High-Speed Rail Development Programme 2008/9

Principal Consultant

Final Report for Workstream 1

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SYSTRA

mvaconsultancy

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1 Background

1.1 Introduction

The Principal Consultant is required to develop a strategy for a UK high-speed rail network in five stages, with a formal report to be issued after each.

- Workstream 1 – Determine the starting point for the study by evaluating relevant work already completed elsewhere, including an open call for further relevant material;
- Workstream 2 – Determine the strategic choices to be made in defining the high-speed network using the principal categories such as national and local policy, target markets and technical considerations, in consultation with various stakeholders;
- Workstream 3 – Create and document assessment and appraisal methodologies through development of a strategic business case model, incorporating a ridership forecast model which can later be applied to route and network options; identify, at strategic level, the full economic benefits, assess capital costs, evaluate environmental impact, evaluate CO2 emissions; use these models to generate performance indicators for options;
- Workstream 4 – Evaluate corridor options by application of tools developed in Workstream 3, building on previous studies and identifying key constraints, to produce status reports and route development reports.
- Workstream 5 – Using output from all other Workstreams, define an overall network development strategy, including a preferred long-term network specification; phasing; the overall case for the national network based on benefits delivered; and the level of investment.

1.2 Objectives for Workstream 1

Many individuals and organisations have undertaken work into the feasibility and viability of a high-speed rail network for the UK, so before proceeding with our study, we have reviewed previously published work.

Our study will include an assessment of strategic choices, development of corridor designs for the network and building a model for forecasting and appraisal of likely benefits. It is therefore important that we first assess the relevant earlier work, with a particular view to the following objectives:

- To avoid replicating work that has already been done
- To identify relevant reference material
- To determine whether any changes are required to our current work programme in the light of previous work
- To identify strengths and weaknesses in previous work, and hence areas where we consider that we can move the high-speed rail debate forward by addressing specific gaps or weaknesses
- To ensure that we are familiar with arguments and cases that have previously been made, so that we understand how our future conclusions support or contradict previous studies

- To secure a common level of understanding of the body of work on high-speed rail for Greengauge 21, the Steering Group and the SYSTRA-MVA project team.

1.3 The Atkins Report

The most comprehensive study undertaken to date is the Atkins report. Atkins was commissioned by the Strategic Rail Authority (SRA) to carry out a High-Speed Line (HSL) feasibility study to establish whether there is a transport and business case for constructing a new HSL in the UK from London to the North. This study took place between August 2001 and February 2003. The output from this extensive study consists of 15 "Milestone" Reports and an executive summary report, and we make frequent reference to these reports in this document.

In all that follows, each Milestone report is referred to as e.g. *Atkins 4* for the Milestone Report 4.

An update to the Atkins Report, *Because Transport Matters*, was published in March 2007. This report is referenced separately under its own title.

1.4 Other Review Work Undertaken

As described in our Inception Report, we have reviewed various sources for previous work in addition to the Atkins study:

- Documents available publicly on the internet
- Previous studies carried out by SYSTRA-MVA
- Documents from various sources in the possession of Greengauge 21
- Documents in the possession of stakeholders interviewed as part of the Consultation process
- Documents received in response to a general call for material placed in Modern Railways and New Civil Engineer

We have interviewed or contacted the following individuals or organisations in order to obtain a better technical appreciation of the work that they have undertaken. Interview notes are provided as an Appendix.

- Arup, to discuss their proposal for an extension of HS1 to Heathrow and creation of the "Heathrow Hub"
- Jeremy Candfield, [Director of RIA and formerly Communications Director of CTRL]
- Colin Elliff, to review his study for 2M Group, entitled '*Joining-up Britain – High-Speed North'* and more recent developments of it
- Nigel Standing, Balfour Beatty, to discuss his work on access to Heathrow
- Richard Davies of ATOC, to discuss their work on carbon emissions
- Sanjay Jamuar of Network Rail, to discuss whether and how our respective studies overlap and if there are synergies (eg sharing of data/ analysis)
- Paul Watkiss, [consultant], formerly of AEA, to discuss his work on carbon emissions
- Seth Williams at Eurostar, to discuss their work on carbon emissions

1.5 Future Review Work

Because of the time lapse between issuing calls for further relevant material and getting a response, the duration of the Consultation process, and the time needed for arranging meetings, we may continue to receive further material after the sign-off of this report. We therefore propose to maintain the Workstream 1 report as a 'living document', and to issue an updated version should any items of particular importance become available after its issue. This is in accordance with the process for managing the risk relating to the timing of the calls for papers documented in the risk register.

1.6 Bibliography

A full bibliography of the reports and documents reviewed is contained in Appendix A, and this bibliography is fully referenced within the text.

We make frequent reference to various documents which SYSTRA has produced, which catalogue the characteristics of existing high speed line systems. These provide a valuable overview of the status of various aspects of high-sped rail worldwide, and were produced as part of feasibility studies for high-speed rail projects.

Topics covered in these documents include assumptions used to make cost estimates, different types of high-speed rolling stock, a summary of European high-speed rail projects, examples of phasing in completed and current high-speed rail projects, and various technical descriptions and specifications of high-speed rail. These documents also consider a methodology to determine phasing, some relevant considerations on operation and infrastructure costs, and socio-economic benefits of HSR projects.

2 Objectives and Context

2.1 Introduction

We recognised from the start of the Greengauge 21 High-speed Rail Development Programme that before developing a network of high-speed rail lines, it was essential to know what type of network we are trying to define and to be clear of the transport objectives. During this study, it will be primarily during Workstream 2 that these objectives are defined.

Here we set out what objectives have been defined in the context of previous studies (for those limited number of cases where the objectives of the network are actually stated).

2.2 Objectives for HSR

Many papers reviewed refer to objectives of high-speed rail, whether directly or implicitly through the benefits which they cite in support of it.

Northern Way North-South Connections (*Steer Davies Gleave (SDG), August 2007* [43] starts by discussing both government policy, as stated in the White Paper [**20**] and the Eddington Report [**23**], and the objectives of the Northern Way (defined group of Regional Development Agencies).

The Eddington Report itself details how improvements in transport infrastructure, including but not limited to implementation of high-speed rail, will result in increased GDP. It also outlines how micro-economic drivers such as innovation, agglomeration, labour markets, competition, and globally mobile activities can be affected by improvements in the country's transport infrastructure. Particular points which Eddington makes include:

- On page 4 he argues that better transportation links reduce the impact of a structural economy change from manufacturing to service by providing a better commuter network for those whose employment moves to the city
- He provides case studies to argue how transport affects the economy taking different factors (management of network, maturity of economy, transport requirements, global geography, etc) into account (pp 19-40)
- He identifies which factors of transport improvement affect the performance of the economy (pp 3-18)

The Greengauge 21 Manifesto [29] and *HS2 Report* [27] describe how high-speed rail can be effective in delivering regional economic regeneration, tackling congestion on the existing road and rail networks, relieving pressure on slots at major airports by providing alternative connections, and tackling climate change by encouraging transfer to a more carbon-efficient mode of transport.

The experience of appraising the route options for the CTRL was that improved journey times did not in themselves justify the line, and that the argument was made instead around increased capacity (*Interview with Jeremy Candfield, Appendix B).*

Finally, the *Conservative Party presentation to the National Rail Forum* [60] presents as objectives national and regional economic regeneration, provision of extra commuter capacity, and provision of environmentally friendly transport.

Taken together, these reports demonstrate a significant level of commonality of objectives:

- Regional economic regeneration by providing reduced journey times, to London in particular
- Release of capacity on the existing rail network, particularly commuter capacity into major cities
- Transfer of traffic from road to rail, easing congestion on the road network and reducing carbon emissions
- Transfer of domestic air traffic to rail, releasing slots at major airports and reducing carbon emissions
- Providing direct rail links to Europe via HS1

2.3 Context of a High-Speed Network

Government policy sets context for any major infrastructure development. Policy relevant to high-speed rail development is summarised in *Eddington* [23], *Stern* [44] and *TaSTS* [22]. Scottish Government policy is summarised in *Scotland's National Transport Strategy* [39], while Welsh Assembly policy is summarised in *The Wales Transport Strategy* [62]. Government policy and its impact on high-speed rail development is considered in detail during Workstream 2.

Atkins 7 [**8**], Chapters 2 and 3 provide useful input into the context in which arguments for a high-speed network are being made, specifically this report contains useful data related to the travel demand:

- Mode shares by trip length (para 2.3)
- Mode share for key city pairs (para 3.8)
- Exogenous demand growth by mode (para 3.52)
- Highway speeds, including expected changes (para 3.66)

In their paper *High-Speed Rail: International Comparisons* for the Committee for Integrated Transport [41], Steer Davis Gleave analyse the conditions for high-speed rail to be competitive and review different countries' positions in relation to these conditions. As well as providing valuable background information and data in chapter 3 of the report, they conclude that:

- High-speed rail provides time benefits for journeys between 200km and 800km, and benefits are greatest for journeys of between 300km and 550 km.
- The distribution of populations in Britain along corridors are conducive to high-speed rail development.
- In Britain the benefits of providing extra capacity would be at least as important as those from improving journey times.

3 Network Construction

3.1 Routes Considered

Atkins proposed 16 options for the UK linking London to the North, which were identified by the following factors:

- **A combination of possible paths** Atkins identified 12 sections as candidates to be a part of the HSL network as described in the report *Atkins 4* [6](pages 3-4 to 3-31). Options were defined as combinations of these sections.
- **Considerations of route constraints** In order to take into account terrain, environmental, and population factors the method of the "least-cost path" was used. The method is described in *Atkins 3* [5], pages 3-9, and a description of route constraints is given in *Atkins 4* [6] (pages 2-2 to 2-5).
- **Consideration of various types of routes (reserved/non-reserved tracks, types of HSL and various lengths)** The concepts for designing these various types of routes are presented in *Atkins 3* [5], pages 3-3 to 3-8.

The options for the final network are presented in *Atkins 4* [6] pages 2-10 to 2-27 (a concise description is also available in the executive summary of *Atkins 4*).

The major findings of the cost-benefit analysis of the different route options considered are the following:

- Long routes that serve Scotland directly can yield very high net benefits, though their capital costs are very high.
- A two-trunk network (that is with one westerly line that goes from London to Birmingham and Liverpool/Manchester, and one eastern line that goes from London via Nottingham to Leeds) performs better than a network that has a common trunk between London and Birmingham (but that branches off).
- The economic gains related to building only one trunk (easterly or westerly, as described above) depend on the degree to which the ECML is upgraded. In the case of the less extensive ECML 1c upgrade an easterly trunk would perform better in terms of net benefits than a westerly trunk. In the case of the more extensive ECML 2+ upgrade, a westerly trunk would perform better. Current plans are for a less extensive infrastructure upgrade on the ECML, but with improved timetabling resulting in additional train paths. Network Rail believe that six Intercity paths (plus one freight) can be found with the current infrastructure.

