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Item 8 of the provisional agenda
High-speed Trains

Review of implemented methodologies for the development of High-speed Train networks

Note by the secretariat

I. Mandate

1. At its last session, the Working Party on Rail Transport (SC.2) adopted the proposal by the secretariat for the development of a master plan for high-speed trains (ECE/TRANS/SC.2/2012/4, ECE/TRANS/SC.2/218) and requested the secretariat to take actions towards the implementation of the master plan.

2. The secretariat prepared a review of existing methodologies already implemented by different Governments and organizations on the development of high-speed train networks for review and discussion by the Working Party.

II. High-speed trains

3. The development of high-speed networks coincides with the revitalization of rail in the past two decades. It is, in fact, an essential part of it. Wherever high-speed and very high-speed lines have been built, they have proven to be an enormous success for passenger transport. These networks have met customer demand and passenger numbers have frequently grown in double-digit percentages in those member States that have built these lines. The first high-speed line between Paris and Lyon was primarily constructed to resolve capacity problems. Since then, it has become evident that time is a major competitive factor for rail. It is essentially high-speed lines that contribute to the growth of modal share for rail in passenger transport. This growth is also partially due to the

European rail supply industry that has taken over product development and is now able to provide a range of different models of very high-speed trains.[1]

4. What are the benefits of high-speed trains? There is the obvious benefit for the passenger. It is now possible to travel from Paris to Brussels in 1h30, from Madrid to Barcelona in 2h38 or from Rome to Naples in 1h27. Passengers can get on and off trains in city centres. No more lengthy travel to and from airports or check in times are needed. In terms of modal shift from air to rail, the effect has been evident. On all these lines, the demand for rail transport has multiplied, resulting in a greater market share of rail. The Thalys line between Paris and Brussels is a prime example in this respect.

5. Over the last half century, four different operational models of high-speed rail have emerged, consisting of various combinations of new train and track technology:

(a) Dedicated: The world's first operational high-speed rail model is Japan's Shinkansen ("new trunk line"), which has separate high-speed tracks that serve high-speed trains exclusively. The system was developed because the existing rail network was heavily congested with conventional passenger and freight trains and the track gauge did not support the new high-speed trains.

(b) Mixed high-speed: Exemplified by France's TGV (Train à Grande Vitesse), this model includes both dedicated, high-speed tracks that serve only high-speed trains and upgraded, conventional tracks that serve both high-speed and conventional trains.

(c) Mixed conventional: Spain's AVE (Alta Velocidad Espanola) has dedicated high-speed, standard-gauge tracks that serve both high-speed and conventional trains equipped with a gauge-changing system, and conventional, nonstandard gauge tracks that serve only conventional trains.

(d) Fully mixed: In this model, exemplified by Germany's ICE (Inter-City Express), most of the tracks are compatible with all high-speed, conventional passenger, and freight trains.

III. Implemented methodologies at international level

6. The secretariat researched the currently implemented methodologies by Governments and international organizations for developing high-speed train networks. The following is a summary:

A. The case of United States of America[2]

7. In AMTRAK's January 2011 report, "High-speed Rail in America," America 2050 "evaluated 7,870 miles of proposed high-speed rail corridors of less than 600 miles against data for variables that contribute to passenger rail ridership." Of the corridors evaluated, only the Washington–Boston corridor received a higher rating for success over the Los Angeles–San Francisco corridor. The variables considered in this study included "population, employment, transit ridership, population and employment within areas served by transit, air ridership along the corridor, and highway congestions.

[1] Michael Clausecker, Director General UNIFE, Nike Bonnen, UNIFE Public Affairs Manager, Article on "Railway Transformation" book of Roland Berger Strategy Consultants.

[2] High-speed rail in America, full report, 2011.

8. The United States has embarked on a programme of building high-speed rail corridors in the nation’s most urbanized corridors and regions. While the potential to gain ridership is certainly not the only factor in a project’s success (the ability to secure funding, maintain local support, and overcome design and engineering challenges is equally critical), ridership demand is important enough to be used as a preliminary screen of a proposed project’s utility. The long term success of the new federal High-speed Intercity Passenger Rail programme is dependent on investing in corridors with the potential to attract ridership and realize rail benefits, establishing a positive track record for the programme as a sound investment in our national economy.

9. High-speed Rail (HSR) is defined differently around the world. Outside the United States, HSR generally refers to trains that travel above 150 miles per hour (250 kilometres per hour). The European Union defines HSR as newly built lines equipped for speeds of greater than 155 miles per hour (250 km per hour) or upgraded lines equipped for speeds of greater than 124 miles per hour (200 km per hour). The federal government has defined three categories of high-speed rail in the United States: Core Express Corridors, Regional Corridors, and Emerging/ Feeder Routes, to reflect the great variety of regional characteristics and suitability for passenger rail nationwide.

Table 1
Definitions of High-speed Rail and Intercity Passenger Rail

	Corridor Length (miles)	*Top Speeds (mph)*	*Dedicated tracks*	*Population Served*	*Level of Service*
Core Express Corridors	Up to 500	125–250	Yes, except in terminal areas	Major population centers	Frequent express, electrified
Regional Corridors	100–500	90–125	Dedicated and shared tracks	Mid-sized urban areas and smaller communities	Frequent
Emerging/ Feeder Routes	100–500	Up to 90	Shared tracks	Moderate population centers, with smaller, more distant areas	Less frequent

Source: America 2050.

