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CONTINUOUS RAILWAY SYSTEMS: AN INNOVATIVE APPROACH TO IMPROVE HIGH SPEED RAIL SUSTAINABILITY

Lara R. Brunello[1], Jonathan M. Bunker[2], Luis J. Ferreira[3]

ABSTRACT. The forgotten practice of detaching carriages from moving express trains still holds intriguing insights for today's railway industry. Travel time and energy savings with increased accessibility were only a few of the benefits of non-stopping trains with detachable coaches. The revival of the *continuous transport* concept could greatly improve the sustainability of more modern practices, such as high speed rail systems, thanks to technologies not available in the past. Nowadays in fact it would be possible to deploy innovative transport approaches that only few decades ago were inconceivable due to prevailing safety issues. This paper represents a first step in creating a framework for the appraisal of sustainable *Continuous Railway Systems*. A formative methodology for analysing the effectiveness of such an innovative concept is presented with particular consideration of the potential impacts on the economy, society and the environment. This paper also reviews operational methods and associated safe working issues of the docking between moving trains; moreover it shows the need for further theoretical and practical research in this new area of investigation to face the posed challenges.

INTRODUCTION

For about a century the practice of detaching carriages from moving express trains took place all through the United Kingdom, involving nearly all railway companies. It was also experimented in other countries, such as France and Holland; however it has been almost forgotten after only 50 years since its last service. Such practice represents an interesting model of applied continuous transport where trains circulated without stopping and meanwhile served stations along the line with detachable coaches. In this way it was possible to save travel time and engine miles while offering an accessible service.

[1] PhD Candidate, School of Urban Development, Queensland University of Technology, Brisbane, Australia, e-mail: l.brunello@qut.edu.au

[2] Senior Lecturer, School of Urban Development, Queensland University of Technology, Brisbane, Australia, e-mail: j.bunker@qut.edu.au

[3] Chair in Transport Efficiency, School of Urban Development, Queensland University of Technology, Brisbane, Australia, and transport advisor at the Queensland Transport Department of Main Roads, e-mail: l.ferreira@qut.edu.au

Today proposing the re-deployment of a similar practice might be possible thanks to technological advances in the railway industry that allow for command and control of trains in real time and other devices that support a feasible framework. However the evaluation of innovative transport approaches is critical in comparing between stated objectives and expected results. New technologies offer promises as well as risks and their effectiveness should be carefully addressed. This paper presents a developing research method to investigate continuous transport approaches as means to improve sustainability of rail transportation, and particularly of high speed systems. The study will highlight challenges for the development of research in this new transportation area and suggestions for further research.

The first section of this paper introduces the concept and applications of Continuous Railway Systems. This is followed by some insights on the technology available to move non-stop trains. The investigation then drifts on how Continuous Railway Systems could represent an innovative solution for high speed rail systems' apparent incongruence with sustainable mobility, addressing the accessibility, profitability and ecologic short-comings of conventional railways. The underlying hypotheses are that a sustainable transport system should serve efficiently not only major cities, but also smaller urban areas along interregional corridors, possibly integrating existing systems or infrastructure; save travel time and answer to the accessibility issue, allowing greater coverage area; carry both passengers and freight, allowing for new business opportunities and funding sources; expand rail networks to build a spine for future developments providing new transport choices and sustainable mobility means (Brunello, 2006).

CONTINUOUS TRANSPORT BACKGROUND

The need to improve the working of railways, tramways, and the like, has been in the mind of mankind since the first journey. Around the mid 19th century few experiments were conducted with the intent to expedite the service by running non-stop trains, so that the time taken to complete a journey could be reduced while a higher average speed could be maintained. The first documented detachable coach to slip from a running train took place in 1858 operated by the London, Brighton & South Coast Railway (LB&SCR). A working timetable carried the following special direction for those railway servants concerned in the operation (Fryer, 1997): 'On leaving London Bridge, the Brighton part of the train will be in front. Each part will have two guards and two tail lights, so that when detached at Haywards Heath each part will form a perfectly appointed train.'

At that time, the detachment consisted basically of uncoupling the rear part of the train and hand breaking the detached coach until reaching the intended platform. Once separated the *slip portion* could only be slowed down with no means to continue moving. In later years, some other provisions where added such as a guard compartment and slip gear at both ends of the detachable coach also allowing the practice on the return journey, without turntables; side corridors and vestibules were used to allow passengers to move into the detachable carriage just before the announced slipping; and the sound of bells or horns would be employed to prevent anyone on the platform from stepping behind the passing main train while the slip portion was still moving.

