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PROJECT FINAL REPORT

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Project acronym: SPECTRUM

Project title: Solutions and Processes to Enhance the Competitiveness of Transport by Rail in Unexploited Markets

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Name of the scientific representative of the project's co-ordinator[1], Mr Tom Zunder, NewRai – Newcastle Centre for Railway research, Newcastle Univerity

Tel: +44(0) 191 208 3975

Fax:

E-mail: tom.zunder@ncl.ac.uk

Project website address: www.spectrumrail.info

[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement.

4.1 Final publishable summary report

This section must be of suitable quality to enable direct publication by the Commission and should preferably not exceed 40 pages. This report should address a wide audience, including the general public.

The publishable summary has to include **5 distinct parts** described below:

- An executive summary (not exceeding 1 page).
- A summary description of project context and objectives (not exceeding 4 pages).
- **A description of the main S&T results/foregrounds (not exceeding 25 pages),**
- The potential impact (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and exploitation of results (not exceeding 10 pages).
- The address of the project public website, if applicable as well as relevant contact details.

Furthermore, project logo, diagrams or photographs illustrating and promoting the work of the project (including videos, etc…), as well as the list of all beneficiaries with the corresponding contact names can be submitted without any restriction.

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4.1.1 Executive Summary

SPECTRUM developed rail logistics services and technology to capture market share from mono-modal road-based logistics operations. It specifically targeted the market of low-density high value goods. The project adopted a demand led approach; it did not assume "generally accepted" beliefs about logistics demand There is a potential LDHV good market of 1.9 billion tonnes (12% of the freight flows) that could be transported by rail.

SPECTRUM designed a higher speed freight train that performs similarly to a passenger train, offering faster, more reliable and more flexible rail freight services. It developed new power systems for reefers, new bogies, a new lightweight wagon, and transhipment options that include city logistics. The cost-benefit analysis shows that the SPECTRUM service can boost the attractiveness of rail freight.

The SPECTRUM consortium comprised of 22 partners from 10 countries and consisted of a broad range of expertise in the shape of Universities and research organisations, consultants, infrastructure managers, logistics companies, wagon and system builders and associations like the International Union of Railways – UIC. The makeup of the consortium reflected the first principal's approach of the project.

From its inception the SPECTRUM project was market driven. SPECTRUM clearly identifies the needs of the customer and addresses these needs appropriately, adopting a first principles approach to rail freight. Historically rail freight has been the preferred mode for larger shipments, favouring aggregates and bulk cargoes with few time and quality of service constraints. LDHV goods have a very different set of requirements from those traditionally transported by rail. The market analysis has been instrumental in identifying these requirements, working alongside potential end users supporting a comprehensive demand study.

The needs of the customer were aligned against the constraints of the railway infrastructure and logistics and vehicle concept developed accordingly in conjunction with all project stakeholders.

This resulted in project outcomes broadly consisting of:

- Market analysis consisting of origin destination matrices for LDHV goods by road
- Identification of barriers to transporting LDHV goods by rail
- New measures in support of high performance vehicles operating in passenger timetables
- Two vehicle designs adopting various levels of technology
- LCC, CBA and commercial evaluation
- Demonstration of power conversion and control technologies for rail freight and temperature controlled cargoes

SPECTRUM showed that suitable logistics services could increase the attractiveness of rail freight and achieve modal shift in previously unexploited markets and the technology demonstration led to a contract being signed to supply static power convertors to Singapore SMRT transport authority.

SPECTRUM met all of it's objectives, has shown initial market uptake and was a success.

4.1.2 Project Context and Objectives

Modern manufacturing techniques and logistics require reliable delivery of time-sensitive lower density and higher value goods. This presents a market opportunity for rail freight to grow, partly due to increasing congestion on roads, and mainly due to the need for the cost effective, reliable and environmentally friendly transport of goods. At the same time, to meet customer requirements, rail freight has to rise to the challenge of providing a reliable and available service as well as complying with other market demands. Depending on the market segment these may be faster transport time, specialised handling systems, tracking and tracing, greater flexibility, lower prices or premium services. Furthermore, in congested road situations rail freight may have a competitive advantage in comparison to other modes of transport.

