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Revision of project evaluation as part of the German Federal transport infrastructure plan

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Abstract

This paper shows the current situation in the revision of the present evaluation method for the Federal Transport Infrastructure Plan (FTIP) in 2015. New to the evaluation process is a superior prioritizing strategy, which the degree of urgency for adaptions on the transport infrastructure has to be orientated on. This prioritizing strategy also enables a consistent merge of the single assessment modules. A focus is set on the further development of the cost-benefit analysis (CBA) as the core assessment tool of the FTIP evaluation process. Within the CBA-module the authors especially react to the topics 'plausibility check on investment costs', 'measuring and assessing of infrastructure caused changes in reliability', as well as to a big survey on values of travel time savings (VTTS).

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Keywords: German Federal Transport Infrastructure Plan (FTIP); cost-benefit analysis; investment costs; reliability; value of travel time savings; prioritizing strategy

1. Introduction

1.1. Classification of the Federal Transport Infrastructure Plan

The Federal Government is – referring to the basic law - responsible for construction and maintenance of the national transport infrastructure. Key regulation element in this context is the Federal Transport Infrastructure Plan

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(FTIP). It is usually in effect for 10 to 15 years and states, which requirements for maintenance, expansion and new construction investments exist. Thereby the budget law postulates that appropriate economic viability analyses have to be conducted for considered measures. This is why during the establishment of the FTIP the macroeconomic advantages of all "project ideas" and their degree of urgency have to be determined. The urgency classification is modeled in three categories: "urgent need", "additional need" and "no need". The upgrading and new construction projects should be handled according to these categories. When and in which order the projects within one urgency classification will be realized, is not determined by the FTIP, but through the release of financial means in the course of the annual budget deployment. Following this process the FTIP is a planning tool of the federal government, but neither a financial plan nor a law.

The Federal Ministry for Transport and Digital Infrastructure (BMVI) is currently preparing the FTIP for the year 2015. On one hand, basics like the traffic demand forecast are adapted to the assumed frame conditions of the year 2030 as horizon for the FTIP 2015. On the other hand, it is essential to check and optimize the methodology of the decision-making process. The development includes all aspects of decision-making: firstly, the target system in regard of the prioritizing strategy needs to be assimilated to the social and political developments. Secondly, the evaluation methodology has to be aligned with respect to the international standards, progress in research, extended knowledge, and the efficiency of its application. This article will present principle methods for the evaluation of single projects, as well as outline of the decision-making process. Additionally it will explain selected improvements in both areas.

1.2. Evaluation of the projects

The evaluation method for new and expansion construction projects needs to be able to evaluate and assess the impacts of considered projects in terms of traffic flow, traffic safety, noise and environment effects, city planning potentials as well as the quality of regional connectivity and accessibility.

In FTIP 2015, four evaluation modules are used for this purpose (see Fig. 1). As far as possible, all monetisable effects need to be captured in the cost-benefit analysis (CBA) (Module A). As a result, it provides an economic benefit-cost-ratio, which reflects the profitability of the used financial means. Owing to the long tradition of the CBA in the FTIP, it is an elaborated process with many single indicators, meaning that it covers a wide range of effects caused by considered infrastructure projects. The CBA includes the effects of most of the targets addressed by the planning process, whereby environmental indicators (e.g. noise pollution, $C0_2$.), as well as travel time savings are included.

