

Systems analysis of point-relaying machines

Numerous factors influence the operation of relaying points. Apart from the time needed for the actual work and the desired quality of the result, the safety of workers and local conditions are important considerations. This article shows the advantages and disadvantages of various point-relaying machines and indicates which individual relaying methods might be used most efficiently in what circumstances, taking into account the operational hindrance costs arising on account of the construction work.

For the sake of simplicity, this article uses the term “points” to cover all forms of pointwork (i.e. including various types of crossing). Given their structural features, points figure amongst those permanent-way components that are particularly subject to wear. They have to be replaced at the end of their service life, the mean length of which is approximately 25 years. About two thirds of all points in Germany are fitted on mainline tracks with permanent traffic and must therefore satisfy particularly tough requirements as regards vehicle dynamics, track geometry and technical permanent-way features. Sensitive line sections, such the throats of large stations within the big European

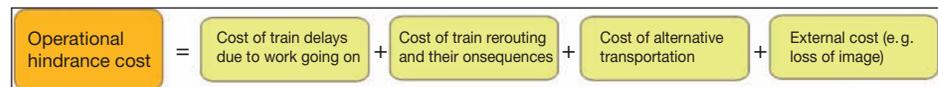


Fig. 1: Components of operational hindrance costs

conurbations, can easily become operational bottlenecks when work has to be carried out on points. The reason for this is that at least two of the possible “roads” that could be set (including access to and from branch lines) are not available. Every year, railway infrastructure managers replace several thousand points across Europe. A variety of relaying methods can be used for this work, each of which has its pros and cons, depending on local conditions. This means that the total duration and number of track possessions required for laying points, combined with the operational hindrance costs, are extremely relevant for main lines with heavy traffic, but the same factors are virtually insignificant in the case of secondary lines. The operational hindrance costs are comprised of the individual components listed in Fig. 1 and can easily run up to a sum in excess of EUR 10 000, depending on the type and duration of the interruptions to train services. For this reason, the aim of any construction work on operationally sensitive main lines must be to keep the operational hindrance costs as low as possible and to make it possible for train services to be resumed as soon as possible. It ought not to be forgotten that the railway infrastructure manager loses revenues from selling train paths every minute that the track is not available. Hence, an economically efficient and speedy method of point replacement ought to be used in order to guarantee a high-quality installation, which will also satisfy all the other requirements. Examples of such methods are the WM 500 gantry crane and the railway slewing crane (Fig. 2).

Different point-relaying methods are used in the various parts of the world, but the majority of these use railway slewing cranes. All too rarely is proper consideration given in advance to the possibility that using a gantry crane as an alternative might be considerably more advantageous in terms of both the duration and the quality of work and that it might reduce construction costs significantly in certain conditions. The WM 500’s technology makes it possible to reduce the time required for laying points by as much as 60 %, compared with conventional working methods.

The relaying method ought already to be decided on during planning and will depend on the type and extent of the construction work. For this purpose, however, responsible planners need to be assisted by suitable decision-support tools that give them the opportunity to decide quickly and accurately which relaying method might be used particularly efficiently under what site conditions. In the study reported on here, various relaying methods were examined in terms of their technological features, their effect on the long-term track geometry and their economic efficiency. Another particularly important question, apart from the choice of relaying method, is the material logistics, including the delivery of the points from the factory to the site, as well as their on-site transport to the place of installation. Different methods of installation exist here too, and, once again, they depend on the site conditions and have a significant influence on disruptions to train services. The various methods are:



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Fig. 2: Point installation using a WM 500 (left) and a railway slewing crane (right)

- ▷ assembling the points “in the gap”,
- ▷ preassembly of point segments in a suitable depot in the immediate vicinity of the place of installation, and
- ▷ delivery of points just-in-time on suitable wagons.

The third of these three methods, i.e. just-in-time delivery, is the fastest one and causes the least stress on the components. The individual point segments are taken directly from the transport wagon and fitted on site.