One of the EC objectives presented in the 2011 White Paper is to shift 30% of current road freight transported over 300 km to other modes such as rail or waterborne transport by 2030 and more than 50% by 2050. In order to achieve this and to allow rail to compete with road transport, an improved railway system for different markets is required.

Little research had been conducted to explore the size and scope of the low density, high value (LDHV) goods market. Accordingly, the SPECTRUM project went to great lengths to identify and analyse the LDHV goods market. A transport demand analysis, market intelligence and a number of case studies served as a comprehensive analysis of the LDHV goods market. Presently the LDHV goods market is almost exclusively satisfied by road transport.

With this in mind the SPECTRUM project aimed to develop a rail freight train/system that provided a higher speed service for high value, low density and time sensitive goods with the performance characteristics of a passenger train. SPECTRUM took a longer term, radical and first principles approach to deliver a new rail freight offering that competes with road and air in the growing sectors of logistics where rail freight has traditionally little to offer.

The SPECTRUM project worked towards a freight train that:

- Behaved like a passenger train in terms of installed power, speed, acceleration, braking and momentum: allowing full scheduling on inter-urban and suburban train networks.
- Had a standardised and universal power supply system for the delivery of power to temperature controlled containers (reefers) in a controlled fashion
- Was able to operate intensively over a wide range of national domestic and international lines and routes without constraint.
- Was capable of rapid and flexible response to cargo demands
- Was of a modular design that can address inter-modal and logistics (palletised goods) markets.
- Was cost competitive with road transport over short, medium and long haul sectors
- Was able to collect and deliver cargo close to the point of origin and delivery with minimal road sectors

- Was capable of application in a wide variety of traffic and commodity applications

4.1.3 Main Scientific and Technical Results

Market Analysis

The following types of products were identified as time sensitive, high value and low density goods:

- Goods with a density of 230 kg/m3 or lower, including packaging (i.e. gross-weight), except live animals, transport equipment, tractors, electrical machinery, explosives.
- Goods with a density higher than 230 and lower than 300 kg/m3 and with a value of €0.50 per kg or higher (i.e. trade value, excluding taxes and not the retail value).
- Perishable goods transported (even if the density is 300 kg/m3 or higher and the value is lower than €0.50/kg). Examples: dairy products, fresh and frozen fruits/vegetable and meat.

These are goods that (1) can be transported in small units; (2) are close to the end consumer (i.e. finished and almost finished goods); (3) are non-bulky products and are sometimes time-sensitive. In other words: consumables, parcels and time critical palletised cargo.

High-density goods with low value (such as coal, sand, gravel, etc.) are not eligible for the SPECTRUM train.

Based on a transport demand analysis, market intelligence, interviews and four industrial case studies, the SPECTRUM rail freight concept is able to run within different business options. However, the perspective of the SPECTRUM concept determines how well the rail freight sector will exploit the potential. Different types of business models were assessed on costs resulting in the following business options for the SPECTRUM project:

- Train services that were short-distance, fast, reliable, frequent and flexible operating, but no exclusively on hub-and-spoke networks.
- Train services that provided constant, reliable temperature control possibilities on a range of service models
- Train services that were connected with urban rail networks and possibly with urban consolidation centres/logistics parks and austere terminals deep within urban areas but designed to allow rail to deliver/collect within very short range of the shipper/receiver.

It is also possible to make combinations, where necessary, of some or all of the options into a whole new model of rail freight business operations. The services should at least be able to compete with road transport in terms of service and product competitiveness. But the service should avoid competing with existing rail operations. These services are already available and focus on a different market.

In order to obtain a credible and accepted position in the transport market, the SPECTRUM services had to improve quality parameters (e.g. reliability, safety, flexibility) and/or reduce costs.