High-speed line costs for three particular options were estimated later in the study. These included capital costs as well as operating and maintenance costs. The analysis is presented in *Atkins 8* [9] pages 4-1 to 4-3. The costs for the other options were also assessed and are presented in *Atkins 8* Appendix A.

This analysis indicates that the economic profitability of high-speed rail depends particularly on significant reductions in journey times (as well as the offer of a premium service), indicating that travel time should be a major priority in the choice of high-speed rail routes.

Other route options which have been put forward include:

- A single four-track route to the North proposed by Colin Elliff. This is described in the document *Joining Up Britain – High Speed North* [25], produced for the 2M Group of London councils opposed

to a 3rd runway at Heathrow. This proposal was discussed at greater length in an interview with Colin. His belief is that a double-track line could operate 15 trains per hour, and his scheme would allow the principal population centres in the UK to all be joined more cheaply and with less line construction time than would be the case with the two corridors proposed in the current study. A write-up on the interview is contained in Appendix B.

- Arup, in *Heathrow Hub* [3], have proposed a rail hub at Heathrow, connected to HS1 and Euston as the centre of a national high-speed network. We are arranging for Michel Leboeuf to meet with Colin Bostock of Arup to understand their proposals in greater detail.
- Virgin Rail Group, in *The 2020 Vision for the East Coast Main Line* [61], outline a vision for upgrading the ECML to operate at up to 205 mph. This scheme was put forward as part of a franchise bid, and was developed by a group of consultants on behalf of Virgin Rail comprising Steer Davies Gleave, Bechtel, ERM and AEA. The document itself is a leaflet which describes the vision, but does not develop or justify the idea in any detail.

3.2 Overview of High Speed Rail

Although also covered in *Atkins,* the reports written by Systra are a useful definitive source of information giving an overview of high-speed rail lines and systems now in use or under construction around the world. The points made in these documents are various and detailed, and it is intended that they will form an information source during Workstream 4.

This information includes:

- Specifications of high-speed rail in Europe
- List of standard and reference documents and organisations
- Tables comparing high-speed rail in different European countries
- Transport policy of the European Union ([51]pp. 11-13, 45-48)
- Descriptions of completed and in-progress high speed rail projects
    - French lines and projects
    - European projects: Germany, Spain, Italy, Belgium, Great Britain and The Netherlands
    - World-wide projects: Japan's Shinkansen system, Korean Train eXpress (KTX), Taiwan ([53] pp. 49-68)e
- Guiding design principles behind the design of the French high-speed rail system ([53] pp. 38-39, 53-61):
    - Compatibility with the existing rail network
    - New lines and technology specific to passenger traffic
    - High-speed services and reduced travel times, with high frequencies and direct service
    - Use of existing stations, instead of constructing new stations specifically for high-speed lines

3.3 Stations: Integration of High-Speed Rail with other Transport Modes

Two related issues must be addressed when designing high-speed rail stations:

- Should the stations be part of previously existing rail stations, or should they be totally new constructions?
- Should the stations be built in city centres or on the outskirts?

Clearly, the answers to these questions have a profound impact on the "intermodality" of the new high-speed rail lines; that is their successful integration with other transport modes. A well-integrated high-speed rail system (one that is highly intermodal) makes it easy for passengers to make transfers between high-speed lines and other transport modes.

Lloyds Register Rail report into the approaches to city centres [32] makes a valuable contribution to the assessment of the infrastructure needed to bring high-speed rail services to a number of city centres, by using existing transport corridors, classic rail networks and redundant assets.

The issues related to the placement of high-speed rail stations are further well discussed in the following documents:

- *History* [51] pp. 111-118: "Appendix 5 – Station Location Alternatives"
- *Technical Specifications* [53] *pp. 15-16, 39*
- *Equipements et Systèmes Ferroviaires* [56], pp. 11, 35-38
- *Atkins 4* [6], pp. 4-1 to 4-15
- *Etude Socio-économique du Premier Tronçon LGV Kénitra* [47], pp 33-44

The document written by SYSTRA on the technical specifications of high speed rail lines addresses the ease of connections and the operational compatibility between the high speed network and the existing rail network, including the relationship with regional transportation ([53] pp. 81-82). This document also touches on such items as express lines versus lines with multiple stops, as well as the choice of branching points ([53] pp. 54-55).

Atkins 9 explicitly links the choice of station location with intermodality, coming to the conclusion that integration with classic rail is a high-priority item ([10] pp. 2-19, 2-20, 7-2). Indeed, as outlined by Jeremy Candfield during his interview (*Interview with Jeremy Candfield, Appendix B)*, decisions taken on where to make connections to the existing network were one of the key determinants of the route of HS1 (CTRL)

The report on a high-speed rail connection at Amiens *Pré-études fonctionnelles LGV Paris-Londres, les enjeux d'une desserte TGV pour Amiens* [55] considers the effects that a high-speed line station can have on a city, based on French examples ([55] pp. 40-50). On pages 54 to 59, various scenarios for the location of the high speed train station in Amiens are compared and analysed, taking into consideration, among other things, the economic implications of each scenario.

3.4 High-Speed Technology: Infrastructure

This section is an attempt to draw together the more useful resources relating to high-speed rail infrastructure, organised under the following headings:

- General information related to Infrastructure
- Tracks
- Route Alignment
- Structure
- Signalling
- Energy
- Stations
- Workshops and depots

This information will be particularly useful in Workstream 4, when the technical characteristics and constraints for high-speed rail in the UK will be defined.

3.4.1 General Information Related to Infrastructure

Atkins 3 [**5**] presents elements to take into consideration when initially defining a high-speed line, such as including a dedicated freight line or not, location of stations, infrastructure options, etc. ([**5**] pp. 7-19 to 7-21).

SYSTRA's international comparative study of various high speed rail systems throughout the world includes information about their infrastructure ([51] pp. 18-31).

Another SYSTRA document discusses operating difficulties that can arise as a result of mixing high-speed trains with other types of services, as well as some issues and limitations related to grade ([56] pp. 12-16). This document also provides a detailed table summarizing the technical characteristics of the system chosen in the study (p. 20).

The document *Compared Costs of a High Speed and a Conventional Line*, produced as part of the study for a high-speed line, discusses rail infrastructure and the impacts of differences in infrastructure on construction costs ([46] pp. 1-4).

Atkins 4 study also presents issues concerning appropriate infrastructure for freight traffic, as well as a comparison between two line options: East Coast and West Coast ([**6**] pp. 5-1 to 5-2).

3.4.2 Tracks

The SYSTRA documents provide technical descriptions of track components, such as general descriptions of:

- Recommended rail type, inclination of rail
- Types of sleepers and fasteners
- Track laying: ballast vs. concrete (Germany)
- Types and specifications of switches ([41] pp. 14-16)

Much more detailed descriptions for the track subsystem of high-speed rail can be found, as well ([53] pp. 17-28, p. 41, [56] pp. 24-29, [51] pp. 101-104).

3.4.3 Route Alignment

SYSTRA's technical specifications document describes route alignment constraints such as grade and curves ([46] pp. 21-23). *Atkins 4* addresses the same issues, plus other elements such as design speed and junctions to the design criteria for route alignment ([**6**] pp 3-1 to 3-3).

3.4.4 Structures

SYSTRA's document on technical specifications of high-speed rail provides an interesting description of the issues surrounding the construction of civil engineering structures (viaducts and tunnels) for a high-speed line, as well as security measures related to over-line structures ([56] p. 30). Pages 32 to 33 discuss the construction of noise-screens, underground (cut and cover) sections and landscaping in the interest of better integration of the high-speed line with urban environments.

The SYSTRA study *Faisabilité de la LGV Casablanca-Rabat-Tanger: Etude Socio-économique du Premier Tronçon* ([47] pp. 23-25) provides descriptions and illustrations of infrastructure on cuttings and embankments.

3.4.5 Signalling

SYSTRA's technical documents provide some general information about cab signalling and blocks ([51] pp. 88-89), as well as more detailed information on cab-signalling for high-speed trains ([51] pp. 90-102). The examples of different systems are of particularly interest:

- France: TVM430 ([51] pp. 91-97)
- German LZB system ([51] pp. 98-100)
- ERTMS system (European Rail Traffic Management System) ([51] pp. 101-102)

The ERTMS/ETCS signalling system will eventually replace the TVM and LZB systems ([53]p. 7). An additional description of ERTMS is provided, as well as a description of the central signalling and control station ([53] pp. 8-11, pp. 44-46).

New generations of cab-signalling systems allow for very short headways (3 minutes or less) on high-speed rail lines ([53] p. 92). The choice of signalling system is also provided ([56] pp. 48-51).

All the documents studied indicate that a UK high-speed rail network should use cab signalling with ERTMS, or suitable variant (as with HS1).

3.4.6 Energy

The *Rail Technical Strategy Summary* sets energy-related goals for the UK rail system: universal regenerative braking on electrified railways and reduction in train mass ([**19**] pp. 24-26).

SYSTRA provides general information about overhead line electrification (OHLE) for rail systems, including a discussion of OHLE for higher-speed trains in particular ([51] p. 78).

SYSTRA's document on the technical specifications of HSR, in particular the chapter "Description of Energy System for High Speed Rail" ([51] pp. 29-34), as well as pages 43 to 47 of SYSTRA [56] provide

very interesting detailed descriptions of many aspects of the energy system, including specifications and maintenance of different components.

3.4.7 Stations

Atkins 4 addresses these same issues by first dividing high-speed rail stations into 3 categories (newly built, remodelled, untouched) and then analyzing the characteristics of those stations falling into each category ([**6**] pp 4-1 to 4-15).

SYSTRA describes the technical characteristics of high-speed rail stations, such as track and platform layout. The merits of locating stations in the city versus in the suburbs ([56] pp. 35-38, [47] pp. 33-44) are also discussed. The question is posed as to whether high-speed lines should be based on existing lines, or whether they should be completely new and separate. A discussion on mixing different kinds of service on the same line is also included ([56], p. 11).

Other texts related to high-speed rail stations are listed in section 3.3 above.

3.4.8 Workshop and Depot

Atkins 4 considers workshop and depot locations for a high-speed line in London ([**6**] p. 5-1). The *North Pole Depot* document gives some technical information about the site [**14**].