1. Research Findings

10. High-speed rails function in very specific conditions: primarily in corridors of approximately 100–600 miles in length where it can connect major employment centres and population hubs with other large and moderate-sized employment centres and population hubs. Such corridors exist primarily in the nation’s 11 mega regions, where over 70 per cent of the nation’s population and productivity (as measured by regional GDP) is concentrated.

11. Some of the most promising rail corridors for attracting ridership in the United States are in corridors of less than 150 miles. These shorter corridors, such as New York–Philadelphia, Los Angeles–San Diego, and Chicago–Milwaukee, can anchor investments in longer, multi-city corridors and be priced to attract both high-speed commuting and intercity trips.

12. Very large cities are potentially powerful generators of rail ridership. The presence of a very large city on a corridor with medium-size and smaller cities has greater impact than connecting medium cities of the same size for generating ridership.

13. Composition of the workforce within a metro region may have significant implications on regional intercity travel. People who work in knowledge industries, such as

those in the financial sector, tend to be more mobile and travel more for business than those in industrial sectors.

2. Study Design

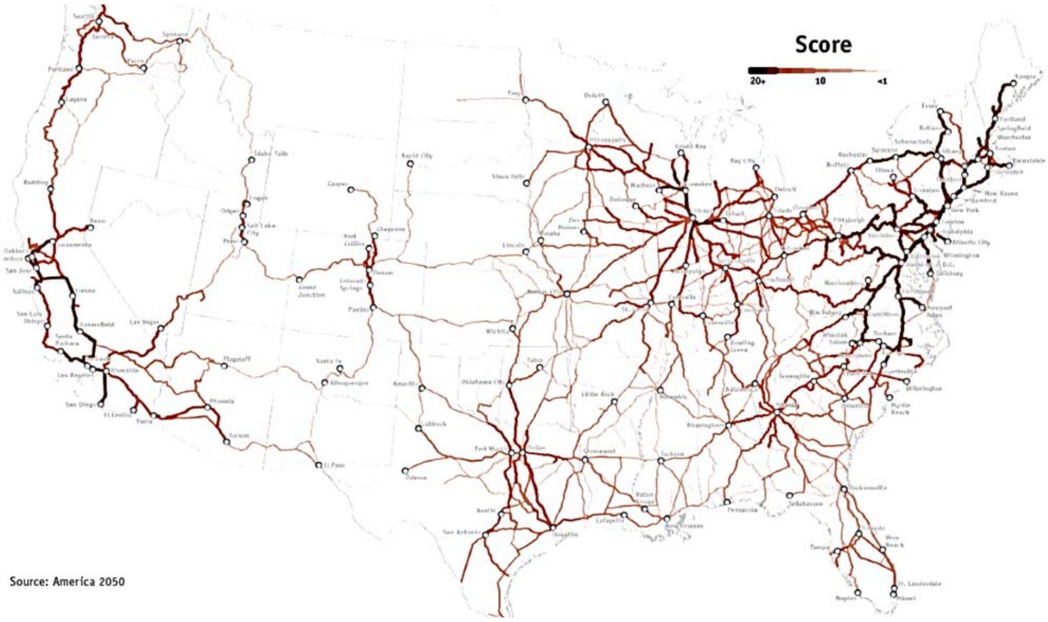
14. This study evaluated 7,870 rail corridors of less than 600 miles against data for variables that contribute to passenger rail ridership. These variables include: population, employment, transit ridership, population and employment within areas served by transit, air ridership along the corridor, and highway congestion. The data was collected spatially, using geographic information systems (GIS) analysis, by establishing 2-mile, 10-mile, and 25-mile service areas for the intercity rail station in each metropolitan area along the rail corridor, or in the absence of a train station, the centre of the central business district of the metropolitan area. Data was collected for every metropolitan area along the route for a dozen variables, shown below. A score was then computed for each rail corridor on a per-mile basis, based on the sum of a weighted average of these dozen criteria. Scores range from 0–20.15.

Table 2
Criteria Used to Develop Corridor Score

Primary Factors: Weighted 3X	
Regional Population (25 Mile)	(RP)
Employment CBD (2 Mile)	(ECBD)
Secondary Factors: Weighted 2X	
Transit Connectivity Employment	(TCE)
Transit Connectivity Population	(TCP)
City Population (10 Mile)	(CP)
City Employment (10 Mile)	(CE)
Regional Population Growth Factor	(RPGF)
Regional Air Market	(RAM)
Tertiary Factors: Weighted 1X	
Commuter Rail Connectivity Population	(CRP)
Corridor Traffic Congestion	(CTC)
Share of Financial Workers	(SF)
Share of Workers in Tourism Industry	(ST)

Source: High-speed Rail in America.

Figure 1
Scoring of Rail Corridors



3. Preparing Data for Equation

15. First, each criterion was divided by the total length (in miles) of the corridor. This step results in the data being on a per mile basis, which allows for comparison between corridors of varying lengths. Without this step, longer corridors with more data points would have had an advantage over shorter corridors.