The potential impact of the SPECTUM rail depends on how the SPECTRUM rail service will deal with the characteristics of the markets. The service will have to meet the logistics requirements of the shippers involved. In this matter, the SPECTRUM service will have to focus on the logistics aspects.

Due the extra investments and the higher operational costs derived from new technologies. To justify these costs, the expected impacts of the SPECTRUM rail should be well demonstrated to the potential users.

Benefits will be most evident if the SPECTRUM service is introduced in an operational environment, dedicated to one client, and using rail sidings or rail terminal equipment on client premises. Second option is to apply the SPECTRUM service in a supply chain environment where there is a high freight demand over a certain distance. The benefits will however be less evident when impact is measured on a supply chain on a global scale.

Finally, it is challenging for transport and logistics service providers to incorporate the SPECTRUM offering into their service portfolio in a way that the benefits to their clients can be maximised, while additional costs are minimised.

If however this is overcome, there is a potential of 1.9 billion tons (12% of the freight flows), that could be transported by rail. A bit less ambitious target, where road freight flows are studied at a distance of over 300 kilometres (as referred to in the DG MOVE White Paper), a market potential was shown of about 1.4 billion tons (9% of the freight flows)

The SPECTRUM project could save 2.9 billion euros of external costs if only 10% of the traffic is shifted to rail over a ten year period. At least if a linear build up is considered. Additionally 20 million tonnes of carbon emission could be saved.

It was concluded that the SPECTRUM concept has a huge demand to satisfy, and this demand is in alignment with the broad concept of a freight train that performs similarly to a passenger train offering faster, more reliable and flexible rail freight services.

Capacity Management

In conjunction with three infrastructure managers, Network Rail (UK), Trafikverket (Sweden) and TCDD (Turkey), SPECTRUM explored the option to integrate freight and passenger services.

Based on the market analysis demand study, four service areas were selected for investigation.

As well as exhibiting significant demand, the service areas were selected to cover a variety of typographies and operating conditions including national and international services.

Service area 1 was a national transport in central Europe. Central Europe is very active in the transport of LDHV goods. Chosen as country was Switzerland, also to show the possibility of use of the SPECTRUM concept over a comparably short distance.

Service area 2 analysed intermodal transport in Scandinavia. Sweden in particular is very active in the transport of LDHV goods.

International transport in Western Europe was covered by the third service area. Many countries in the region are very active in LDHV transport, especially Spain and Italy and of the international top relations identified in D1.3 a significant number are between France and Italy, France and Spain, Spain and Portugal and Italy and Spain. Italy, Spain and France also have a high volume of LDHV goods transported nationally. Due to the track gauge In Spain and Portugal a relation between France and Italy was chosen.

Finally, service area 4 covered international transport over a long distance through several countries in Eastern Europe. In this region Turkey is very interesting because of the high volume of LDHV transports between Turkey and the EU, especially central Europe. A relation between Turkey and Germany was therefore chosen.

To analyse the behaviour of a SPECTRUM train which was incorporated into the current timetable, four routes within different service areas, identified within D1.2 as areas of initial interest to the SPECTRUM concept have been modelled employing event based simulation. Each route allows the analysis of the SPECTRUM concept in a different context; route 1 was a national route in Central Europe, route 2 an international and has the potential to include intermodal transport, route 3 was international in Western Europe and route 4 is located between Turkey and the EU.

Given the following performance characteristics:

- A speed of at least 140km/h
- Length: 389 m
- Load: 960 tons
- Payload: 520 tons
- Electric Locomotive(s): German class 146.1

Table 1 demonstrates that it is possible to incorporate a number of SPECTRUM trains within the current freight and passenger timetables for each of the routes. Note that the routes were not comparable since the characteristics of each route differ greatly, along with the demand for LDHV goods.

