HSIPR Best Practices: Public Benefits Assessment

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Prepared by:
Steer Davies Gleave
883 Boylston Street, 3rd Floor
Boston, MA 02116
(617) 391-2300 – www.steerdaviesgleave.com
Under subcontract to Charles River Associates

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1 Introduction

Public benefits assessment

The purpose of assessing a transportation project's public benefits is to accurately understand the contribution of the project to societal welfare or well-being. By public benefits we mean the outcomes that accrue to the general public, including from the mobility, economic, social, cultural or environmental aspects of a project.

Assessment of public benefits is one of several analytical components of transportation project appraisal. A project's benefits assessment depends heavily (but not exclusively) on its ridership and revenue forecasts, and the implications that these have regarding project impacts on travelers and the general population. The other main elements of project appraisal are operating, maintenance and capital costs estimates. The outputs of a public benefits assessment provide a key input to the project appraisal, whether this takes the form of a cost benefit analysis (CBA) or similar method, or a less formally-structured decision process.

The report is intended for non-specialists who may be called upon to review high speed or intercity passenger rail (HSIPR) project pubic benefits assessments prepared by others. It provides information on the range of data and methods used in HSIPR benefits assessment at different stages of study, and flags particular areas or subjects that will generally require in depth examination by subject area experts. The intent is to provide information and guidance that will assist generalist reviewers to understand and evaluate benefits assessment studies. Similar reports have been prepared in the areas of HSIPR ridership and revenue forecasting and operating cost estimation.

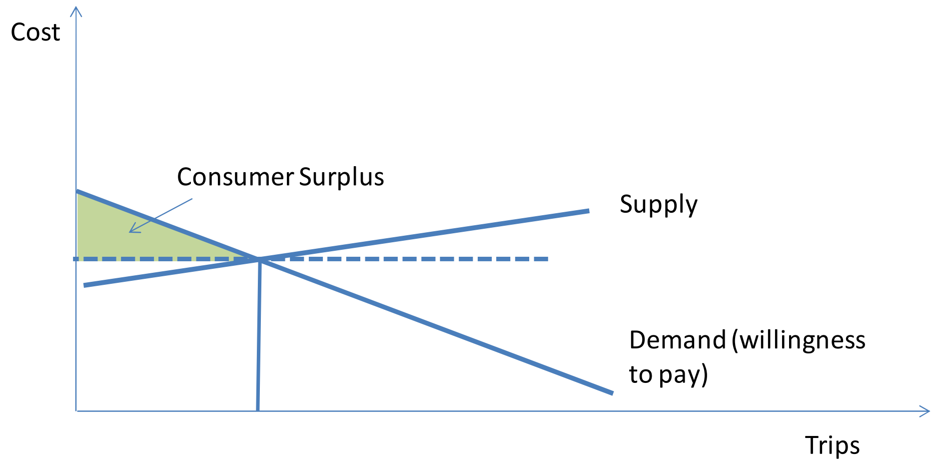
Project assessment does not consider transportation impacts in absolute terms; rather it considers a *build* (project) situation and a specified *no-build* situation, with the project benefits and costs defined from a comparison of the two. It is common to define the no-build situation as the set of "committed" (i.e. officially approved) future network improvements, or as the minimum set of improvements needed to avoid significant deterioration of travel conditions in the future, but other definitions are possible. The no-build situation used in a study needs to be agreed with its sponsors, reviewers and audience early in the study process. Forecasts of ridership and other impacts must be prepared for both the no-build and build situations in order for the project benefits and costs to be computed.

Brief overview of welfare economics

While it is beyond the scope of this report to present in detail the economics of project appraisal, it is useful for the following discussion to introduce some key concepts.

The concept of equilibrium between the demand for and supply of transportation services is central to transportation forecasting and project appraisal. Demand can be illustrated in a diagram as a downwards sloping curve relating the cost of travel and the number of trips being made (see the *demand curve* in the figure below). Put simply, the demand curve classifies all potential travelers from left to right according to their decreasing *willingness to pay* (WtP). At a given travel cost, only those individuals with a WtP higher than the cost will undertake the trip. The benefit that a traveler derives from a trip is equal to the difference between the individual's WtP and the actual cost paid. This difference is called the *consumer surplus,* and the sum of the consumer surplus for all travelers forms the green triangle in Figure 1-1 below.

FIGURE 1-1. TRANSPORTATION SUPPLY AND DEMAND CURVES



Note that the term travel *cost* frequently refers to *generalized cost* - the sum of the monetary and non-monetary costs of a trip, where the latter relate to the perceived cost of travel time. Time and cost are two of the most important trip attributes that influence tripmaking decisions, but other tangible and intangible attributes do so as well. These others are referred to below as *travel quality* or *non-standard level of service* attributes, and are often considered separately from generalized cost. It must be admitted that this (common) distinction between generalized cost and non-standard level of service attributes is somewhat arbitrary.

In a mode choice context, consumer surplus can also sometimes be expressed in a way that is related to the models used to predict mode choices. These models are frequently derived from economic utility theory, and the same derivation leads to a natural measure (called the *expected maximum perceived utility* or *EMPU*) of the benefits that users obtain from a given choice set of modal options and their attributes. It can be shown that, under commonly-accepted conditions, this measure is equivalent to the consumer surplus as defined above. In the particular case of logit or nested logit mode choice models, which are widely used in practice for mode choice forecasting, the EMPU takes a particular functional form known as the *logsum*.

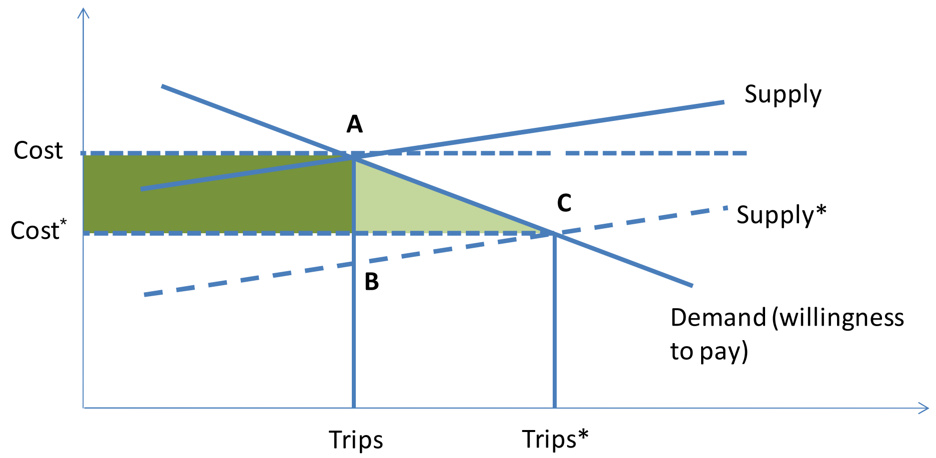
The supply of transportation services is represented by a (usually) upwards sloping curve relating the cost of the last trip (to the traveler) for each level of demand (see the *supply curve* in the figure). The cost typically increases with the level of demand (for a given level of investment) because of crowding, congestion etc. On the supply side there is an analogue to the consumer surplus, which is called *producer surplus*. It is the difference between the cost of undertaking a trip and the cost of providing it, but this has no intuitive interpretation for publicly provided or funded services. <u>Changes</u> in producer surplus may have an intuitive interpretation, which is considered further below.

We provide two examples to illustrate the calculation of welfare changes.

Consider first a travel cost decrease due to a transportation system improvement. Figure 1-2 illustrates this example. The equilibrium situation before the improvement is represented by the intersection of supply and demand curves at point A, with the indicated levels of Cost and Trips. Within an equilibrium framework, a transportation improvement is represented by a shift in (typically) the supply curve. As a result of speeding up service, providing more capacity or implementing other improvements, the cost of undertaking a trip will fall for every level of demand. As can be seen in Figure 1-2, this initially causes a drop in travel costs from A to B. However, the lower costs make more trips worthwhile and so demand increases. Since increased demand causes the travel costs to rise, there will be a series of adjustments that ends in the new equilibrium situation C, where the demand and the new supply curves intersect, corresponding to Cost* and

Trips*. Understanding the relationships between travel cost and demand, between demand and cost of supply, and what the equilibrium situation is with and without a transportation improvement, are the basic tasks of ridership and revenue forecasting.

FIGURE 1-2. CHANGE IN CONSUMER SURPLUS FROM A COST CHANGE

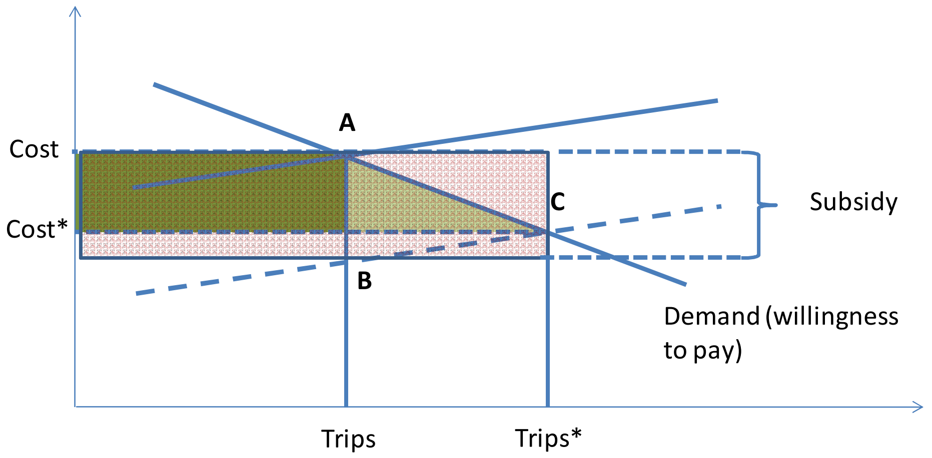


Considering Figure 1-2, the green areas show the *change in consumer surplus* (for convenience this will generally be referred to as just the *consumer surplus*) resulting from the improvement. The dark green rectangle represents benefits to existing travelers (i.e. those who travel both before and after the improvement) and the light green triangle represents benefits to new travelers; the demand curve is approximated by a linear segment between A and C. Accordingly, the consumer surplus is calculated by a method, often referred to as the *rule of a half*, that accounts for the full reduction in travel costs *times* the number of existing travelers, *plus* *half* of the reduction in travel costs *times* the number of new travelers.

A second example corresponds to a change in fares only, for example as a result of a subsidy. Such a change affects both the consumer as well as the producer surplus. Figure 1-3 illustrates both of these surplus changes, with the positive consumer surplus shown as the green areas and the negative producer surplus change as the patterned area. Note that changes that affect only non-monetary costs do not result in a change in producer surplus (which, for brevity, will be referred to as *producer surplus* from here on).

The analysis illustrates an important point: a reduction in fares will cause a net loss in public benefits, which is evident from the relative size of the green and patterned areas in the above figure. This occurs for two reasons: a) higher demand may reduce travel benefits (for instance because of crowding) for all travelers; and b) new travelers are only credited with benefits corresponding to half the fare reduction while the operator loses the full fare reduction. To complete the analysis, one would also need to consider other impacts of increased rail travel, such as environmental gains, less congested roads, and others.

FIGURE 1-3. CHANGE IN CONSUMER AND PRODUCER SURPLUS FROM A FARE CHANGE



As noted above, the EMPU (or logsum for logit or nested logit models) provides an alternative way of computing (absolute) consumer surplus in a mode choice context. Accordingly, the difference in EMPUs or logsums between a no-build and build situation, appropriately converted into monetary units, measures the change in consumer surplus associated to the project. Calculating the consumer surplus change in this way can sometimes be advantageous compared to the rule of a half, for example when the set of available modes is different between the two situations.

