Infrastructure asset management: Better decision making by using "Value of Time"	TOPIC: Infrastructure SESSION: Track Monitoring and Maintenance ABSTRACT NO: 16.4

R Steinegger, *E-mail:* rolf.steinegger@sbb.ch, *Phone:* +41-512-205893, *Fax:* +41-512-205014
Swiss Federal Railways
I-ASM-TI-EB-SI-BI, Schanzenstrasse 5, 3000 Bern 65, Switzerland

1 Background

The sale of slots to freight and passenger carriers is the major task of the division infrastructure of the Swiss Federal Railways SBB. To meet the demand for capacity and to guarantee a high level of quality (security, reliability, environmental issues) will be the basis for the long-term success. An increase of slots sold to the carriers of 30% basically on main lines is planned within the next ten years.

The Swiss Federal Railways operate a dense network with frequent services, which is already charged to ist maximum capacity. Large investment programs provide for the gradual and punctual development. At the same time the value of the assets must be preserved. New technologies are introduced within the scope of maintenance and renewal.

The railway infrastructure is cost-intensiv. The International Union of Railways (UIC) has undertaken an international benchmark project on the costs of infrastructure (InfraCost). Both investment project and life-cycle-costs of the entire network were compared. The complete results of the benchmark study have been carefully interpreted and conclusions for specific conditions in Switzerland have been derived.

Capacity management and development of the network are based on a long-term and precice planning (by the minute) for the strongly systematic timetable. Therefore investments are highly effective, e.g. specific increase in nodes-capacity, single to double track or increase of speed on selectes parts of a line. Comparisons have shown that a network charged to ist maximum capacity leads to lowest performance-referred characteristic cost-values.

The principle purpose of asset management is to keep life cycle cost constantly as low as possible (maintenance and renewal). Costing levers exist for components, methodes and processes in planning and construction. The cost-driver-analysis shows that there is a need for new procedures and methodes to reduce neccessary track access time during the entire life cycle. Planning processes are optimized in order to reduce costst by forming clusters of several work sites (e.g. harmonisation of planning schedule, kind of work).

New technologies are designed for long life span, minimum maintenance and high reliability and to meet the needs of operation. Functionality is definded by the rule "as much as needed, and not as much as (technically) possible". The requirements for long-lived components are determind for future needs today (e.g. gross tonnage, axle load, speed). The product portfolio is a mirror of constant migration from older to newest technology. New methodes for maintenance and renewal are introduced in shorter periods and promise rapid savings. Active cooperation of collaborators and coworkers in all business processes is required.

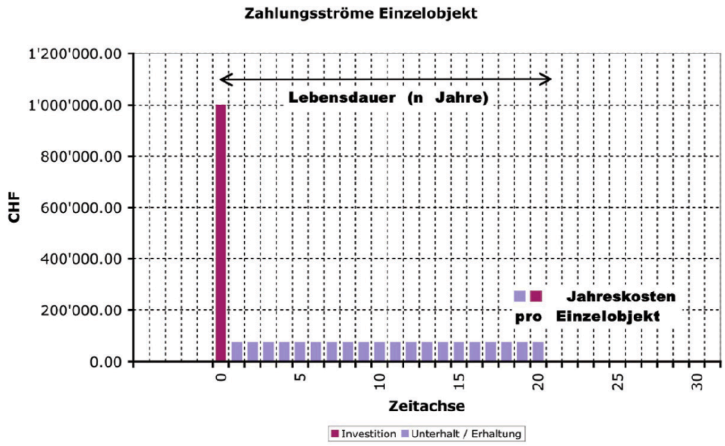
The product portfolio enables the asset manager to develop his systems systematically and specifically. The key for low infrastructure costs are: clearly definded requirements for functionaliy (RAMS) as well as renewal and maintenance to an even and steadily high quality level. The key drivers for innovations are functionality, reliability and capacity. The paper shows part of the methodical approach and explains how reliability and capacity are measured and integrated in the LCC-cost-model. This model is used by the portfolio manager to take either decisions about the product portfolio and to set goals for innovation projects, which are later on managed in a milestones-project-controlling.

