The sustainable freight railway: Designing the freight vehicle – track system for higher delivered tonnage with improved availability at reduced cost

SUSTRAIL

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EXECUTIVE SUMMARY

The goal of Deliverable 5.4 is to consider the implementation of the innovations developed by the SUSTRAIL project and consider their deployment and the barriers to be overcome. Whilst initial price and the business case dominate any purchasing decision, they are not the only factors to be considered.

Some of the innovations developed in the SUSTRAIL project have dependencies such as the double Lenoir links and Longitudinal Links being required to be used together, whilst others can be introduced when available, such as friction modifiers.

It is quite clear that the majority of the innovations will require validation / certification before use on European rail networks. There are some standards that are common across Europe, but it must be assumed that generally each country will have to approve these innovations before use. Also many of these innovations do not have a manufacturer identified yet, so the timing plan developed here reflects possible implementation rather than committed implementation.

This report includes the Innovation Information documents in the appendices for all the innovations considered in Deliverable 5.4. It also includes an overview for both the rolling stock and infrastructure innovations with indicative timing and potential next steps to achieve this.

1. INTRODUCTION

Innovations cannot be considered truly useful if they are not implemented. The wide range of innovations considered within the SUSTRAIL project all have some potential benefits, but this alone will not necessarily mean they will be readily taken up by the rail industry. It is important that we carefully consider the barriers to their implementation and demonstrate good reasons to adopt them within the project.

Railways have been established across Europe for over 100 years, during this time continuous improvement has resulted in an evolving whole system that requires careful consideration for the introduction of new technology and processes to ensure they are compatible with the existing environment. This aspect is considered for all the SUSTRAIL innovations as their introduction will be progressive and will therefore run alongside the existing systems that they will ultimately replace. A good example of this is the service life of wagons being in the order of 35+ years, meaning that conventional wagons and SUSTRAIL wagons will operate alongside each other for many years to come.

This Deliverable (5.4) will consider all of the innovations developed in Work Package 3 (Rolling Stock) and Work Package 4 (Infrastructure). It will consider the feasibility of the innovation to be developed into a useable product and the steps required to do so, such as product approval and testing etc. It will also consider phasing issues and dependencies, such supporting innovations.

One important output from this work is to identify the key beneficiary of a given innovation as it is vital to identify the issues they face to enable us to fully consider the implementation barriers. A good example of this would be the justification of improved vehicle suspension, which makes the vehicle initially more expensive to buy, but this is offset by reduced track damage which could in turn lead to reduced track access charges for the vehicle operator. Purchase price, maintenance and operating costs are all of course key decision points for any product, but reliability is key to avoid unexpected issues and legislation and standards can also play a key role in driving the adoption of new technology.

Each innovation has been considered by the appropriate project partner for the following criteria:-

- Innovation Opportunity / Need
- Next Development Steps / Deployment
- Issues and Dependencies

A copy of each innovation information sheet has been included in Appendix 1 for Infrastructure Innovations and Appendix 2 for Rolling Stock Innovations.

This Deliverable (5.4) does not stand alone but should be considered complimentary to the business case, human factors and other work being undertaken in Work Package 5 as a whole. This is because implementation will depend on many factors in addition to those considered in this deliverable, including financial performance (purchase price, payback period etc.), which is complicated by the impact of other factors such as track access charges, infrastructure requirements, maintenance costs, local market conditions, training requirements and also reliability performance.

Work Package 5 consists of 5 Tasks with 7 Deliverables (please see table 1 below).

Table 1 – Work Package 5 overview

Work Package 5	
D5.1	LCC and RAMS final report
D5.2	Economic benefit final report
D5.3	Access charge incentive final report
D5.4	Technical implementation final report
D5.5	Interim business case synthesis
D5.6	Final business case synthesis report
D5.7	An impact analysis for operation of the optimised freight train

Deliverable 5.4 had been split into 4 sub-tasks:-

Sub-Task 5.4.1 – interfacing of novel track forms with existing track forms. This Task will assess the phasing issues associated with the introducing of new track technologies and compatibility of new S&C technologies with signalling systems.

Sub-Task 5.4.2 - interfacing of novel vehicle technologies with their predecessors. Such factors will include coupling, power supply (e.g. migration from diesel traction to electric traction and the associated performance improvements) and train control systems. This task will also assess the new infrastructure such as depot facilities that would need to be provided to support the novel vehicle technologies.

Sub-Task 5.4.3 – human factors and technical assessments of workforce skill sets. Please note that this sub –task has now been incorporated into D5.7

Sub-Task 5.4.4 – Operational aspects of the freight train of the future will require specific attention. Please note that this sub –task has now been incorporated into D5.7

1.1 Methodology

The information for each innovation was obtained in the form of a reporting document (Innovation Information) from the appropriate project member. These documents are included in the appendices.

For each innovation, consideration was given to identify the main beneficiary, potential implementation timing and key dependencies. It should be noted that a manufacturer has not been identified as yet for a number of the innovations and therefore the timing should be considered as indicative rather than committed.

The aim of the documents was to capture the status of each innovation in terms of readiness to implement or outstanding work to complete before deployment is possible. The documents do not consider the innovation benefits, financial aspects, training or human factors as these are captured elsewhere within Work Package 5.

Deliverable 5.1 (LCC and RAMS Report) and Deliverable 5.2 (economic benefits) concentrate on a number of innovations that could be quantified and included with confidence into the calculations regarding their whole life performance. To support this approach additional information has been included on Novel Suspension, Disc Brakes (both from Work Package 3) and Premium Rail Steel (Work Package 4).

Please see Work Packages 3 and 4 for more technical detail on the innovations discussed within this report.

2. SUB-TASK 5.4.1 – INTERFACING OF NOVEL TRACK FORMS WITH EXISTING TRACK FORMS

This sub-task considers the infrastructure innovations (including earthworks) developed in Work Package 4 and will assess any phasing or compatibility issues between them and the existing infrastructure systems.

All of the innovations in the table below are considered suitable for implementation, although a number will require further development. None of these infrastructure innovations have any dependencies that would prevent introduction individually as soon as they are ready and they do not have any interface issues with existing infrastructure. A good example of this is Premium Rail Steel, there are already multiple materials in use for rail and joining these materials together is included in the development process.

The key barriers to implementation are generally the development of maintenance and inspection techniques, training packages and approval/certification. The human factors and training aspects are considered within D5.7 and so will not be further considered within this report.

Maintenance and inspection techniques will need to be developed for all of the innovations. This includes the impact of their application on site and maintenance of the innovation itself. A particular need for the rail profile and material innovations is the development of new rail welding processes. A welding process for Plain Line Premium Steel Rail has been developed, but this remains an issue for the S&C application, however work is underway on this.

The monitoring and modelling tools will require inspection and maintenance data to support their development and to set action limits and validate the results. A good example of this would be the development of analysis tools for the geo-textile sensor system. It is necessary to understand the sensor outputs under normal seasonal variations and with various ground types to be able to identify abnormal events readings, which would indicate a problem with the earthworks being monitored. Part of the development process for the monitoring systems should include data analysis and fault diagnosis as well as the development of the equipment itself.

Figure 1 – Multifunctional Geo-textile and Acqusition Unit

Power supplies and communication links to remote locations can be expensive to install and vulnerable to cable theft and vandalism. Whilst battery systems are available, they in turn introduce a maintenance requirement. Development should therefore consider energy harvesting or other stand-alone systems that can provide long term performance with minimum intervention.

Product approval / certification for use will be required for the majority of the Work Package 4 innovations. Whilst there are some common EU standards in place, such as EN Standards for rail, generally local approval will be required for use in each country. Dependent upon complexity and risk modelling the approval process can take between 3 to 18 months.

A number of innovations are or will be available in 2015 as they have a manufacturer or supplier already involved (for example Premium Rail Steel), but those with predicted dates do not. The predicted dates are based upon the time to complete the next development phases with sometime for approvals and should be considered as the earliest possible dates for implementation. The SUSTRAIL innovation owners will pursue future development opportunities.

The main beneficiary has been identified for each innovation as they are the most likely to want to implement the innovations. Generally the Infrastructure Manager is the main beneficiary for each of the innovations considered within Work Package 4. These innovations offer a wide variety of improvements including improved asset life and asset condition assessment with reduced maintenance liabilities. On-going development of these SUSTRAIL innovations must concentrate on ensuring product reliability and cost effectiveness to provide an attractive incentive for Infrastructure Managers to invest in these innovations.

Listed below are the vehicle innovations from Work Package 4 that are supported by an Innovation Information sheet in Appendix 1.