This analysis needs to be undertaken for each market segment: for each origin and destination, trip purpose and affected market. The sum of all consumer and producer surpluses constitutes the net public benefit (or *economic welfare*) produced by the project.

Unit of account: resource costs or market prices

Market prices are the monetary prices at which goods and services are traded in the market place. Resource costs are the underlying economic costs of producing goods and services. The main causes of differences between the two values are indirect taxes[1] such as sales or fuel tax, which represent a transfer between economic agents but do not correspond to actual resource consumption and its costs; other price distortions can also intervene. Investment decisions by the public sector should ultimately be based on the amount and cost to society of the resources that will be consumed as a result; transfer payments between agents do not affect the investment's overall social costs or benefits.

Notwithstanding the ultimate use of resource costs for public sector project assessment, the impact quantifications and cost and benefit calculations used in assessments can be undertaken in terms of either resource costs or market prices. In the former case, the resource costs are first established (by eliminating transfer payments and other distorting cost components from market prices) and then used thereafter in the calculations; in the latter, the assessment explicitly accounts for and tracks the transfer payment components. While this choice causes no material difference in the conclusions from the assessment, using a market price unit of account can enable a more explicit treatment of revenue and cost transfers, and allow the application of decision rules that take into account net consumption of public sector funds. In the US it is more common to perform benefits assessments using resource costs, with transfers netted out from the beginning; in the UK, for example, it is more common to use market prices and to track transfers

[1] Indirect taxes are those levied on consumption (such as sales tax), as opposed to direct levies (such as income tax).

explicitly. In either case, once the unit of account is chosen, it is important to carry out all benefit valuations and cost estimates in consistent units throughout the assessment.

For example, if resource costs are used for a benefits assessment, then benefits due to fuel cost savings should be counted net of gas and sales tax. Values of time for in-work travel should be the perceived cost to firms, while non-work values of time measured as willingness to pay need to be adjusted down to reflect indirect taxes. If, on the other hand, benefit assessment is undertaken in market values, then fuel cost savings should include the fuel tax component, but there would be a corresponding negative entry for the government to reflect the reduction in fuel tax receipts. Non-work values of time measured as willingness to pay do not need adjustment, but work values need to be adjusted upwards to include indirect taxes.

Additionality and double-counting

When accumulating benefits into an overall project assessment, it is imperative to ensure that all impacts are captured once, and only once. If transfer payment impacts are included, they must enter the accounts for both the payer and the recipient. It can be challenging to apply these principles rigorously and consistently.

The impacts of a transportation investment on the economy are likely to be widespread, with implications not only for travel times and costs, but also for land use, employment, prices, wages and tax payments. However, most of these other impacts are either transfers, or different ways of capturing impacts already accounted for (double counting). For instance, individuals may respond to the travel time savings produced by a transportation improvement by living in a “nicer” area or taking a job offer further from home. Increased accessibility of a location can also lead to increased property prices. However, it is important to realize that these impacts are mostly transfers: employment growth in one location will in all but special circumstances be taken from elsewhere; increased property prices in one location will be accompanied by small reductions everywhere else. Although some of these impacts may be of interest to policy makers, from an economics perspective they are not additional in most cases.

Structure of benefits

In the assessment of practice and methods of benefit estimation, the following structure has been adopted in this report. This mirrors the scope of potential rail project benefits measured in many methodologies used around the world.

- User benefits
  - Generalized travel costs
    - In-vehicle travel time
    - Waiting, access and egress times
    - Out-of-pocket costs
  - Travel quality
    - Crowding
    - Comfort
    - Travel time variance and reliability
- Non-user benefits
  - Decongestion benefits
    - Highway decongestion
    - Air decongestion
    - Rail decongestion
  - Environment
    - Noise
    - Air quality

        - Carbon emissions
        - Landscape/townscape
    - Travel safety
    - Option values
- Financial benefits
    - Operator revenues
    - Tax revenues
- Extensions and modifications to benefits assessment
    - Wider economic impacts
    - Infrastructure substitution impacts
    - Indirect impacts

Each of these various project benefits components is discussed in detail in section 2 below. The discussion provides information about the benefit component and its quantification and valuation, with reference to common practice in the US and around the world. In most cases, the discussion also indicates whether the particular benefit component has a major (first order) or less significant (second order) impact on demand forecasts, and also briefly identifies aspects of the methodology that are well established or still being researched. Section 3 then provides a presentation of the approaches and methods that are appropriate for incorporating each of these benefits components at preliminary, intermediate and final levels of project study, along with a discussion of potential pitfalls that study reviewers should be alert to.

2 Project benefits components

Introduction

This section identifies methodological approaches to quantifying public benefits for high-speed and intercity passenger rail (HSIPR) projects. It draws upon:

- National government, government agency and international (e.g. European Union) guidance on public benefits assessment;
- Academic research; and
- Actual evaluations undertaken for rail investment projects.

Table 2-1 below sets out a framework for calculating the different benefits components typically considered in HSIPR project assessment. In the table, variables *ij* refer to a particular origin-destination pair, *NB* refers to a no-build situation without the project, *B* refers to the build situation with the project, and other variables are as indicated. The different components will be discussed in detail below. In some cases, the table simply refers to “project specific analyses” rather than specific calculations; these analyses are also discussed in more detail in the appropriate sections below.

In practice, the values described here are frequently computed in terms of daily or shorter (e.g. peak) periods. (This may be because these values derive from travel demand model outputs, which often refer to daily or shorter period travel patterns.) In practice, monetized benefit measures must frequently be expressed as annual values in order to be compared to annual values of capital and O&M costs, in order to establish a project benefit-cost time stream for use in (say) a net present value calculation. In this case, shorter-period results must be aggregated to daily totals, which must be converted in turn to equivalent annual values, using factors that reflect the variations in travel volumes over the corresponding time periods.

Similarly, to estimate the full time stream of annual project benefits, it is common to explicitly develop annual benefits for a limited number of specific years, and then to interpolate (and extrapolate, as required) to develop values for each of the other years included in the time stream. (Again, this is may be because the travel demand model runs that provide key ridership and travel conditions inputs to the benefits assessment were carried out for a limited number of forecast years.) Intermediate year values are typically estimated based on a straight-line growth assumption, although other approaches are possible. Adjustments may be applied to the estimates in the years immediately following service opening to account for *ramp-up*: the phenomenon that demand in a service’s initial years is frequently less than anticipated, because people need time to become familiar with the new travel option and to incorporate it fully in their decision-making. At the other end of the time stream, extrapolation beyond the range of explicitly-modeled years is fraught with uncertainty. Simplistic assumptions can easily lead to unrealistic values for the extrapolated years, so conservative assumptions (e.g. something less than a continuation of straight-line growth) should generally be applied. In some cases, only a single year is explicitly modeled and used for benefits calculations; growth assumptions based on analyses of socio-economic and other exogenous factors must then be applied to develop values for other years.

TABLE 2-1. BENEFIT CALCULATION FRAMEWORK

	Variable	No Build	Build	Benefit (to be summed across *ij*'s)
Ridership	Rail ridership	D^{NB}_{ij}	D^{B}_{ij}	
	Total travel demand	V_{ij}	V_{ij}	
User Benefits	In-vehicle time	IVT^{NB}_{ij}	IVT^{B}_{ij}	
	Wait, access/egress time or headway penalties	P^{NB}_{ij}	P^{B}_{ij}	
	Values of time	VoT		
	Generalized cost (GC)	$GC^{NB}_{ij} = (IVT^{NB}_{ij} + P^{NB}_{ij})*VoT$	$GC^{B}_{ij} = (IVT^{B}_{ij} + P^{B}_{ij})*VoT$	$(GC^{B}_{ij} - GC^{NB}_{ij}) * (D^{B}_{ij} + D^{NB}_{ij}) /2$
	or EMPU (logsum) monetized	$EMPU^{NB}_{ij}$	$EMPU^{B}_{ij}$	$(EMPU^{B}_{ij} - EMPU^{NB}_{ij}) * V_{ij}$
Travel Quality		Project-specific analysis		
Non-user Benefits	Change in highway vehicle miles		dVM_{ij}	
	Marginal congestion cost	MC_{ij}		
	Highway decongestion			$dVM_{ij} * MC_{ij}$
	Air decongestion	Project-specific analysis		
	Rail decongestion	From operating cost analysis		
Noise	Lden (a noise measure)	N^{NB}_{ij}	N^{B}_{ij}	
	Affected population	AP^{NB}_{ij}	AP^{B}_{ij}	
	Noise cost			$N^{B}_{ij} * AP^{B}_{ij} - N^{NB}_{ij} * AP^{NB}_{ij}$
Air Quality	Change in highway VMs for relevant *ij*'s		dVM_{ij}	
	Pollutant emissions per VM for pollutant *p*	PE^{p}		
	Emission cost factor	EC^{p}		
	Air quality cost	**(to be summed over *p*'s)**		$AQ^{p}_{ij} = dVM_{ij}*PE^{p}*EC^{p}$
Carbon	Change in vehicle miles by mode *m*		dVM^{m}_{ij}	
	Carbon cost per mile by mode *m*	CC^{m}		
	Carbon cost	**(to be summed over *m*'s)**		$dVM^{m}_{ij}*CC^{m}$
Crash Costs	Crash rates per VM by mode *m* and category *c*	CR^{mc}		
	Crash costs by category *c*	CrC^{c}		
	Crash costs			$dVM^{m}_{ij}*CR^{mc}*CrC^{c}$
Operator Revenues	Fares	F^{NB}_{ij}	F^{B}_{ij}	
	Change in revenues	$OR^{NB}_{ij} = F^{NB}_{ij} * D^{NB}_{ij}$	$OR^{B}_{ij} = F^{B}_{ij} * D^{B}_{ij}$	$= OR^{B}_{ij} - OR^{NB}_{ij}$
Toll Revenues	Tolls	T_{ij}		
	Change in revenues			$=dVM_{ij} * T_{ij}$

User benefits

User benefits are the impacts on passengers who travel on the improved railroad system: travelers must *use* the improvement to benefit from it. User benefits typically result from changes in travel attributes such as travel time[2], out-of-pocket costs and the quality of the traveling environment, singly or in combination.

Generalized travel costs

The *generalized travel cost* is a composite cost measure that may incorporate monetized in-vehicle travel time; waiting, access and egress times; and out-of-pocket costs. The introduction of a new high speed rail service may affect some or all of these travel attributes, and so affect the generalized cost of travel. Because these variables affect mode choice, they are also directly incorporated in the EMPU or logsum measure when this approach is used for benefits assessment.

An HSIPR study's ridership and revenue forecasting component (which is covered separately in this report) quantifies a project's impacts on travel costs and volumes. The focus here is on methods to calculate the social benefits resulting from a change in the generalized cost of an individual trip. Table 2-1 shows how these trip-level values are then combined with values that measure demand or travel level changes to compute aggregate social benefits.

In-vehicle travel time

Determining the equivalent monetary value of a change in travel time requires a factor to convert time to monetary units. The *value of time* is the monetary amount equivalent – in terms of how much it changes traveler behavior and/or benefits valuation – to one hour of travel time. Different values of time may apply depending on some or all of the following trip characteristics:

- *Mode*: Buses, trains, cars, air, cyclists/pedestrians
- *Trip purpose*: Business travel, residence-workplace, other (non-business) purpose
- *Distance*: For example long trips *vs.* local travel on a train

The appropriate segmentation of values of time depends on the segmentation used in the demand modeling. If demand projections are not available for different market segments, average values of time should be used. Most guidance provides recommended values or ranges to use, but suggests that local values should be used if available.