2 System-decisions

In the product management individual objects are not only compared, but the behavior of the costs over the time for whole systems is important. As a basis for decisions therefore the sum of all m objects, that build a sytem, is taken into account. These system-costs (LCC) will vary over time depending on the decisions of the product managers.

2.1.1 Object-LCC

The model costs in the Life Cycle management are determined as annually equal payments. These result in the case of the investments for replacement to a payment stream in the first year and with the recurring costs (maintenance, disturbance recovery, value of the time) from the total of all costs over the life cycle divided by the life span.

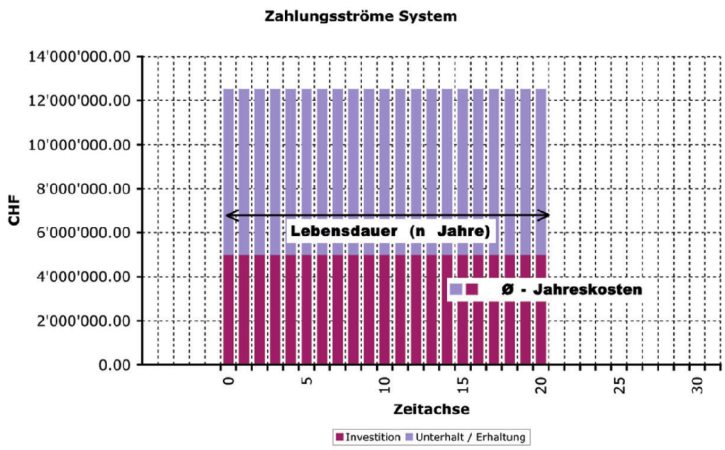


2.1.2 System-LCC

In Life Cycle Management so-called systems are a quantity of m homogeneous items (objects) (examples: 19'000 engines for switches in the network of the SBB, 7'800 km of track, etc.).

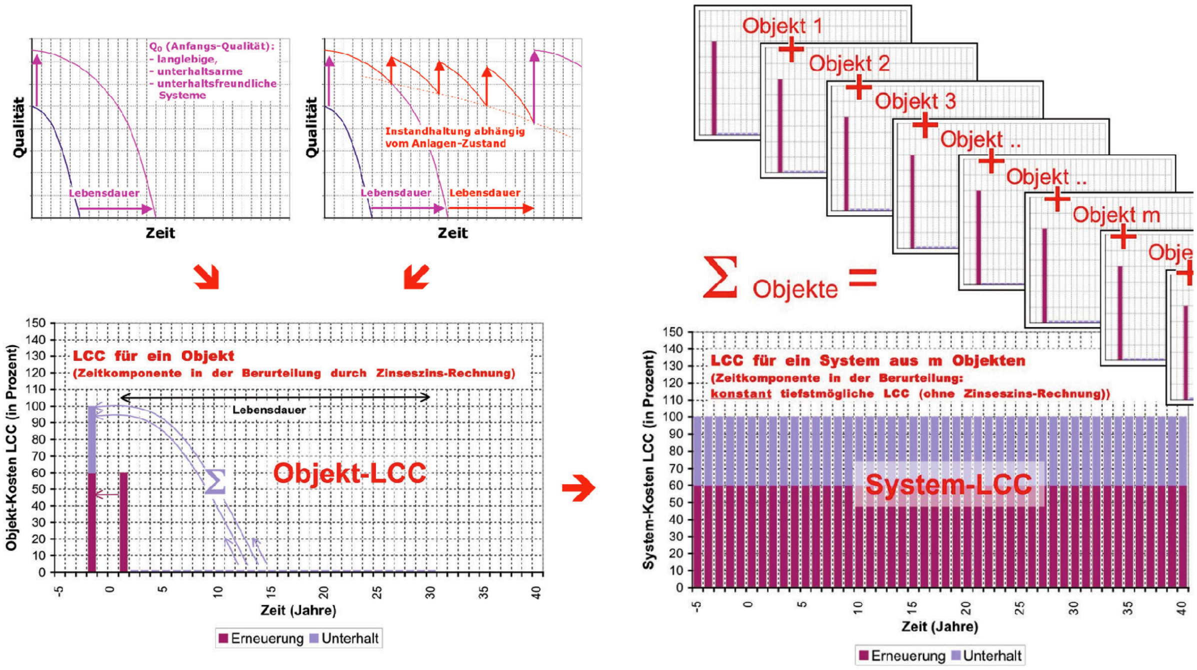
So that the calculations can be made at reasonable expenditure, the following acceptance are usually met:

- Consideration period = average life span for a single object (n years)
- Constant application statistics during the view period (number of objects m)
- a-swung system,
  i.e. constant annual renewal rate (= 1/n)



Calculation of the annual system costs (payments):

- Replacement of investments:
  average annual payment of the system = average costs per single object * m objects/n years
- recurring costs (maintenance)
  annual average payment (system) = annual costs (for one object) * m objects



2.3 Migrations-strategies for innovations

The question about the migration strategy arises during the introduction of new systems, procedures or processes (innovation) for every product-manager. Of course the selection of the strategy has a crucial influence on the economy calculation. The introduction of a new type (system or item) entails an expansion of the assortment in each case (except with the version "immediate replacement") over the time of the migration. This applies even if the newly introduced type replaces several existing types. In the evaluation this must be likewise considered as well as in the planning of formations, storekeeping etc.. Several basic strategies are to be taken into account:

- An **immediate replacement of all items (objects)** by a new product. This replacement strategy is usually not applicable by the large number of items in the network and the associated high investments. Also the supply and assembly capacities (industry and SBB) must be sufficient large with this version.
- An **accelerated replacement** (in relation to the tidy replacement), is possible e.g. in the context of maintenance for individual components (example: the insulators of the railway catenary in a tunnel can be replaced instead of cleaned with somewhat same expenditure).
- A **tidy replacement** within the framework of the sequential replacement or the tidy maintenance (with wearing parts). This is often a quite more passable and also meaningful way. It is to be noted however that the migration duration can be very long. For a typical item of the track (e.g. switches, catches, etc.) it easily takes the average of approximately 30 to 40 years. Actually, however the real periods are even longer (e.g. it takes 75 years (!) to replace 95% of the switches which are situated today in the Swiss network; for wearing parts the duration is smaller). Also this means that for this long time the know-how has to be keep alive (parallel additional expenditure!).
- With a **delayed replacement** (e.g. only with selected subsets) the asset manager reacts to short investment budgets. Such a strategy is usually not recommended however, because it is still substantially more strictly judged in the dynamic economy calculation than both other versions. Usually higher (today's!) investments lead to savings in the maintenance, which become effective only strongly delayed. Also the fulfilment of the conversion decision moves to the far future. Those Migration duration extends e.g. for switches to over 150 years for 95% of the items, if only each second switch is replaced by a new and better type. On the other hand this corresponds whith periods, that are actually quite situated with version decisions for single buildings (bridges, tunnel, retaining walls, etc.).

3 Life-Cycle-Cost

The model-costs in Life-Cycle-Management are:

- Investment for replacement
- Maintenance
- Operation (direct costs)
  Those operational costs in connection with disturbances and maintenance are however small compared to the following described value of time (management, energy consumption and wear of brakes, etc.). It is therefore

suggested (provisionally) not to monetarise the direct and thus checkout-effective operation subsequent costs of the unavailability in the Life Cycle management.

- Value of Time (indirect costs)
  The consideration of the value of the time is an indispensable (however not sufficient) condition for an effective Life Cycle management. The installation course effected can take place either qualitively or quantitatively. The second way promises a more objective comparability of the different versions for decision-making.
  Which value is to be taken into the calculation of the Life Cycle Cost? A suggestion for the answer of this question is the following composition of ideas for the value of time VoT.