Table 2 – Infrastructure Innovations

Innovation	Beneficiary	Implementation Timing	Dependencies
RAIL - Premium rail steel (plain line)	Infrastructure Manager	Available 2015	Training for welding techniques and local certification if required.
RAIL – Premium rail steel (S&C)	Infrastructure Manager	Available late-2015	Development of welding repair techniques and local certification if required.
RAIL – Fatigue life prediction	Infrastructure Manager	Predicted for 2018	Further development of model and verification required.
RAIL – Effect on track forces by changing rail profile	Infrastructure Manager	Predicted for 2016	Training for welding techniques and local certification if required.
EARTHWORKS – sensor in geo-textiles	Infrastructure Manager	Available late-2015	Installation of the sensor-embedded geo-grids requires extra care compared to normal geo-grids in order to prevent failure of the optical fibre
RAIL - Impact of inspection and monitoring technologies (with	Infrastructure Manager & Train Operator	Available 2015	Development of alarm settings for specific vehicles and routes.

MerMec).			
RAIL – Switch lubrication testing	Infrastructure Manager	Available 2016	Environment testing facility to be procured to extend testing temperature range (2016 on)
RAIL – Smart Washer	Infrastructure Manager	Predicted 2018	Prototype testing to be concluded with development to final product.
RAIL – Rail Fastening Device	Infrastructure Manager	Predicted 2017	Prototype testing to be concluded with development to final product.

The current level of infrastructure maintenance and inspection is already proving problematical to accommodate with existing traffic levels, so the anticipated increases in freight traffic (see Chapter 3 below for more detail) and passenger traffic across much of Europe over the next 20 to 30 years will also impact upon the infrastructure by increasing traffic levels driving increased track system degradation and at the same time potentially reducing track access for maintenance and inspection. Introducing new materials, smart monitoring and predictive modelling will allow infrastructure operators to manage their assets safely and efficiently via increased infrastructure resilience and right first time repair.

Figure 2 – Rail Contact Fatigue & Deformation

Identifying vehicles with potentially track damaging issues via on-board monitoring or trackside monitoring will help to prevent unexpected track faults and will provide assurance that the track friendly systems are maintained and allow track access charges to be optimized for those vehicles.

2.1 SUB-TASK 5.4.1 – Detailed discussion of Premium Rail Steel

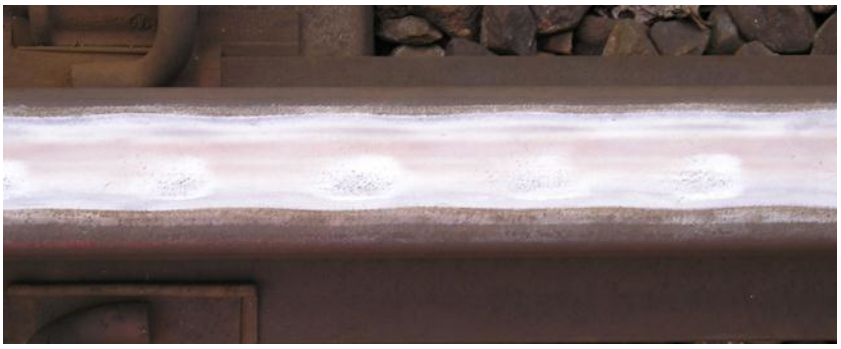
Premium Rail Steel offers significant benefits for infrastructure operators to extend the rail service life and reduce maintenance and inspection operations in specific applications. It is not suitable for areas where rail life is already high as the benefits are reduced if other track maintenance operations would impact upon the extended rail life, for example ballast renewal, sleeper pad and rail pad renewal etc.

Development of the best applications will be based on vehicle speed differentials with associated track cant effects, traffic types and track curvature etc. A certain level of local experience will need to be developed to identify the best areas to install the Premium Rail, but generally the guidance is:-

- High rail - all curves less than 2500m radius in Cats 1A, 1, 2 and 3 track
- High rail - any other curves where the rail life is less than 10 years due to RCF and/or wear
- Low rail - any sites where spalling, corrugation or lipping reduces current rail life to less than 10 years

Figure 3 - Installation

Figure 4 - Corrugation



Once installed Premium Rail will require less maintenance and inspection, but as it is used alongside other rail products it is important to ensure that the benefits are not wasted by carrying out unnecessary maintenance work by assuming all rail at a given location is of the same type. Accurate location of Premium Rail must be recorded and track workers trained to understand the different maintenance and inspection processes.

Plain line rail applications have been under trial in a number of UK locations and the maintenance and inspection processes are now understood. Premium Rail for this application can be considered suitable for implementation and is now available commercially. EN approval/certification of Premium Rail would be required for use as a standard product European-wide.

Switches & Crossings applications are also under trial but the welding repair process for switch blades and the joining processes are still under development. Further work is also required to identify the most appropriate S&C applications.

3. Sub-Task 5.4.2 - interfacing of novel vehicle technologies with their predecessors

This sub-task considers the implementation barriers / requirements for the vehicle innovations developed in Work Package 3, such as locomotive traction type, power supplies, coupling, driver and operator control and infrastructure requirements. Please note that Deliverable 5.7 considers the human factors, training and operational aspects.

The SUSTRAIL vehicle has been considered in two phases, the first is Demonstrator 1 – 'Optimised Conventional Technology' (which will be manufactured by the SUSTRAIL project industrial partners) and includes the following innovations:

- Modified Y25 primary springs
- Double Lenoir dampers and Longitudinal Links
- High resistance damping material
- Axle coating
- Novel wheel shape
- Disk brakes
- Electronic brake controller
- lightweight bogie based on shape and components
- Light weight body based on novel steels
- Axle monitoring through vibration measurements and acoustic emission
- Thermal sensors to monitor axle boxes

The second phase is Demonstrator 2 – 'Innovative Technology' and is a paper based design study. Within this study the following addition innovations are considered:-

- Hydraulic dampers
- Steering linkages
- Centre pivot stiffness
- Independently rotating wheels
- Use of friction modifier at wheel
- Lightweight bogie based on novel materials
- Lightweight bogie based on hybrid solution
- Aerodynamic fairings
- Noise control measures
- Novel wheel steel
- Energy harvesting

All of the innovations in the table below (Table 3) are considered suitable for implementation, although most will require further development before introduction into service. Some of these vehicle innovations do have dependencies that would require supporting changes. Good examples of this are the novel running gear and disc brake innovations, which would require a modified bogie to accommodate the longitudinal links with double Lenoir links and the brake calliper mounting and this would also benefit from a lighter body structure to offset any weight increase for the bogie assembly.

There are no innovations that impact the choice of locomotive power (diesel or electric traction etc.), but the introduction of intelligent systems on board the wagons, such as brake control / monitoring and on-board axle box temperature monitoring will require power supplies and a means of communicating the data in real time to the driver and / or the vehicle

operator. Mixing SUSTRAIL vehicles and current design vehicles in one train would be possible in theory, but in practical terms this may cause problems to connect up the control and monitoring systems along the whole length of the train and of course would limit the higher speed potential of the SUSTRAIL vehicle.

Part of the development process will include the determination of trigger limits for the monitoring systems and determination of appropriate corrective action, for example at what point would a signal drive a required corrective action or inspection from the next scheduled maintenance to one requiring immediate attention?

Maintenance and inspection techniques will need to be developed for all of the vehicle innovations. The use of axle coatings to reduce cracks resulting from debris impact will drive the development of crack detection techniques that can penetrate or be installed beneath the protective coating without damaging it. Improvements to component life and reliability will also drive revised maintenance scheduling. The introduction of disc brakes will allow increased maintenance intervals and also benefit in terms of reduced wheel wear and noise emissions.

Product approval / certification for use will be required for all of the Work Package 3 innovations. Whilst there are some common EU standards in place, generally local approval will be required for use in each country and possibly will also need to meet individual operator requirements.

Disc brakes are the only Work Package 3 innovation that is available in 2015 as they have a manufacturer or supplier already in place for various passenger train and locomotive applications, but the others do not and so predicted dates have been determined. The predicted dates are based upon the time to complete the next development phases with sometime for certification / approvals and should be considered as the earliest possible dates for implementation. The SUSTRAIL innovation owners will pursue future development opportunities.

The Vehicle Operator has been identified as the main beneficiary for the vehicle innovations, but those innovations that offer reduced track damage and noise performance will also be of interest to the Infrastructure Manager as they offer the potential to extend infrastructure life and allow train paths to be utilised in noise sensitive areas or to allow extended operating hours. For these reasons it is likely that the use of innovative vehicles would result in revised track access charges. This aspect is considered elsewhere within Work Package 5.

