The early stage of design – key to a successful rail project

Bernhard Kohl, MSc. and Gregor Leitner, MSc.
ILF Consulting Engineers
Harrachstraße 26, 4020 Linz, Austria
e-mail: info.linz@ilf.com

Abstract

Experience shows that considerable problems may arise in a rail project, if relevant aspects – which may not be obvious in the early stage of a project – are not taken into account adequately. In addition to addressing the key technical aspects it is essential to perform a screening with a wide-spread perspective addressing the following topics:

- Environmental impact: it is in particular crucial to identify critical zones in the planning area where the impact may not be acceptable or the measures required to achieve acceptability may cause considerable additional cost or significant project modifications
- Cost issues: lack of information with respect to basic data as well as lack of knowledge with respect to the project itself need to be addressed thoroughly to reduce risks and fuzziness of cost estimates
- Public acceptance of the project: although involving affected interest groups in the design process already at an early stage initiates difficult discussions, it helps to identify serious problems and to avoid escalating conflicts. It is much easier to establish a faithful communication culture and to find acceptable solutions at the beginning of the project than later in the process.

Problems can be overcome by establishing a multistage / multidisciplinary design approach as a tool for the development of a well-balanced and optimized solution. This approach shall be supported by a well structured communication process involving effected interested groups which starts working in the project.

1. Background

In the past 20 years big investments have been made in the modernisation of the Austrian rail network – in particular in the two major axis – the “Westbahn” running from east to west, from Vienna via Linz, Salzburg, through Germany towards Innsbruck and further on towards Switzerland, and the “Südbahn”, running from north-east to south-west from Vienna towards Graz and Klagenfurt and further on towards Italy. These renewal works are comprising various types of railway projects in different sections, such as

Figure 1 – the new Vienna-St. Pölten highspeed railway line

new railway lines, like the 50 km long new high-speed line form Vienna to St. Pölten crossing through the Tullnerfeld, the upgrading of existing sections by increasing capacity and maximum speed – like the quadrupling of the “Westbahn” between St. Pölten and Wels, as well as the renewal of big stations like Vienna Westbahnhof, Linz, Salzburg and Innsbruck, and the upgrading of existing and the development of new freight terminals and marshalling yards. Whereas large parts of the projects along the Westbahn are already in operation, reducing the travel time for instance between Linz and Vienna from approx. 2 hours in the early 90’s to 1 hour 15 minute in 2013, the projects along the Südbahn, in particular the large tunnel projects – like Koralmtunnel and Semmering base tunnel – are still under way.

The experience made in the design process of many of these projects induced the development of a flexible, multidisciplinary design approach, which is nowadays well-established in Austria and generally applicable for different kinds of traffic infrastructure projects. This approach includes a specific process as well as a specific methodical approach but has not been documented in design guidelines so far.

Currently two guidelines are in preparation, which are addressing elements of this approach.

- The update of RVS 04.01.11 guideline on environmental studies for traffic infrastructure projects, which is applicable for roads but in fact is defining the state of the art for rail projects as well.
- A new RVE 12.01.01 guideline defining the scope of the design works for characteristic planning phases of rail projects.

The focus of the present paper is to define the outline of this approach with reference to practical aspects. The authors of this paper have been involved in several major infrastructure projects in a leading management position with insight into the decision making process in the project stage addressed in this paper. They are also members of the working groups of the Austrian Society for the Research on Road-Rail-Transport, which are elaborating the guidelines mentioned above.

2. The ideal design process of a rail project

The ideal design process of a rail project – in a very generalized representation – is shown in figure 2. It can be separated in three different major design stages:

- **Stage 1: Project preparation phase**
  In this phase the project idea is developed and the scope and the objectives of the project have to be defined.
- **Stage 2: General design phase**
  This phase includes the whole process of the step-by-step elaboration of the project including the decision on alternatives as well as the evaluation of an integrated project including all secondary structures and measures required for its implementation into the existing infrastructure and the environment. This stage ends with the permission of the project.
- **Stage 3: Detailed design and construction phase**
  This stage is typically elaborated in a linear step-by-step process which is relying on well-established technical guidelines and standardized procedures.