An appropriate combination of delivery and relaying methods thus provides a good basis for ensuring the smooth replacement of points within the limited time available.

1 Point-relaying methods

In principle, point segments can be transported in the vicinity of the installation site in two different ways. One method very often applied in practice is to transfer them with the help of a steel lifting beam suspended from the jib of the railway slewing crane. The alternative is to carry them on support frames, such as those used on the WM 500.

The steel lifting beam is a welded sectional-steel structure with a load-carrying capacity of up to forty tonnes. To ensure safe and careful transport of the material, its hoist position usually has to be tested several times over before it is considered safe to lift and transfer the actual point segment. This is a precaution to ensure that raised segments will not turn in an uncontrolled manner during transport and that there will be no slippage in the slings.

The support frame, on the other hand, consists of a torsion-proof welded-steel beam frame with attached rail clamps or



Fig. 3: Rail clamp on the support frame (left) and sling device on the lifting beam (right)

pairs of self-activating rail-head clamps (Fig. 3) holding the point segments. In contrast to the lifting beam method, no slings are needed here to hold the point segments. There is thus also no need test the hoist position first when a support frame is used. Support frames have a load-carrying capacity of up to 42 tonnes, depending on their design. They can only be used on cranes of the gantry type, such as the WM 500.

1.1 The WM 500

The WM 500 is a point-relaying and point-segment-transport system that belongs to the category that uses a combination of gantry cranes and support frames. The

entire WM 500 relaying composition consists of various individual sections, which can be combined in different ways for particular uses. The core of the system is a gantry crane for lifting points and known as “PK1” (Fig. 4). This works in combination with a carrier vehicle, which can also run on crawlers and is known as “WRW”. A different gantry crane for lifting points, known as “PK2”, is also available as part of the WM 500 series. The entire system can thus work both on-track and off-track and needs neither auxiliary nor transport rails. A smoothed ballast formation provides an adequate running surface for it. The “WRW” is able to bridge sections where there is no access from the side, so there is no need for time-consuming planking of the running



Fig. 4: The “PK1” gantry-crane point-laying system

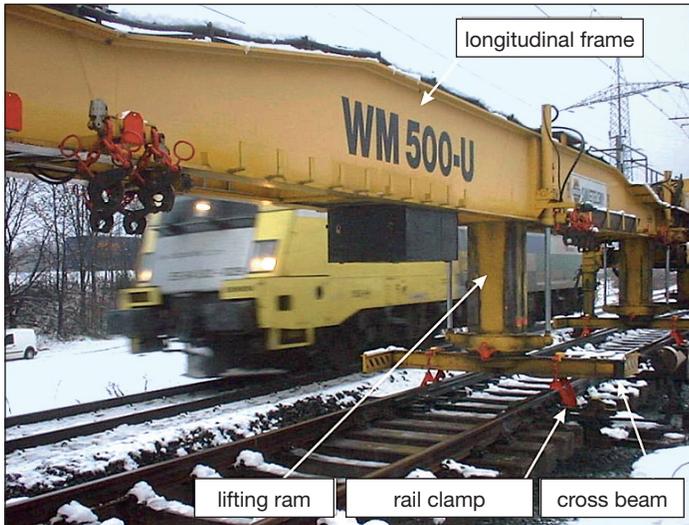


Fig. 5: Design of the "PK1" gantry crane for the WM 500 series (left and right)

