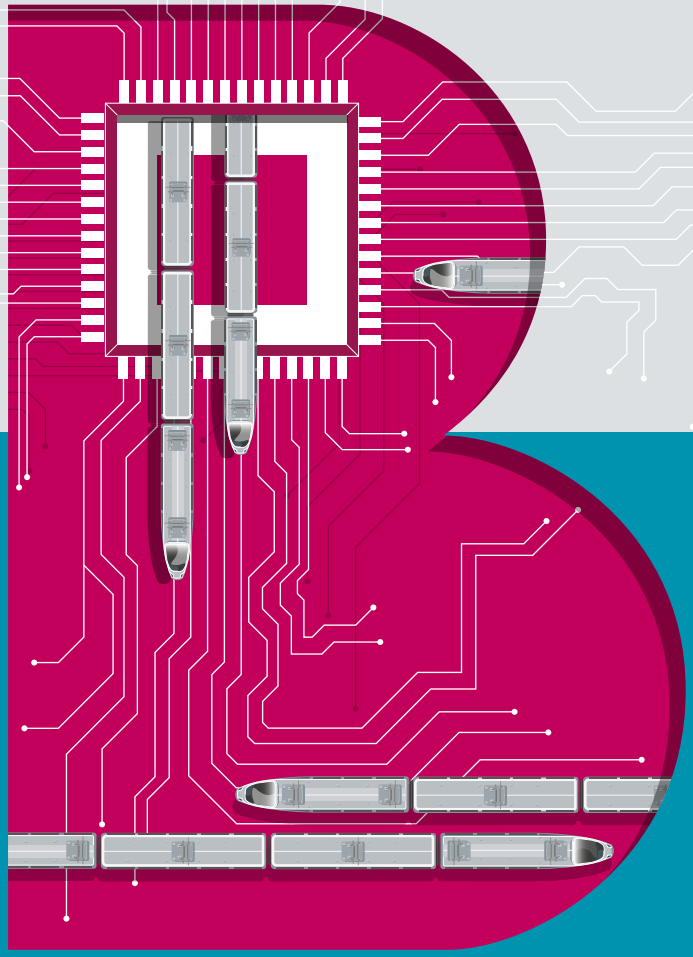
THINK ACT

BEYOND MAINSTREAM



June 2016

On the digital track

Leveraging digitization in rolling stock maintenance

Roland Berger

THE BIG

3

INCLUDES
RESULTS OF OUR 4TH EXECUTIVE RAIL RADAR
→ P. 4

74%

of executives regard efficiency of operations incl. improvement of flexibility and quality as the top priority.

Page 5

20%

is the potential to lower maintenance costs as a major portion of operating costs if digitization is properly understood and implemented.

Page 8

6

levers to push services further in the (digital) direction of rolling stock maintenance 4.0.

Page 13

Adapting to change.

Traditional players in the rail market must react quickly to the numerous changes approaching at high speed.

Maintenance represents a major portion of costs for all rail companies alike – be they public or private, passenger or cargo operators. Railways have undergone a big wave of optimization and continuous improvements since the rail reforms in the 1990s. Asked to assess their performance on maintenance costs, 44% of the respondents in our recent Executive Rail Radar 2016 classified themselves as "good" and 9% even suggested they were "best in class". Their self-assessment with regard to vehicle availability was even more glowing: 40% think of their company as "good" and 20% as "best in class".

Our research suggests, however, that these assessments are overly optimistic. The ongoing liberalization of the railway industry on the one hand and the unstoppable march of digitization on the other mean that the European railway market – including rolling stock maintenance – has no choice but to adapt to stay competitive. And there is further need to reduce costs driven both by the fight for a higher intermodal market share and higher expectations from transport authorities (TAs).

TAs in France for instance regularly complain about increasing maintenance costs, while also feeling that competition in the industry is increasing at the same time. As purchasers of public transport, TAs expect that the forthcoming liberalization and growing competition will be a decisive lever in bringing down maintenance costs – in France, for instance, regions formed collaborations to create a purchasing group to try to get the best conditions on new rolling stock and maintenance – but more sophisticated rolling stock translates to increased maintenance costs.

CEO respondents listed three topics as top priorities for the future: 1. efficiency of operations including the improvement of flexibility and quality; 2. profitability and financial sustainability; and 3. digitization. In other words: executives do consider digitization an important topic for the industry. → A

THE SURVEY'S SCOPE

How rail executives deal with pressing changes

This publication is based on our project experience and several market studies. Part of the data stems from our last "Executive Rail Radar", the other from various personal interviews with rail operators where we discussed various challenges and opportunities, particularly of digitization.

