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Transport infrastructure data:
Benchmarking Transport Infrastructure Construction Costs

National approaches in the benchmarking of road, rail and inland waterway infrastructure construction costs

Revision

Submitted by the Group of Experts on Benchmarking of Transport Infrastructure Construction Costs

Introduction

An important pillar of the mandate of the Group of Experts on Benchmarking of Transport Infrastructure Construction Costs (GE.4) was to identify models, methodologies, tools and good practices for evaluating, calculating and analysing inland transport infrastructure construction costs. The Group prepared and distributed a set of four open questions to gather the required information. At its eleventh session (April 2021) the Group considered the information collected so far and requested the secretariat to reach out to the individual countries which had contributed to the document and ask them to check their data for accuracy and/ or to provide corrections and more up to date information if available. The annex below provides a moderately revised and edited version of the initial text offering an overview of national approaches used for benchmarking of road, rail and inland waterway infrastructure construction costs in ECE member States.

Annex

Responses of relevance for road, rail and inland waterway transport infrastructure per country

I. How do you go about calculating, forecasting and evaluating transport infrastructure construction costs?

A. Croatia

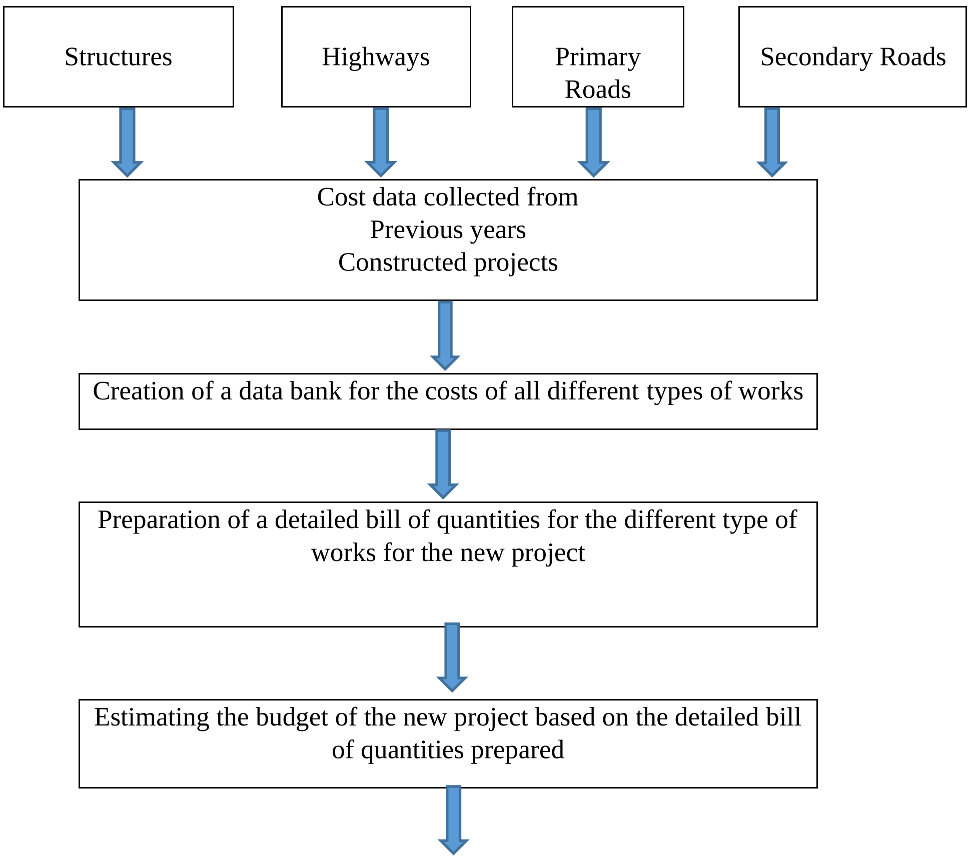
1. Development of the transport infrastructure network is based on the Transport Development Strategy of the Republic of Croatia 2017–2030. As large infrastructure projects are often co-financed under European Union funds, feasibility studies and a Cost Benefit Analysis (CBA) are mandatory. Ex-ante and ex-post evaluation are performed taking into consideration the prepared feasibility study and CBA. Moreover, cost estimates of infrastructure projects are based on market studies and experience with similar projects.

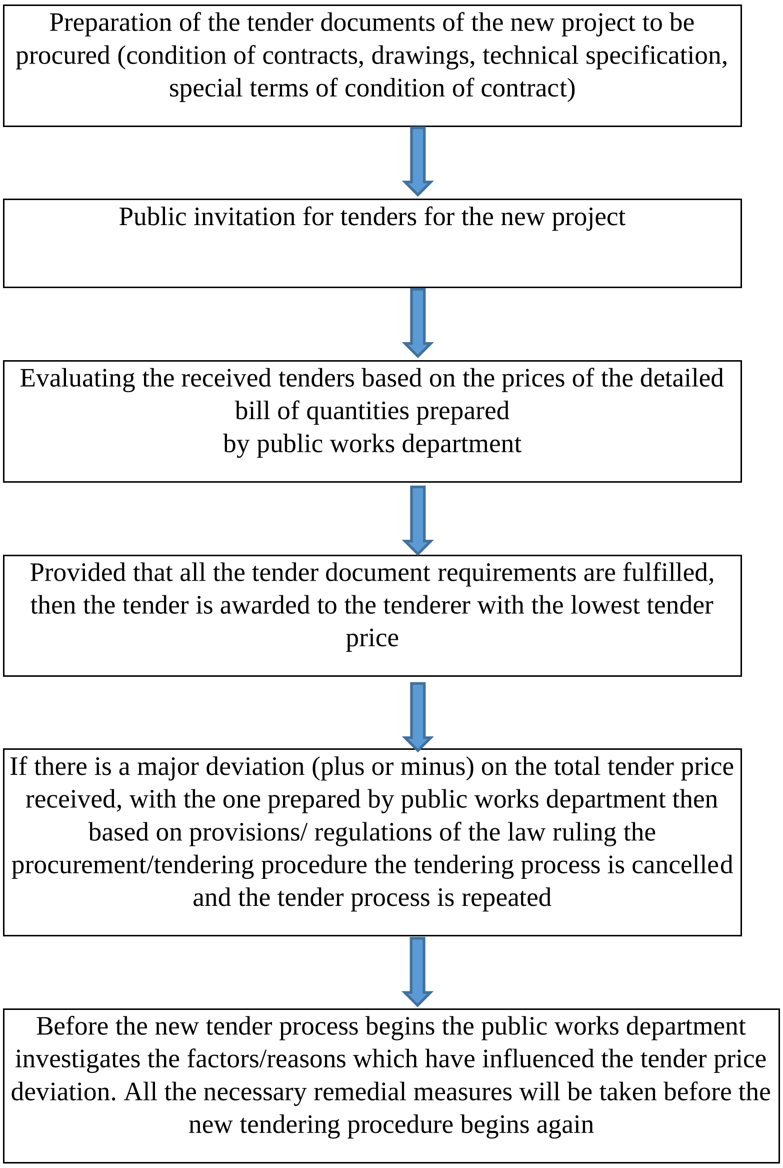
2. Moreover, construction of transport infrastructure is subject to open international procurement/tender procedures. The tender is awarded to the tenderer with the lowest tender price.

B. Cyprus

3. Cost data are collected from the previous years constructed/completed projects for all different type of works in structures, highway (including various works: earthworks, drainage, traffic management, health and safety etc.); consequently, a data bank has been created based on the cost data.

Figure I
Flow chart indicating the process for the evaluating, calculating and analyzing the road transport infrastructure construction cost along with the tendering procedure





C. Latvia

4. The procedure how the executors of construction works must calculate construction costs for all types of structures including engineering structures is stipulated in the Resolution of the Cabinet of Ministers No. 239 “Regulations on Latvian Construction Norm 501-17 “Order of Determining Construction Costs”. Construction costs include costs for construction materials, work costs, rent of construction equipment and machinery, labour costs, wear of equipment (depreciation), overhead costs and profit, as well as, other costs related to construction (e.g. clearing of construction site, relocation of utilities).

5. Planned construction costs are determined based on the prices of similar works defined in other concluded construction contracts, forecasts of macro-economic development indexes, changes in the construction market of transport infrastructure and related development forecasts.

D. Poland

6. The planned cost of construction work is calculated using the index method as the sum of the products of the price index and the number of reference units, according to the formula:

$$WRB = \Sigma\ WCi \times ni$$

where:
WRB - value of planned cost of construction work;
WCi - price index of the i-th cost component;
ni - the number of reference units for the i-th cost component.

7. The basis for calculating the planned value of construction work is:

(a) statement of work;

(b) price indices.

8. Cost components are determined considering the structure of the classification system of Common Procurement Glossary, using, depending on the scope and type of construction work covered by the contract, the groups, classes or categories of work referred to in the Common Procurement Glossary.

9. If the work contract includes construction within the scope of the Construction Law, the cost components must correspond at the very least to the groups of work covered in the Common Procurement Glossary and include:

(a) cost of site preparation work;

(b) cost of construction work for basic facilities;

(c) cost of installation work;

(d) cost of finishing work;

(e) cost of work related to land development and construction of ancillary facilities.

10. The price index of a given cost component is determined based on market data or in the absence of such data - based on commonly used catalogues and price lists.

11. The number of reference units is determined based on the statement of work.

12. Where there is not a single suitable price index, these costs should be calculated to produce an individual cost estimate.

13. When preparing the cost estimate, you can make use of currently available publications.

14. The estimate may also be prepared based on a cost analysis of a completed order or parts thereof and thus based on individual analyses.

15. Sources of information for individual data collection can be:

(a) concluded agreements or contracts;

(b) prices from current publications, guides, catalogues, and offers;

(c) prognostic data in the area of shaping prices.

E. Sweden

16. Trafikverket uses four different methods or approaches depending on the stage in the processes of inquiry, planning or production.