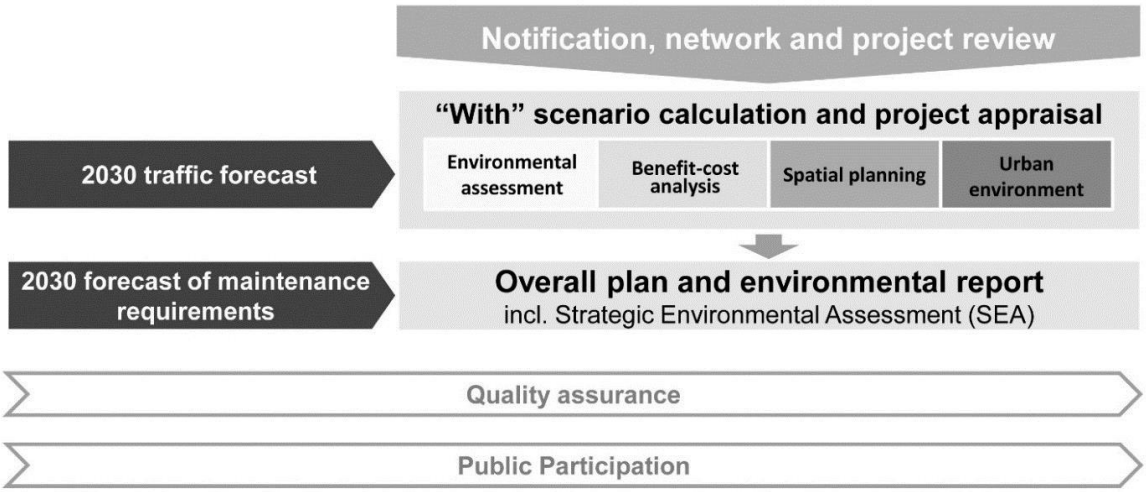

Fig. 1: Overall process of the FTIP 2015 (own illustration on the basis of BMVI 2014)

However, some targets and their range of achievement can still not be depicted within CBA. To these cases belong the additional environmental effects, like the spatial utilisation or the protection of non-dissected regions. These non-monetised indicators are represented in the environmental and nature-focused evaluation (Module B). The third evaluation module covering the spatial impact assessment (Module C) includes the quality of accessibility and connectivity for different regions. In this process, the deficiencies in the connection between regional centres and metropolitan centres are measured. Furthermore, the accessibility of regions with regard to the closest infrastructure access (motorway junction, airport, long distance traffic train station etc.) is evaluated. In contrast to CBA, which acquires the economic network-wide sum of the accessibility improvements in terms of time savings (allocative advantage), the spatial impact assessment considers aspects belonging to the distribution theory like the question of minimal accessibilities in regions (distributive advantage). The fourth and last module is the urban development evaluation (Module D) of transport infrastructure projects. Therein specified is the aim to relieve developed areas and people living within them, specifically through road bypass projects.

In combination, the four modules facilitate the project evaluation with respect to all targets. The FTIP will be established out of the project evaluation results in combination with the maintenance requirement projections (compare chapter 3).

2. Progression of the Cost-Benefit Analysis

2.1. Improvement of the cost-benefit analysis, an overview

The used methodology in FTIP already distinguishes itself through a high complexity. International comparison studies (i.e. Bickel et al. 2005) and some analyses on behalf of BMVI (i.e. Nagel et al., 2010) offer numerous starting points for the improvement of the methodology. The goal is to enhance the output accuracy and the transparency of the CBA results. As part of the further development of the FTIP-methodology, the CBA has undergone a general examination. Within this examination, the following points should be considered:

- Standardized and regular actualization of different valuation rates and the discount rate
- Verification of the topicality and appropriateness of the indicators
- Identification of areas of improvement and solutions, indicating whether they can be realized within FTIP 2015 or not.

The CBA for FTIP 2015 will in major parts be oriented in terms of its process on the recent FTIPs. The CBA shall presumably capture the following areas of effect:

- Operational and provision costs in passenger and freight transport
- Valuation of travel and transport time savings in passenger and freight transport (new to freight transport)
- Traffic safety
- Reliability (new indicator)
- Environmental effects (air pollutant emission, noise emission, climate endangering).

Freshly added were the indicators ‘reliability’ and ‘life cycle emissions of greenhouse gases during the construction and operation of infrastructure‘. Moreover, in the future benefits from transport time savings in freight transport (for example due to reduced capital binding costs) will be considered as well. Some indicators out of the FTIP 2003 can be abandoned. In particular the consideration of employment endowing effects has been dropped, since the scenario for the transport demand forecast 2030 already assumes full employment.