The Greengauge 21 *High Speed Two* proposal [**27**] suggests that the HS2 line could use the North Pole Depot.

SYSTRA describes the maintenance of the rolling-stock, as well as the workshop and necessary tools ([56] pp. 39-42).

3.5 Construction Costs

This section covers reports which may be useful in determining the construction costs of the high-speed line. The principal topics covered under this section are:

- Overall costs of projects performed
- Unit costs
- Comparative analysis of costs

A final sub-section covers additional information that does not fall under these headings.

3.5.1 Overall Costs

The report *LGV Rhin – Rhône Branche Est – Expertise du Coût de la Première Tranche (2005)* [54] presents a cost analysis for rail equipment on pages 119-125, and on pages 112-3 presents some cost issues relating to the following items:

- Tracks and catenaries
- Energy supply
- Telecommunications
- Security systems

Atkins 8 presents the capital costs for all the scenarios proposed by the Atkins report on page 4-1 and in appendix C [**9**].

SYSTRA's report on phasing for HSR projects presents several case studies of high-speed rail projects (both completed and currently under construction), and provides the overall construction cost for each of them, phase by phase [52].

SYSTRA also has useful spreadsheets that provide estimations of overall construction costs from 2006. Other overall cost estimates, from the project to increase the capacity on the Paris-Lyon line, are also available [**33**].

3.5.2 Unit Costs

Atkins 8 [**9**] presents on pages 3-1 to 3-4 the derivation of unitary costs for civil engineering works, systems, bridges and occupation crossings, grade separated junctions, stations, land, demolition and compensation, depot costs, rolling-stock, upgrades of classic networks, expropriation costs, and client and professional fees. A description of each item is given on pages P2-1 to 2-3. The sources used for the HSL capital cost model are presented on pages 2-6 to 2-7.

A study carried out by SYSTRA for the high-speed line Rhone-Rhein presents the development of unit costs between 1998 and 2004 for the following equipment ([54] pages 126-130):

- Security system
- Catenary
- Tracks
- Track equipment

In the context of studies for the doubling of the Paris-Lyon HSL [45] and for the Sud Europe Atlantique (SEA) HSL [59], SYSTRA has assembled a database of construction costs for different elements of HSR lines. Different cost estimates for easy and for difficult terrain are provided, as are comparative lists of construction cost estimates for various HSR projects.

3.5.3 Comparative Analysis of Construction Costs

Atkins 8 pages 7-1 to 7-6 contains a cost comparison analysis which includes:

- Channel Tunnel Rail Link (CTRL) costs (with a table for each section) on page 7-1
- An international comparison of costs of rail schemes in France, the Netherlands, Shinkansen, Korea, Taiwan on pages 7-2 to 7-6

An international comparison of infrastructure costs is presented in the report on the Rhone-Rhein HSL on pages 146-148 [54]. The comparative analysis includes examples from Belgium, Italy, Spain, France and the CTRL.

3.5.4 Further Cost Information

The report *LGV RR* contains some discussions on the following issues:

- The policy to adopt when buying construction material and equipment
- Evolution of steel price
- Cost and organization of basic construction work

It further presents some ideas for optimizing the costs of the following items (LGV RR pages 148-152):

- Junctions
- Stations
- Electrical supply
- Tunnel conception and construction
- Track foundation structure

3.6 Network Construction and Phasing

The development of a high-speed rail network in the UK will require a phased approach. This section covers information that is available in previous reports relating to:

- Phasing principles
- Project phasing within the Authorizing [Statutory] Instrument
- Phasing case studies

3.6.1 Phasing Principles

SYSTRA's document on the phasing of high-speed rail projects [52] outlines phasing principles on page 4. It describes the reasons for phasing as well as some of its requirements.

The SYSTRA study on high-speed rail in Morocco [57] presents a qualitative multi-criteria analysis performed in order to determine the phasing of the different lines within the scope of the project. The criteria considered include time savings, travel demand and costs. This method could serve as inspiration for an analysis of the British case.

Recommendations Méthodologiques pour l'Evaluation Socio-économique des Projets Ferroviaires (French Ministry of Transport, 2006 [**33**]) gives a quantitative approach to phasing in section 5.3.5 Cas du phasage du projet and annexe n° 7 : Optimisation du phasage d'un projet ferroviaire. In this section the high-speed line is constructed either in one phase or in two phases. The comparison highlights the most critical elements in determining a project phasing scheme. The comparison is based on the profitability, expressed in NPV and IRR, of different scenarios. Through this method it is possible to determine in which project phasing is the most profitable and how to optimise it.

3.6.2 Project Phasing within the Authorising [Statutory] Instrument

Atkins 3 [**5**] presents on pages 7-14 to 7-16 the implications of project phasing in the context of the authorising instrument (authorisation to construct, operate, use the railway, acquire land, etc.). It also presents the following on pages 7-1 and 7-17:

- Elements on which the phasing should be based
- Reasons why it is desirable to phase a project in terms of authorising procedures
- Policies for a good division between the various instruments

3.6.3 Phasing Case Studies

The SYSTRA report on HSR phasing [52] describes some case studies of phased construction of high-speed lines, and gives reasons and strategies for such phasing. The case studies cover the following projects:

- Paris-Lyon (pages 10-15)
- Rhône-Alpes line (pages 16-20)
- Mediterranean high-speed line (pages 21-24)
- French south-west axis (pages 25-37)
- Paris-London (pages 38-48)
- LGV Est Européenne (pages 49-55)
- KTX: Seoul – Busan high speed line (pages 56-59)

4 Network Operations

4.1 High-Speed Technology: Rolling-Stock

A high-speed rail system design requires a specified rolling-stock technology to ensure that the requirements of the passenger, the operator and the infrastructure manager are met. The SYSTRA report on HSR technical specifications ([53] page 13) presents a classification of fleets according to speed. This may be used as useful introductory material.

The other reports reviewed cover relevant material about the high-speed rail rolling-stock used throughout the world with a special focus on French rolling-stock. Some useful information was also found about Pendolino trains.

4.1.1 High-Speed Rail Rolling-Stock used Internationally

A description of different types of rolling-stock for high-speed rail used around the world is provided by SYSTRA in *High Speed Fleet Classification* [50]. The following types are described: TGV-DUPLEX; TGV-PBKA; TGV POS; EUROSTAR; ICE 1; ICE 2; ICE 3; SHINKANSEN 500; ETR 500.

Technical specifications of these types of rolling-stock are provided based on information from train-set manufacturers and operating railway networks ([50] pages 9-70). The specifications include performance, power car descriptions and electric characteristics, passenger trailer descriptions, and motorised bogie specifications. Special attention is given to traction and braking curves with visual supports ([50] pages 64-70).

A tabular comparative analysis of different models of rolling-stock is also presented in [50] pp. 71-82, covering general specifications, performance indicators, power car description and electric characteristics, etc. However, the study does not provide any sort of conclusion to which type of rolling-stock may offer the best performance. Moreover, it should be noted that no prices are provided throughout the analysis.

4.1.2 The French High-Speed System

An extensive description of the French system (referred to as TGV, *Train de Grande Vitesse*) and its advantages is presented in the SYSTRA report on technical specifications ([53] pages 28-50, 93). Design characteristics key to the success of TGV rolling-stock are described as:

- The principle of train-sets enabling TGV system to use existing rail structure as well as new specialized infrastructure (pp. 39, 41, 46-47)
- The choice of electric traction (pp. 42)
- Other elements (pp. 43-44, 49, 50, 93)

A diagram of TGV 24000 rolling-stock presented on page 100 may be of interest.

4.1.3 Pendolino Trains: Pros and Cons

Tilting trains (Pendolino trains) are discussed in a SYSTRA technical document [56], pages 7-10. The description includes:

- The purpose of Pendolino suspension

- The benefits that it could provide for instance in terms of speed
- The constraints
- An estimation of costs

4.2 Train Service Schedule

The reports reviewed provide some useful information about service patterns and journey times, in particular in the report from Atkins and in the paper by Sven Andersen [**2**]

Atkins 3 [**5**] presents on pages 3-12 to 3-13 the service pattern assumptions used in their modelling, such as interval pattern, round trip times, and reliability.

Atkins 4 [**6**] presents the method used to calculate journey times on pages 6-2 to 6-4. A table showing acceleration and deceleration characteristics of high-speed trains by speed band is included. Another table summarizes the various service patterns. A graphical depiction of service patterns is shown in Appendix D of the document.

Atkins 7 [**8**] presents the service pattern and journey times defined for 2016 and 2031 (pages 4-2 to 4-4) with details for all options presented in Appendix C.

Sven Andersen's paper [**2**] offers reflections and propositions on HSR service for the UK.

Andersen argues that HSR in the UK should operate at 320 km/h, with a headway of about 3 minutes. He suggests that, on a single trunk to London/Heathrow, there should be 16 high speed trains per hour and per direction, of which 4 go to Heathrow and 12 to London. He further recommends that there be at least one train per hour between all HSR stations. He provides a detailed proposition of the scheduling of a typical hour of service. This is an interesting analysis as it leads to a level of operation beyond that which has been achieved in practice. It will be useful to revisit this work during Workstream 4.

At junctions, velocity of trains going straight can remain 320 km/h. Trains turning out must reduce their speed to 220 km/h.

SYSTRA presents some issues related to scheduling [53]:

- Scheduling and train-sets (page 58): multiple or single unit
- Scheduling as a technical and economic equilibrium based on market studies, traffic forecasts, etc. (page 59)

4.3 Operational Costs

Several reports contain relevant information. What follows has been split between cost information from projects outside UK and cost information in the context of the UK.

4.3.1 Cost Information in the Context of the UK

Atkins 8 [**9**] is an extremely relevant document that examines operating costs in the UK context:

- Inputs and outputs associated with the determination of operating costs (pp. 2-3 to 2-5)

- Source data from the UK train operating company (TOC) on costs (pp. 2-7 to 2-8)
- Operating and maintenance costs estimates for all of the scenarios considered in the Atkins report (pp. 4-2 to 4-9, appendix D)
- Comparisons of UK rail operating and maintenance costs (pp. 7-6 and 7-7)
- Whole life costing based on such considerations of ballasted versus slab track, signalling systems, axle loads, maintenance regimes, etc. (pp. 7-7 to 7-10)

4.3.2 Cost Information from Projects Outside UK

SYSTRA provides relevant information on maintenance, operations and operating costs, based primarily on the French TGV network. It also mentions specific strategies or system design elements that can help to reduce costs ([53] pp. 46-52, 62).