Our Executive Rail Radar 2016 is the **4th edition** of our survey, which we launched to support executive-level thinking across the rail industry. The theme of this year's survey was the changes in the business environment that impact rolling stock maintenance activities, and the way companies position themselves to manage them.

Our survey was answered by **about 80 senior railway industry executives** from train operators, integrated railway groups, municipal transport companies and rail infrastructure providers i**n 15 European countries**, with the goal of determining how top managers of rail companies deal with the many pressing changes they face. We received responses from roughly equal numbers of executives from the long-distance and regional passenger sector as well as the rail cargo sector.

A REVIEW OF TERMS

Predictive vs. condition-based vs. preventive vs. modular maintenance:

Predictive maintenance

data analytics help to predict the condition of the vehicle/asset over time; this allows operators to define the optimal maintenance regime for a particular vehicle based on its life cycle and cost.

Condition-based maintenance

Here, sensors directly monitor the vehicle/asset during normal operating conditions. Maintenance is conducted based on the condition of the vehicle/asset assessed by the sensors.

Preventive (or interval-based) maintenance

is carried out on a regular basis.
The intervals are fixed and based on distance covered and/or time.

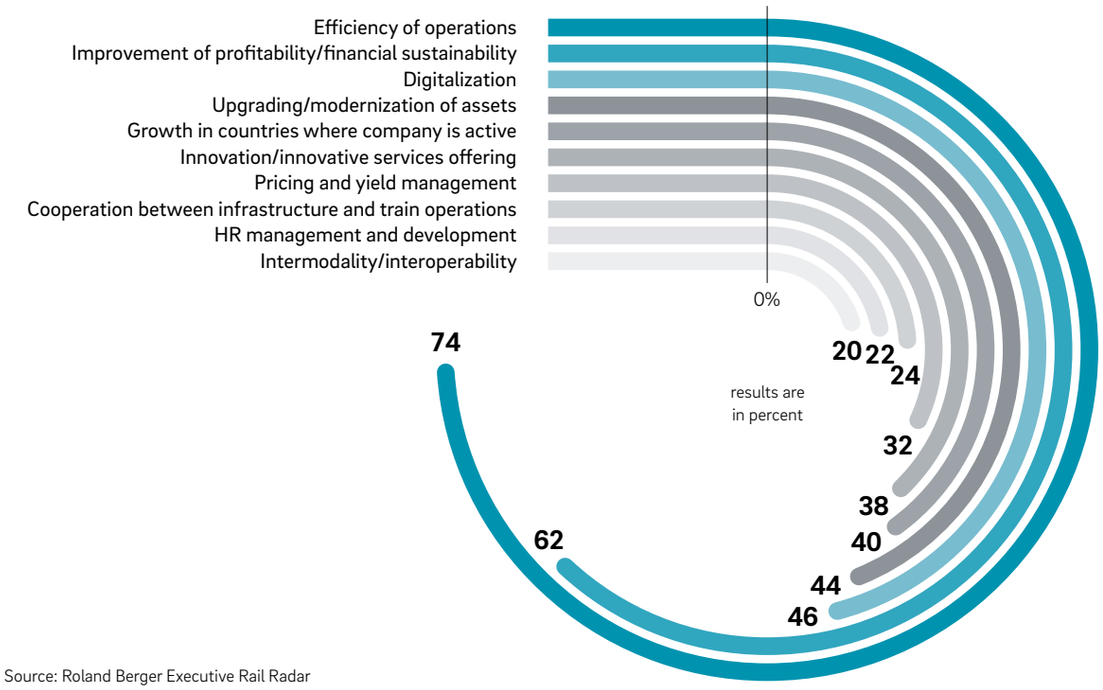
Modular maintenance

is independent of the three types above.
It consists of replacing components during light maintenance and thus reducing the need for periodic maintenance of the whole vehicle at once.

A

TOP OF THE AGENDA

Efficiency of operations, sustainable profitability and digitization were the most frequent responses cited by CEOs



Source: Roland Berger Executive Rail Radar

Topics that once ranked higher as priorities such as growth, cooperation between operators and infrastructure managers, and pricing, are now at the bottom of the list. In the context of scarce resources to finance railway systems and competition with other transportation modes, railways increasingly have to demonstrate their efficiency (operational and economic). This is particularly important with respect to making the best use of available assets, such as rolling stock, in the first place.

New technologies are regarded as being required to both better serve the end customer (the passenger) during their "connected mobility" journeys and significantly improve railway efficiency.