4 Value of Time

The Monetarisierung of the value of the time promises to complete the calculation of life cycle costs as valuable decision basis in the asset management. Instead of the purely qualitative consideration of the drivers functionality, availability and capacity, these are brought quantitatively to measuring and therefor objectively comparably into decision making. Thereby it is sufficient to determine the value of the time in an relative (adequate) manner.

To know the absolute "correct" value of the time is however impossible, since no direct costs arise to the predominant part. The current value is not immediately checkout effective, it develops however indirect monetary effects.

There are two kinds of VoT:

- **Planned non-availability** (investment-projects or maintenance-work)
  and therefore reduction of capacity **("value of capacity")**
- **Unplanned non-availability**
  breakdown and work to restore service **("value of availability")**

An overview over time for different views to estimate or calculate the Value of Time is given. Economical conditions for the company as well as for the whole economy of the country are respected:

- view of customer (value of time)
- view of transportation company/carrier:
  - Loss of income and costs to payback customers in case of unpunctuality (remuneration)
  - Costs for handling bad punctuality
- view of infrastructure company
  - More investments (e.g. because of ongoing bad punctuality)
  - Costs for handling bad punctuality

  For the SBB as an integrated enterprise, to know exactly where (in which division) costs are to be taken in account is not in every case necessary. The optimization must take place on the level of the whole company.
  In all other respects every infrastructure company depends on the transport enterprises directly, since proceeds an success in the long run likewise originate from the route sales from the sales from transportations to the customers. The customer view (passenger, goods customer) is therefore just as meaningful and necessary as the pure system view.

On the end of the section consequences are drawn and one value each in CHF per hour of route allocation for the "value of the capacity" and the "value of the availability" is suggested. These values can be used in the management as basis for decisions over versions with objects and systems (calculation of the life cycle costs). For further conceivable applications (bonus/penalty, etc..) these values of the time are not meant to be used.

4.1 Figures of traffic

Figures Swiss Federal Railways SBB, year 2001.

Pessenger Traffic

Pessengers:	13'365 Mio pessenger-km
Trains:	101 Mio km pro Jahr
Extent of utilization:	132 Pessengers per train (40 up to 440)
Trains per day and line:	94 average (30 up to 275)

Freight Traffic

Trains:	28.0 Mio km per year

Extent of utilization: 363 Tons (netto) per train (Brutto-weight 704 Tons)

Trains per day and line: 32 average

For the following calculations an average extent of utilization of 132 pessengers per train/313 net-tons per train is used.

4.2 View of customer

The value of the time VoT is examined by serveal autors since longer with different dispositions. The following compilation is based on international research work and benchmark studies of the UIC. The values were harmonized with the purchasing power parities of the OECD.

Country	Study	VoT (CHF/h)	Net (km)	Mio train-km	Mio TU*)
Pessenger traffic					
Norway	Jernbaneverket JBV 2002[1)]	40	4'138	37.4	5.0
Nederlands	Hague Constulting Group 1990[2)]	15	4'755	129	19
Denmark	Jovicic and Hansen (2003)[2)]	15	3'147	67.7	7.4
Finland	Karasmaa (2001)[2)]	6			
Germany	Bundesverkehrswegeplan (1998)[3)]	25	53'700	723	139
Switzerland	Verifizierung Prognosemethoden Bsp. Einfuehrung ICN	19–25	4'564	117	21
	Verlaesslichkeit als Entscheidungsvariable	31			
	diverse	11–54			
plausible "frequent value"		**25 CHF/h**			
freight traffic					
Norway	Jernbaneverket JBV[1)] (Net-Tons)	16.00	4'138	37.4	5.0