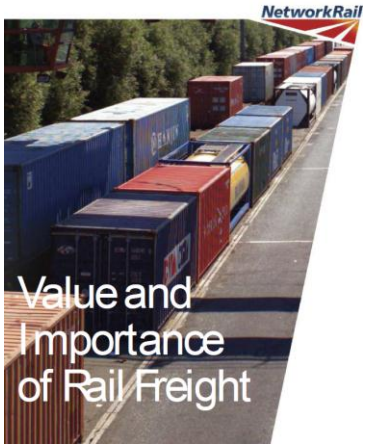
Listed below are the vehicle innovations from Work Package 3 that are supported by an Innovation Information sheet in Appendix 2.

Table 3 – Vehicle Innovations

Innovation	Beneficiary	Implementation Timing	Dependencies
Vehicle – Novel running gear	Vehicle Operator	Predicted 2017	New bogie required to accommodate the novel suspension. Prototype testing to be concluded with development to final product.
Vehicle – Axle mounted disc brakes	Vehicle Operator & Infrastructure Manager	Available 2015	New bogie required to accommodate the revised braking system. Training for maintenance techniques and local certification if required. This may be restricted for use only for wholly disc brake equipped trains.

Vehicle – On board axle box temperature monitoring	Vehicle Operator	Predicted 2017	Power supply and communication to be included in future development. Prototype testing to be concluded with development to final product.
Vehicle – Spring inserts for reduction of structure borne noise emissions	Vehicle Operator & Infrastructure Manager	Predicted 2016	Known technology for passenger train application. Prototype testing to be concluded with development to final product.
Vehicle – Axle Coating	Vehicle Operator & Owner	Predicted 2016	Development of non-destructive testing process required with associated training and local certification if required.
Vehicle – Wagon wheel set	Vehicle Operator	Predicted 2018	Prototype testing to be concluded with development to final product.
Vehicle – Friction modifiers	Vehicle Operator & Owner	Predicted 2017	Friction modifier testing to be concluded with development of dispensing system.
Vehicle - Aerodynamic fairings	Vehicle Operator	Predicted 2016	Prototype testing to be concluded with development to final product.

To help identify the potential size of the market for the SUSTRAIL wagon, information was gathered on the number of intermodal wagons that are on the UK network. There is not a single source of data for that, but research suggests circa 4000+ British Railways era wagons plus in excess of 4000 newer builds, giving a minimum total of around 8000+ units in total. Information published by Freightliner (UK Freight Company) states that the average life span for a wagon is 35 years, which would suggest a replacement rate of around 214 wagons per year for the UK alone at the current market share for rail freight. However the rail industry across Europe has plans to increase market share considerably from current levels, for example in the UK the Value and Importance of Rail Freight report published by Network Rail anticipates:-



"Over the next decade, we expect freight demand to grow by at least 30%; the equivalent of 240 additional freight trains a day, and by as much as 140% over the next 30 years"

This would result in a significant increase in the numbers of wagons in service over the next 20 to 30 years. When this market share increase is considered along with the number of market countries, then the business opportunity for wagon makers to produce a SUSTRAIL

type of vehicle is attractive and should in turn produce a vehicle at much more competitive prices due to high potential unit numbers, this would in turn reduce the payback period and drive increased implementation. Also in time the technology introduced by the Sustrail intermodal vehicle could also be introduced to other wagon types, perhaps via modularised components such as replacement bogies.

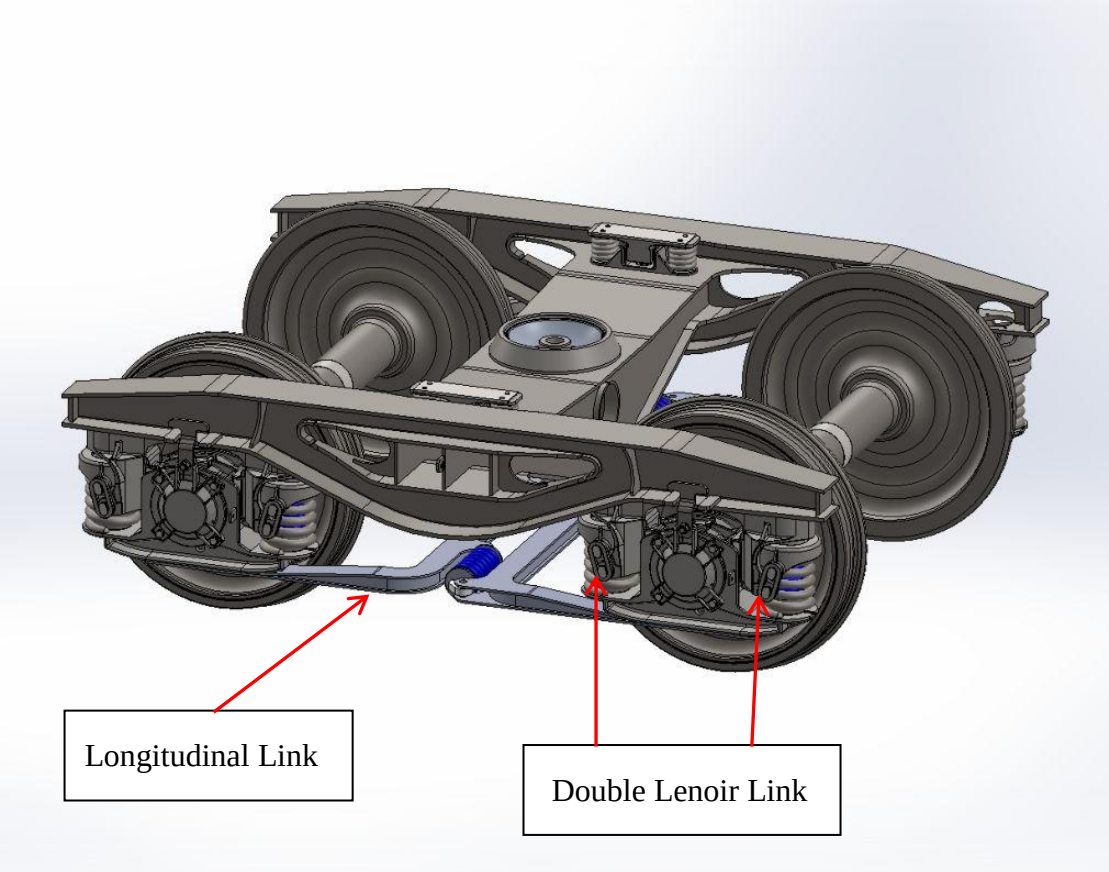
The purchase cost of the SUSTRAIL wagon and the whole life costs including access charging are considered in detail within Deliverables 5.1 and 5.2. These results are a part of the data required to conduct a CBA of the SUSTRAIL improvements, however they need to be generalised to the route level and extended in several ways before the final payback period to the freight operator can be calculated. In particular, there are additional benefits from track damage reduction, which can be passed through to the freight operator via track access charges. There are also potential benefits from CO2 reduction, which were quantified in the Interim Business Case – these rely on weight reduction or aerodynamic improvements, which may depend on the more ambitious SUSTRAIL Futuristic vehicle design. Finally, there should be a positive feedback from demand and revenue gains, if the SUSTRAIL vehicle allows freight operators to offer rail freight service at lower cost and higher speeds.

3.1 SUB-TASK 5.4.1 – Detailed discussion of Novel Running Gear and Disc Brakes

3.1.1 Novel Suspension

The novel suspension system developed by the SUSTRAIL project includes double Lenoir links and longitudinal linkages on a modified Y25 bogie.

Figure 5 – The SUSTRAIL Bogie Design



Single Lenoir links already feature as part of freight vehicle suspension systems, so double Lenoir Links do not pose any major challenges from a maintenance and inspection aspect over conventional freight vehicles in current service. Likewise Longitudinal Links do feature in some passenger vehicle applications so some experience is already available.

The challenge from a maintenance aspect will be confirming the service life and maintenance schedule for a new configuration and application in freight vehicles and also allowing for the impact of potentially higher running speeds on the maintenance cycle.

