Alleviating suffering on the metre gauge

Following severe wheel-rail interaction problems on Swiss metre-gauge networks, the RailPlus association has launched a technical study to investigate and address the issue, as Technical Manager Markus Barth explains to Reinhard Christeller.

Over the past decade, several of the larger metre-gauge railway operators in Switzerland have been experiencing a significant increase in wheel-rail interaction problems such as corrugation, wear and rolling contact fatigue. Some of the phenomena that were previously unknown developed rapidly over time, leading to a dramatic increase in maintenance costs and a severe impact on operations.

In some cases the problems reduced the availability of rolling stock to such an extent that train services had to be cancelled and replaced by buses. One of the operators reported levels of wheel wear that were three to five times greater than had been seen in the past. Its stock of spare wheels quickly ran out, with drastic consequences in terms of vehicle availability.

Switzerland's metre-gauge railways both large and small play an important role in the country's integrated public transport network. With a combined route length of more than 1 400 km they account for roughly a quarter of the total rail network. However, because EU regulations do not require the separation of infrastructure and operations on narrow gauge railways, the stand-alone metre-gauge operators all remain integrated companies.

Stadler supplied three Beh4/8 'Spatz' panoramic EMUs to TMR in 2011 for use on the cross-border Martigny – Chamonix route.

Unlike the country's 1 435 mm gauge railways, which largely follow common international standards, there has in the past been much less standardisation between metre-gauge lines. But in the 21st century the various operators began to see the benefits of closer collaboration. The RailPlus association was founded in 2003 to harness the benefits of synergies in purchasing, staff training, ancillary services and technical co-operation as well as lobbying, with the ultimate aim of increasing competitiveness. Today the association has 20 members. It has established nine working groups to address a range of topics from finance to rolling stock and infrastructure.

Systematic response

The impact of the wheel-rail problems on such an important element of the national rail system was soon recognised by the Federal Office for Transport as a systematic threat to the overall efficiency and competitiveness of rail transport. According to Swiss law, it is BAV's duty to ensure the efficiency of the national transport network as a whole. However, it may transfer responsibility for higher-level system tasks in the rail sector to infrastructure managers or third parties, with a specific objective of making operations more efficient and/or achieving cost benefits.

In this case, BAV felt that it would be appropriate to task RailPlus with undertaking a systematic investigation of the wheel-rail phenomena, looking into the causes and making recommendations for possible measures to alleviate the problems. The association was appointed as system leader for the study in 2021, with an overall budget of SFr12m. All 20 members of RailPlus are participating in the project, and five Swiss tramway operators have also joined the initiative. The work is due to be completed by 2026.

RailPlus Technical Board Manager Markus Barth says the association quickly recognised that the complex

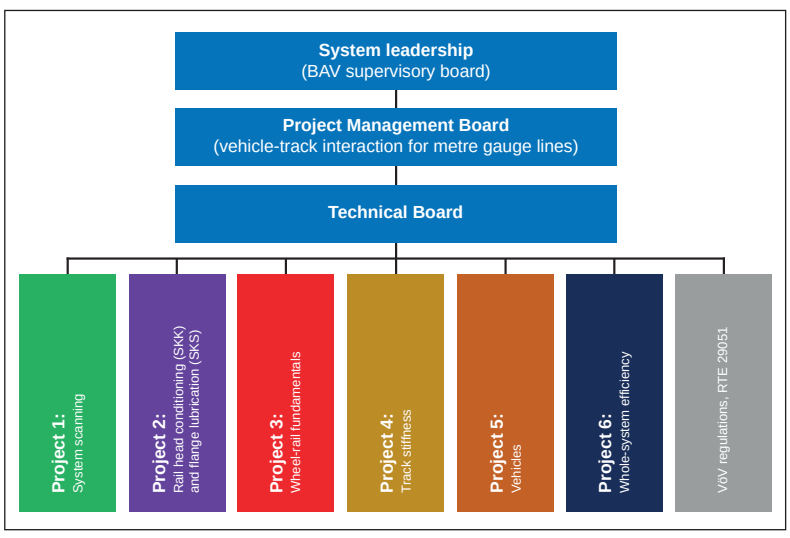

Fig 1. Findings from the six study areas are expected to lead to recommended specifications and eventually find their way into the regulatory framework.

interaction between vehicles and tracks on the country's metre-gauge networks was under increasing stress. It therefore divided the project into two phases.