Values of time recommended for specific trip purposes are often derived from revealed preference or stated preference studies. Stated preference techniques are designed to uncover preferences at a high level of disaggregation by asking people how much they would pay for a change in service. Revealed preference techniques seek to use observed behavior to deduce values of time.

For business-related travel, the value of travel time savings to use in a benefits valuation may be based on the resource or opportunity cost of the time spent traveling. This may be estimated based on gross hourly variable labor costs. Further segmentation between location and mode may be achieved by complementary analyses or surveys of variation in salaries.

Table 2-2 and Table 2-3 below provide examples of values of time used in various countries for evaluating transportation improvements.

[2] Here we use travel time to mean total generalized travel time, including waiting time, access and egress times.

TABLE 2-2. VALUES OF TIME IN EUROPE

2002$ per passenger-hour, Resource costs

Country	Business	Commute -Short Distance	Commute - Long Distance	Other - Short Distance	Other - Long Distance
Denmark	22.56	6.06	7.78	5.09	6.52
France	24.97	9.87	12.67	8.27	10.62
Germany	23.57	6.80	8.73	5.71	7.32
Italy	25.20	9.99	12.82	8.38	10.76
Spain	24.39	9.31	11.95	7.80	10.02
United Kingdom	24.27	6.97	8.95	5.85	7.51

Source: HEATCo, 2005[3]

TABLE 2-3. VALUES OF TIME RECOMMENDED BY USDOT

2000$ per passenger-hour

Category	Short Distance	Long Distance
Personal	$10.60	$14.80
Business	$21.20	$21.20
All Purposes	$11.20	$15.60

Source: US Department of Transportation, Office of the Secretary of Transportation, 2003.
Revised Departmental Guidance: Valuation of Travel Time in Economic Analysis

The European values shown in Table 2-2 were prepared by HEATCo (2005), which was an effort that attempted to develop consistent guidelines for project assessment over a number of European countries. It provided, among other things, values of time by country derived from international meta-analyses of value of time studies. The HEATCo research demonstrates that there is a convergent estimate of the value of business time saved across European countries at around $24 (2002$), while the US values suggested by USDOT are slightly lower at $22.33 (adjusted from the Figure in Table 2.3 above to 2002$ prices by wage rate data[4]). There is more variation in values of time for commuting and leisure across Europe. However, the US values are significantly higher for non-work purposes.

The values of time presented in the tables above are national averages and can be used as default values in project assessment. USDOT guidance[5] recognizes that intercity travel time is likely to be more valuable than time spent in local travel, and this conclusion will generally apply in HSR assessment. Note that the average value of time will vary depending on the mode, trip purpose and project location. It is therefore recommended that area-, purpose- and location-specific values of time are used, particularly in the final stage of assessments.

<u>Assessment</u>

In-vehicle travel time is a first-order determinant of project benefits, and accurate estimation and valuation of travel time changes are essential for public benefits estimation at all levels of analysis. Values of time specific to a project area should be developed wherever possible.

[3] Developing Harmonized European Approaches for Transport Costing and Project Assessment (HEATCo 2005).

[4] Average Earnings Data 2000-2002, Bureau of Labor Statistics.

[5] Departmental Guidance for the Valuation of Travel Time in Economic Analysis. USDOT Memorandum. April 1997.

Most aspects of travel time valuation are well established. Areas of current research relevant to HSIPR valuation include the possible variation of travel time by length of trip (travelers who spend an extended time in a relatively comfortable environment may be able to work productively, whereas this might not be feasible for a shorter trip); and the valuation of small travel time savings (is there a social or economic value associated with saving miniscule amounts of time). Reviewers should remain informed about progress in understanding these issues.

Waiting, access, egress time

Waiting, access and egress time are usually included in the overall generalized travel cost along with in-vehicle travel time. Different components of the total travel time may be perceived as differently onerous by travelers and so the monetization of these components may involve different values of time or, equivalently, different factors that multiply the value of in-vehicle travel time.

Within UK appraisal guidance, for example, non-work time spent waiting is imputed a value that is two and half times that of in-vehicle time. This reflects empirical evidence that people will pay considerably more to reduce the time spent walking and waiting than they will for an equivalent saving in time spent riding in a vehicle. This approach does not extend to business travel, however: in terms of the resource cost to a firm (or the economy) of lost time, it is irrelevant whether the time is spent waiting or traveling. As regards the inconvenience to the traveler associated with waiting, it is assumed that if a job requires regular travel, the traveler is compensated for any associated inconvenience through his or her wage.

Frequency of service affects both waiting time and schedule delay (the difference between a traveler's desired time of arrival at a destination and the actual arrival time imposed by the service schedule), and so is usually incorporated in benefits valuation in some way.

In the UK, headway penalties are applied that reflect (i) the relationship between headway (the time between vehicle arrivals) and average waiting time; and (ii) the weight given to waiting time compared with ride time. In particular, these penalties reflect the fact that wait times may not vary directly with headways since, when service intervals are long, passengers tend to schedule their arrival at a station or stop based on the expected arrival time of the vehicle. Table 2-4 below gives some indicative headway penalties that are used by the UK *Passenger Demand Forecasting Handbook* (PDFH), split by different types of fare-paying passengers. The headway penalties may also vary by other factors such as total in-vehicle travel time: the longer the trip, the less important is the headway. For detailed modeling and evaluation, the PDFH recommends distinguishing between passengers who plan their trip and those who do not, as well as by trip purpose[6].

In the US, it is perhaps more common to estimate directly the amount of wait time and to weight it appropriately in the benefits valuation. For frequent irregular services (such as urban buses), the wait time is usually assumed to be half the service headway; but for less frequent scheduled services (such as rail), the wait time may be less than this value since, as noted above, many travelers will use the schedule and their assessment of service reliability to time their arrival at the station.

Weighting factors for access/egress times tend to reflect the uncertainty about travel times to/from stations or stops. This applies to car access in particular, whether it is by single-occupant (self-driven) vehicle or via pick up/drop off. Congestion contributes to this uncertainty, and so commuter travel often exhibits higher weighting factors for these time components.

[6] PDFH, June 2005.

TABLE 2-4. EXAMPLES OF HEADWAY PENALTIES

Equivalent Time Penalty (minutes)		
Headway (minutes)	Full fare & season passengers	Reduced fare passengers
5	5	5
10	10	10
15	15	14
20	19	17
30	26	21
40	31	23
60	39	27
90	51	33
120	63	39
180	87	51

Source: PDFH, 2005

In urban transportation planning, it is common to apply values of time to the out-of-vehicle time components that are two to three times higher than that for in-vehicle time. For high-speed rail planning, however, out-of-vehicle time values tend to be closer to the value of in-vehicle time.

As a final comment, the values of time used in ridership forecasting should reflect the relative weighting that travelers place on non-ride time components, and these should reflect observed behavior where possible. In some circumstances it may therefore be perfectly valid for different values of time to be applied during forecasting, but a single value used in public benefits assessment. For example, from society's point of view all business-related travel time components may be weighted similarly (to align the benefits measure with true economic output changes), but there may be reasons why workers react differently to different time components in their travel behavior. As before, the specific values used to monetize travel time components for forecasting should ideally derive from locally-performed willingness to pay studies.

Assessment

It is usually important to account for waiting, access and egress times in a public benefits assessment, although there is greater variation in the methods for doing this than is the case for in-vehicle time. Urban transportation modeling approaches almost always weight out-of-vehicle time components more heavily (i.e. impute a higher time value to them) than in-vehicle time, in recognition of their typically greater perceived contribution to travel disutility. On the other hand, there is evidence that, for HSR, the difference between travelers' valuations of in-vehicle *vs*. these out-of-vehicle components is less than is typically the case for urban transit modes (i.e. the corresponding values of time are more nearly equal). Reviewers should verify the reasonableness of the assumed relationship between service frequency and wait time.

Out-of-pocket cost

Out-of-pocket costs are an important generalized travel cost component. For public transportation this is typically the fare; automobile out-of-pocket costs typically include fuel and toll payments.

Assessment

User out-of-pocket costs (rail fares) are generally an important determinant of project benefits. For a service that is not competitively provided, fares are considered as a pure transfer between the user and the operator. Therefore, a fare increase will negatively affect the passengers who continue to use rail after the increase (reduced consumer surplus), but this may be offset by increased revenues to train operators (increased producer surplus).

For rail trips that are made both before and after the fare change, there is a zero net benefit. For a rail fare decrease that attracts new rail trips, however, the fares have already been taken into account by the individuals shifting mode, reducing travel cost on the original mode. Their benefits, already net of any fares, are measured by application of the rule of a half. On the operator's side, the additional fares from new travelers mean higher revenues (whether or not the fares have changed). Since the travelers' impacts are already included in the rule of a half assessment, these revenue gains are net additional benefits. In aggregate therefore, new rail revenue should be incorporated as a benefit.

Take an example of two individuals traveling between the same origin and destination. By automobile the trip takes 60 minutes and costs $10. By rail the trip takes 90 minutes and costs $5. Person A has a value of time of $5 per hour, which means that the generalized trip costs are $15 by car and $12.50 by rail, and rail is the preferred mode. Person B has a value of time of $15, meaning that the car is cheaper at a generalized cost of $25 versus $27.50 by rail.

A new investment speeds up the rail trip to 60 minutes, but it now costs $7.50 instead of $5. The impact for Person A is straightforward: $2.50 worth of time savings minus $2.50 of fare increase. For Person B, the cost of rail has now fallen to $22.50 and is now cheaper than car. The user benefit is calculated from the rule of a half as $2.50 (($27.50-$22.50)/2).

For the operator, the impacts are $2.50 in increased fare from Person A and the $7.50 fare from Person B. The following table summarizes the impacts:

	Person A	Person B	Total
Time	$2.5	$0	$2.5
Fare	-$2.5	-$7.5	-$10
Car generalized cost	$0	$10	$10
Total user benefit	**$0**	**$2.5**	**$2.5**
Operator Revenues	$2.5	$7.5	$10
Net	**$2.5**	**$10**	**$12.5**

As can be seen, the impacts of fare payments on users are exactly offset by revenues to the operator. For existing user A, that leaves $2.50 worth of time savings. New rail user B receives a $2.50 saving after having paid the higher rail fare. In addition, the operator receives a $7.50 increase in revenues.

One could go through these calculations by identifying all the above impacts for new rail travelers. That would, however, require the analyst to know the precise value of each of the travel cost components of the original modes. The benefits assessment framework provides a much easier route to arriving at the same answer: time savings as calculated by the rule of a half, plus changes in revenues to the operator.

Travel quality

Travelers can also derive benefits from improvements to trip attributes other than time and cost; these are sometimes called *non-traditional level of service attributes*, but will be referred to simply as elements of *travel quality* here. These can include, among other things, the on-board facilities and environment, the security of the trip and the available travel information. While it may be difficult to define exactly what constitutes travel quality, it may nonetheless be appropriate to account for it in a benefits assessment, particularly in later stages of study. Commonly-used travel quality elements are discussed in the sections below. Again, these may also be included in an EMPU or logsum calculation.

Crowding

When demand is near capacity, a project that increases rail capacity may produce benefits by reducing crowding. This is because poor travel conditions (e.g. overcrowding) may reduce willingness to pay for a travel time saving (HEATCo, 2005). There is also a negative relationship between crowding and the ability of travelers to make productive use of time on the train.

Comfort

Another potential HSIPR benefit is an improvement in quality of the travel experience. In the US, this is sometimes referred to as *comfort*, while in the UK it is referred to as *ambience*. The International Union of Railways (UIC)[7] gives an example of in-depth assessments that were undertaken into the overall experience of traveling on high speed rail. The UIC investigated the benefits of new trains with modern features, spacious interiors, storage space, and facilities such as internet access. The physical experience of the trip was also taken into account, with improved HSR ride quality, noise levels and temperature control all able to add benefit over other transportation modes.