Table 1: Output of simulation models

Route	Additional SPECTRUM trains incorporated per week	Speed km/h	% of LDHV demand possible to accommodate.
Daillens- Chur	11	140	10%
Hallsberg- Copenhagen	2	140	80%
Turin- Lyon	4	140	50%

Halkali- Kapikule	53	140	60%

By aiming to integrate freight and passenger services, the SPECTRUM concept introduced a new dimension to rail freight, requiring a change to current capacity management working practices. This will impact on the way in which infrastructure managers design timetables and operate trains whilst still adhering to EU regulations i.e. be fair and non discriminatory.

Although every infrastructure manager in the EU has to comply with the same legislation, there is still opportunity for different approaches to timetabling, this is influenced by the different contexts in which the various infrastructure managers operate. The report includes specific descriptions of capacity management from the perspective of three infrastructure managers; Network Rail, Trafikverket and TCDD.

Trafikverket's present planning process allows for fast, time sensitive intermodal freight services demanding on-time, accurate train dispatching. The valuation of goods would have to be modified, since the prioritization between trains, in the planning stage, is based on socio-economic calculations.

TCDD's present planning process is categorised by train type – freight and passenger. Within these categories data for vehicle speed and brake weight, infrastructure (gradient, curve etc.) and general rolling stock characteristics are used to produce timetable simulations.

Negotiations during the timetable development process at Network Rail typically take up to 16 months. These aim to most effectively allocate network capacity for passenger and freight traffic to the best economic benefit of the railway industry, without compromising the condition of the network infrastructure.

Conflicting path requests such as operators wanting to run their trains in the same timetable channel were identified. The mitigation of such conflicts generally means that the timetable designers seek to modify the conflicting requests by use of their experience, rule of thumb or through use of computing systems. If no solution can be found this may lead to a declaration of congestion for the concerned section according the EU directive 2001/14. Such a declaration means that the infrastructure must work out a capacity enhancement plan which details how the removal of the removal of the capacity constraint is to be managed. It seems that a SPECTRUM concept will lead to some questions on the construction of timetables and the agreement of priorities, as well as the way in which operational conflicts are handled.

For a SPECTRUM concept to reach its full potential i.e. capturing large portions of LDHV goods currently being transported by road transport, it is essential that capacity management and terminal operation practices are reviewed.

Quick handling at terminals, located close to the pre- and end haulage points with suitable affordable transshipment equipment for swift transfer of goods from trains to delivery vehicles are as important as the train itself. The train can be expected to enter terminals at any time during the day. This will contribute to a fuller utilization of terminal capacity.

The European rail freight market, as we know it, is characterised by a number of national markets and international market segments with different framework conditions. Market deregulation has not been fully accomplished in all European countries. Today´s rail transport systems consist of wagonload, block train, intermodal and other similar services.

In the previous chapter it was noted that the lack of access to terminals, particularly in and around urban areas presents a significant challenge and therefore barrier to intermodal transport.

There are lots of new systems for intermodal transport that aim at reducing the need for handling equipment, as well as time and cost for terminal handling. Transhipment can be made possible from any flat surface adjacent to the track. The allocation of the costs for these systems varies from those of transhipment systems using cranes or reach stackers.

The use of horizontal sideway transhipment and/or roll-on/roll-off systems provide even more opportunities to load or unload trains outside the existing intermodal rail terminal network. These solutions would only require flat surfaces next to the rails. Generally these solutions require more expensive rail wagons and depend on trucks.

From a logistical point of view, relying on trucks fitted with handling equipment is likely to require well organized collaboration between train and truck operating companies.

Of course, a new, modern and high performing train itself does not make a business case. Equally high performing capacity and terminal management must accompany the high performance vehicle with flexible and alternative routes for procurement of cargo to avoid empty running and an infrastructure that is robust and accessible. Capacity management, network routing, terminal handling and last mile shipments of LDHV goods must be managed in a service offering that provides the customer added value and on terms that are commercially viable for the forwarder.

