RUN2Rail: New ideas and concepts for the next generation of running gear

Prof. Stefano Bruni from the Department of Mechanical Engineering at Politecnico di Milano provides an overview of the RUN2Rail project (part of the Shift2Rail initiative) and its goal to identify and develop the key methods and tools that are required to allow the design and manufacture of the next generation of running gear.

THE DEVELOPMENT of a new generation of running gear is pivotal to achieving the ambitious goals set by Shift2Rail for future European trains, encompassing the substantial reduction of life-cycle costs, improved reliability and energy efficiency, the reduction of noise emissions and of other externalities and the achievement of full interoperability of the rolling stock. The RUN2Rail[1] (Innovative RUNning gear soluTiOns for new dependable, sustainable, intelligent and comfortable RAIL vehicles) project aims to identify and develop the key methods and tools required to allow the design and manufacture of the next generation of running gear. The project is part of the Shift2Rail initiative and it has been granted EU funds[2].

The project is led by UNIFE and Politecnico di Milano and is composed of 15 organisations from both industry and academia representing eight European countries. It contains four thematic workstreams:

1. WS1: Innovative sensors and condition monitoring
2. WS2: Optimised materials and manufacturing technologies
3. WS3: Active suspensions and mechatronics
4. WS4: Noise and vibration.

However, these are not seen as developing separately, but rather as having strong interaction, exploiting cross-fertilisation between different fields of technology and the integration of different branches of engineering such as mechanical, materials, electronic and electrical.

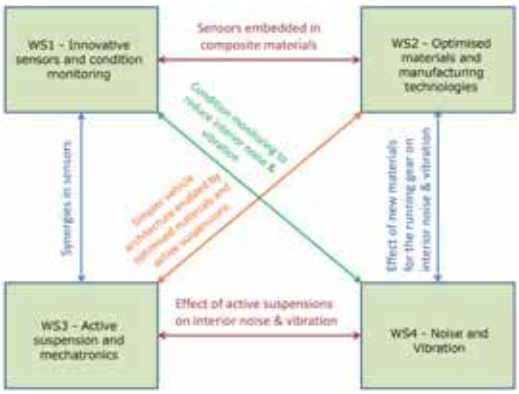
Sensors and condition monitoring

In recent years there has been an increase in interest for implementing condition monitoring in railway vehicles, with the aim of improving RAMS (Reliability, Maintainability, Availability and Safety), also through the implementation of predictive maintenance strategies. However, the initial cost and complexity of monitoring hardware still represents a barrier to this process. RUN2Rail is exploring the potential for advanced applications of condition monitoring in the next generation of running gear, looking at solutions already available in other sectors but also aiming to formulate new solutions specifically targeted to the railway market.

First of all, a general architecture for an on-board condition monitoring system and a set of requirements for the system has been defined. Based on this, suitable components for condition monitoring systems are being identified. RAMS analyses will be performed to select ›

RIGHT: The four thematic Run2Rail workstreams and their interactions

FIGURE 1



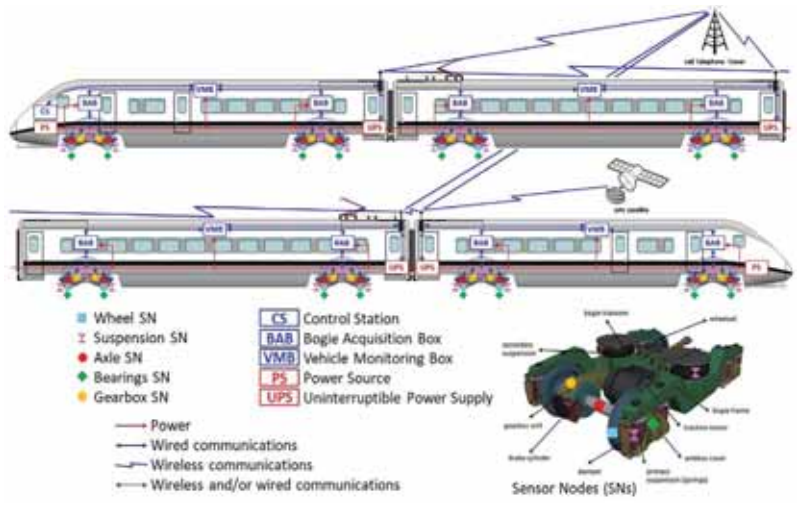
"The development of a new generation of running gear is pivotal to achieving the ambitious goals set by Shift2Rail for future European trains"

the components suitable for operation in the railway environment. In parallel, data processing techniques are being defined to extract information on the condition of the running gear that can be used to implement predictive maintenance policies. The outcome of this work will be a technology concept for the condition monitoring system. The applications addressed are:

- For wheelset axles, use of embedded self-powered sensors to monitor the in-service fatigue stress cycles
- Feasibility analysis of a low-cost strain-gauge-based measuring system that can be used for monitoring wheel/rail contact forces
- Monitoring of the powertrain system through the measure of the instantaneous angular velocity, allowing to diagnose the health of the gear chain using easy-to-access encoder signals
- Monitoring of suspension components based on bogie-mounted acceleration sensors.

BELOW: Overview of the on-board condition monitoring system

FIGURE 2



Optimised materials and manufacturing processes

Novel materials bring enormous potential in the design of railway running gear – for example in reducing weight and forces and in improving reliability. But different techniques are required in both design and manufacturing to allow this potential to be realised. The Run2Rail project is looking into innovative materials and manufacturing processes to support new running gear design being carried out in the other parts of the project.

Novel material and manufacturing solutions are being proposed and evaluated to meet the identified requirements. Virtual (CAE) modelling and simulated manufacturing of the selected components will be carried out, considering the candidate materials solutions envisaged and the relevant load cases. Potential materials and manufacturing processes include:

- Carbon fibre composites
- Additive manufacturing by SLMD (Selective Laser Melting Deposition)
- New metallic alloys with improved mechanical properties
- Powder manufacturing by gas atomisation process
- Use of a robotic system for the laying of composite fibres.

Although significant research has previously been carried out into the potential use of composite materials in railway vehicles (one example is the Kawasaki EFWING bogie), the actual adoption has been very slow. This is partly due to the different manufacturing methods and failure modes of these innovative materials. The key areas where standards or cultures need to be changed will also be reviewed and proposals made which will allow the adoption of innovative materials.

The results of this work will be a step-change in the running gear of rail vehicles. The aim is to quantify the potential – and any shortcomings – of new materials. The benefits will be assessed and will include reduced bogie weight, reduced track forces, simpler designs and reduced life-cycle costs.

Mechatronic suspensions and control technology

Research on active suspension in rail vehicles has been carried out for several decades. Very few studies, however, reached implementation in commercial vehicles because of the increased initial cost of the vehicle and a fear for reduced reliability due to more complexity. It has also become obvious that a reduction of vibration levels in the carbody to improve ride comfort is generally not economically interesting enough to achieve

a breakthrough of active technology. Improvement to ride comfort must go along with other features such as increased passenger capacity, reduced maintenance cost or lower vehicle cost by simplified vehicle layout. The aforementioned issues will be addressed along with many others.

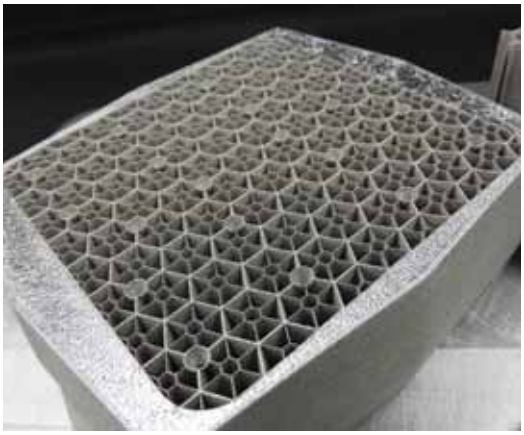
A comparison between different types of actuators regarding their performance and cost shall also be carried out. Especially applications from, for instance, the automotive industry shall be looked at regarding their applicability in railway vehicles.

Also, new concepts for actuations on existing vehicles that shall optimise the cost benefit ratio shall be investigated.

A type of vehicle on which active suspension can be very effective is the two-axle rail vehicle. This type of vehicle is simple and cheaper compared to bogie vehicles but has many dynamic limitations. Therefore, in the second part of this task it will be investigated whether active technology can make single axle running gear vehicles a competitive alternative to today's bogie vehicles. Benefits would be reduced weight and energy consumption.

Finally, proposals will be made on what an authorisation procedure could look like which guarantees a manageable homologation process on one side, and a reliable operation on the other. Which impact might the introduction of active technology have on existing standards?

