FOREWORD

The next 20-30 years will see unprecedented demand for growth in transport. European railways have to deliver increased productivity to fulfil the growth demand across all modes in freight and passenger services by 80% and 50% respectively by 2050.

The vision of DYNAFREIGHT (Innovative technical solutions for improved train DYNAmics and operation of longer FREIGHt Trains) is to contribute to the objectives of the EU White Paper on Transport 2011, which states that by 2030 a shift of 30% of road freight over 300km to rail, or a doubling of the freight transport by rail compared to 2005, should be achieved. Future models of locomotives will strongly contribute to the achievement of this challenge, supporting the realisation of the goal by providing more attractive rail freight services to the final customer, with competitive rail solutions, maximizing flexibility and efficiency while reducing the operating and maintenance costs.

The final goal of DYNAFREIGHT is to provide the necessary inputs for the development of the next railway freight propulsion concepts within Shift2Rail Innovation Programme 5, contributing to overcoming the problems of operational and technical nature that have been negatively affecting the overall capacity, performance and competitiveness of the EU rail freight industry.

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PROJECT STRUCTURE

DYNAFREIGHT addresses freight running gear for locomotives and the operation of long freight trains, with the following high-level objectives :

- Improved performances: traction, speed, running dynamics and wheel/rail efforts
- Reduced rail freight noise at the source
- Enhance capacity/traffic throughput with the operation of longer trains (up to 1,500m)
- Reduced operation and maintenance costs (reduce wheel and rail wear, smarter maintenance, etc.)

Two primary technical Work Packages (WP) will focus on the following key areas identified by the project :

- WP2 will focus on the investigation, development and demonstration of new concepts for freight bogies. A final integration and implementation into a three-axle bogie virtual model to demonstrate the feasibility of the proposed new design concepts will be undertaken.
- WP3 will define functional and technical requirements of radio controlled traction and braking, propose safety precautions in train configuration and brake application, identify adaptions needed in the infrastructure for long-train operation and coordinate the common work to be carried out with the corresponding S2R-CFM project, FFL4E.