Travel time variance and reliability

Reduction in travel time variance and unreliability can be an important HSR benefit. Particularly where it runs on dedicated track, HSR may avoid congestion delays common on other transportation modes. In these circumstances, it also has a better ability to recover from unforeseen events more quickly than is typically possible on shared lines. Ongoing research provides evidence that reductions in travel time variability (or improvements in its reliability) tend to be valued more highly than savings in scheduled ride time[8].

Assessment

Travel time reliability has been found to be a significant travel choice factor, especially for business travel. Techniques to measure and predict it, however, are poorly developed, and this limits the extent to which public benefits assessment efforts are able to incorporate it in an overall evaluation.

The empirical evidence needed to enable the assessment of other trip quality improvements is also currently weak. Only where these are a particular aim of an investment or likely to form a significant element of public benefits should the quantification of quality gains be required. Reviewers should be cautious where a large proportion of claimed benefits are driven by valuations of quality factors. However, even in these cases the lack of existing data would require original and customized research into passenger valuations of trip quality.

Non-user benefits

A rail project may also produce benefits to users of other transportation modes, referred to as non-user benefits. The following sections discuss the main components of non-user benefits.

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[7] Société Nationale des Chemins de Fer (SNCF), 2008. “SNCF researches to meet customers’ satisfaction about comfort and services.” Presentation at the 6th World Congress on High-Speed Rail, Amsterdam.

[8] http://www.dft.gov.uk/webtag/documents/expert/unit3.5.7.php

Decongestion benefits

True high speed rail can have a competitive advantage on trips between approximately 150 and 400 miles. For longer and shorter trips, respectively, air and private auto are usually preferred. Within the competitive range, the provision of high speed rail services can have benefits for passengers traveling on alternative transportation modes if there is a significant shift by travelers to the new high speed services. In the US, it is estimated that the great majority of trips on new HSR lines will be diverted from other modes. It is widely accepted that, for such projects, induced travel should be less than around 10% of total HSR ridership.

However, the "transformational" nature of the rail service is relevant here. Where the service improvement opens up new and attractive destinations, the proportion of new trips may be higher (for example the European Channel Tunnel service linking London with Paris and Brussels). Also, there may be specific city pairs that have infrequent air service and would benefit greatly from frequent HSR service (for example Central Valley cities to Los Angeles and San Francisco on the proposed California HSR system). For these city pairs, the proportion of induced travel might be much higher than 10%. The ridership and revenue forecasting task should examine and resolve the issue of new travel induced by a HSR project, with the results of these forecasts used in the public benefits assessment task.

Highway decongestion

If diversions by automobile users to HSR lead to less traffic and higher speeds, highway decongestion may be a possible source of benefits. These benefits will result from travel time savings and possibly from reduced automobile vehicle operating costs – although the latter may be negative if highway speeds are already high. The importance of such impacts will depend on the level of congestion on the highways that directly compete with HSR. Of course, the great majority of trips on congested highway networks are urban trips, especially peak period commuting trips. Diversions to HSR are likely to be a tiny fraction of this total, and so claims that a HSR project will produce significant highway decongestion benefits should be critically examined. The US *Highway Capacity Manual*[9] can be used to predict the travel time and level of service on roadways at different traffic volumes.

Typical values of marginal congestion cost per vehicle are often available, but these values should ideally be specific to each study area and type of road. The *Railway Project Appraisal Guidelines* (RAILPAG)[10], a framework commonly-used in the EU for railway project appraisal, suggest using the World Bank Highway Design Model (HDM) with local data to estimate changes in vehicle operating costs resulting from road decongestion. A recent US rail evaluation used an average vehicle operating cost per mile of $0.58 for an average of small, medium and large cars and SUVs, based on data from the American Automobile Association[11]. It is less common in the US to account for the effects of different congestion levels on vehicle operating costs, although tools for this purpose, such as the FHWA's Sketch-Planning Analysis Spreadsheet Model (SPASM), are available.

Air decongestion

The introduction of high speed rail can impact air travelers through two main effects. If competing air connections are close to capacity, diversion of demand from air to rail may substantially relieve air delays, producing travel time savings for the remaining air passengers and operating cost savings to the airlines. On the other hand, if there is a significant reduction in demand for air, as has been seen on several high speed rail connections in Europe, there may be a reduction in air departure frequencies, which will be a disbenefit

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[9] Transportation Research Board, *Highway Capacity Manual 2010*.

[10] EU Commission and European Investment Bank, 2005. Railway Project Appraisal Guidelines.

[11] Economic Development Research Group Inc, 2010. Economic Impact of Passenger Rail Expansion along the New Hampshire Capital Corridor.

for remaining air travelers on the route. In extreme cases (for example, Paris-Lyon or, say, New York-Boston with true HSR), the airlines may substantially reduce the frequency of air service as most air travelers shift to rail; however, in such cases the user benefits will greatly outweigh the non-user disbenefits.

Air passenger diversions to rail might not lead to airport decongestion if the airlines respond to the freed-up capacity by introducing new routes or services. There may be substantial travel benefits from these new air services. Scenario testing can be used to examine the competitive responses of airlines to the introduction of high speed rail service. Aided by surveys, such analyses can be used to estimate the non-user benefits to air travelers where mode shift to rail is thought to be important.

A rigorous assessment of non-user benefits must therefore carefully evaluate the likely reduction in operations (if any) that would be produced by the diversion of air passengers to HSR, and determine the most likely future levels of airport operations and airport capacity in the absence of HSR.

Future levels of airport operations are projected in the activity forecasts produced internally by many major airports, as well as the Terminal Area Forecasts (TAF) produced by the FAA for all airports with commercial service in the US. These forecasts typically provide estimates of both future passengers and future operations, and therefore implicitly take into account changes in fleet mix expected to occur over time. The level of passengers per operation in the forecast year of the HSR study should therefore be used to translate the reduction in air passengers from diversion to HSR into the estimated reduction in airport operations used in the benefits analysis.

The estimated delay reduction described above can be converted to time savings per passenger by dividing by the average number of passengers per operation (again using this ratio as computed using the forecasts of operations and passengers for the forecast year). The time savings per passenger can then be translated into a dollar value of benefits by applying a value of travel time savings.

Values of time used for the estimation of time savings benefits should be project-specific, and generally consistent with those used in the ridership forecasts. More specifically, the benefits analysis should use values of time derived from the mode choice models used to produce the ridership forecasts. If a preliminary proposal does not involve the application of mode choice models (or otherwise make use of project-specific values of time in estimating ridership), standard values should be used.

The USDOT's regulatory guidance provides values of time for use in economic analysis, and these same values are also published in the FAA's official guidance for investment and regulatory decisionmaking.[12] For reference purposes the relevant values from these publications are summarized in Table 2-5.

TABLE 2-5. VALUES OF AIR TRAVELER TIME SAVINGS

Trip purpose	Value of time 2000$/pax-hr	Sensitivity Range	
		Low	High
Personal	$23.30	$20.00	$30.00
Business	$40.10	$32.10	$48.10
All purposes	$28.60	$23.80	$35.60

Source: US Department of Transportation, Office of the Secretary, *Revised Departmental Guidance - Value of Travel Time in Economic Analysis*, Revision 1, Tables 4 and 5, February 11, 2003.

[12] GRA, Incorporated, *Economic Values for FAA Investment and Regulatory Decisions: A Guide*, Final Report, Revised Oct. 3, 2007.

There may also be other ancillary benefits that result from the diversion of air passengers to HSR that are not directly related to aircraft operations. For example, a reduction in the volume of air passengers using an airport may reduce ground access congestion, resulting in additional time savings to passengers. Likewise, fewer flight delays may lower the costs to the airlines of ground operations (gate personnel and ramp workers who are paid on an hourly basis). These benefits have generally not been included in the public benefits assessments of proposed HSR systems. They are likely to be small in comparison to the other non-user benefits described above, representing second order effects.

Rail decongestion

High speed rail on dedicated track has the potential to reduce congestion and traffic on existing rail lines for other services[13]. This can be especially important in the case of heavily used commuter rail lines, and major freight rail lines. Diversions to HSR may result in a reduction in crowding, travel time and crashes, and an increase in reliability and capacity for the remaining users of the traditional rail services. These diversions from conventional rail may also deliver savings in the cost of operating the rail services. If relevant, this should be assessed as part of the rail operating cost estimates discussed elsewhere in this report.

Assessment

The highway decongestion benefits of a rail project will usually be small to negligible, and in most cases reviewers should critically examine claims of significant project benefits from this effect. The extent of airport decongestion benefits will depend in part on the response of airlines to the introduction or improvement of rail service. A study's assumptions in this regard should be reviewed and assessed as to their reasonableness. The magnitude of rail decongestion benefits will depend strongly on the characteristics of the corridor in which the project will operate.

In all cases, the cost to a study of assessing non-user benefits can be significant. It is therefore important to come to a view early in the project appraisal process on which effects are likely to be important so that appropriate levels of resources can be allocated to more detailed quantification and valuation of non-user benefits at later stages of the project assessment.

Environment

In general, the scope of environmental effects of an HSIPR project should be considered at an early stage in assessment. FRA guidance[14] suggests that factors such as air quality, water quality, noise and vibration, impacts on endangered species or wildlife, flood hazards and floodplain management, coastal zone management, efficient use of energy resources, aesthetic and design quality impacts, land use and impacts on the socioeconomic environment ("liveability") should all be included in an assessment. These project impacts may be experienced at the local level, the regional level, and/or the global level.

The FRA guidance only identifies the impacts that should be considered: the extent of analysis in a benefits assessment, and the corresponding level of effort, need to be proportionate to the likely effect of the impact on the evaluation results. Environmental impacts are an integral part of the planning process and critical to alternatives assessment. However, in part due to the difficulties in measuring and monetizing environmental impacts, these tend to have a small overall impact within a strictly quantitative cost-benefit analysis. Due to this difficulty in valuing environmental benefits, they are often described qualitatively, although techniques to improve the robustness of quantification and monetization have been developed and

[13] De Rus et al, 2009. Economic Analysis of High Speed Rail in Europe.

[14] Department of Transportation, Federal Railroad Administration, 2010. High-speed Intercity Passenger Rail (HSIPR) Program, Notices, Federal Register.

are increasingly in use in countries such as Sweden, Mexico and the UK. Specific examples are given under each impact below.

Noise

The noise generated by a rail project is among the most commonly considered environmental impacts. Noise impacts can occur directly through additional rail lines or through more frequent or faster services. These disbenefits may be partially offset via mode shifts and the reduction in noise from less air or highway traffic. In practice, however, the latter are unlikely to be significant.

In order to assess the impacts of changes in noise levels from the introduction of a high speed rail project, HEATCo recommends a valuation based on the number of people exposed to a certain noise level before and after the introduction of the project. In the Nash 1991[15] study, evidence from a range of work is cited in concluding that a high speed rail route and a highway would create approximately the same level of noise, but that widening an existing road would have less of a noise impact than implementing a new rail line unless the rail line was located in an existing noisy corridor.

To assess a change in noise level, Denmark has developed a noise annoyance index to express the impact upon the inhabitants of dwellings surrounding a project. This takes into account inhabitants' perceptions of the noise level as measured in physical terms. A unit price is then attached to the index to include annoyance costs (observed from individuals' behaviors such as house prices) and health costs (long term health effects caused by noise exposure). Table 2-6 provides values used in some European countries.