Firstly, there was an urgent need to find and implement holding measures that could alleviate the worst of the problems and reduce the requirement for excessive vehicle and track maintenance as quickly as possible. Secondly, more fundamental 'system decisions' will have to be made for the future.

One of the greatest challenges for the participants is that the interaction between vehicles and track is still not fully understood, even at an international level. Barth believes that there is more to be learned, which then has to be usefully translated to the conditions which apply on metre-gauge railways. 'We would welcome an exchange of experience with other operators', he adds.

The association and its members are looking for the latest technical knowledge which could help them develop economically prioritised recommendations to optimise both vehicles and tracks in a way that can further develop the overall system. Even this second phase has a degree of urgency, as a major programme of track renewals envisages that up to 50% of the combined network length will need relaying in the coming years.

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>
> *Markus Barth, Technical Board Manager, RailPlus*

Identifying the causes

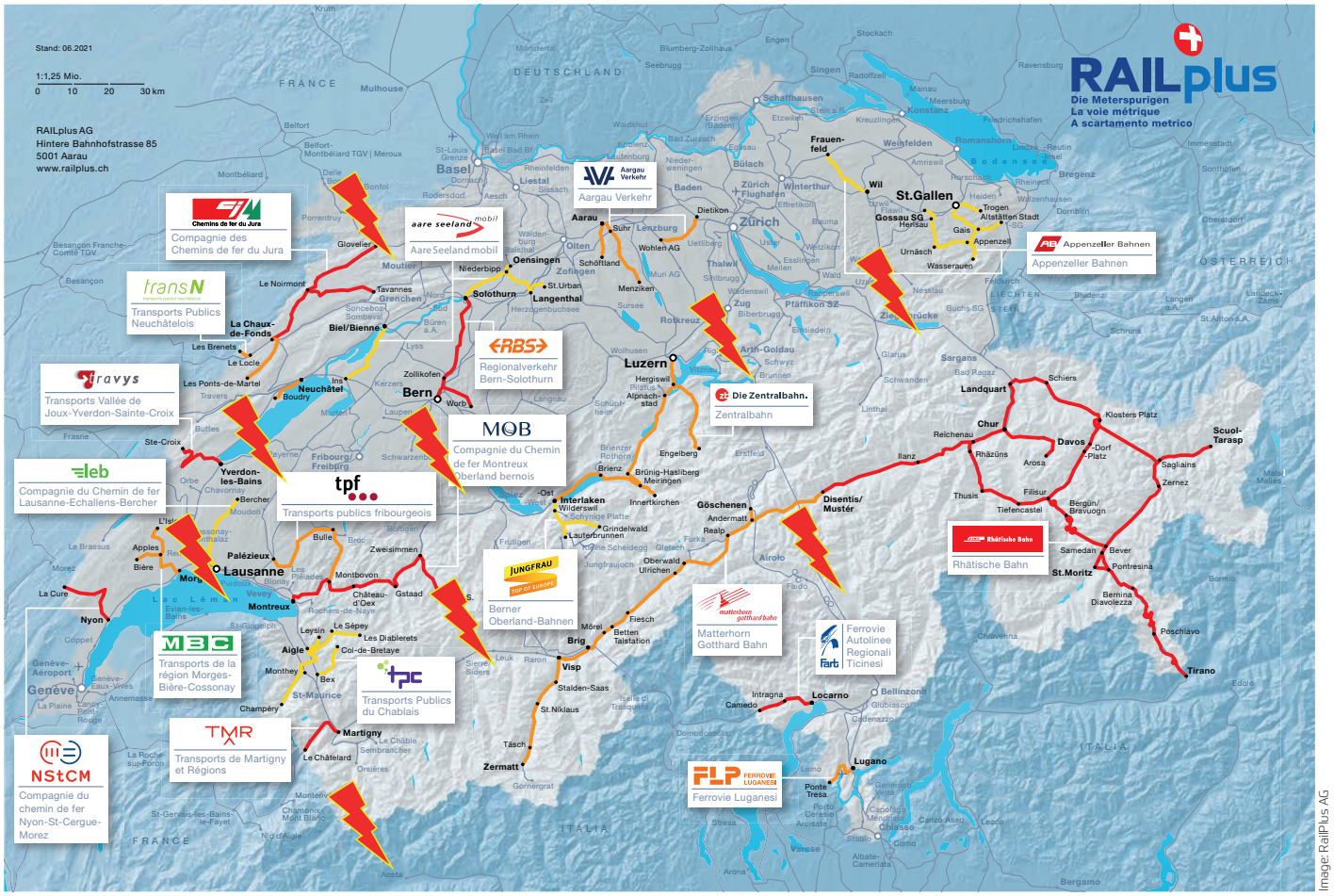
Three main problem areas have been detected, and Barth explains that RailPlus has defined six sub-projects to address them (Fig 1).