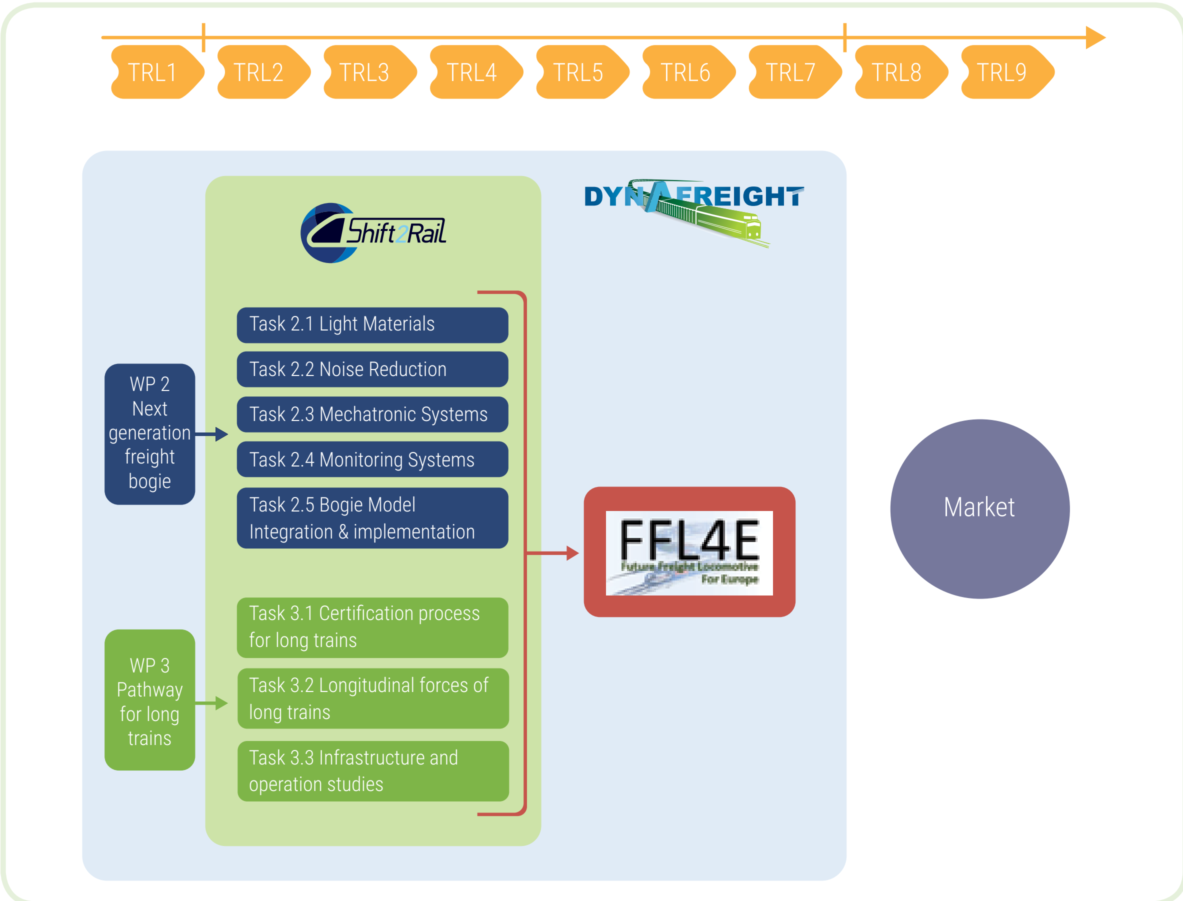

Fig. 1: DYNAFREIGHT project structure within S2R frame

WP2-NEXT GENERATION OF FREIGHT LOCOMOTIVE'S BOGIE

WP2 will develop a novel freight locomotive bogie concept which will reduce wheel and track wear, run with less noise and have lower life cycle costs than current locomotive bogie designs. This will be achieved through developments in the use of advanced materials and manufacturing processes, the use of noise optimized wheelsets and noise absorbing structures, the adoption of passive and mechatronic systems for radial steering of bogies and the monitoring of the most maintenance cost-intensive bogie elements.

Task 2.1 Light materials assessment for rail freight bogie application

Vehicle dynamics and finite element tools were used to review the potential for reduction in bogie mass using conventional and more radical manufacturing methods. The study focused on the bogie frame as this was the component with the greatest mass (17% of the bogie mass in the target bogie).

For more conventional construction methods, the work revealed that optimisation of the existing design including variations in material thickness and using higher strength steel could result in a 43% reduction of the bogie frame mass. The vehicle dynamics studies show that this would translate into a 12.5% reduction in track damage, a 5% reduction in energy consumption, and a 1% reduction in track access charges.

More radical construction methods and the use of novel materials such as glass or carbon fibre composites were also briefly reviewed and pointers taken from other industries.

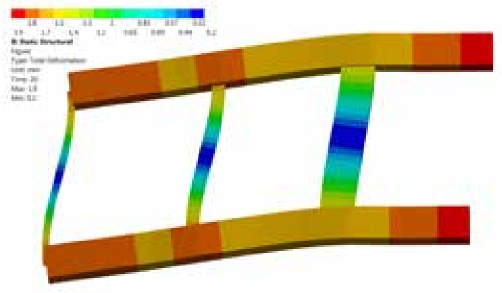

Fig. 2: Maximum deflection 43% mass reduction

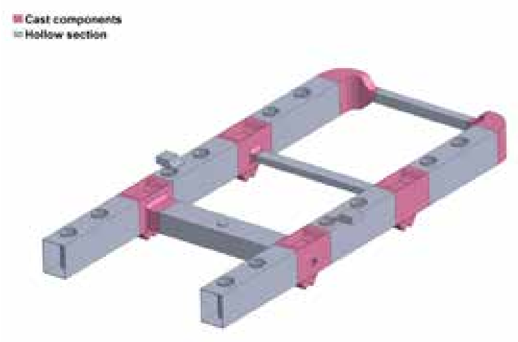

Fig. 3: Sketch of one of DYNAFREIGHT bogie options with a 32% weight reduction

Task 2.2 Noise reduction

The goal of this task is to reduce running gear related noise emissions of rail freight locomotives.