*) Transport Units TU = pessenger-km or freight-Ton-km
1) prom@in-workshop november 2002 in Budapest: Prof. Dr. Jørn Vatn (Norwegian National Rail Administration and SINTEF Industrial Management, Trondheim).
2) Arnd König, Georg Abay, Kay W Axhausen: Time is Money – The valuation of travel time savings in Switzerland, Paper presented at STRC 2003, Ascona
3) business: 40 CHF/h, others: 11 CHF/h

4.3 View of the transportation company

The aspect is a commercial: Requirements for reimbursement of customer (IVT series of publications 122: Federal Institut of Technology Zuerich, Institut for traffic planning, transportation engineering, roads and building of railways, July 1999).

In the model it is assumed that late arrivals in nodes lead to remuneration to the customer, whereby only a partly remuneration of the costs is considered.

- Remuneration of the excess fare for reservation
- 20% of the transport fare for freight

The estimated value is:

1 to 7 CHF/pessenger and hour

4 to 40 CHF/net-ton and hour

(depending on the duration of the delay)

4.4 View of the infrastructure company

4.4.1 Investments in the infrastructure

The model assumes investments for travel time gains can be a consequence of too low system availability (among other reasons). Both planned as well as unplanned capacity restrictions can be considered (sections with a speed restriction due to construction work, delay minutes due to break downs).

With such an investment the travel time gain becomes lastingly secured, the implementation however lasts for a long time. This in contrast for instance to organizational measures (which can be much more rapidly realized) or also in comparison to the application of more highly available items. Here the same availability must be achieved again at the the next replacement (which by any means is not self-evident with the technological development (shorter life-span, more complex systems, etc.) and the actual restriction for economic decisions by public companies like railways caused by the rules of GATT/WTO).

The assumption may be at first sight, that the selected beginning results in expensive travel time costs. The comparison with other beginnings shows however that the costs are relatively low for each passenger.

The investment costs amount to approximately 55’000.00 CHF for one minute travel time gain per daily driving course. The capital costs of the investment are calculated and amounted with an internal interest of 5% and a cash recovery period of 50 years. For one minute travel time gain the costs are 55’000.00 * 0.055/365 = 8.40 CHF/per train and day.

Maintenance costs for railway facilities amounted to approximately 65% of the capital outlays and result therefore in 36’000.00 CHF, distributed on 50 years * 365 days thus approximately results in 2.00 CHF/train and day.

The initial costs for one minute travel time gain amounts to thus: 10.40 CHF/train.

The pessenger-hour is worth approx.: 4.70 CHF/pessenger and hour

4.4.2 Commercial: Loss of capacity (less income trough sold slots)

A late train blocks that route for a following train, the infrastructure can sell therefore fewer slots and the income becomes smaller. A delay of e.g. 5 minutes reduces the amount of sold slots by one (estimation).

The estimated value is:

13 to 35 CHF/pessenger and hour

6 to 14 CHF/net-ton und hour

(depending on the duration of the delay)

4.5 From the view of the customer to the asset-managers view

On the basis several examples in the study IVT series of publications 122 the connection between the “value of one passenger hour”/“value of one net-ton-hour” is converted into costs:

Value of one hour in CHF incident/delay	customer-view	view transport	view infrastructure	total SSB	view asset-management
Interregio	–1.–/h*P remuneration	–21/–47			delay 5 min.*)
Bern–Luzern	(–10.–/h*P income)		–171/–244	–192/–291	3’000 CHF/h
cargo-train	–15.–/h*to remuneration		0/0		delay 10 min.*)
Chiasso–Basel	(–8.–/h*to income)		–356/–283	–356/–283	1’900 CHF/h
cargo-train	–50.–/h*to remuneration	0/–2’530			delay 30 min.*)
Chiasso–Basel	(–14.–/h*to income)		–2’089/–1’107	–2’089/–3’637	5’700 CHF/h
Intercity	–1.–/h*P remuneration	–68/–247			delay 10 min.*)
Genève–St.Gallen	(–20.–/h*P income)		–694/–608	–762/–855	4’800 CHF/h
S-Bahn Zurich	–1.–/h*P remuneration	–41/–54			delay 5 min.*)
S7 W’thur-R’wil	(–10.–/h*P income)		–133/–176	–174/–230	2’400 CHF/h
plausible “frequent value”		ca. 10%	ca. 90%	100%	**3’500 CHF/h**
procedure for calculation	–			② calculation according to model IVT	① delay ③ slot-hour