SYSTRA studies on the planned Sud Europe Atlantique lines provide useful information on the costs of operations and maintenance. It includes both observed costs of existing lines and techniques for estimating these costs. A discussion of the observed lifespan of various infrastructure elements is also provided [59].

Another SYSTRA study provides a good deal of information about the costs of acquisition and maintenance of rolling-stock ([57] pp. 27-31, 50-78), including estimates of the lifespan of the fleet.

5 Demand and Revenue Forecasting

5.1 Introduction

Demand forecasts are critical to any assessment of the viability of high-speed rail. They drive both revenue and economic benefits. We consider the elements of forecasting under the following headings:

- Current markets – existing mode shares
- Growth assumptions
- Forecasting methodology
- Demand forecasts for specific schemes
- Benchmarking

Under each of these headings, we consider the relevant papers we have reviewed.

5.2 Current markets

In the UK, the data on rail and air flows is good, but that on car is very poor. *Atkins 7* [**8**], Chapters 2 and 3 provide:

- Mode shares by trip length (para 2.3)
- Mode share for key city pairs (para 3.8).

High Speed 2: Economic and Regeneration Impacts for Birmingham (SDG, May 2008) [42] provides estimated mode and purpose shares for travel between London and the West Midlands, along with some costs and journey times (sections 3.1 – 3.7).

5.3 Growth assumptions

Atkins 7 [**8**] also provides

- Exogenous demand growth by mode (para 3.52)
- Highway speeds, including expected changes (para 3.66).

High Speed 2: Economic and Regeneration Impacts for Birmingham (SDG, May 2008) [42] provides growth assumptions drawn from Rail White Paper, RUSs and NTM for other modes. They are shown in section 3.12.

5.4 Forecasting Methodology

Atkins 7 [**8**] gives very limited details of the forecasting approach in Appendix A. However, it assumes knowledge of the PLANET Strategic model and only provides details of changes from this.

High Speed 2: Economic and Regeneration Impacts for Birmingham (SDG, May 2008) [42] has based its forecasts on MOIRA, but recognises the weakness of this model for this purpose (section 3.29).

Northern Way: North-South Connections (SDG August 2007) [43] utilises forecasts from the Atkins study.

Recommandations Methodologiques pour l'Evaluation Socio-Economique des Projets Ferroviaires (French Ministry of Transport) [**33**] describes in Annex 5 (7.2.4.5) a number of forecasting tools such as the time-price trade off and gravity models.

5.5 Demand Forecasts for specific schemes

Atkins 7 [**8**] gives forecasts for a wide range of options, including sensitivity to fares (para 4.47), frequency (para 4.52), journey times (para 4.54 - 4.57). Details of the impact of the mode constant are provided in para 4.58, 4.59. The sensitivity to classic rail services and fares, and air fares are shown in paras 4.60 – 4.68. Sensitivities to values of time and other model parameters are shown in para 4.77.

High Speed 2: Economic and Regeneration Impacts for Birmingham (SDG, May 2008) [42] provides indicative forecasts for travel between London and the West Midlands, based on clear assumptions regarding journey times and service frequency. It also provides average yields and revenue forecasts. Sections 3.21 – 3.28 are most relevant.

Atkins 7 also provides forecasts for certain alternatives to high-speed rail, notably classic rail enhancements, highway improvements and air capacity increases.

5.6 Benchmarking

High-Speed Rail Market Shares (SYSTRA 2006) [48] summarises market shares by mode for a number of high-speed lines in France, Germany, Spain and Japan.

Benchmarking for Lisboa-Porto High Speed Line (MVA, 2003) [**34**] provides a range of benchmarking material, albeit some of it dated. The report includes mode shares, pricing, growth in demand, occupancy levels, product policy, and the key drivers of demand (chapter 7). The report covers the experience of SNCF TGVs, Thalys, Eurostar, plus limited evidence from other markets.

5.7 Conclusions

Demand forecasting methods used in previous studies all have their limitations. There is nothing in these previous studies to alter our view that a completely fresh approach to forecasting must be developed, as per our current plans.

6 Appraisal Methods

6.1 Framework for Previous Appraisal Studies

Transport appraisal is carried out to provide input to efficient policy development and resource allocation across government. To be effective, transport appraisal must deal consistently with competing proposals, be even-handed across modes and take account of a wide range of effects.

The Government's White paper *A New Deal for Transport: Better for Everyone* (DETR, 1998) [**20**] set in place the policy context for dealing with transport and highlighted the complexity of transport problems and the interaction with other policy areas. The White paper signalled a move away from 'predict and provide' towards providing integrated solutions. As part of this shift the New Approach to Transport Appraisal (NATA) was introduced to appraise and inform the prioritisation of transport investment proposals.

Transport schemes for which Scottish Government approval is needed are required to be appraised according to the *Scottish Transport Appraisal Guidance*, or STAG. This is an objective-led appraisal process, which is described in *Scottish Transport Appraisal Guidance* [40]

NATA has evolved substantially since its original launch in 1998, and indeed is being reviewed currently through the NATA Refresh programme. This review will bring NATA up to date, will reflect the Stern and Eddington reports, and will provide a method for appraisal which is consistent with current government policy as described in Towards a Sustainable Transport System (TaSTS) [**22**].

NATA is now the basis for:

- appraisal of multi-modal studies
- appraisal of Highways Agency road schemes and Local Transport Plans major road and public transport schemes
- Department for Transport appraisal criteria (formerly Strategic Rail Authority's Appraisal Criteria)
- the project appraisal framework for seaports
- the appraisal process employed during the development of the Government's airports strategy.

Within the context of this report the primary role of NATA has been the development of Guidance on the Methodology for Multi-Modal Studies (GOMMMS). GOMMMS provides a framework for appraising multi-modal studies of regional and national importance.

Within the above framework the impacts of transport projects and their appraisal, were categorised into five high level criteria:

- economy
- environment
- safety
- accessibility
- integration

The TaSTS programme has modified these into five goals:

- competitiveness and productivity
- climate change
- equality of opportunity
- quality of life and natural environment
- health, safety and security

This chapter primarily addresses the first two criteria in TaSTS, reviewing existing work into findings and methodology. It also considers certain issues that are specific to the HSR programme, namely the capacity released on the rest of the rail network, impact on other modes and funding sources.

6.2 Overall Business and Economic Case, and Direct Economic Benefits

6.2.1 The Atkins Report

The most comprehensive quantitative analysis into the economic benefits of the high-speed rail is contained in *Atkins 9 para 5.1 to 5.96* [**10**]. Cost benefit analysis was carried out for various design options, and benefits were calculated as a sum of 'benefits to rails users' + 'benefits to other transport system users'.

Rail user benefits = journey time saving + net fare revenue + accident savings

- **Journey time savings** were calculated for those switching to high-speed rail from other modes, and converted to monetary values using the Transport Economic Note (TEN) published by DfT. £8.2 bn of the £10.8 bn total benefits were estimated to be produced from journey time savings.
- **Fare revenue** was estimated by increasing the lowest current standard ticket by 30%
- **Accident savings** were estimated based on passenger kilometres travelled on different modes, and a series of modal accident rates

Benefits to non rail users = journey time saving as a result of congestion reduction and vehicle operating costs of those who switch from road to rail (based on TEN) **+** freed capacity on classic rail**.**

The benefit-cost ratio (BCR) was calculated for each design option and discounted to present day value. This follows the standard methodology of appraising transport schemes as outlined in NATA and GOMMMS. Based on this analysis the best BCRs were found to be for high-speed rail with:

- a passenger only line
- a single line serving London – or two single lines, rather than a core southern section with two branches East and West
- a westerly orientation (although easterly options can also be viable, particularly if the full 2+ upgrade is not implemented on ECML)
- more than one London terminus, particularly if these provide connections for international travel
- stations in city centres
- the fastest possible journey times
- a perception of premium service

The benchmark in the report for a viable scheme is a BCR of at least 2. This was found to be the case only if trains operate to city centres.

Other factors, such as cost increases, phasing development, high-speed service frequencies, the SRA's Capacity Utilisation Policy and construction delays, have little overall impact on the economic case.

Reliability of rail services was cited by respondents to the high-speed rail SP/RP surveys within *Atkins 6* [**7**] (Table 12 on page 3-13) as the single most important attribute to survey respondents, and was cited by 84% of air users, 78% of car users and 86% of rail users.

6.2.2 Other Papers

The Economic Effects of High Speed Rail Investment (de Rus, 2008) [**18**] seeks to set out an overall case for high-speed rail investment. It rightly sets out that investment in high-speed rail should be evaluated in the same way as other possible uses of public funds (assuming some public funding is required). However, it omits some of the benefits associated with high-speed rail (eg Wider Economic Benefits), environmental benefits, and confuses the cost element between high-speed rail and other local rail services.

Under What Circumstances is Investment in High-Speed Rail Worthwhile Nash & de Rus, 2007) [**35**] likewise aims to fill a perceived gap in the quantitative analysis of the value of high-speed rail schemes. They draw some interesting conclusions, in particular that high-speed rail can rarely be justified on the basis of time savings and generated traffic alone, but must most likely be justified on the basis of providing new capacity. For this to be of value there must be congestion on or environmental concerns with competing modes. However their overall methodology is unlikely to be of value to this study.

High Speed 2: Economic and Regeneration Impacts for Birmingham (SDG, May 2008) [42] (section 4.22) provides estimates of direct economic benefits calculated in a standard way from the demand forecasts.

6.3 Wider Economic Benefits

6.3.1 Quantitative Studies

Most papers which make reference to the wider economic benefits (WEB) from high-speed rail are qualitative in nature, and make various qualitative arguments in favour of high-speed rail as an enabler of economic regeneration, of economic growth, or of agglomeration benefits. The papers which follow however, all provide a quantitative estimate of WEB in some form.

High Speed 2: Economic and Regeneration Impacts for Birmingham (SDG, May 2008) [42] specifically focuses on Wider Economic Benefits. Chapter 4 of the report is dedicated to an extensive discussion of this area, including the theory, methodology and results. It covers agglomeration benefits, spatial and sectoral distribution of benefits. Potential regeneration impacts are considered in Chapter 5, including impacts on office rentals, potential commuting from West Midlands to London, business relocation, and inward investment, albeit this Chapter considers all these elements in a qualitative way.

Northern Way: North-South Connections (SDG August 2007) [43] sets out a methodology for estimating agglomeration benefits in Appendix A. The results of applying this methodology are shown in sections 2.14 – 2.28.

Regional Productivity Differentials: Explaining the Gap (Boddy et al) [**13**] (referenced by Northern Way report) is an academic paper seeking to explain reasons for productivity differentials in UK regions. It finds that journey time to conurbation and specifically London is an important factor (see page 13).