Before the out-break of World War I, the practice of slipping coaches from running trains reached its utmost both in England and in Ireland with more than 200 slips performed daily. In fact slipping was considered an economic means of saving engine kilometres and

LB&SCR in 1914 ran 12,000 fewer kilometres than would have been the case if an equal service had been supplied with no slips being made at all (Fryer, 1997).

Along with the detaching of coaches on the run, another idea arose to complete such practice. It was the idea of a *Continuous Transport System*, where not only it would have been possible to obviate the stopping in order to drop passengers or goods at various points on the route, but also to load them in the same manner, i.e. without stopping the main train. For almost a century and half, authors and inventors referred to improvements relating to methods of working and controlling non-stop trains with detachable and attachable coaches. Ideas were often at the limits of imagination, especially in the early days; suggestions and data multiplied with the passing of time, up to the point of repetition.

While in 1902 John Brown of Belfast, one of the first to patent the idea, describes the service as 'a through express provided from any one station to any other station along the route, the main portion of the train travelling continuously at a uniform rate and taking up and slipping the cars without slackening speed'. In 2006 the topic is still addressed by Chinese and Japanese authors as a system where a mother train continuously travels without stopping on a main line and a car float, also called child train, child wagon or slip wagon, is joined or separated during travelling (Cheng, 2006; Manabu et al., 2006).

Over a period of about 150 years, many different methods of operating Continuous Transport Systems have been proposed. In 1962 Leonard Barry of Detroit classified previous work identifying two major differences. He defined as a *wave train* a temporary configuration of self-driven carriages, which couple at the front of a moving train and progressively regress to the back until the last position is reached when ready to leave the train to perform a designated stop (Barry, 1962). The other operative system identified by Barry was the *rear end transfer* in which units of carriages (either self-driven or with a locomotive) that form a train connect from the back instead of the front and thus the transfer service of passengers and goods is provided through the tail of the train.

By the end of the 1970s new ways of operating a Continuous Transport System were invented, such as the *mid train transfer*, a selective extraction of carriages out of the train, and new fields of application were investigated, such as magnetic levitation, or even other transport modes. For example the combination of the non-stop movement with road traffic and the usage of vehicles designed to provide privacy for the passengers, brought trends toward the development of the Personal Rapid Transit (PRT) concept. In this case, small self-propelled vehicles are guided by rails, or other track system, even below the road surface, in tubes or over hanged, and their destination is determined by the passenger. Vehicles travel bumper to bumper at a generally high rate of speed and usually in a closed loop, but can be capable of self-steering, switching from the main track into secondary tracks to perform a selected stop. Quite ironically Francis-Cyrill Perrott (1995) defined with an international patent these vehicles, capable of selecting their own route, with the appellative CAR (Compact Automatic Railway).

According to some interpretations (TCRP, 2003) application of Continuous Transport Systems can be found nowadays only as cable hauled transit modes, where vehicles are either permanently attached to a rope or can attach and detach by means of a grip mechanism. Examples of ropeways include both surface and aerial transit modes, such as cable cars, funicular railways, cable-hauled automated people movers, aerial tramways, gondolas, ski lifts and funitels. All of these carriers can operate in a back-and-forth shuttle operation or can be part of a continuously circulating system. However if a Continuous Transport System is defined in simple terms as a system in which stops are not necessary to perform the transfer of a load, refuelling in mid-air and even docking in space between rockets can also be distinguished as such.

This paper attempts to revive the concept of Continuous Transport Systems, as highlighted above, in application to railways, also here called *Continuous Railway Systems*, and investigate feasibility issues and technological advances that might improve the sustainability of those rail systems concerning high speed.

TOWARD A TECHNOLOGY TO MOVE NON-STOP TRAINS

The practice of slipping carriages in the United Kingdom fell in disuse by 1960 for several reasons. A fundamental element, which contributed at reducing and eventually interrupting it, is certainly the increase of rail traffic with consequent strengthening of safety regulations. The detachment of carriages on the run was a procedure conducted at sight and signalling was made of coloured lamps and discs or sounds. Undoubtedly the human factor was crucial and thus worrisome; however automatic devices did not substitute human vigilance until recent years and yet not completely. The lack of technology that could precisely and surely state the position of slip portions while granting direct and continuous communication between stations, detached coaches and trains made it harder to ensure safe operations while managing increasing traffic. Therefore a decision had to be taken if reductions of line capacity, to ensure enough space between subsequent trains to allow safe detachment of slip portions, were worthier than time lost through stops; also considering that the introduction of electric locomotives had increased average speeds.

