expensive Decreased sales/ resale value	Decreased sales/ resale value Vehicle to be scrapped earlier

Source: McKinsey

Credit ratings vary among rail OEMs



1 Only 7 of 10 rated
2 Moody's 15-year cumulative default probabilities for rating, 2015 data
Source: Moody's; McKinsey

B3 The financial strength of OEMs is becoming a bigger determinant in winning large projects

OEMs' and suppliers' financial health will become an increasingly important determinant for being awarded large rolling stock and rail infrastructure projects as customers seek to minimize their risk exposure. Customers are aware of the financial distress project failures might bring in their wake, as well as the problems of shifting cash flows too close to delivery. This especially applies to turnkey projects – the Riad or Bangkok metros are cases in point – where the project value can extend beyond EUR 5 billion.

Customers need to protect themselves against counterparty default, so projects typically contain clauses defining guarantees, penalties, and compensation covering delivery timing and product quality levels. These payments can be very high depending on the project complexity. However, the necessity to provide financial safeguards against failure can increase the financial pressure on OEMs and suppliers during projects, straining their capabilities and ultimately increasing the chances of the supplier/manufacturer defaulting. Contractual agreements and safeguards may become worthless in these situations, with the manufacturers and/or suppliers being unable to pay the contractual penalties or compensation.

Credit ratings represent the risk of an issuer defaulting on their debt. For example, ratings range from Aaa (minimal credit risk) to C (already in default) in the system employed by Moody's. Credit risk ratings are widely used in the financial services industry and beyond as a standard measure for assessing the risk associated with an investment.

Looking at the rating of key players in the rolling stock industry, one can see big differences among the companies. Some manufacturers receive high ratings from the large agencies and are therefore considered very safe, but the lower end of the scale paints a dramatically different picture. Some large rolling stock OEMs have a Moody's rating of Ba1 to Ba3, implying a 15-year default probability based on historical default rates of between 15 to 35 percent, making it clear that a supplier's/OEM's default during a project is a real risk.

Growing customer awareness in this field requires that manufacturers act. They can try to improve their ratings via measures that include lowering their leverage, diversifying their business, and/or growing through M&A activities (see A1). Otherwise they may need to buy a guarantee that could amount to some 7 percent of guarantee value for a 15-year lifetime given a 15-year default risk of around 11 percent. If their 15-year default risk is approx. 40 percent, a sample calculation using the credit default swap spread indicates they would have to buy a guarantee covering 30 percent of the guarantee value, which could be prohibitively high.

Overall, financial strength will play an increasing role in the customer's assessment of an OEM in the tender evaluation as customers are demanding increasingly high guarantees and liability coverage from OEMs.

Industry use case of advanced and graph analytics – identifying and solving the root causes for delays in mining train operations

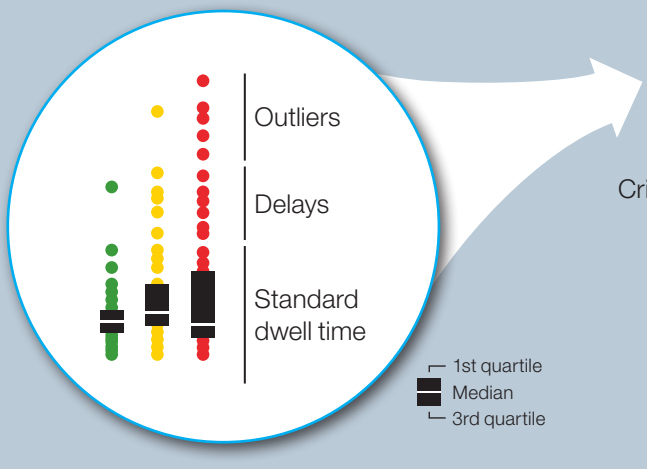
Situation
For mining companies where individual trains carry ore in the value of more than USD 1 million punctuality is essential. While small delays in arriving at the port destination already result in substantial penalty payments, even bigger delays trigger revenue losses for the mining company if trains have to be canceled and freight ships are not loaded on time.

Approach
The analysis consisted of more than 12 million data points generated by the operations control systems (OCS), interlocking system and point machines over a period of six months. Only the systems already installed generated the information, no additional sensors were applied. For example, the dwell times for the trains in each of the track segments were analyzed. With the help of advanced analytics methods, key delay reasons for every train in every network segment were identified. Then graph analytics were used to find key problem spots in the network.

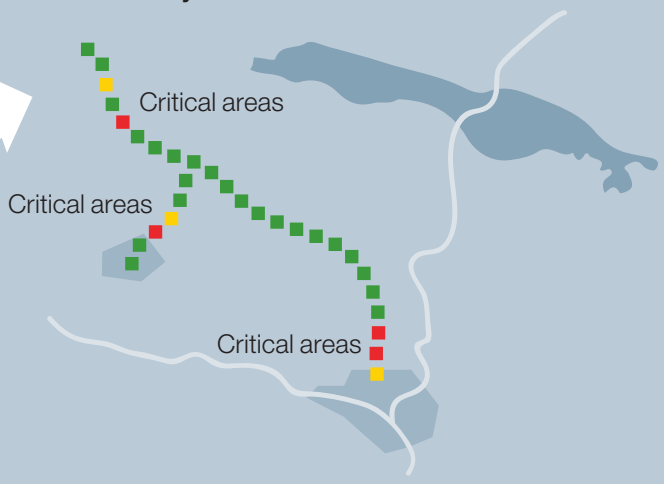
Finding
The advanced analytics showed that the delays were caused by a small set of points and at very specific track areas. Concrete countermeasures were proposed to fix the root causes at the most critical points, e.g., construction changes on the layout before points or changes to the point machines. Furthermore, the operations team can now optimize the scheduling based on the analytic results since they have more detailed information about the risk profiles of the main infrastructure components and can consider this information in the operations planning.