(a) In the early stages of the planning process a study of strategic choice of measures is conducted wherein rough cost estimations aimed at capturing the largest cost items are calculated. These items are quantified, and the corresponding costs are evaluated by analysing key figures from previously completed construction projects. For internal use, there are templates available with and without pre-filled values.

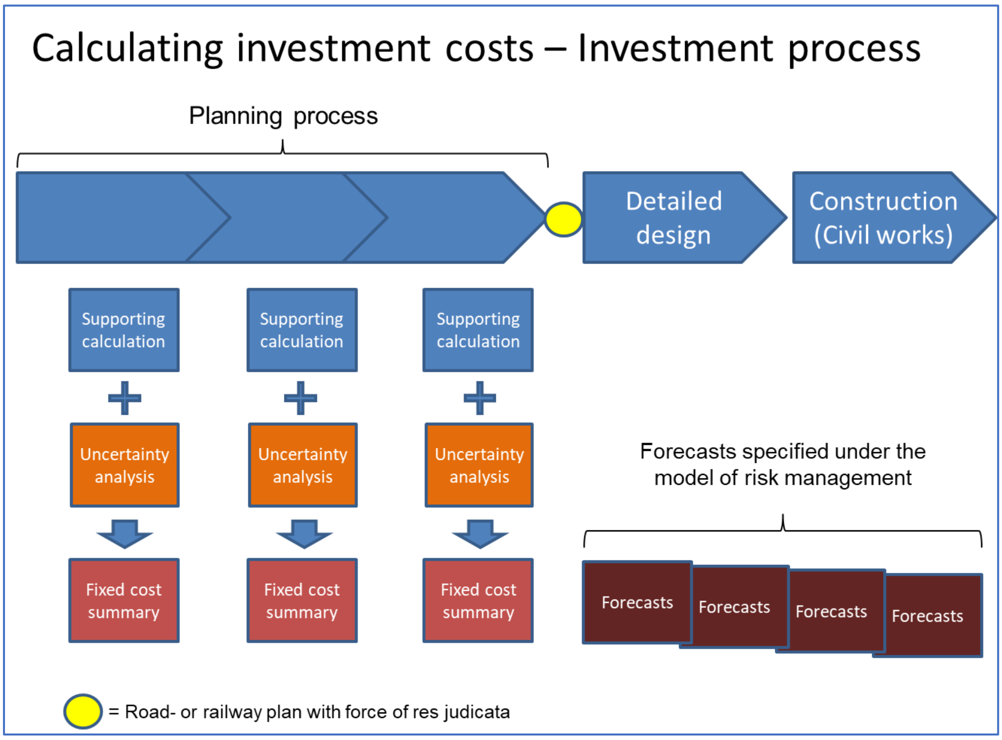
(b) In the next phase of the planning process (preliminary studies of a number of possible alternatives → railway/road study of one proposed alternative), two methods are used. First, a so-called supporting calculation is conducted. In general, these types of estimations are conducted by external consultants and are based on traditional methods for estimating construction costs (i.e. quantity * prices per item). The template used allows for triple estimations.

(c) In addition to the supporting calculation, a separate evaluation is made using the successive principle method. The evaluation is based on an analysis of uncertainty that is conducted by a balanced and competent analysis group. This group makes forecasts of the final investment cost. Moreover, they identify and evaluate uncertain items that are important with respect to cost. The method is used to evaluate the uncertainty of the investment cost.

(d) Based on the result from the two underlying evaluations mentioned above, the final evaluated expected total costs are documented in the template summary of total cost. The summary of total cost is conducted based on the supporting calculation and the result from the analysis of uncertainty to ensure a common layout and transparency for any given stage of the planning process. The documents are later used to follow up the actual final cost compared to the estimated costs.

17. When a project enters the detailed planning and construction phases, the calculation process goes on to ongoing forecasting work.

Figure II
Calculating investment costs – Investment process



F. Turkey

18. By means of:

- Feasibility studies
- Official unit prices and unit price analysis (updated annually for all kinds of construction works)
- Similar infrastructure construction projects previously completed.

II. How do you compare transport infrastructure construction costs over time and normalize these costs by region/ time?

A. Croatia

19. Ex-post evaluation of transport infrastructure construction costs is conducted a few years after the projects has been finalized.

20. Developments of the construction market are carefully monitored in order to obtain the best value for invested money, including changes depending on global financial market flows as well as crises.

21. The costs of inland waterways construction cannot be compared because each location is specific. In general, costs are defined through public procurement procedures/tenders, in accordance with operational construction plans. The planned costs of transport infrastructure construction are being monitored through the estimated prices on the market at the time of the call for tenders and through ex-post evaluation after the project is completed.

B. Cyprus

22. The prices collected in the database are re-evaluated over time taking into consideration major issues that can affect the prices like deviation on the cost of labour, petrol, inert materials, construction steel, VAT (Value added tax) etc.

23. The prices collected in the database take into account the region/part of the country.

C. Latvia

24. To compare the construction costs the following indicator is used: changes of the average costs for the reconstruction of one km of 7.5 m wide asphalt pavement in several years. These costs include those works, the cost of which constitutes the major part of project cost. Unit prices for specific works are average prices offered by contractors in construction tenders in respective years. Costs are not determined for each region specifically; they are determined for the whole of Latvia.

D. Sweden

25. After an infrastructure construction project is completed, the final costs are analysed in comparison to previously evaluated costs. Both evaluations and final costs are specified by a common structure.

Block	*Name*
1	Project administration
2	Inquiry and planning
3	Design
4	Acquisition of land and property
5	Environmental measures
6	Contract works – Earth works
6.1	Earth works
6.2	Structures
6.3	Tunnels

Block	*Name*
7	Contract works - Railway
7.1	Track works
7.2	Electrical works
7.3	Environmental measures
7.4	Telecommunication works
8	Unique measures and archaeology
9	Delivery and end of project
10	Overall uncertainty (only budget)

26. All figures are converted to comparable price levels using indices.

27. This common structure makes it possible to aggregate several projects and do benchmarking between different project, regions etc.

28. The followed-up investment costs from major infrastructure construction projects are compiled and categorized in an Excel-sheet, thus allowing for usage in evaluation of future projects.

E. Turkey

29. Official deflator coefficients are published for each sector (tourism, agriculture, mining, energy, transportation ...). This calculation is based on the monetary value of all goods and services produced in an economy. Thus, predictive approaches can be made as year-based and sector-based.

30. In addition; various parametric assumptions, depending on the terrain conditions for regional differences, provide useful results in practice.

III. How do you make sure that the mechanism you use to calculate and assess transport infrastructure costs also serves as a tool for costs control?

A. Croatia

31. The prepared feasibility studies and Cost Benefit Analysis are subject to ex-post controls a few years after project finalisation.

32. In the inland waterway sector, this is ensured in a way that aside from the construction of transport infrastructure, the supervision of the execution of works are subject to control by supervising engineers whom issue reports on the process.

B. Cyprus

33. Based on the information collected in the database, the Budget of the New Project is calculated through a detailed Bill of Quantities of all the works to be executed.

34. The correctness of the estimated budget is almost assured because a) it is based on the collected costs in the database of the recently constructed/completed projects (considering also the region of the project) and b) the relevant corrections are made to these costs based on the deviation regarding cost of labour, petrol, inert materials, VAT, etc.

C. Latvia

35. Cost control mechanism in road construction sector is not established.

D. Sweden

36. The common structure described above in paragraph 25-28, is used throughout the whole investment process.

E. Turkey

37. Since transportation investments are affected by many parameters in practice, it is not easy to reach the precise results with preliminary evaluation and calculation mechanisms. Comparative data and analytical approaches are used to reach the nearest predictive approaches.

IV. Do you use different cost calculation and evaluation methodologies for construction in different modes? If yes, please explain.

A. Croatia

38. The methodology for calculating and evaluating the construction of transport infrastructure for certain modes is applied in compliance with the regulations relating to different sources of financing. During the preparation of project documentation, alternative solutions are presented, and cost estimates are given depending on the type of water structures. The final assessment of an eligible water structure is influenced by price, environmental impact and efficiency.

B. Cyprus

39. Generally, the same process is used for all modes; however, there are road transport infrastructure projects where Design, Build, Financing and Operating DBFO () or Design and Build (DB) approaches are used. These methods are used for very special and expensive projects like the construction of the airports, desalination plants etc.

C. Latvia

40. This question does not fall under the responsibility of Latvian State Roads.

D. Sweden

41. The analysis of uncertainty is generally not conducted for projects with an expected total cost below SEK 25 million. The level of ambition with respect to the scope of the analysis group and length – in terms of days – of the analysis is adapted to the size and complexity of the project. Projects with an expected total cost above SEK 500 million, require a larger analysis group, more experienced facilitators and a two-day analysis-workshop.

E. Turkey

42. Different cost calculation and evaluation methodologies are used when technical risks are identified.

43. Risks may involve soil characteristics and properties of the project area (ground water level, weak soils, liquefaction risks, or areas in needs of rehabilitation etc.).

44. Risks may also be identified based on similar previously implemented projects carried out under similar terrain and climate conditions (flat terrain, sloping-steep terrain, hydrologic data etc).