TABLE 2-6. EXAMPLE NOISE EXPOSURE COST FACTORS

2002$, factor costs, per year per person exposed[16].

Lden[17]	**Denmark**			**France**			**Germany**		
dB(A)[18]	Road	Rail	Aircraft	Road	Rail	Aircraft	Road	Rail	Aircraft
≥51	12	0	19	8	0	14	9	0	14
≥66	194	133	301	143	98	221	147	101	227
≥81	525	464	731	385	341	538	397	351	553
Lden	**Italy**			**Spain**			**United Kingdom**		
dB(A)	Road	Rail	Aircraft	Road	Rail	Aircraft	Road	Rail	Aircraft
≥51	8	0	12	7	0	9	10	0	16
≥66	126	86	196	99	68	153	161	110	249
≥81	341	302	476	268	237	373	434	384	605

Source: HEATCo, 2005

Most other European guidance on noise assessment gives recommended values to use for valuing the change in noise levels; however local values are again preferable.

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[15] Nash, 1991. The Case for High Speed Rail. Institute of Transport Studies, University of Leeds. Working Paper 323.

[16] Notes: The central values comprise the WTP for reducing annoyance based on stated preference studies (see Working group on health and socio-economic aspects, 2003. Valuation of Noise. Position paper of the Working group on health and socio-economic aspects) and quantifiable costs of health effects.

[17] Lden (level day-evening-night) is a measure of continuous noise that gives extra weight to night time noise in recognition of its more disruptive impact.

[18] dB(A) is the measure of decibels from a frequency response curve that resembles the normal frequency hearing curve for most people.

Assessment

The HEATCo research demonstrated that relatively low levels of rail-produced noise (<51 dB(A)) are not perceived as a problem. This is a consensus across the six European countries surveyed. There is also a consensus that for a given level of dB(A), rail noise is perceived as less of a problem than equivalent air or car noise. The values assigned to rail noise vary across countries, with the willingness to pay for amelioration of "high" noise (>81 dB(A)) ranging between $237 and $464 (2002$).

One of the difficult issues in assessing noise impacts is establishing the population affected. For direct impacts of new/enhanced rail services, this is required as part of planning approval in many countries. The methodology for measuring noise nuisance impacts has been well established as part of the methodology of Environmental Impact Assessments; however, this detailed analysis is sometimes not incorporated in less detailed work. Establishing the benefit from highway traffic noise reduction is more challenging: in general the change in traffic volumes from diversion to rail is unlikely to lead to a perceived change in noise levels.

The methods for measuring and valuing noise impacts are theoretically sound but challenging to implement. In practice, noise mitigation measures (such as sound barriers) can do much to ameliorate significant impacts. However, typically these will not be designed until the detailed design stage of the project, which normally follows evaluation and funding approval.

Air quality

The introduction of a high speed rail service is likely to have little impact on local air quality as the lines are electrified. Travel shifts from other modes in the corridor may reduce total emissions; however, mode shift changes are likely to have too dispersed an impact to affect local air quality. The exception may be in the vicinity of city center stations, particularly if significant car parking is provided. To assess quantitatively the impact on local air quality, the changes in vehicle emissions from a project need to be calculated. These should be based on forecast changes in vehicle usage and manufacturer guidelines or national vehicle emission rates. The spatial definition of the air quality management area is critical. Likely future improvements in vehicle fuel efficiency and emissions controls should be taken into account when forecasting future emission rates. To convert these emissions into monetized benefits the simplest calculations are based on a cost per ton of pollutant emitted.

The FRA's 1997 Commercial Feasibility Study[19] suggested that sulfur dioxide emissions be valued at $600 per ton. A study of rail expansion along the New Hampshire Capital Corridor[20] estimated particulate matter (PM) emission costs at $938 per ton and nitrous oxides at $1,376 per ton in 2009. Climate (emissions credit) exchanges, where they exist, can provide current market-based prices from trading results for each type of emission, and these can be used to calculate emissions prices.

Assessment

More sophisticated techniques may take into account the size of the surrounding population and emission dispersal rates to value the impact of the change in air quality; however, the guidance reviewed does not suggest a methodology for doing this. When using monetary values for emissions, it must be explicitly noted what impacts are being included. This is typically a failing in existing studies, with some valuing the impact on welfare loss due to death and illness, production loss and rehabilitation, agriculture production loss and corrosion and blackening of buildings and mitigation costs. Some studies also apply different values according to whether the pollution will occur in a built-up area or not.

[19] Federal Railroad Administration, 1997. High-Speed Ground Transportation for America.

[20] Economic Development Research Group Inc, 2010. Economic Impact of Passenger Rail Expansion along the New Hampshire Capital Corridor.

TABLE 2-7. EXAMPLE ROAD TRANSPORTATION EMISSION COST FACTORS

2002$, factor prices, per ton of pollutant emitted[21]

Pollutant emitted	NOx	NMVOC	SO2	PM2.5	
Effective pollutant	Crops	O3	Deposition, Crops	Primary PM2.5	
Local environment				Urban	
Denmark	1,692	752	1,786	488,800	Outside built-up areas
France	4,324	752	4,042	404,200	50,760
Germany	2,914	1,034	4,230	404,200	78,020
Italy	3,008	1,504	3,290	347,800	75200
Spain	2,538	470	1,974	263,200	65,800
United Kingdom	1,504	658	2,726	423,000	38,540

Source: HEATCo, 2005

TABLE 2-8. CO2 EMISSIONS BY MODE (US)[22]

	Pounds CO2 Emissions per passenger mile
Private Auto	0.96
Bus Transit	0.64
Heavy Rail Transit	0.22
Light Rail Transit	0.36
Commuter Rail	0.33
Van Pool	0.22

Carbon emissions

The valuation of carbon dioxide emissions from the construction and operation of a high speed rail project may also be included in the environmental analysis. This should include at a minimum the CO2 associated with electricity generation for the rail line, which will depend on the generation methods that are used. The valuation should also incorporate savings in CO2 emissions on modes from which high speed rail passengers have transferred. Some studies also account for the emissions associated with the project construction and rolling stock manufacture, although this is less common.

Transportation represents 29% of US greenhouse gas emissions[23]. The average CO2 emissions per passenger-mile from the operation (but not the construction) of each mode in the US are compared in Table 2-8.

To value the impact of carbon emissions generated by a project, most countries use a unit cost per ton of CO2; representative values are shown in Table 2-9. In Sweden this is based on the state-determined

[21] Notes: Cost categories included are: human health, crop losses, material damages. Values are applicable to all emissions at ground level (e.g. diesel locomotives).

[22] Public Transportation's Role in Responding to Climate Change. FTA January 2010.

[23] U.S. Environmental Protection Agency, Inventory of Greenhouse Gas Emissions and Sinks: 1990-2007, April 2009.

taxation of CO_2 as an estimate for the socio-economic costs resulting from CO_2 emissions. The Netherlands' guidance suggests that the costs of measures to reduce emissions can serve as shadow prices. The recommended values from HEATCo combine both these methods.

TABLE 2-9. EXAMPLE CO2 EMISSION UNIT COSTS

	CO2 $2004/ton
Denmark	39
France	26
Germany	204
Japan	20
New Zealand	12
Norway	12
Sweden	212
UK	115

Source: PIARC Technical Committee on Economic and Financial Evaluation (C9), 2004
UK from WebTag estimated value for 2004

A 1997 FRA[24] study suggests that CO_2 emissions be valued at $15 per ton. The study into rail expansion along the New Hampshire Capital Corridor[25] estimated CO_2 emission costs in 2009 at $6 per ton of CO_2.

Assessment

While the method for calculating CO_2 emissions quantities is straightforward, there is significant variation by country in the monetary value imputed to CO_2 emissions. In the US, there is no general consensus or official guidance regarding the assessment of project-related CO_2 emissions changes.

Landscape/Townscape

High speed rail services can cause visual intrusion or change the appearance of the surrounding viewscape. The effect of this is difficult to quantify; most of the guidance reviewed included landscape impacts under non-monetized impacts or simply assigned a positive or negative score for the impacts. Because of widespread NIMBY ("not in my backyard") opposition to new rail lines, this is an area deserving of considerable attention.

Assessment

It may be possible to carry out project specific research to obtain data on willingness to pay for viewscape quality, although this is rarely done. Nevertheless in order to identify high speed rail's impact on the environment, it is important to assess the environment in which the high speed line will be situated, the topography where it will be located, whether a new transportation corridor will need to be created, the characteristics and quality of the landscapes that it traverses, and the character of the built-up areas and

[24] Federal Railroad Administration, 1997. High-Speed Ground Transportation for America.

[25] Economic Development Research Group Inc, 2010. Economic Impact of Passenger Rail Expansion along the New Hampshire Capital Corridor.

population centers[26] that it will affect. This would be valuable input to (necessarily political) decisions about responding to any NIMBY opposition.

Travel safety

To value the impact of changes in transportation safety resulting from a HSIPR project, the first step is to estimate the change in crash numbers. This may be based on data about local crash levels by different modes or from national statistics about crashes by mode.

Crashes are generally distinguished in categories based on the nature and severity of injuries and damages; for example:

- Fatality: death within 30 days for causes arising out of the crash;
- Serious personal injury: casualties who require hospital treatment and have lasting injuries, but who do not die within the recording period for a fatality; and
- Slight personal injury: casualties whose injuries either do not require hospital treatment or quickly subside following treatment.
- Property damage only (PDO): crash without casualties

The valuation of a crash can be divided into direct economic costs, indirect economic costs and the value of safety *per se*. HEATCo recommends using the following values:

- Value of safety: WTP for safeguarding human life based on stated preference studies carried out in the country concerned;
- Direct and indirect economic costs of injuries (mainly medical and rehabilitation costs, administrative costs of the legal system, and production losses): cost values for the country under assessment; and
- Costs of material damage from crashes: cost values for the average damage caused by PDO crashes in the country under assessment.

If local values are not available, then average values for crash rates by mode are usually available for use. De Rus[27] emphasizes that there has never been a fatality on a purpose-built HSR line and points out that the safety record of conventional rail is much better than that of cars. Therefore estimates of passenger diversions from car to rail will almost certainly result in a safety benefit. These benefits to diverted auto trips should also include the value of reduced incident-related delays to other autos.

The study of rail expansion along the New Hampshire Capital Corridor[28] estimated crash costs using crash rates per 100 million vehicle-miles from the Bureau of Transportation Statistics and converting from crash rates per vehicle to passengers affected by assuming 25 passengers per bus and 250 passengers per train.

[26] Nash, 1991. The Case for High Speed Rail. Institute of Transport Studies, University of Leeds. Working Paper 323.

[27] De Rus et al, 2009. Economic Analysis of High Speed Rail in Europe.

[28] Economic Development Research Group Inc, 2010. Economic Impact of Passenger Rail Expansion along the New Hampshire Capital Corridor.

TABLE 2-10. CRASH RATES PER 100 MILLION VEHICLE-MILES

	Property Damage	Personal Injury	Fatality
Auto	206	90	1.5
Transit	585	7.6	0

The AASHTO manual on User Benefit Analysis for Highways[29] provides information on the assumptions for average perceived user cost per crash.

TABLE 2-11. AVERAGE PERCEIVED USER COSTS PER CRASH

Property Damage	Injury (non-fatal)	All Injury Accidents	Fatality
$3,900	$138,100	$202,300	$3,753,200

Note: 2000$ and year 2000 crash rates

Assessment

Relatively detailed automobile crash rate data are available in the US at the national level and often more locally. The lack of US experience with true high-speed rail suggests that rates from other countries may need to be referenced, although in transferring such rates it will be important to recognize any differences regarding operations (mixed or dedicated), alignment and horizontal clearance specifications, and other factors that may affect safety performance.