Impact
In this case the OEM proved to be the partner of choice for such a kind of analytics since the deep knowledge on how to interpret system-generated data combined with engineering/domain know-how is essential to draw the right conclusions. Major improvement potential can be generated in partnerships between OEMs and operators and their knowledge and related best practices. Increase in train punctuality of 10 to 20 percent is achievable. The annual savings typically outweigh the investment by a factor of >5.

Train dwell time analysis (illustrative)



Area analysis



C1 Digitization and advanced analytics are shifting value chain control points, creating new business models

Advancements in digital solutions, connectivity technology, remote monitoring, and big data analytics will offer new opportunities in the service space for traditional OEMs provided they manage to adapt their current business models successfully. The power of big data analytics has substantially increased in recent years. Since this technology is becoming ever more available and at low cost, OEMs are expanding their business models and taking over a growing number of tasks from rail operating companies and rolling stock owners in the service business.

Most OEMs already offer real-time monitoring and predictive maintenance solutions with remote support as part of their portfolio. Apart from advances in technology and cost efficiency, customers' preference for asset availability further contributes to this development. Customers only pay for the availability of rolling stock, so the increase in reliability via predictive maintenance solutions and remote support helps significantly boost OEMs' value proposition (especially if supplemented by new contract types such as "lifecycle cost based" or "power by the hour"). OEMs are destined to benefit from growth in this service space as rail-operating companies lack the scale to develop such holistic solutions in-house.

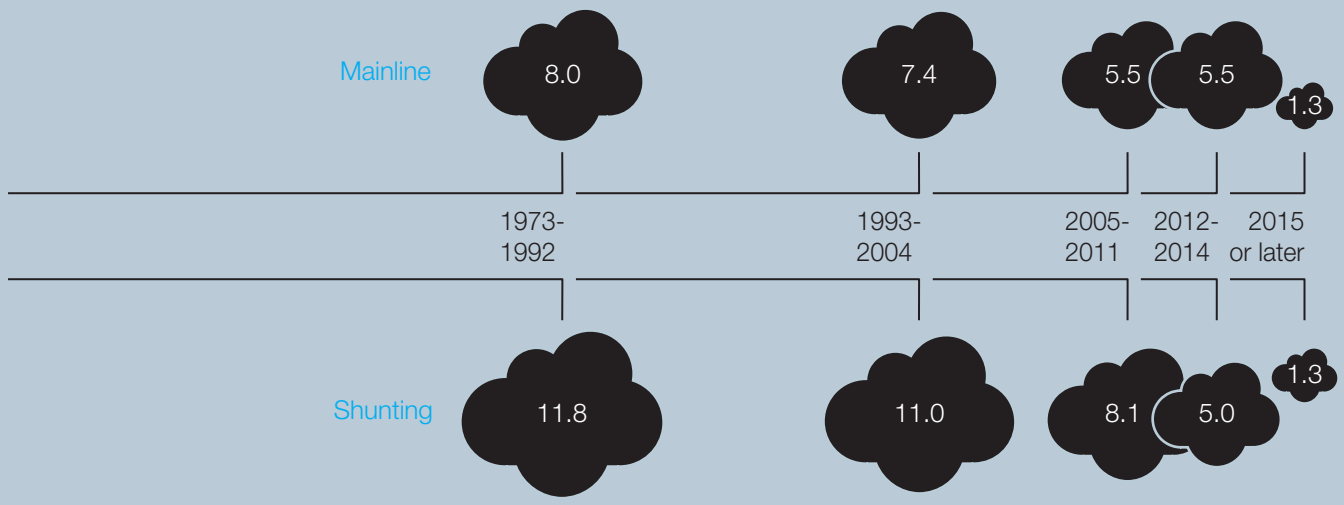
One of the most recent examples in the industry is a Siemens contract to maintain high-speed trains for RENFE in Spain. Huge volumes of data are collected and analyzed with the help of advanced analytics. The service team then decides on the maintenance and overhaul regime for the trains based on forecasts and legal requirements. Out of 2,300 trips, only one journey ended with a delay of more than 15 minutes caused by technical failures of the train – that is a 99.9 percent on-time rate. The increase in reliability allows the customer to offer new attractive packages to their passengers and compete with low-cost flights that are booked at short notice (e.g., a ticket refund if the train is more than five minutes delayed). Other examples of a combination of digital processes and advanced analytics resulting in an optimized maintenance regime also exist in contracts with private railways. Alstom maintains Italian operator ntv's high-speed fleet of 25 trains, with a guaranteed availability of 23 trains each day. A similar contract with an even smaller reserve exists between Stadler and Westbahn.

Technical advances using digitization and big data analytics will lower maintenance costs significantly over the next decade. The industry use case of advanced analytics for a mining company (see opposite page) underlines the inherent potential that exists to optimize existing systems. Whereas reserves of around 10 to 20 percent were common in classical planning and maintenance environments of larger railways, the new technology cuts the reserve to below 10 percent with higher train reliability. Besides the additional service business opportunities, OEMs thus need to take into account less demand for new vehicles due to more efficient use of the trains.

Solutions from the digital space are not limited to rail operations and maintenance, of course, but are also likely to have a huge impact on the industry's product development processes. Offering, for example, test drives in client-configured products or utilizing digital twin concepts may further boost OEMs' value propositions.