F. Czechia (case study)

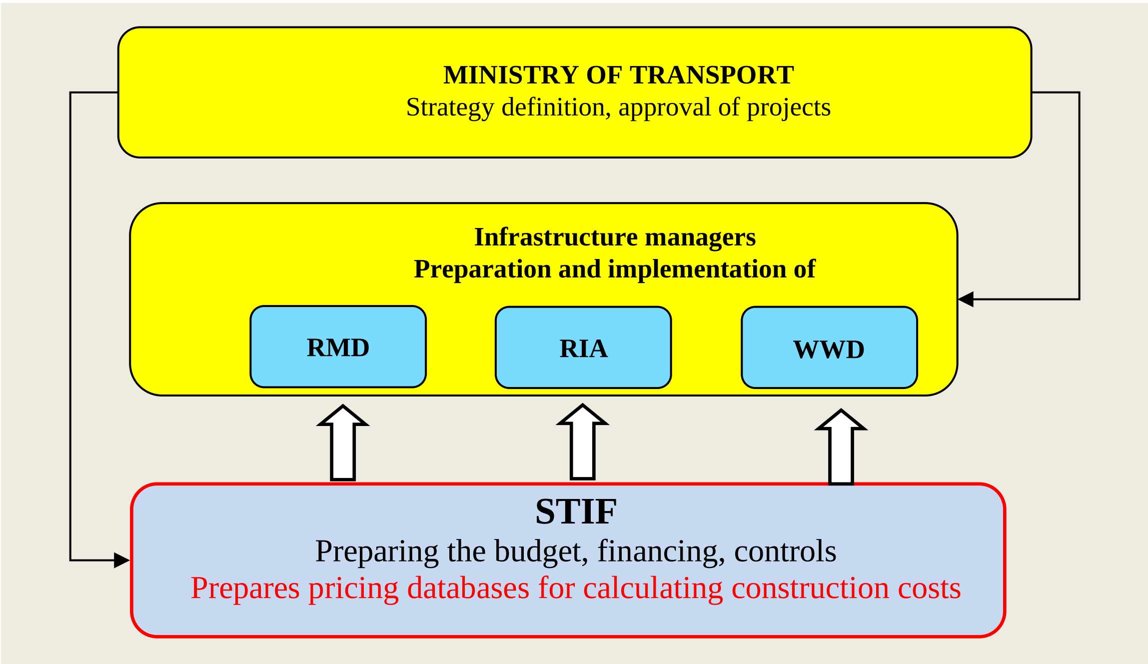
Model, methodology and best practice for evaluating, calculating and analysing inland transport infrastructure construction costs in the Czech Republic

(a) Key information on transport infrastructure in the Czech Republic

45. The total length of the network of roads and motorways in the Czech Republic is 55,792 km. Motorways and Class I roads are owned by the state whilst Class 2 and Class 3 roads are owned by the regions. The railway network in the Czech Republic is rather dense for historic reasons and its current total lengths is 9,539 km.

46. Figure III shows the organigramme of state transport infrastructure development.

Figure III
Organigramme of state transport infrastructure development

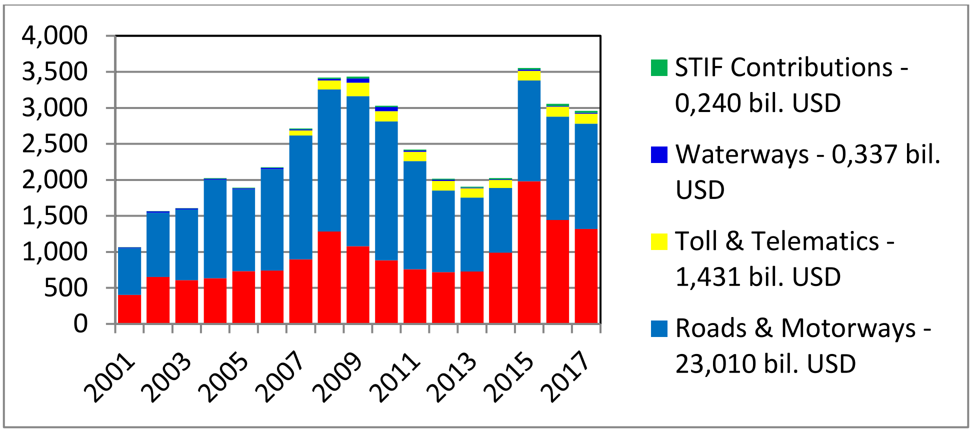


47. Development directions and strategies for state infrastructure of national importance in the Czech Republic are defined by the Ministry of Transport. The Road and Motorway Directorate (RMD), Railway Infrastructure Administration (RIA) and Waterways Directorate (WWD) serve as the executive authorities for individual transport modes. These organisations are preparing the projects, are in charge of implementation and building of transport constructions and providing for operation and maintenance in their role of infrastructure managers.

48. The State Transport Infrastructure Fund (STIF) has been set up for the purpose of financing. This is an authority similar to a bank which provides national resources as well as European Union funds. STIF is an implementing agency of European Union funds in the Czech Republic. This means that STIF finances projects, prepares budgets and is responsible for an efficient financing. These are the main reasons why STIF needs a clear standard for how to calculate or estimate construction costs and why STIF prepares pricing databases for transport infrastructure constructions.

49. Financial resources in the total amount of USD 40.855 billion were provided via STIF for transport infrastructure in the Czech Republic in the period 2001–2017. Figure IV presents the overview of financing in years 2001–2017 for individual transport modes, including tolls, telematics and contributions provided in line with the Act on STIF.

Figure IV
Financial resources provided to STIF beneficiaries in the period 2001-2017 (in billion USD)



Note: Conversion from CZK to USD was done using the Czech National Bank exchange rate of 31 December 2016: USD/CZK 25.639

(b) Estimation and calculation of transport infrastructure construction costs

50. For understanding construction costs estimation and calculation, it is important to know the process and stages of construction preparation in the Czech Republic. Construction preparation has four stages, which s answers the questions “Why? Where? What? Who?” The first stage, the Feasibility Study, is used for selection of the best project alternative or version and includes economic assessment of projects. After the approval of the Feasibility Study, project preparation can start. Then the project continues with Zoning Permit Design Documents. The appropriate project location is defined at this stage. Detailed Design for Building Permit represents the next stage. The Detailed Design for Contract and Construction is made before the contractor tender. These are the four stages of construction preparation. For each of these stages, a different pricing database is used, as shown in the table below.

No	*Stages of preparation*	*Answer to question*	*Pricing database*	*Level of Detail*
1.	Feasibility Study	Why?	Pricing Norms	Specific type of road or railway - number of kilometres
2.	Zoning Permit Design Documents	Where?	Object Indicators	Construction objects
3.	Building Permit Design Documents	What?	Price Index of Crucial Components of Objects	Crucial components of the objects
4.	Contract & Construction Design Documents	Who?	Industrial Classification of Building Structures and Works	Aggregated items including wages, machines, material, supplementary construction

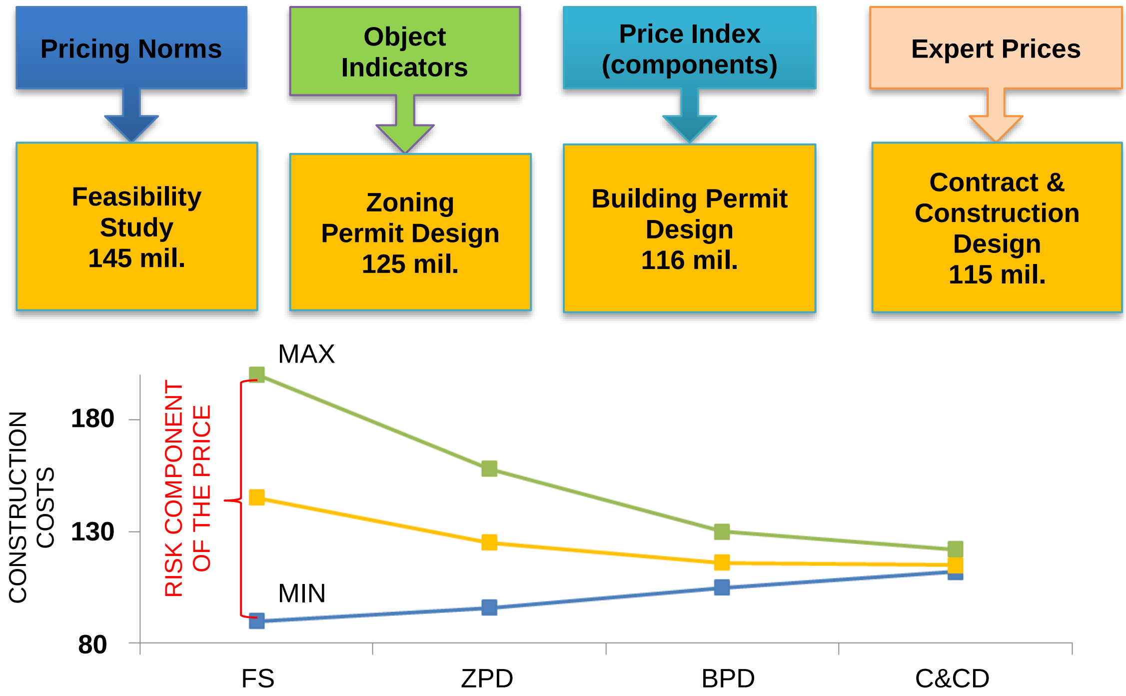
51. This means that Pricing Norms are used for the Feasibility Study and construction costs are estimated based on the number of kilometres of a specific type of road or railway.

Construction costs for Zoning Permit Design Documents are defined based on Object Indicators. Construction objects represent the level of detail used for Zoning Permit Design Documents. The structure of items for Pricing Index of Crucial Components of Objects, used for Building Permit Design Documents, is more detailed. The crucial components of a motorway object for example are excavations, embankments, motorway surface, marking or ditches.

52. The pricing database for Contract and Construction Design Documents is the most detailed and the most important from the construction costs point of view. This is because contract conditions in motorway, road and railway constructions in Czechia are usually based on the International Federation of Consulting Engineers (FIDIC) Red Book (measuring contracts). The items structure in this pricing database is used for the contractor tender and for invoicing during construction. Items from this most detailed database have a high degree of aggregation, including costs of wages, machines, material, as well as supplementary construction. The price of individual items does not come out from the past statistic prices but from an expert calculation. Another reason why the pricing database for Contract and Construction Design is the most important from the price point of view is that this is essential for pricing calculation for all other databases. Each component is made out of several items, each object is made out of several components and finally the construction consists of several objects. The basic price of the item translates into the complete final price of the construction during the entire process of preparation. All the prices are linked to achieve price stability during preparation. Prices are created from bottom to top, while classification (objects, construction components and individual items) are created from the top to bottom.