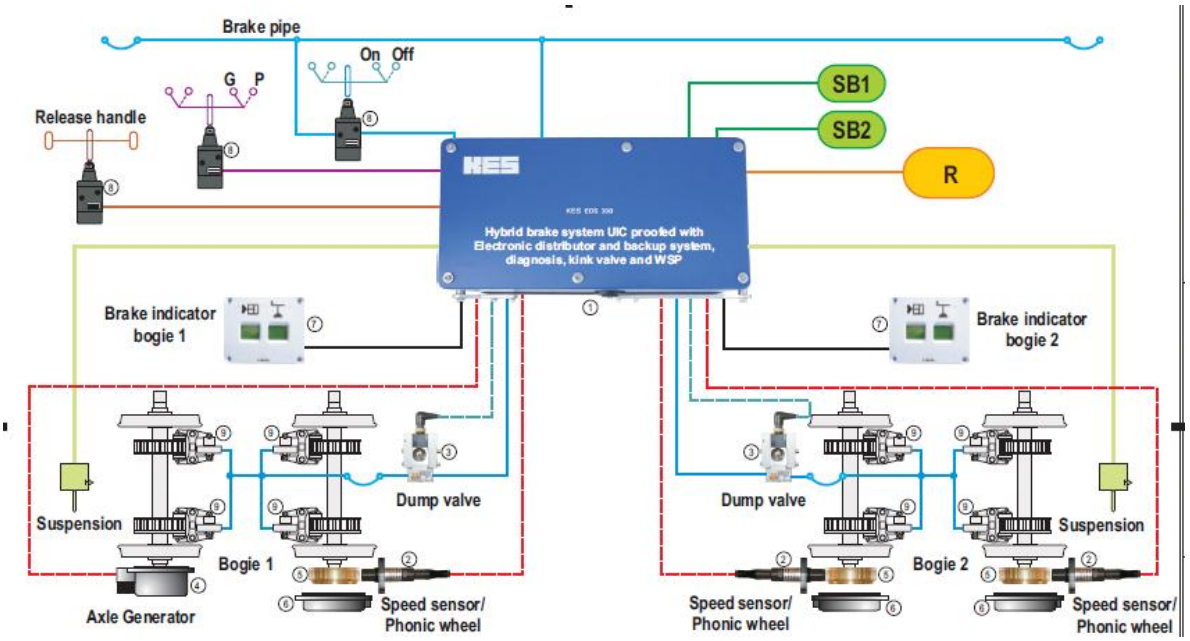
The SUSTRAIL project will build a demonstrator vehicle, so whilst not commercially available yet a prototype will be designed, built and tested allowing the development of maintenance processes and production facilities to allow future vehicles to become available around 2017.

3.1.2 Disc Brakes

The application of disc brakes for freight wagon applications impacts upon wheel maintenance and inspection as much as for the braking system as a whole. Conventional freight wagons use block brakes acting upon the wheel tread, which causes wear and heat input into the wheel tread resulting in increased requirement for wheel grinding / profiling. If wheels are not appropriately maintained, they can also cause track damage.

Whilst it is clear from the LCC and RAMs modelling that there are whole life cost benefits to be achieved, from an implementation point of view experience will need to be built up to determine the reduction in the wheel maintenance requirement, particularly if more sophisticated brake control systems are used to prevent wheel lock up and if higher speeds obtainable with the SUSTRAIL vehicle are exploited. Likewise brake pad and disc life will also need to be understood in the freight vehicle application.

Figure 6 – Braking System Overview



From a training aspect, maintenance operators will require training in the braking system and in the changes to scheduling. If electronic control of the braking system is introduced then the training will also have to include compressed air, power supplies and the full control system. Figure 6 provides and overview of the system required for each wagon.

Development of maintenance processes will also be required for the brake discs as these will be located on the axles and will require wheel removal for replacement, whilst at the same time consideration needs to be given for any axle protective coatings.

Disc brakes are currently in use on passenger vehicles, but from a manufacturing aspect bogie, axle and braking system components will need to be modified for freight vehicle applications. The SUSTRAIL demonstrator vehicle will include a disc brake system and will therefore allow the bogie modifications to be constructed and validated in a production environment.

4. CONCLUSIONS

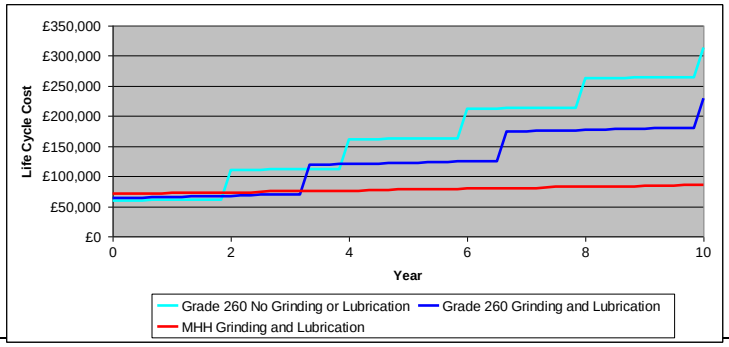
All of the innovations considered in this report are viable and could be introduced at some point. The aim of this report is to consider the impact of introducing these innovations onto the existing infrastructure (Work Package 4 innovations) and interfacing with existing rolling stock (Work Package 3 innovations).

Generally the infrastructure innovations are suitable for introduction as soon as they are available and have very few dependencies. Those for the vehicle are more dependent upon supporting changes, such as on-board power supplies and modified bogies for the novel suspension and disc brake innovations. Mostly there is a need to develop maintenance and inspection processes, including revised scheduling and to ensure the trigger levels for the monitoring systems are understood and can be relied upon to provide robust fault detection. Training must be developed to ensure the innovations are successfully introduced and will provide the anticipated outcomes for the benefit of improved asset life and reliability.

This report has identified some indicative implementation dates for each innovation. They are intended as a guide only as manufacturers or suppliers have not been identified for many of these innovations at this stage and so the timing reflects the anticipated development and certification time required before introduction on to the rail network.

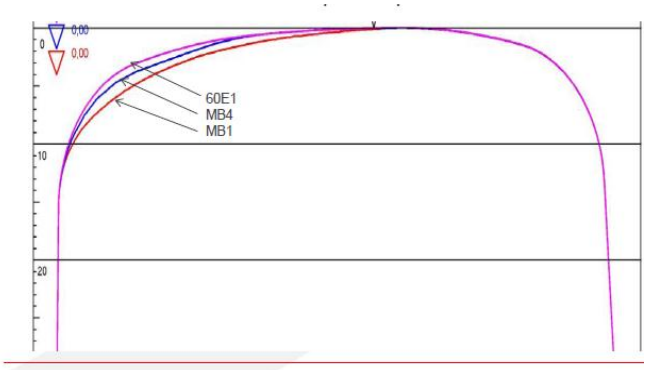
The key driver for the implementation of the SUSTRAIL innovations is obtain an overall cost benefit at an affordable initial purchase price, this is applicable for both for the vehicle and infrastructure innovations. At this stage of development it is difficult to determine accurate costs for all of the innovations given their current level of development and local market conditions, but the potential improvements to be gained by mass production will drive efficiencies of manufacture that will improve the current payback periods to enable a much greater take up. The intention to increase the rail freight market share throughout Europe will further improve the price competitiveness of the SUSTRAIL wagon to more conventional types as potential sales volumes increase significantly. Initial purchase price barriers can be overcome if the payback period is acceptable and risk free and this will drive the development of improved reliability. The full business case will be included in Deliverable 5.6.

APPENDIX 1 - INFRASTRUCTURE INNOVATIONS

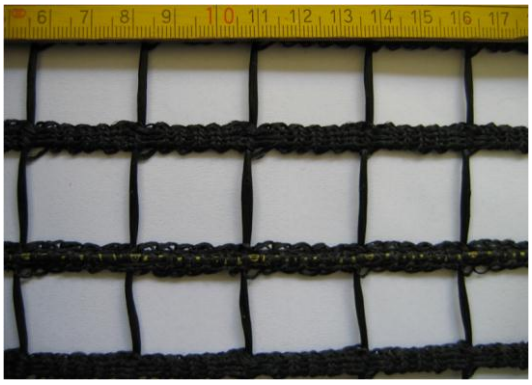
Innovation Title	**Premium Rail Steel (plain line)**
Lead Contact	***Name, organisation, email and phone number*** Rob Lambert, Tata Steel, Robert.lambert@tatasteel.com, M:+44 (0)7789 271686
Opportunity / Need	***What need or opportunity does the innovation address?*** Rail wear and rolling contact fatigue damage on <2500m radius curves
Proposed Innovation	***Include benefits, current level of development, photos and overview*** Premium rail steels such as HP335 and MHH375 offer higher hardness's and more beneficial microstructures than conventional plain line rail steels (R260). This results in reduced rail wear and rolling contact fatigue damage with resulting reduced replacement regimes and lower levels of inspection and grinding. The graph below shows the data for a typical 1000m Radius Curve (500m long, 25MGTPA) – Standard vs. Premium Rail with grinding and lubrication. 
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** Trial sites on the UK network have confirmed the performance predictions and premium rail material is fully commercialised and available as a standard product. UK approval of HP335 for general use has been obtained.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** EN approval/certification of HP335 would be required for use as a standard product European-wide. MHH is already covered within the EN specification.