Scheduling of timetables is an integrated part of developing a business model. Currently, lead-time for timetable development within rail freight is long, typically 1.5- 2 years from inception through negotiation to implementation. This is not in keeping with today’s commercial terms, where shipping contracts are negotiated, renegotiated and terminated continuously.

Crucially, the transportation of time sensitive LDHV goods by rail requires a new method of prioritisation; both in the planning process and in operational traffic management and the way in which conflicts are resolved. It is therefore necessary that the management and supporting technologies for timetabling and traffic management evolve simultaneously.

Engineering Design

The vehicle specification focussed on the following seven key aspects as shown in :

1. Lightweight body structure (to promote improved dynamic performance)

2. Running gear and vehicle dynamics (to meet improved dynamic and ride quality)

3. Electrical systems and coupling (to enable an on-board power convertor to supply power to reefers)

4. Condition Monitoring of both the vehicle components/systems and goods (for improved safety)

5. Appropriate cargo handling (for intermodal freight including micro swap bodies)

6. Appropriate propulsion/traction to meet the dynamic requirements of the train

7. Tracking &Tracing (for improved security and logistical efficiency)

Table 2: SPECTRUM Train Technical Specification

Design Element	Specification
1. Lightweight Structural Design	
Type of wagon	Flat wagon
Length (Loading gauge)	To meet ISO, Swap bodies, reefers (20', 40', 45')
Width (loading gauge)	ISO, Swap bodies, reefers (20', 40', 45')
Height (loading gauge)	Dependent on wheel size
Types of containers carried	ISO, Swap bodies, reefers (20', 40', 45')
Tare/load	Axle load 17t (indicative)
The train configuration	Fixed formation, articulated, eight wagons
Length of train set	104 ft fixed formation
Materials of main frame and major components	High strength steels; composites
Interoperability	Loading and track gauge
Type of container holding device (spigots vs twistlocks)	UIC Spigots
Couplings	Automatic coupler
Buffers	Not applicable
2. Running Gear and Vehicle Dynamics	
2.1 Dynamic Characteristics	
Ride quality	Limiting accelerations for goods needs to be stipulated
Braking performance	Deceleration: 0.7 m/s^2 Max operating gradient: 15‰ Sustained braking period: to be determined
Maximum speed	140 to 160 km/h
Maximum acceleration	0.5 m/s^2 Wheelset inertia: minimised Rolling resistance: minimised
Maximum deceleration	0.7 m/s^2 Wheelset inertia: minimised
Curve radii	Minimum radius: 150 m
Derailment resistance	Comply with EN 14363
Vehicle-track interaction	P2 force: minimised Ride force peak counting: minimised RFCs: minimised Tγ: minimised
2.2 Running Gear	
Type of bogie	Does not need to be stipulated now
Length	Dictated by other parameters
Width	Dictated by other parameters

Design Element	Specification
Height	Minimised. Dictated by wheel diameter, 9'6" container height, ContainerMover 300 height and loading gauge
Materials	Dictated by other parameters
Wheel diameter	Minimum: 760 mm, unless standards are challenged
Axle load	17 t (indicative)
Track Gauge	1435 mm
Loading Gauge	UIC GC (minimum)
2.3 Braking System	
Type of driver's brake valve	Dependent on the type of loco
Type of braking system	, According to UIC 543 and 546 for speeds not exceeding 160km/h
Specific characteristics	Requirement for EP system
3. Power Supply	
3.1 Electrical Systems	
Power convertors	• According to the UIC 552 code. • Digitally controlled (flexible) power converter to supply reefers with correct voltage/amperage.
Configuration	One convertor per wagon
Power generation for reefers	Directly from locomotive standard power
Reliability (availability) in terms of failure rate of the existing refrigerated containers	> 99%
Reefer characteristics (voltage, performance, capacity, nominal Amps, starting Amps, power needed to keep the temperature constant, etc…)	380V or 460V 3 phases 50Hz or 60Hz
General electrical system	According to: EN 50155 EN 61373 EN 50121-3-2 EN 50160 EN 50125 EN 50306 EN 50264 EN 60529
3.2 Electrical Couplings	
Type of connectors	EN 61984 EN 175301-801
Data transmission system (wifi, Internet) for insuring the on board communication between refrigerated containers for real time fleet monitoring?	Set according to Tracking and Tracing requirements (see point 7.)
4. Condition Monitoring	
4.1 Railway Vehicle	
Tri-axial accelerations	• Vertical acceleration limit for goods: 0.4 g • Lateral acceleration limit for goods: 0.4 g