Option values

The provision of a high speed rail line will also provide benefits that result from non-users having the option to use this service even if they rarely or never become users. This can be valued through an individual's willingness to pay for the option of having a service available; however, there is a risk of double counting when separating this from an individual's willingness to pay for his or her actual use of a service.

Assessment

Although the concept of option values is cited in guidance (e.g., WebTAG in the UK), it is rarely assessed in practice. It is most relevant where, for example, regular air or auto users may want to have rail service as a backup option in the event of extreme weather or other events.

Financial impacts

Operator revenues

As discussed in the section on fare impacts under User Benefits above, changes in rail operator revenues should be accounted for in a benefits assessment. Similarly, any changes in revenues to operators of other transportation services that are priced at other than competitive market rates, such as toll roads, should also be included. If the same entity operates both conventional and high-speed rail services, the revenue impacts of diversions should reflect both the revenue loss on the conventional and the revenue gain on the high speed service.

Tax revenues

More generally, a parallel situation exists for government revenues if a benefits assessment uses market prices rather than resource costs as the units of account. Recall that in this case transfer payments must be

[29] American Association of State Highway and Transportation Officials, 2003. User Benefit Analysis for Highways.

explicitly tracked, and so any change in revenues from indirect taxation should be accounted for as a benefit or disbenefit. For instance, government revenues from motor fuel taxes will fall if a high speed rail line successfully captures travel from automobiles and this should be included as a disbenefit. As another example, rail in the UK is exempt from value added tax (VAT), so increased rail ridership will cause a net reduction in VAT receipts if spending is diverted from VAT-liable expenditures to fares.

Extensions and modifications to benefits assessment

Finally, a project assessment may include additional benefits or involve alternative and less-conventional measurement techniques. The importance of these will vary from project to project and many are not currently included in conventional US project appraisal. It is important to note that not all of these are additional to the economic benefits captured in the assessment of benefits already described. For example, property value and job impacts may be of interest to decision makers, but they normally cancel out at a larger geographical level.

Wider economic impacts

Conventional assessments of transport benefits concentrate on capturing the direct benefits to users and non-users within the transportation sector. This disregards the potential implications of a project on the wider economy. This is not a problem, however, as long as the economy outside the transportation sector is in perfect competition. Under this assumption, the wider implications of the project represent the manifestation of the transportation benefits as individual actors adapt their behavior. Benefits may be transformed from time and costs savings into other effects, such as changes in prices, wages or the distribution of employment, but the end result of all such final impacts will be identical to the direct benefits.

The assumption of perfect competition is, of course, not a realistic one and recent research has exposed the potential implications for the assessment of transportation investments. Several effects have been identified that may cause the direct benefits of a transportation project to magnify (or, potentially, diminish) as they ripple through the economy.

Wider Economic Impacts (WEIs) is the term frequently used to describe the impacts on the public that conventional benefits assessment fails to capture because of deviations from perfect competition. They include:

- **Agglomeration economies**. Beyond time and cost savings, increased connectivity may allow firms to access a larger labor or product market and may facilitate increased interaction between firms, with resulting synergies of knowledge, resource and service pooling, etc. Indeed, these types of effects, called agglomeration benefits, are among the underlying reasons for why big cities exist. Improved connectivity effectively makes a city larger by extending the physical distance that individuals are willing to travel.
- **Imperfect competition effects**. Conventional assessment of time savings assumes that in transportation-using sectors, prices equal unit production costs at the margin. Hence, benefits to the economy from reducing time spent traveling during work are estimated as the equivalent cost savings to firms (gross hourly labor cost). However, it is generally not true that prices equal marginal costs. Some firms hold market power and are therefore able to extract a margin on top of their unit costs. Other firms have high fixed costs that need to be recovered through a price-cost margin. Since the real societal benefit of reduced work travel time is the value of what can now be produced using this time (rather than the firm's cost of that time), these price cost margins mean that conventional benefits assessment underestimates benefits.
- **Additional labor supply.** Where a transportation project improves connectivity between households and work places, the improved access to jobs may lead more people to take up work. While the

work/non-work decision is a private one, it will affect the rest of society through income tax. Conventional CBA only captures the benefits to the individuals traveling - the increase in income tax receipts is therefore additional to the time and cost savings.

- **More productive jobs.** Similarly, if a transportation improvement enables more people to work in productive city centers, the tax raised on any increased productivity is not captured in appraisal.

Methods for assessing WEIs are currently included in official guidance in England and Wales, and are being researched and developed in New Zealand:

- **England and Wales** – The original method for assessing WEIs was developed by the UK Department for Transport. The method is outlined as part of the official guidelines for the appraisal of transportation projects (webTAG)[30] and includes a detailed description of the calculations as well as the data and elasticities required to undertaken the analysis. Although the method is not yet officially required (its status is "in consultation"), it has been widely applied and it is expected to be used for major transportation investments.

- **New Zealand** – The official New Zealand manual for transportation assessments, the Economic Evaluation Manual (EMM)[31], describes the requirements for the assessment of agglomeration benefits from transportation projects. It is largely based on the UK method, but contains the local data required for its application. A further set of methods for the other WEIs has been developed, and is in the process of being included in the EEM.

The assessment of WEIs is furthermore recommended by guidance in the Netherlands[32], Scotland[33] and Australia[34], as well by in the European Union's manual for investment appraisal[35]. In Norway[36] and the US[37], research is underway with the view to include some or all of the above WEIs as part of requirements of transportation benefits assessments.

Assessment

Consensus over the existence and importance of these impacts has been building over time, both in academic circles and among practitioners. Methods used in other countries generally build on the approach originally developed by the UK Department for Transport and involve a set of additional analyses making use of much of the same data required by the public benefits assessment. However, additional data is needed,

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[30] See DfTs Guidance unit on Wider Impacts: (http://www.dft.gov.uk/webtag/documents/expert/pdf/unit3.5.14c.pdf)

[31] See NZTAs manual on evaluation: (http://www.nzta.govt.nz/resources/economic-evaluation-manual/volume-1/docs/eem1-jan2010.pdf)

[32] See NEI and CPB's Guide to Cost Benefit Analysis: (http://www.rijkswaterstaat.nl/images/Guide%20for%20Cost-Benefit%20Analysis%20I_tcm174-275340.pdf)

[33] See STAG unit on Wider Impacts: (http://www.transportscotland.gov.uk/stag/td/Part2/Economy/9.1.2)

[34] See Infrastructure Australia's Outline Prioritization Methodology: (http://www.planning.wa.gov.au/Publications/Downloads_GetFile.aspx?ID=1852&File=Appendix%20M.pdf)

[35] See European Commission's Guide to Cost Benefit Analysis: (http://ec.europa.eu/regional_policy/sources/docgener/guides/cost/guide2008_en.pdf)

[36] See the Norwegian Ministry of Transport's research specification: (http://www.regjeringen.no/en/dep/sd/tema/transport-og-telekommunikasjonsforskning/samferdselsforskning/transportforskning/program-for-overordnet-transportforsknin.html?id=416075)

[37] The ongoing TCRP project H-39 is reviewing US evidence for transit project agglomeration effects, with the intention of developing methods for including such impacts within FTA's evaluation guidelines.

such as on the relationship between economic density and productivity (agglomeration elasticities), labor supply elasticities and price cost margins; these are typically the outputs of custom local research.

Wider Economic Impacts have been found to add between 5% and 40% to conventionally-measured project user benefits. This means that the inclusion of WEIs in assessment may affect both the conclusions regarding the public benefits of individual projects, as well as the ranking of mutually exclusive project options. No research is currently available regarding these impacts for HSR projects in the US. Study reviewers will need to be alert to emerging US guidance regarding the incorporation of these impacts in project benefits assessment.

Second round impacts

An investment in HSR may reduce or delay the need for investment in other infrastructure such as highways, conventional rail or airports. For example, a road widening project along a corridor with new or improved rail service may be deferred or eliminated if there is sufficient mode shift from road to rail to reduce highway congestion and/or its growth. However, these other projects will themselves produce their own set of benefits, and the loss (or postponement) of these benefits must also be included in a proper assessment. Because of the potential extent and difficulty of quantifying these impacts, the cost savings and benefits loss from second round impacts are frequently not considered in US project evaluation, for practical reasons as much as anything.

In some cases introduction of a new HSIPR service may lead to a reduction in existing services. While operating costs may decrease as a result, some travelers may also experience a reduction in service levels. This can happen for example on a capacity-constrained rail line if a conventional service with many stops is replaced by a high speed service with fewer stops. It is therefore important that the demand modeling work reflects a realistic service offer in the scenario with high speed rail, and does not simply assume that a high speed service will be added to existing services. In some cases this may require a detailed operational analysis.

Assessment

The incorporation of second-round impacts in rail project assessment can be delicate because of its dependence on detailed assumptions regarding changes in the nature and timing of improvements to other infrastructure as a result of the rail project. If incorporated, the assessment of second round impacts must consider, in all impacted modes, both the avoidance (or deferral) of infrastructure costs, as well as the associated loss (or postponement) of traveler benefits. It is a mistake to consider only the cost-reducing impacts without also taking account of the reduced benefits.

As a rail project moves to increased levels of study detail, any assumptions about second round impacts should be increasingly reviewed and approved by official planning bodies such as state DOTs or local MPOs. In all cases the assumptions should be made explicit in a project assessment document.

Indirect impacts

Appraisals often quantify a range of indirect project impacts that typically include changes in land use (and the associated employment and population), property values and regional product. Although information about such impacts may be valued by decision makers, the impacts generally are not additional to the benefits captured as part of CBA; rather they represent the final incidence of the direct project impacts on users, and so represent a double-counting of those impacts. For instance, a project may increase the attractiveness of a location because it becomes easier to access. The fundamental project benefit consists of the time savings experienced by travelers to and from the location, but these gains may also manifest themselves in land value increases.

Following are examples of such indirect impacts that are sometimes considered in HSIPR project assessment:

- **Employment** - When building a high speed line there will be direct job creation from the construction of the line and the direct expenditure that will occur in the area around the high speed line. When valuing a project's employment impacts, it is important to assess the overall labor market, as the project might only redistribute jobs within the area rather than produce a net increase in the total number of jobs. Rail project construction may also create a local labor shortage, driving up labor costs to the possible detriment of the local economy.
- **Demographics** – High speed rail projects may encourage the relocation of people to an area through the expansion of businesses and economic growth there. However, a project may also have the opposite impact, with people moving away from an area as the ease of traveling to that area is improved. Kantor[38] suggests that with the reduced transportation time and cost made possible by high speed rail, development can occur outside the main cities. Conversely, HSR can increase the dominance of the major city, causing employment losses in specialized job categories in smaller cities along the HSR line. This may also result in the relocation of businesses and firms from expensive centers to inexpensive suburbs having good connections to associated locations. This has been seen in France, with firms locating in Nantes because of its good links to Paris.
- **Property values** – A high speed rail project can have a large positive impact on property values. Properties within walking distance of a station experience the highest price increases. The price effect tends to deepen over time as the system and usage mature, and properties in densely populated settings experience the greatest increases.
- **Productivity** – It is often claimed that transportation projects contribute to economic development though increased productivity. There are several channels through which improved transportation can affect productivity: reduced travel times and freight costs to businesses and wider economic impacts are probably the most important. However, it is important to note that such gains are, again, effects that are usually captured elsewhere in an evaluation and expressed as a different benefit. Business time savings and freight cost reductions, for instance, are normally already captured as time savings or decongestion benefits.