$Value_n/Length\ of\ Corridor_n$

16. For each criterion, the corridor was given a rank from zero to 7,870, based on their relative value.

$Rank\ (Value_n/Length_n)$

17. These ranks were then converted to a value between 0 and 1 by dividing the rank by the maximum rank in each category and subtracting that result from 1. This yielded a number between 0 and 1 for each entry with the highest value 1 and lowest 0.

$1 – (Rank_n\ /\ Maximum\ Rank)$

18. The final equation was then applied to these adjusted corridor ranks.

Corridor Score = 3*(RP+ECBD)

+2*(TCE+TCP+CP+CE+RPGF+RAM) + (CRP+CTC+SF+ST)

19. Using the equation presented above, a score for every existing or proposed corridor of less than 600 miles in length in the country was calculated. Scores range from 0 – 20.15. This score represents a weighted per-mile average of data along the length of a corridor between any two end points. The top scoring corridor was New York–Washington, D.C. with a score of 20.15. This total score represents data obtained not only from New York and Washington, D.C. but also the metropolitan regions of Philadelphia and Baltimore that lie in between. This corridor analysis is better suited for estimating rail demand than a simple city pair analysis, as it accounts for the “network effects” of major intermediate stations. The ability of trains to gain passengers at intermediate stations is an advantage

over aviation; trains can pick up additional passengers while avoiding the inconvenience and fuel expenditure of an airplane making intermediate stops. The normalization of the corridors on a per-mile basis ensures that longer corridors would not automatically score higher than shorter corridors. However, longer corridors with intermediate stations in cities of medium or large size do score higher than long corridors with few stations in between the end points, unless the end points are large generators of ridership (like in California).

4. How to Interpret the Scores in the Study

20. There is no single number above which a corridor is suitable for high-speed rail and below which it is not. Rather, these scores represent a relative ranking across twelve criteria that contribute to intercity rail ridership. While it would be tempting to designate ranges of score that indicate suitability for Core Express versus Regional and Emerging/Feeder, the relative nature of our ranking system prevents this. Instead, it was suggested that given the significant capital requirements of Core Express, these types of investments should be reserved for the highest ranking corridors. For example, a score of 19 means that for most of the criteria used, the corridor was in the top one per cent of all corridors analysed. All corridors with scores in this range include metropolitan regions with large central business districts, large regional populations, and transit connections. These are the corridors in the country most suited for Core Express service.

21. Corridors with scores of 10 and below were in the bottom 50 per cent of most of the criteria analysed. These corridors consisted mostly of relatively small or medium sized cities spaced at distances at the outer range of rail travel with only sparsely populated land in between. These corridors would not justify priority federal funding for Core Express, given their relative low ranking. Of course, investment decisions about the level of service and design of the system must weigh multiple considerations, in addition to projected ridership demand. A corridor’s relative strength in ridership demand should be weighed with other investment criteria, such as engineering constraints, right-of way conditions, and potential conflicts with freight traffic.

5. Regional Parameters

22. Total **population** of the service area is the most basic driver of intercity rail ridership, aside from the quality of service provided. Larger cities and regions generate more trips, because of a larger potential customer base and greater numbers of destinations for visitors and business trips. Population density is an important determinant of rail ridership; different levels of density account for the variation in ridership between regions of the same population size, but different land development patterns. High residential densities around a train station provide access to greater numbers of potential passengers. Higher densities along transit corridors connecting to a train station also increases the number of people who can access the train station easily. Also, as residential densities increase, car ownership declines; families that own fewer or no cars are more likely to take transit and intercity rail.

23. **Projected population growth** is also critical to assessing the potential of a high-speed rail corridor. In regions that are growing quickly, high-speed rail and related regional development strategies have the potential to shape urban growth patterns over the next half century. Many of the cities that grew rapidly around the interstate highway system in the second half of the twentieth century are projected to continue to grow at high rates in the coming decades and have the opportunity to redirect future growth to urban cores around rail stations.

24. **Employment and employment density** are major generators of ridership for intercity rail systems. The market for high-speed rail, especially for Core Express service in which ticket prices tend to be high, depends heavily on business travel. Rail’s competitive

advantage over other modes is its ability to link city centres and cover significant distances in a relatively short amount of time. Large central business districts are critical in focusing intercity business travel into areas that are easily accessed by rail. For this reason, while total regional population might have more predictive capacity than total regional employment, the existence of large clusters of centralized employment in central business districts is relatively more important to predicting intercity rail ridership than population density.

25. The **composition of the labour market** also impacts the potential ridership of new high-speed rail systems. Since knowledge industries require bringing people together for face-to-face communication and knowledge exchange, cities and regions with high levels of knowledge sector employment will benefit the most from introduction of high-speed rail systems.

26. The presence of local and regional **transit systems** is critical to intercity ridership for two reasons. First, as mentioned above, transit increases the catchment area of intercity rail, connecting departing passengers to the station and arriving passengers to their destinations around the region, all without the need to park or rent a car. Second, a successful transit network is dependent on the major destinations of a region (employment, government, services, institutions, homes) being concentrated in central business districts (CBDs) accessible by that system.

