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17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

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FROM MANUAL INSPECTION TO PERMANENT MONITORING OF TURNOUTS

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Abstract

The condition of turnouts is still evaluated manually by the inspection staff. Generally, the railway infrastructure manager blocks the track section during the inspection time. This leads to a decreasing availability. Moreover, employees are working in danger areas. Nonetheless, all of those inspection tasks have further challenges. The evaluated condition depends on the subjective assessment of the staff and the inspections carried out are not completely reproducible and do not allow a prognosis of maintenance demands yet. Finally, the manual inspections are executed without the load-impact of rail vehicles. These facts show the need for a shift from a manual inspection to an automatic self-inspection of turnouts towards a smart infrastructure. The measurement systems for open track and turnouts as also for the fix-installed, wayside sensors of eight companies were thus chosen and analysed and then compared with the inspection tasks of the Swiss Federal Railways to identify the feasibility of this automatic self-inspection.

Keywords: turnout, infrastructure, inspection, maintenance demands, prognoses

1 Introduction

Turnouts are essential assets for railway operation. The capacity of the rail network and possible speed are influenced by the condition and construction type of turnouts [1]. Within a track section, turnouts represent an area of discontinuity of the rather homogenous track structure. The track geometry is changed due to the different specifications of the main construction parts of turnouts. Furthermore, the different length of sleepers also influences track peculiarity by changing the stiffness along the turnout [2].
Variable construction parts of turnouts must endure high dynamic forces during the passage of a rail vehicle [2]. The crossing nose is one of the parts that is most strongly influenced. To prevent the thin crossing nose from barging of the rail wheel, it is constructed with a lower surface level. Unfortunately, this difference has negative effects, because the wheel has to drop at the force transmission point. This vertical movement generates high dynamic forces and an impact on the crossing nose, [3, 4]. The check rails are also located within the crossing panel to guarantee a safe passage of the rail vehicle. Furthermore, they ensure that the wheel will not damage the crossing nose by creating a fix defined flange way. However, this also creates additional forces [3].
The switch panel is not subjected to such an influence of extraordinary forces. As opposed to the crossing nose, the running edge of this area is similarly constructed as in the open track. An almost equal wear mechanism thus occurs in this area, [3]. However, the contact area between the wheel and rail changes with the beginning of the switching toes and different force transmissions appear. In order to achieve a secure fit of the switch rails at the stock rails, they are specially ground for each other. As a result, the switch toes are very thin and

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the profile is weakened. The high forces during the passage lead to plastic deformations of the switch toes [5]. Within the closure panel, virtually the same conditions are found as in the open track. Different dynamic forces are only generated if a rail vehicle negotiates the diverging track of turnouts. These are the results of the missing transition curve [6]. These different dynamic forces lead to a rapid deterioration of the main components and further to a decreasing quality of the turnout [6]. To guarantee a safe passage of the rail vehicle and also a comfortable ride for the passenger, it is essential to carry out specific maintenance tasks [5]. The actual condition of each component and of the turnout overall must be known.

2 Inspection strategy

Currently, the inspection is executed manually. The infrastructure manager generally blocks the track section during the inspection time. This leads to a decreased availability. However, there are also differences between the national strategies and implementation methods.
In Switzerland, the inspection tasks are done during the railway operation within the intervals between train passages. The staff has to protect themselves while carrying out inspection tasks. Only if they cannot guarantee their own safety while performing different measurements or due to the alignment, an additional person, known as the "safety guard", is present to guarantee the safety of the inspection team. Despite this, those track sections where speeds greater than 160 km/h are permitted must be blocked in Switzerland too, because of the high speeds mean approaching rail vehicles cannot always be recognised in good time [7].
Inspection and gauge measurement tasks are done manually at fix defined time intervals. These intervals depend on the type of the turnout and also the permitted speed on the track section, but the inspection is still time-based, [8]. Moreover, specific aspects of the current inspection procedure should also be mentioned. The evaluation of the actual condition is done by the inspection staff. They thus describe each component in addition to the whole turnout. Due to this procedure, the estimation of deterioration and the actual condition are dependent on the subjective assessment made by the staff. Furthermore, all the measurements are done without the inclusion of the rail vehicle load-impact.
The scatter of the manually collected measurement data and also the description of the actual condition make prediction of the maintenance demands and the optimal timing scarcely possible. A detection of the deterioration rate at an early state and reproducible measurement data could be done with an automatic machine based inspection of a turnout. Furthermore, entering the hazard zone for the inspection tasks would no longer be necessary and this would naturally mean that any risks could be considerably reduced.