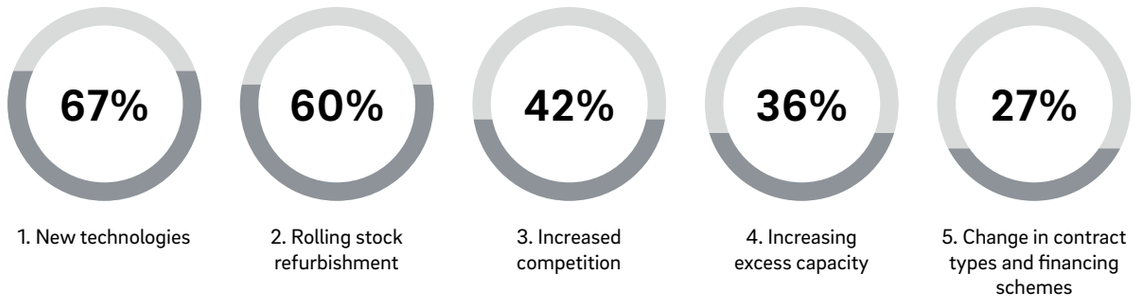
Refurbishment of rolling stock placed second in our survey, which was a surprise. It seems that the option of upgrading rolling stock at a reasonable price (extending lifetime and leaving open the possibility to introduce new components) is becoming a more attractive option than purchasing new rolling stock in some cases. Some of our recent work for railway clients examined this issue extensively. → B

When asked about rolling stock maintenance, respondents highlighted condition-based and predictive maintenance as major trends in the industry – unsurprising given the technological advances now available on the market. → C

Condition-based and predictive maintenance are enabled by remote monitoring of vehicle condition and intelligent data analytics. This, too, can be combined with modular revisions and leads to less downtime of the machines in question – the number one service KPI beside cost. However, the industry has been slow to adopt such maintenance methods (although both buzzwords have been around for 20 years now). Perhaps soon we will be able to claim that the industry is indeed implementing changes to include digitization and more generally new technologies.

B

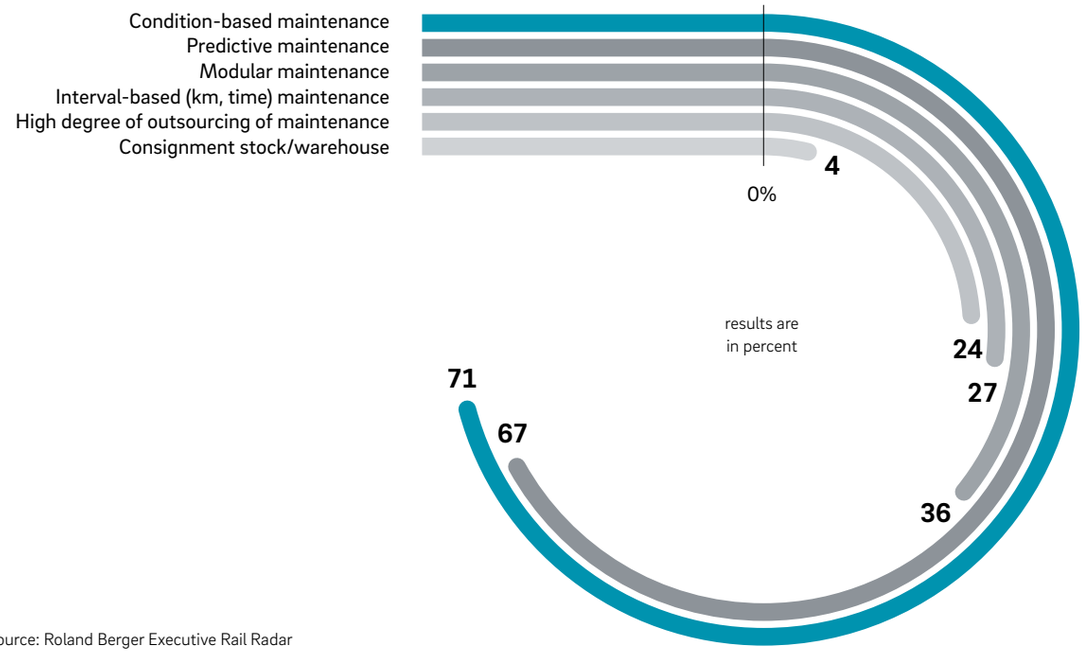
NEW TECHNOLOGIES AND DIGITIZATION
are regarded as the main changes facing railway operators in the context of rolling stock



Source: Roland Berger Executive Rail Radar

C

MAIN TRENDS IN MAINTENANCE
Condition-based and predictive maintenance are the top trends cited in the maintenance context



Source: Roland Berger Executive Rail Radar

Prepare for the digital promise. Costs of asset management and rolling stock maintenance will drop remarkably. Here are the levers you need.

