Newsletter

Welcome to the AUTOMAIN project!

This project provides new concepts and innovations to decrease time needed for rail maintenance and inspection ("possession-time"). Project results offer rail infrastructure managers step-change solutions to increase capacity for trains.

This to allow a modal shift from road to rail which is one of the main target points of the European Commission to make the European area more competitive and greener.

At nighttime there is a competition between track inspection & maintenance with rail freight traffic. Both are in most cases forced by passenger traffic to the night. Reduction of time for inspection & maintenance creates more capacity for freight trains.

The project also touched possibilities for more efficiency in maintenance operations and -planning.

This brochure will give you an overview of the projects' results. A multi- disciplinary team consisting of infrastructure managers, rail-contractors, universities, research institutes and consultancy firms bundled their expertise into innovative solutions that can be implemented within a range of 5-10 years.

A broad set of potential new approaches or techniques are presented in this brochure. It spans from applying new methodologies in the rail infrastructure maintenance industry by using the Toyota Lean approach, new inspection tools, a different approach for large maintenance works like grinding and tamping to new integral approach for maintenance- and inspection planning & scheduling.

This joint-research work was made possible through funding by the European Commission Research framework (FP7).

We hope that our project results are inviting for further implementation or development in your organization. The AUTOMAIN project partners are very enthusiastic on putting the project innovations into practice.

Henri Olink
Coordinator of the AUTOMAIN project

Innovation 1

Lean Analysis of Track Maintenance

The concept of "lean manufacturing" has been around for many years, derived mostly from the Toyota Production System, concentrating on reducing waste in production processes. As part of the AUTOMAIN project, these principles were applied to key track maintenance processes including tamping, grinding and S&C maintenance.

The project engaged support from KM&T who are specialists in Lean Analysis techniques, a high proportion of their consultants being ex-Toyota employees. Working with support from the University of Birmingham, they undertook an initial analysis of tamping, taking into consideration the process right from the early planning stage through to execution. The investigation involved Structured Observations where staff from KM&T attended an actual maintenance shift, noting down what activities took place, timings, resources involved etc. This was then followed by Value Stream Mapping workshops attended by experienced front-line maintenance staff, where the process was mapped out using sticky-notes to describe the various stages and people involved in a typical maintenance shift – see Figure 1. This also provided an excellent opportunity to gather ideas from those at the sharp end of ways in which processes, practices and equipment could be improved.

- There is scope to reduce the duration of possessions by employing best practice such as using data from track recording cars to calculate vertical and lateral alignment corrections, having multi-skilled staff, and enabling adjacent lines to remain open to bi-directional traffic during maintenance.
- There are a number of technological developments that could further enhance productivity such as multi-functional high output machines capable of recording and working in either direction, and which minimise set-up times on site.
- There is often insufficient emphasis placed on the longevity of the maintenance that is performed, with targets currently based only on track lengths maintained.
- There is scope to improve the planning of track maintenance, and this appears to have even greater potential to reduce overall possession times than improvements to the actual maintenance processes and technology.
- There is a need for a more reactive approach to planning and undertaking maintenance, with a shorter interval between planning and implementation, facilitated by improvements to both technology and process.

The success of the study on tamping lead to similar exercises being undertaken for grinding and S&C maintenance activities, and the information gathered from all three exercises was used to support and inform subsequent parts of the AUTOMAIN project. A full copy of the subsequent reports can be found on the ATUOMAIN website.

Figure 1 – Value Stream Map of the stages involved in planning a typical tamping shift

Several railway administrations participated, namely Network Rail, Deutsche Bahn, SNCF, ProRail and Trafikverket, the last two being through their maintenance contractor Strukton. This meant that it was also possible to compare and contrast the different approaches taken by different European railway administrations, and the investigation threw up some interesting findings:

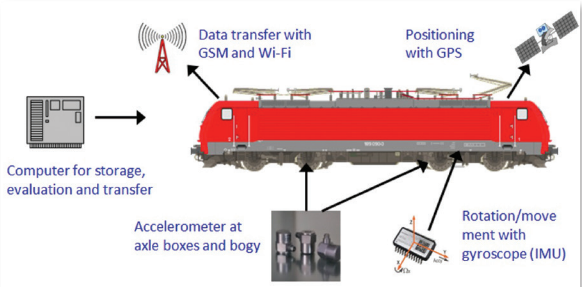
Innovation 2

In-Service track monitoring using a freight locomotive

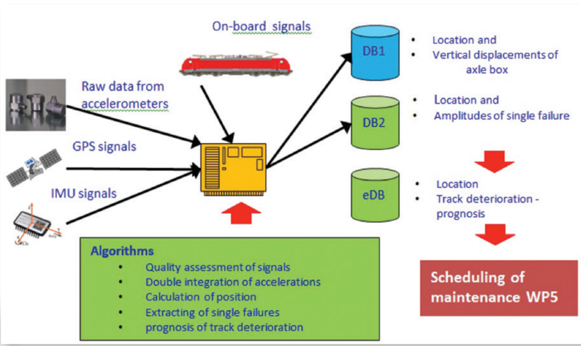
Measurement trains need much capacity on the network as they need to measure at low speed. This innovation makes a distinction between inspection and monitoring. Continuous monitoring can help to detect abrasion or degradation of the tracks by pointing out changes in the data daily provided. Daily monitoring is possible by measurement with in-service trains running at normal speed. AUTOMAIN tested two approaches: measurement with a freight locomotive and using a passenger train.

The freight train measurement will be demonstrated by Deutsche Bahn on the European Freight Route between Rotterdam and Dillingen. On this line a lot of heavy trains are operating and the track degradation is higher than on other lines. In the UK measurements were made on a part of Southern Railways' commuter train network.

Both tests use different measurement devices. The Deutsch Bahn test uses an advanced measurement concept installed on a class 189 freight locomotive, shown in the diagram below.



The monitoring system provides track alignment and track defect information. These data can be displayed using a web based interface. The analysis will include a maintenance assessment, based on the failure prediction algorithms.



The selected system design, which took into account the high requirements of the railway, will ensure high quality measurements and long-term stability. The system was installed in November 2013 and first results are expected in December or January. A measurement device mounted on a commuter train bogie was used and is still in operation in the UK.

Both systems will be used to identify and quantify the benefits of measurement systems on in-service trains and will be a reference system for future simplification and developments. A maintenance strategy that will take into account the prognosis of track degradation is necessary to achieve all benefits form in-service trains measurements systems.

Advanced Switch & Crossing Inspection

Switches and crossing (S&C) are a critical part of any railway system, and although they make up on average just 5% of the total track length, they account for up to 30% of the annual maintenance and renewal budget. If not properly maintained or inspected with sufficient rigour, S&C can also cause derailments that tend to result in significant disruption to train services, and even the loss of life. Across Europe, there have been a number of serious derailments at S&C in recent years due to missing or loose track components. But there is also a significant issue relating to the quality of repairs carried out to switch rails and crossings.

A typical repair will involve preparation of the damaged surface, welding additional material to that damaged section, and then grinding it back to the required profile. However, the tools currently available do not enable a sufficiently accurate assessment of repair to be made, and this can cause serious problems. In the UK for example, there have been four derailments as a result of inadequate repair and inspection of switch rails in recent years, two at London Waterloo in 2006, one in Glasgow in 2007, and a fourth near the Princes Street Gardens in Edinburgh 2011.

There is also a more widespread problem where a poorly repaired switch means that the maintenance team have to return prematurely to site in order to undertake further repair work. While such cases do not necessarily pose a significant derailment risk, this causes additional disruption, and takes up valuable time and resources that could be employed elsewhere.

As part of the AUTOMAIN project, the University of Birmingham has therefore developed a lightweight laser based trolley to accurately assess rail profiles through S&C. The trolley uses two scanning lasers commonly employed in the production industry to scan all the important contacting surfaces through S&C, as shown in Figure 1.

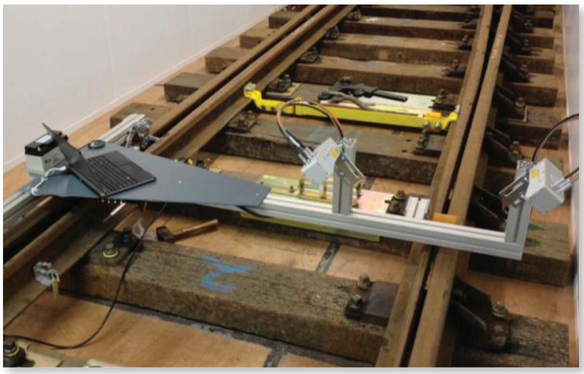
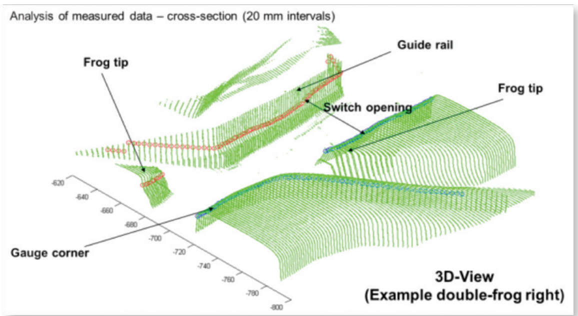