Hence it can be stated that the practice of slipping cars from running trains ceased mainly for lack of technological development rather than contingent factors. As such its revival could be beneficial if technological issues could be properly addressed. In this regard a review has been conducted within the scope of the present research to give an overview on the most recent findings, not only as infrastructure or rolling stock, but especially in the fields of train control and traffic management, that could allow for safe working of a Continuous Railway System (Brunello, 2007).

Advances made in the last decade for command and control of railway traffic and their pioneering applications in high speed rail systems offer great potential for further innovative exploitations. For example, methods to minimize distances between trains have been investigated as means to increase track utilization, but these methods seem to have greater potential and they are developed in more comprehensive studies to regulate network traffic. The ERTMS (European Railway Traffic Management System) project foresees the development of three application levels to reach an integrated control over the network thanks to radio based communications, moving block sections and real time data exchange. Also the recent proposals made by Alcatel (Uebel, 2006) and Alstom (Lacote et al., 2006) for combining wireless direct communication between successive trains with the supervision of regional centres, allow to control the separation distance on the specification of position and speed of relative trains and the condition of track on which they run. This can increase line capacity and train speeds, but implies a greater need for up-to-date monitoring and accurate measurement of all factors involved.

First of all, detection of train position needs great accuracy and the application of a global positioning system (GPS) could provide advantages over track side equipment in terms of precision with continuous, instead of intermittent, data exchange and thanks to absolute location, without relying on the recognition of such equipment identification. However GPS suffers specific drawbacks, such as instability and short range imprecision. To overcome this data degradation, the Railway Technical Research Institute (RTRI) has developed a method that selects alternative techniques for data correction upon the reception reliability index value. Results from running tests have demonstrated that, applying selectively GPS, tachometer generators and curvature collation, it is possible to prevent improper data reception and accumulated errors, with all detected positions within a range of 4 m (Sasaki, 2005).

Other techniques that might also be helpful to control the relative distance between successive trains and devices could be based on optical, electromagnetic or ultrasound sensors. Several of these methods have been developed for the Automatic Split-Combine (ASC) system in Shinkansen lines with the aim to provide for a collision avoidance system and an onboard back-up braking pattern. Also the Institut National de Recherche sur les Transports et leur Securite (INRETS) has designed a co-operative radar sensor using a transponder inside targets and based on a numerical correlation receiver with a very broad band, so that a train could approach the preceding one safely, especially in case of broken-down trains (Tatkeu et al., 2004). Notable is the fact that this project was initiated to explore new possibilities for development of automatic guided transport modes, such as *people-movers*. These fall within the classification of PRT, which is to be considered a branch of Continuous Transport Systems. Therefore it could be said that research has already been conducted on the control of approaching trains that are about to connect in motion. However, existing protocols work for speeds up to 30 km/h even without a shunter's help; so, to foresee connection during motion at cruise speed, a number of other considerations need to be addressed in future research.

A further reflection, which can be briefly dealt with here, regards infrastructure. In the literature, the main problem addressed concerning continuous transport has been the route choice of vehicles that form the aggregation of the train. As known in railways, route choice has always been performed by moving switches on tracks. They are very long and thus heavy, especially if used in high-speed lines, and it takes time to move them. Nowadays switches are mechanically sophisticated and expensive; they can be remotely controlled and require careful maintenance and heating in cold conditions; furthermore they might cause derailment or collision if wrongly set. However, using switches becomes critical in Continuous Railway Systems, where spacing between vehicles might be shorter than usual and where route choice might depend on each different vehicle passing over switches in close succession. Before coupling, these vehicles in fact need to enter the same line of the main train, and soon after uncoupling they need to divert into secondary branches to perform stops.