A first step was to characterize the main noise sources of a Co'Co' locomotive under different running scenarios (80, 120 and 160 km/h). Measurements were conducted with a microphone array at a test track as shown in Figure below, which shows higher noise emitted at the end axles compared with the intermediate axles. Track-Decay-Rate and Rail-roughness measurements were performed according to standards in order to characterize the rail in the measurement area. This data, together with the rail-vibration were used to calculate the wheel-roughness.

The mitigation potential of measures such as wheel optimization and lateral skirts were the focus of this task:

The evaluation of the wheel noise emission based TWINS' algorithm was performed. The dynamic characteristics and the FRF of the undamped wheel and a wheel with brake discs were measured at laboratory and shown in Figure 4.

The mitigation potential of the lateral skirts will be assessed by pass by measurements with a microphone array.

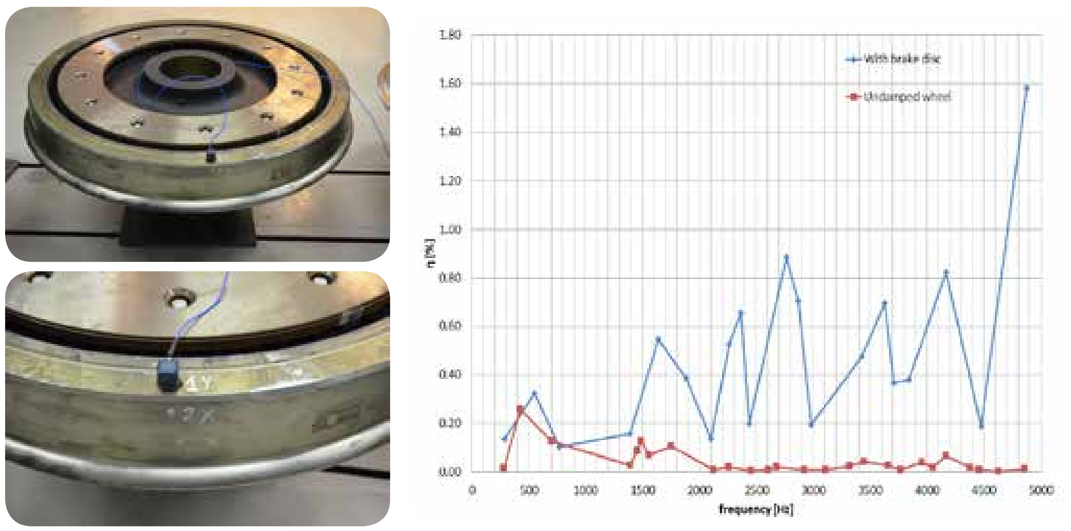

Figure 4: Wheel lab testing and results of the damping factor

Task 2.3 Passive and mechatronic systems for radial steering of bogies

This task aims at defining new concepts for steering bogies for Co-Co freight. The main benefits expected are: significant reduction of wheel wear and damage, improved traction in curves and reduced resistance to motion in sharp curves.

A review of existing concepts for steering bogies was performed, analyzing the existing state-of-the-art and outlining the advantages and disadvantages of the different concepts considering the specific case a bogie for a freight locomotive with 3-axle bogies. As a result, a selection of concepts to be investigated was identified:

- Passive steering using mechanical links (PSM)
- Passive steering using hydraulic actuation (PSH)
- Active steering using secondary yaw control (SYC)
- Active steering using secondary yaw control with wheelset articulation (SYC&WA)
- Active steering using hydraulic actuation (ASH)

Following the identification of the concepts which are relevant to this study, multi-body system (MBS) models were defined with the aim of assessing their benefits. A baseline vehicle was defined representing a realistic example of a freight locomotive with Co-Co bogies. Other MBS models were then defined to investigate the steering concepts described. This work is still on-going, but a complete analysis is already available for the SYC concept and preliminary results are available for the SYC and ASH concepts, showing that:

- The SYC concept brings limited benefits when compared to the baseline case. The wear number reduction on the different wheelsets is in the range of 0-20% depending on the wheelset.
- On the other hand, the ASH concept enables a substantial reduction (90% and more compared to the baseline vehicle) of the wear index on all wheelsets

In conclusion, SYC is a concept for active steering that can be easily implemented, with reduced impact on the design of the bogie, but only brings limited benefits in terms of reduction of wheel wear (and rail profiles wear), whereas the ASH concept is a more challenging concept from the point of view of bogie design, but could potentially lead to a substantial reduction of wear, especially in sharp curves.