2.2. Cost focus: Plausibility check of the investment costs

During the development of the evaluation method, the estimation of the investment costs in addition to the benefit side was improved. Within the scope of a research project, construction costs for completed infrastructure projects were examined for this purpose (Aviso & Bung, 2014). For a few projects, an analysis of the historical development of cost categories was possible. Compared to the sum of the overall investments in these 18 projects, a cost increase of altogether 36% was discovered. The cost increases are assignable to both: construction price rises and project

modifications. The latter is caused on the one hand by regulation changes (for example increased safety and environmental requirements) and on the other hand by planning ascertainment and performance changes during construction, respectively. The amount of the cost increase fluctuates between different projects. Hence, one can derive that a general procedure for the coverage of the cost uncertainty (e.g. 20% risk buffer) would be unsuitable. An aim of the FTIP 2015 is for that reason to make the investment cost project specifically plausible.
As a result (see Fig. 2), a methodology for the plausibility check was developed focussing in general on two cost drivers: On the one hand, past projects have shown that especially environmental regulations can lead to cost increases. Therefore, in the future possible environmental conflicts will be examined to anticipate cost risks (e.g. expansive structure design), before the assessment of the project will be carried out. On the other hand, the assumed investment costs are analysed. In this step, especially the technical feasibility as well as the reasonableness of the assumed costs are in the focus of actions. For this reason, in the above explained research project construction costs were analysed in terms of the kind of project they belong to (e.g. the expansion from 2 to 4 lanes). Out of these ex-post analyses mean cost rates and reliance scopes for construction parts (e.g. Euro per km length for grounding works) were derived.

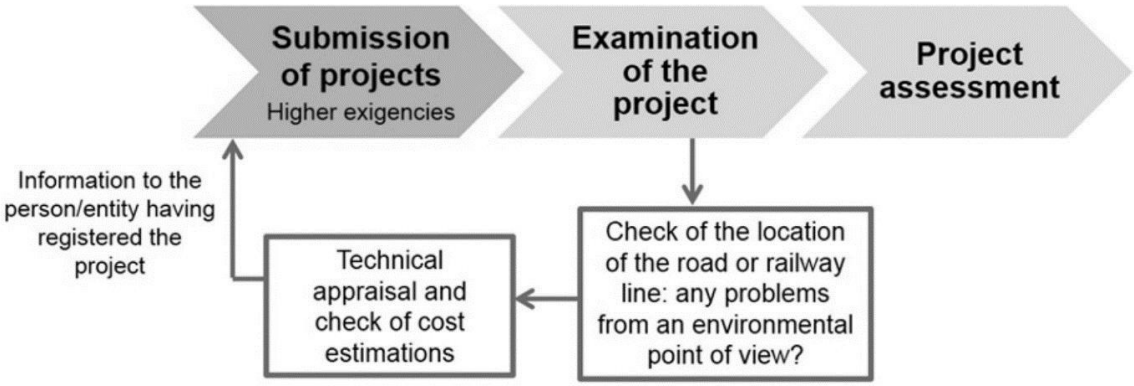

Fig. 2: Procedure to check cost plausibility of announced projects in FTIP 2015.

Finally, the comparative cost rates determined in the project can only serve as an orientation. Many projects feature specialties (e.g. special construction forms), which were not considered sufficiently in the ex-post analysis. The comparative cost rates serve to make the projects plausible at a first glance. In case of conspicuousness, single assessments are needed. If even the detailed assessments lead to uncertain results, a feedback of the findings to the project initiator is performed. The initiator will then be demanded to adapt the planning materials accordingly and to actualize the cost forecast. A project will only be accepted for the evaluation procedure when the cost plausibility check was finalized satisfactorily.