3 Analysis of automatic inspection

All inspection tasks are listed in the technical regulations of Swiss Federal Railways. To analyse the possibility of an automatic and machine-based inspection, it was first necessary to classify the inspection tasks in the context of the different turnout components. After this step, all of the 91 inspection tasks for turnouts were compared with the available technologies for open track and turnouts and also with the fix installed wayside sensors.
The analysis itself was executed on the basis of a simple comparison of each single inspection task with the acquisition option of the technologies and systems. A categorisation into five groups of the facility for an automatic inspection was thus performed. Possible inspection tasks were separated from those which are not possible. Furthermore, those tasks, which can only be carried out by automatic inspection under specific preconditions or with the assistance of another technology, were assigned to a separate category. Within this classification, several inspection tasks are mentioned, which in theory it is possible to carry out through the use of a number of different technologies, even when this is not yet being done. Allowance was made for these by the introduction of another inspection task category. The same pro-

cedure was made for those tasks, which are theoretically not possible. Eight international companies were chosen for this analysis:

- DMA Srl, Torino (Italy)
- Eurailscout Inspection & Analysis B.V., Amersfoort (Netherlands)
- Fugro RailData, Utrecht (Netherlands)
- MER MEC Sp.A., Monopoli (Italy)
- Plasser & Theurer – Export von Bahnbaumaschinen GmbH, Vienna (Austria)
- Protran Technology LLC, New Jersey (USA)
- Terra Vermessungen AG, Zurich (Switzerland)
- VAE GmbH und voestalpine SIGNALING Zeltweg GmbH, Zeltweg (Austria).

Each one of these companies is a distributer of its own different systems or technologies each with its own specific modes of operation. This represents a good array of potential technologies for the analysis. The assessment thus also comprises the technologies of one company which are specially constructed for a wayside application on turnouts. Other systems can be used for onboard-monitoring systems on passenger or freight trains. In addition, self-propelled diagnostic vehicles were included in this investigation.
The condition of turnouts can be determined by use of a variety of cameras or other optical systems. Moreover, some of the companies mentioned offer systems with special cameras, which are able to record the surrounding environment in almost 360°. Furthermore, laser technologies are able to scan the rail profiles. The mode of operation differs from system to system. The possibility of using different determining methods and different fields of application promises relatively good results for an automatic and permanent inspection of turnouts.

4 Results

The research showed the differences between the modes of operation in the technologies considered. It was found that from 21 % to 62 % of the 91 different inspection tasks can be performed automatically by the system or with a combination of technologies from each company considered (Fig. 1).