*North-West Productivity Rail Study (*Colin Buchanan, 2008) [**15**] uses WEB analysis to appraise different schemes in the North-West. Those with the greatest benefits were schemes which released the maximum capacity on the classic network into Manchester, backing up conclusions drawn elsewhere that released capacity is an important benefit of high-speed rail.

The Atkins 2007 study *Because Transport Matters* [**4**] did provide some estimates of WEBs. 3 routes were considered - West coast alignment, East coast alignment, and a full network. Following DfT Methodology, Atkins estimated the GDP growth with respect to each of the 3 above options (page 8) as £16bn, £20bn, and £44bn respectively over 60 years. Improvements instigated in other local services were not taken into account and therefore these estimates are prudent. The results predict that high-speed rail will increase economic productivity of both the growing Southern regions, and Northern cities.

Recommandations Methodologiques pour l'Evaluation Socio-Economique des Projets Ferroviaires (French Ministry of Transport) [**33**] emphasises the importance of agglomeration benefits in terms of business location, accessibility, etc, but then states a specific study should be undertaken, without advising on the methodology for this – see section 8.2.3 and Annex 9 (11.2.2.3).

Pré-études fonctionnelles LGV Paris Londres par Amiens (SYSTRA 2005) [55] does not provide a quantified basis for estimating agglomeration benefits ; however, it does analyse and come to clear conclusions on the circumstances when such benefits occur. The summary (page 7) sets out the following conditions necessary to achieve such benefits:

- The city needs to have a critical size – small towns will not benefit from high-speed rail; this size is not quantified, but from the context, we can conclude at least 100,000 population
- The train service needs to be sufficiently attractive, both in terms of journey time and frequency; at least 5 return trips per day are required
- It is essential to have a strategy for economic development that takes advantage of the new HSR by, for example, creation of zones of business activity around the station
- The station needs to be well located; the city centre is best; stations on the edge of the city can be made to work if development can take place in the locality and there are good transport links to the city centre; stations outside the city (park and ride) will attract no wider economic benefits.

6.3.2 The Eddington Transport Study, December 2006

The *Eddington Study* [**23**] is one of the more comprehensive papers that explains how wider economic benefits are directly accrued from developing transport systems, but is still a theoretical qualitative paper. Section 1 is the most relevant of the study's 4 sections. The study qualitatively discusses the effects of transport on the economy and provides academic evidence to support, and the DfT make frequent reference to it in *Delivering a sustainable railway* [**21**].

Eddington argues on page 4 that better transportation links reduce the impact of a structural economy change where industry is moving from manufacturing to service by providing a better commuter network for those whose employment moves to the city. He provides quantitative support to show that increased spending in public structures increases GDP (pp 10-11), although admits that cause and effect is unclear.

Further case studies are provided to argue how transport affects the economy taking different factors (management of network, maturity of economy, transport requirements, global geography, etc) into account (pp 19-40). Eddington also identifies what factors of transport improvement affect the performance of the economy (pp 3-18). Improvements in speed, reliability, network coverage, cost, comfort, safety can all have a effect on micro-economic drivers: innovation, agglomeration, labour markets, competition, trade, globally mobile activity, etc.

Eddington finally discusses the need for further development in wider economic benefits appraisals for transport planning (pp 41-45).

6.3.3 Other Qualitative Studies

The following studies make reference to WEB without providing any real quantitative evaluation:

- Several Greengauge 21 studies have been produced; however are all qualitative and generally assess the societal need for high-speed rail as oppose to providing a business case with quantitative analysis
- Greengauge 21 in *The Impact of High Speed Rail on Heathrow Airport* [**31**]report discuss the economic benefits of extending high-speed lines to Heathrow, improving access to mainland Europe
- Colin Eliff in *Joining up Britain* [**25**] (page 9) states that according to DfT, 7/10 foreign companies want to be based one hour from Heathrow, and therefore better connectivity to the airport needs to be provided to unlock this potential in economic growth
- The *Greengauge 21 Manifesto* [**29**] cites Lille as an example of successful economic regeneration enabled by high-speed rail [page 8]
- *High-Speed Trains and the Development and Regeneration of Cities (Harman, 2006*) [**28**] (page 21) describes several case studies from all over the world and concludes a positive effect on the economy is seen when its service sector expands at the same time as the introduction of high-speed rail
- *High-speed rail: International Comparisons* (SDG, 2004) [41] (para 5.40 page 49) argues that there is scepticism in the UK government about by how much transportation can affect economic growth; it is accepted that transportation can affect the location of growth, but not its efficiency
- *Because Transport Matters* (Atkins, 2007) [**4**] made further comments about the agglomeration benefits [page 26]. The study maintains its original conclusion that to maximise the agglomeration benefits a high-speed line's stations need to be in city centres.

6.4 Environmental Impact

6.4.1 Background

The environmental agenda has become increasingly important in recent years, and *The Greengauge 21 Manifesto* [**29**] (page 25) specifically mentions the importance of high-speed rail in addressing greenhouse gas emissions, over dependence on fossil fuels and poor quality environment.

However, previous studies into high-speed rail have tended to overlook its environmental impact, or have considered it in only a qualitative way. Indeed, assessment of environmental impact has been described as a weakness in the overall appraisal of high-speed rail by David Spaven, Chairman of Transform

Scotland. In a response to Spaven's environmental assessments, Greengauge 21 argue that his assumptions are false, and have led to him invalid conclusions [**30**].

6.4.2 Assessing Environmental Impact

Atkins undertook the most comprehensive analysis of the environmental impacts of high-speed rail in the UK. This is described in *Atkins 9 and associated appendices, particularly B, E and G* [**10**]. Environment was one of the five appraisal criteria considered in the development of the business case, with full Appraisal Summary Tables completed for each route option.

The environmental impact appraisal was broadly based on GOMMMS using the then current March 2000 Government advice. There were two elements to the environmental appraisal:

- an assessment of land use impact – primarily landscape, heritage, biodiversity and water
- an assessment of air quality and noise impacts

The appraisal in *Atkins* built on previous work. In *Atkins 3* [**5**] para 5.3 and appendix E the key national environmental designations were mapped with a Geographic Information System (GIS). Route concepts were developed in *Atkins 4* [**6**] para 2.11 to minimise the adverse impacts on these locations. The Business Case in *Atkins 9* [**10**] para 3.1 to 3.5 provided the most detailed and up-to-date analysis of the environmental impact, and provides the principal focus for the current report.

Northern Way: North-South Connections (SDG August 2007) [43] mentions the importance of reduction in air traffic as an environmental impact, but does not quantify this benefit.

6.4.3 Land Use Impact Methodology

Atkins 9 Appendix E [**10**] assessed land use impact by quantifying each route option's impact on landscape, heritage, biodiversity and water. Impacts were quantified by the number of designations severed, length of severance and number of designations within proximity. However, they found this technique too simplistic and used instead an approach which combined qualitative impacts with the quantitative ones. Impacts overall ranged from "slight adverse" to "very large adverse".

Colin Elliff on p4 of his *Presentation to the Lib-Dem Party Conference 2008* [**26**] has proposed that high-speed lines should follow existing transport corridors to minimise the land use impact.

6.4.4 Air Quality Impact Methodology

Air quality impact covers changes in emission levels of carbon dioxide, nitrous oxides and particulate matter (PM10). Most previous studies which have quantified these impacts have simply used average emission rates per passenger-km. The DfT in association with Delta Rail in *Estimation of Rail Environmental Costs* (2007) [**1**] have developed a very in-depth model that can be used to assess emissions of CO_2 and other air pollutants, as well as the noise impacts described in the next section, but this methodology is much more detailed than is possible as part of the current study.

The air quality assessment in *Atkins 9 para 3.31 to 3.43* [**10**] explored the impact on emissions of high-speed rail due to journeys being switched between rail, road and air. Emissions were calculated using highways vehicle kilometres and emissions rates given in the *Design Manual for Roads and Bridges (DMRB) Volume 11 section 3, part 1*. The figures used per passenger-km for rail were 32.2g CO_2, 0.0486g NO_x, and 0.0018 PM10.

The Rail Safety and Standards Board completed a report in 2007 entitled *The Case for Rail: The first sustainable development review of the mainline railways of Great Britain* [**36**]. As with *Atkins*, the impact on CO_2 emissions is estimated based on passenger-km, though the figures used appear to differ from those used by Atkins.

The picture on emissions which emerges from the various papers reviewed is far from uniform:

- All the options considered in *Atkins 9 para 3.4* [**10**] deliver a reduction in emissions from road and classic rail, but not from aviation. *Atkins 9 para 3.42* predicts that high-speed rail will reduce passenger-km travelled by air, but not sufficiently to reduce the number of flights. This is in contrast to qualitative arguments in many papers reviewed, which cite the reduction of flights at Heathrow as a significant environmental benefit, suggesting that Atkins' modelling air vs. high-speed rail may be over-cautious.
- Colin Elliff on p4 of his *Presentation to the Lib-Dem Party Conference 2008* [**26**] asserts that high-speed rail should be developed so as not to increase total emissions from the transport sector. He claims that to achieve this high-speed rail must eliminate most UK internal aviation, though he does not cite the sources of these figures.
- *High-Speed 2* (Greengauge 21, 2007) [**27**] (page 31) draws attention to Japan where train speeds have increased from 210 km/h to 320 km/h without an increase in energy consumption or emissions. This contrasts with the 2007 Government white paper which refers to the relatively poor performance of trains running at 300-350 km/h when compared with current 200 km/h operations.
- *Because Transport Matters* (Atkins 2007) [**4**] (page 29) estimated that the for every person diverted from air, between 6 and 7 are diverted from classic rail for the full network and East Coast options, increasng to approximately18 on the West Coast options.
- *Delivering a Sustainable Railway* (DfT) [**21**] para 6.15 page 62 argues that high-speed rail travel is not a 'green option' based on the present electricity generation mix. The Government estimates that carbon emissions per passenger for a journey between London and Edinburgh will be approximately 7 kg of carbon for conventional-speed rail, 14 kg for high-speed rail, and 26 kg for aviation. Other research carried out by Virgin, AEA, Greengauge 21, and also by the DfT in their written parliamentary answer in 2004 contradict these findings highlighting the need for evidence based carbon emissions estimations on proposed HSR options and specifications.

The case around emissions seems at best not proven, and this is therefore an area where the current study's planned new forecasting models, combined with some appropriate emissions estimates based on planned meetings with various report authors, can contribute new evidence to the debate.