Several authors have suggested overcoming the problem of switching by introducing the concept of having active trains and passive track. Instead of trains passively passing over switches with no control, they proposed complex self-steering cars capable of selecting their own routes, such as those suggested for PRT systems. Other authors think that having two sets of interchangeable wheels might be more economical than steering wheels and among them Stahn Uwe (2003) proposes an interesting solution. His method consists of fixed turning points where normal track is doubled on the outside of the branching line by a higher piece of rail. Vehicles intentioned to turn will pull down the extra set of flanged wheels that will drag them onto the branch line. These methods are not universally valid, nor has their effectiveness been experimented, but they show that having passive track might be possible. For example, it could be evaluated if it might be feasible to use dual-gauge track for the operation of Continuous Railway Systems. In fact, a network, where the main train runs on a *broader* gauge track and chasing trains on *narrower* gauge lines, allows for connection between the two types of trains on dual-gauge sections with the advantage of no moving parts. In this case, broader and narrower are only indicative since one of them could stand for the standard gauge and the other one be smaller or larger. The point made here is simply to suggest alternatives to solve the infrastructure conundrum to move non-stop trains. Of course there are several issues to be considered and especially safety risks arise from this passive infrastructure, which should be carefully tackled and often re-conducible to traffic management systems.

Figure 1. Hypothetical passive switch bifurcation of gauges.

The next section considers few other possible and interesting clarifications regarding issues both of technological as well as environmental, social and economic nature.

DOCKING, THE THIRD DIMENSION OF RAIL SUSTAINABILITY

Returning to consider the slipping practice, it is noted that changes in demand led to discontinue service in some places, while in others it became necessary to stop the whole train to serve boarding passengers. To obviate to such inconvenience, the idea of attachable wagons to running trains arose with many suggestions, but the lack of appropriate technology never made it possible. As seen in the previous section, nowadays we would have the means to allow for safe working of a Continuous Railway System, however the question to be posed is 'what would be the rationale for such a practice?' and the answer is linked to sustainability.

In today's economy and society, impacts of transportation systems, such as congestion, accidents, pollution, energy consumption and dispersed land use patterns, are shaking the fragile equilibrium between economic growth, social development and the environment. Thus most governments are keen to address sustainable transport and achieve efficient and safe transport, in the best possible social and environmental circumstances. In this perspective, the current research focus is to investigate possible improvements to enhance rail transportation and especially fill the gap that prevents high speed rail systems to be regarded as fully supportive of sustainability. Such a gap is mainly due to poor accessibility, which is instead to be recovered, being one of the pillars for sustainable mobility and thus essential in foreseeable future transport systems. Another gap is the difficulty encountered by high speed rail systems to be self-funding. With high costs of construction and maintenance, often the public sector withdraws its investments support, while the private sector would have great interest if high speed rail systems were better designed for freight services, where there is more profit to be made (Brunello et al., 2006).

Therefore sustainability has more than one dimension. The concept is certainly related to the natural environment and thus forming the very ground for the sustenance of human life, but also it spans to economic development and social growth, including equity and justice. In this sense accessibility represents a vital indicator of sustainability, being a key element for the economic functioning of societies and their quality of life, allowing for opportunities and uncapping market potentials. Especially in an era of mounting globalisation industries face shifts in networking economic geography and need to adapt to new business models to satisfy informed stakeholders worldwide. Thus sustainability is related to competitiveness where social responsibility and ethical behaviour move along with the ability to generate funds for new investment. Hence advances in technology help bring about that breakthrough that allows the industry to progress beyond the bounds of system optimisation and support strategic development which eventually leads to sustainability.

Considering competitiveness from a perspective of degrees-of-freedom-of-movement, railways, as guided surface transport with only a single degree of freedom, need to compensate their impaired mobility with the advantages derived from the exploitation of their core strengths. Railways have in fact the potential to support heavy axle loads, to drive vehicles at high speeds and to scale capacity as required. These specific capabilities if conveniently implemented yield market spaces against competing transport modes. According to Dr Dave van der Meulen, by cross-relating these capabilities it is possible to reveal strengths and weaknesses of railway markets. He has predicted in fact that, after the emergence of high speed intercity passenger trains in the 1960's and heavy haul in the 1970's, the third mainline of the railway renaissance is carried by intermodal services with high axle loads and high speeds (van der Meulen, 2006).

Intermodal express services might be the answer to substantially improve the sustainability of freight transportation, working on an integrated approach where roads, railways, ports and airports come together to expand markets as well as provide for new business opportunities. The potential in fact exists for new approaches to intermodal operations, incorporating both high axle loads, such as double-stack container trains, and dedicated high-speed rail lines. Thanks to the favourable combination of high speed and high axle loads, express intermodal could lead towards innovation in infrastructure and car design producing new outcomes. It is expected in fact that with the application of advanced technologies in railways, the introduction of new concepts will enhance transport sustainability (Brunello et al., 2008).