Wheel wear has increased, and different types of damage have been observed such as visible riffles or head checks, squats and cracks due to rolling contact fatigue. These phenomena have been worsening steadily over the past decade since they were first detected, leading to shortened maintenance intervals and an increased risk of failure.

Similar damage has been observed on the tracks where metre-gauge railways typically have tighter curve radii than their standard gauge counterparts. Curves of 200 m radius are common, and on some lines the curves can occasionally be as tight as 80 m. A typical pattern being seen on some railways is the emergence of corrugation on the inner rail of the many tight curves with a 60 mm wavelength. This rail damage leads to ballast crushing and the fatigue of bogie components, as well as side effects such as noise emission, rattling and squealing.

Barth says a number of possible causes have already been identified and their individual and combined effects are now being investigated.

In particular, he notes, there have been changes to the design of rolling stock and modern track construction



RailPlus currently has 20 members operating metre-gauge networks spread across Switzerland. The nine most affected by the wheel-rail interaction problems are marked with the jagged arrows.

Image: RailPlus AG

technologies, as well as operational changes. In the case of rolling stock, the previous maximum axleload of 13·5 tonnes has been increased to 16 tonnes, while modern locomotives and power cars have increased power ratings. Changes in bogie design, such as longer wheelbases and stiffer bogies, new wheel materials as well as changes to maintenance procedures may also have to be taken into consideration.

Train architectures have also changed, which affects the dynamic behaviour of the vehicles. Some railways have introduced articulated trainsets, where each vehicle is not supported on its own bogies. Others are powered by a small motor car with fixed two-axle running gear, supporting the unpowered trailer vehicles to either side.

On the infrastructure side, new types of rail materials have been introduced. Trackwork has become more rigid, due to the use of heavier rails and the replacement of wood or steel sleepers by harder concrete types. Alterations to maintenance procedures and changed environmental conditions may also have an influence. And finally, the enhanced national timetables and increasing ridership mean that many railways are operating more trains to tighter schedules, increasing track loadings and reducing the time available for maintenance.

Top-of-rail conditioning

As a first pragmatic measure that was quick to introduce, top-of-rail conditioning was applied to some of the worst affected curves, notably on the curve-rich Matterhorn-Gotthard-Bahn.

This was implemented to address the so-called slip-stick effect, which is mainly observed on the inner rail in tight curves when the rails are dry. Rather than rotating freely, the wheel 'sticks' to the rail for a moment, and then slips quickly until it sticks again, at high frequencies of several hundred Hz.