2.3. Benefit focus: New benefit component "reliability"

For some years, the term "reliability" in transport or reliable transport system has been being discussed regularly and accordingly claims towards political stakeholders have been being made to take action for more reliable transport systems. In this respect, it was essential to consider this topic during the revision of the methodology for the FTIP.

Soon it was realized that theoretical knowledge about reliability was even internationally not very extensive. Even the definition of the term cannot be given intuitively. In general, a trip from A to B is rated as unreliable if the traveller stucks in a traffic jam or his train is delayed. In terms of a commuter, who is delayed every morning because of "the same" traffic jam, this congestion is very reliable. Reliability in this context is defined as the deviation from an expected mean of the travel or transport time, or the deviation from an expected arrival time, whereby both delays and early arrivals have to be considered. Deviations from the expected travel time can be mathematically described by a distribution of travel times or arrival times. In case of 'certain traffic congestions' a higher (expected) mean of the travel time can be stated, even though the dispersion around this mean can be very low.

For specific transport carriers as well as for the differentiation between passenger and freight transport the different characteristics of reliability have to be adapted too. Unreliability in traffic systems affects at a first level the means of transportation, e.g. automobiles, trains etc. At a second level, passenger and freight that are carried by these means of transport are affected. During the conception of the methodology for the new FTIP, only the effects on the second level are to be assessed, meaning that a focus is set on the effects on passenger and freight by the unreliability of one or more means of transport. For example, a train operated relation with major time variations does not have a relevant impact on the indicator 'unreliability', if the trains serving this relation only feature low occupancy rates. Additionally it is important to mention that in the course of the evaluation process for the FTIP only improvements of reliability due to infrastructure measures are allowed to be considered. This is especially problematic in the railway sector, since unreliability often occurs due to problems with the rolling stock, through deficiencies in the existing technical infrastructure or through delays on "upstream" sectors.

In general, three approaches for measuring and assessing reliability or unreliability, respectively, for one route can be used (Significance, Goudappel, Nea, page 14 and following):

- Standard deviation of travel time distribution
- (Anticipated) buffer times to avoid delays
- Deviations from contracted arrival times in schedule bound systems (schedule delay) in frequency (percentage of arrivals) and extent (delays measured by e.g. minutes).

For rail passenger transport, the third alternative is not easy to implement, since the FTIP rail network 2030 does not contain a schedule. For that reason, the modelling of reliability can only be realized by an endogenous train line system, though de facto the transport industry uses buffer times. The buffer times transform delay risks - meaning possibly arising time losses - into certain time losses compared to an undisrupted journey. These are the costs of the risk reduction. The buffer times are calculated in such a way that - together with the mean travel time - they cover the travel and transport time distribution up to only a very small quantile.

Independent from the explicit definition of reliability, it is always related to one relation, meaning one trip from A to B. However, the routes used on a given relation are determined by solving the shortest past problem based on travel times, costs, etc. Repeatedly literature suggests to use the deviation from the mean travel time as a measure for the unreliability and to estimate it track related as a function of the volume-to-capacity ratio. In this way a simultaneous shortest path algorithm, which integrates the reliability, could be tried. This, on the other hand implies an essential constraint: the standard deviations from the average travel time of sequential route sections must not be correlated with each other. This is the more unlikely the shorter the route sections are.

For the transport carrier inland waterway, reliability is only defined by the water level fluctuations and the resulting maximum loading of ships. In the following, only the approach for the transport carrier road is illustrated, since in this area good results already exist. The research design has been determined as follows:

- Functional determination of the standard deviation for the travel times as a parameter of reliability
- Consideration of only the congestion related variability of the travel time. This corresponds to the logic that within the framework of the FTIP only infrastructure changes of the reliability can be assessed. Moreover in highly frequented areas the same speeds for trucks and passenger cars can be used.
- The functional connection between volume-capacity ratio and standard deviation is approximated in regard of the particular route sections on the base of simulations. During this process, a correlation analysis has to prove the independence of the disruptions on adjacent route sections.