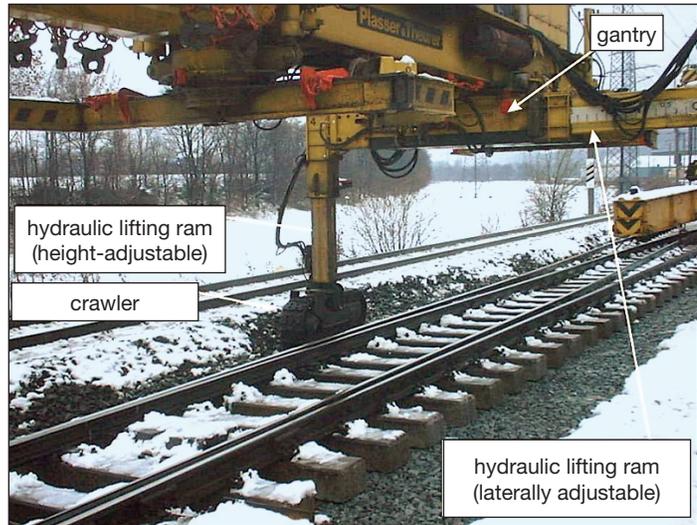


Fig. 6: The "WRW" as the transport vehicle for the "PK1"



surface. The WM 500 is a specialized system for the rapid renewal of points and track panels, and there is no need to close the adjacent track while it is operating. The point segments to be installed can be picked up by the "PK1" either laterally or longitudinally, directly at the front of the machine. This means that this method fits in particularly well with the track-laying version combined with just-in-time delivery. All working movements of the WM 500's sections are radio-remote-controlled, so that, theoretically at least, one remote-control panel ought to be enough for operating all the machines. The "PK1" consists of a longitudinal frame mounted on two lifting gantries. Each of these is supported on two crawler-mounted, vertically adjustable hydraulic lifting rams. Three lifting rams are integrated in the longitudinal frame, as shown in Fig. 5. The lifting height is designed to ensure that the point segments can be picked up directly from a flat wagon. The longitudinal frame can be shifted laterally using the hydraulic rams, thus making a stepping movement perpendicular to the track axis. If it is intended to lay fully-welded point segments with a maximum length of 80 metres (corresponding, for example, to a 60-760-

1:14 simple point on concrete sleepers and a track panel with a length of 25 metres), two "PK1"s can be used in tandem with one another.

The "WRW" is a two-mode vehicle based on the design of a flat wagon. However, it also includes optional equipment, such as two additional four-wheel bogies and two hydraulically extendable crawlers that can be steered both lengthwise and crosswise. The maximum speed of the crawlers is 1000 m/h. On-track movement can be performed under the machine's own power at a maximum speed of 10 km/h. Furthermore, the "loading area of the "WRW" can be slewed laterally by 300 mm in either direction in order to avoid obstacles at the assembly depot. The "WRW" is used both for transporting the "PK1" crane between engineering sites (Fig. 6) and as a transfer platform for the point segments to be installed at an individual site.

1.2 Railway slewing crane

State-of-the-art permanent-way cranes are the outcome of years of research and development. They are remote controlled,

and their features include fast lifting and slewing speeds, short set-up and close-down times and the possibility of working under live catenaries. Some of the models are equipped with counterbalances, permitting work to be carried out without fouling the clearance gauge of adjacent tracks. In Germany, three classes of crane are currently in use for various load situations. Heavyweight cranes are capable of picking up pre-assembled concrete-sleeper point segments with radii of up to 2500 m and fitting them at the place of installation. The maximum length of a segment can be 40 metres, and the segment can weigh up to 50 tonnes.

2 Analysis of point-relaying machines

The following sections offer analyses of the different requirements made of point-relaying methods with the aim of establishing the advantages and disadvantages of each of the methods described above. These requirements are: economic efficiency, safety of personnel and quality of installation.