In several recent rail market studies, Roland Berger experts focused on the potential of digitization. Our results are relatable and comparable and thus allow for some generalizations.

Clearly, mainline railways, in comparison to urban or cargo rail operators, feature the highest level of digitization. Along the value chain they use software solutions to improve maintenance planning and asset management (i.e. for transparency, data analysis and decision-making). Digitization is used at a higher level for implementation (i.e. the provision of materials, execution of management decisions and overall operations).

Maintenance specialists use hand-held devices to access software/data on site. While the required data for innovative solutions is often available, operators can still lack the expertise (e.g. statistical analysis) to maximize effects.

Cargo operators have a big interest in digital activities too (which is in line with the responses from the executives we interviewed). They extend the application of digitization to operations (i.e. capacity planning, tracking of their rolling stock and driving behavior).

This contrasts with urban operators, who use hardly any data at all. They use software tools, which are often outdated and – just like their older fleet – not ready for predictive maintenance solutions. Their systems are sufficient for warehousing or the execution of certain basic functions, but not for intelligent asset management, which would optimize their maintenance cycles for different components. In this sector, there is considerable room for improvement.

WIDESPREAD FEAR OF COMPETITION

Generally speaking, all our interviewees count on progress in digital maintenance activities. While they see limited potential in consignment warehousing or in full outsourcing, they see significant potential in predictive and condition-based maintenance. The perfect solution would be a secured data network with open data exchange between operators, manufacturers and other maintenance providers. Such a network would be optimized for intelligent analytics of large sets of data, able to determine optimum

maintenance regimes, perform automated trouble shooting and eventually allow operators to significantly reduce life cycle costs.

The database would be fed by sensors on vehicles, and other operational data from railways (e.g. on malfunctions), maintenance job data of depots/ maintenance plants, engineering data, maintenance recommendations of the manufacturer, etc. → D

So, ideally, all players would exchange data on the locomotives/vehicles they share. The more data they publish, the more information could be gathered on technical problems, effects of certain maintenance jobs, etc., leading to more accurate predictive measures as a result. Though there is little competition between operators, OEMs and infrastructure companies, competition is still a word that strikes fear into many people; when it comes to openness for the sake of efficiency and lower costs, there is still a lot that will have to change before that routinely occurs.

For the time being, interviewees accept and appreciate the potential they see in digital solutions, especially for long-distance passenger transport. This is because a high-speed train costs up to EUR 30-40 million – the price of a small airliner and with a similar life cycle. When downtime costs are high you increase the availability of the train – and thus its productivity – if it is serviced overnight. Such a routine easily offsets the extra cost of night shifts.

INTELLIGENT DATA ANALYTICS PLUS OPERATIONAL OPTIMIZATION

To optimally tap the potential of digitization and realize savings of up to 20% of maintenance cost, intelligent data analytics will have to be complemented with troubleshooting support for irregularities. The efficiency levers are perfectly obvious: if train operators can remotely identify any relevant dysfunction and cause of failure, they can directly decide on the necessary maintenance or repair activities. The sector already has speedy communication between rolling stock and depots, i.e. the train or locomotive and its maintenance staff as well as colleagues (or digital systems) in charge of capacity planning, which could provide the framework for data transmission. For such a chain reaction to run smoothly, however, there are some apparent data requirements too. For the operators, real-time (or at least near-time) condition data are a prerequisite for any sound analysis of a technical failure or the prediction of a potential failure. Again, it is data transparency on current operations and potential scheduling scenarios that allows for the identification of the best solution for any failure that may occur.

"An integrated software platform for fleet management and maintenance would facilitate easier and reliable processes."

Head of Production Management,
Passenger division of state-owned railway

There are a multitude of data-based applications that can help optimize train operations. Consider the following three examples.

ENERGY CONSUMPTION

This is a major cost which is always being monitored by operators in order to improve efficiency. As already mentioned, driver-assisted systems for energy optimization do exist; they require data on driving behavior like acceleration and braking information.

WAGON MANAGEMENT

On-board units for freight wagons, currently disconnected, could collect condition information to support maintenance as well as operational planning.

Sensors are the first step; data would then have to include the weight of the wagons and their load to support resource planning, optimization of vehicle rotations plus real-time condition data for the maintenance of rolling stock.