Founded on simulations for real bottleneck situations on federal motorways the below mentioned model, for which a quantifier with a length relation was introduced, was developed. For the quantifier a non-correlation of the route sections can be assumed (compare with Geistefeld & Hohmann, page 23 and following).

The model has to be applied for each individual section as subject to the (maximum) volume-to-capacity ratio of the section (if necessary through the summary of consecutive sections for the same bottleneck) (1):

$$s_R(x) = \begin{cases} a \cdot (x - 0{,}75)^b \cdot \sqrt{\dfrac{L}{L_{Reference}}} & \text{for } x \geq 0{,}75 \\ 0 & \text{else} \end{cases} \tag{1}$$

being

s_R = section related standard deviation of the travel time [h]
x = volume-to-capacity ratio of the section
a,b = parameters resulting from regression
L = section length [km]
$L_{Reference}$ = reference length [km]

With the standard deviations of *n* individual sections within a route the resulting standard deviation for the travel time of the total route can be calculated using equation (2):

$$s_{R,total} = \sqrt{\sum_{i=1}^{n} s_{R,i}^{2}} \tag{2}$$

being

$s_{R,total}$ = standard deviation of the travel time on the total route [h]
$s_{R,i}$ = standard deviation of the travel time on the trip i [h]
n = number of sections within the route.

An empirical validation of the coherences derived from regression analysis is not directly possible. This is due to the fact, that in the course of the simulation for the estimation of the functions, the influences on infrastructure could be isolated, while in reality weather, accidents etc. can have an additional impact on unreliability and therefore the final standard deviation.

2.4. Benefit focus: Valuation for travel time savings and reliability

Within the scope of the new FTIP methodology, two research projects for the determination of valuation approaches for travel or transport times and reliability were initiated. One study focuses on passenger, the other on freight transport. In both studies, revealed (RP) and stated preferences (SP) surveys were conducted. In the passenger transport survey about 3200 people and in freight transport survey about 450 companies participated.

The studies have submitted tentative results, which are momentarily being validated. In accordance to this exercise in passenger transport, the Value of Time (VOT) will from now on be determined as a function of the travel distance (see Fig. 3). With increasing travel distance between origin and destination the valuation for time savings increases. This applies to all trip purposes in passenger transport. The results of the study suggest that time rates for the student transport are lower than average; therefore in FTIP 2015 a differentiation for trip purposes is aimed at. Because of the usually short student transport distances the sample only supports distances of <70 km for a separate travel time value. Furthermore FTIP 2015 will for the first time include a VOT for transported goods. Until now only the potential cost savings for vehicles and staff in case of transport time savings were considered. From now on decreased capital costs and logistic advantages on the receiver's side because of transport time savings are also considered. The VOT in freight transport will be determined dependent on the travel distance and the category of goods.

Moreover, the studies primarily captured cost rates for the Value of Reliability (VOR). It became evident that a standard deviation of the travel time and its meaning were hard to inquire about. For the time being no generally acknowledged methods for the collection of VOR exist. In passenger transport, tolerances for delayed arrivals in delay intervals were used. In freight transport the interview was designed by putting punctuality/unpunctuality of transports in the focus (percentage of delayed arrivals and average delay of delayed transports). Especially the VOR and the VOT in freight transport are momentarily being validated. For this reason, this Fig. 3 shows only preliminary VOT in passenger transport.