6.4.5 Noise Impacts Methodology

Estimation of Rail Environmental Costs (AEA / DfT) [**1**] developed a model to quantify noise impacts (section 5 pages 47 to 60). The report provides a detailed methodology which in essence was developed around the Calculation of Railway Noise (CRN) methodology. However, the data requirements of this methodology mean it is not usable in the context of the current study.

Atkins 9 [**10**] (para 3.49) describes the modal shift from roads, classic rail and air transport to high-speed rail as being unlikely to make a material difference to noise levels at properties currently affected by these transport modes.

6.5 Capacity Released on Classic Network

6.5.1 The Atkins Report

Atkins is the only report to go into any detail on this subject. *Atkins 7* [**8**] gives considerable attention to the impact on the classic rail network, with paras 5.3 – 5.17 being dedicated to this area. It gives details of the reduction in crowding that may be anticipated; this crowding impact is not valued in economic terms.

The Atkins proposals would be most likely to open up opportunities for rationalising classic services on the West Coast and East Coast routes (*Atkins 9 Appendix D.9* [**10**]). The ECML is substantially less complex than the WCML but there remain a number of areas which suffer from network and passenger congestion such as south of Hitchin. Further details of congested sections are given within Appendix D of *Atkins 9*.

Atkins 9 (App D p 28) claimed it was neither practical nor appropriate to make an accurate assessment of capacity released as a result of modifications to ECML and WCML services. This would be a major exercise so they adopted a strategic approach to the assessment of the extent and location of capacity release for each of the HSL options considered.

A spreadsheet model was used to assess the capacity released, based on the number of paths released on respectively 15 and 23 constrained sections of the ECML and WCML. The outputs of this model were then interpreted against the known or anticipated aspirations of stakeholders. Based on the results the most promising opportunities for use of released capacity were:

- Regional passenger services
  - Doncaster-Darlington
  - Colwich-Manchester (via Stoke) (limited)
- Local passenger services
  - King's Cross-Peterborough
  - Euston-Rugby (outer suburban)
  - Colwich-Manchester (via Stoke)
  - Carstairs-Glasgow
- Freight
  - Peterborough-Doncaster
  - Willesden-Rugby

The released train paths were valued by allocating likely new services to them. Atkins (Table D.4) estimated the values of released capacity at £80m for the lowest option and £460-730m for the highest. Most options were valued at between £180 - £470m.

6.5.2 Other Studies

The studies which follow are all qualitative in terms of the way they address capacity released on the classic network

- *High Speed 2: Economic and Regeneration Impacts for Birmingham* (SDG, May 2008) [42] discusses in Chapter 6 the opportunities released on the classic network. It provides an estimate

of the additional train service that could be run, but does not seek to place an economic value on it.

- *Northern Way: North-South Connections* (SDG August 2007) [43] describes in Chapter 3 the current and future capacity constraints on the rail network, uses this to justify increased capacity (in the form of a HSR network), but does not assess how much capacity this would actually release.
- The *Greengauge 21 Manifesto* [**29**] asserts on p2 that one of the key advantages of HS is the ability to increase capacity of the commuter network in London through new HS services and increased commuter services on the classic network as a result of a reduction in classic intercity services. The Greengauge 21 proposal for HS2 (page 3) notes increased capacity for commuting in the growth areas of Milton Keynes and South Midlands as well in the Birmingham-Coventry corridor.
- *High-Speed 2* (Greengauge 21, 2007) [**27**] states on p18 that the lines would also free up capacity for additional freight services, due to the removal on InterCity services, on the busiest route in the country, the WCML as well as on the Southampton-West Midlands corridor.
- *The 2020 Vision for the East Coast Main Line* (Virgin Rail Group) [61] includes a new high-speed line between Peterborough and Doncaster which would have freed up considerable capacity on the existing ECML at Grantham, Newark and Retford.

6.6 Impact on Other Transport Modes

6.6.1 Road

Atkins 7 [**8**] assesses the impact on other modes in Chapter 5. Para 5.2 provides mode shares which can be compared to the base mode shares (para 2.3). Highway impacts are shown in paras 5.30 – 5.33; air impacts in paras 5.34 – 5.37.

High Speed 2: Economic and Regeneration Impacts for Birmingham (SDG, May 2008) [42] assumes that half of the generated rail travel has been abstracted from car, but no justification is provided (section 4.18). Note this is in the context of London to/from the West Midlands where there is no current air service.

Recommandations Methodologiques pour l'Evaluation Socio-Economique des Projets Ferroviaires (French Ministry of Transport) [**33**] section 8.1.3.2.4 gives economic benefits for the reduction in car traffic.

6.6.2 Air

The Greengauge 21 report on London Heathrow (*The Impact of High Speed Rail on Heathrow Airport*, 2006) [**31**] goes into some detail on pages 13-14 on expected modal shift from air to rail on the Heathrow to domestic and international destinations market.

Analysis by Greengauge 21 as part of a report on the impact of high-speed rail on Heathrow Airport (page 12) confirmed that rail competes strongly where it offers journeys in the less than 3 hour timeband, and went on to estimate the associated air–rail transfer. The analysis identified a total of 12.8 million, or 19% of total airport usage, travelling on routes with a high propensity to transfer to high-speed rail. This includes only Heathrow but there would be similar volumes of passengers from all the other London and South East airports combined together. Not all of this is likely to transfer, and the report suggests a more likely figure is up to two-thirds of the potential share, or 12% of total Heathrow demand.

The Atkins Report by contrast estimates that the impact on air demand will be relatively modest, with an overall reduction in point-to-point UK domestic air travel of up to 7%. The impact of high-speed rail would vary between different markets, with the greatest change between London and Manchester (11% reduction) in the short term (2016) and between London and Edinburgh (24% reduction) in the longer term (2031). The reasons for this reduced impact include Atkins's assumptions that:

- growth in air travel would be unconstrained by capacity (this was DfT advice at the time)
- high-speed rail would have a fare premium, while air passengers at the time paid little or no APD

6.6.3 Underground

In *Atkins 7 para 5.39* [**8**] it was assumed that the majority of high-speed services would terminate at Euston. It was estimated (para 5.57) that high-speed lines will place considerable strain on the underground network, with an extra 14% peak hour passengers in 2016 and 29% extra by 2031.

During the Atkins study significant consultation took place with TfL. TfL strongly favoured any option that reduced pressure on the Underground in Central London including:

- terminating high-speed lines outside the central area; TfL particularly supported Stratford or Heathrow as potential termini
- use of Paddington in preference to Euston or Kings Cross/St Pancras as a main terminal
- provision of an inner suburban stop to facilitate interchange onto other lines before reaching the main central London terminus, TfL cited Willesden Junction as a potential location.

TfL noted (para 5.59) that the planned upgrades for the Victoria, Northern and Piccadilly lines would facilitate an increase in service capacity but this will only mitigate existing overcrowding, not provide additional capacity for HS. However, TfL were developing Cross River Tram at the time, which would have provided additional capacity from Kings Cross and Euston towards Holborn and Waterloo. Crossrail Line 2, which would run between Waterloo and Kings Cross could also alleviate increased demand in the longer term.

6.7 Funding

The *Greengauge 21 Manifesto* [**29**] asserts that public funding must be kept to a minimum through:

- route selection and scheme design
- application of technology to minimise capital and operating costs
- continuity funding to ensure efficient and timely implementation
- effective management of the construction and procurement process.

The *Greengauge 21 Manifesto* pages 28-29 recommends a new model of funding including using surpluses created by successful rail franchises and future road user charging to fund the network. Alongside the revenue stream from transport users, Greengauge 21 highlights other sources of finance (page 30):

- central government grant
- property development funding
- EU funding
- regional agencies.

Atkins 10 [**11**] provides substantial detail on funding of a high-speed network (page 8-22). The report examines the financial structures and funding mechanisms used in other high-speed lines including:

- UK - CTRL/HS1
- Japan – Shinkansen HSL
- Netherlands – HSL Zuid
- France – TGV
- Italy – TAV
- Germany – ICE
- Spain – AVE

Each example has an in-depth case study including lessons learnt and implications on development of UK high-speed rail.

Atkins 10 page 37 goes on to consider four main PPP options for funding:

- Design Build & separate Operations
- Design Build Finance & Operate
- Design Build Finance Maintain & separate Operations
- Design Build Finance Transfer & separate Operations.

The report suggests a hybrid incorporating features that provide a deliverable project and one that is value for money by transferring and sharing risks where appropriate (page 47). It recommends a DBFM&O to be used to deliver high-speed lines procured outside the regulatory regime, while DBFT&O is used where high-speed lines are within the regulatory regime.

High Speed 2: Economic and Regeneration Impacts for Birmingham (SDG, May 2008) Appendix A1 [42] briefly discusses financial impacts and funding opportunities, but does not give significant guidance.

In Arup's proposal for a High Speed link to Heathrow (Arup 2008 web reference: http://www.arup.com/unitedkingdom/newsitem.cfm?pageID=11678) [**3**] their proposed financial model includes raising revenue from the sale of the train paths that would be created by extending high-speed rail and by introducing a new station and passenger facilities at Heathrow.

7 Conclusions

7.1 General Conclusions

The most striking conclusion which emerges from this review of previous work in the UK and abroad is that previous material is of greater value in informing the design and operation of the high-speed network than in informing its appraisal.

The most definitive UK study that considered route options, *Atkins,* is very comprehensive, but its findings have to be read in context, considering its timing and in particular the national rail structures that existed at that time and the anticipation of upgrade work on the network that has not yet taken place. Consequently the technical value of the study is great, but the conclusions need to be re-set in today's context.

There is certainly a valuable body of knowledge from previous international projects which can be used to inform and to drive design decisions relevant for the UK. There are a number of studies that appraise the various options, including French, German and Japanese solutions for the technology of high-speed rail. These discuss the integration of high-speed rail with other transport modes and go into significant depth about the comparative infrastructure and rolling-stock solutions that have been adopted. There are one of two studies that relate to project costing, phasing of construction and operating costs that will be interesting sources of reference for this study.

In the UK, a number of different high-speed rail schemes have been put forward, with varying levels of detail in the design. A combination of this UK and international material will prove valuable to support the eventual proposals for the UK high-speed network.

By contrast, in appraising the benefits of high-speed lines, there are significant gaps in work done to date. Previously used demand forecasting models all have their limitations, while the justification of wider economic benefits from high-speed rail has in most cases been on the basis of qualitative argument rather than evidence. Such benefits are considered crucial to making of a case for high-speed rail and this area is therefore one where the Greengauge 21 High-Speed Rail Development Programme can make a significant contribution.