*) Down Time, resp. Time To Restore

The income losses (fewer possible sold slots) is by far largest proportion of the costs of one route allocation hour from view of the Asset management.

Since the set costs with increasing duration of delay are superproportionally increasingly set, one hour of route allocation has likewise an increasing value with the duration of the disturbance. This effect is however not taken into account for the following suggestions.

5 Value of Availability

Value of one hour in CHF	customer-view	view transport	view infrastructure	total SBB	view Asset-Management
pessenger traffic					
several VoT-Studien	–25.–/h*P				
IVT-Modell	ca. –1 bis–7.–/h*P remuneration	ca. 10%			
	ca. –15 bis –35.–/h*P income		ca. 90%	100%	3'500 CHF/h
a european train-operating company	–21.–/h*P				2'300 CHF/h
Freight traffic					
Jernbanverket JBV (Nowegen)	–16.–/h*to				
IVT-Modell	ca. –4 bis –40.–/h*to remuneration	ca. 10%			
	ca. –6 bis –14.–/h*to income		ca. 90%	100%	3'500 CHF/h
plausible value	**3'500 CHF/h unplanned route allocation ("value of availability")**				

It is suggested to assume the value of (lost) time due to unplanned unavailability of systems (disturbances: delays) with **3'500 CHF/hour "value of availability" of route allocation (down time)** in the Life Cycle management.

6 Value of Capacity

Planned route allocation should be much less valuable than unplanned blockage of routes:

- The associated route restriction is small compared with the disturbances, since the work is often carried out at the night or in edge hours, during those the potential demand of transportation is significantly smaller than during daytime (exceptions on individual lines or parts of the network: e.g. North-South axis freight traffic, S-Bahn Zurich with regular night-services).
- (Temporary) service restrictions are plannable for the customers. This is a crucial factor for the acceptance, thus adequate communication of such restrictions has high priority. The evaluation in this type of "lost train hours" from customer view is however substantially lower than a suffered delay in regular traffic.
  Effects of complete shut-down of lines on weekends or during vacation time can be considered with a adequate hour rate. In such projects (e.g. Clustering) local conditions can be better adapted.
- The technical timetable reserves actually represent a permanent travel time extension. Since they are however planned and not more than approximately 2 minutes per distance, the effects are obviously smaller than possibly with unplanned, larger delays.

It is suggested to assume the value of (lost) capacity due to planned work (investment projects and maintenance) with **1'000 CHF/hour "value of capacity" of route allocation** in the Life Cycle management.

7 Conclusions

Availability and capacity along with functionality are the major keys for succes of the division infrastructure of the Swiss Federal Railways SBB.

With the installation course of the "value of time" VoT a meaningful and objective instrument is created, in order to quantify the availability and the capacity for the calculation of the Life Cycle Cost. There are two kinds of VoT:

- **Planned non-availability** (investment-projects or maintenance-work)
  and therefore reduction of capacity **("value of capacity")**
- **Unplanned non-availability**
  breakdown and work to restore service **("value of availability")**

This goes beyond the usual purely qualitative view added to the quantative hard-facts of investment cost. With the definition of a value for one hour of Downtime of one track a comprehensible comparison is enabled in simple and practicable way. As base for decisions in the product management and with innovation projects these values supply necessary assurance.

The used values in CHF are verified constantly on the basis examples. For specific parts of the network adapted costs can be used, in order to illustrate e.g. a particularly high density of traffic or to justify the specific use of high performance systems according to the density.