Emission regulations have become more aggressive over the years

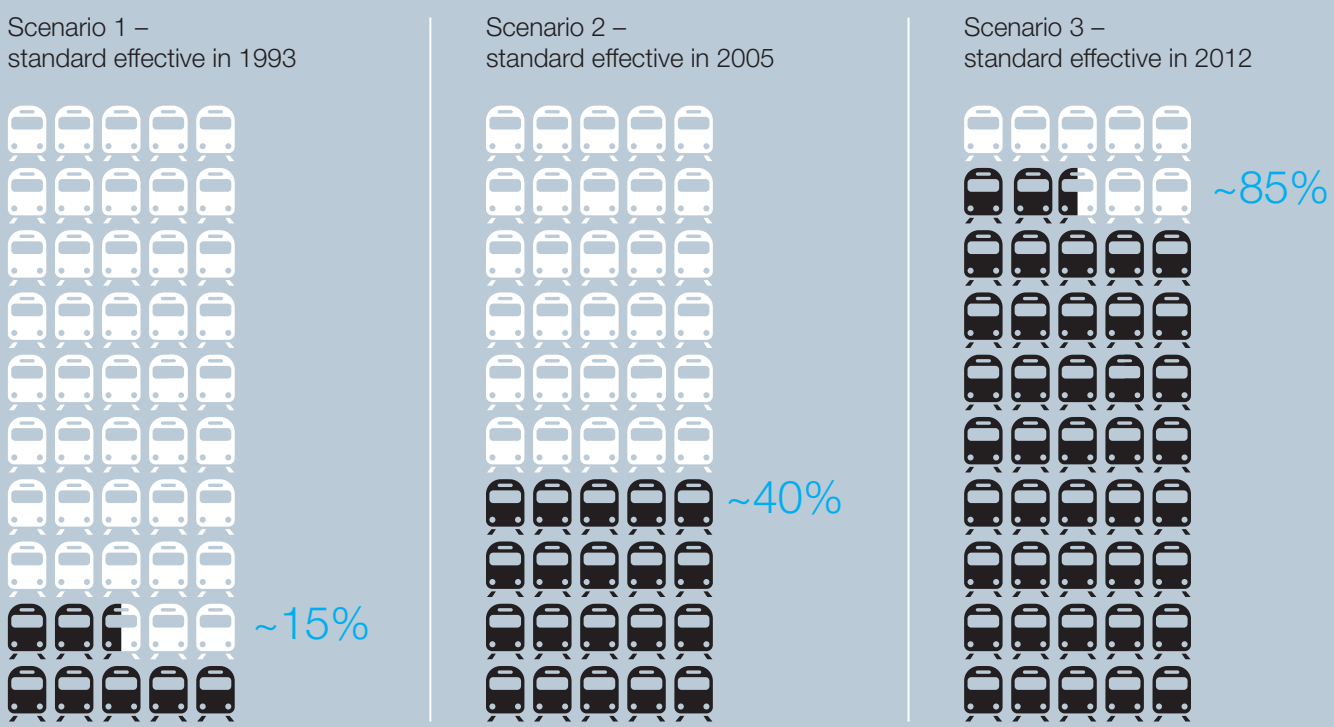
Maximum NOx emission standards permitted in the US, g per bhp and hour



Source: DieselNet; McKinsey

Operators face high risks in case grandfathering clauses will be seized

Fleet affected by applying different emission standards in North America



Source: McKinsey

C2 Holistic energy efficiency and emission standards are becoming increasingly important, with more opportunity for retrofitting

Emission regulations and enforcement of new energy efficiency standards by regulatory bodies have greatly intensified over the past 10 years, resulting in technical challenges for OEMs. Permissible maximum NOx emission levels in the US have been substantially reduced over the last decade (76 percent for mainline and 84 percent for shunting locomotives).

An example how emission standard regulations change customer behavior and challenges OEMs is the introduction of Tier-4 standards in the US, which became effective in 2015. As the new standard requires a more complex emission exhaust control system, customers feared higher costs and lower reliability. As a result they ordered locomotives in advance (before 2015), hence not falling under the new regulations. After that, orders for locomotives from US railroad companies declined and almost came to a halt. However, one of the largest diesel locomotive manufacturers in the US was not even able to deliver a Tier-4-compliant locomotive until the end of 2015 as a new engine generation had to be developed. This directly resulted in lost orders, and – potentially even worse – the OEM now must start acquainting its customer base with the new technology from scratch.