Finally, some qualitative arguments for high-speed rail do not yet appear to be well-supported by published evidence. In particular, a clear relationship between the construction of a high-speed rail network and a reduction in carbon emissions has not yet been quantified. Similarly, the relationship between high-speed rail connections to London Heathrow Airport and a reduction in short-haul flights requires further evidence. The Greengauge 21 High-Speed Rail Development Programme can therefore add further value to the high-speed rail debate if it can address these issues in a way that is logical and empirical.

7.2 Impacts on the Workplan

The review carried out for Workstream 1 provides a sound basis for moving forward into Workstream 2 as planned; with the development of strategic design choices. The material gathered during Workstream 1 will be used to inform the Workstream 2 discussions and the absence of literature in certain areas will also enable our team to explore key areas where substantiation of arguments is required.

During Workstream 3 we plan to devote significant attention to production of a new model for demand forecasts for high-speed rail, and to the development of models to estimate wider economic benefits. These components of the workstream can therefore also proceed as planned. The importance attached to carbon emissions however, and the largely qualitative nature of the work in this area so far, suggests that we need to devote more time and effort to this component of Workstream 3 than had previously been envisaged.

The nature of the benefit of a link to Heathrow will be dealt with under the current plans for Workstream 3. We planned to forecast modal shift as part of the demand forecasting model, and the change in demand from air to high-speed rail, separately for end to end passengers and for those inter-lining at Heathrow, will be one element of that analysis.

This review has highlighted some valuable reference material to support Workstreams 4 and 5, which can proceed as planned, drawing on a combination of UK and International design material.

8 Appendix A – Bibliography

This bibliography lists all the reports we reviewed as part of this workstream. Reports are only referenced in the main text where there are substantive relevant points to draw from them.

1 AEA Energy & Environment, *The NMF Environmental Modules: Estimation of Rail Environmental Costs.*
The environmental model was developed for DfT by AEA Energy & Environment, DeltaRail, and Paul Watkiss Associates to assess the environmental impacts and damage costs from passenger rail services in Great Britain. The environmental impacts, and associated social costs, are estimated for carbon dioxide (CO2), 3 other air pollutants (NOx, SO2 and PM10) and environmental noise.

2 Andersen, Sven, *A vision for a High-Speed Network in Great Britain.*
Proposal for a high-speed line and an operating timetable

3 Arup Ltd, *Heathrow Hub.*
Proposal to build high-speed rail hub at Heathrow.

4 Atkins, *Because Transport Matters: High Speed Rail*, 2007.
Review of both the East and West coast route options.

5 Atkins, *High Speed Line Study – Milestone 3 Interim Report (Atkins 3)*, December 2001.
Early level ideas of what is covered in later chapters (which is more indepth and concise). This document may be useful.

6 Atkins, *High Speed Line Study – Milestone 4 Option Development (Atkins 4)*, December 2001.
Different options are highlighted based on various combinations of segregated and non-segregated track, various types of track (Skinkansen/LGV/Singles), and various lengths. A network for non-segregated track is identified, and design criteria for route alignment and route sections are outlined. Stations are identified that will require major remodelling, or minor remodelling based on various route designs or options. Freight options are considered, along with depot capacity, dispersal at London termini, and non-high-speed rail options. This document is relevant to the current Greengauge 21 study as it presents several options considered for a high-speed network.

7 Atkins, *High Speed Line Study – Milestone 6 Stated Preference and Revealed Preference Surveys (Atkins 6)*, January 2003.
Results of SP and RP surveys into anticipated high-speed rail usage

8 Atkins, *High Speed Line Study – Milestone 7 HSL Transport Case (Atkins 7)*, January 2003.
This report provides a more detailed look into the demand, also focusing on future projections of various transport mode (airports program, classic rail upgrade, new classic rail paths, road program) utlisation without HSL. Outlines the planned changes to the ECML and the WCML and incorporated these into an option where no HSL is introduced - however rejected as this would need to occur with a doubling of train ticket prices to reduce overcrowding. Journey time improvements and estimated trains per hour planned discussed. there are sensitivity test for HSL demand based on various HSL characteristics (Pricing, freq., JT, customer response), management of network, air scenarios, infrastructure augmentation, demand

modelling parameters. Heathrow demand and Europe demand assessed. Impact on other modes assessed. Impact of HSL on projected road congestion is minimal; road speeds largely unaffected.
The service patterns for the options presented in this document may be useful.

9 Atkins, *High Speed Line Study – Milestone 8 Cost Model (Atkins 8)*, April 2002.
Capital cost model, operating and maintenance cost model. Derivation of unit costs, HSL cost by option, Non HSL option costs, Risk assessment, cost benchmarking. App of results inc. This document is very useful for cost considerations.

10 Atkins, *High Speed Line Study – Milestone 9 HSL Business Model (Atkins 9),* December 2002.
Environmental appraisal - land use, air and noise pollution; Safety appraisal - forecast in change in accident levels; Economic appraisal: CB analysis, reliability, WEB, accessibility, integration appraisal, alternative option appraisal.

11 Atkins, *High Speed Line Study – Milestone 10 Financial Case (Atkins 10)*, January 2003.
Financial Report provided by Ernst & Young

12 Atkins, *High Speed Line Study, Addendum to Summary Report ,* 2003.
This appendix to the summary report modifies the cost benefit analyses of the various HSR options in order to take into consideration the likely case of only a minor upgrade to the existing ECML (ECML 1c)

13 Boddy et al - *Regional Productivity Differentials: Explaining the Gap.*
Academic paper seeking to explain reasons for productivity differentials in UK regions

14 British Rail Residuary Body, *North Pole Depot.*
Documents relating to sale of this depot, giving its dimensions, characteristics and accessibility.

15 Buchanan, Colin – *North West Productivity Rail Study, 2008.*
WEB appraisal of various possible schemes

16 Cole, Stuart, *Connections to Wales.*
Proposals for high-speed links to Wales

17 Cole, Stuart, *Hydrogen Railways.*
Proposals for powering trains by hydrogen

18 De Rus, Ginés, *The Economic Effects of High Speed Rail Investment*, August 2008.
This document seeks to set out an overall case for high-speed rail investment

19 Department for Transport, *Rail Technical Strategy (RTS)*, July 2007.
Published with the DfT *White Paper,* the *Rail Technical Strategy (RTS)* brings together a long-term vision of the railway as a system (freight and passenger service) in the United Kingdom. It creates target areas of development and recommends ways to optimize the use of existing technology and predict the impact of new technology. This document only mentions high-speed rail in passing.

20 Department for Transport, *A New Deal for Transport: Better for Everyone - White Paper*, 1998.
This document sets out the UK's approach to transport as of 1998.

21 Department for Transport, *White Paper: Delivering a Sustainable Railway*, July 2007.
This document presents policies in order to develop a sustainable railway

22 Department for Transport, *Towards a Sustainable Transport System,* October 2007.
Supporting economic growth in a low carbon world. Short-, middle- and long-term vision for the UK transportation system.

23 Eddington, Rod, *The Eddington Transport Study – The case for action: Sir Rod Eddington's advice to Government,* December 2006.
The *Eddington Study* is one of the more comprehensive papers that explains how wider economic benefits are directly accrued from developing transport systems, but is still a theoretical qualitative paper.

24 Elliff, Colin, *High Speed Rail: Where are the Engineers?*
Recommendations of routes for HSR in the UK.

25 Elliff, Colin, *Joining Up Britain- High-Speed North.*
Proposals put forward to build a single central spine route with branches to major cities to East and West. Prepared for 2M Group, a collection on London councils opposed to expansion at Heathrow.

26 Elliff, Colin, *Presentation to Lib-Dem Conference* 2008.
Presentation of proposals for high-speed network. Includes eight "guiding principles" for high-speed rail development in the UK

27 Greengauge 21, *High Speed Two,* June 2007.
Proposition of a HS2 line connecting London and Heathrow to Birmingham along the North West corridor.

28 Greengauge 21, *High Speed Trains and the Development and Regeneration of Cities,* June 2006.
Qualitative assessment of the wider economic impact of high-speed rail on European cities

29 Greenguage 21, *Manifesto: The High Speed Rail Initiative*, January 2006.
"Call to action" opinion piece putting forward Greengauge 21 views. All detail or data included is taken from WS Atkins study.

30 Greengauge 21 – *Response to David Spaven.*
Rebuttal of arguments made in this paper "Are High-Speed Railways Good for the Environment?"

31 Greengauge 21 – *The Impact of High-Speed Rail on Heathrow Airport,* March 2006.
Qualitative argument for a high-speed rail hub at Heathrow

32 Lloyds Register Rail*, High speed line city approaches civil engineering solutions.*
Describes solutions to bringing high-speed rail services to a number of city centres by using existing transport corridors, classic rail networks and redundant assets.

33 Ministère des transports français, *Recommandations Methodologiques pour l'Evaluation Socio-Economique des Projets Ferroviaires,* 2008.
The official French reference guide (put out by the French ministry of transport) on the economic analysis of railway projects

34 MVA, *Benchmarking for Lisboa-Porto High Speed Line,* 2003.
A range of demand benchmarking material, albeit some of it dated. Includes mode shares, pricing, growth in demand, occupancy levels, product policy, and the key drivers of demand.

35 Nash & de Rus – *In What Circumstances is Investment in High-Speed Rail Worthwhile?,* 2007.
Analysis of the conditions under which high-speed rail delivers benefits

36 Rail Safety and Standards Board (RSSB), *The Case for Rail: The first sustainable development review of the mainline railways of Great Britain,* 2007.
Estimated impact on CO_2 emissions based on passenger-km

37 Reynolds Hardyman & Partners, *UK High-Speed Rail Links.*
Proposals for high-speed rail link to North and Scotland

38 Scottish Association for Public Transport, *High-Speed Rail in Britain.*
Proposals for high-speed links to Scotland

39 Scottish Government, *Scotland's National Transport Strategy*
Presents the transport strategy and policy of the Scottish Government

40 Scottish Government, *Scottish Transport Appraisal Guidance*
Describes the STAG Appraisal process in detail

41 Steer Davies Gleave – *High-speed rail: International Comparisons.*
Comparison of high-speed rail schemes in various countries, and the conditions which make high-speed rail beneficial

42 Steer Davies Gleave (SDG), *High Speed 2: Economic and Regeneration Impacts for Birmingham*, May 2008.
Report on study into likely economic benefits for Greengauge 21 and Birmingham City Council

43 Steer Davies Gleave (SDG), *Northern Way North-South Connections,* August 2007
This document derives an overarching objective that relates to increased productivity in the region.