Figure 1 – Laser Based S&C Inspection Trolley

The trolley has initially been developed to assess S&C against Network Rail standards, and algorithms have been successfully demonstrated for the assessment of switch blades. Algorithms to assess crossing profiles are currently under development, and the longer term ambition is to use this technology to inspect S&C from service vehicles running at line speeds. The trolley also has the potential to gather sufficient data points to build up an accurate 3D model of the switch, potentially enabling more advanced assessment of the true risk of derailment to be made using vehicle dynamics modelling software for example. There have been a number of other developments as part of the AUTOMAIN project to improve the maintenance and inspection of S&C, and full details of these and the laser based inspection trolley can be found in the Work Package 3 reports on the AUTOMAIN website.

Track measurement in switches

Today's effectiveness of operation depends very often on the flexibility within operation and the availability of tracks in stations and marshalling yards. Only a handful of closed switches can influence operation dramatically. Therefore, in Automain SP3.1 an Automatic Switch Inspection device was developed. A laser scanning measurement system is used to measure cross sections in 2 cm steps in the whole turnout. In Automain we used a laser scanning device of the SIM car by Strukton/Eurailscout with a software developed by DB. All these measurements were done with 40 km/h. The identification of the switch / frog was tested with GPS, map mapping and RFID's. After the tests, RFID's were chosen because of the future possibility to do the complete processing online on the car. Therefore special switch information must be available, which can be written on the tag.



The measurement car with an additional post-processing software is also able to measure the track geometry. That opportunity offers a reduction of "wiggle-runs" of the regular Track Geometry Measurement cars in stations too. The demonstrator shows impressively, that approx. 130 Switches can be inspected during one night shift, compared by 5 per day by the traditional hand measurements. Another advantage is the fact, that the measurement train get a own "screenplay" and a schedule. No traffic interruption is necessary, no staff is in dangerous tracks.

After the measurement a post-processing plot the inspection results and copy them to the inspection data base.

All ideas of industry and railways were fitted in a perfect way together in Automain to get very fast the results and the step change in inspection!

Innovation 3
High Performance Grinding

The approach rail grinding varies throughout Europe, and there are an increasing number of technologies available to remove material from the rail head. But it was though that there are also significant improvements to be made to planning and the execution of grinding to maximise effectiveness, while minimising the disruption caused by this maintenance activity. Therefore, as part of the AUTOMAIN project, a Lean Analysis study was commissioned to identify areas of improvement in the planning and undertaking of a typical grinding shift. This study, performed by industry experts KM&T with the support of the University of Birmingham, included two core elements:

- Structured Observations where a grinding shift was observed and evaluated by representatives from KM&T
- Value Stream Mapping workshops where experienced operator and planners were brought together to "map out" the stages involved in planning and undertaking a typical maintenance shift, and suggest ways in which this could be improved

The study involved three railway administrations, namely Network Rail, Deutsche Bahn and Trafikverket, and it highlighted some significant differences in the approach they take. For example, planning / lead times vary from 12 months to 48 months in advance, and total cycle times (i.e. the total amount of time spent on planning and undertaking maintenance) varied between 500 minutes to 3 000 minutes.

But there were also general themes such as the need to make better use of ultrasonic inspection data, to optimise grinding plans according to the actual volume and type of traffic on a given route, and to ensure that those planning grinding fully appreciate key factors that influence the success of a given maintenance possessions.

There were various technological innovations suggested to reduce waste as defined according to the principles of Lean.

Examples included the use of service vehicles to undertake pre-maintenance inspections, and improved methods to measure, quantify and predict RCF to enable a more targeted approach to be taken. Performance incentives and Key Performance Indicators were also highlighted as an issue as these are not sufficiently well aligned to drive the efficient use of available possession time. This potentially includes:

- encouraging the use of track friendly vehicle designs by introducing differential track access charging to reduce the problem "at source"
- setting maintenance targets that incorporate the quality and longevity of the maintenance undertaken
- aligning performance indicators to minimise overall possession time and maximise maintenance effectiveness and longevity
- ensure that performance indicators do not result in overly aggressive grinding practices that can actually damage the railhead

As for the actual grinding activity, the breakdown of time spent on different activities for a typical maintenance shift is shown in Figure 1.