Innovation Title	**Premium Rail Steel (Switches & Crossings)**
Lead Contact	***Name, organisation, email and phone number*** Rob Lambert, Tata Steel, Robert.lambert@tatasteel.com, M:+44 (0)7789 271686
Opportunity / Need	***What need or opportunity does the innovation address?*** Wear, plastic flow and rolling contact fatigue of switch and crossing (S&C) components.
Proposed Innovation	***Include benefits, current level of development, photos and overview*** Premium rail steels such as HP335 and BLF360 offer more resistance to S&C degradation. Both materials are utilised in S&C switchblades and offer better resistance to RCF in the case of BLF360 and wear and plastic flow in the case of HP335.  (a) (b) **Figure 3.8: Photograph from a test site showing (a) R260 switch blade and (b) Bainitic switch blade after a similar level of traffic.**
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** BLF360 homologated by SNCF for movable points in high speed lines. HP335 approved for use under plain line approval, however further development of repair methods and degradation mechanisms is required. Further work to investigate premium rail in crossings is required.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Weld repair of premium rails in switchblades. Joining welding of bainitic steels

Innovation Title	**Fatigue life prediction of modern rail steels**
Lead Contact	***Name, organisation, email and phone number*** Dr David Fletcher, USFD, d.i.fletcher@sheffield.ac.uk, +44(0)114 2227760
Opportunity / Need	***What need or opportunity does the innovation address?*** • Rail fatigue (squats, rolling contact fatigue, rail foot corrosion cracking) presents a safety risk, and incurs high costs for prevention and management • Current management of this risk is based largely on past performance of conventional rail steels • Modern rail steels offer advantages of wear resistance and modified internal residual stress distributions, but their behaviour in fatigue may not be as predicted for older steels. Rail management, and understanding of safety risk, will benefit from better understanding of modern rail steels.
Proposed Innovation	***Include benefits, current level of development, photos and overview*** SustRail has supported development of rail fatigue modelling, in particular, research on crack growth through rail bending in transition zones. This work needs to be combined with existing modelling for contact stress driven crack growth. There is the opportunity to add residual stress from rail manufacturing to the models, thereby giving a much better representation of the stress state in modern rails and its dependence on the track support system.
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** The modelling work developed in SustRail requires validation against rail performance in service over a longer duration than was available in the current project. Refinement of the model to consider novel residual stress distributions and combination of track support and contact stresses is also required. To achieve impact it will also be important to package this model in a form accessible to end users such as track design teams or rail replacement planning/procurement staff. For example, a 'look-up table' or spreadsheet based model capturing the findings will be more appropriate than a finite element simulation. This work is on the scale of a full PhD project, with a typical cost of around £100k.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Achieving impact of this innovation depends on working closely with infrastructure managers to present output in a form which can be assessed. Validation data from rails already in service will be key to building confidence in the predictions made.

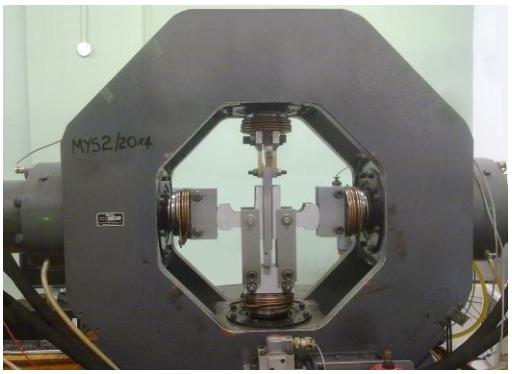
Innovation Title	**Effects on track forces by changing the rail profile**
Lead Contact	***Name, organisation, email and phone number*** Ulla Juntti, Luleå University of Technology, ulla.juntti@ltu.se, +46 70 336 19 91
Opportunity / Need	***What need or opportunity does the innovation address?*** Reducing rail, wear and plastic deformation in heavy haul tracks, 25 tonnes axle loads or higher
Proposed Innovation	***Include benefits, current level of development, photos and overview*** Improved rail grinding strategy to reduced rail wear and rolling contact fatigue damage with resulting reduced increased technical life length and increased life cycle cost. Figure 1 shows the current grinding strategy on the section Kiruna – Riksgränsen on the Iron Ore line.  Figure 1. Rail Profiles MB1 on high rail, MB4 and 60 E1 on low rail and tangent track.
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** On The effects of changing rail profile can be summarized as to: • Reduce surface stress; the gauge corner has been lowered (flattened) by grinding. • prevent rolling contact fatigue (RCF), plastic deformation, corrugation and wear • increases the life length on rails and wheels Future work is to follow up, analyse and correct the grinding strategy to optimise the life length of the rails.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Approval/certification would be required for European wide use. Training required for repair techniques (weld repair process).

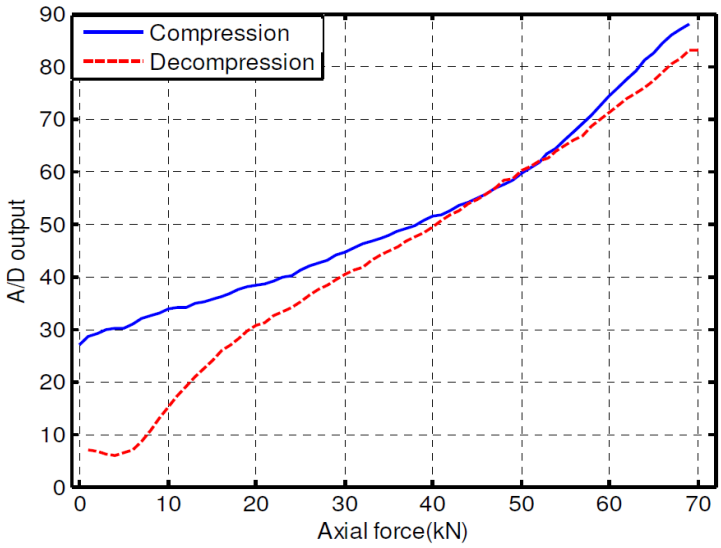
Innovation Title	**Sensor integrated Geo-grids for structural health monitoring of railway infrastructure**
Lead Contact	***Name, organisation, email and phone number*** Donato Zangani, D'Appolonia S.p.A., donato.zangani@dappolonia.it, phone +39 010 3628148
Opportunity / Need	***What need or opportunity does the innovation address?*** The railway substructure can be subjected to particular events such as extreme-rainfalls, landslides, uneven settlements and other similar events which are becoming much more common than in the past due to climate changes, and this requires the infrastructure managers to look from a different perspective infrastructure maintenance issues. What was previously consider as "extreme" is now "common" and thus actions need to be taken to be ready when such events will happen. This is made most apparent when dealing with slopes since slope failure can often be catastrophic, occurring suddenly with little to no warning; however, it should be noted that progressive slope failure can also occur, and that massive shear failure can occur suddenly on flat ground as well as sloped. Such events show the importance of monitoring the track and the infrastructure in order to detect any anomaly, prevent failure and repair the structure minimising disruptions to train services and reduce maintenance costs to restore the normal service conditions.
Proposed Innovation	***Include benefits, current level of development, photos and overview*** Sensor Integrated Geotextiles have been developed to offer the chance to monitor the infrastructure where such materials are integrated in addition of the usual functions geotextiles perform (strengthening, filtration, stabilisation, separation, drainage). The Structural Health Monitoring (SHM) is the result of the integration with the structure of distributed fibre optical sensors, whose response can be collected and processed almost continuously or can be carried out at predetermined time intervals. An efficient signal processing technique is used to process the raw sensor measurements and draw from them an estimate of the damage size and location, being able to distinguish the damage from other perturbations caused by environmental disturbances. The system automatically generates warning alarms when there is a structural risk, or when maintenance is required. The monitoring function is performed thanks to a distributed optical fibre embedded within the geo-grid. The fibre itself is the sensing element which can be used as local sensing element or as distributed sensing cable, with sensing lengths up to several kilometres. The benefits of using sensor embedded geo-grids within the railway substructure can encompass: • Indicate impending failure • Provide a warning • Reveal unknowns • Evaluate critical design assumptions • Assess contractor's means and methods