Design Element	Specification
	• Longitudinal acceleration limit for goods: 1.0 g
Bearings/Axle boxes	According BS EN 15437-2
Braking System	Monitor degradation in braking performance and abnormal temperatures (both high and low) of braking system components (not a requirement)
Wheel wear and Structure	Monitor fatigue overload
Container presence detection	Detector located at the spigots
4.2 Goods	
Temperature control	Chilled and Frozen (EN 12830; Regulation 852/2004; to include chilled goods HACCP 850/2004)
Humidity	Module included where required.
Data logging system	Integrated with Tracking and Tracing System (see below)
5. Propulsion/Traction Characteristics	
Line classification (DC/AC)	AC Interoperable system
Provision for last mile	Small diesel electric engine
6. Freight Handling/Operational Characteristics	
Horizontal	
Vertical	
Combination	
7. Tracking and Tracing	
Type of communication system	Compatible with Bluetooth, Satellite, GPS, GPRS, CAN bus, RS-232
Design Type	Modular design (same equipment to cover refrigerated and non-refrigerated goods)
Reliability	> 99%
Compliance	Conform • EN 13486, Class 1 • 37/2005 as of 2.2.2005 • 852/2004 as of 1.1.2006 • HACCP Comply • EN 12830, Class 1 (specifications) • EN 13485 (regulation) • EN 13486 (regulation)

The unique features of the SPECTRUM train are described

Table 3: Unique SPECTRUM features

Feature	Comments
On board electrical supply of 3x400V to reefer containers via Power Converters	• Eliminates use of diesel gensets per reefer container

InnovaTrain Transhipment System	• No need for dedicated terminal (only a road siding) • Compatible for application of other transhipment techniques such as MetroCargo, reach stackers and portal cranes
Covers over 90% of LDHV goods	• Wagon structure optimised for low payload • Covers most LDHV goods loading units o 20'/40'/45' ISO containers o Swap bodies C745 and A1360 o Reefers o Micro swap bodies
Higher maximum speed	• Up to 160km/h
Mixed running with passenger trains	• Due to o Higher maximum speed o Improved acceleration and deceleration patterns o Improved ride quality o Shorter train set (<300m)
Running Gear and suspension for high speed and low noise application	• Optimised for 160km/h • Ride quality comparable to passenger trains • Modified braking system (applying disc brakes)
Tracking and tracing	• Improved security • Capability for logistics stakeholders to trace goods • Condition monitoring of vital

	components and systems
Wagon design	• New section profiles • Geometry and materials optimised for lightweighting • Incorporates the power converter and InnovaTrain transhipment adaptor frames.

Economic Evaluation

A central part of the work of the Consortium was devoted to the economic evaluation of the SPECTRUM concepts. Every time an investment decision has to be taken, one form or another of weighting costs against benefits is involved, and some form of calculation over time is needed to compare the former with the latter when they accrue in different years.

For this purpose the methodology adopted was based on the "Guide to cost-benefit analysis of investment projects" of the European Commission. Cost benefit analysis (CBA) is an essential tool for estimating the economic benefits of investment projects.

The objective of CBA was to identify and monetise (i.e. attach a monetary value to) all possible impacts in order to determine the project costs and benefits; the results are then aggregated (net benefits) and conclusions are drawn as to whether the project is desirable and worth implementing. Costs and benefits have been evaluated on an incremental basis, by considering the difference between the project scenario and an alternative scenario without the project (sensitivity analysis).