Within this breakdown, significant scope was identified to reduce time spent on non-value adding activities, examples of which variously included slag collection and the need to verifiy the final ground rail profile manually.
As with the earlier study on tamping, the study provided an excellent opportunity for front-line staff to air their views and suggestions for improvement, and the information gathered from the exercise was used to inform subsequent AUTOMAIN activities. A full copy of the report and its recommendations can be found on the ATUOMAIN website.

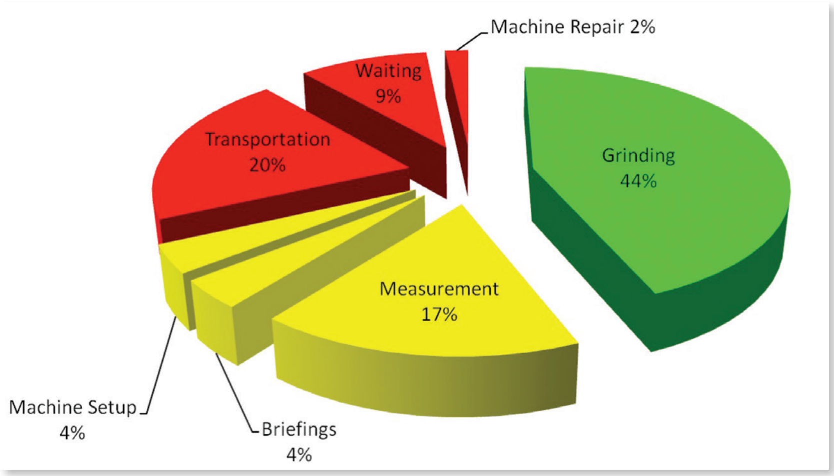


Figure 1 – Breakdown of Time Spent During Typical Grinding Shift

High performance tamping

Tamping restores the required track geometry and is necessary for safety reasons. Depending on the state of the track and the operational conditions the tamping intervals are between 2 and 7 years.

For highly loaded tracks high performance or high efficient tamping is necessary to reduce possession time and to provide more time for operation. The research of AutoMain points out, that for example

- detailed analyses and optimization of planning and maintenance processes,
- the use of high performance tamping machines like three or four sleepers tamping machines,
- the development and use of high performance single failure tamping machines or
- improved maintenance strategies using forecast of deterioration and combined maintenance activities.

are adequate possibilities/adjusting lever to increase efficiency of maintenance and thus reduce possession time in short or mid-term.

Detailed analyses of the track geometry showed the impact of single failures on the need for tamping. In cases where the distances between single failures are greater than the minimum distance, which depends on boundary conditions, the use of improved single failure tamping machines reduces the possession time noticable.

Looking into the future and therefore into the mid- and long-term perspective the

- direct use of track recording car measurements for the tamping machine or
- ·an improved fix-point measurement system with higher measurement speed

will reduce possession time noticeable.

The maximum possession time reduction will be achieved if the maintenance is reduced to the minimum. This would be possible if

- the root causes for single failures or "local need" for maintenance will be removed or
- the track design is changed or optimized, e.g. slab track or under sleeper with pads.

In both cases the economic impact has to be taken into account by estimation the life cycle costs.

The change or improvement of track construction is necessary in any case if the possession time has to be reduced below the "natural limit of the track". More trains on a track results in general in higher deterioration and therefore more maintenance.

Innovation 4

Modular switches & crossings

Switches and Crossings are key components in the railway networks. They need more maintenance than the normal track as they are more complex and have movable parts. Many track failures causes train delays and these are more frequent in S&C than in normal track if calculated by track length. Degradation is depending on factors such as traffic load, speed and intensity.

For tracks with high loads and intensity the need of modular design and efficient methods are essential to reduce the track possession time for inspection, renewal and replacement of infrastructure in order to increase the time for more time for operation.