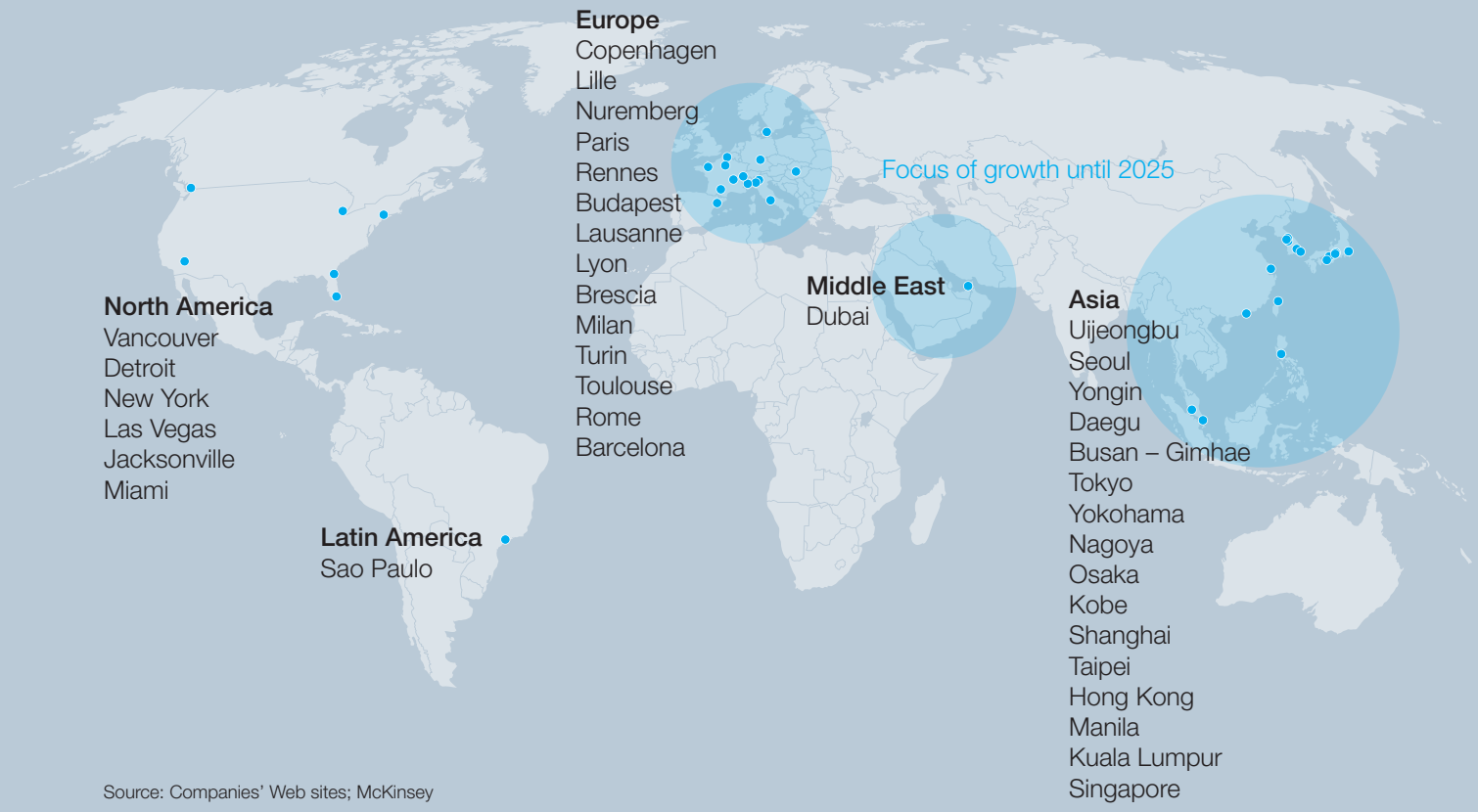
Today, rail operators often prefer rebuilding their existing fleet to buying new vehicles because of lower capex requirements, existing capabilities in maintenance, and existing homologation. Additionally, retrofitting today allows manufacturers to achieve almost the same energy efficiency levels as with new vehicles. Even driver assistance systems can help reduce energy consumption significantly. In a large urban agglomeration these systems help cut energy bills by 7 to 10 percent. OEMs are therefore coming under pressure to find innovative methods and technologies for offering energy-efficient and compliant equipment to customers at affordable costs.

Examples of these technologies could be wireless transmission of electric energy as currently applied in trams and trolley buses or expanding the “supercap” technology to use braking energy as a cost-efficient energy source for the train’s next acceleration process. Swiss supplier ABB has developed a technology that allows trolley buses to recharge their batteries within 15 seconds at regular stops. Bombardier also sells a system that allows catenary-free operation for trams.

In any case, OEMs will have to invest further and early on to be ahead of the curve when it comes to new emission standards and energy efficiency. The risk of being excluded from contracts in certain regions is compounded by the danger that customers will not trust solutions developed later if OEMs cannot establish a positive track record in testing and operations.

Wide range of automated metro systems already running around the globe

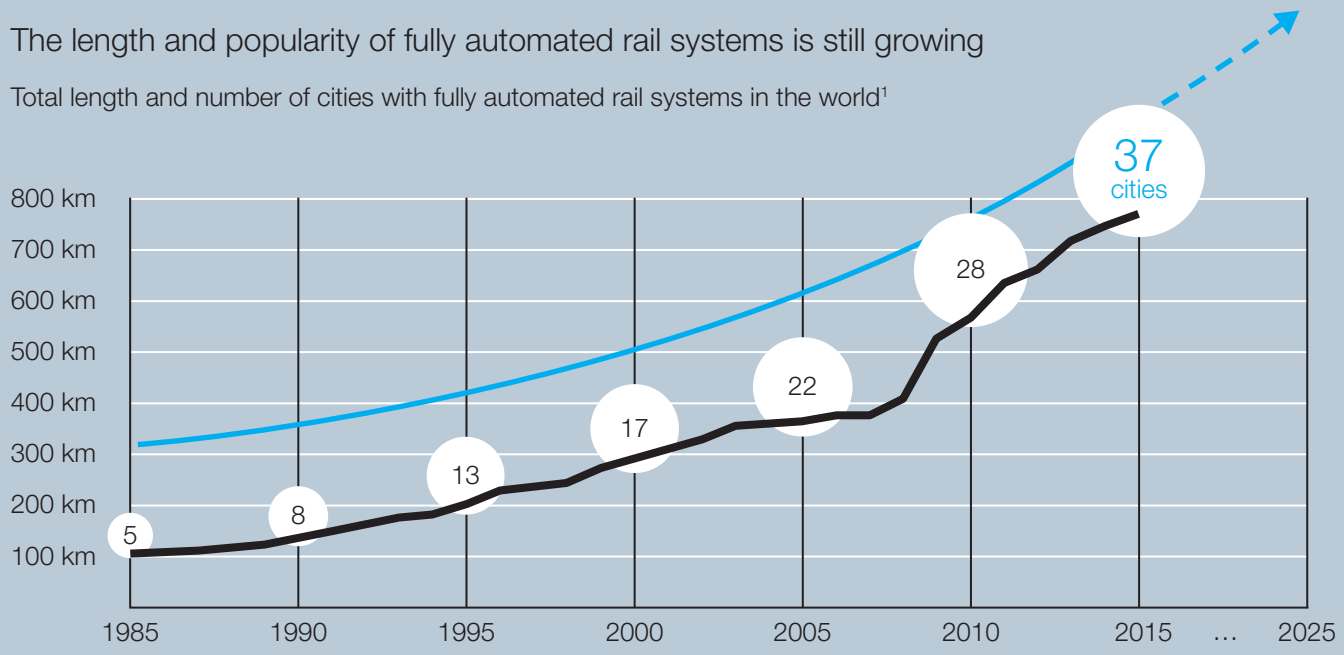
Cities with automated metro lines, as of 2015



