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New technologies applied to railway maintenance

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Abstract

Rarely in the history of rail maintenance has there been such a clear opportunity to introduce new technology and to leverage information and communication systems aiming to search for improvements in equipment maintenance, infrastructure or in maintenance operations.

It is currently possible to find-out in the market a wide range of monitoring devices, interfaces or communication systems configurable at a moderate cost, as well as computing technology with sufficient processing capacity to diagnose in real time and even anticipate the future behavior of the systems.

This initially favorable situation also poses two major challenges: the new *on-hand* digital solutions will not bring the desired added-value without suitable integration and probable adaption to the existing business processes and tools, which is not usually easy according to the new dimension of the project and the greater uncertainty in the outcome. On the other hand the wider diagnostic and interconnection possibilities of digital systems, usually able to provide huge volumes of data, make the identification of key parameters difficult enough to draw effective conclusions in terms of maintenance optimization, thus data structuring, data filtering and prediction algorithms play a fundamental role.

Alstom, with its global experience in railway maintenance and more than 25 years in maintaining Very High Speed Trains, will show few examples of new technologies brought to equipment maintenance and operational management, as well as those difficulties and relevant findings in this process.

Keywords: optimal railway maintenance, augmented reality, predictive plataforms, drones, big data, machine learning, real time equipement diagnostics.

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Since its very beginning, railway maintenance has evolved at a pace marked by technology innovations integrated in rail and infrastructure equipment as well as the set of methods and tools acquired by the industry. However just in the third quarter of the twentieth century electronic and communication systems burst into the railway industry to accompany and mark the future of this activity.

An important milestone which is part of this Third Industrial Revolution or era of automation is the incorporation of digital systems. The leap from analog to digital control systems, apart from improving accuracy and response times in the regulation of systems, significantly increased the diagnostic capacity by progressively developing controllers and interfaces capable of managing larger volumes of information per unit-time and to extend the scope of connected devices at even increasingly competitive costs of acquisition and operation. Even though it was a real source of improvement for railway maintenance execution, the processing and communication speeds already achieved could not lead to real-time data sharing and remote systems diagnosis.

At this time we navigate within the Fourth Industrial Revolution [Industry 4.0 or Connected Industry], reaching outstanding levels of computing power, intelligence and development of communication systems, including wireless, which are allowing to an unprecedented qualitative leap in the execution of maintenance operations and in the organization of the railway maintenance activity.

Opportunities are extraordinary: from planning the execution of the maintenance activity in advance after predicting the future behavior of the systems, to considering the results of previous decisions and feed the process through Machine Learning and Artificial Intelligence, and to detect new business opportunities or optimization possibilities benefitting our clients or the company itself from massive data analysis [Big Data].

But the advantages also bring important challenges to be mastered so that the introduction of the new technology adds real added-value to the maintenance activity and does not become a mere digital showcase. The vertiginous technological development puts on the table an enormous volume of data provided by the equipment that needs to be interpreted, filtered andtransformed into useful information for decision making, and which in turn encourages the continuous appearance of data analysis tools which must be observed. On the other hand, this scenario provides complementary information to the maintainer (service demand, infrastructure status, environmental parameters, etc.) that may imply new opportunities or changes in maintenance management models. This requires adequate skills and competencies: from the global vision necessary to direct investments in digital transformation, to the ability to interpret the technical and operational data available to transform them into useful information for business decisions.

Currently more than 50% of the companies adopting Internet of Things are not sure of the return of their investment. New technologies are routinely evaluated and deployed in such a fragmented way that it is not possible to assess in advance the joint effect of their integration. 27% of companies are not sure of the questions they should ask around data, and 31% do not store the information that is generated. This indicates that the level of maturity is not yet high and we are only at the beginning of the learning curve.

How the organization adapts itself to this new scenario, how information is shared, how resources are organized, and how processes are designed to make operational decisions reliable and efficient enough will be key to the success of the system, and in any case the possible solution to the challenges posed.

1. Technological offer

The market is currently able to provide technological gadgets to particular users or companies combining remarkable processing capacity and communication interfaces compatible with the main standards for domestic and industrial communication.

Many of these gadgets will soon incorporate communication interfaces allowing to operate in bands compatible with 5G technology, therefore they will multiply the communication speed by 50 to 100 times, and will be considered fully connected devices. The future of railway maintenance will go through the proper integration and use of these devices.