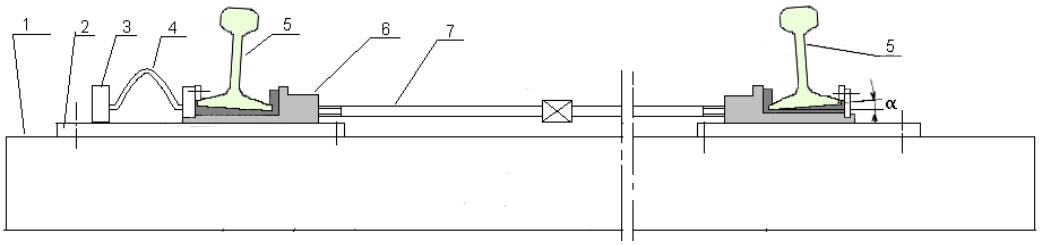
	• Minimize damage to adjacent structures • Control construction • Provide data to help select remedial methods to fix problems • Document performance for assessing damages • Inform stakeholders • Satisfy regulators • Reduce litigation • Advance state-of-knowledge Some pictures of typical geo-grids with embedded fibre optical sensors for continuous monitoring are shown hereafter.   It is important to recognize that this approach only provides an organized way to help make rational decisions based on quantified information. Geotechnical instrumentation by itself does not change the outcome but can minimise the impact of a particular event. Placing geotechnical instrumentation in an embankment to monitor stability does not alter the factor of safety of the embankment. It is only through the intelligent use of the data from the geotechnical instrumentation that engineers can better foresee potential outcomes and take appropriate actions to alter the events or reduce the consequences.
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** We are looking for pilot case installations for the demonstration of the structural health monitoring services. The cases of highest interest and applicability are areas with higher risk of subsoil failure. An installation was already carried out in Germany in 2007 in correspondence of a curve of a railroad near Chemnitz (Germany) characterised by very high

	traffic volume. The portion of the embankment interested by the installation was more than 100 years old and has been selected since it was under reconstruction. Periodic measurements have been carried out in order to detect any movement within the embankment and its evolution during time. Hereafter some pictures taken during the installation of the sensor embedded geo-grids and during the interrogation of the sensors.  
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Installation of the sensor-embedded geo-grids requires extra care compared to normal geo-grids in order to prevent failure of the optical fibre (even if being embedded in the fabric provides additional protection). For the above reason supervision of the installation from experienced technicians is required. Permanent monitoring requires the availability of a reading unit, which is expensive (of the order of 50-100k€) and of a permanent infrastructure (for the protection of the unit, the power supply, the data collection and transmission). Such solution is therefore indicated for the monitoring of critical infrastructures. Periodic monitoring is a more economical solution, since the availability of the reading unit is required only for one day or for the few days needed to perform the acquisition of the sensors data. This solution is indicated for those structures for which a periodic monitoring can be acceptable or after the occurrence of a particular event.

Innovation Title	**Track Force Measuring System**
Lead Contact	***Name, organisation, email and phone number*** Dan Larsson, Damill AB, email:dan.larsson@damill.com, ph: +46 70 6675885
Opportunity / Need	***What need or opportunity does the innovation address?*** By measuring forces and steering ability of trains we can pinpoint vehicles that cause abnormal degradation of the track and/or those who are prone to derail.
Proposed Innovation	***Include benefits, current level of development, photos and overview*** This innovation checks for bad actors among vehicles regarding their track forces. This is done by using a minimum set of sensors in track which make the system both robust and cost effective. The system combines functions from several commercial systems of today sold under function titles such as ALC, TPD, WID and WILD. As added functionality comes the integrated vehicle identification by wheel pattern or RFID-readers, the vibration measurements and the measurement of angle-of-attack (AoA). The last two functions are solved without any need of extra sensors. System also auto-adjust the axle load calculation by using a set of selected vehicles as a real-time reference. Two systems are currently running while subset functions such as railway scales has been sold as a standard product to the mining industry  
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** Installation of 2-3 more stations during the nearest year, producing more reference data to work as a base for alarm setting. Also development of a SMS alarm functions to support the web page presentation.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** None

Innovation Title	**Switch Lubrication testing**
Lead Contact	***Name, organisation, email and phone number*** Dr David Fletcher, USFD, d.i.fletcher@sheffield.ac.uk, +44(0)114 2227760
Opportunity / Need	***What need or opportunity does the innovation address?*** • Assess the quality of lubricants for base plates before they are used in track • Reduce costs of introducing new lubricants • Accelerate innovation in baseplate maintenance
Proposed Innovation	***Include benefits, current level of development, photos and overview*** A test machine and methodology has been developed and trialled (see photo). The machine applies varying vertical forces and horizontal movements to simulate both the loading associated with points being changed and that associated with vehicles traversing the switch blade. 
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** Testing has successfully been undertaken and is available. Future development to include installing an environment chamber to allow the influence of contaminants and low temperatures to be investigated. Estimated cost £50,000. Timescale subject to funding.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** It is not anticipated that this facility will be in sufficient demand for staff to be permanently assigned, so test programmes will coordinated with staff availability.

Innovation Title	**Smart Washer**
Lead Contact	Dr Crinela Pislaru, University of Huddersfield, c.pislaru@hud.ac.uk, 01484 472162
Opportunity / Need	***What need or opportunity does the innovation address?*** In the rail industry the assembly and maintenance of critical threaded fasteners is widely acknowledged to be a necessary yet an expensive, time consuming activity and subject to human error. The failure implications of such fasteners can be catastrophic, as can the failure of the present manual systems which aim to ensure their integrity.
Proposed Innovation	***Include benefits, current level of development, photos and overview*** Smart washer technology will be capable of monitoring fastener integrity, transferring the data to ensure remote condition monitoring and enabling the transition from time based planned preventive maintenance to a condition-based approach with integrated audit and quality assurance features. Practical lab tests have shown a non-linear relationship between the sensor resistivity and the axial load over the range 20 to 70 kN for compression (bolt tightening) and decompression (bolt slackening). 
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** • **Phase 1 (approx. 12 months) -** includes pre-prototype testing, assessment of environmental influences and the range of technical specifications and measurement capabilities. • **Phase 2 (approx. 24 months) -** includes clamping force measurement, RFID tag, energy harvesting, data transmission and miniaturisation, development of measurement system and the design and testing of the production prototype.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Approval/certification would be required for European wide use.

Innovation Title	**The rail fastening device**
Lead Contact	***Name, organisation, email and phone number*** George Tumanishvili, Georgian Technical University, ge.tumanishvili@gmail.com, +995 597 002073.
Opportunity / Need	***What need or opportunity does the innovation address?*** Wheel and rail wear mostly in curves; derailment; rolling contact fatigue damage; vibrations and noise; energy consumption.
Proposed Innovation	***Include benefits, current level of development, photos and overview*** Developed rail fastening device to: avoid change of the rail gauge and rail cant and improve damping properties of the truck by equidistant lateral sprung displacement of both rails.  1 - sleeper, 2 – immovable rail pad, 3 – support, 4 – elastic member (It can be executed turned on 90 degrees, between rails or outside an outer rail, as helical or flat spring), 5 – rail, 6 - movable rail pad, 7 – threaded cross–beam. The immovable rail pad 2 with support 3 is fixed on the sleeper 1.The elastic element 4 is installed on the outer rail side (inside of acting of lateral force) between the support 3 and movable rail pad 6 which is installed on the immovable rail pad by guide slot (it is not shown in the drawing). The threaded cross-beam 8 is installed between rails on the threaded cinematic pair 7.
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** Development of the design of the rail fastening device, its fabrication and testing in the real conditions.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Approval/certification would be required for European wide use. Training required for repair techniques (repair process).

APPENDIX 2 – ROLLING STOCK INNOVATIONS

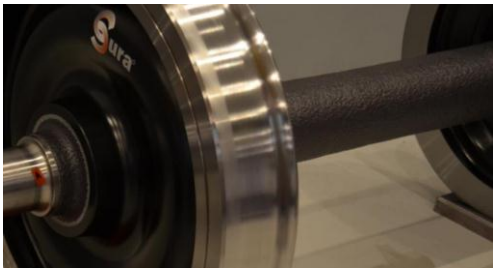
Innovation Title	**Novel Running Gear**
Lead Contact	***Name, organisation, email and phone number*** Simon Iwnicki s.iwnicki@hud.ac.uk
Opportunity / Need	***What need or opportunity does the innovation address?*** The conventional Y25 or 3 piece type bogies are not adequate to provide higher running speeds with lower track forces as required by the SUSTRAIL project.
Proposed Innovation	***Include benefits, current level of development, photos and overview*** Several innovations are proposed including:- DOUBLE LENOIR LINKS: The double Lenoir link suspension provides much lower longitudinal primary stiffness than the conventional Y25 running gear which can provide significantly reduced lateral track forces while still utilising standard components and methods which are well established within the railway industry.  LONGITUDINAL LINKAGES A disadvantage of the double Lenoir link is that it can lead to low critical speed and vehicle instability at line speeds. In order to improve the running behavior of the SUSTRAIL vehicle it was decided to assess the benefit of using a longitudinal linkage to provide increased stability. 
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** A prototype SUSTRAIL freight vehicle is being constructed at the REMARUL premises in Cluj, Romania. Tests are scheduled for spring 2015.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Although all bogie designs have been agreed within the project and components ordered there are currently some delivery issues with braking components and this may cause a short delay with knock on effects on testing and approval.