Source: Companies' Web sites; McKinsey

The length and popularity of fully automated rail systems is still growing

Total length and number of cities with fully automated rail systems in the world[1]



1 Hong Kong's 3.8 km in Disneyland not included in calculation
Source: UITP; McKinsey

C3 Autonomous rail operations are becoming common, requiring technical prerequisites for new product families

Urban metro lines are increasingly being operated partially or completely autonomously. The length of autonomous metro lines worldwide has gone up by a factor of approx. eight since 1985, and is projected to grow even further in the next decade. The UIIP forecasts a rise from 800 km automated metro lines in 2015 to 2,200 km by 2025. However, investments in fully automated urban transit systems still require a great deal of technological foresight and entrepreneurial spirit, mostly due to biased safety perceptions of passengers and rail operators.

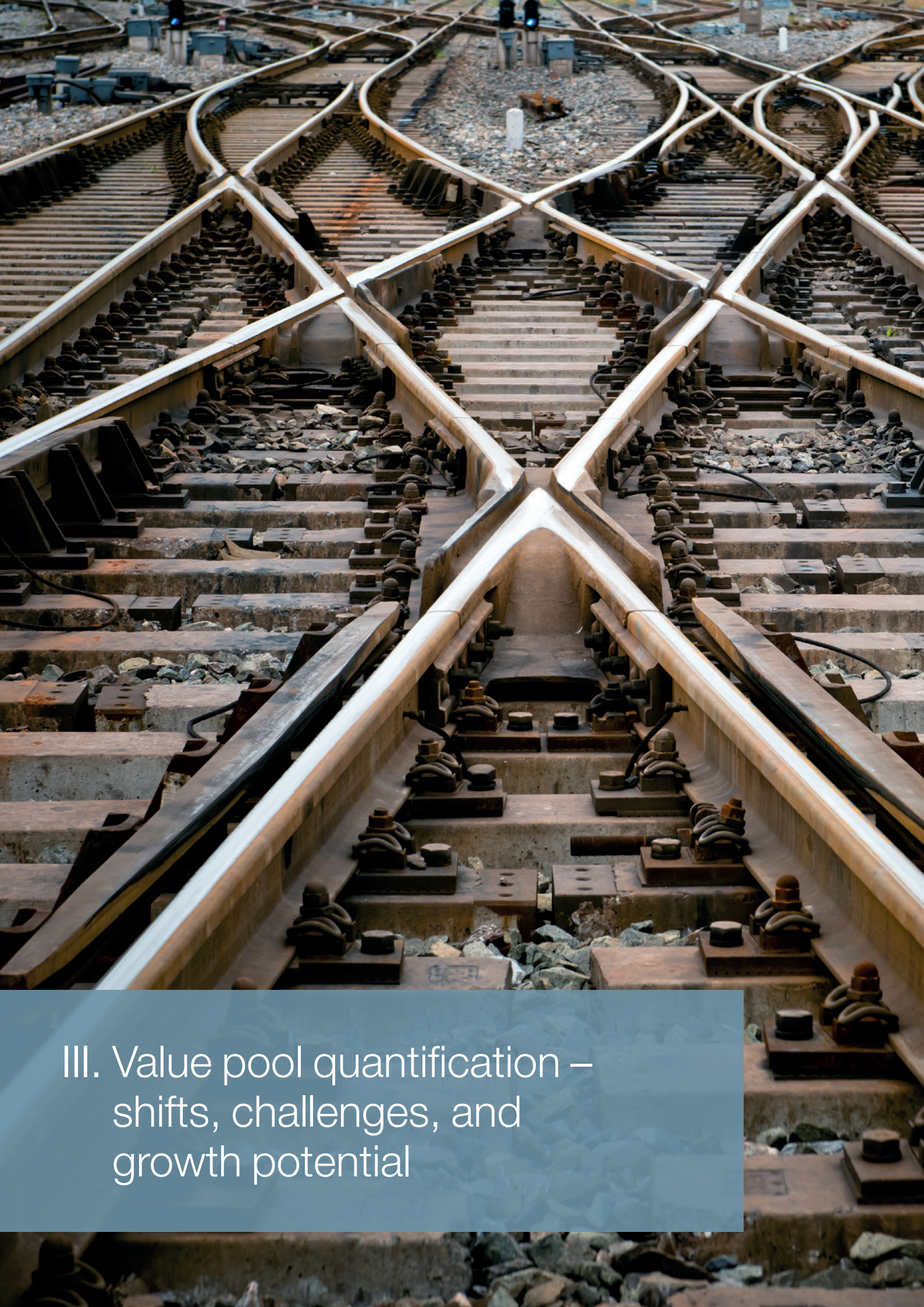
Nonetheless, the market outlook for autonomous train operation is very positive over the coming years, and large-scale automated rail operations are likely due to three main reasons:

- Technology is becoming ever more available at reliable and cost-efficient performance levels.
- Legal constraints on automated operations, particularly in public transit, can be expected to diminish (also driven by the advances made in autonomous car operation).
- Rail operating talent is becoming scarcer (i.e., drivers), and wage levels are increasing in selected geographies, e.g., Australia and China.