Assessment

In view of the potential for double counting benefits when considering indirect impacts, any incorporation of such impacts in a project's overall benefits assessment should be carefully examined. If these impacts are presented in order to provide a different perspective on a project's impacts, appropriate explanations and caveats about additionality and double-counting of benefits should be provided.

[38] Kantor, 2008. The Economic Impact of the California High-Speed Rail in the Sacramento/Central Valley Area.

3 Best practice

Overview of project progression

In notional terms, three stages of project development can be distinguished. At each stage, differing approaches and methods are used to study a project and ascertain whether it should be developed any further. The stages are:

- **Preliminary** – This is an initial screening of a project to investigate whether a project merits further analysis or to prioritize it among a long list of options;
- **Intermediate** – This is a more in depth analysis of a project to investigate whether it merits the significant efforts involved in final stage development and/or to select between broad engineering and service design variants; and
- **Final** - At this stage the purpose of study is to robustly demonstrate that the preferred alternative provides value for money, and possibly to select between a very small number of minor project variants.

This typology is only approximate, as an individual study may investigate different components at different stages (for example, due to the availability of data or prior work on some components). Moreover, a project does not necessarily transition sequentially through each of these stages but may, depending on circumstances, skip one or (rarely) more stages. Nonetheless, as a guide to the different possible levels of study, the typology is useful.

The previous section discussed the various benefits that should be investigated during the appraisal of a high speed rail project. This section will outline the level of investigation needed, the types of data used and the impact assessment method applied for each benefit at each of the three stages of project development. The exact focus for each project at each stage of development will, however, depend on what the main impacts are thought to be. If the main benefits are likely to be travel quality, relatively more effort should be spent on quantifying those gains than if the principal improvement is in travel time. As noted previously, many of the inputs used in a transportation project benefits assessment derive from the ridership and revenue forecasting activity. The stage of project development influences correspondingly the methods used for both demand forecasting and public benefits assessment.

The following sections elaborate on the methods and data needs corresponding to each of these levels of project development.

Preliminary stage

At the preliminary stage, the public benefits assessment should be developed to allow the project sponsor, stakeholders or funding authority to gauge the likely magnitude of the HSIPR project benefits and to determine whether there are any “show-stoppers”. The focus is generally on evaluating the reduction in generalized travel costs, and identifying (and quantifying if possible) any significant negative benefits. Preliminary stage analyses are frequently used to screen potentially large numbers of candidate projects in order to eliminate some and identify those most deserving of further study.

At this stage of analysis, benefits assessments are likely to be based on a correspondingly preliminary estimate of the ridership, travel times and costs. If other significant user benefits are anticipated, such as major improvements in travel quality or reliability, these will need to be explained and indicative estimates made. The assessment of non-user benefits should normally focus on impacts to other transportation system users (for example, highway crash reductions) and significant environmental implications. It will suffice to indicate whether the HSIPR will have a positive or negative impact on non-users and indicate its likely magnitude. A high level assessment of the revenue outcomes of the project should be made, based on the results of the preliminary stage ridership and revenue forecasting. Lastly, if the project is likely to provide significant wider economic impacts or other benefits, these can be highlighted at this stage, taking care to avoid double counting of these benefits with user benefits.

Where possible a monetized value should be derived for each impact, using unit values from guidance or previous projects; however, at this stage the rough magnitude of the positive or negative impact is generally sufficient.

TABLE 3-1. PRELIMINARY STAGE APPROACH TO BENEFITS ASSESSMENT

Element	Valuation
User Benefits	
Generalized travel costs	
To quantify the changes in generalized travel costs, high level estimates are needed for: • Demand with and without the project • Likely impact on travel time from the new project based on current project development. • Access, egress and waiting times to be included in overall travel costs. • Changes in out-of-pocket travel costs.	Values of time from government guidance and/or similar projects should be used to monetize the time savings.
Travel quality	
Assessment about whether the new project is likely to: • Reduce crowding on the network • Improve current levels of comfort and convenience • Improve travel time variance and reliability currently expected on the network.	Positive or negative, order of magnitude (low, medium, high)
Non-user benefits	
Decongestion benefits	
Likelihood that the project will encourage mode shift and from which modes	Positive or negative impact on air and highway congestion, order of magnitude (low, medium, high)
Environment	
Assess whether the project would have an impact on: • Noise levels in the corridor • Air quality in the corridor via mode shift effects • Carbon emissions using average emissions rates by mode • Landscape in the corridor	Positive or negative impact with "show-stoppers" identified, order of magnitude (low, medium, high)
Travel safety	
High level assessment of impact of project on crash levels	Positive or negative, order of magnitude (low, medium, high)

Element	Valuation
Financial impacts	
Revenues	
Estimation of impact on revenues	From ridership and revenue analysis
Extensions and modifications to the benefits assessment	
Wider economic benefits	
Identification of potentially significant benefits	Qualitative description
Option values	
Indicative value of extra mode choice	Positive or negative
Second round impacts	
Identification of potentially significant benefits	Qualitative description
Indirect impacts	
If desirable, an expression of the likely impacts on, for example, employment, incomes, productivity and property values. It is important to note that these impacts are not additional to benefits captured elsewhere.	Qualitative description

Common errors and pitfalls

Some HSIPR benefits assessment errors can be found in all study stages. One of the most common is for the different components of the study to base their analyses and conclusions on differing project definitions. The operating cost analysis, for example, might assume one service frequency while the ridership forecasts and/or benefits assessment assume a different frequency. Even if a study begins with a consistent project definition, it is easy for such divergence to occur as initial concepts are revised and refined, especially when work progresses at a quick pace and involves multiple groups having less than perfect communications.

Another potential cause of error across stages is the use of inconsistent units of accounts when quantifying different benefits. A choice must be made to either measure benefits in terms of resource cost or market value, where the former eliminates transfer payments (e.g. indirect taxes) and other price distortions to derive the true economic cost of consuming resources, whereas the latter uses actual traded prices and accounts for transfer payments through a separate tracking. Once the choice has been made, all benefits and costs must be expressed in the same unit of account.

Double counting of benefits is another very common error that reviewers should be alert to. Studies may incorporate extensions to standard benefits assessments (such as wider economic benefits, indirect impacts and others) that can make it easy for such errors to be committed. For example, in the current stage of knowledge about wider economic benefits in the US, the burden of proof is normally on the assessment study team to show that consideration of these factors does not constitute double-counting. Caution must be applied when reviewing such claims and clear demonstration and expert review of their robustness are required before they are accepted as a benefit.

Turning now to the errors and pitfalls common to preliminary stage studies in particular, assessments at this stage often rely heavily on professional judgment about the nature and magnitude of significant impacts, and about their monetization, because project-specific data is frequently lacking. This can cause both objective errors as well as a subjective upward bias in estimated benefits. Study reviewers should examine the reasonableness of the (many) assumptions that must be made for this stage of project assessment.

It is likely that the values of time used to monetize time savings will be obtained from government guidance or from other studies. The values used should be carefully reviewed as regards their relevance and applicability to the project study area.

The reliance on data and results from previous studies may also cause a failure to recognize the full range of impacts of a particular project. The impacts of HSR investments on, in particular, the environment, tend to be very project specific and it is important that such impacts are not discounted purely based on lack of significance in previous studies.

Intermediate stage

At the intermediate stage of project benefits assessment, a reasonably detailed project specification should be available, and intermediate stage travel demand modeling should have been completed. Using these sources, benefit quantification should be project-specific where possible, while the methods used to monetize the quantified impacts may refer to industry standards at this stage.

Ridership, travel times and costs, and access and egress times costs corresponding to the project specification should be quantified using the ridership forecasting results and monetized using standard figures. Where gaps still exist for quantifying particular benefits, data may be used from similar projects. Impacts on other modes can be assessed based on the predicted level of mode shift. As far as possible, data on environmental and travel safety impacts should be project specific, but at this stage results may still be used from other similar projects. A high level estimation of the financial implications of the project on users and operators should be made. Lastly, quantification of any wider economic impacts or other effects, if thought important, should be made at this stage.

At this stage the estimates of generalized travel cost changes should be relatively accurate, with appropriate values of time applied to the different parts of the trip and, and at least indicatively, differentiated by trip purpose and mode. Impacts on decongestion of existing modes (if any) or changes in travel safety should be quantified, using appropriate assumptions if not output by the demand forecasting activity. Additional assumptions may have to be made about externality impacts, such as emissions and time lost to congestion. If not part of the demand forecasting work, sensitivities should be tested around the quantified impacts.

Justified unit values should be used to monetize each quantified impact. These unit values (such as values of time, value of congestion, noise and crash externalities per mile traveled) may be drawn from guidance or manuals, or obtained from values used on similar projects. Where possible, they should be broken down (for example, by user type and mode) to provide a more detailed and accurate valuation of project impacts.

TABLE 3-2. INTERMEDIATE STAGE APPROACH TO BENEFITS ASSESSMENT

Element	Valuation
User benefits	
Generalized travel costs	
• The project specification should include information on service frequency and travel time. • Estimates of current travel times by other modes should be available. • To calculate access and egress times, the new rail station needs to be located and access/egress options identified. At this stage high level estimates by mode are satisfactory, based on planned service frequency patterns. • Estimates of the expected rail fare compared to alternative mode costs. • Intermediate stage ridership forecasts are available.	• Using the overall changes in travel time estimates, the impact should be monetized using recommended values of time from national guidance or similar projects. Values of time should be differentiated by trip purpose. • Separate values of time are usually used for changes in waiting, access and egress times as these are perceived to be more onerous. Values of time may again be differentiated by trip purpose.
Travel quality	
Drawing on data from similar projects, an assessment of the project's impact on travel quality should be undertaken. This should look specifically at: • Crowding levels • Comfort • Travel time variance and reliability	• Where changes in travel quality are not thought to be significant, it would be sufficient to perform a qualitative assessment of whether the impact is positive or negative and/or the likely order of magnitude. • However, if the project involves significant impacts on travel quality, it is recommended to quantified them.
Non-user benefits	
Decongestion benefits	
Estimation of mode shift should be used to provide a high level assessment of the impact of the project on congestion levels.	Travel time and cost reduction estimates based on mode shifts from existing modes and data on / estimates of travel time and cost externalities per mile.
Environment	
Using data from other projects, produce a high level assessment of the environmental impact in the corridor of the project, investigating specifically: • Noise levels • Air quality • Carbon emissions • Landscape intrusion	Using guidance regarding the monetized values for noise, emissions and carbon develop initial monetary impact. Landscape intrusion values are specific to the area and without specific project evaluation this is likely to remain a positive or negative judgment at this stage.

Element	Valuation
Travel safety	
Using estimates of current crash rates on existing links, estimated project crash rates and the mode shift, the overall change in crash numbers can be estimated.	The value of the change in crashes should then be monetized using the valuation of different crash types included in guidance.
Financial impacts	
Revenues	
Fare revenue stream based on anticipated fare structure and levels.	Revenue stream from ridership and revenue work
Extensions and modifications to the benefits assessment	
Wider economic benefits	
High level assessment of the potential for wider economic benefits in the corridor	If the preliminary analysis suggested that they are important, a high-level estimate of Wider Economic Benefits should be undertaken.
Option values	
If found to be important in the preliminary analysis, the catchment size for the new high speed line needs to be assessed in order to estimate the number of people who will be provided with enhanced travel opportunities.	Evidential discussion of potential benefits
Second round impacts	
Estimation of the magnitude of the cost and benefit deferral or reduction impacts on other infrastructure	Evidential discussion of potential impacts
Indirect impacts	
It may be desirable to express the impacts of the project in terms of changes in: • Employment • Demographics • Property values • Productivity	Where desirable and possible, high level estimates of such impacts may be made, noting that they are not additional to benefits captured elsewhere and should not be double-counted.