53. Inclusion of the risk component of the price based on risk analysis represents another important factor for ensuring price stability within the process of design preparation and implementation of projects. At the stage of the Feasibility Study, there is a big difference between maximum and minimum price due to a lack of information regarding the project. However, by estimating the risk component of the price, price increases during the preparation phase are avoided. In the subsequent stages of the construction process the cost remains relatively stable and is not raised as was encountered in the past. Increasing accuracy of construction costs calculation during construction preparation with the inclusion of the risk component of the prices is displayed in Figure V.

Figure V
Increasing accuracy of construction costs during construction preparation with inclusion of the risk component of the prices)



54. Pricing databases are regularly updated according to the needs, depending on technical development and practical experience from previous year. Ministry of Transport approves these databases updates and prescribes an obligation to use these databases for estimation and calculation of transport infrastructure construction costs of the projects financed by STIF. At present, we are focusing on two topics within the area of transport infrastructure constructions pricing – calculation of construction lifecycle costs and introduction of the BIM method (Building Information Modelling or Building Information Management). We are testing software for defining of bridge lifecycle costs, working on standardising and drafting of methodologies, technical rules and instructions for 5D information models that will include not only spatial positions, but also time planning and calculation of construction costs. We are persuaded that introducing of the BIM method represents an opportunity for increasing productivity within the construction sector, rendering it more attractive for the younger generation and improving competitiveness and efficiency of preparation, implementation, and management of transport constructions.

(c) Analysis of construction costs of roads and motorways

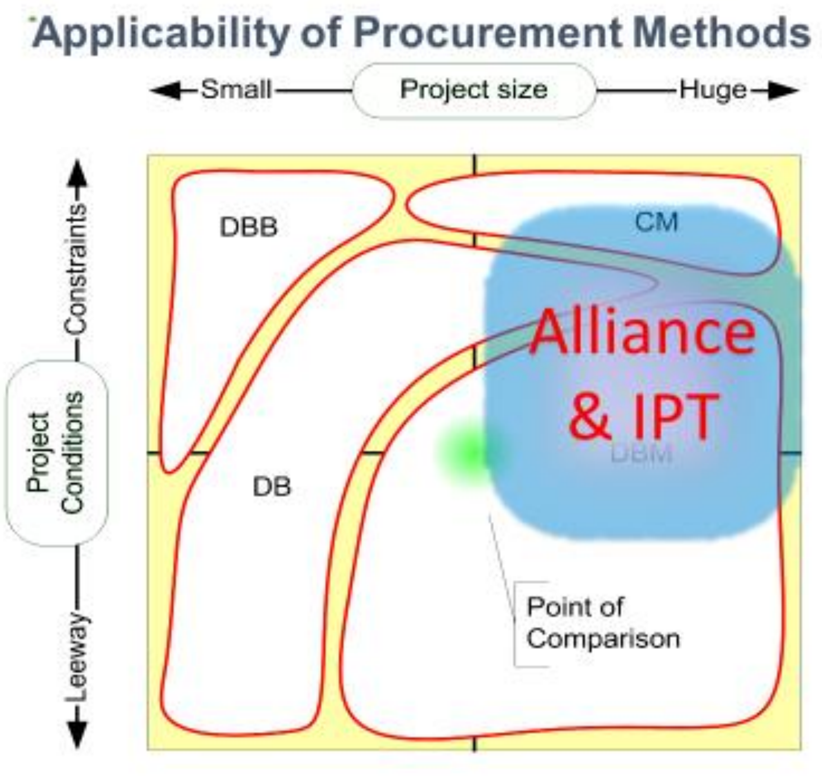
55. In addition to systematic updating of supporting documents for transport constructions pricing during project preparation, the winning bids from tenders for contractors for work organised by the Road and Motorway Directorate are being analysed over the long term. In total, 1,649 constructions have been analysed since 2004. A long-term statistic of real prices offered by construction contractors is thus available. As roads and motorways are funded from public resources, this bid prices development statistic has been transparently published online under the link www.merne-naklady-staveb.cz.

G. Finland (case study)

56. The Finnish Transport Infrastructure Agency (FTIA) is responsible for Finnish road, railway and maritime investments and maintenance. FTIA`s annual budget (2020) is about 2 billion €, of which 650 million € is investments. FTIAs budget is about 25 per cent of Finland's infrastructure markets volume. FTIAs personnel are about 600 people, of which about 10 per cent work in construction projects.

57. FTIA does not have any production capacities at all. All projects are outsourced. FTIA uses several contract models. Most common is the traditional Design Bid Build method. Design Build, where design and build phases are combined into the same agreement is also quite common. The advantage of the latter is that it encourages contractors to be innovative and more productive. This is possible, when the planning and design belongs to the contractor and the owner only defines the standards, functionality and quality of the project. Construction management provides the owner with a central focal point for managing and administering all phases of the project construction, including threats planning, design, construction as integrated tasks. Public-Private Partnerships (PPP) projects, where design, build, operate and maintain phases and private financing are combined into the same long-term agreement, are also used to a limited extent. Alliance or Integrated Project Team (IPT) projects is a new method of contracting. Owner and one or more service providers (designer, constructor, supplier etc.) are working as an integrated project team. The method has nowadays been heavily used in large, risky projects, mainly because of risk management and for creating innovation and productivity gains.

Figure VI
Applicability of Procurement methods



58. FTIA does not use unit price-based contracts at all. That is partly a strategic decision and partly, because FTIA wants to make civil engineering projects more productive. FTIA is a small organization and there are no resources for supervision.

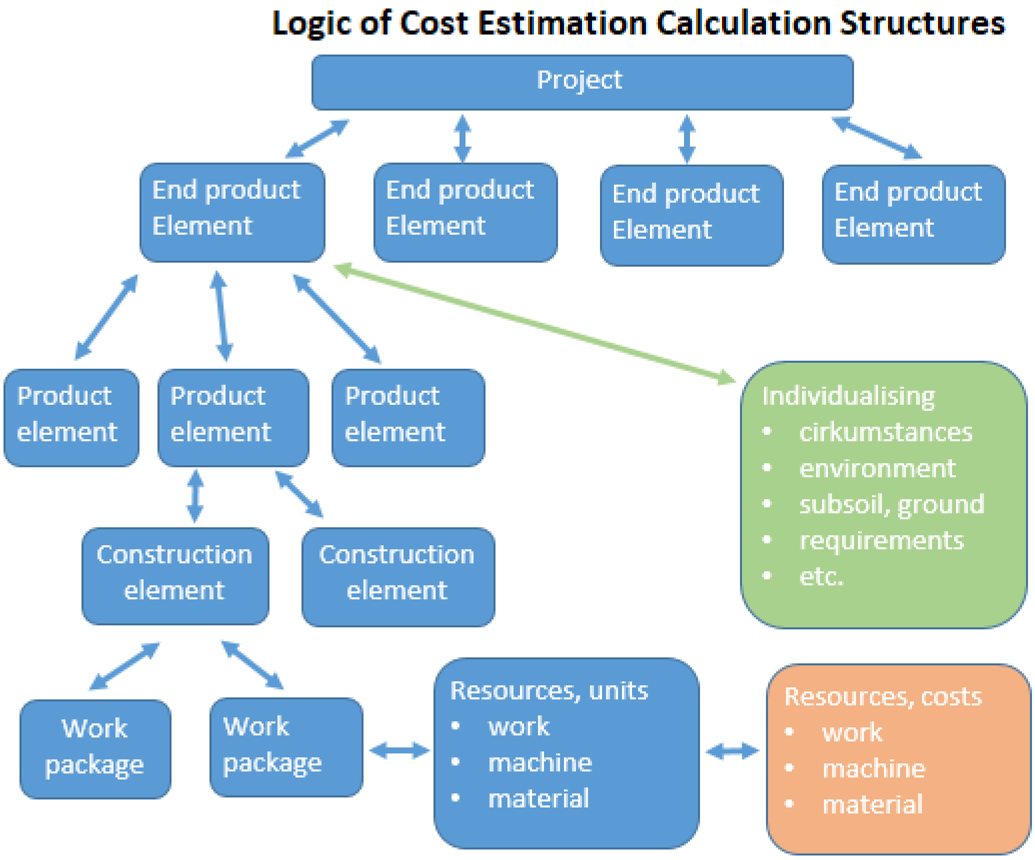
59. In the tendering process and in contracts, FTIA has a bill of quantities, but that is for information purposes only, it does not provide a justification for payments. The normal way in all contract models is payment through a lump sum. Naturally, there are parts and elements, that are based on unit prices, but that is because of risk management. In cases where the quantity of some works is not at all known (for example rock blasting), it may be paid based on a unit price.

60. When contractors count their offers, they count, the amount of resources they need to get the work done. They know their own achievement of resources in different works and in different situations.

61. In construction cost estimation, FTIA is trying to simulate the contractor's method. FTIA uses average combination of resources and impending work achievements. The method is called standard cost estimation.

62. The cost estimation calculation is based on the Finnish Infra2015 construction element and project nomenclature. It consists of about 1,000 construction elements. These elements define the workload in a project. In the Finnish cost estimation system, the elements and their structures are all modelled in accordance with the amount of resources needed. Then the project is individualized by using data on the circumstances, environmental factors, subsoil and ground requirements etc. The idea is that the more detailed the information of the project the better the cost estimation.

Figure VII
Logic of Cost Estimation Calculation Structures



63. FTIA tries to estimate, how much a given project will cost. It does not come up with an estimation by comparing a project to other projects. When FTIA has the whole cost estimation calculation in its data system, the calculations are made and risk factors are identified.