44 Stern, Nicholas, *Review on the Economics of Climate Change, October* 2006.
Report on the economic impacts of global warming, and making the case for taking action now

45 SYSTRA*, Augmentation de la capacité de la LGV Paris Lyon*.2008.
Preliminary document examining the technical implications of a double of the Paris-Lyon HSR line. Particularly interesting for its estimations of construction costs.

46 SYSTRA*, Compared Costs of a High Speed and a Conventional Line (ComparedCost HSL/CL),* September 2006.
This document presents the characteristics of HSL infrastructure that makes a HSL more expensive than a Conventional Line. There are diagrams in this document that may be useful.

47 SYSTRA, *Faisabilité de la LGV Casablanca – Rabat – Tanger : Etude Socio-économique du Premier Tronçon LGV Kénitra – Tanger (Faisab Kenetra/Tanger),* April 2007.
This document is part of a study carried out by Systra for the project of high-speed line Casablanca è Rabat – Tanger. This document is useful for infrastructure and rolling stock consideration.

48 SYSTRA, *High Speed Rail Market Shares*, 2006.
This document summarises market shares by mode for a number of high-speed lines in France, Germany, Spain and Japan.

49 SYSTRA, *Iran – Cost Benefit Analysis Assumptions for the Costs (IranCost),* June 2007.
This document is a memo written as part of the study carried out by SYSTRA for a high-speed rail project in Iran. It is a memo documenting the assumptions used in order to make cost estimations for Iran. It includes information on construction and operating costs of the French high speed rail system that may be useful for the current GG21 study.

50 SYSTRA, *Iran – High Speed Fleet Classification (IranFleet),* June 2007.
This document is a part of the study carried out by SYSTRA for a high-speed rail project in Iran. It describes different types of high speed rolling stock used throughout Europe. A useful comparative table of is provided.

51 SYSTRA, *Iran – Summary Report about History, Superstructure Specifications, Traffic and Costs Elements for the HSR Systems in the World (IranHist),* June 2007.
This document is a part of the study carried out by SYSTRA for a high-speed rail project in Iran. This document offers an extremely useful summary of European high-speed rail projects, as well as general notions on costs and specifications.

52 SYSTRA*, Iran – Feasibility of Stage Construction (IranStages)*, June 2007.
This document is a part of the study carried out by SYSTRA for a high-speed rail project in Iran. It describes examples of phasing in completed and current high-speed rail projects, though no conclusions are offered. It also provides overall investment costs of these HSR projects.

53 SYSTRA*, Iran - Summary Report about Technical Classification and Main Technologies for the HSR Systems in the World (IranTech),* June 2007.
This document is a part of the study carried out by SYSTRA for a high-speed rail project in Iran. It offers extremely useful technical descriptions and specifications of high-speed rail.

54 SYSTRA, *LGV Rhin – Rhône Branche Est – Expertise du Coût de la Première Tranche (LGV RR)*, 2005.
This document is a part of a study carried out by SYSTRA for the High-Speed Line LGV Rhein-Rhone. It contains some considerations about construction costs that may be very useful.

55 SYSTRA *Pré-études fonctionnelles LGV Paris-Londres, les enjeux d'une desserte TGV pour Amiens* 2005.
Preliminary study of the effects that the creation of a TGV station in Amiens (on the Paris-London line) would have on the city.

56 SYSTRA, *Schéma Directeur Grande Vitesse du Maroc – Equipements et Systèmes Ferroviaires (SD Maroc SYS)*, December 05.
This document is part of the Master Plan for the development of a high-speed rail network in Morocco carried out by Systra. This document presents detailed description of rail system that may be of interest for the current study.

57 SYSTRA, *Schéma Directeur Grande Vitesse du Maroc – Document de Synthèse (SD Maroc Synth)*, Décembre 2005.
This document is the Master Plan for the development of a high-speed rail network in Morocco carried out by Systra. It contains a methodology to determine phasing that may be useful as well as some relevant considerations on operation and infrastructure costs.

58 SYSTRA, *Schéma Directeur Grande Vitesse du Maroc – Bilan Socio-Economique (SD Maroc BilanSocioEco)*, Décembre 2005.
This document is part of the Master Plan for the development of a high-speed rail network in Morocco carried out by Systra. This document presents the socio-economic balance of the project. Some costs presented in this document may be useful.

59 SYSTRA, *Sud Europe Atlantique,* 2007.
Useful cost estimates, as well as observed costs for operation and maintenance of HSR lines in France. Includes discussions of observed life spans of infrastructure elements.

60 Villiers, Teresa, *Conservative Party presentation to the National Rail Forum.*
Overview of Conservative Party's vision for high-speed rail

61 Virgin Rail Group, *The 2020 Vision for the East Coast Main Line.*
Summarises proposals for upgrading the East Coast Main Line as part of an unsuccessful franchise bid.

62 Welsh Assembly Government, *The Wales Transport Strategy*
Presents the transport strategy and policy of the Welsh Assembly

9 Appendix B – Notes of Interviews

9.1 Jeremy Candfield

This interview was held at the Railway Industry Association on 26th November.

9.2 Colin Elliff

This interview was held at MVA's offices in Hanover Square on 27th November 2008.

Colin Elliff is a chartered civil engineer with over 25 years' experience working in the railway industry. He is acting as Transport Advisor to the 2M Group of London and South-East councils opposed to Heathrow expansion.

Colin's motivation for pursuing a high-speed rail scheme is similar to that seen from other sources: need for increased rail capacity to deal with a growing population, economic regeneration and environmental considerations, in particular the avoidance of airport expansion by promoting high speed rail as a superior transport alternative to short-haul aviation. However he also highlighted the need to address peak oil.

Colin's belief is that a high-speed rail network must connect all the major population centres with frequent direct services in a way that the existing WCML does not, for example, connect Manchester and Liverpool with Edinburgh and Glasgow. He believes that Greengauge 21's HS2 proposals replicate this problem. His motivation for this view is that a London-centric network would lead to London picking up all the economic benefits going, the two-way street phenomenon highlighted elsewhere. He also believes that high speed rail represents a unique opportunity to address the flaws in the existing network, and that it is a mistake to adhere strictly to existing main line axes (eg the ECML, built for speed along flat land rather than for connecting major intermediate population centres).

Colin's scheme (entitled 'High Speed North') is based around a single spine route North from London, with branches to major cities. He cites the advantages of this scheme as:

- It will be more cost-efficient to build than two separate corridors: if four-track is required this will be 20% more expensive than two-track and a lot less expensive than building two corridors
- The 'spine and spur' configuration optimises network development on non-London centric axes; thus Transpennine and CrossCountry flows are covered
- By following motorway corridors rather than specific main line corridors, the capacity enhancement benefits can be optimised. Colin believes that diversion of approx 15 express (200km/hr) services from the existing 3 Northern main lines (WCML, MML, ECML) would liberate around 40 paths/hour for slower speed passengers and freight, by reduction of speed differentials
- By concentrating flows (eg Edinburgh/Glasgow/Newcastle and Liverpool/Manchester/Sheffield to London onto single lines of route, it will deliver the high load factors that are needed to make high-speed rail environmentally friendly
- It connects all principal Midlands, Northern and Scottish conurbations for minimised route length, delivering the maximum network for the investment

High Speed North is conceived on the basis of 15 tph, though Colin believes this could be extended to 20 with appropriate signalling technology. An alternative option to achieve increased capacity would be to construct critical sections four-tracked.

High Speed North is designed for speeds of 300 km/hr with a 4.2 km minimum radius, and follows the M1 corridor, and further north, the A1/ECML. Following existing transportation corridors is considered essential, to minimise environmental impact and potential controversy. Motorways (in particular early routes such as the M1, built straight and level through easy topography) offer clear corridors for parallel construction, with adjacent residential development discouraged by the existing noise nuisance. Railways, on the other hand, tend to have urban development clustered around stations and this often precludes parallel new build, especially to high speed alignments.

The scheme also envisages a line to the West ('High Speed West'), though this is separate and would be added later. Colin was undecided as to whether this would be viable as a dedicated new route advancing from London, and suggested that targeted improvements to the existing Great Western Main Line (eg Didcot to Swindon quadrupling and a more direct inland Exeter-Plymouth route, avoiding Dawlish sea wall, may be the most effective solution.

Colin believes that links to Europe from UK provincial cities are important, and that any network must therefore connect into HS1 and must be built or (in the case of access to existing city centre hubs) converted to continental gauge. For this reason he advocates building the Northern spine route northwards from London and HS1, delivering incremental improvements as the line grows northwards.

Colin claims that this scheme delivers journey times of 2¾ hours to Glasgow with a stop in Edinburgh.

The London terminus for High Speed North would be located at Euston. To optimise connections, both to HS1 and to Tube and local rail network, an underground travelator link is proposed to the nearby Kings Cross / St Pancras hub. Euston's availability depends upon diverting suburban services onto Crossrail, liberating both paths and platforms at Euston. This would require a new chord from the Great Western line to the WCML at Willesden; with no residential development and only low-value light industrial use on the proposed line of route, Colin believes that this proposal would be relatively cheap and uncontroversial. Additionally, it would address the puzzling imbalance between east and west sided flows in the current Crossrail proposal (24tph vs 14tph) and add major value to the scheme.

Colin believes that access to Heathrow is important (on account of its status as the UK's principal intercontinental hub airport), but not to any other airports. He further believes that the Greengauge solution of direct hourly services from eg Birmingham to Heathrow will not be viable (e.g. 300,000 pax/year predicted from Birmingham to Heathrow equates to 65 pax/hr). He has also considered the Arup Heathrow Hub proposal, but believes it to be inappropriate for the following reasons:

- It will add circa 10 minutes to all journeys from the North to London
- It will not address issues of inadequate local surface access and congestion
- It requires much expensive and unnecessary new infrastructure (eg 25km tunnel from central London and local distributor network to access airport terminals)
- Onward routeing to the North, either through the Chilterns or via the M25 to the M1 corridor, will be difficult, expensive and controversial

Colin believes that the fundamental problem at Heathrow is inadequate surface access in all directions except to central London (its only rail links are the Piccadilly Line and Heathrow Express). This creates massive local traffic congestion, and encourages domestic flights to Heathrow from northern England as a preferable alternative to cross-London Tube connections. His solution is therefore to separately develop

Heathrow Express into a 'compass point' network linking north, south, east and west to outer-suburban hubs such as Woking, Reading, Watford and Stevenage. The northern orbital loop from Heathrow would connect to High Speed North at a new interchange station at Cricklewood. By virtue of connection with frequent through services from the North, access to HS1 would also be achieved.

9.3 Nigel Standing

This interview took place at MVA's Hanover Square offices on 19th November 2008.