Among the multiple angles in which one can approach to railway digitization, one could be the expected usage in maintenance operations. In this way we can have:

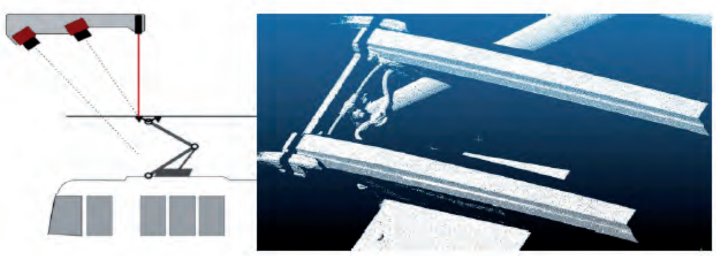
- Asset monitoring and diagnosticssystems
- Maintenance supportdevices
- Integration Platforms, data processing and interface with business managementsystems

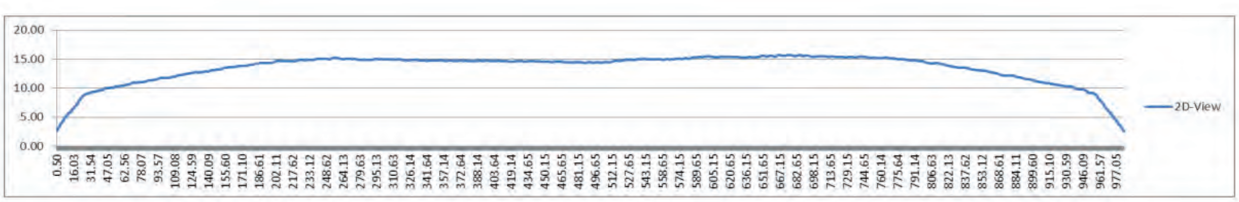
Asset monitoring and diagnostics systemsprovide to the maintainer built-in technology or later integration possibilities, as well as monitoring solutions that minimize physical interventions in the asset. All of them have the objective of continuously and reliably retrieve key parameters to determine or to infer the equipment performance.

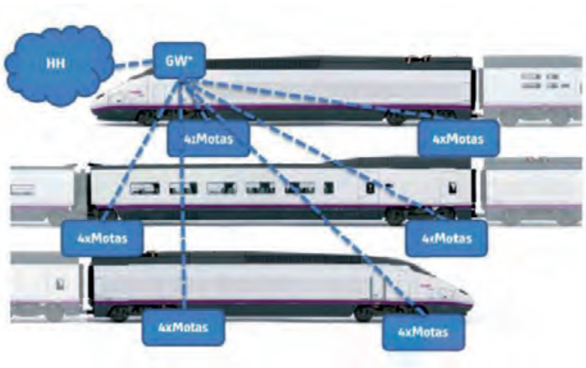
The expected performance of these systems is primarily measured in terms of reliability and quality to monitor key parameters, which can be physical (distance, temperature, pressure, vibration, voltage, current) or presence and usage (number of actions) and in terms of the required time for data transmission. Therefore, reliability, precision and communication performances in relation to investment and operating costs will be relevant factors to consider in your selection.

Some examples of monitoring technology are optical and laser systems to perform dimensional checks, thermographic technology, inductive, electrical or optical systems to confirm the presence or position of an element, number of maneuvers or displacement, instrumentation for measurement pressure, etc.

These systems currently allow, for example, temperature and vibration monitoring at grease-box bearings even in conventional and high-speed vehicles. They also provide means to measure and to identify degradation patterns in elements subjected to wearing such as pantograph contact strips or the brake disks, or to monitor interlocking control and driving systems (point machines) through electrical parameters.