Table 3
Scoring of a Sample of Short, Medium, and Long Corridors

Short Corridors – 150 Miles or Less			
Origin	*Destination*	*Length*	*Score*
New York NY	Philadelphia PA	91	19.86
Los Angeles CA	San Diego CA	150	19.62
Chicago IL	Milwaukee WI	86	19.38
Washington, D.C.	Richmond VA	110	18.31
Sacramento CA	San Francisco CA	139	18.21
Tampa FL	Orlando FL	84	13.63
Mid-Length Corridors – 150–300 Miles or Less			
Origin	*Destination*	*Length*	*Score*
Washington, D.C.	New York NY	224	20.15
Boston MA	New York NY	231	19.87
Portland OR	Seattle WA	185	17.37
Chicago IL	Saint Louis MO	282	16.19
Birmingham AL	Atlanta GA	164	15.93
Atlanta GA	Charlotte NC	257	15.68
Dallas TX	Houston TX	243	16.12

San Antonio TX	Houston TX	211	13.92
Long Corridors – Greater than 300 Miles			
Origin	*Destination*	*Length*	*Score*
Washington, D.C.			
Los Angeles CA			
Los Angeles CA			
Chicago IL			
Washington DC			
San Antonio TX			
Tampa FL			
Charlotte NC			
New Orleans LA			
Denver CO			

Source: America 2050.

Table 4
Population Profile for Major Cities in Northeast Megaregion

	2 mi.		*10 mi.*		*25 mi.*		*Projected 2040 Growth*
	Pop.	*Rank*	*Pop.*	*Rank*	*Pop.*	*Rank*	
New York	520 000	1	7 300 000	1	14 000 000	1	13 %
Philadelphia	220 000	3	2 100 000	4	4 600 000	4	13 %
Washington	140 000	8	1 900 000	5	4 500 000	6	29 %
Boston	170 000	5	1 700 000	6	3 400 000	12	13 %
Baltimore	170 000	4	1 300 000	15	2 500 000	20	35 %
Hartford	100 000	16	600 000	48	1 700 000	36	14 %
Providence	120 000	10	700 000	38	1 700 000	37	17 %

Source: America 2050 analysis of 2000 U.S. Census and 2010 Woods and Poole Economics.

B. The case of Australia[3]

27. The first phase in a future HSR programme would be a preparation and corridor protection phase, which would precede a formal commitment to build the HSR system. This phase would provide the necessary policy foundation for the procurement, construction and operation of a future HSR programme. It would require alignment between the participating governments on the programme objectives, mechanisms and timeframes for resolving issues, and the delivery of enabling regulation or legislation.

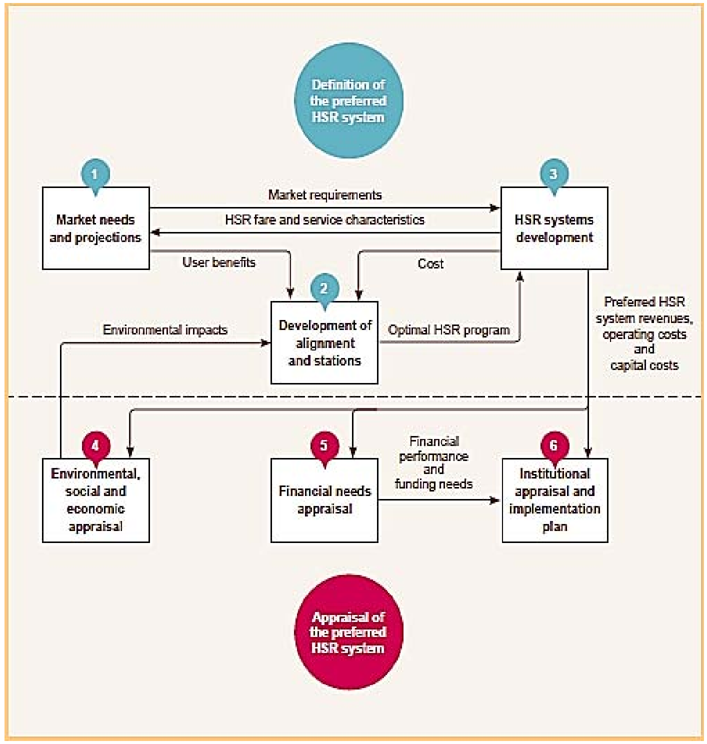
[3] High-speed Rail Study Phase 2 Report, 2012.

28. The proposed model for pursuing multijurisdictional agreements of the type needed to support the HSR programme is to adopt a "gated approach" using a series of formal agreements. Each formal agreement in the process would need to be in place prior to progressing to the next stage, ensuring alignment of governments at critical milestones. The first gate would be a Memorandum of Understanding (MoU) between the Australian, ACT and state governments to formalise the engagement on the HSR programme and to set out the responsibilities of the parties, the process to be followed and the timelines for resolving issues. Subsequent gates would involve formal intergovernmental agreements (IGAs), first to protect an HSR corridor and later to develop and implement a stage or stages of HSR.