Other concepts are being studied in the project and results will be reported in future publications and communications.

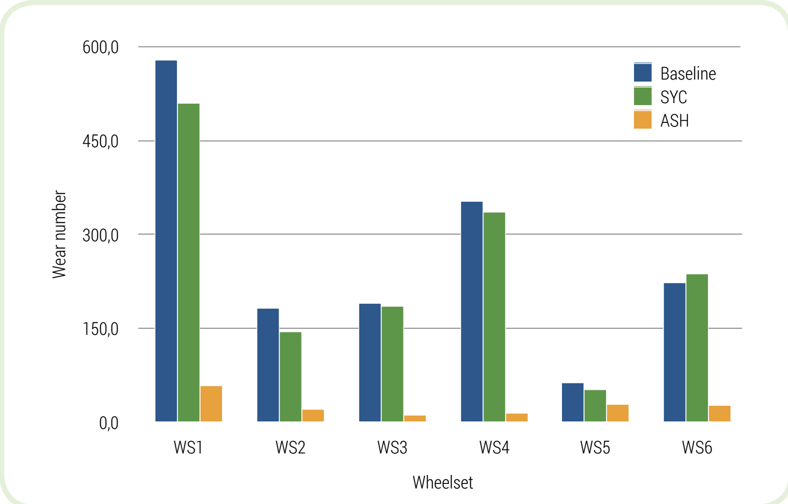

Figure 5: Comparison of the Tγ wear number
for the baseline vehicle, SYC and ASH

Task 2.4 Monitoring Systems

Condition monitoring of the dynamic interaction between locomotive and track has a large potential to reduce LCC of the overall system, but today it is essentially confined to sensors put on the track at a limited number of sites. The current work focusses on introducing sensors in the bogies to continuously monitor the system and reduce LCC.

The first step was to analyse the current LCC of a Co'Co' freight locomotive (assuming life of 30 years and 230,000km/year). The weight percentage of the main bogie components was then established in order to determine the most costly maintenance systems (figure below).

As a result, the monitoring study focused on key bogie components like wheelset, bogie frame and suspension components, as well as brake and lubrication equipment. For each application described, the increase in initial bogie cost was compared with expected benefits like reduced bogie inspection and maintenance costs.

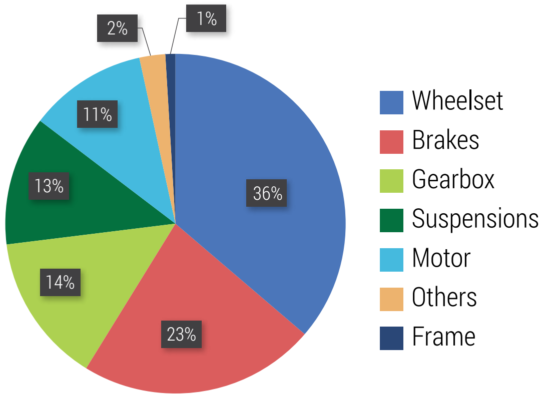

Figure 6: Maintenance costs weight percentage of a Co'Co' bogie system

Task 2.5 Bogie Model Integration and Implementation

This work integrates prior results into a virtual Co'Co' bogie model in order to demonstrate the feasibility of the proposed new design concept from an integration/manufacturing point of view.

In a first step, a noise absorbing structure was designed and manufactured, as shown in Figure below. While a test can be made to check the noise reduction, the simulation method from Task 2.2 is an option. The design damped sheet steel is gapless, shielding the biggest possible area so as to increase bogie noise mitigation. Design calculations were in accordance with EN13749.

A second step will integrate successful mechatronic concepts from Task 2.3 to evaluate feasibility, as well as a monitoring solution.