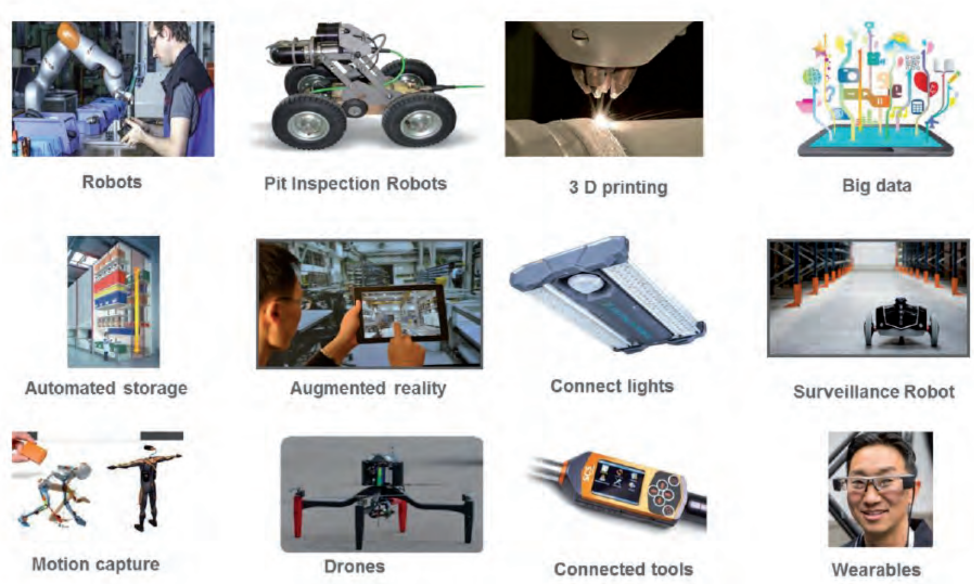
Technology evolution is in turn providing monitoring devices with the necessary intelligence to produce and transmit in real time only the relevant diagnostic information, thus reducing the frequency and volume of raw data transmission to optimize the battery autonomy when they lack external power. In turn they allow to download, if required, the full-recorded data postponed in time.

Devices or systems supporting maintenance execution can be directly used as a complement or replacement of maintenance activities, either to improve the safety, reliability or ergonomics of operations, or to enhance the efficiency and optimize the costs of the intervention by automating the process.

They are in fact the most popular gadgets in the Connected Industry or IIoT since many of them find eventual applications in maintenance or repair workshops and could be part of what is usually designated as Workshop of the Future.

These devices include Robots and Cobots -Collaborative robots- Additive Manufacturing and 3D Scan, Augmented and Virtual Reality (AR / VR), Connected Tools, Wearables or smart technology integrated in clothing, Drones, Smart Glasses, etc.

The main value of these tools is the possibility of improving the process efficiency and safety by automating labor-allocated tasks, as well as the possibility to reinforce both process control and process quality.



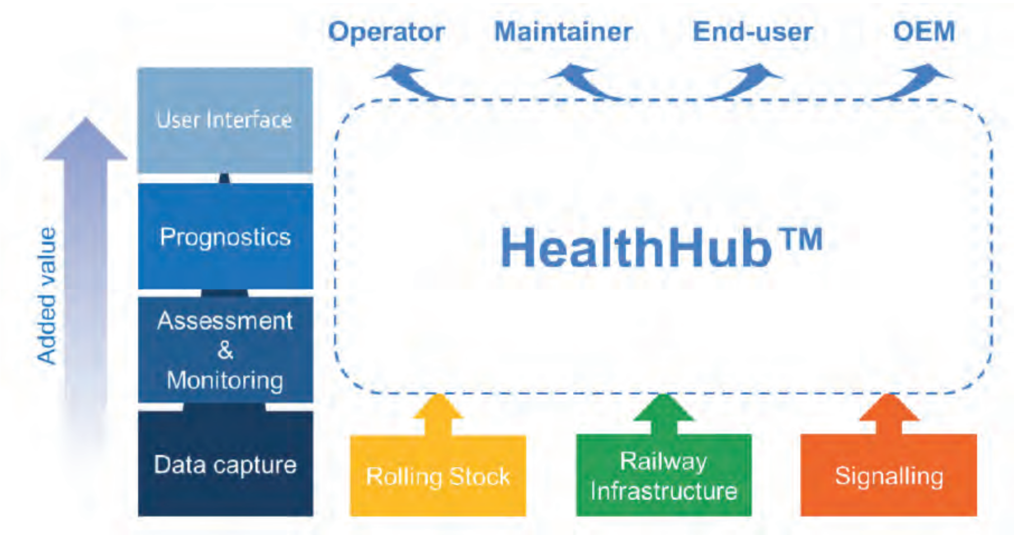
Data processing, integration and interface platformsare the nexus in the Connected Industry leveraging integrated systems and corporate applications to provide real added value to maintenance activities.

Large technology providers, communications and industrial services are developing data integration platforms and associated Cloud Computing services, Reporting, Security Management, intending to concentrate activity and to become an industrial benchmark. In parallel Open Source platforms are also emerging intending to provide roughly equivalentservices.

On the other hand, data transmission protocols are also being adapted to the Connected Industry, for example Sigfox, LoRa standards improving the efficiency and optimizing the energy consumption of the interface.

