Cost-Benefit Analysis (CBA) and Cost-Effectiveness Analysis (CEA) in the RESTRAIL framework

1.1 Introduction and definitions

Cost Benefits analysis can be defined as a systematic process for calculating and comparing benefits and costs of several projects using the following steps (Commonwealth of Australia, 2006; Meunier, 2009):

- Identify alternatives
- Define alternatives in a way that allows fair comparison
- Adjust for occurrence of costs and benefits at different times
- Calculate monetary values for things that are not usually expressed in money
- Cope with uncertainty in the data
- Sum up a pattern of costs and benefits to provide the support for decision making

There are some alternatives to formal CBA when outcomes cannot (or can hardly) be quantified. First, one can attempt to attach monetary values to benefits so that they can be measured on the same basis as costs. Second, is to quantify benefits and determine ratios of the quantity of benefits per spent monetary unit, i.e. what is called a cost effectiveness analysis (CEA) (Commonwealth of Australia, 2006). At a very general level, these two techniques can be theoretically defined below, adapted from World Road Association, Technical Committee C2, safer road operations (2012):

$$\text{Cost Effectiveness Analysis (CEA)} = \frac{\text{Number of accidents /or incidents prevented}}{\text{Cost of implementation}}$$

$$\text{Cost Benefits Analysis (CBA)} = \frac{\text{Present value of all benefits}}{\text{Present value of the implementation costs}}$$

Making the CEA and CBA of different safety measures comparable requires relating both the assessed performance and the costs of implementing the measure to a certain time reference (World Road Association, Technical Committee C2, safer road operations, 2012).

1.2 Collected data for costs, effectiveness and benefits assessment

Different types of measures for costs can be used. Implementation costs are those related to all means of production (labour and capital) that are employed to implement the measure. Maintenance and operation costs are those related to the maintenance and operation of the measure. Secondary effects of implemented measures (i.e. effects on other field(s) such as safety, environment, mobility etc.) can be eventually considered; given that the effect can be established and can be either positive or negative).

Various measures of impacts can be used, some being directly related to a performance in terms of accidents and their consequences and some being only indirectly related to accidents or

incidents. The former can be directly associated to monetary values whereas the latter would require making explicit assumptions linking the observed performance value and the inferred potential impact in terms of rail accidents or incidents reduction. For rail safety, the estimation of the reduction of accidents due to trespass or suicide that will be achieved by a particular (set of) measure(s) is obviously a crucial step for the assessment. Evidence and theories from the research can support some predictions about the manner in which the existing pattern of accidents would change if a new measure were introduced. Nevertheless, as stressed in the domain of road safety evaluation, “it is important to monitor the new pattern of accident after a measure has been introduced in order to check the accuracy of the prediction” (World Road Association, Technical Committee C2, safer road operations, 2012).

In order to be able to get comparable implementation costs for all safety measures, independent of the duration of their safety effects, the easiest method is to convert investment costs to annual capital costs, i.e. by converting investment costs to an annuity with the value of the original cost investment. The total costs can thus be obtained by adding the investment costs expressed as annuities to the annual costs of operation and maintenance (World Road Association, Technical Committee C2, safer road operations, 2012).

1.3 Choosing between CBA and CEA

As exposed in World Road Association, Technical Committee C2, safer road operations (2012), CEA has the main advantage that “only data about the implementation costs and an estimate of the accidents prevented are needed”. It is thus particularly appropriate for comparing projects whose benefits are not easily measureable in monetary terms, and/or projects with clear goals where a substantial component of the benefits are not measurable in monetary units. In addition to information used in CEA, CBA requires “the monetary valuation of the accident costs (that includes the valuation of human life, which is very controversial)” as well as other impacts, e.g. delays on traffic, environmental impact, etc.

To help in choosing between CBA and CEA, the table below provides a short reminder of the main advantages and limits of CBA and CEA.

Advantages and disadvantages of CEA and CBA

	CEA	CBA
Advantages	- is easier to calculate than cost-benefit ratio due to the fact that less information is required and that this information is more accessible; - gives a clear highlight on the safety effects of the measure(s);	- is useful when there are multiple objectives (e.g., both safety, environment and mobility), because it considers all relevant impacts; - is useful when several objectives are partly conflicting - is useful when it refers to goods that do not have market prices
Disadvantages	- can only be used for ranking measures with a common (single) target, not for decision since it does not state if the benefits of the measure exceeds the costs - disregards the effects of the safety measures on other aspects than safety	- data collection can be complex for costs as well as benefits - not all effects can be assessed (e.g. distributional effects)

However, as stated by World Road Association, Technical Committee C2, and safer road operations (2012) one of the greatest problems in cost-benefit analysis is to obtain valid and reliable monetary valuations of all relevant impacts. This objective is rarely, if ever, fully realized. It is therefore often relevant to carry out a cost-effectiveness analysis in addition to, or instead of, a cost-benefit analysis".