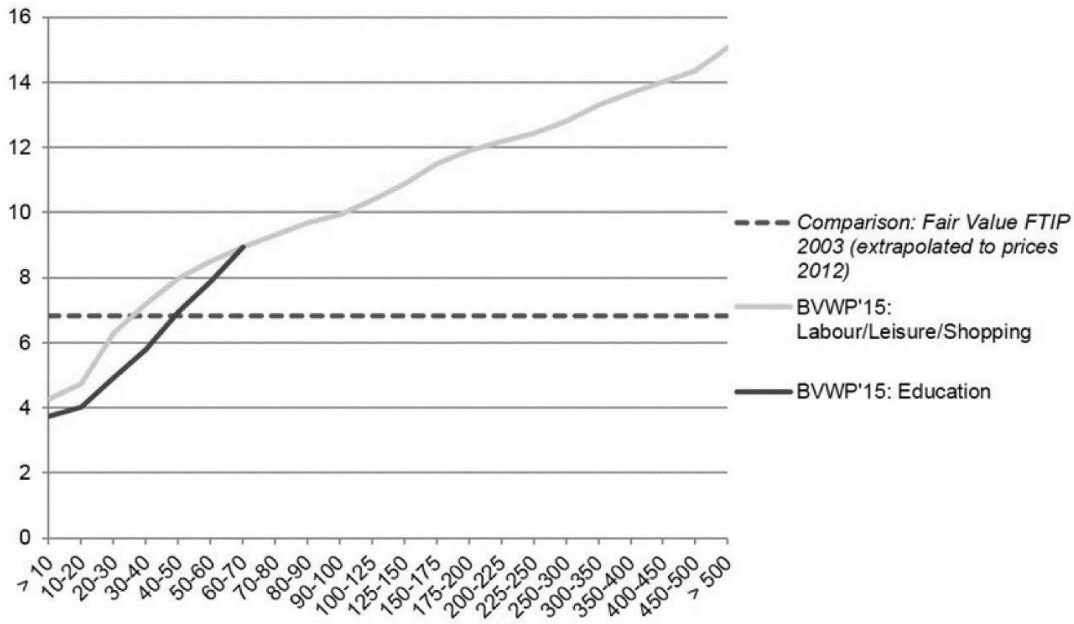

Fig. 3: Distance-dependent time values of non-economic passenger transport (tentative results on the basis of TNS Infratest & IVT (2014).

3. Decision-Making

The evaluation modules A to D (compare Fig. 1) are developed in a way, that double counting of project impacts can be avoided. Due to this the module results can be initially considered to be independent from each other. The next step is to combine the individual aspects to an overall decision so that the selection of suitable projects and the set-up of an urgency sequence (staging) in descending order are possible. The prioritisation should on the one hand be transparent, reasonable and standardized. On the other hand, it has to take account of individual conditions of certain projects within the huge number of approximately 2500 projects.

Out of these requirements it arises that the evaluation modules should be connected through a context logical prioritizing rule. Like in the past, the FTIP relinquishes on an aggregated value judgement, which could be assessed for example by a cost-utility analysis (weighted benefit analysis). Instead, a successive prioritizing rule should be developed which uses all evaluation modules with their distinct results. For that reason, the new general guidelines for the FTIP 2015 (BMVI, 2014) arrange for the following three prioritizing steps:

- Determination of necessary financial means for maintenance and replacement
- Distribution of the remaining financial means to the different transport carriers
- Urgency classification of projects for each transport carrier

The first step in the prioritizing strategy for the FTIP 2015 is the compilation and assessment of maintenance and replacement requirements until 2030 for the three transport carriers road, railway and waterway. The condition for both the road, rail and waterway sections and the civil structure works show significant deficiencies. Accordingly it was determined that maintenance and replacement of infrastructure have priority over expansion and new construction projects. The maintenance and replacement requirements of the traffic networks will be determined on the base of forecasts of actual maintenance needs and are assumed to be set. The investment budget remaining after the subtraction of maintenance needs is available for new and expansion projects.

The purpose of the prioritizing step 2 is it to determine the resource allocation for expansion and new construction projects for the three transport carriers road, railway and waterway, considering the political targets for FTIP 2015 and the strategic investment scenarios that are deduced from these targets.