Integration Platforms are the core of Big Data, setting-up the basic structure to provide integrity and analysis potential to exchanged data, from which it is possible to launch algorithms and processing routines to extract the relevant information.

In the field of railway maintenance, this basic data structuring is even more important because of the great heterogeneity in the sources (customer, infrastructure, vehicles, maintenance) and in the information provided, sometimes lacking the minimum required reliability to subject to analysis.



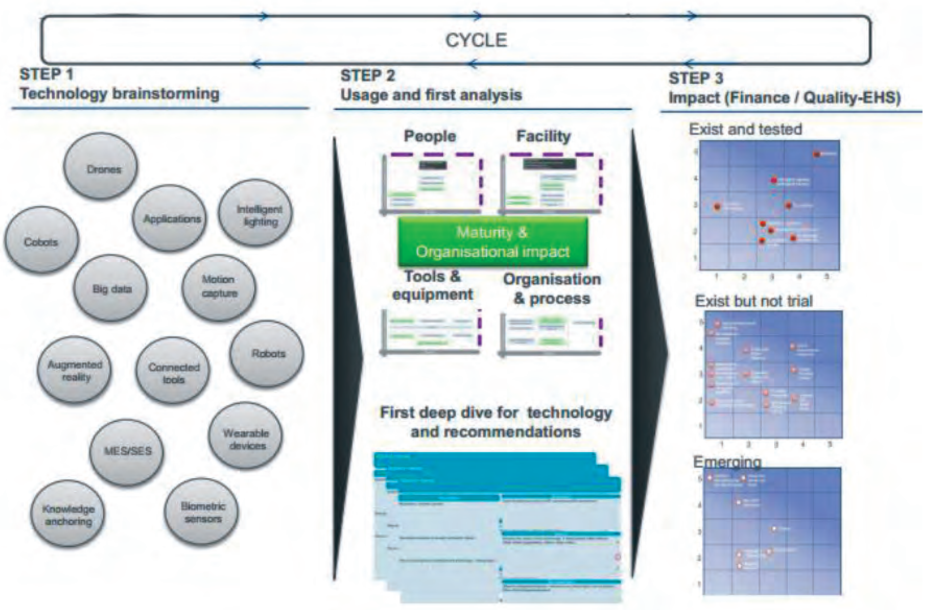
Decisions surrounding the selection and management of these platforms are complex and due to the current dynamism that they must be supported by work groups with adequate vision and technical skills.

2. Adoption strategy

Defining a clear strategy for introducing new technology, providing it with a plan and specific resources for its achievement and involving all levels of the organization are key factors to secure the integration project.

To this end, it may be appropriate to carry out an initial evaluation of the possibilities of the new technology to solve those relevant problems and inefficiencies noticed by the organization together with the required changes or adaptations. On the other hand, segmenting new tools according to their state of maturity and risk for evolution, together with the ratio [outcome quality -cost of the investment], will provide better insight into the possibilities of technological devices and into the associated risks.

Raising the introduction of Connected Tools in a rail maintenance workshop would require assessing how the new technology will bring value and will help to optimize the process together with an estimation of the expected return, likewise identifying the adjustments or redesign requirements in the maintenance process, staff training needs and logistics support to get the tool fully operational whenever it is required by the maintainer.



The action plan derived from the integration strategy must be ambitious and shall consider all the optimization possibilities offered by the new technology, but at the same time it should be developed in continuous and small steps, without stopping.

It is common practice to develop Proofs of Concept in the early stages of that process to confirm that the performance of the new devices is in line with expectations and the investment is justified. They are usually small-scale tests intending to get closer to the current operating conditions. But the outcome may not be conclusive or could be distorted if testing conditions are not representative, or if the device is forced to integration into the existing process rather than into a redesigned one.