Lean Analysis with tools like Value Stream Mapping has been very useful in the work and shows both wastes and opportunities. Following are example of improvements for reducing possession time in short or mid-term:

- Implement increased lengths of spare parts, will reduce need of adaptation out in track during installation.
- Create standard work in order to optimize planning and maintenance processes:
    - a lot of activities which is done doesn't add value to the process
    - some activities is done within the track possession time but can be done outside the possession time
    - a lot of activities can be done more efficient which means shorter time and with more secured result
- Implement stock of non-standard material, will reduce the use of temporary solutions which has negative effect on both the quality of temporary reparations and the need of going out to track several times for maintenance and inspection activities.

In mid and long term perspective the AutoMain project has given two improvements, one that reduces possession time in track for inspection and one who increase the technical level of the result.

- On-line measurement through camera from Overhead (OH) line. With this equipment inspections can be done basically from anywhere anytime and without the need of having people to go out in track. This is very good both for S&C which are placed in tunnels or far away but also from a safety aspect since no people has to be out in track.
- Panel replacement. Today only small parts is replaced during the maintenance activities. The technical level of the S&C will decrease for every event and needs to be done with a higher frequency. By replacement of panels the technical level of the S&C can be kept high for a long time. This is done by installation of pre-assembled large panels of S&C. These panels are assembled in a workshop with very good conditions of having a good result of the maintenance activity.

Figure 1 – On-line camera from OH-line for measurements in S&C

Figure 2 – S&C panel transported by a KIROV crane in Falun in Sweden

Innovation 5

Outcome 1: Integrate both global planning and local scheduling of maintenance operations

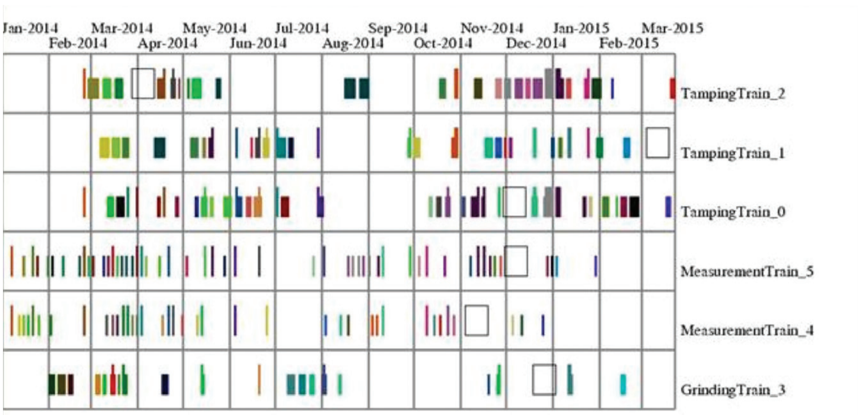
AUTOMAIN developed a new planning concept to optimize maintenance activities, resources and timetable slots. The algorithms embedded in our tool enable to synchronize different levels of planning and scheduling. Indeed, both macroscopic and microscopic aspects are integrated in a same approach. To the best of our knowledge, this integration is something new, developed within WP5 of project AUTOMAIN.

The need to handle different levels is quite clear. Indeed, scheduling individually each maintenance operation without a global view might lead to machine unavailability or incompatible operations being planned simultaneously. However, not taking into account particularities of operations at a more detailed level may also result to conflicts with other trains or unfeasible task times.

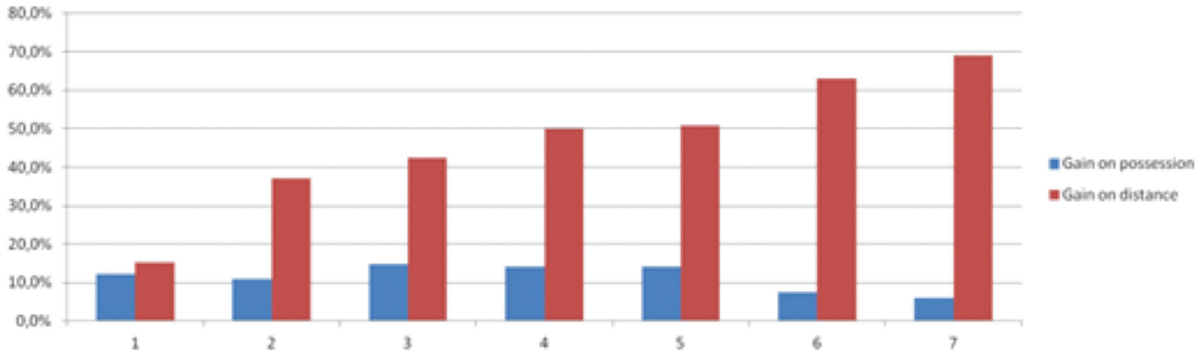
The macroscopic vision consists in having a global optimization of a fleet of maintenance machines, such as measurement, grinding and tamping machines, and defining for each of them its activity over a time horizon of several months or years. Obviously, sufficient travel time should be allowed between successive operations of a single machine. It is also necessary to make sure that incompatible operations are not performed at the same time, and that no operations are planned during the machine's own maintenance. Another aspect is the need to perform operations in a certain order. This kind of inter-operation constraints must be integrated to make sure that the resulting optimized planning will be feasible. Finally, the optimization of possession time requires to have a global vision on all operations, in order to identify those which can be combined during the same track possessions.