The level of analysis used in CBA must be defined with reference to the society in which the project has a relevant impact. In fact, Financial Analysis (FA) and Cost Benefit Analysis differ because the first one uses the "private" point of view of the subjects who run the project/operations (and/or make it feasible); whereas the cost-benefit analysis makes an evaluation from the perspective of the "public" point of view, in that it compares differential costs and benefits that are borne or taken by the community.

The analyses were based on a reliable business plan for the deployment of SPECTRUM service in three selected "service areas". The reference "universe" into which unit costs and revenues and unit benefits have been expanded included 3 service areas representative of the entire European Union. Those are the Scandinavian route (Hallsberg – Mjölby – Malmö –Köbenhavn), the Swiss route (Daillens- Chur) and the route between Italy and France (Lyon-Turin).

The SPECTRUM service is expected to increase the competitiveness of rail freight transport vs road, mainly via the increase of rail transport and handling performance, which in turn decreases the duration of logistic operations and door-to-door transport time. The impact of the increased competitiveness of rail through the deployment of SPECTRUM service is assessed as the impact of the service on modal shift from road to rail on the corridors concerned with the service areas. The modal shift has been assessed in a multi-variable scenario based of different assumptions of cost increase (due to the premium quality of SPECTRUM service compared to regular rail) and transit time (assumed to be lower for SPECTRUM).

As concerns the outcomes of the financial analysis, it can be underlined that the SPECTRUM service can boost the attractiveness of rail freight, increasing the modal split for rail, if the decrease in transit time is ensured, even if accompanied by a cost increase of 20-30% compared to regular rail services. Such a range of "premium tariff" is assumed to generate modal shift to SPECTRUM service, and proves to be sufficient to ensure the financial feasibility of the service in specific service areas, such as in the domestic intermodal transport, which characterises the "Service Area 1 - Switzerland" surveyed.

Since we cannot realistically assume a market tariff for SPECTRUM services, we approached the analysis so as to compare different levels of the unit tariff within a range which starts from the unit production costs. The sensitivity analysis records the variation of the FA outcomes depending on the various % increases applied to such benchmark tariff. **The most favourable scenario is in Service Area 2, characterised by low production costs, a higher rail traffic and where the SPECTRUM service could be activated with a significant frequency.** A break-even tariff of some 0.07 Euro/tonkm has been estimated (with some variation according to the specific service areas, while the average revenue in the freight transport sector in Europe can be assessed at around 0.045 Euro/tonkm for rail (and 0.116 Euro/tonkm for road).

In the same methodological framework, a CBA was carried out in order to investigate the viability of the SPECTRUM project from the public point of view, that is including non monetary and non market items in the analysis, such as shadow prices and external effects.

The CBA has covered several categories of impacts, that have been calculated for the three Service Areas.

The categories of impact covered by the CBA were the investment and operative costs for the implementation of SPECTRUM trains, the users surplus (difference between Generalised Logistic Costs borne by transport/logistics operators when using SPECTRUM service and GLC connected to "pre-shift" mode, i.e. road or traditional rail) and the differences in external costs generated by freight transport activities connected to the variations of the externalities (air pollution and climate change, noise, accidents, up- and down-stream processes, nature and landscape, biodiversity losses, soil and water pollution, congestion).

For analysing the impact on air pollution/climate change, noise and accidents, specific analysis were carried out in order to take into account the specific characteristics of the SPECTRUM service; for the other categories of externalities, the standard parameters of rail traffic were appropriate for calculating the impact of the SPECTRUM service.

Results of the CBAs made per Service Area show that the introduction of a SPECTRUM service in the market is positive for society and the transport users in Service Area 1 and 2, in terms of Net Present Value, that is the sum of the present values of incoming and outgoing cash flows over a certain period of time. In those rail freight transport environments and corridors, the high costs of investment are compensated by the benefits gained in a 30-year time horizon (2014-2044). In Service Area 3 (Italy-France) the SPECTRUM scenario implies a smaller amount of total costs for 11.1 million Euro. However, the overall benefits do not reach the same amount.