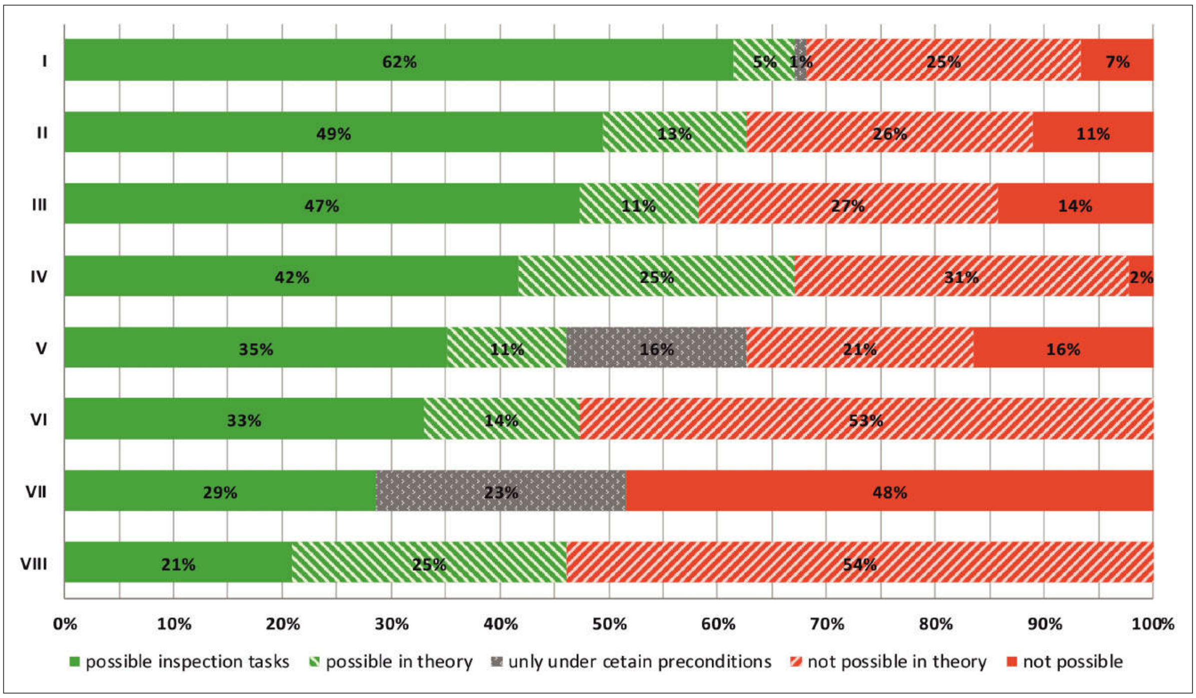

Figure 1 Percentage of automation of the respective technologies

Nevertheless, the majority of the inspection tasks is only possible in theory or under certain preconditions or even not possible in theory. As a result, an accumulation of the category groups is necessary. Those inspection tasks, which can only be carried out under certain preconditions, were assigned to the category of the possible inspection tasks. Through this allocation, the classification was reduced to implementations that are possible or not possible. On this basis every single system or chosen combination from each company was now able to perform from 46 % to 67 % of all the necessary inspection tasks (Fig. 2).
This is a quite high possible automation level. At this point it shall be pointed out that a target of 100 % should be reached, however, otherwise the remaining inspection tasks will still need to be carried out manually. This would have a negative effect and the advantages of an automatic and permanent inspection would be put at risk.

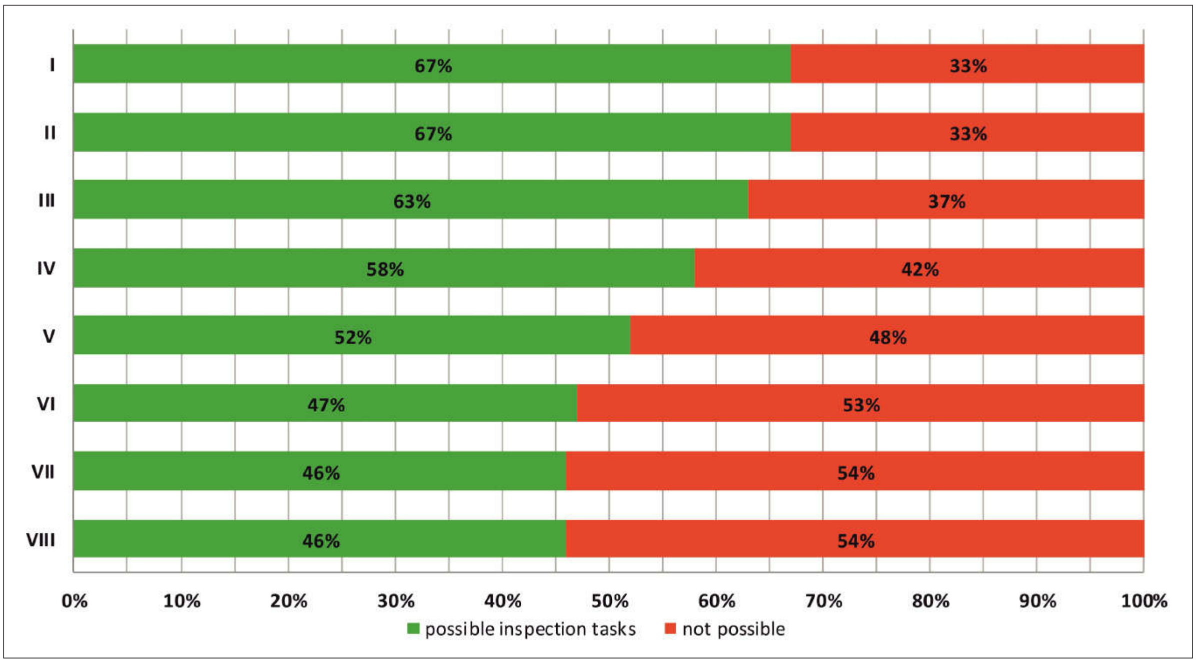

Figure 2 Percentage of automation in the various technologies (summarised)