FIGURE 3

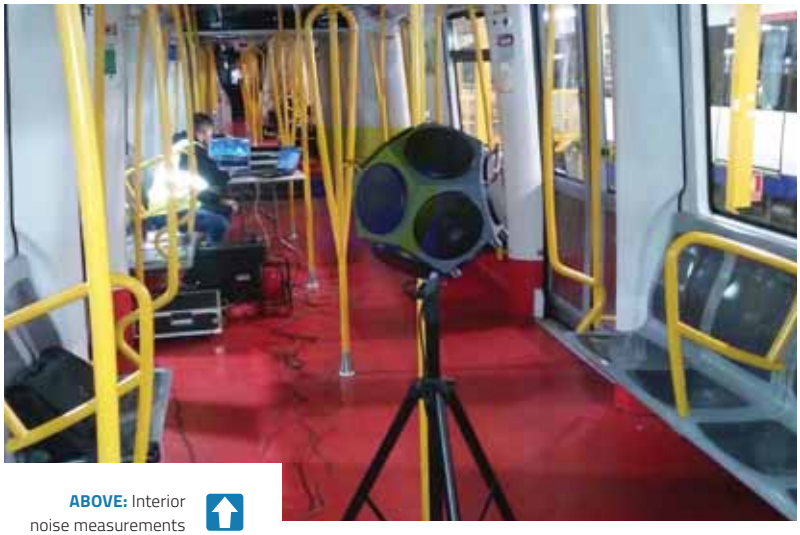


LEFT: 3D metal printing enables the manufacturing of parts having complex shapes, opening new areas to the design and manufacturing of running gear components

Methods for predicting the transmission of noise and vibration into rail vehicles

The acoustic environment inside a rail vehicle is an important aspect of the comfort of passengers and staff. The main source of noise in many situations

FIGURE 4



ABOVE: Interior noise measurements performed in the project

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is generated at the wheel/rail interface and this is transmitted from the running gear to the carbody through structural vibration and airborne paths. These paths are complex and current prediction methodologies are not sufficiently reliable.

Therefore, the project aims to develop validated tools and methodologies for predicting the transmission of noise and vibration from the running gear into the carbody. The work is focused on developing simulation models that can be used as 'virtual test methods' and validating them using field experiments. The structure-borne transmission path will be addressed by determining the wheelset vibration, characterising suspension elements in the laboratory and developing simulation models for the vibration of the bogie frame. The airborne transmission path will be addressed by predicting the noise radiated by the wheels, track and bogie frame. These will be implemented together in a single model capable of representing various different bogie designs. The method will be demonstrated for an example case study and validated against experiments.

In addition, a variety of new and existing techniques for reducing noise and vibration transmission from running gear in order to improve passenger comfort will be assessed using the models. The implications for noise of introducing new materials and active control solutions developed in other parts of the project will also be assessed.

Impact, regulatory issues and cooperation with Shift2Rail

RUN2Rail includes a cross-cutting workstream (WS) known as 'Impact Management Support and Assessment'. It addresses the evaluation of impacts for the new technologies explored in the thematic WS and is looking into aspects related with the authorisation of vehicles with innovative components. The direct impacts aimed for in RUN2Rail's thematic WS involve getting its outputs to affect positively the right stakeholders.

The cross-cutting Impact WS not only addresses the direct impacts, by creating an 'impact-conscious' project, but also:

- A broad scope of economic, social and environmental impacts on stakeholders both within and outside the railway sector
- The whole impact pathway, from the end of the project to its exploitation for Shift2Rail Technological Demonstrator TD1.4, to the envisaged entry into service of running gear based on RUN2Rail concepts
- The whole life-cycle of running gear.

Key questions that are being approached are:

- How can condition monitoring improve maintenance?
- What are the environmental impacts of novel materials and manufacturing processes?
- What needs to be done to make authorisation of vehicles with active components inexpensive, easy and safe?
- How do novel materials and suspensions affect noise emission?

RUN2Rail is drawing input mainly from previous projects (e.g. IMPACT-1 for its approach and Roll2Rail for its Universal Cost Model UCM), through on-going collaboration with the Shift2Rail Call For Members project, PIVOT, and through interaction with the key stakeholders in the RUN2Rail Advisory Group.

Initial work has led to the issue of a first deliverable on targeted impacts, and work is now proceeding on approach refinement in order to have a framework ready for thematic WS input at the end of 2018.

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REFERENCES

1. www.run2rail.eu
2. Under the Grant Agreement number 777564