A further sensitivity analysis has involved the assumptions on the evolution of the cost of transport by road. The possible modification of unit tariffs of all road solutions have a considerable impact on the SPECTRUM traffic, which in terms of financial results do not modify the overall picture (since the decreases or increases involves not only revenues but also costs), whereas it greatly varies the public economic results. In fact, in the case of less SPECTRUM traffic, the benefits from the reduced externalities will not be sufficient to make up for the costs of implementing the new services; correspondingly, the CBA indicators would remarkably improve in the case of higher SPECTRUM traffic (deriving from an increase of road prices).

4.1.4 Potential Impact

The SPECTRUM project was a project that aimed to shif goods from road to rail. It was demonstrated that the project should have a great impact on certain markets, moving LHDV goods that are currently traveling by road around Europe.

Thanks to the new technological solutions adopted for the design of the SPECTRUM service, the most relevant impact coming from the implementation of the new service was related to the expected increase in the competitiveness of rail as compared to other modes of transport. The direct effect is an improvement of rail transport and handling performance, which in turn can be measured in terms of duration of logistic operations and door-to-door transport time.

The impact of the SPECTRUM train is then analysed by ’implementation scenarios’ of parameters and assumptions. The service potential is assessed as the impact of the service on modal split through modal shift. The resulting outcome is a prediction on the SPECTRUM train solution volumes and impact on the regional transport system and trade flows. These effects have been investigated as input for the assessment of modal shift generated resulting from the implementation of the solutions designed.

The basic principle of the evaluation model adopted was to compare a "baseline scenario", i.e. what would happen at a future year if the solutions designed are not implemented, against the "project/implementation scenario", i.e. what is expected to happen at that time if the SPECTRUM solutions are implemented and marketed.

According to the traffic estimations, the SPECTRUM service will attract a varying amount of goods from the existing road and rail services and will also generate new traffic, depending on the service area considered.

SPECTRUM directly addresses key elements of the 2011 White Paper on decarbonisation of transport. SPECTRUM work will support the development of attractive rail logistics solutions to encourage modal shift, as part of co-modal supply chains, from road and air to rail. We recommend that the EU focus on the development of co-modal solutions that explore non rail business, and encourage innovation in these fields since the potential for growth is far greater than in traditional and mature sectors such as timber or aggregates, and far less prone to become low price commodity business, as is the case in intermodal container traffic.

Traffic is becoming lighter and less dense. In SPECTRUM we analysed typical cargo weights and found that they are well below the previous axle loads. To that end we were able to lightweight the vehicles far more than previously. The EU needs to examine the call from the rail sector for heavier trains, and use the recent opportunities in mandatory weighing of all sea containers to research the actual weights of cargoes. We need to avoid a focus on a perceived nature of rail freight that is outdated.

SPECTRUM directly supports the development of an open competitive market in rail freight since it has identified the potential for higher added value and therefore more profitable business. This means that entrepreneurs are more likely to invest in businesses that have rail elements, developing competition and in the case of Central and Eastern Europe addressing the lack of capital available for rail freight developments noted in many reports.

Mixed running will yield great capacity gains on the rail network, and as such safe trains with operational envelopes similar to passenger trains need to be developed for mixed running.

The modal silos need to be removed from EU policy. It is noticeable that in SPECTRUM we found that a sectoral approach, especially one on the temperature controlled supply chains, rather than the rail/road/air/sea modes would have led to a more focused approach from point of origin to end user not just in operational logistics but also in technology design.

CONTACT DETAILS:

Project Coordinator: Mr Tom Zunder, tom.zunder@ncl.ac.uk +44(0) 191 208 3975

Web Address: www.spectrumrail.info