The third rail specific technology to adjust capacity as required is the capability of linking vehicles by coupling. Thanks to automatic devices, trains can be quickly composed in shunting yards or joined at stations. In this way train length is managed according to needs; however line capacity influences circulation the most and it can be best improved owing to traffic management systems.

As seen in the previous section, methods are available to regulate network traffic by minimising distances between trains and thus as a means to increase track utilisation. The highest level of development of ERTMS foresees for its future applications the deployment of moving block sections, in which the safe spacing between trains is controlled and regulated upon real time exchange of data. Within this context it is possible to anticipate how the shrinking of block sections could potentially boost capacity to the extent of allowing trains to join in motion. Besides all possible considerations on communication techniques and their reliability, likelihood of such an event taking place derives mainly by the development of rail docking.

While coupling indicates merely the connecting devices to join carriages, docking stands for the whole operation of coupling, implying also the necessity of a wider contact between the vehicles to allow for a through passage. Moreover the first does not provide any particular reference to the speed at which all the operation could take place, while the second gives a hint on a possible movement between the joining vehicles. Thus *docking* is assumed as the term to name the technology that grants seamless attaching of carriages to moving trains. Said this, it is important now to link docking with its capability to leverage rail market spaces and bring about that renovating breakthrough which is expected to open not-thought-before opportunities.

The following figure clearly represents the above exposed concepts. The latent idea on the necessity of a third dimensional element, capable of mediating the conflict between loads and speeds, finds expression in the cross-relation of axle loads versus speed, where the difference is made by docking.

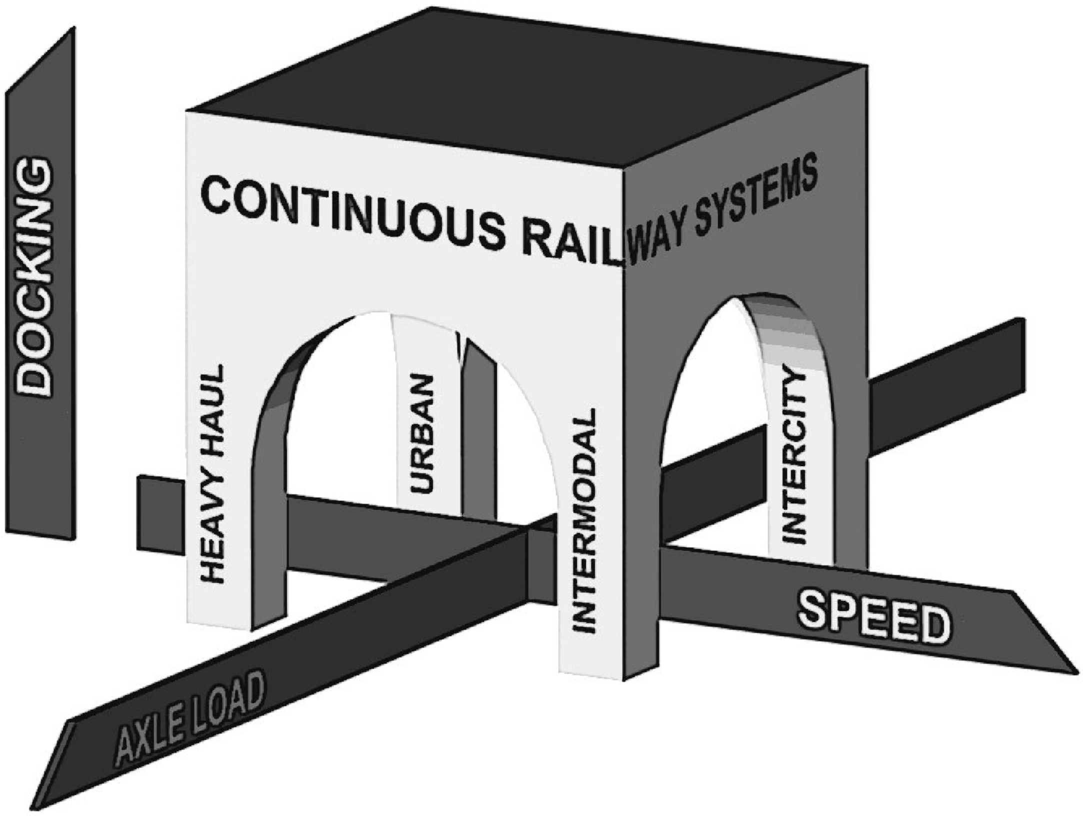

Figure 2. Docking as a means to leverage and integrate rail market spaces.