64. Afterwards estimation is compared to the contractor’s tender and finally to the final cost of the project. In the calculation they have estimations of all parts of the project, so focus is given to those parts which may be more problematic. When there are several projects in the calculation system, FTIA analyzes the data and produces statistics also used for further improvement of the calculation model.

65. FTIA wants the cost calculation to be a regular part of the planning or design process. That makes the effective cost management of the project possible. Project costs are known throughout the entire project cycle and can be compared with prices of alternative technical solutions.

66. The most laborious part in cost estimation is to handle the large quantity of data surrounding planning and design and have it reflected in the cost calculation system. In large projects, the amount of data is significant. FTIA wants to build an interface between infrastructure models and its own cost calculation system. In doing so it will be possible to automate various steps involved in the cost estimation process.

H. Turkey (case study)

1. Calculating, forecasting and evaluating transport infrastructure construction costs

67. Highway infrastructure cost studies in Turkey are being done across three categories: for road construction costs, for road maintenance costs and for superstructure costs such as the construction of bridges and tunnels. Infrastructure cost information is needed for the

separate phases of the projects. These phases consist of planning, implementation, and management phases. The purpose of road infrastructure cost studies is done:

- to improve productivity, to ensure common understanding of terminology;
- to ease cost-benefit analyses and financial feasibility studies;
- to use in tender procedures;
- to obtain the best competitive situation in order to offer the projects on best competitive tendering;
- to control cost overruns;
- to do better estimation of budget and budget allocations;
- to get data for privatization, etc.

The cost data and analysis is important especially for decision makers and planners for the road authorities, consultants, financial institutions, infrastructure markets, etc.

68. In Turkey cost estimation studies are performed using three different methods such as: (1) Actual costs on realized and completed projects; (2) Cost estimates depending on preliminary works and design for real projects using unit prices for bidding; and (3) Cost estimates on virtual projects.

69. Cost estimating is an attempt to forecast the actual cost of a project. Cost estimates play an important role for determination of the bid amount as well as development of the project budget. Inaccurate cost estimates may lead to lost opportunities, lower than expected returns and unsuccessful projects. Estimating in general requires a detailed study of the bidding documents including construction drawings and specifications, a quantity takeoff, and determination of costs.

2. Cost estimates depending on preliminary works and design for real projects using unit prices for bidding

70. In general cost estimates could be classified into two groups: preliminary cost estimates and detailed cost estimates. Preliminary cost estimates are usually prepared before drawings and specifications are available and detailed cost estimates are prepared after construction drawings and specifications are available.

(a) Preliminary estimates

71. Preliminary cost estimates are usually performed at the early stages of the projects with limited information since drawing and specifications are not available. One of the main reasons for having preliminary estimates is to decide about feasibility of a project. If a project is determined as feasible based on the preliminary estimate than detailed design, bidding and construction stages could be initiated, therefore early estimates play a crucial role on committing resources for further development of a project. Preliminary estimates could also be used for the evaluation of different project alternatives and also for development of an initial project budget. Preliminary cost estimates are not expected to be fully accurate since detailed drawings are not available and there are several uncertainties present about project cost at the early stages. However, a quick and reasonably accurate estimate is needed based on the information available, especially when a feasibility decision is to be made. In general data of past projects are used to develop preliminary cost estimates. A very simple method to determine a preliminary cost estimate is to use average unit cost of similar projects.

(b) Detailed estimates

72. Detailed estimating requires determination of the quantities and all the costs to complete the project. The first step of detailed estimation is investigation of the bidding documents for preparation of quantity takeoff. A quantity takeoff is a detailed calculation of quantities for each work item that is going to be performed to complete the project. Quantity takeoff is an important step of estimating and bidding and a complete set of bid documents including drawings, specifications and conditions of contract are needed for preparation of quantity takeoff accurately.

(c) Contract types

73. Other than privatization there are two general classifications of contracts used in the construction industry based on the way in which a contractor is paid: fixed price contracts and cost-plus contracts. In fixed price contracts, contractors agree to construct the facility on a fixed price basis where either the overall price (lump sum contract) or unit prices (unit price contract) are fixed.

74. In lump-sum pricing, a contractor's fee for services is established as a total contract amount. A price is agreed upon by the client (owner) and the contractor for the whole project. The risks due to market fluctuations belong to the contractor. So, it is a nice system for the client (owner) who knows exactly how much the job will cost (unless there is an unforeseen event) and will get his job completed in the minimum time. However, in this system, a complete control must be kept on the job since the contractor may use poor material and unqualified labor. The owner may be in an adversary position with the contractor especially if the scope of work is not clearly defined. For the contractor, the advantage of lump sum pricing is that it gives him a set target to shoot for. The disadvantage lies in the fact that a lump sum contract allows no flexibility for adjustments thus, a risk premium is required to financially cover the cost of unforeseen job conditions. Poor cost estimating may result in disastrous situations for the contractor.

75. The unit pricing method establishes payments based on the amount of production or quantity of works completed at a fixed price. In Turkey, in unit price contracts, costs can be calculated by multiplying quantities with unit prices which are published every year by the Ministry of Environment and Urban Planning. However, sometimes, r unit prices offered by the contractor are used.

76. A combination of lump-sum and unit-price contracts is also possible. In mega projects where quantities associated with some part of work are determined, whereas some quantities cannot be clarified due to uncertainties (about geological conditions, poor scope definition etc.), a combination of lump-sum and unit-price can be used. Although a lumpsum price is determined, for the unclear part of work, contractor may be paid in unit-prices.

(d) Overhead costs

77. Overhead costs are expenses that cannot be related to any specific item of work. If the costs can be related to an item of work they should be included under the material, labor, or equipment costs. The overhead costs are usually estimated as a percentage of total project cost. In calculation of unit prices of Ministry of Environment and Urban Planning the overhead expenses and profit is taken as 25 percent of the cost.

(e) Cost overruns

78. If the actual cost exceeds the tender cost, an increase of up to 20 per cent of the tender price is made by the General Directorate of Highways, up to 40 per cent is made by the Presidency of the Republic, for more than 40 per cent the contract is cancelled, and a new tender is made to complete project. Due to budget constraint, benchmarking of transport infrastructure construction costs is significant for having realistic construction costs and a stable investment program with no cost explosions.

3. Construction cost data collection depending on completed projects

(a) Construction cost of roads

79. As mentioned above the purpose of road infrastructure construction is to calculate realized road unit costs and ranges, to find out which parameters are important to specify costs, to determine investment and current budget based on more realistic parameters, in order to perform benefit-cost analysis based on realistic construction, maintenance, and operation costs. The road infrastructure construction cost study is performed every 10 years. The results of these studies will lead to work rational, cost effective and will ensure data for planning, budgeting, productivity, strategic planning, privatization, determine performance criteria's, etc. Road projects Infrastructure cost have been calculated regarding road standard as motorways, state and provincial roads.

80. For road construction cost calculation to ease benchmarking infrastructure construction cost, superstructures cost as bridges and tunnels separately are excluded and calculated separately. In addition, the investment projects under investment programs have been very different than each other, definition on road construction projects were deemed necessary and were done as resurfacing, resurfacing by strengthening, pavement replacement, road conditioning, reconstruction, new construction and capacity enlargement. These are:

(i) Resurfacing

81. Placing a new surface of an existing road in order to service in good condition, to increase skid resistance, to seal by aiming to preserve road from negative atmospheric conditions, to increase driver comfort, to extend pavement life, etc. The aim is not to increase the bearing capacity of pavement however to extend its lifetime by preserving the road from bad weather conditions.

(ii) Resurfacing by strengthening

82. Renewing of road surface with reinstalling bituminous layer either directly or by removing a determined depth of the pavement by milling to increase bearing capacity of road and to eliminate road defects.

(iii) Pavement replacement

83. Renewing of the pavement either by removing the total thickness of all paving layers, existing asphalt layers from an existing road way, and then providing a new paved surface without changing capacity or geometry of the road, i.e. without changing subgrade.

(iv) Road conditioning

84. Reconditioning includes improvement of grades, curves, intersections or sight distances in order to improve traffic safety or changing the subgrade to widen shoulders or to correct structural problems in addition to resurfacing or pavement replacement.

(v) Reconstruction

85. The total rebuilding of both pavement and subgrade of an existing highway. Work which either changes the location of the existing subgrade shoulder points or removes all the existing pavement and base course for at least 50 per cent of the length of the project. In other words, it is the rebuilding of an existing roads’ pavement and subgrade to correct road geometry, to increase road safety, to ease maintenance works and to increase preservation.

(vi) New construction

86. Same as reconstruction and involves the construction of additional through travel lanes beyond the work associated with reconstruction.

(vii) Capacity enlargement

87. There is not any existing road for this kind of project. This is the new building of a road with all parts; subgrade, pavement, structures, etc.

88. In addition to the road project types explained above, project sizes have also been regarded for construction cost studies of road projects in Turkey. Projects sizes has been regarded as a parameter and taken into consideration as small size, medium size, large size and mega projects. The more complex and difficult projects are large size or mega projects, on the other hand easy projects in terms of terrain type and projects type are small or medium size projects. In addition, many parameters have been regarded when the costs studies based on size of projects. As an analysis method descriptive analysis has been also used.

89. Not only the type of project but also project standards, pavement type, project length, project size (including bridge length, tunnel, etc.), construction duration, degree of urbanization, bidding type, terrain type, etc. are regarded as parameters. Multiple regressions are applied to data sets. The effect of independent variables on dependent variables is

analyzed and stepwise regression is used. All cost is calculated regarding units as TL/Km and TL/LanexKm.

90. On the other hand, land acquisition cost, design cost, environmental mitigation, construction and project management costs are calculated and given as percentages. Construction cost work types such as earthworks, superstructures, pavement, bridges, and tunnels, miscellaneous have been also calculated and given as percentages.