2.1 Economic efficiency

When performing a simplified assessment of economic efficiency, two main cost items are taken into consideration: firstly, the operational hindrance costs (already mentioned) and, secondly, the technological costs, which are mainly influenced by the costs of the relaying method (i.e. the cost of the equipment used). There is an interrelationship between the impact on train services (expressed in terms of the operational hindrance costs) and the costs arising from the relaying method. This means

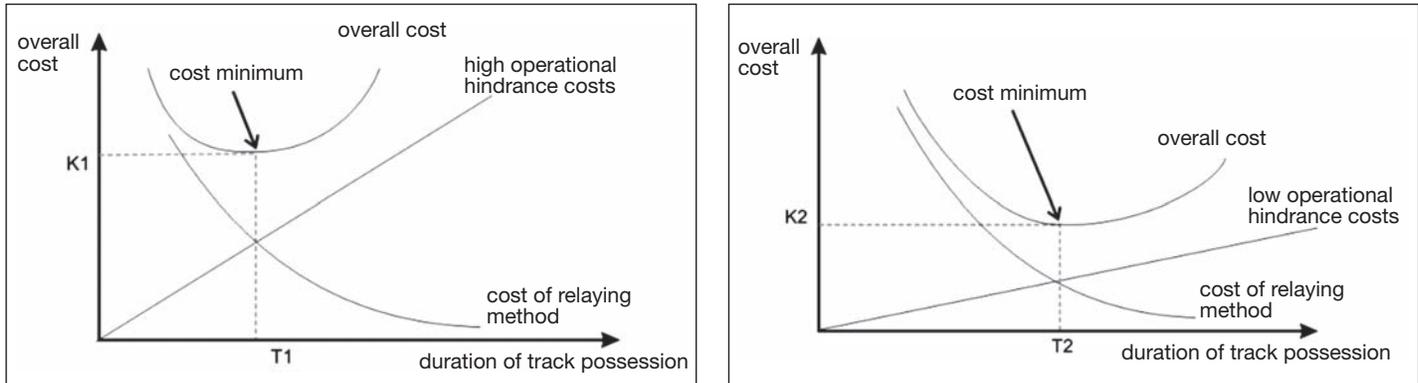


Fig. 7: Principle of the overall costs of an engineering site with different operational hindrance costs

that, if the operational hindrance costs are expected to be high, more attention ought to be paid to rapid handling of the construction work, and the technological costs will be less significant in this case. The opposite to this holds true in cases in which low operational hindrance costs are expected, when less attention needs to be paid to rapid completion of the construction work.

The minimum costs (Fig. 7) describe the point at which the relationship between the operational hindrance costs and the

technological costs is at its optimum. In practice, this means: the higher the density of traffic over the line, the higher the operational hindrance costs will be if the line is not available, and the faster the relaying work ought to be finished. It is therefore advisable to invest in an appropriately fast relaying method. If the duration of the track closure (and consequently the operational hindrance costs) becomes a noticeable cost factor, the faster method ought always to be used. For technological reasons, this will mean using the WM 500

(but taking the individual site conditions into account).

2.2 Safety

The safety of workers during point relaying is absolutely crucial. A railway engineering site is generally an area of increased danger, with trains running on the adjacent tracks, and the work in progress on the site itself also endangers the gang. This work includes, for example, working under