Increasing operating speeds would decrease travel times, however the marginally decreasing travel times might not justify at some point the increased costs associated with higher speeds. Thus docking influences travel times without further increasing speeds. It consents in fact to save time without stopping the main train to transfer passengers and goods and it enhances line capacity thanks to continuously running main trains at not excessively high, but constant speed.

Swelling of capacity is noticeable in the above figure as the docking operation increases with larger portions of the legs, representing four major rail market spaces (*heavy haul*, *express intermodal*, *inter-city passenger* and *urban rail*). Continuous Railway Systems sit on top of these, where capacity has reached its highest levels and docking grants smooth attaching and detaching of coaches between moving trains. Integration of rail spaces would be realised through the interoperable combination of local systems with network systems. This to say that every part of the system working in collaboration to transfer loads through the network smoothly cooperates to provide a joint global and local service. The outcome could be a combined service of harmonised operations where trains can split and join thanks to specialised infrastructure and interconnections, as reviewed in the previous section.

In addition, having dedicated infrastructure with clear separation between passengers and freight allows for great capacity thanks to homogeneous speeds; however in less heavy trafficked routes mixed traffic is chosen as the only possible alternative, balancing line capacity and costs. In these situations it might be especially convenient to merge passenger and freight services in one continuous system, where vehicles could be designed for both services. This new interpretation of 'shared use', usually strictly confined to infrastructure overran by different types of trains, would instead permit transportation on the same train of passengers and containerised, or palletised, goods. As example of mixed service, an experiment was conducted between Amsterdam Airport Schiphol and Milan in 2000 that triggered haulers' interest for its potential benefits. It only lasted a little more than one year due to lack of appropriate wagons and equipment to offer combined services, such as difficulty in sharing spaces, relocation of transhipment and bureaucratic hurdles, however it underlined the benefit of carrying freight on passenger trains to take advantage of high speed and high frequency to cut delivery times (van Ham et al, 2002).

Railways thus need to invest in innovation if they are to be economically sustainable and bring about that breakthrough to position themselves for significant growth both as intermodal express services on high speed rail lines, where high-capacity high-value freight would be the utmost expression, and as passenger carriers, fulfilling effectively to social and environmental responsibility. Speculations are also open for new business opportunities and public private partnerships within a context of changing logistics industry, where progressive railways will face global challenges.

EXPERT BASED EVALUATION

To support future decision making, research is necessary to evaluate new transport systems under a sustainability framework and assess their capability of integrating transport and land use toward sustainable development. The formative methodology presented here intends to pose the roots for the appraisal of Continuous Railway Systems as a transport alternative to improve high speed rail sustainability. In this sense, new evaluative tools are necessary to consider wider ranges of benefits and impacts arising from the innovative technology of docking.

Continuous Railway Systems call for a strategic change in the planning policies. As such, they need to develop an auto-evaluation process that unfolds from the programming stages involving stakeholders with practices of negotiation and social inclusion. In this logic, evaluation becomes part of shaping the project itself, revealing its function of learning as a process of knowledge gained through continuous adjustments in the balance of means and resources. This theoretical methodological perspective redefines the objectives of the strategic evaluation integrating predictive methodologies (forecasting methods) with the concept of process (scenario construction), reinforcing the link and interaction between evaluation and planning.

The objective of vision and scenario construction is in fact the result of a process of evaluation and multi-sector decision, becoming the framework on which the different parties can define and build new developmental horizons (Banister et al., 2005). As per the research project, the introduction of innovative policies calls for an evaluation process that is based on the definition of the evaluation criteria, on the construction of a co-shared scenario and on the analysis of development perspective. The starting point of the process is constituted by an interaction across varied but relevant skill sets achieved through a *backcasting Delphi technique* (Nelson et al., 1999). Traditionally the Delphi method has been used in making forecasts of the future through iterative questionnaires and feedbacks with expert respondents. Backcasting, on the other hand, makes judgements about the steps needed to reach a desired future scenario. Together they work backwards to determine the feasibility of the proposal, and then assess necessary policies and other inputs that will produce the desired outcome or a set of potentially feasible alternative solutions on which experts have agreed.