Photo: RailPlus AG

Various examples of rail and wheel damage experienced by metre gauge operators in recent years.

This is due to the differences between the high static adhesion coefficient and the low sliding friction coefficient. Top-of-rail conditioning applies a thin layer of friction modifier that changes the adhesion properties between wheel and rail. This ensures a constant adhesion coefficient of about 0·4, eliminating the slip-stick effect.

After a year of testing and systematic measurements, MGB was able to report a reduction in wheel wear of more than two-thirds, with wear values falling below historic levels. But although modern conditioning agents are supposed to be environmentally safe, Barth says there are concerns that the modifiers could accumulate in the places where they are applied, so it might be advisable not to have to use them over very long periods. It would be better to find a combination of rolling stock and track design parameters that would eliminate the effect without intervention.

Longer-term research

RailPlus has now defined its main objectives for the longer-term research, aimed at tackling the roots of the phenomena and eradicating them as far as possible. Barth says these should ideally cover as wide a range of use cases as possible, extending from suburban railways with relatively high speeds on fairly straight and level lines to mountain railways with steep gradients, many tight curves and harsher meteorological conditions.

He confirms that RailPlus has submitted its proposals for a detailed research programme to BAV and is currently awaiting approval (Fig 2). Basic investigations will be undertaken into the specific wheel-rail interaction forces on metre-gauge railways, with a focus on running behaviour and contact geometry. Work is also planned to simulate the interaction between vehicles and track. Together, this work should establish the basis for further research and the application of the findings to the different types of operation.

Depending on the individual parameters for each railway, the project team aims to establish guidelines to optimise the railhead geometry and the wheel running surface, along with recommendations for optimised vehicle architectures. One sub-project will have a special focus on the design of bogies and running gear.

Barth says the research programme should produce solutions for improving the overall economics of metre-gauge railways at a system level. Once the findings have been consolidated, he anticipates that RailPlus members will be able to incorporate the specific metre-gauge standards into their technical specifications for any future tenders. They may also — finally — be integrated in the legal framework at either a Swiss or international level.

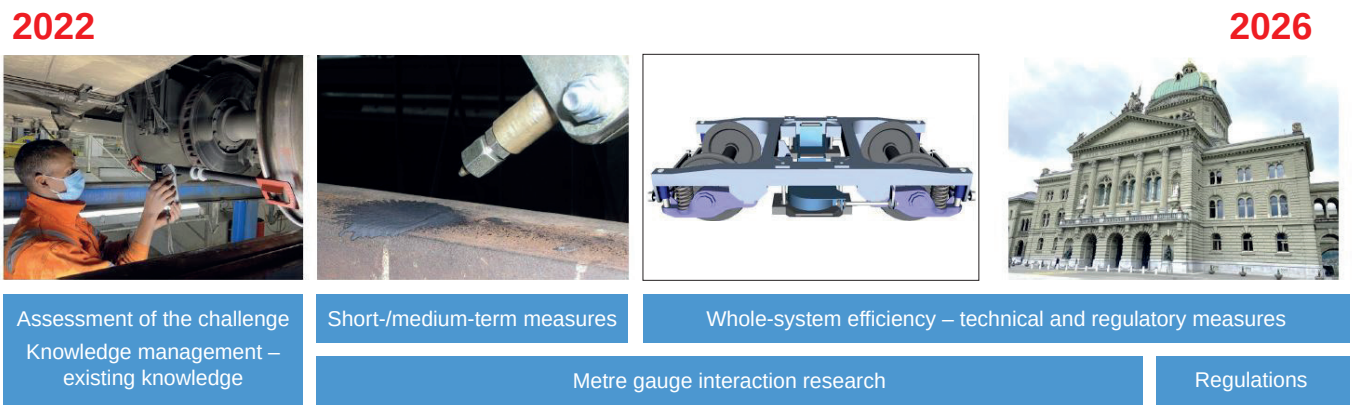


Fig 2. The five-year research programme is scheduled to be completed in 2026.