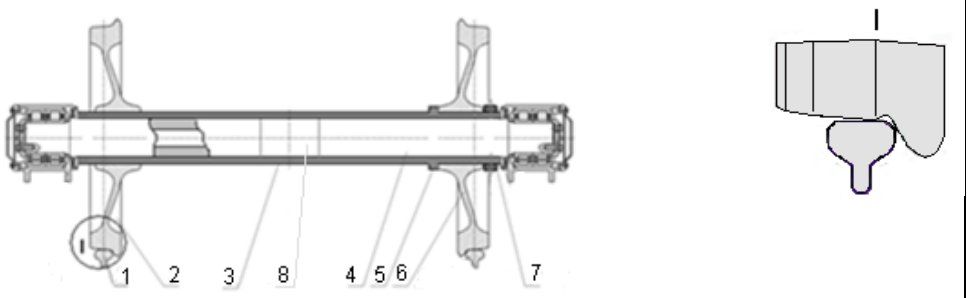
Innovation Title	**Disc brakes mounted on the axle wheel**
Lead Contact	***Name, organisation, email and phone number*** KES Keschwari Electronic Systems GmbH & Co. KG, Reihekamp 16, 30890 Barsinghausen, Germany, +94 510580960, office@kesgmbh.com
Opportunity / Need	***What need or opportunity does the innovation address?*** Lower noise emission, higher velocity of the freight wagon.
Proposed Innovation	***Include benefits, current level of development, photos and overview*** Noise reduction potential 8 dB(A) compared to cast iron brakes (no roughen of wheel surface) + 2-3 dB(A) because no conventional brake leverage is necessary + 2-3 dB(A) if wheel mounted disc brakes are used (additional shadowing and damping effect) Description of the technique or method There are 2 types of braking systems for freight wagons. One type is block brakes, which brakes the freight wagon through friction between the brake shoe and the surface of the wheel. The other one are disc brakes, which can be mounted on the shaft or on the web of the wheel. The advantage of disc brakes is that there is no friction brake force which acts directly on the wheel surface. That reduces the wear of the wheel, eliminates the temperate input into the wheel through the friction brake force (brake shoes), reduces the roughness of the wheel surface and with it the noise emission of the wheel rail contact. The reduction of the wear leads to a lower frequency of reprofiling the wheel profile and a reduction of the maintenance costs. On the other hand, the disc brakes lead to higher investment costs and it is said, that only disc brakes make sense, if the freight wagon has a mileage of 160,000 – 200,000 km/year. Description of noise reduction potential Disc brakes preserve the wheel surface and do not roughen the wheel running surface. This reduces the noise emissions of the vehicle up to 8 dB(A) compared to cast iron brakes. Furthermore, the rattling of the brake leverage will be significantly reduced because only the calliper and the brake cylinder are mounted without play on the bogie frame.
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** Homologation and measurements on test track.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Higher costs at the beginning (investment costs) but with a mileage of 100.000 km/a better LCC that block brakes. Modifications are required to the bogie to provide a signal to show the status of the brake.

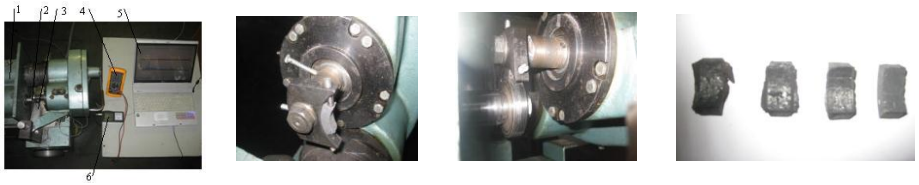
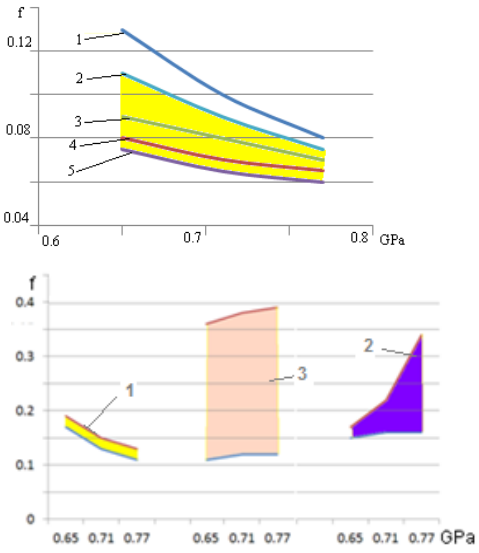
Innovation Title	**On-board axle box temperature monitoring and bogie acceleration inspection**
Lead Contact	***Name, organisation, email and phone number*** François DEFOSSEZ, MERMEC, francois.defossez@mermecgroup.com, Tel : +33 491 100 1978
Opportunity / Need	***What need or opportunity does the innovation address?*** MERMEC proposes to develop an on-board monitoring system for the measurement of the temperature of the axle boxes. The current situation is that these measurements are mainly done by wayside monitoring systems which are installed on the track to inspect the vehicles (Hot axle box detectors). The problems of such measurements are that they are not made continuously, and furthermore, they are made from a certain distance of the axle boxes. Moreover, this proposition also deals with an on-board measurement of the acceleration applied on the bogie, to assess either the quality of the track or the wagon.
Proposed Innovation	***Include benefits, current level of development, photos and overview*** The main idea is to design a simple, integrated, easy to install and economically efficient system. This portable system could be installed temporarily on a freight wagon. In this case, the monitoring system could make measurements for a short period, maybe on problematic wagons that need to be checked, and then could be removed and installed on another one. The proposed innovation aims to measure the temperature of the 4 axle box of a dedicated boogie, plus the acceleration in 3 axis for each side of the bogie. Each on-board sensor transmits to a coordinator (receiver) all the acquisitions that are made by mean of wireless network. The acquisitions are stored on the receiver database for further processing.
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** This proposition has been tested and validated in laboratory. It will be assessed on the Faurei Railway test sites in order to be validated in a real railway environment. Regarding the results of these tests, the prototype could need some modifications, improvements. Work on real data processing would also be needed and require some time. The improvement would need some months and the deployment could be envisaged within 2 or 3 years.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Certification would be required for concrete railway use. The proposed monitoring system uses sensors and transmission protocol adapted to Railways.

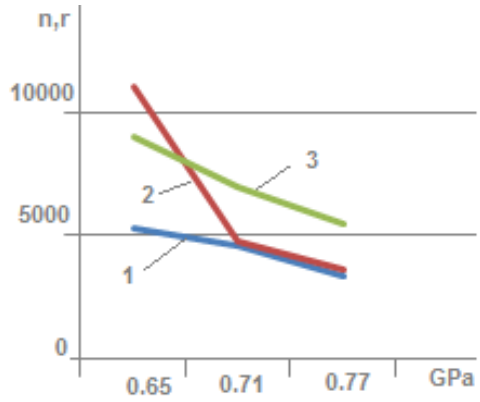
Innovation Title	**Spring Inserts for Reduction of Structure-borne noise emission**
Lead Contact	***Name, organisation, email and phone number*** Uwe Pöggel, Freudenberg Schwab Vibration Control GmbH & Co.KG, Berliner Straße 17, 16727 Velten, Germany, Tel.:+49(3304)365371, uwe.poeggel@freudenberg-schwab.com
Opportunity / Need	***What need or opportunity does the innovation address?*** Structure-borne noise emission of the bogie and car body
Proposed Innovation	***Include benefits, current level of development, photos and overview*** Noise reduction potential Unknown Description of the technique or method It is known that tare freight wagons have a higher noise emission than laden ones. One aspect, which is responsible for this behaviour, is the structure borne sound of the freight wagon. Excited through the wheel rail contact, the waves and vibrations are transmitted over the structure of the wheel, axle box, bogie frame to the car body. For that transmission the primary and secondary suspension works as a structure-borne sound bridge. To avoid this structure-borne sound bridges, spring inserts can be used. They are made of two metal plates and between them is an elastomer with a characteristic stiffness and damping. Description of noise reduction potential Structure-borne sound is excited by vibrations with a frequency higher than 100 Hz. As very important for the noise emission are seen bending waves in the structure. Nevertheless, other waves like longitudinal waves, shear waves or Rayleigh waves are also possible in the structure. They can overlap themselves and excite the structure to critical bending vibrations. In freight wagons the source of the vibrations is the wheel rail contact. The roughness of the wheel and rail excites the wheel to high frequency vibrations which transmit themselves over the primary suspension, the bogie frame and secondary suspension to the car body structure. To interrupt this chain, the structure-borne sound bridges have to be avoided and therefore spring inserts can be used. To avoid the transmission of high frequency vibrations, a big difference in the impedance between two bodies, coupled with a spring/damper element, is very important. This theory is used by the spring inserts. Through the usage of the spring inserts, a high impedance difference between the axle box and the primary suspension is created. Another fact is, that the elastomer in the spring insert works as reflector and reflects some vibrations directly. So they will not transmit over the primary suspension and not excite the car body to bending waves.
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** Measurements on a test track to validate the real effect. Costs: Prototype - 8 Pieces, 163.00 Euro/ piece Series production: 200 Pieces, 82.50 Euro/piece 500 Pieces, 67.52 Euro/piece 1000 Pieces, 58.23 Euro/piece

Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Well known in passenger service but no experiences for freight trains.

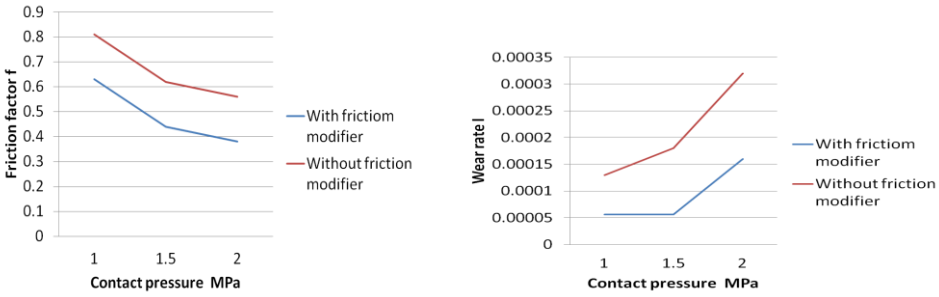
Innovation Title	**Axle coating**
Lead Contact	***Name, organisation, email and phone number*** Steven Cervello, Lucchini RS, s.cervello@LucchiniRS.it, tel: +39 035 963483
Opportunity / Need	***What need or opportunity does the innovation address?*** Protection of railway axles from impacts and environmental corrosion, increased overall quality, safety and dependability of the rolling stock.
Proposed Innovation	***Include benefits, current level of development, photos and overview*** An innovative thick axle coating protects the axle from impacts and corrosion, preventing the possible occurrence of surface defects in service and cancelling the need for periodic visual inspection (EVIC). ▪ Developed to meet the requirements of EN13261 class 1 coatings (anti impact resistance); normally required for high speed vehicles. ▪ Epoxy resin reinforced by synthetic fibres to increase structural resistance ▪ Excellent adhesion to smooth metal surface ▪ High protection against corrosion ▪ High resistance to impact in a wide range of temperature (-40 to + 150°C) ▪ Resistance to axle over-heating due to heavy braking demonstrated by means of dynamic tests. 
Next Steps and Deployment	***Outline future development plans including timing (include deployment phases if appropriate), milestones and anticipated costs*** The traditional non-destructive magnetic particles inspection of surface cracks cannot be performed on the coated axle, since the coating is not removable. Therefore, a modified NDT procedure based on ultrasonic inspection with specific probes is being defined and validated.
Issues and Dependencies	***Please note any issues or dependencies that may influence deployment e.g. training, legislation etc.*** Approval/certification would be required for European wide use.

Innovation Title	Wagon wheel-set
Lead Contact	***Name, organisation, email and phone number*** George Tumanishvili, Georgian Technical University, ge.tumanishvili@gmail.com, +995 597 002073.
Opportunity / Need	***What need or opportunity does the innovation address?*** Wheel and rail wear; rolling contact fatigue damage; vibrations and noise; energy consumption; avoiding of mixing of modifiers having different purposes (increase and decrease of the friction factor).
Proposed Innovation	***Include benefits, current level of development, photos and overview*** Developed wheel-set to: avoid interaction of flange root with rail corner and separate tread and steering (flange) surfaces; decrease of creep by ensuring independent rotation of wheels; decrease stress concentration on the components of the shaft and probability of failure.  1 – wheel, 2 - outer hollow shaft, 3 - middle place, 4 - inner shaft, 5 - shaft nave, 6 – wheel, 7 - set collar
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** Next step is testing of the wagon wheel-set which can be performed in two stages: • Development and testing of wheels with separated tread and steering surfaces in the real conditions: the separation of the tread and steering surfaces will be realised by cutting the races on the existent wheels which does not require great expenses; use of the friction modifiers for tread and steering surfaces (see SUSTRAIL innovation information “Friction modifiers”); • Development of the wheel-set design with compound shafts, its fabrication and testing in the real conditions.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Approval/certification would be required for European wide use. Training required for repair techniques.

Innovation Title	**The Ecologically friendly friction modifiers for wheels, rails and brake pads**
Lead Contact	***Name, organisation, email and phone number*** George Tumanishvili, Georgian Technical University, ge.tumanishvili@gmail.com, +995 597 002073.
Opportunity / Need	***What need or opportunity does the innovation address?*** Wear of wheel and rail tread surfaces, flange surfaces and brake pads; rolling contact fatigue damage; environmental pollution by modifiers, vibrations and noise; energy consumption; derailment.
Proposed Innovation	***Include benefits, current level of development, photos and overview*** Developed friction modifiers of two different types (for decrease and stabilization of the friction factor for flange and rail gauge surfaces and for increase and stabilization of the friction factor for tread and brake shoe surfaces) to: decrease energy consumption and maintenance and repair costs. Laboratory researches on the twin disc machine are carried out which have shown positive results.  a b c d Twin disk machine and measuring means: a – twin discs, b – test sample of brake shoe in expandable arbour of machine; c - test sample of brake shoe before test; d - test samples of brake shoe after tests. 1-twin disk machine, 2-triboelements, 3- products of wear, 4-tester, 5-personnel computer, 6-vibrometer  Dependence of friction factors on the contact stress (a) and number of revolutions (b) for initial linear contact of disks



Dependence of the variation ranges of friction factors (a) and number of revolutions till removal of friction modifiers (b) on the contact stress for initial linear contact of disks for three types of friction modifiers for tread surfaces



Dependences of the friction factor and wear rate on the contact pressure for brake shoes

Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** Next step is testing of the friction modifiers in the real operational conditions: fabrication of the friction modifiers in GTU; development of design of the device for feeding friction modifiers and its fabrication.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Approval/certification would be required for European wide use. Training required for repair techniques.

Innovation Title	**Covered container decks (aerodynamic fairings)**
Lead Contact	***Name, organisation, email and phone number*** Dr David Fletcher, USFD, d.i.fletcher@sheffield.ac.uk, +44(0)114 2227760
Opportunity / Need	***What need or opportunity does the innovation address?*** • Reduce energy consumption when carrying freight
Proposed Innovation	***Include benefits, current level of development, photos and overview*** Innovation is a cover for container decks to reduce the aerodynamic drag. An initial feasibility study has been undertaken in SustRail. A cost-benefit analysis on the covers for the deck of container flat wagons has established a break-even weight for a smooth covering that balances the reduction in aerodynamic drag with the cost of transporting the extra weight of the cover.   Initial: With cover: Image from http://www.whdavis.co.uk/index.php/products/rail_freight_wagons/superlow_45/ The break-even weight depends on fuel cost, efficiency of the loco, the anticipated loading history and speed of the wagon, and weather (wind speeds). Neglecting development, commissioning, and installation the mass of covering for which the force required to transport the mass is less than the projected savings from increased aerodynamic efficiency is about 20kg/m, equivalent to about 1mm thick steel sheet. This assumes that the vehicle is laden about half the time, and travels at an average speed of 120km/hr.
Next Steps and Deployment	***Outline future development plans including timing(include deployment phases if appropriate), milestones and anticipated costs*** Gauge industry interest in the innovation. Design the lightweight, durable cover. Tests, trials. Marketing.
Issues and Dependencies	***Please note any issues or dependencies that may impact deployment e.g. training, legislation etc.*** Safety in operation will be considered in the design process