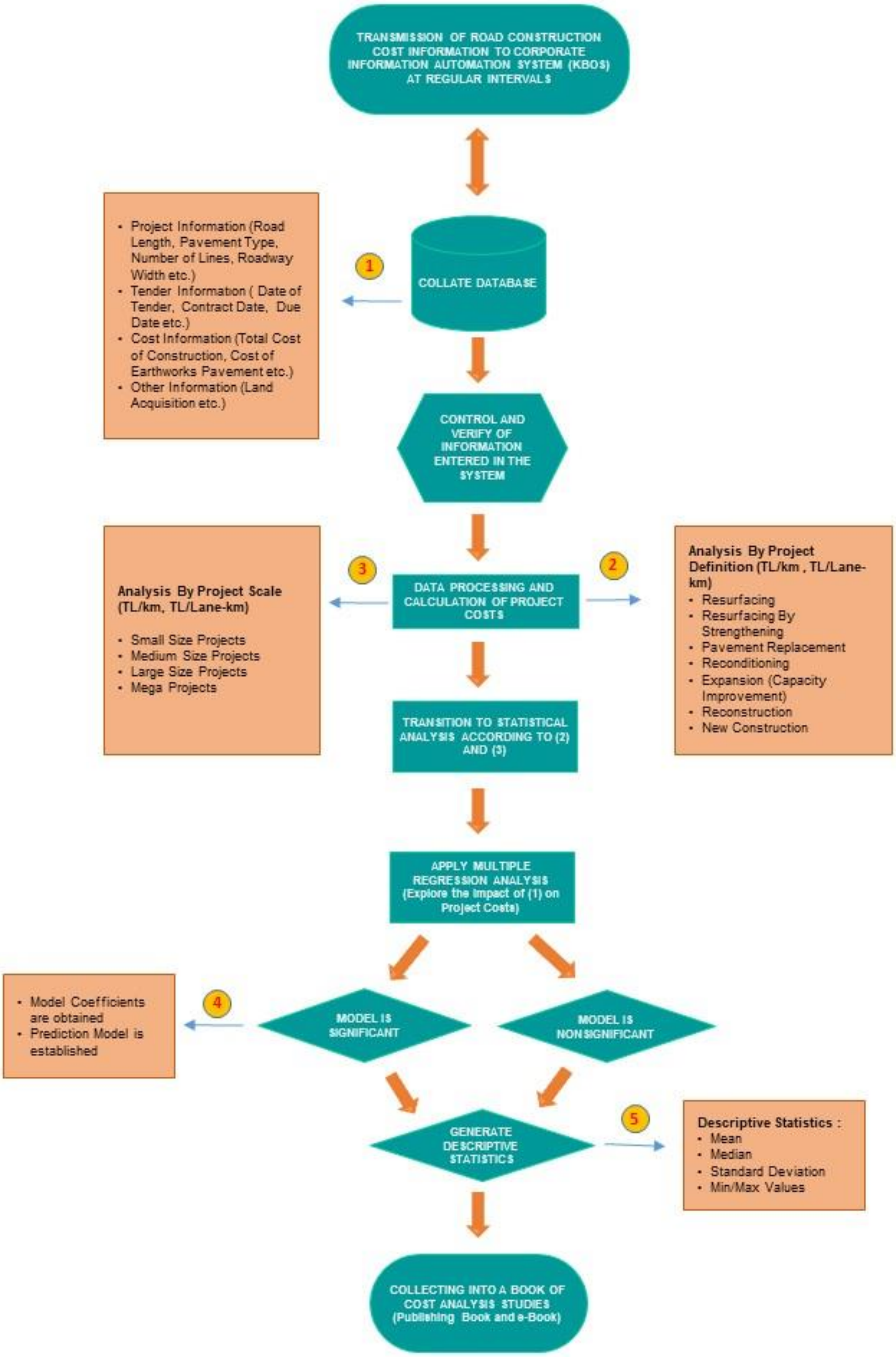
91. Construction costs are also very different according to whether the projects are passing through urban areas or rural areas. The degree of urbanization is important and this parameter is also considered.

92. Cost overruns of road projects have also been analyzed and tried to be explained.

93. The following flowchart shows the processes of actual cost calculation from actual road projects starting from the step of data collection, storing of data to the step of statistical analysis to explain how the road infrastructure cost changes depending on which parameters, data overruns and so on.

Figure VIII

Flowchart which shows the processes of cost calculation and analysis on actual projects



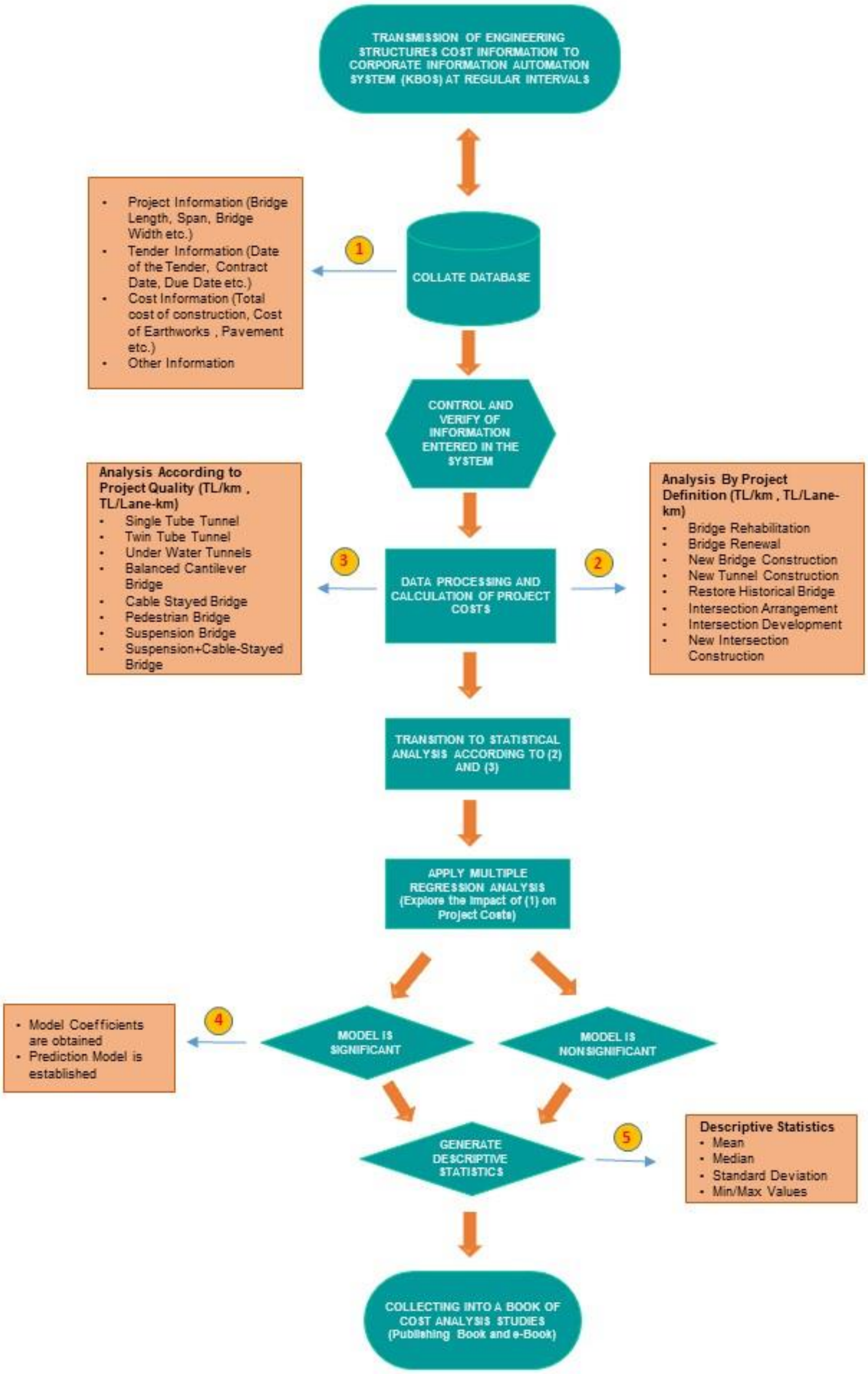
(viii) The road's superstructure such as bridges and tunnels costs

94. The road superstructure construction cost on the other hand is also performed every 10 years regarding completed projects. The superstructures as tunnel and bridges have been regarded and their unit cost as given as TL/m2 for bridges and TL/m for tunnels regarding a single tube tunnel and twin tube tunnel. For bridges costs are also subdivided as sub-structure costs and over structure costs.

95. The following flowchart shows the processes of actual cost calculation from actual road' superstructure projects starting from the step of data collection, storing of data to the step of statistical analysis to explain how the road's superstructures cost changes depending on which parameters, data overruns and so on.

Figure IX

Flowchart which shows the processes of cost calculation and analysis on actual road's superstructure projects



(ix) Construction Cost Calculations on Virtual Projects:

96. In Turkey in addition to construction cost calculation on real completed projects, cost is also calculated practicing unit costs on virtual projects every year. Different virtual projects are used to regard different parameters. These parameters are road class; terrain type; geometry of road as platform width, pavement with, shoulder width; average, horizontal and vertical curvature; roughness; and different road pavement type regarding traffic composition. Terrain type is regarded as flat, rolling and mountainous. Road class is also regarded as motorways, primary roads and secondary roads. On the other hand, carriageway is regarded as single carriageway and double carriageway roads, but the number of lanes is not taken into account. The cost is given as TL per km. The following table is an example for flat terrain type. These tables are produced annually for rolling and mountainous terrain type also. This table is produced with 2019 prices. Theis data is mostly used for benefit-cost analysis.