29. Once there is a mandate to implement a preferred HSR system, a publicly-owned HSR Development Authority (HSRDA) would be created to develop, procure and integrate the HSR system, including procuring and owning the required land. A single coordinating authority, with appropriate professional management expertise, would be required to effectively and efficiently progress the detailed planning required to develop and procure an HSR system (the HSRDA would later evolve into an HSR development and management authority in the operational phase, and would prepare and manage train operations concessions). The HSRDA could be owned jointly by the Australian Government, ACT Government and relevant state governments.

Figure 2
Phase 2 study modules

Module		Study objectives
System definition		
1	Market needs and projections	Projected travel demand in the east coast corridor.
2	Development of alignment and stations	The preferred HSR system, including corridor, alignment, transport products and system specifications. The optimal HSR program for staging the physical construction and provision of services on the preferred HSR system.
3	HSR systems development	HSR system alternatives that could best serve the projected travel market effectively, and the aggregate and segmented travel demand and market shares that could be served by each.
System appraisal		
4	Environmental, social and economic appraisal	The specific environmental, social and economic impacts of the recommended HSR program, their effect on community groups, and the overall net cost or benefit of those impacts to Australia. The nature, extent and value of any opportunity created for an integrated HSR/corridor regional development concept. The nature and cost of any complementary access projects and their contribution to achieving the assessed performance of the HSR program.
5	Financial needs appraisal	The financing needs, financial performance and commercial viability of the HSR program. Any commercial financing gap and ways of funding and financing such a gap, including through public-private financing and funding partnerships. The key risks to the HSR program and its successful performance, the implications of these risks and possible mitigation measures, if any.
6	Institutional appraisal and implementation plan	The most appropriate institutional framework for governance, planning, procurement, construction, operation and regulation of the HSR program. An effective implementation plan for creating the recommended institutional framework and delivering the HSR program and for securing, if merited, an integrated HSR/corridor regional development concept.



30. The purpose of study was to advise the Minister for Infrastructure and Transport on 12 matters (“the study objectives”). Six interrelated technical modules, as illustrated in above table, combine to address these study objectives in two parts:

(a) Definition of the preferred HSR system for the east coast of Australia;

(b) Appraisal of the preferred HSR system.

Module 1 Market needs and projections

31. Demand models were developed to forecast the likely future travel market on the east coast of Australia and the potential future demand for HSR, based on the likely attractiveness of travel via a future HSR system compared to travel via alternative modes. The first year of HSR operations was designated as 2035 for assessment purposes, and a long-term horizon of 50 years was adopted, consistent with Australian Transport Council (ATC) guidelines. For the purposes of demand modelling, the base year was 2009 and three forecast years were established (2035, 2050 and 2065) for which detailed forecasts were developed. Forecasts without HSR (the “base case”) and with HSR (the “reference case”) were then derived for each year of the evaluation period. Demand for intermediate years (between 2035 and 2065) was derived by interpolation, and for years through to 2085 by extrapolation.

32. Primary market research was undertaken to support the development of the demand models and to define various inputs to the appraisal (such as the value of time for travellers). HSR fares were modelled on a per kilometre basis (incorporating a “flagfall” and a distance component) and set such that they were broadly comparable with corresponding forecast air fares on the Sydney–Melbourne and Brisbane–Sydney air routes. Access costs such as taxi fares, airport and station parking charges and metropolitan bus and rail fares were assumed to remain constant in real terms.

Module 2 Development of alignments and stations

33. The development of alignment and station location options had to be compatible with delivering the necessary system performance to meet market needs while also ensuring the environmental, social and economic sustainability of the system. A large number of alternative alignments (up to 50 for each regional alignment section) and station locations were tested, with the preferred alignment and station locations selected based on a balance of construction and operating costs, user benefits (e.g. relative journey times) and environmental considerations.

34. Regional station locations were selected on the basis of potential demand. Similarly, stations on the periphery of the capital cities (other than Canberra) were selected on the basis of their accessibility to the potential market. A strategic environmental assessment framework, consistent with Australian Government guidelines, was developed and its key principles incorporated in the selection of the preferred alignment and station locations to reduce the potential for negative environmental impacts.

Module 3 HSR system development

35. The design of the preferred HSR system was based on the premise that any future HSR system would need to become an effective component of future integrated transport networks on the east coast. A central consideration was the need to ensure that the HSR would deliver an effective and affordable transport solution that was attractive to customers. To achieve this, HSR fare and service characteristics, such as end-to-end journey times, would have to be competitive with alternative modes, particularly air travel.

36. For the purposes of the demand assessment and appraisal, average fares for HSR business and leisure travel were designed to be competitive with, and comparable to, air fares on the main inter-capital routes, after taking into account relative access times and costs. For example, the reference case assumes the average HSR single (one-way in $2012) economy fare between Sydney and Melbourne in 2065 would be $A141 for a business passenger and $A86 for a leisure passenger. This variation reflects the tendency for passengers travelling for business to pay more for a ticket than those travelling for leisure (a result of the booking methods used, the higher tendency of business travellers to purchase flexible tickets, and the tendency to travel at peak times). The corresponding average air fares (one-way in $2012) in 2065 were estimated as $A137 and $A69 respectively. In practice, a range of fares would be offered, targeted to market segments and influenced by seat utilisation patterns and competitive pressures, as is currently the case with the airlines, where current air fares paid for inter-city business travel can vary from the overall average by as much as 65 per cent. Sensitivity tests also considered average fares up to 30 per cent and 50 per cent higher, as well as 50 per cent lower in the context of a price war with the airlines.