3. The management of the new process will determine the outcome

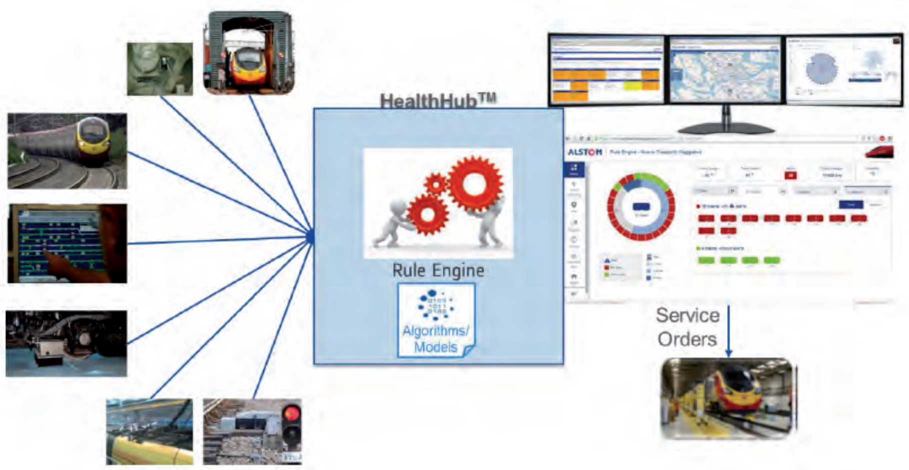
Although the integration plans are bult in small steps, the strategy should be conceived over the final management vision of processes and tools required in the maintenance activity, including in-between synergies and the need for integrating platforms and data processing tools.

An example of this vision is found over the use of asset monitoring systems and the development of Predictive Maintenance algorithms.

Scheduled preventive maintenance task are being progressively relieved by Condition Based Maintenance (CBM), insofar as it has been possible to access to new reliable diagnostic information for railway equipment. Currently technology allows going a step further, applying Predictive Maintenance techniques in order to model and to predict the behavior of the system till failure, and even applying Proactive Maintenance to detect and act in advance in the causes that generate degradation performance of the component or equipment.

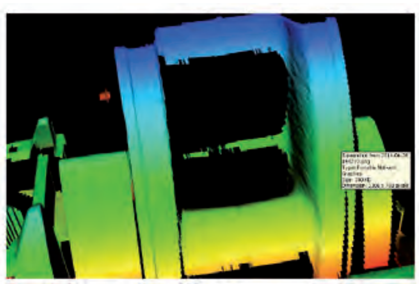
In this way, it would be possible to dynamically plan maintenance tasks, to avoid unexpected Service-Affecting Failures and to optimize maintenance intervals, maximizing the reliability and availability of the fleet.

As a result, it may be eventually required to modify the maintenance process to reconsider the execution of corrective tasks in order to keep the vehicle in operation as per the joint evaluation of the predictive model and the real-time reported alerts and events.



Time	Description	Area	Links	Ack
2017-07-03 11:33	[1B-8F] Aislamiento de chopper auxiliar Aislamiento de chopper auxiliar #01-1B-8F	sergio.lopez@alstom.com 2017-07-03 17:03:18		☒
2017-07-03 11:33	[1B-0E] Aislamiento de ventilacion del chopper aux Aislamiento de ventilacion del chopper aux #01-1B-0E	-		☐
2017-06-27 20:03	[30-26] Falta de rendimiento en frenado electrico Falta de rendimiento en frenado electrico #0C-30-26	-		☐

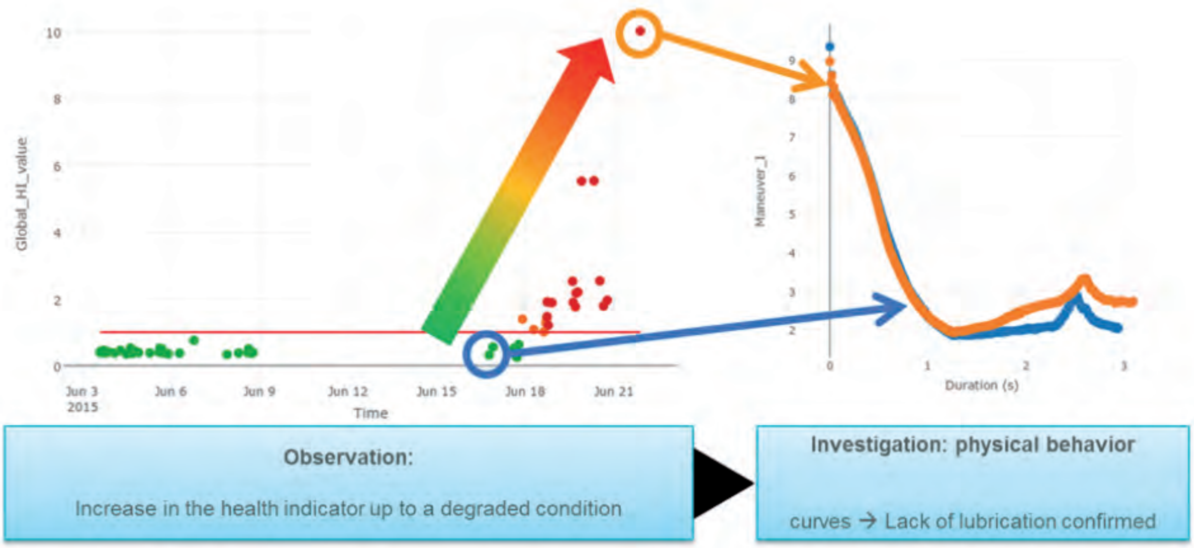
At present it is possible to diagnose the condition of a good number of rolling stock and infrastructure equipment, for which predictive algorithms are being developed to adapt the maintenance strategy and ease operational decisions, including:



- Wear of brake pads and brakediscs
- Wear and detection of defects in pantograph contacttrips
- Wheel profile scan to identify defects, and determine the limits ofuse
- Missing or incorrect positioning of exterior elements: fairings, doors,etc.
- Axle-box and motor bearings condition.
- Components diagnosis in main equipment: Traction, Brake, Doors, Train ControlSystem
- Operating condition of PointMachines

The removal of a significant number of maintenance interventions at first-level visits comes true, especially those associated with integrity and wear checking, thus improving the fleet availability by reducing the immobilization periods.

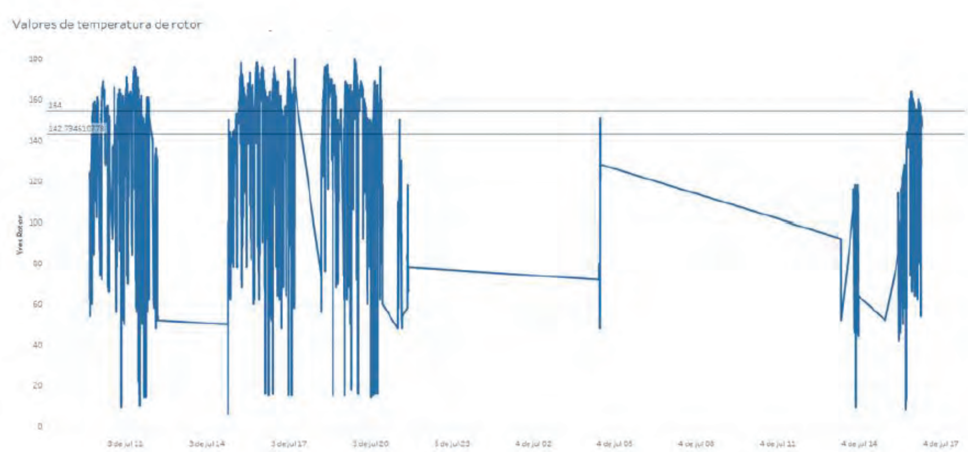
At infrastructure level, one another case-study comes from predictive algorithms already developed for RFI Point Machines after analyzing more than 100,000 maneuvers in 20 devices, allowing the identification and validation of suitable Health Indicators. Detection patterns of lack of lubricant, presence of obstacles and non-compliant deformations were identified, making possible to update the maintenance strategy.



There could come also changes in the maintenance processes when a new device is integrated to complement and sometimes provide more accurate information to the maintenance activity.

Specific monitoring devices allow remote data collection from equipment maintenance ports, often providing wider and more precise information than the one retrieved from the train control system.

Maintenance data currently collected from AVE S100 Motor Blocks are being managed to develop and validate models for traction degraded operation, so that automatic alerts could be configured and the root cause for possible failures could be more rapidly investigated, improving troubleshooting and providing means to enhance the fleet availability.



The new decision-making process consistently manages the former available information and established criteria, jointly with the information provided by the new monitoring system, thus providing means for questioning the maintenance interventions and decisions made so far.

4. Conclusions

The progress in processing technologies and the emergence of the Connected Industry are incentives to reconsider the way in which the railway maintenance activity is organized and executed.

Pioneering actions such as the use of augmented reality in the execution of maintenance tasks, the development of predictive platforms and technologies or the use of drones to perform infrastructure maintenance and inspections at electric substation are some examples of initiatives that are starting to shape this change.

But the real leap will come from reliable data interpretation by Big Data techniques and Machine Learning to effectively cross-check commercial service information, maintenance interventions, real-time equipment diagnostics, infrastructure condition and external conditions. At the horizon one can expect a notable increase in the performance of railway vehicles in terms of service availability and reliability as well as opportunities to optimize maintenance costs.

An adequate integration of technology devices and the revision of maintenance processes, together with the development of competencies and skills for the effective data processing will be key-drivers to succeed.

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