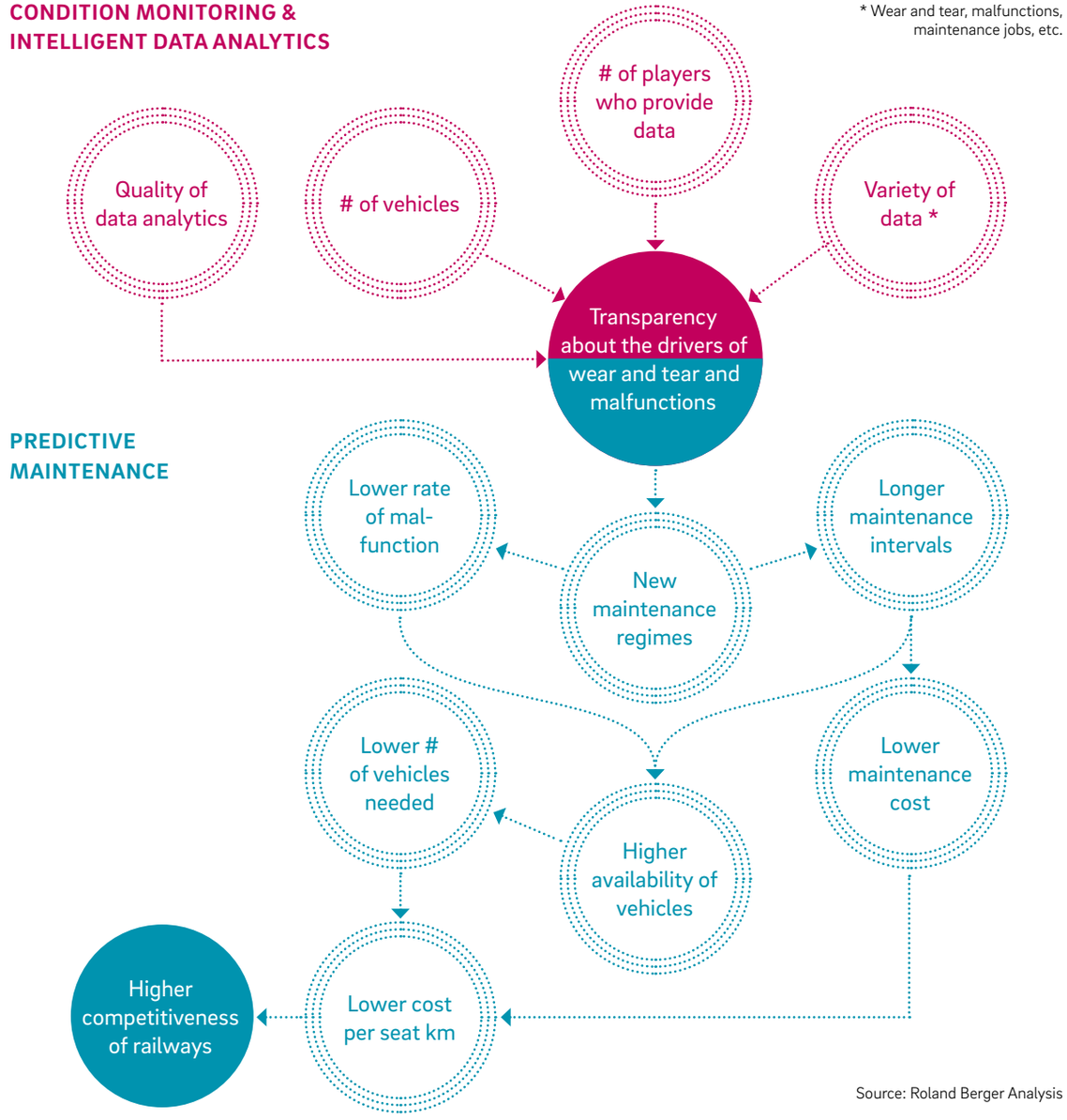
COMMUNICATION PLATFORM

Technically speaking, operators need two-way communication to facilitate data transfer between drivers/ vehicles and those managing the fleet.

D

MAIN RESULT OF PREDICTIVE MAINTENANCE

Higher competitiveness of railways is the ultimate goal



Source: Roland Berger Analysis

For the sake of brevity, we have only outlined a few areas where asset management and maintenance are ripe for improvement. The results are a summary of the insights Roland Berger experts have gained working with our clients in the rail industry.

FLEET AVAILABILITY IS KING

The operators' key challenges always stem from issues that impact fleet availability, such as maintenance regimes, reliability and spare parts. The target availability is usually defined by the fleet operator (e.g. 93-95%). If the fleet misses this target, there are negative consequences such as penalties by transport authorities, cost of renting/purchasing additional vehicles or revenue losses. This means that a substantial increase in availability helps reduce the total fleet size and thus realize cost savings. Increasing availability, however, is sometimes easier said than done.