Worldwide growth in autonomous rail operations is centered in Europe (accounting for around 40 percent), Asia (approx. 30 percent) and the Middle East (some 20 percent) by 2025 on suitable systems. The rapid advances in rail automation will focus on the urban transit segment, but will not be limited to that. First examples of automated heavy-haul systems are expected to go operational soon: a large Australian mining company is one. The increase in rail automation – both in urban transit as well as in the mainline business – requires that OEMs invest in and offer proven technology at affordable costs and with the highest safety standards.

This means OEMs will increasingly need to align their systems with the entire rail and mobility infrastructure. Historically, a closed system was required for automated trains that included, for example, glass walls to encapsulate the tracks in train stations. Looking ahead, the tremendous advances in automation and sensor technology driven by the automotive industry (with sensors that are now much better at recognizing obstacles on the tracks, for instance) will increasingly make open autonomous rail systems the standard in public transit.

OEMs not only need to ensure that ever more sensor technology is built into trains: they should also reflect these developments in their platform strategies to be able to scale adoption and additional built-in technology into their products at later stages.



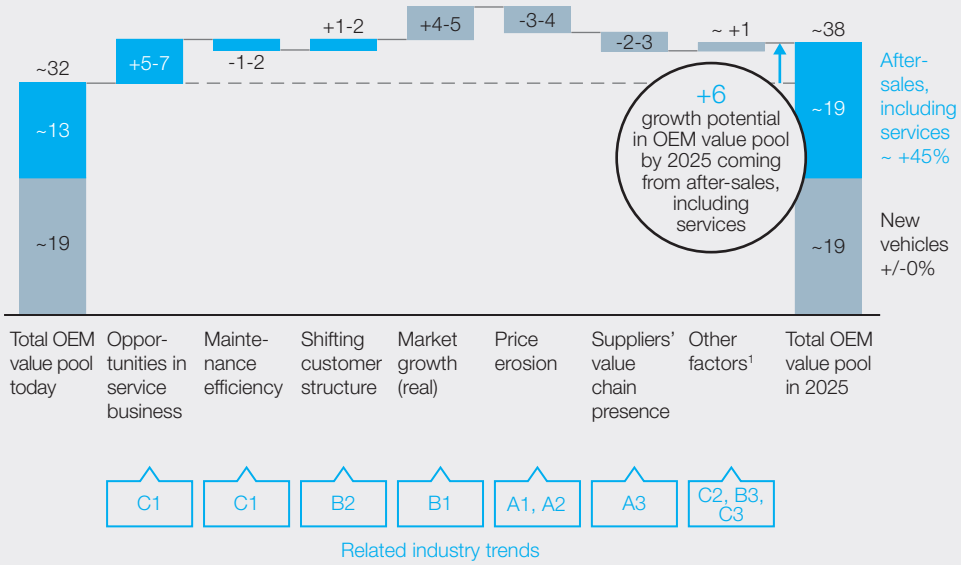
III. Value pool quantification – shifts, challenges, and growth potential

In terms of revenues, the global rolling stock market totals approx. EUR 120 billion p.a. today and comprises EUR 50 to 60 billion in the new vehicle business and EUR 60 to 70 billion in the after-sales and service segment. Of this, the annual OEM-specific value pool in the rolling stock industry is around EUR 32 billion, derived from assumptions regarding the reach of the OEM value chain in the industry's respective segments (around 35 percent in the new vehicles business and the after-sales and service segment, 30 percent in the spare parts business, and 10 percent in the maintenance labor service business).

The rolling stock OEM value pool is projected to grow from today's approx. EUR 32 billion p.a. to EUR 38 billion p.a. by 2025. This 18 percent real-term growth estimate assumes current value without any additional inflation through to 2025. The OEM value pool for new vehicles will remain constant at around EUR 19 billion p.a., while the after-sales and service segment will add an additional EUR 6 billion, taking that segment from EUR 13 billion today to EUR 19 billion p.a. in 2025, reflecting real-term growth of around 45 percent over the next decade.

Exhibit 3: OEMs' value pool will grow by ~EUR 6 billion (+18%) by 2025, driven by significant opportunities in the service segment

Development in OEM value pool by 2025 by segment, EUR billions (real terms)



1 Includes additional capex need for autonomous rail operations as well as slight price level incline as customers demand more financial securities and improved emission standards due to regulation
Source: McKinsey

After-sales and service

The main source of this growth potential for OEMs lies in the service business. Building on solutions from the digital space and utilizing big data analytics in, e.g., real-time monitoring and predictive maintenance solutions, OEMs can unlock an additional value pool of EUR 5 to 7 billion by 2025 in the service business. This additional share for OEMs does not represent real market growth, but rather a shift. Rail operators who are able to build their

capabilities in the area of predictive maintenance solutions, for example, will capture this value, and rail operators who lack the required scale to build their own capabilities will cede the value to those who can. By 2025, we foresee OEMs tripling their share of value chain activities, capturing some 30 percent (vs. around 10 percent today). This value includes both analytics and actual maintenance services, excluding the spare parts business.