A strategic investment scenario can be defined for example by the fact that it favours the most economical solution and only orientates itself on the cost-benefit analysis. Within the budget left after maintenance investments, a combination of projects of all three transport carriers can be found, which mostly achieve the target set. In case of a focus on other targets (e.g. bottleneck avoidance) other financial distributions can arise.

For the preparation of the political discussion on the distribution of financial means FTIP 2015 depicts the effects of the different investment scenarios by summarizing the impacts over all included projects. Within this process, it is demonstrated how the total effects of the overall plan change because of different investment strategies and the consequential distribution of financial means. As a quality assurance for this process, the overall plan based on the pre-selected projects will be evaluated as a whole regarding the total effects on the requirements of the target system. The decision on the second step of prioritization is therefore based on the results of the project evaluations but cross-checked by the benefit of the overall plan.

On the third prioritizing step the urgency sequence for each transport carrier is performed. The cost-benefit analysis provides the foundation of the decision-making. The CBA-module includes the major part of the project effects. For that reason the BCR (benefit-cost rate) serves as the central criterion for the distinction between urgent requirements and additional requirements. The other evaluation modules allow deviation from the efficiency criterion in individual cases. Projects with critical environmental and nature conservation assessment results or with outstanding spatial impact can be correspondingly down- or upgraded.

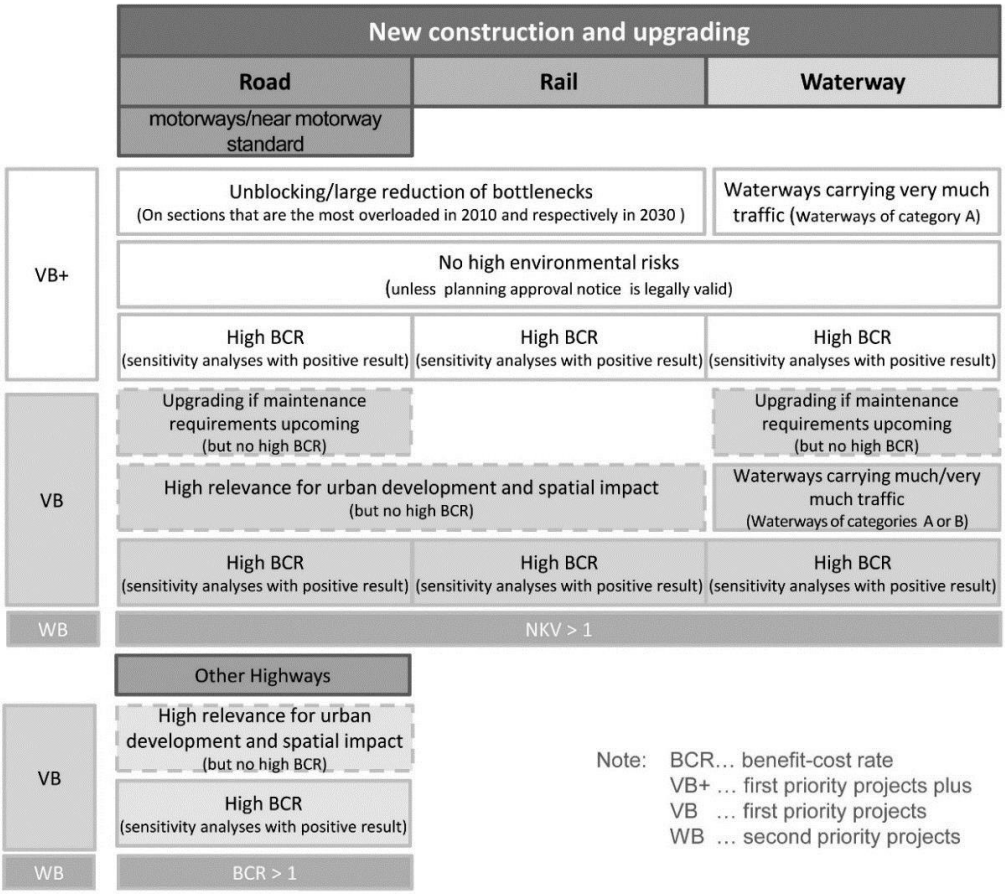

Fig. 4: Classification of the projects into the urgency (BMVI 2014)