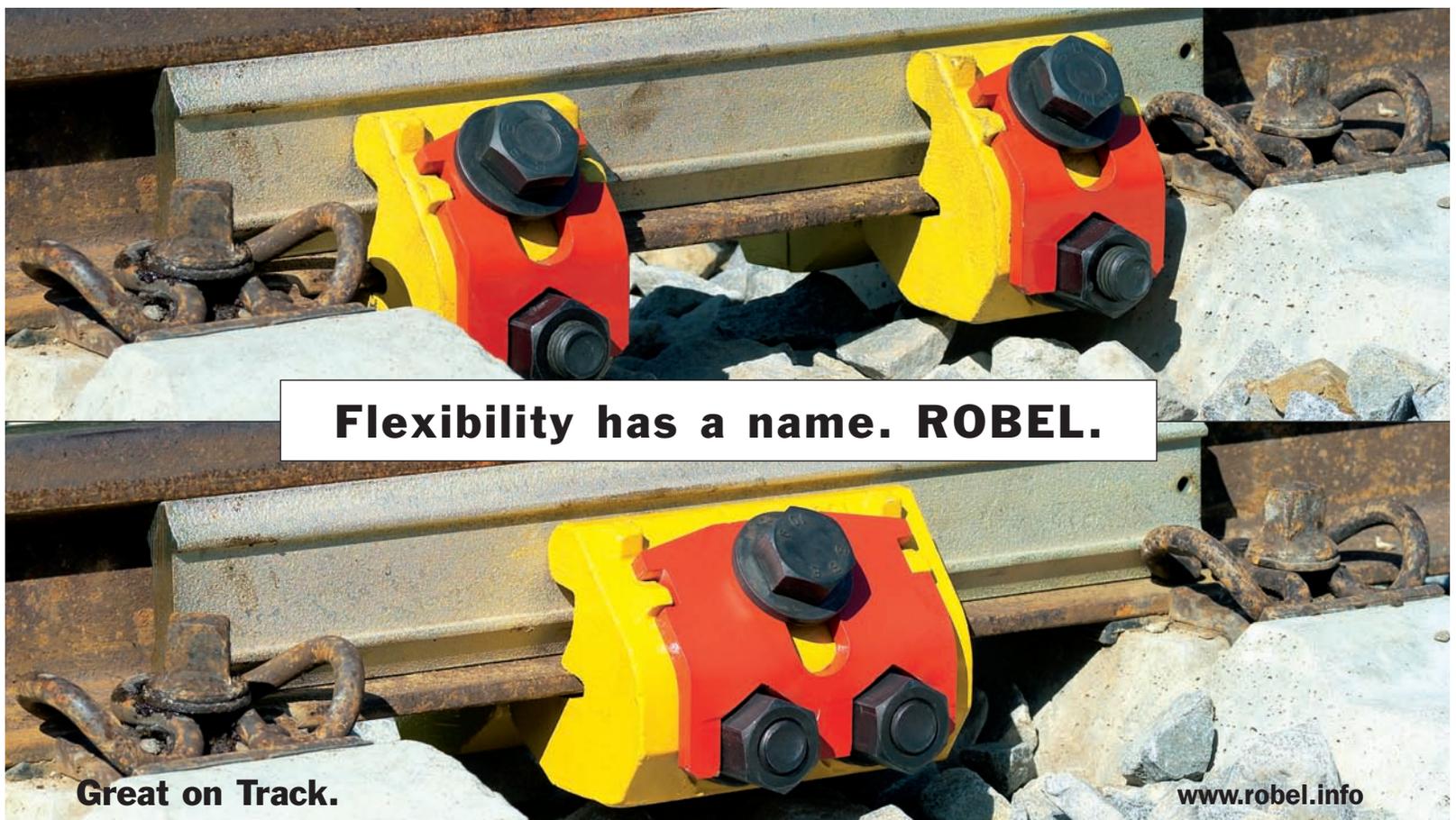




Fig. 8: Dangers caused by suspended loads

suspended loads (Fig. 8). Thanks to the WM 500's technology, however, it is not usually necessary to do any work under suspended loads when it is the machine used. All machines, such as the "WRW" and the "PK1", are radio-remote-controlled. This type of control makes it possible for operators always to choose a safe position with a good view.

Another potential risk of crushing or life-threatening injuries occurs when the workers have to escort the wagons transferring the point segments from the place of assembly to the place of installation.

Generally, the potential danger is reduced on a site with good visibility and where only a minimum amount of working time is spent within danger areas. The use of the WM 500 reduces the potential danger, as

the total time that the workers are required to spend within danger areas is shorter.

▷ mode of delivery of the point segments (transport chain).

2.3 Quality of installation

The points are manufactured and assembled in the factory more or less under "laboratory conditions". However, they will then need to be dismantled again, the extent of which depends on the transport and installation methods selected. This is when the excellent dimensional accuracy achieved during manufacturing in the factory can be lost. Installation methods ought to guarantee that the accuracy achieved in the factory is re-created as precisely as possible.