Despite the growth potential for OEMs inherent in holistic digital maintenance solutions and big data applications, these advancements will also lead to a substantial increase in efficiency, reducing maintenance costs by between 15 to 25 percent in the long run and leading to a decrease in the OEM value pool of EUR 1 to 2 billion by 2025.

Customer structures will also eventually shift towards more financial investors buying rolling stock. These players have limited in-house capabilities in contrast to incumbent players with captive maintenance operations. This differential will effectively present OEMs with a value pool potential of EUR 1 to 2 billion by 2025 from additional maintenance and service contracts being tendered by financial investors who lack in-house capabilities.

New vehicles business

The new vehicles market is projected to grow by around 2 percent annually through to 2025 based on unit growth. This growth translates to OEM value pool growth of EUR 4 to 5 billion (measured in real terms without inflation), particularly in the urban transit market in emerging economies as the strongest growth segment.

However, OEMs also need to be prepared as their market position comes under pressure from multiple sources. The overall industry price level for new vehicles will be under pressure in the long run and reduce the OEM value pool by a further EUR 3 to 4 billion. This stems from two main sources:

- OEMs will need to lower their prices in the medium term to avoid costs of underutilization as the global rolling stock market faces significant production overcapacity of 40 to 60 percent across North America, Europe, and Asia.

- As can already be observed today, CRRC is tackling export markets with competitive offers (e.g., recent transactions involved a price gap of between 15 and 25 percent to competitors according to press reports).

In addition, suppliers will continue to bite into the OEMs' value chain share as they also strive for more holistic solutions from the digital and big data analytics space themselves. This will increase their value chain share from around 65 percent now to 70 percent in 2025, likely decreasing the OEM value pool by EUR 2 to 3 billion.

New emission standards and energy efficiency regulations are bound to change – there is not yet a clear indication of the shape grandfathering policies will take. We can nonetheless posit that stricter standards are likely to impact the OEM value pool positively in the long run. It is possible that the OEM value pool will grow in rail operations too as rolling stock becomes more complex in view of increasing automation, especially in the fast-growing urban transit segment (such as fully automated metro lines).

Conclusive outlook

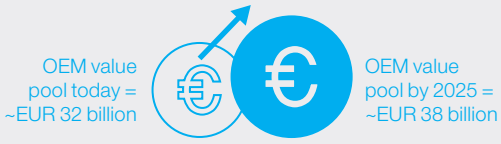
The OEM value pool is growing significantly, fueled by opportunities in the after-sales and service business, where OEMs can build on holistic solutions from the digital space and big data analytics. However, the new vehicles business remains a vital component for rolling stock OEMs to secure their fleet in the long run.

Overall, the character of the global rolling stock business for OEMs is changing. We are experiencing a shift from a primarily product-only business towards a lifecycle business. In this lifecycle business, OEMs' share of the value pool no longer comes mostly from selling vehicles but is essentially split between selling vehicles on the one hand and servicing and maintaining them over their full lifecycle on the other hand. Customers' top priority is to secure availability of their assets, which is revealed in the growing number of full lifecycle-focused contracts that they are demanding. Recent examples of this include the long-term contract for RENFE's high-speed trains between Barcelona and Madrid, which includes real-time monitoring and state-of-the-art predictive maintenance models.

More importantly, this shift in the OEM value pool has the potential to sustain long-term profitability for OEMs, who can traditionally earn higher margins in the service business than in the asset-intense and complex new vehicles business. As a result, the growth in profits may even outperform the value pool increase.

Exhibit 4: The net impact of identified rolling stock trends will be an OEM value pool growth of ~EUR 6 billion by 2025

Overview of shifts to the OEM value pool



	Industry trend identified	OEM value pool impact EUR billions	Rationale
A1	The rolling stock industry is facing heavy consolidation pressure due to large global overcapacity	↓ -2-3	Global overcapacity (~40% in North America, ~40% in Europe, and ~60% in Asia) is pressuring OEMs to lower prices in the mid-term to avoid the costs of underutilization. Assumption: ~10-15% price erosion by 2025, leading to an OEM value pool reduction of EUR 2-3 billion
A2	The Chinese industry leader is tackling export markets with rolling stock and beyond, resulting in great price pressure	↓ -1-2	Chinese player CRRC is tackling international markets with low-price competitive offers (typically 15-25% below those of established western OEMs), leading to increased price pressure in these markets. Assumption: 10-20% price erosion on top in Europe and North America, resulting in an OEM value pool reduction of EUR 1-2 billion
A3	Tier-1 suppliers are capturing an increasing share of the value chain and profits due to limited competition in core components	↓ -2-3	Suppliers continue to bite into OEMs' value chain share by expanding their value chain presence from ~65% today to ~70% by 2025 as they are also offering more holistic solutions utilizing the digital space and big data analytics for their components. Resulting in an OEM value pool reduction of EUR 2-3 billion