A simplified technique will be adopted to conduct the present research, deriving from recent experiences where the Delphi method has been applied for the ex-post evaluation of Dutch compact urban development (Geurs, 2006). In that case participants received general information about the project beforehand and discussed the scenario during a one-day workshop. Follow-ups consisted in translating scenario narratives in quantitative terms sent back to experts for revision. In this case, drawing from Linstone and Turoff (2002), who advise that a technical study would be best served by a small panel of luminaries, a careful selection of experts will be first conducted to gather a multi-disciplinary advisory group. Secondly, informed about the project, they will be individually interviewed to discuss possible alternatives, instruments and impacts. Lastly their contributions will be incorporated into the final scenario to obtain the evaluated version of the research project.

Continuous Railway Systems might support a vision of future scenarios made of massive sequences of transit oriented developments, where the railway network would be the principal fibre to uphold economic growth, social progress and environmental preservation. Foreseen scenarios will have to be investigated through critical thinking to construct the desired final scenario, which will then be analysed to determine possible instruments to bring about the favoured changes. In the same manner, the estimation of potential demand cannot be forecasted through the analysis of existing trends, but it needs to be addressed considering the benefits of improved accessibility, expanded from a local to an interregional level, servicing as many communities along the way as possible, and valuing option benefits, not only for travel, as it has already been investigated in the literature (Geurs et al., 2004), but also for freight, which is still to be made known. The gap in this lies on the fact that all efforts have been directed toward residents' evaluation of public transport services while the concept of option value is applicable also to car ownership and freight facilities (UK DfT, 2004) and eventually to any transport infrastructure.

CONCLUSIONS

This paper has presented the concept of continuous transport especially in its application to railways as an alternative operation to avoid the stopping of a whole train at stations. The practice of slipping coaches from running trains took place in scheduled service for 102 years in the United Kingdom. The objectives were to increase the mean speed of transport and the capacity of the line, while reducing travel times and enabling shorter platforms to suffice. A proper Continuous Railway System, where coaches attach and detach from running trains, however was never deployed, even though several proposals and different methods were suggested. The principal reasons for this might be that the issue of safety in performing the connections between moving trains is still to be properly addressed and that there is a strong need for adequate evaluation of innovative technologies and systems.

To be sustainable in the long term, railways need to invest in innovation, but to take such decisions, evaluation of benefits and impacts of these innovative technologies need to be carried out using new perspectives and methods. Deriving from the backcasting Delphi technique, the expert advisory group approach, selected within an international context and for excellence of expertise, might form a flexible and valuable tool for the construction of favoured scenarios and the analysis of impacts to assess effectiveness in the present research project. The importance of such evaluation needs to be highlighted for the advantage of building a co-shared scenario. It will yield innovation with practical results and plausible future implications. It is a concrete approach to determine realistic changes and their influences, especially in a context where railways could provide a reliable and high quality service within a reasonable timeframe, while other modes are becoming overwhelmed with congestion, safety and air quality concerns. Given the severity of road transport impacts, the need for innovative solutions is not limited to instruments that could drive a modal shift toward more sustainable modes of transport. It is important that new transport projects will be accompanied by a series of supportive policies evaluated for their long term impacts, thus within a sustainable framework.

In this sense this paper represents a milestone in initiating a research process into a field of developing technology that could greatly improve the sustainability of railways, starting from high speed systems to the whole integration of rail market spaces. Continuous Railway Systems could mix freight and passengers services, local and interregional hauling, and boost line capacity. Accompanied by environmental responsibility, Continuous Railway Systems could also support strategic development, where accessibility is upheld as a social and economic virtue.

To draw attention to this new ground of transportation, the current research has reviewed methods of safe–working for the operation of docking, which is the essential technological innovation for rail sustainability allowing connection between moving trains. The paper has examined correlated technologies for minimising distances between trains with an increasing need for accuracy in monitoring and measuring involved factors, studying the architecture of new traffic managements systems and suggesting possible direction of investigation in the design of infrastructure and rolling stock.

The present paper has touched these gaps in the attempt to give an input to further investigations and discussions over a transport area, which seems to be promising on one hand, while on the other it almost sounds implausible to the point of being abandoned and forgotten.

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