Significantly urgent projects of the first category "urgent needs" will be labelled accordingly (urgent need plus) and should be realized at the first possibility. These projects can for example be contributing essentially to the elimination of bottlenecks. The prioritization is derived from network deficiencies analyses, which have shown that the number of congested situations will strongly increase in accordance to the demand forecast for distinguished network links. This problem does not only affect the network partially, it impacts it widely, especially on important primary routes for freight transport. Financial means should, according to the deficiencies analysis, be invested in such a way that the traffic flow on the major transport axes is secured. Fig. 4 illustrates the completed prioritizing strategies.

The prioritizing scheme uses all evaluation modules in a comprehensible process, while avoiding complex regulations or weighting factors. The decision-finding is based on a small set of prioritizing rules, which can be easily validated and adjusted if necessary. To emphasize the transparency of the process, it is standard to display the results of each single indicator for all considered projects in its original unit and thus to provide a multi-criteria analysis.

4. Outlook

The preparations for FTIP 2015 are mostly finished. Within the preparation process, the further extension of the evaluation methodology was prominently addressed. Topics like "reliability" are being investigated on international platforms simultaneously. On the basis of the traffic forecast 2030 and the modernized evaluation methodology, the assessment of projects under consideration for FTIP will be executed in 2015. Finally the draft for FTIP 2015 will be derived from the evaluation results and the superior prioritizing rules. The draft will depict the evaluation outcomes, a suggestion for the urgency classification and for the expected financial distribution between the different transport carriers. Additionally all detailed assessment results will be published online in a project information system (PRINS).

The draft of FTIP 2015 will undergo a parliamentary consultation procedure before the actual cabinet decision. In addition interested citizens can comment on the draft in written form. This citizens' involvement is part of the Strategic Environmental Assessment (SEA). The FTIP 2015, after the cabinet decision, will build the foundation for the developmental laws enacted by the German Federal Parliament.

References

Aviso GmbH/Bung Ingenieure AG (2014) *Entwicklung eines Verfahrens zur Plausibilisierung von Investitionskosten von angemeldeten Verkehrsinfrastrukturvorhaben im Rahmen der Bundesverkehrswegeplanung* (Los 1)

Bickel, P., Burgess, A., Hunt, A., Laird, J., Lieb, Ch., Lindberg, G., Odgaard, T. (2005) *State-of-the-art in Project Assessment*, HEATCO - Developing Harmonised European Approaches for Transport Costing and Project Assessment

BMVI – Bundesministerium für Verkehr und digitale Infrastruktur (Hrsg., 2014) *Grundkonzeption für den Bundesverkehrswegeplan 2015*, Bonn

Significance, Goudappel Coffeng, Nea (2012) *Erfassung des Indikators Zuverlässigkeit des Verkehrsablaufs im Bewertungsverfahren der Bundesverkehrswegeplanung*

Geistefeldt, J., Hohmann, S.: *Ermittlung des Zusammenhangs von Infrastruktur und Zuverlässigkeit des Verkehrsablaufs für den Verkehrsträger Straße*. Schlussbericht 2014

Nagel, K., Winter, M., Beckers, T., Röhling, W., Liedtke, G., Scholz, A. (2010) *Analyse der verkehrsprognostischen Instrumente der zundesverkehrswegeplanung*

TNS Infratest & IVT (ETH Zürich) (März 2014) *Ermittlung von Bewertungsansätzen für Reisezeiten und Zuverlässigkeit auf der Basis eines Modells für modale Verlagerungen im nicht-gewerblichen und gewerblichen Personenverkehr für die Bundesverkehrswegeplanung*. Entwurf des Schlussberichts, Zürich