Industry trend identified	OEM value pool impact EUR billions	Rationale
B1 Market growth is driven by urbanization especially in emerging countries, resulting in a value-driven footprint/localization	↑ +4-5	New vehicles business market will grow by ~2% p.a. until 2025 (real growth, measured in units), with the largest growth areas being the urban transit segment, particularly in the emerging economies, which will grow at ~7% p.a. Growth of the OEM value pool in the new vehicles business of EUR +4-5 billion Market growth in after-sales and service segment foreseen flat in real terms until 2025
B2 Investments are increasingly being made by financial investors with a TCO perspective, demanding more standardized products	↑ +1-2	Financial investors are increasingly becoming buyers of rolling stock, predicted to make up ~40% of sales in Europe by 2025 (vs. ~25% today), and ~70% in the US (vs. ~60% today). Key characteristics are a) a high incentive to maintain their assets well (utilization), b) they are likely to award maintenance business to best and most efficient OEM, and c) they lack in-house capabilities (no captive maintenance business like incumbent rail operators) Maintenance business will become addressable for OEMs, growing the value pool by EUR 1-2 billion (incl. ~5% price erosion due to competitive tendering process)
B3 The financial strength of OEMs is becoming a bigger determinant in winning large projects	→ +0-1	Rolling stock projects are becoming ever more complex and customers are demanding higher securities and warranty obligations from OEMs Financial health is therefore becoming an asset to OEMs and increasing demand for securities will need to be factored in over the long term. Assumption of a ~2% price mark-up, growing the OEM value pool by EUR 0-1 billion
C1 Digitization and advanced analytics are shifting value chain control points, creating new business models	↑ +5-7	Digital solutions and big data analytics are opening up a world of new potential for OEMs in the service business via product offerings such as predictive maintenance and real-time monitoring. Assumption: OEMs will be able to increase their share of the maintenance labor service market from ~10% today to ~30% by 2025, growing the OEM value pool by EUR 5-7 billion
	↓ -1-2	However, these advancements in the maintenance business will also improve long-term maintenance cost efficiency significantly as assets will be utilized better and major breakdowns will be actively prevented. Assumption: long-term decrease in maintenance costs by 15-25%, shrinking the OEM value pool by EUR 1-2 billion
C2 Holistic energy efficiency and emission standards are becoming increasingly important, with more opportunity for retrofitting	→ ~+0	Stricter regulation of emission standards in the future possible but not yet clear – potentially growth opportunitites if grandfathering clause is seized. Assumption: grandfathering rights remain untouched
C3 Autonomous rail operations are becoming common, requiring technical prerequisites for new product families	→ +0-1	With an increase in autonomous rail operations particularly fueled by the urban transit market, rolling stock is becoming more complex, particularly in light of additional safety requirements in the early stages. Assumption: ~2-5% increase in product prices due to higher complexity, growing the OEM value pool by EUR +0-1 billion

Source: McKinsey

IV. Recommendations for rolling stock manufacturers

In light of the trends described and their implications for the global rolling stock industry over the coming years, OEMs need to rethink their current business models and value proposition to position themselves for the imminent growth potential. OEMs' core segment of new vehicles will remain under pressure from limited real-term market growth, suppliers that bite into the OEM value pool share, and price pressure due to emerging players tackling export markets. Growth will mostly take place in segments that are currently noncore, particularly in the service business. The main reasons for this are:

- Customers are demanding availability rather than just vehicles. This results in more responsibility along the lifecycle for the OEM.
- Customers – particularly the new breed of financial investors and smaller/new railway operators – are running their business model with reduced in-house maintenance capabilities, and sometimes none at all.
- Advanced digital technology available at an increasingly affordable cost allows for ever more sophisticated predictive maintenance regimes that require deep expertise in big data management.

Given the very nature of these growth opportunities in the service business, additional players – such as established suppliers or new entrants from the tech industry – will likely also be attracted to enter the rolling stock market with targeted digital solutions in the long run. Traditional rolling stock OEMs can optimally prepare themselves to capture the new value potential by evolving their current business models towards the new segments and improving their performance in this field. There is no universal panacea for adapting the current OEM business model to capture the new growth potential. However, we have discerned several effective approaches that established OEMs – both in the rolling stock industry as well as in adjacent industries – adopt when adjusting their business models. In particular, we recommend they consider the following four approaches:

Strengthen their service business. Rolling stock OEMs need to increasingly focus on strengthening their service portfolio to capture the future growth potential. This includes strengthening both their offering as well as their internal delivery capabilities for holistic maintenance and service solutions from the big data space, leveraging advanced analytics. To win in these areas, OEMs need to scale their big data capabilities and foster a flexible and innovative digital organization.

Tailor sales activities to the new customer landscape. Rolling stock OEMs need to broaden their sales capabilities to encompass a more heterogeneous customer landscape that includes financial investors, leasing companies, and private rail players in addition to traditional operators. To win in these segments, OEMs need to clearly reflect changing customer characteristics and needs to offer appropriate solutions.

Focus on cost efficiency. Rolling stock OEMs need to produce the basic vehicle at lower cost to ensure price competitiveness and remain profitable in the light of intensified competition, an increasing shift of growth towards emerging markets, and increasingly cost-conscious customers taking on a TCO perspective. To win in these fields, OEMs may consider initiatives such as footprint localization, capacity level reviews, and holistic efficiency programs.

Leverage partnerships. Rolling stock OEMs may want to investigate opportunities to form and leverage strategic and operational partnerships within the industry and beyond. To achieve this, OEMs need to form scalable ecosystems and profitable partnerships that allow them to offer the greatest value to customers and tap the full potential of the new pools that are developing as a result of all the developments described in this brochure.

□ □ □

The rolling stock industry is undergoing huge transformation triggered by shifts in industry and competitive landscape, changes in demand and customer landscape, as well as technology-driven disruption and growth opportunities. Some of the key trends and corresponding shifts in the OEM value pool may not manifest themselves immediately. But since adapting current business models is a multiyear process, it is imperative that rolling stock OEMs start preparing now. New potential in the value pool means new value propositions, and it is never too early for OEMs to begin conversations and start making strategic decisions to articulate the potential of new offerings. This is especially important since the major growth area is advanced services, which require new business models, new customer interactions, and also probably new talent in the manufacturers' organizations. OEMs can begin looking now at how leveraging external partnerships and establishing cross-functional teams will equip them with the skills and open mindset required for experimenting, innovating, and remaining competitive in the long run.

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