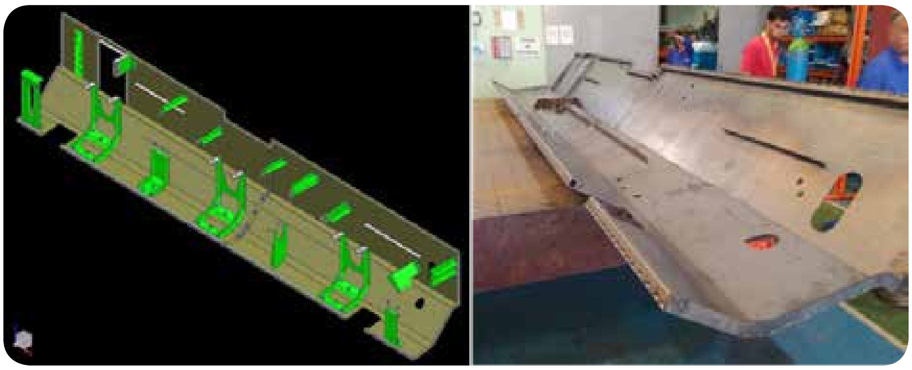

Figure 7: Designed (left) and manufactured (right) lateral skirt

Link with S2R:

DYNAFREIGHT WP2 is part of the work being carried out to develop a novel freight locomotive bogie for use in TD5.5 of the Shift2Rail Innovation Programme 5 for developing new freight locomotives and contributing to overcoming the problems of operational and technical nature that have been negatively affecting the overall capacity, performance and competitiveness of the EU rail freight industry.

WP3-TECHNICAL SOLUTION FOR REGULAR OPERATION OF 1,500 M LONG FREIGHT TRAINS

DYNAFREIGHT WP3 partners are preparing the path for regular operations of long freight trains (up to 1,500m), following the outcomes of the MARATHON EU project and in collaboration with Shift2Rail founder project FFL4E.

Task 3.1 Functional requirements of radio controlled traction and braking

Task 3.1 of DYNAFREIGHT project will specify the functional requirements of radio remote control systems for distributed power in mainline freight operations. During the first period of the project the partners successfully :

- Defined the user cases and the system requirements
- Defined the systems requirements specification for the overall system functionality, with Deutsche Bahn from FF4LE as main partner for this. The radio interface definition will be derived from this specification. The following has been achieved to date:
  - Selected GSM-R as the transmission method. It will allow cross boarder operation of a train without the need to care for frequency management, provided there is existing GSM-R infrastructure.
  - Agreed on the overall architecture with the DPS (distributed power system), the TCMS and the radio. DYNAFREIGHT will provide a SIL3 certified radio control with Ethernet interface to the TCN of the demonstrator locomotives and an integrated GSM-R modem. Detailed interface specification and hardware are being prepared.
  - Set the approach for connecting the master and slave locomotives: this refers to the activation of the radio modem and the specific conditions on when the master locomotive has to communicate with the slave locomotive. Considerations for calling a third or fourth and form longer and heavier trains are also taken into account.
- Conducted a safety workshop and a preliminary hazard analysis together with FFL4E. This sets the basis for defining the safety level of the functions performed by the radio remote system.

The team will continue working towards the project objectives and providing the equipment for the demonstration of the complementary project FFL4E.