On the other hand, microscopic constraints must be considered for each maintenance operation. The most significant of these considerations is, naturally, to integrate maintenance within the commercial traffic.

The link between global and local is obtained by specific algorithms which are able to split large operations over several possessions, and which find the optimal routes of machines over the network between operations. These algorithms have to deal both with the global planning aspects and with local considerations. Consequently, our tool is composed of several modules dedicated to these specific problems to provide ultimately a global planning defining when and how each maintenance operation is performed.



Outcome 2: Capability to optimize different criteria



The tool developed within WP5 of AUTOMAIN is able to deal with objectives of different natures. For instance, it can optimize either capacity of the network, by minimizing track possession times, or machine usage, by minimizing the number of km traveled between operations, or even find compromises between these criteria.

Optimizing network capacity is made possible by combining several operations into a single possession. Obviously, these operations must be compatible with each other when it is decided to combine them. Even if tests should be performed on a braoder range of situations, early experimentations showed that the reduction in possession time obtained by the optimization algorithms developed could reach up to 14% compared with basic planning rules.

Besides, a maintenance planning of machines over a time horizon of a few months generates a lot of travels from the end of an operation towards the beginning of the next operation planned on the same machine. Depending on the sequence of operations on each machine, the total distance traveled by machines can vary in great proportions. Intuitively, the ideal situation would be to perform operations geographically close to each other during the same time period. Given the deadlines potentially imposed on operations, this is not always possible. Moreover, the computational complexity of this type of problem is known to be very high. Even with only one machine, the well-know Traveling Salesman Problem (TSP) has a high theoretical complexity. For these reasons, dedicated algorithms were developed and applied successfully. The first results show that using this type of algorithms to minimize distance traveled can save up to 69% if full priority is given to this criterion, or 42% if possession time is also optimized.

Hence, depending on the needs and on the user, the tool developed within WP5 of AUTOMAIN is able to optimize criteria of different natures. One major advantage over other tools is that it can handle them simultaneously and can thus somehow bring together the different approaches of the different stakeholders of the maintenance business, in particular infrastructure managers and machine owners. Indeed, the objectives of these actors are often different, resulting in negotiations and iterations to build together acceptable plannings.

Past and upcoming events

Past events

- TRA2012. AUTOMAIN was present in Athens from the 23 to 26 April 2012 and it presented the structure and the main Innovations planned before the end of the project in January 2014.
- INNOTRANS 2014. The AUTOMAIN project was showcased from 18 to 21 September 2012 at InnoTrans 2012 in Berlin. AUTOMAIN partners organized a breakfast and gave a presentation on the progress of AUTOMAIN project.
- Sweden National Workshop. Lulea University of Technology organized with the support of UNIFE a national session on November 4th and 5th 2013. During the event, more than 60 participants had the opportunity to discuss with AUTOMAIN partners the main results achieved and exchange knowledge about the future challenges in the track maintenance field.

Upcoming events

- France National Workshop. SNCF, UNIFE and UIC will hold the AUTOMAIN National Workshop at the UIC headquarters in Paris on January 9th 2014. The event will focus on the main results in the fields of high-speed inspection and maintenance, Lean Analysis and planning and scheduling.
- UK National Workshop. AUTOMAIN will be presented at the Network Rail headquarters in Milton Keynes, on January 22nd 2014.
- Germany National Workshop. AUTOMAIN will be also presented and discussed with a focus on planning and scheduling at the Braunschweig University on January 27th.
- The Netherlands Workshop. The event will take place at the ProRail headquarters in Utrecht on January 29th 2014. There will be a general overview of the project results and the evaluation of their exploitation potential.

NOTES

Automain partners

Project Coordinator