Due to the different modes of operation of fix-installed wayside applications, these provide a very satisfactory support of a different determination type to the other inspection and measurement systems. By combining the wayside technologies with the onboard-monitoring systems or independent inspection and measurement systems from the remaining other seven companies, the percentage of each combination could be increased by 30 %. With this result, at least 96 % of all inspection tasks could be performed automatically and with no need to deploy any inspection staff in the danger area (Fig. 3).
Only 4 % cannot be executed with this combination, but these inspection tasks may be possible using another combination. An examination of a combination of all the technologies has not yet been done, because it would appear to be very unlikely that an infrastructure manager would be able to acquire all of these systems.
At this point, an important aspect of the percentages must be mentioned. The feasibility of each system should not be seen as an indicator of concordant inspection tasks between the different technologies. The percentage acquired is only the sum of the 91 inspection tasks, which it is possible to perform with the technology, of this single company. This percentage provides no information accordant inspection tasks using resources provided by different companies. It is thus possible that two equal percentages may not have matching inspection tasks.

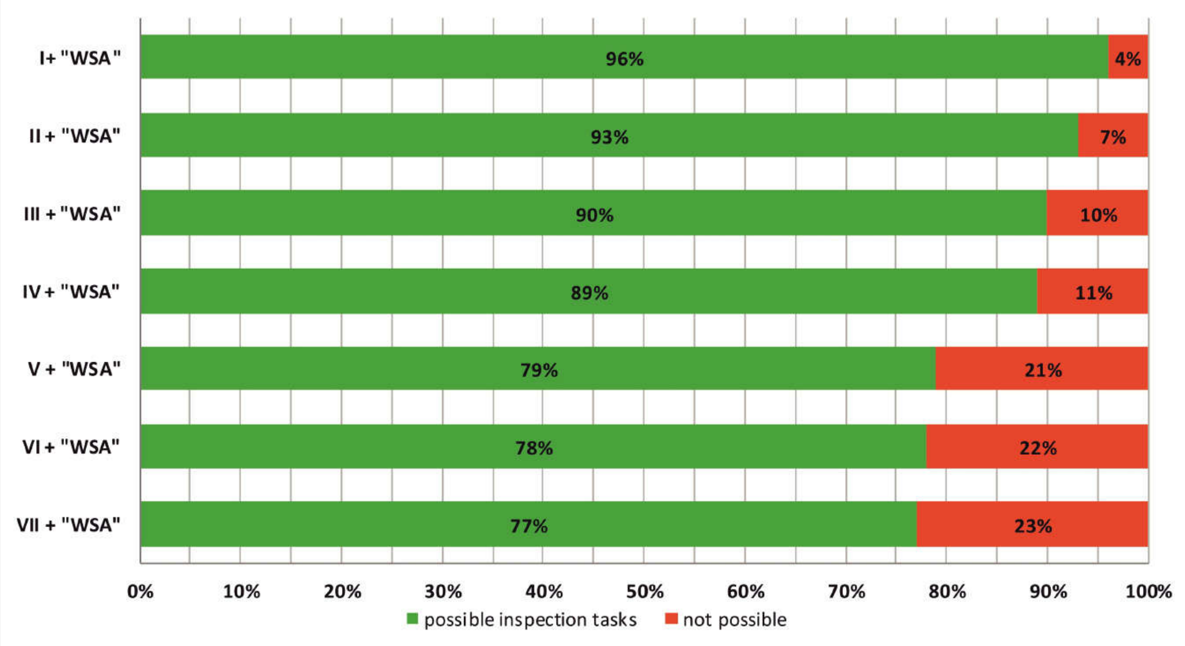

Figure 3 Percentage of automation of the respective technologies combined with wayside application ("WSA")

5 Conclusion

This study points to the opportunity for an automatic and permanent inspection of a turnout. A combination of wayside sensors with onboard inspection and measurement technologies enables a very high automation possibility of 96 %. A combined system, as shown here, would make it possible to collect reproducible inspection data and ensure potential time series, for predicting the optimal maintenance tasks and the time in which they should be done. This would have a positive influence on the lifetime of a turnout. The feasibility of an inspection during the intervals between trains in running operation is not currently possible. The independent system must change the travel direction for inspections of the through and diverging track. Further advanced research is thus necessary for the achievement of integration into the railway operation. Nonetheless, this present study shows the possibility for a chance of the manual strategy and the opportunity for an automatic and permanent inspection of turnouts.

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