Assessing the quality of installation achieved by the point-laying methods described is a very complex procedure that can generally only be done by compiling long-term documentation on point geometry and the repair work needed on the points afterwards.

It is difficult to assign the effects on life-cycle costs to individual points. For the time being, no publicly accessible long-term measurements by railway infrastructure managers are available. Therefore it is not possible to define any monetary approaches that would allow a comparison to be drawn of the costs of the point-laying quality achieved by the individual methods. Nevertheless, factors do exist that have an immediate impact on the quality of the laying procedure. Interviews with railway infrastructure managers and track contractors have shown that the quality of installation is significantly influenced by the following factors, which also play an important role in life-cycle costs:

- ▷ quality of rail joints
- ▷ unrolling of point segments
- ▷ gauge narrowing, and

In order to facilitate and speed up the laying procedure, the new point segment is first connected to the existing track. This can result in an effect known as "unrolling", which occurs as the rest of the segment is slowly moved into its final position (Fig. 9). Unrolling causes high bending stress on the entire segment. Furthermore, this bending greatly stresses the rail fastenings and these might even be irreversibly deformed in certain conditions. It is the design of lifting beams which is the reason why this unrolling cannot be ruled out when these are used rather than support frames.

Once the points have been fitted, a final acceptance test is carried out before they are allowed to enter service. The purpose of this is to make sure that there is no deviation from the nominal track gauge.

Track gauge narrowing occurs when the point segment is lifted up and an unsuitable means of transport is used. Above all, this affects heavy point segments, particularly those on concrete sleepers. The phenomenon of track gauge narrowing results from the force components, which are a function, firstly, of the angle shown as " α " in Fig. 10 (i.e. the angle of each individual sling at the rail base), and, secondly, of the point of sling attachment up to the lifting beam. The wider the area of the point segment which has to be spanned, the smaller the value of α , which means an increase in the horizontal force component (H1) acting on the structural element. The forces that occur are transmitted to the point segment through rail and bolt fastenings and can lead to lasting gauge narrowing and deformation. The larger the vertical distance between the lifting beam and the segment, the greater the value of α and the smaller the horizontal force (H2). Support frames pick up points

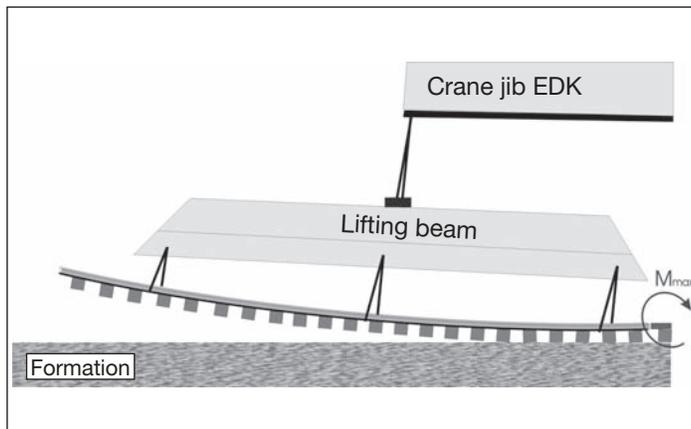


Fig. 9: Schematic representation of the "unrolling" of a point segment

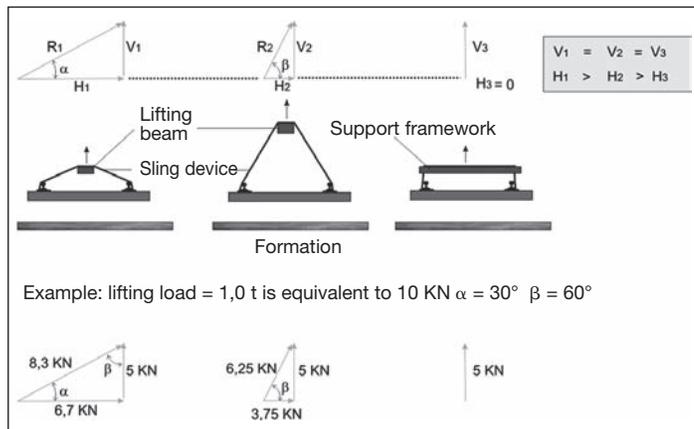


Fig. 10: The problem of track gauge narrowing

directly using rail clamps, so that the horizontal force component (H3) is zero.