1.4 Reference costs and values to be used

1.4.1 Values of preventive causality

Values of Preventing a Casualty (VPC) refers to the references for estimating fatalities and injuries statistical values related to railways accidents. Some recent changes should be also underlined. For example in France, two different values can be used since an official report (CGSP 2013) very recently proposed a significant update for the Value of Statistical Life (VSL) as shown in the following table:

Value of Statistical Life (VSL)

	Fatalities	**Serious Injury**	**Slight Injury**
Current reference value	1 342 000 euros	143 000 euros	5 752 euros
Proposed value by CGSP (2013)	3 000 000 euros^{2010}	450 000 euros^{2010}	60 000 euros^{2010}

1.4.2 Values of time for estimating cost of delays

ERA (2013) suggested a procedure in line with the EC Directive 2009/149/EC, related to estimating delay costs for an accidents based on the information of its real duration. In the context of RESTRAIL, and as far as the data are available, estimating the delay costs induced by trespassers behaviours - even in the absence of accidents[1] – can provide some additional information for CEA and CBA.

Values of Time (VT) refer to the monetary value of delays incurred by users of rail transport (passengers and freight customers) as a consequence of accidents or incidents. It is proposed to be calculated using the following formula (from ERA 2013):

- VT = monetary value of travel time savings

- Value of time for a passenger of a train (VTP):

VTP = [VT of work passengers]*[Average percentage of work passengers per year] + [VT of non-work passengers]*[Average percentage of non-work passengers per year]

VTP is measured in € per passenger per hour.

- Value of time for a freight train (VTF):

VTF = [VT of freight trains]*[(Tonne-Km)/ (Freight Train-Km)]

VTF is measured in € per freight tonne per hour

- Average tonnes of goods transported per train in one year = (Tonne-Km)/(Freight Train-Km)

- Cost of 1 minute of delay of a train for Passenger (CMP)

[1] As even in the absence of accidents, the detection of trespassers on the tracks will induce speed restriction or even traffic interruption until trespassers are found, extracted to a position of safety and safe conditions for traffic are restored.

CMP = K1[2]*(VTP/60)*[(Passenger-Km)/(Passenger Train-Km)]

Average number of passengers per train in one year = (Passenger-Km)/(Passenger Train-Km)

- Cost of 1 minute of delay of a train for Freight train (CMF):

CMF= K22* (VTF/60)

- Cost of delays of an accident = CMP*(Minutes of delay of passenger trains) + CMF*(Minutes of delay of freight trains)

Delays are to be calculated as follows:

- real delays on the railway lines where accidents occurred,
- real delays or, if not possible, estimated delays on the other affected lines.

1.4.3 Other reference value to be defined

Real Discount Rate is used to convert annual monetary value to a present valued. As explained in Meunier (2009) and quoted by World Road Association, Technical Committee C2, safer road operations (2012):

"The discount rate is an interest rate that is chosen to reflect the time value of money. The discount rate represents the minimum rate of return that would be considered by an agency to provide an attractive investment. Thus, the minimum attractive rate of return is judged in comparison with other opportunities to invest public funds wisely to obtain improvements that benefit the public." At the European level, the EC Research project, UNITE, recommended a rate of 3% while the European Commission Directorate General (ECDG) Regional Policy (2002) suggests the use of a European social discount rate equal to 5% (Bickel, Friederich, Burgess et al., 2006). Florio et al. (2008) provides an extended explanation of the approaches to compute social discount ratio, corresponding formula and indicator as well as some values for some countries (see table below). Thus, EC Working Document No 4 suggested a reference social discount rate (SDR) for 2007- 2013 of 3.5% for the countries not eligible for the Cohesion Fund (CF) and 5.5% for the CF countries. However in special circumstances, country or region-specific SDRs may be utilized and proposers would justify their assessments based on specific empirical estimates.

Values for Social Discount Rate to be used for CBA in some European countries (Florio et al. 2008)

Countries	Social discount rate as calculated in [Florio et al. (2008)]
Austria	4.1
Denmark	3.5
France	3.4
Italy	3.3
Germany	3.1
Netherlands	2.8
Sweden	4.1

[2] Factors K1 and K2 are between the value of time and the value of delay, as estimated by stated preference studies, to take into account that the time lost as a result of delays is perceived significantly more negative than normal travel time.