Typically, there are three obstacles to overcome.

- → With rigid time- and distance-based **maintenance regimes** the fleet may be forced into expensive, unproductive downtimes. This is where predictive maintenance offers a clear advantage over regulatory bodies or traditional (preventive) maintenance planners, who are focused on rules rather than on the actual condition of the components or the entire train.
- → **Reliability** of both the material and its professional maintenance is a key factor. This is because unplanned downtime caused by malfunctions (e.g. after repairs or revisions as well as unforeseen breakdowns and accidents) requires disproportionately more work to diagnose and repair.
- → The classic tradeoff between **spare part availability** and stock level optimization continues to be an area for optimization. This is still an issue with significant potential for cost savings, as innovative ideas or product offerings are missing or not yet well implemented. In the near future, additive manufacturing ("3D printing"), as in the aviation industry, might offer an answer – at least for some applications and materials. This intervention goes along well with liberalization and digitization, because it can easily be contracted out to independent specialists.

CHALLENGES IN PUTTING DIGITIZATION INTO PRACTICE

Although some innovative solutions are already available, operators face challenges in implementing them. Innovative solutions are meant to result in a significant cost reduction and the increase of production flexibility. However, if a rail operator stretches the maintenance intervals based on real condition data, the new maintenance regime will require the adjustment of regulatory frameworks and contracts with the granter of a concession. Receiving regulatory allowance is a complex process, to say the least.

Sometimes it is a question of organization, too. First there is the outside perspective. Incumbent operators complain about rigid organization and unions that obstruct the introduction of innovative processes and products. Then there is a stricter inside perspective on organization.

There is huge potential for using intelligent data analytics not just for maintenance but also for operations and sales. However, this requires the alignment of all systems and data interfaces with information on vehicle rotations and productivity or the train formation, its length and load. Last but not least, there is the challenge of data interpretation. Currently, error codes are not accessible to operators and cooperation with OEMs is rather basic.

"The problem is not the amount of operations data available but the ability of maintainers and operators to use it."

Deputy Director Operations,
Mass transit operator

At times, innovative solutions are missing and sometimes their implementation is a challenge. Nothing less than a new mindset is necessary to tap the full potential of integrating digitization into the rail industry.