Common errors and pitfalls

Intermediate stage assessments typically entail a mixture of general professional judgment with data and values developed specifically for the project(s) under consideration.

Reliance by the benefits assessment on professional judgment regarding the nature, magnitude and quantification of significant project impacts should be carefully scrutinized. Assessments would be expected to provide analyses of the sensitivity of results and conclusions to the specific assumptions made, and situations where key conclusions of the assessment depend directly on such assumptions would be of concern.

Assessments at this stage may include some consideration and quantification of benefits associated with non-standard level of service attributes. The impact quantification and monetization methods used for such characteristics should be examined and judged as to their reasonableness and consistency with accepted approaches.

Many of the preliminary stage errors and pitfalls discussed above (discrepancies in project definition, inconsistent units of account, double counting of benefits) continue to be of potential concern in intermediate stage studies.

Final stage

At the final stage of study, the project specification will be essentially finalized (apart possibly from very minor variants of the project definition). All benefit valuations should be project-specific and derived from the detailed final stage demand forecasts.

Detailed ridership and mode shift information should inform more detailed monetization of the benefits. Changes in travel times should be valued by trip purpose and mode using project-specific values from the demand forecasts and local data. Travel quality benefits should be based on passenger demand levels and project specific valuations of non-traditional level of service attributes.

Decongestion benefits (if any) should be estimated from a detailed prediction of time savings from mode shifts, based on a comparison of present and future demand and capacity. Environmental impacts should be assessed and valued using data from the project's environmental review and using local values for the monetization of these impacts where possible. Similarly, estimation of project specific travel safety impacts (changes in crash levels) should be performed using local valuations where possible.

Assessment of the financial implications of the project on users and operators should be quite advanced. It is not unusual, at this stage of study, to have the detailed project financial and business planning become a separate study analysis task (not discussed here).

Detailed quantification of any anticipated wider economic impacts or similar effects should be performed and presented alongside the project direct benefits.

It is important at this stage that all relevant benefits should be monetized and included in the assessment in as detailed form as possible. All user and non-user benefits should be fully developed and included along with possible wider economic benefits of the project. In general, final stage HSIPR benefits assessment requires considerable detail and accuracy in the values used for monetization. Project-specific values should be derived from original data collection wherever possible. Detailed analyses of willingness to pay should complement relevant data gathered from existing sources. For important benefit elements, a range of sensitivity tests should be performed.

TABLE 3-3. FINAL STAGE APPROACH TO BENEFITS ASSESSMENT

Element	Valuation
User benefits	
Generalized travel costs	
• The project specification should include detailed information on frequency and travel time. Detailed demand forecasting will provide ridership information from which to value time savings. Any multi-modal modeling will show the effect of the new project on existing modes. However, if this is not available, assumptions based on mode shift and current travel times should be used. • To calculate access and egress times, the new rail station needs to be located and its access/egress characteristics analyzed. This may involve detailed consideration of the local population distribution and links to the station. Service frequency patterns can be used to calculate the average waiting time. • A comparison of the financial cost for the user of traveling by different modes, for high speed rail this will be the price of the ticket compared to the costs of the modes from which the users were diverted. For cars this would be a combination of mileage-based and toll and parking costs.	• From travel time information, any travel time impact should be monetized using either using recommended values of time or project-specific values. Values of time will typically be differentiated by trip purpose and by mode. Travel costs should then be compared between the build and no-build scenarios. • Values of access/egress and wait times will typically be developed from project-specific stated preference surveys. Government guidance and accepted practice may suggest or override these. • The total impact on travel costs in the base and project scenarios can be compared using ridership information by mode in the different scenarios.
Travel quality	
To assess the impact on travel quality the following factors should be investigated: • The level of crowding estimated using the demand forecasting results and capacity provision on the different modes. • The level of comfort will result from the facilities provided on board the train, as described by the project specification. • Travel time variance and reliability can be estimated from similar projects	Crowding benefits can be calculated weighting the time spent in crowded conditions by penalties based on the level of crowding. Penalties may be based on existing literature or project specific research. Travel quality levels may encourage in-vehicle working and impact the values of time, as time may be more productive than on other forms of transportation.

Element	Valuation
Non-user benefits	
Decongestion benefits	
The level of decongestion can be estimated from shifts from existing modes (air, highway) to the new project. This is achievable through network modeling if applicable.	Decongestion benefits will depend on the level of demand and capacity on the existing infrastructure. Reductions in airport delays can be calculated using airside delay models. Changes in auto travel times can be calculated using highway capacity methods. The impact on travel quality for public transit modes, especially commuter rail, can be calculated using rail operations models. Similar models can be used to quantify freight rail impacts.
Environment	
Each environmental impact should be assessed in detail: • The level of noise from the high speed train should be based on manufacturer specifications. Current transportation noise levels can be based on local measurements or vehicle specifications. An estimate of the population affected by the noise should also be undertaken. • Manufacturer's specifications of emission levels should be used to estimate the air quality impacts of the rail project. Emission levels for other modes should be empirically measured. • Manufacturer's specifications of carbon consumption should be used to estimate the CO2 impacts of the rail project. • Local area evaluations should be undertaken to assess the landscape intrusion impact of the introduction of a high speed rail link	Monetary values for noise levels, emissions and carbon should be used where available to value any changes. The value of any non-quantifiable impacts, such as on landscape intrusion, should be monetized using stated preference techniques, if at all possible; alternatively, they should be discussed qualitatively in detail.
Travel safety	
Current crash rates on air, highway and rail links should be assessed, and the change estimated from the VMT reduction in based on mode shift and ridership forecasts. HSR crash rates are almost without exception estimated to be zero for projects on dedicated track.	The value of the change in crashes should then be monetized using the valuation of different crash types and severities included in guidance.
Financial impacts	
Revenues	
The revenue stream for the project can be calculated using ridership demand forecasts and the fare assumptions. Any non-fare revenue (from retail sales on board the train or in the station including ground rents, advertising, etc.) should be estimated	Calculation of a long term revenue stream.

Element	Valuation
Extensions and modifications to the benefits assessment	
Wider economic benefits	
Unless found to be immaterial in the preliminary and intermediate stage, it is suggested that a quantification of the wider economic benefits in the corridor is undertaken.	Should be consistent with emerging guidance, and avoid double counting of user benefits.
Option values	
Unless found to be immaterial as part of the preliminary or intermediate analysis, the catchment size for the new high speed line needs to be assessed in order to estimate the number of people who will be provided with enhanced travel opportunities.	Magnitude of impact through benchmarking with similar projects.
Second round impacts	
Quantification of the magnitude of the cost and benefit reduction or deferral impacts of the project on other infrastructure.	Might be omitted. Accounting for cost reduction or deferral without considering lost or deferred benefits is an error.
Indirect impacts	
If desired, a full quantification for the other economic impacts should be undertaken. This could include: • Employment • Demographics • Property values • Productivity	No widely accepted methods exist for the quantification of indirect impacts, although many tools are in use. Any quantification will need to note that the impacts identified are not additional to benefits captured elsewhere, and caution against double counting.

Common errors and pitfalls

The caveats mentioned for preliminary and intermediate levels of study continue to apply at the final stage. However, at this stage there should be minimal reliance on assumptions or generic guidance that are not substantiated by reference to project-specific conditions.

Reviewers should pay particular attention to the quality of traveler surveys used to develop the models used in the forecasting task. (Of course, these models should also be reviewed as part of the ridership modeling due diligence, and specific review items are mentioned in the corresponding chapter of this report.) Model coefficients imply values relevant to benefits assessments (such as values of time and – in some cases – of non-traditional level of service attributes) that should be checked for their reasonableness to the project context.

Incorporation of extensions to conventional benefits measures will need to be fully justified, and the specific evaluation methods and values used will need to be reviewed as to their overall validity and specific applicability to the project. In a final stage assessment, for example, the decision to include wider economic benefits should be explained in full, with reference to specific aspects of the local economy that substantiate their incorporation. Similarly, inclusion of second-round impacts (avoidance or deferral of other infrastructure investments) will need to demonstrate a careful analysis of changes in the magnitude and timing of both costs and benefits of these other investments. As always, reviewers should be alert to possible situations of benefits double-counting, for example via consideration of indirect impacts.

4 Public benefits checklists

This chapter presents a ridership and revenue checklist in the form of a series of seven tables intended to be used by reviewers of HSIPR studies. Each table corresponds to one component of a HSIPR public benefits assessment, and lists various items related to the component that reviewers should be alert to. The seven components are:

1. Ridership
2. User benefits
3. Travel quality
4. Non-user benefits
5. Externalities
6. Operator revenues
7. Optional analyses

The checklist tables provide a reasonably detailed and comprehensive listing of items under each main component. Not all the items are expected to be included in all study stages. Preliminary and intermediate stage studies in particular might not include some of these items. The discussions in Chapters 2 and 3 will serve as helpful guides to reviewers in determining whether or not these items should be included in a study under review.

TABLE 4-1. RIDERSHIP CHECKLIST

Required Item	Methods
Origin – destination ridership data for:	These data are developed by the ridership and revenue forecasting activity using data and methods that will differ depending on the study stage.
• A no-build and one or more build scenarios	
• Two or more future years	
• Each market segment / trip purpose	

TABLE 4-2. USER BENEFITS CHECKLIST

Required Item	Methods
Origin-destination in-vehicle time data for the same segmentation as the ridership data (see Table 4-1)	These data are developed by the ridership and revenue forecasting activity using data and methods that will differ depending on the study stage.
Origin-destination access/egress times and costs for the same segmentation as the ridership data (see Table 4-1)	
Origin-destination headway penalties or wait times for the same segmentation as the ridership data (see Table 4-1)	
Values of time relevant to the study area, by purpose and future year	Existing data or study specific research

TABLE 4-3. TRAVEL QUALITY CHECKLIST

Required Item	Methods
Assessment of crowding relief on existing services	Project-specific analysis; vehicle capacities
Assessment of improvements in travel comfort	Project-specific analysis; vehicle specifications
Assessment of reductions in travel time variability	Project-specific analysis; reliability data

TABLE 4-4. NON-USER BENEFITS CHECKLIST

Required Item	Methods
Reduction in highway vehicle-miles traveled	Data on diversion away from highway travel
Decongestion benefit	Data on congestion externality per highway vehicle-mile traveled
Air decongestion	Project-specific analysis, if appropriate
Rail decongestion	From operating cost analysis

TABLE 4-5. OTHER EXTERNALITIES CHECKLIST

Required Item	Methods
Change in vehicle-miles traveled by mode	From ridership and revenue forecasts, plus data on diversion away from other modes
Externality per vehicle-mile travelled by type of externality and mode	Data on crash, air pollution and carbon externality per vehicle-mile traveled
Assessment of population affected by noise	Project-specific analysis of alignment, using GIS and technical operations details to identify spatial area and the number of residents affected
Assessment of noise externality	Data on externality per person affected

TABLE 4-6. REVENUES CHECKLIST

Required Item	Methods
Rail operator revenues	From ridership and revenue forecasts
Toll operator revenues	Assessment of reduction in highway volumes on tolled links, and average tolls per trip.

TABLE 4-7. OPTIONAL ANALYSES CHECKLIST

Required Item	Methods
Wider economic benefits	Based on published guidance and local data. Must avoid double counting of user benefits. Claimed impacts should be well-justified.
Option values	Project-specific analysis, if appropriate.
Second round or indirect impacts	Project-specific analysis. These are not additional to benefits captured elsewhere, but may be of interest to decision makers. Impacts considered from investments avoided or deferred in other modes should consider costs as well as benefits eliminated or deferred.

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