Module 4 Environmental, social and economic appraisal

37. An assessment of the environmental impacts of HSR was integrated into the evaluation of alignment options and station options using a Geographic Information System (GIS) toolkit that identified sites of ecological and heritage value along the HSR alignment options. These assessments were combined with other considerations, such as engineering parameters, constructability, cost, and user benefits, to determine the preferred alignment and station locations. In addition, the assessment of environmental issues associated with HSR addressed noise and vibration, energy use, carbon emissions/greenhouse gas considerations, the implications of climate change, and the promotion of ecologically sustainable development.

Module 5 Financial needs appraisal

38. Financial modelling of the reference case was undertaken to assess the potential financing needs, financial performance and commercial viability of the HSR programme over the evaluation period from 2035 to 2085, having regard to the proposed staging of the preferred HSR system. Future costs and revenues were expressed in $2012 prices discounted to financial year 2028, the assumed commencement of main construction compatible with starting operations in 2035. Air fares were reduced in real terms by 0.5 per cent per year until 2015 and held constant thereafter, consistent with the assumptions about air fares in the Joint Study. Labour-related operating costs were assumed to increase in real terms by 0.2 per cent per year, with actual real wage increases offset by productivity improvements. Fuel prices were assumed to increase in real terms, although much of the increase would be offset by efficiency improvements. Future budgetary impacts for governments were assessed based on the projected future cash flows, which incorporated allowance for risk.

Module 6 Institutional appraisal and implementation plan

39. Appropriate governance and institutional arrangements would need to be established to ensure that, if adopted, the HSR programme is subject to proper public oversight, is effectively and efficiently delivered, and meets its objectives. Specific governance arrangements were developed, having regard to the multi-jurisdictional nature of a future HSR programme and the potential role of the public and private sectors.

C. The case of the United Kingdom of Great Britain and Northern Ireland[4]

40. The HS2 Y network (so named due to its shape) will provide direct high capacity, high-speed links between London, Birmingham, Leeds and Manchester, with intermediate stations in the East Midlands and South Yorkshire. The network will be able to accommodate high capacity trains running initially at speeds of up to 225 mph, with the potential to rise to 250 mph in the future. It will also carry high-speed trains designed to run onto the existing rail network, continuing at conventional speed to a wide range of additional destinations in the United Kingdom, without the need to change trains, via links to the West Coast and East Coast main lines. HS2 is being designed to accommodate the wider and taller trains used elsewhere in Europe. It would, therefore, be possible to run double-deck trains on HS2.

41. The Y network will enable significantly reduced journey times compared to today.

(a) Birmingham to London – 45 min. (currently 1 hr 24 min.).

(b) Manchester to London – 1 hr 8 min. (currently 2 hrs 8 min.).

(c) Leeds to London – 1 hr 28 min. (currently 2 hrs 20 min.).

(d) Glasgow/Edinburgh to London – around 3 hs 30 min. (currently 4 hrs 30 min.).

(e) Birmingham to Leeds – 57 min. (currently 2 hrs).

(f) Birmingham to Manchester – 41 min. (currently 1 hr 30 min.).

(g) Birmingham to Brussels/Paris – just over 3 hrs (currently 4 hrs).

(h) Leeds/Manchester to Brussels/Paris – 3 hrs 30 min. (currently 4 hrs 30 min.).

42. Rail is well suited to many inter-urban markets as it can provide rapid and reliable travel into the heart of city centres. This is reflected in the very substantial increases in demand for inter-city rail travel seen over recent decades. The number of inter-city journeys made on the United Kingdom’s rail network more than doubled between 1994 and 2009 and continued rising even through the recent recession. Network Rail has forecast that by the mid-2020s all capacity for additional or lengthened services on the recently modernised West Coast Main Line will have been exhausted.

43. The Government has considered a range of options for tackling capacity constraints on the United Kingdom’s key north-south inter-city rail routes. Having reviewed the available evidence on demand forecasts and a range of other issues relating to the alternatives to high-speed rail, the Government consider that even very major programmes of enhancements to existing lines would be unable fully to accommodate forecast demand growth and would lead to unacceptable levels of crowding on many routes. Since enhancements to the existing network cannot effectively address capacity constraints in these cases new infrastructure is required. And if new lines are to be built, then the Government broadly has two options – to build new infrastructure matching the speeds of current trains or build new infrastructure which can accommodate the high-speed services seen in countries across Europe and Asia.

44. Analysis carried out by HS2 Ltd for consultation, and refreshed as part of its updated economic analysis in the Economic Case for HS2: Updated Appraisal of Transport User Benefits and Wider Economic Benefits, indicated that the net cost saving from building a

[4] High-speed Rail: Investing in Britain’s Future – Decisions and Next Steps, Department of Transport, January 2012.