A LOOK FROM A DIFFERENT ANGLE

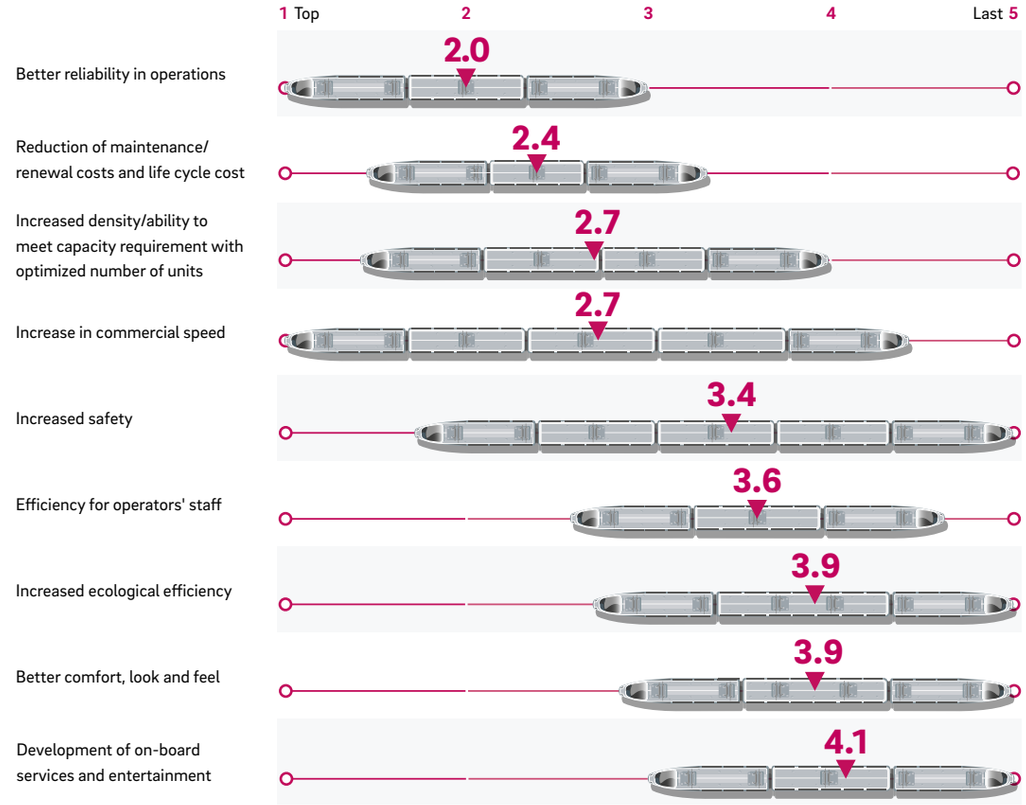
Purchase of new rolling stock

We wanted to get a sense of how important the topic of maintenance is for top executives in the railway sector. This is why we asked them to rank reliability and maintenance costs (among other criteria) in benefits sought when ordering new rolling stock. Not unexpectedly, they were chosen as the key benefits of new rolling stock – significantly more important than increased capacity and speed.

With respect to optimization of rolling stock, efficiency comes first on the agenda of our respondents. A make-or-buy analysis in maintenance – which is a first step for significant outsourcing – is not considered a main issue. A partnership with an OEM in general (not only in maintenance) is regarded as important – though just by a few respondents (who ranked it very high).

INCREASING RELIABILITY AND REDUCING MAINTENANCE COSTS

Key goals when purchasing new rolling stock. Benefits of new rolling stock ranked by respondents in their top five picks.



Source: Roland Berger Executive Rail Radar

FROM CONDITION-BASED TO RELIABILITY-BASED MAINTENANCE

How the aerospace industry embraces change

Condition-based maintenance was introduced in the aerospace industry in the late 1990s by engine manufacturers. Urged to sell "power by the hour" contracts to the airlines (engines are generally buyer-furnished equipment, i.e. bought by airlines and installed by original equipment manufacturers, OEMs), engine manufacturers had to find ways to optimize the maintenance costs of their engines, which they did by improving predictability (replacing components not too early or too late). Turbines have offered a wide range of easily-measurable parameters like temperature or vibration indices for some time. But more recently the principle has been extended to structural parts of the aircraft.

Their maintenance strategy is now fed by Health and Usage Monitoring Systems (HUMS), which is a complete sensor-based system measuring health and performance of mission-critical components of the aircraft.

With the rise of big data and the Internet of Things, the aerospace industry is heading toward new horizons: systems like HUMS generate incredible amounts of real-time data about the usage and condition of the equipment and aircraft. Today's aircraft are loaded with sensors, generating valuable streams – upwards of 100 MB of data per flight hour – of real-time performance data.

Combined with the additional context of engineering data and past maintenance history – for the part in general and for the specific aircraft – and powerful data analytics, optimization of maintenance becomes more reliable and accessible: operators can schedule maintenance based on multiple data (i.e. the real condition of the rolling stock, historical data, and the constraints linked to operations) rather than having to schedule maintenance based on historical data alone.

One condition, however, has been highlighted by the aerospace industry as essential to furthering such progress: increase cooperation between stakeholders to collect and to share the widest range of data enabling robust analysis.

HEALTH AND USAGE MONITORING SYSTEMS (HUMS) LEAD TO REDUCTIONS
A study of HUMS on AH-64 Apaches found

Source: Honeywell

Towards Maintenance 4.0. How to put business models on the digital track.

Based on the project experience of Roland Berger experts, we have come up with six recommendations for maintenance providers to push their market further in the (digital) direction of rolling stock maintenance 4.0. This applies to companies operating trains as well as OEMs.

1. SHARE DATA

The bigger the data pool, the better the results from intelligent data analytics (e.g. on technical failures, wear and tear and the like). Railways, for instance, should adopt a model of "coopetition": competition in train operation and sales & marketing, but cooperation in maintenance. Some airlines have done this and can be role models for the railway sector.

2. INVEST IN SENSORS

A lot of data is already available for rail vehicles. But if there are blind spots in the information, do not shy away from investing in additional sensors. Ideally, equip the vehicles with those sensors during a heavy maintenance project or refurbishment.

3. REVIEW THE BIG PICTURE

Do not focus on rail maintenance alone. The whole value chain, from condition monitoring, defining the optimum maintenance regime to the manual labor in the depot, can be optimized. Only a holistic view of the total life cycle cost of the vehicle or asset will make it possible to optimize the process.

4. TRUST EXTERNAL EXPERTS

The division of labor has its upsides. Work with data analytics experts including start-ups. They can share their innovation know-how within a culture of "trial and error" which is indispensable in yielding results quickly. Mix these experts and start-ups with railway engineers to develop new asset management and maintenance regimes in line with safety requirements.