Table 1
Sample table for road construction costs for virtual projects to be used in Benefit-Cost analysis

YOL YAPIM MALİYETLERİ (VERGİLER HARİÇ)
ARAZİ TİPİ, AĞIR TAŞIT TRAFİĞİ VE PLATFORM GENİŞLİKLERİNE GÖRE
(2019 YILI BİRİM FİYATLARIYLA)
(ROAD CONSTRUCTION COSTS (TAX EXCLUDED) ACCORDING TO TERRAIN TYPE, HEAVY VEHICLE TRAFFIC AND PLATFORM WIDTH)
(WITH 2019 UNIT PRICES)

(TL/KM)

ARAZİ TİPİ *(Terrain Type)*	AĞIR TAŞIT TRAFİĞİ *(Heavy Vehicle Traffic)*	ÜSTYAPI TİPİ *(Pavement Type)*		PLATFORM GENİŞLİĞİ (m) *(Platform Width)*			
				8.00	10.00	12.00	Bölünmüş Yol *(Dual Carriageway)*
DÜZ *(Flat)*	0-50	Tek Kat Sathi Kaplama (Tip Enkesit 1) *(Single Layer Surface Treatment) (Cross Section Type 1)*	Toprak İşleri *(Earthworks)*	691.557	788.248	884.938	1.592.889
			Sanat Yapıları *(Structures)*	276.623	315.299	353.975	637.155
			Üstyapı *(Pavement)*	601.385	751.732	902.078	1.623.740
			Toplam *(Total)*	**1.569.565**	**1.855.278**	**2.140.991**	**3.853.784**
	50-250	Çift Kat Sathi Kaplama (Tip Enkesit 2) *(Double Layer Surface Treatment) (Cross Section Type 2)*	Toprak İşleri *(Earthworks)*	691.557	788.248	884.938	1.592.889
			Sanat Yapıları *(Structures)*	276.623	315.299	353.975	637.155
			Üstyapı *(Pavement)*	637.840	797.300	956.760	1.722.167
			Toplam *(Total)*	**1.606.020**	**1.900.846**	**2.195.673**	**3.952.211**
	250-500	Asfalt Betonu (Tip Enkesit 3-1) *(Asphaltic Concrete) (Cross Section Type 3-1)*	Toprak İşleri *(Earthworks)*	691.557	788.248	884.938	1.592.889
			Sanat Yapıları *(Structures)*	276.623	315.299	353.975	637.155
			Üstyapı *(Pavement)*	1.190.919	1.488.648	1.786.378	3.215.480
			Toplam *(Total)*	**2.159.099**	**2.592.195**	**3.025.291**	**5.445.524**
	500-1000	Asfalt Betonu (Tip Enkesit 3-2) *(Asphaltic Concrete) (Cross Section Type 3-2)*	Toprak İşleri *(Earthworks)*	691.557	788.248	884.938	1.592.889
			Sanat Yapıları *(Structures)*	276.623	315.299	353.975	637.155
			Üstyapı *(Pavement)*	1.235.635	1.544.544	1.853.452	3.336.214
			Toplam *(Total)*	**2.203.815**	**2.648.090**	**3.092.366**	**5.566.258**
	1000-1500	Asfalt Betonu (Tip Enkesit 4) *(Asphaltic Concrete) (Cross Section Type 4)*	Toprak İşleri *(Earthworks)*	691.557	788.248	884.938	1.592.889
			Sanat Yapıları *(Structures)*	276.623	315.299	353.975	637.155
			Üstyapı *(Pavement)*	1.307.018	1.633.773	1.960.528	3.528.950
			Toplam *(Total)*	**2.275.199**	**2.737.320**	**3.199.441**	**5.758.994**
	1500-3000	Asfalt Betonu (Tip Enkesit 5-1) *(Asphaltic Concrete) (Cross Section Type 5-1)*	Toprak İşleri *(Earthworks)*	691.557	788.248	884.938	1.592.889
			Sanat Yapıları *(Structures)*	276.623	315.299	353.975	637.155
			Üstyapı *(Pavement)*	1.382.060	1.727.575	2.073.090	3.731.561
			Toplam *(Total)*	**2.350.240**	**2.831.121**	**3.312.003**	**5.961.605**
	1500-3000	Beton (Tip Enkesit 5-2) *(Concrete) (Cross Section Type 5-2)*	Toprak İşleri *(Earthworks)*	691.557	788.248	884.938	1.592.889
			Sanat Yapıları *(Structures)*	276.623	315.299	353.975	637.155
			Üstyapı *(Pavement)*	972.897	1.216.122	1.459.346	2.675.468
			Toplam *(Total)*	**1.941.078**	**2.319.668**	**2.698.259**	**4.905.512**

97. It is important that road infrastructure investments are made on time to avoid negative effects on the economy. The lifespan, maintenance and construction costs of infrastructure are approximate figures because of the various construction materials, different terrain type, the techniques used and operation conditions. Due to budget constraint, benchmarking of transport infrastructure construction costs is significant for having realistic construction costs and a stable investment program with no cost explosions. Identify suitable methodological approaches, models and tools for gathering and disseminating information about infrastructure construction costs as well as collaboration with potential partners in the public private sector and on the national, regional and international level are crucial from our point of view.

4. Additional questions

(a) Comparison of transport infrastructure construction costs over time and normalization of these costs by region/ time

98. For benchmarking of infrastructure costs of different projects, costs should be converted to comparable price levels using indices. An infrastructure projects construction lasts more than one year even sometimes 5-6 or more years. Construction projects cost are given by bidding year prices. To bring projects cost to comparable levels different indices are being used. The used indices are Construction Costs Indices which were published annually by the Turkish Statistical Institute. In addition, official deflator coefficients which are produced and published annually by the Department of Strategy and Budget for each sectors (tourism, agriculture, mining, energy, transportation, etc.) are also used especially for investment program. This calculation is based on the monetary value of all goods and services produced in an economy. It is calculated by using the evaluation coefficients of the construction report cards and work completion documents used in the tenders for construction, facility and repair works published annually in the official gazette by the Ministry of Environment and Urban Planning . In addition, in order to calculate the foreign exchange cost, the calculation is made according to the Tender Date Exchange Rate information obtained from the Central Bank and revised to present prices with deflator.

(b) How to make sure that the mechanism used to calculate and assess transport infrastructure costs also serves as a tool for costs control:

99Prices or pro forma invoices are obtained from the producers material makers, main dealers, wholesalers and authorized dealers of the work, manufacturing and/or material. Appropriate comparisons are made in the price determination based on market research to be carried out based on the whole work, business group, work item and material market values. The issue of whether the hesitated prices are in line with the real market values is clarified by the written market values to be obtained from the Chambers of Commerce and / or Industry. In addition, the implementation is constantly updated in case of the detection of the directions that are misstated by constantly examining the mechanism we use to calculate and evaluate transportation infrastructure costs.

(c) Are different cost calculation and evaluation methodologies in use for construction in different modes?

100. The Turkish calculation and evaluation methods do not vary according to different transportation systems.

G. Sweden (case study)

1. Background

101. In 2008, based on experiences and development initiatives within the Swedish Transport Administration, the Government of Sweden decided that the successive principle should be applied when calculating road and railway investments with a project cost > €50 million. By then many large infrastructure projects had had serious cost overruns in recent years with the financial consequence that other urgent projects had to be postponed. The aim

with the government directive was to achieve a more realistic estimate of the most likely final cost and an identification of the biggest uncertainties in the actual project to increase the probability for project success as to cost and time. Besides introducing the successive principle for calculations, the government prescribed other measures like the introduction of advisory boards to the projects and systematic and compulsory monthly follow-up of project performance.

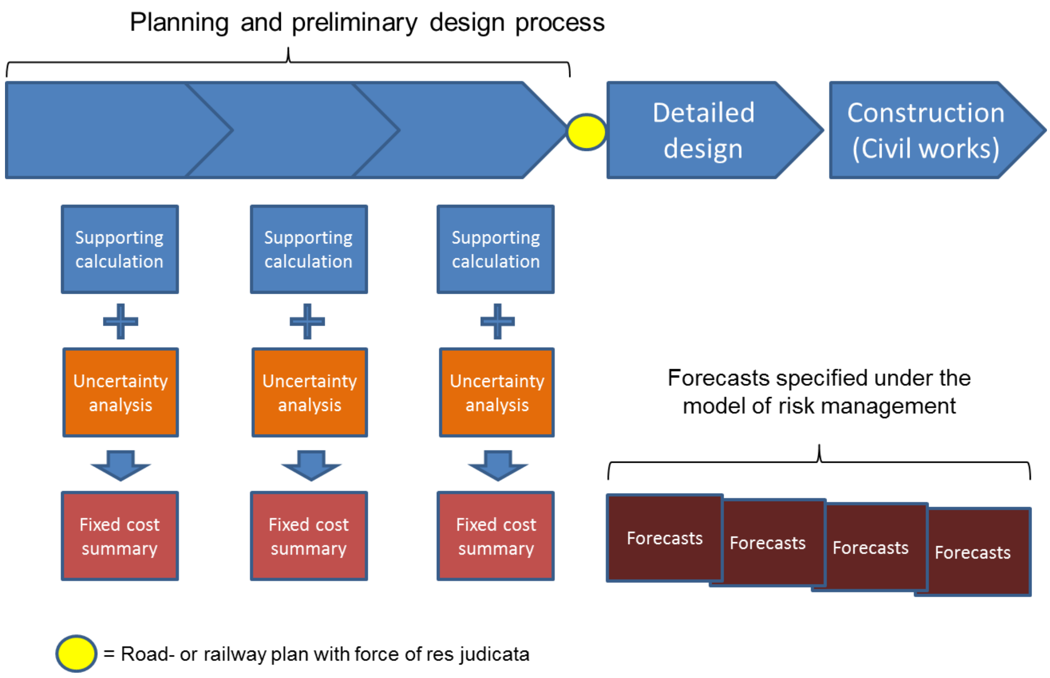
2. The Successive Principle in essence[1]

102. Using the Successive Principle, you can handle the uncertainty or contingency in project budgets. It´s a top-down procedure you in successive steps clarify the many uncertain factors. In this manner it has documented an ability to eliminate unplanned budget overruns and delays. The Successive Principle is based upon an integration of modern statistical theory and psychology with well-known procedures of project management, engineering economy and general management. In fact, it allows human intelligence and intuition to play a more natural role as a supplement to the historical knowledge. Among others it applies research which bypasses the numerous and serious pitfalls, which so far has hindered accurate and neutral expert evaluations.