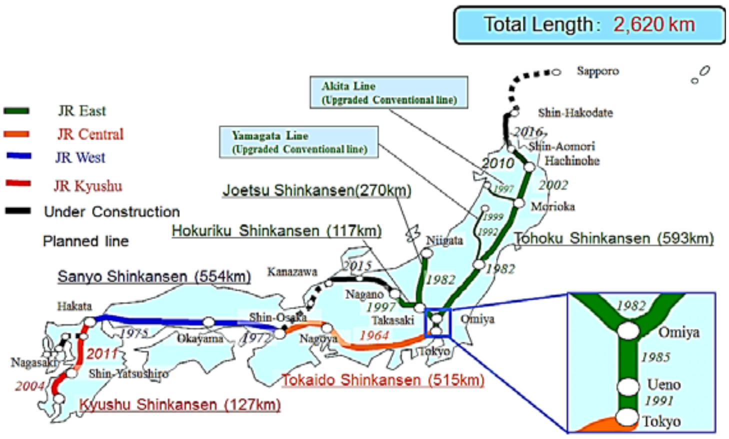
new line along broadly the same route as HS2, but with a conventional line speed of 125 mph, would only be around £1.4 billion. This is because regardless of the speed of a new line, similar tracks, viaducts, stations and tunnels would be needed, so savings would largely relate to the detailed specification of infrastructure and lower rolling stock and fuel costs, and also because a slower line would attract fewer passengers and hence generate reduced revenues. In contrast, the reduction in benefits as a result of slower journey times and reduced passenger numbers would be expected to be as high as £6.2 billion in net present value terms.

45. A Y-shaped national network with links onto the East Coast and West Coast main lines will enable high-speed services to link London, Birmingham, Manchester, the East Midlands, South Yorkshire and Leeds directly. Many of the trains running on HS2 will also be compatible with the existing railway and therefore able to run off the HS2 lines to serve a range of other towns and cities including Liverpool, Preston, York, Newcastle, Glasgow and Edinburgh. They will run at high-speed on HS2 and at conventional speeds on the existing network. Nine out of the United Kingdom’s ten largest conurbations will be connected in this way, providing significant enhancements to inter-city rail capacity and connectivity between the vast majority of the country’s major urban economies.

D. The Case of Japan[5]

46. The figure shows the current Shinkansen network in Japan. The Tokaido Shinkansen line, the first Shinkansen line, was completed in 1964, then other Shinkansen lines were constructed to connect major cities in Japan. Nowadays, the total Shinkansen length is 2,620 (two thousand, six hundred and twenty) km. In the beginning, daily average number of passengers was 80,000 (eighty thousand) passengers per day. As of now, it is 930,000 (nine hundred and thirty thousand) passengers per day. It is over a tenfold increase than the beginning.

Table 5
Shinkansen network in Japan



Source: East Japan Railways.

47. The maximum speed of high-speed trains today is 300 km/h now and it will be 320 km/h in the near future. East Japan Railways can operate 15 trains per hour. During the last 40 years since the first Shinkansen line started operation, no fatal passenger accident has

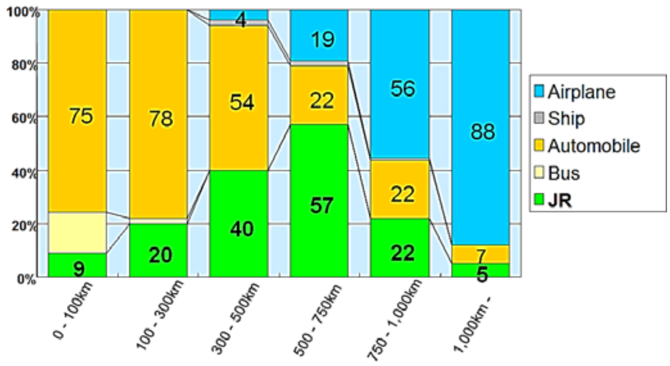
[5] Mr Yasushi Takeuchi, Shinkansen networks and JR East, East Japan Railway Company, 2012

occurred on the Shinkansen. Train delay time is less than 30 seconds for average of all Shinkansen trains per year.

48. The figure shows the Shinkansen share versus other transport modes by distance. Railway sector was enhanced by the Shinkansen lines. Railways have a 40 per cent share between 300 and 500 km, and a 60 per cent share between 500 and 750 km of the market. The Shinkansen has a clear advantage over airplanes in 3 hours riding.

Table 6

Shinkansen share versus other transport modes by distance

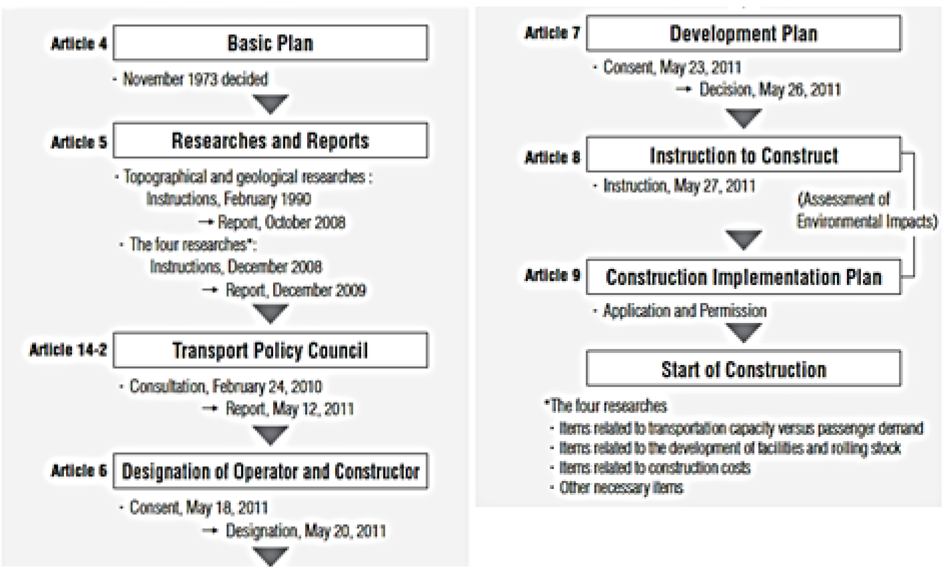


Source: East Japan Railways.