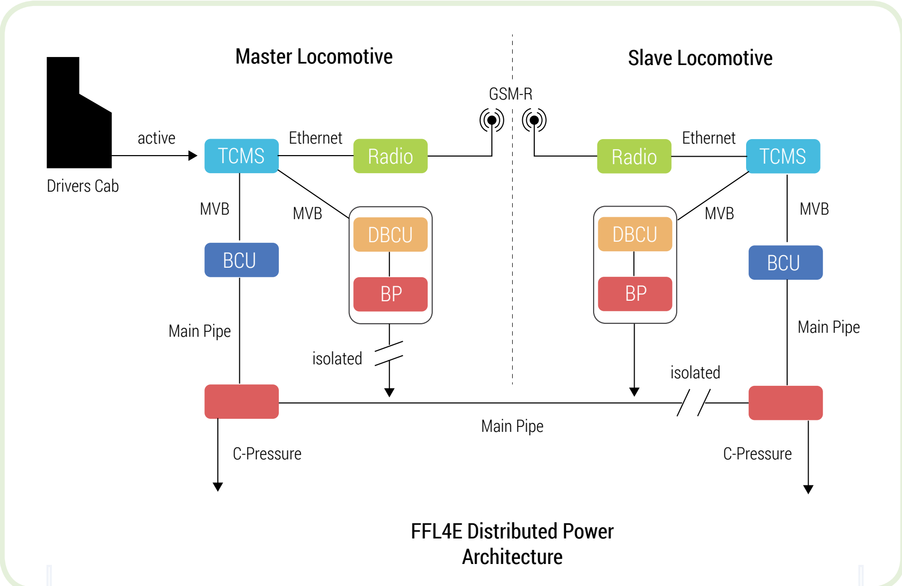

Fig. 8: Distributed Power System Architecture

Task 3.2 Safety precautions in train configuration and brake application

Task 3.2 provides safety precautions in train configuration and brake application when operating long freight trains with distributed traction, UIC pneumatics braking, buffers and draw gears. The methodology is based on extensive simulations, supported by different kinds of measurements.

During the first period of the DYNAFREIGHT project the partners in Task 3.2 have:

- Enhanced the modelling of the brake pneumatics software to represent propagating pressures in the main pipe and brake cylinders of up to 1,500 long trains. The simulation results have been verified against pneumatics measurements. For a first train application, a coal train planned to be a demonstrator in FFL4E, pressure histories have been simulated for different nominal traction and braking scenarios as defined in Task 3.1.
- Improved the longitudinal train dynamics methodology and simulation tool to import pressures from above and in particular to allow for various brake block materials, buffers and draw gears. The modelling of block-wheel friction forces is supported by measurements, and so are the models for buffers and draw gear. Validation of longitudinal inter-vehicle forces is ongoing. The longitudinal forces have also been simulated for the scenarios above (See Figg. 9 and 10).
- Developed a methodology, based on a multibody dynamics software and inspired by the UIC 530-2 Code, to evaluate the risk of train derailment as extensive longitudinal compressive forces occur while negotiating horizontal curves focusing on S-curves. In this way different wagon, payload and buffer configurations have been simulated as longitudinal compressive forces are increased until derailment occurs in the curve in question. Emphasis has been put on the wagons etc of the first train application, but the methodology extends beyond that.
- Compared simulated longitudinal compressive forces from the 1D analysis with tolerable forces from the 3D investigations. This supports the safety precautions that may have to be taken.

Simulations of degraded scenarios, linked to lacking radio communication, of the first train application are soon to be completed. Then longer and more heterogeneous train configurations will be emphasized.

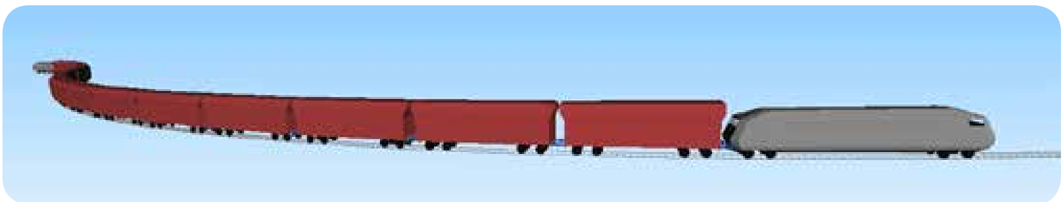

Fig. 9: Graphical representation of the coal train with master and slave locomotives in the 1D dynamics model

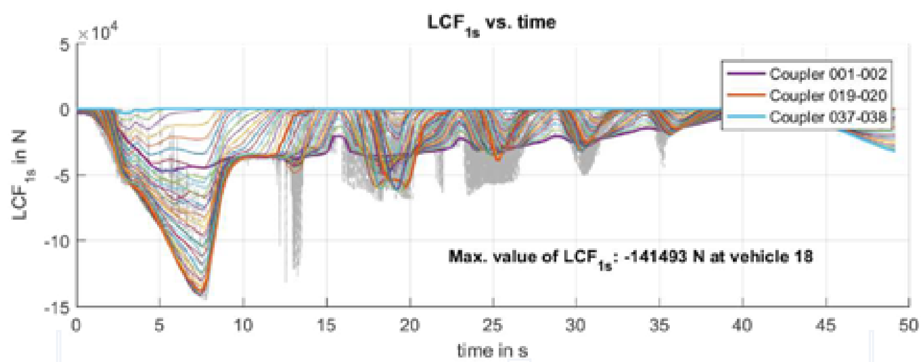

Fig. 10: Exemplary time histories of longitudinal compressive forces (LCF) in wagon buffers during an emergency brake application of the coal train.