3. Established process for calculating investment costs within the Swedish Transport Administration

Figure X

Overall calculation process chart



[1] Lichtenberg & Partners

Supporting calculation: This estimate is normally performed by external consultants and based on traditional bottom-up method for estimations. (Quantity x price per unit). The template allows for three estimations (minimum, most likely, maximum).

Uncertainty analysis using the "Successive principle": A balanced, cross-knowledge and experienced analysis group make forecasts of the final investment cost including identifying and evaluating uncertain items with importance on costs. This method is used to evaluate uncertainty of investment cost.

Fixed cost summary: The fixed estimated cost, from a specific stage in the planning process, based on the supporting calculation and the result from the uncertainty analysis shall be documented in a common way. This documentation is made in a template, which purpose is to secure a common layout and transparency. These documents are used later, when following up the actual final cost compared to planned cost.

103. The uncertainty analysis is performed during a two-day group-seminar and according to a standardized procedure with a work breakdown structure (WBS) based on 10 main blocks (see table 2 below). Every block is tipple-judged by each member of the analysis group as an interval with a minimum, a plausible and a maximal cost.

Table 2
Structure for planning, estimating, follow-up and analysing investment costs

Block	Name	Contents
1	Project administration	All costs related to STA's internal organisation and management of a project
2	Inquiry and planning	Preliminary studies (all possible alternatives), rail- and roadway studies (propose - one alternative)
3	Design	Detailed design
4	Acquisition of land and property	In order to get access to land for building of new constructions.
5	Environmental measures	In order to reduce noise and vibrations, handle contaminated soil, et cetera
6	Contract works – Earth works	
6.1	Earth works - Railway	Excavation, fill, embankment, platforms, buildings
6.2	Structures	Bridges, underpasses (roads, pedestrians, bicycles), retaining walls
6.3	Tunnels	Blasted, drilled or cut-and-cover inclusive entrances and working and rescue tunnels
6.4	Earth works - Roads	Excavation, fill, embankment, hard surface, guard rail
7	Contract works - Railway	
7.1	Track works	Superstructure including ballast, rail, sleepers, point switches
7.2	Electrical works	Electric supply, overhead line, masts, electrical substations, transformers, converter substations
7.3	Signal works	Signalling equipment such as signals, interlocking systems, automatic block signal system
7.4	Telecommunication works	Transmission in copper wire and fibre optic cables, fixed information installations for passengers
8	Unique measures and archaeology	Extraordinary measures (for example moving a ski jumping arena), archaeological excavation
9	Delivery and end of project	Delivery for operation, as-built documents/factual drawings, inspections both regarding internal delivery and contract work
10	Financial reserve for uncertainties	Only used in calculation and budgeting of total costs in early stages. Not used for economic outcomes.

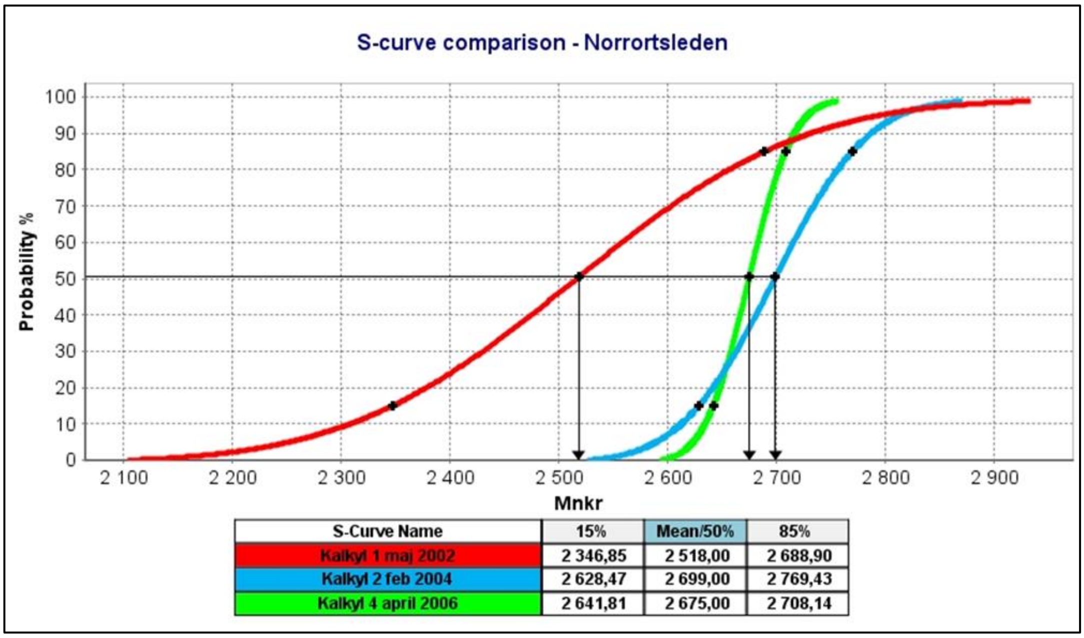
104. Some general uncertainties like the organisation stability (Swedish Transport Administration), market/business cycle, politics, new laws, regulations and decrees, weather conditions will be evaluated separately but included in the overall assessment.

105. The follow-up of actual cost and project performance is part of the established process and data is collected based on the structure in table 2.

4. Interpretation of the results

106. The results from the analysis are presented in a number of reports showing various focus or improvement areas to be addressed further depending on uncertainty or risk spread. Below in Figure XI the s-curve for each estimate is plotted. It is expected that the standard deviation should decrease during the planning phase since risks and uncertainties should decrease as well. Swedish Transport Administration normally uses the last cost estimate applying the 50 per cent probability value as the budget for the project.

Figure XI
S-curve for three consecutive analyses during the planning and preliminary design phase



5. Conclusion

107. The improvement during the last 10 years is substantial. Most large infrastructure projects in Sweden has been finalized within budget and on time. In addition, the quality of the input from Swedish Transport Administration to the Government´s rolling four-year financial infrastructure investment plan has improved noticeably.

V. Conclusion

108. The methods and techniques for assessing the cost of construction are extensive.

109. Through a comparative analysis based on the methods and techniques for determining the cost of construction of future periods - the “planned” cost of construction, we can distinguish the “common components” used by most countries to assess this cost:

- calculation of cost estimates (costs), which in most of the countries discussed above are based on market research and past experience working with similar projects;
- determination and calculation of the costs of the planned construction project by type of work, by analyzing key indicators of previously completed construction projects.
- determination of the scope of work included in the estimate in accordance with the construction technology existing in the country in accordance with applicable norms and standards for the performance of work;
- the existence and development of directives (normative legal acts, methodologies, and methodologies) for assessing the costs of road projects;
- tender for the performance of work - competitive selection of proposals for a road construction project, carried out on a competitive procurement basis.

110. The difference is in the methods of approach to the selection of optimal parameters and acceptable calculations for determining the price of a road construction project. The following individual features of determining the cost of a construction project can be distinguished.

111. In Germany, a special place in the methodology is determined by the analysis of costs and benefits, considering an additional assessment of environmental and nature protection,

spatial planning, and urban development. The costs of the above work was included in the German federal infrastructure plan, envisaged for development until 2030 (FTIP). The purpose of the environmental assessment is to incorporate in the early stages the costs and benefits of environmental aspects (carbon dioxide emissions, air pollutants and noise) in relation to the impact on areas with special environmental properties.

112. In Germany, the value is determined by the selection of the structure and production methods with the possibility of comparison by numerous indicators (parameters). The impact of the parameters is determined by the set of planning periods, directly the construction time, as well as the average service life of the facility. When planning subcontracting work in a project, the calculation is differentiated for maximum costs.

113. In Sweden, the “triple grading template” is used:

- In order to study the investment expenditures in the early stages, calculations are carried out for the largest cost items;
- Next, in the planning process, an auxiliary calculation is carried out, based on traditional methods for assessing the cost of construction (the number of products per unit price);
- An assessment of the uncertainty of investment value is a forecast of the final cost of investments (through this calculation, uncertain elements are identified and evaluated - factors that are important in terms of costs).

114. The final expected total costs are generated and documented as a generalization of the total cost based on an auxiliary calculation and the result of an uncertainty analysis.

115. Upon completion of the project, the expected total costs are used to compare with actual final costs.

116. In Cyprus, to determine the “planned” cost of a project, a data bank is created based on the available costs of past construction periods (years) generated by the type of work. The total price of the tender is formed based on the provisions of the law governing the procurement (tender) procedure. If there is a significant deviation from77 the total price of the tender, the bidding process is cancelled. The factors and reasons that influenced the deviation are investigated, and the tender is repeated.

117. In Croatia, a cost estimate for infrastructure projects is being prepared based on market research and experience working with similar projects. The construction of transport infrastructure is the subject of open international procurement / tender procedures.

118. In Poland, the index method is used to determine the cost of a construction project. In the absence of a single suitable price index, costs are calculated according to an individual estimate. Sources of information for individual estimates are:

- contracts or agreements concluded in past periods (years);
- prices valid in the current period (year) and published in current publications, reference books, catalogs and offers;
- forecast data in the field of pricing.

119. In Turkey, there are official unit prices that are updated annually for all types of construction work through unit price analysis.

120. In Latvia, the planned construction costs are determined based on the prices of similar works defined in other previously concluded construction contracts, forecasts of macroeconomic development indicators, changes in the construction market of the transport infrastructure and forecasts for the development of this market. When planning costs, the conditions of the construction contract are preliminarily agreed upon by the parties (customer-contractor).