49. The construction of the Shinkansen line was one the causes of the bankruptcy of Japanese Railways (JNR). Today, the Japan Railway Construction, Transport and Technology Agency construct all new Shinkansen lines, and each Japanese Railway company pays fees for lending the facilities. Maintenance cost of Shinkansen lines were shouldered by each Japanese Railway company. It needs huge cost to construct Shinkansen lines. The key of Shinkansen project is how to reduce the cost.

Figure 3

Flow of works based on the Nationwide Shinkansen Railway Development Act



Source: Shinkansen Railway Development Act.

50. Figure 3 illustrates the process established by the Nationwide Shinkansen Railway Development Act regarding the development of high-speed trains in Japan.

E. International Transport Forum[6]

51. The public investment in HSR infrastructure can be contemplated as a way of changing the generalized cost of rail travel in corridors where conventional rail, air transport and road are complements or substitutes. Instead of modelling the construction of HSR lines as a new transport mode this specific investment is being considered as an improvement of one of the existing modes of transport, the railway. Therefore, it is possible to ignore total willingness to pay and concentrate on the incremental changes in surpluses or, alternatively, on the changes in resource costs and willingness to pay. ITF follows here a resource cost approach and ignore the distribution of benefits and costs and concentrate on the change in net benefits and costs ignoring transfers. The social profitability of the investment in HSR requires the fulfilment of the following condition:

$$\int_0^T B(H)e^{-(r-g)t}dt > I + \int_0^T C_f e^{-rt}dt + \int_0^T C_q(Q)e^{-(r-g)t}dt$$

where:

B(H): annual social benefits of the project.

C_f: annual fixed maintenance and operating cost.

$C_q(Q)$: annual maintenance and operating cost depending on Q.

Q: passenger-trips.

I: investment costs.

T: project life.

r: social discount rate.

g: annual growth of benefits and costs which depends on the level of real wages and Q.

52. B(H) is the annual gross social benefit of introducing the high-speed rail in the corridor subject to evaluation, where a `conventional transport mode´ operates. The main components of B(H) are: time savings from deviated traffic, increase in quality, generated trips, the reduction of externalities and, in general, any relevant indirect effect in secondary markets including, particularly, the effects on other transport modes (the conventional transport mode). The net present value of the benefits included in equation (1) can be expressed as:

$$\int_0^T B(H)e^{-(r-g)t}dt = \int_0^T [v(\tau^0 - \tau^1)Q_0 + C_C](1+\alpha)e^{-(r-g)t}dt + \sum_{i=1}^{N}\int_0^T \delta_i(q_i^1 - q_i^0)e^{-(r-g)t}dt \text{ , (2)}$$

where:

v: average value of time (including differences in service quality).

τ^0: average user time per trip without the project.

τ^1: average user time per trip with the project.

[6] The Economic Effects of High-speed Rail Investment, August 2008

Q_0: first year diverted demand to HSR.

C_C: annual variable cost of the conventional mode.

α : proportion of generated passengers with the project with respect to Q_0.

δ_i : distorsion in market i.

q^0_i : equilibrium demand in market i without the project.

q^1_i : equilibrium demand in market i with the project.

53. The fulfilment of condition (1) is not sufficient. Even with a positive NPV it might be better to postpone the construction of the new rail infrastructure (even assuming that there is not uncertainty and no new information reveals as a benefit of the delay). Let us assume that the annual growth rate of net benefits is higher than the social discount rate (g>r) and that the new infrastructure last long enough to be compatible with a positive NPV. Even in this case of explosive growth of net benefits the question of optimal timing remains. It is worth waiting one year if:

$$\frac{rI}{1+r} + \frac{B_{T+1} - C_{T+1}}{(1+r)^{T+1}} > \frac{B_1 - C_1 + C_{C1}}{1+r}. \qquad (3)$$

54. It is immediate to calculate the value of the benefits for the first year of operation required for the investment to be socially profitable now (assuming the project shows a positive NPV):

$$B_1 > rI + C_1 - C_{C1}. \qquad (4)$$

55. According to condition (4), the project should be started without delay if the gross benefit of the first year is higher than the first year net social cost: opportunity cost of the capital plus operating and maintenance costs of the new project less the avoidable cost of the conventional transport mode.

IV. Guidance by SC.2

56. SC.2 may wish to consider the above analysis and provide guidance to the secretariat on further review and amend, if needed, the Working Party’s methodology for the development of a master plan on high-speed trains.