5. EMPLOY INNOVATIVE METHODS

Crowd platforms, hackathons and design thinking are new methods for getting the most out of digitization. Most large European rail operators have already organized hackathons, but these have been focused on the customer interface and overall infrastructure. Extending these events to rolling stock maintenance will help in achieving significant cost savings in predictive maintenance. The use of a digital twin of a vehicle, e.g. as practiced by GE, helps in realizing predictive maintenance.

6. IMPROVE YOUR EXCELLENCE

Focusing on digitization does not mean neglecting aspects of organizational and operational excellence. Continue focusing on the classic elements of optimi-

zation: purchasing, sourcing, manufacturing, plant layout, modular maintenance, continuous improvement in depots/workshops, etc., while integrating digitization into the sector.

These recommendations can be used by every actor in the value chain to implement the points above:

→ Operators and OEMs can ensure their competitiveness by implementing the above guidelines and developing business and cooperation models

→ TAs set the expectations and the contractual schemes for the industry; they can set the pace for change in embracing digitization (particularly as they get their mandates from government), and ensure the change is balanced with the provision of positive social impacts, such as protecting jobs in maintenance depots

Railways have lost significant market share to road traffic in the past 70 years. Autonomous driving and intermodality will be the next challenges to the railway sector. Improving products and services is a sine qua non. Reducing operational costs, especially maintenance, is absolutely critical for the sector. Digitizing rolling stock maintenance is one way to continue such cost cutting. But this requires adaptation, which can only be turned to account if the sector guides the digital transformation – that's the order of the day. ◆

FACTS AND FIGURES

The market for rolling stock maintenance in Europe

A pan-European market only exists for spare parts – given that vehicles, transportation cost and time limit the catchment area of maintenance plants.

40%

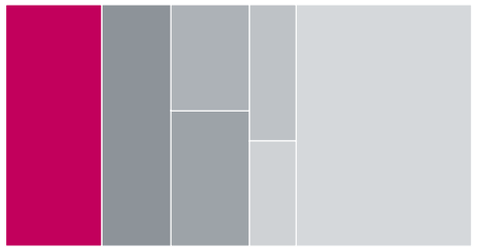
of maintenance is conducted inhouse by railways and mass-transit operators and is therefore not accessible to external providers.

3%

is the expected annual growth of the maintenance market until 2021

16

billion euros in the total market volume p.a. for vehicle maintenance in **Europe**



- **3.3 billion** euro **German** market
- **2.4 billion** euro **French** market
- **1.5 billion** euro **Italian** market
- **1.2 billion** euro **British** market
- **0.9 billion** euro **Polish** market
- **0.7 billion** euro **Spanish** market
- **6.0 billion** euro **other** markets

Source: Unife/Roland Berger

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Roland Berger, founded in 1967, is the only leading global consultancy of German heritage and European origin.
With 2,400 employees working from 36 countries, we have successful operations in all major international markets.
Our 50 offices are located in the key global business hubs.
The consultancy is an independent partnership owned exclusively by 220 Partners.

FURTHER READING

RADICALLY DIGITAL
Shaping the digital transformation

Companies are launching one digitization project after another at breathtaking speed. New platforms, new products, new processes; lower costs or more flexibility – almost every issue has a new hype attached. But are the countless projects embarked upon by Europe's market leaders actually getting them anywhere?
Many of your future competitors and many of your future customers will not be the same ones as you have today. Break out of the traditional patterns of your industry. Come up with your own plan D for digital, custom-tailored to your business. Be radically digital!

PREDICTIVE MAINTENANCE
Is the timing right for the manufacturing sector?

Manufacturers are increasingly seeing maintenance as a strategic business function as they seek to reduce both maintenance costs and downtime, and increase asset lifecycles. Gone are the days where maintenance was seen as a "necessary evil"; manufacturers now have more alternatives than ever to employ a costly "run until it breaks" reactive maintenance strategy, or an inefficient "fix it regardless" preventive maintenance approach. Together with Castrol, Roland Berger has been exploring the use of predictive maintenance technologies by manufacturers in order to co-write this thought piece.

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Publisher

ROLAND BERGER GMBH
Transportation Competence Center
Sederanger 1
80538 Munich
Germany
+49 89 9230-0
www.rolandberger.com

WE WELCOME YOUR QUESTIONS!

ANDREAS SCHWILLING
Partner
andreas.schwilling@rolandberger.com

FRANCOIS GUÉNARD
Principal
francois.guenard@rolandberger.com

DR. KATHERINE NÖLLING
Editor
katherine.noelling@rolandberger.com

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