Task 3.3 Adaptions in the rail infrastructure for long-train operation

The task aims at identifying the barriers and the adaptations needed to make 1.500 m long-train operations feasible, as well as changes in train operations required and related costs. The analysis takes the main point of view of the infrastructure manager, through two case studies of Spanish lines managed by ADIF. A general analysis of the main rail infrastructure characteristics has been developed already, focusing on rail freight corridors in Spain, part of Atlantic and Mediterranean Corridors. The characteristics enabling the operations of long freight trains have been defined, in terms of traffic, characteristic gradients, ATP, block system, radio, power supply system, hotbox detection, level crossings, weight on bridges, block sections and axle counters.

One of the main restrictions to the traffic of longer freight trains is the electrical power demanded by the catenary, especially in the case of rail networks that use DC system. This restriction is being studied in details in the project, and this topic represents a big step ahead made by DYNAFREIGHT beyond the state of the art. Indeed, other projects and actions (i.e. Marathon) have already analysed other types of restrictions, such as those related to dynamics, signalling, level crossings, etc., but there is hardly any work focusing on the issue of energy supply from the substations, especially in the case of direct current. Therefore the DYNAFREIGHT approach will bring added knowledge to other rail infrastructure managers facing the longer freight train market.

Fig. 11: Atlantic Corridor. Analyzed section

Link with S2R :

DYNAFREIGHT WP3 is carried out in close collaboration with WP5 of the founder project FFL4E (Future Freight Locomotive for Europe). These efforts are part of the Shift2Rail Innovation Programme 5 and aim at operation of longer freight trains, up to 1500 m, in Europe to improve the capacity and efficiency of rail freight.

EVENTS AND PUBLICATIONS

DYNAFREIGHT KO meeting

23 November 2016, Brussels

The DYNAFREIGHT Kick-Off meeting was held on the 23rd of November in Brussels. During the event, partners presented the planned work and a fruitful discussion with members of the corresponding CFM project FFL4E (Future Freight Locomotive for Europe) took place, ensuring the full alignment of the two projects in terms of activities and transfer of results.

PTFE General Assembly

30 November 2016, Madrid

Stadler Rail Valencia gave a presentation on DYANFERIGHT during the PTFE General Assembly on the 30th of November 2016, giving an overview of:

- Project data: partners, budget, duration, etc
- Main goal and technical objectives
- Structure of the project
- Explanation on technical tasks and general planning
- Expected Impacts of the project

Transport Logistic Fair

9-12 May 2017, Munich

DYNAFREIGHT information was disseminated during the Transport Logistic fair which took place between 9 and 12 May in Munich. The event gave visitors a complete look at the entire process chain of the transport and logistics sector. DYNAFREIGHT brochures were displayed and distributed at the Technische Universität Berlin stand and UNIFE was also present on 10 May.

IAVSD 2017

14-18 August 2017, Rockhampton, Australia

DYNAFREIGHT was present at the 25th International Symposium on Dynamics of Vehicles on Roads and Tracks at the Central Queensland University in Rockhampton, Australia. Prof. Simon Iwnicki from Huddersfield University presented the first results of Light Materials Assessment.

TRA 2018

16-19 April 2018, Vienna

DYNAFREIGHT submitted two full papers focused on WP2 and WP3 a one poster and the evaluation process is now ongoing.

NOTES

PARTNERS, FACTS & FIGURES

PROJECT COORDINATOR

UNIFE

TECHNICAL LEADER

STADLER

BENEFICIARIES

Lucchini RS; TU Berlin; Politecnico di Milano; University of Huddersfield; KTH; adif; FIT; Laird

TOTAL BUDGET	PARTNERS	DURATION
€1 MILLION	10 PARTNERS	20 MONTHS

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