The point segment ought to be transported carefully from the factory to the place of installation. Attention must be paid to the fact that certain of the points' structural elements, such as its blade, are very sensitive to load alternations during installation.

The transport of segments without lifting beams and with only one sling point per rail side is likely to cause deterioration in the high quality achieved by the point manufacturer. It is important to check the transport chain more closely and to use the most appropriate means of transport to ensure that this high quality is maintained right through until the new points are fitted in their final position. Nowadays, the site supervisor usually determines to what extent quality and careful material transport can be achieved on site. In future, however, it might be the planner who will exert a key early influence by laying down transport

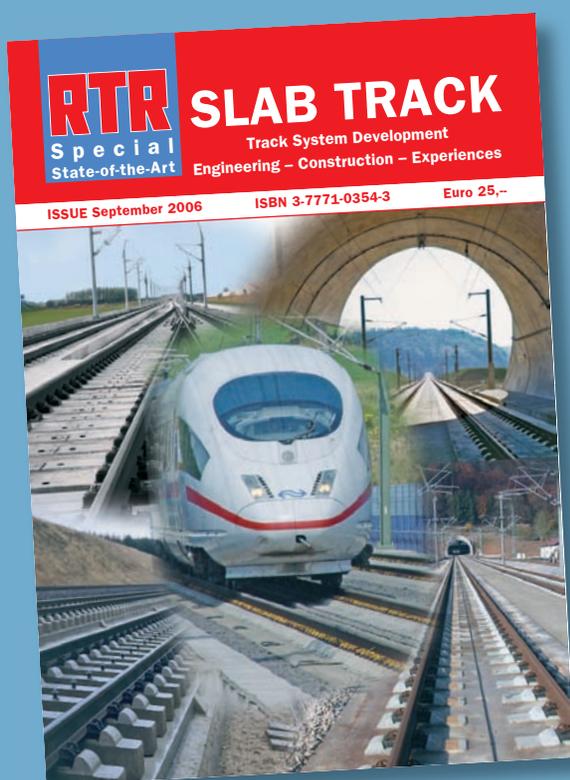
and installation methods in the tender.

3 Summary and conclusion

Point-relaying work causes hindrances on account of track closures and train rerouting and, in addition, reduces the line performance because of the speed reductions imposed in the immediate vicinity of the engineering site. As has been shown above, numerous influences ("duration of relaying", "costs", "safety" and "quality") as well as the local site conditions can be used to point to which method is going to be the most efficient one in a given situation. It is advisable to use the gantry-crane method for relaying points located on heavily-trafficked lines. The reasons lie in the significantly shorter duration of relaying work and the reduction in operational hindrances and hence the costs incurred through them. In a similar manner, the gantry-crane method is recommended for large types of points

with branch radii of more than 760 metres. Lifting-beam methods are suitable for track relaying on lines with low traffic densities, since the longer time usually needed by them is not critical. It must not be forgotten that the relaying of points is influenced by a multitude of factors. A decision-support tool, such as the one presented in this article, helps planners narrow down the choice of individual relaying methods to the most suitable one. Nevertheless, even such a tool cannot replace the individual consideration of every single relaying project.

Not only does the use of the WM 500 make it possible for the costs of the entire relaying project to be minimized but, thanks to the high installation quality achieved, it also reduces the life-cycle costs of point relaying and maintenance. Furthermore, it is possible to reduce the number of workers required and to increase safety at work. In this way, the WM 500 makes an important contribution to lowering permanent-way costs. Low-cost track is an essential prerequisite for a competitive railway system.



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