The focus of this paper is on the early stages of a rail project, because experience shows that many problems arising in a later stage have its origin in omissions or lapses in the early stages. Furthermore, the most relevant decisions have to be taken in the early phases, thus determining to a great extent benefits, costs and other consequences of the project.

In stage 2 – the general design phase – the design process to a great extent depends on the specific characteristics of an individual project. Typically, the process is not linear but includes feedback to earlier steps including the option to implement a modification in the basic project layout. For instance, if the studies demonstrate, that the intended solution turns out to be inacceptable in terms of achieving the required permits with respect to the applicable legal requirements or in terms of acceptance of the project in the public, it may even be necessary to adapt the general scope and the objectives of the project. The same may be required, if it turns out that the objectives can only be achieved with an unacceptable financial effort.

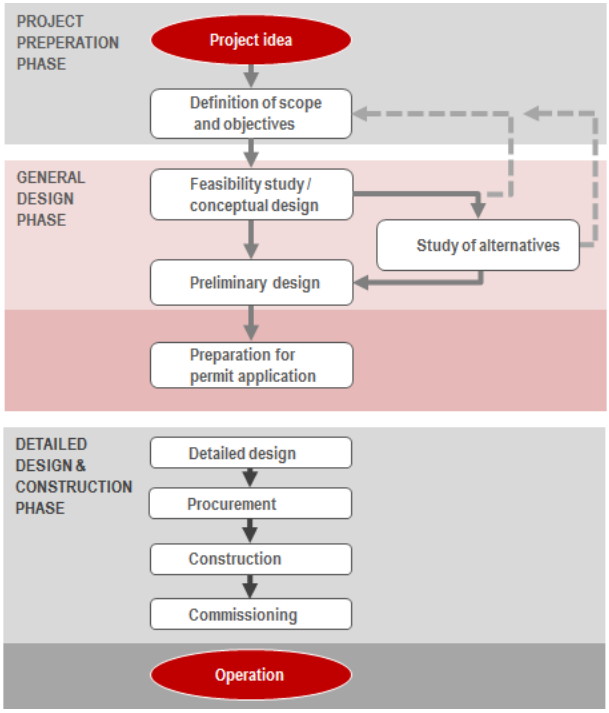

Figure 2 – Design process for a rail infrastructure project

Depending on the type of project, not all steps of the modular structure of the design process in stage 2 are required. In smaller or less complex projects with clear surrounding conditions it may be possible to start directly with the preliminary design as first design phase.

Nevertheless in such projects attention shall be paid to the project preparation phase as well. In practice, it happens quite often, that the motivation for initiating a project as well as its objectives are not considered, argued or documented carefully. This may cause problems at a later stage, as a clear and understandable explanation of the motivation of the project is essential in any kind of public discussion as well as in the permission process. Furthermore to establish clear objectives is a fundamental basis for decision making because the pros and cons of different alternatives need to be evaluated against these targets.

The goal of the individual steps of the general design phase can be defined as follows.

- **Feasibility study / conceptual design**
  The focus of this step cannot be defined universally because it depends on the specific conditions of an individual project. In this step typically basic questions of system layout are addressed: For instance the study may focus on the discussion of net-alternatives or may address the track configuration with respect to capacity requirements (single-track / double-track, configuration of junctions, etc.).
- **Study of alternatives**
  In this step line or site alternatives are studied in a comparative way, the main goal being the selection of the best solution in a holistic well-balanced approach; based on a predefined set of criteria the different alternatives

are evaluated against the project targets established in the project preparation phase.

- **Preliminary design**
  In the preliminary design phase the technical features of the rail project as well as all secondary structures and protective measures shall be defined, to established a stable project basis for the permission phase as well as for cost estimates.
  In the preliminary design phase a project optimisation process shall be executed in order to maximize benefits and minimize cost and negative effects on environment. In this phase again a lot of decisions have to be taken, which are crucial for the quality as well as the cost of the project.

3. Characteristic project types

The general design process presented in chapter 2 has to be adapted to the specific requirements of a project. These requirements depend on project type and complexity as well as on the regional conditions of the planning area. Hence for each individual project the design process shall be tailored individually.

The following characteristic project types may be distinguished:

- New railway line
  Implementation of a new linear rail infrastructure in the planning area.
- New railway station, hub or marshalling yard
  Implementation of a new two-dimensioned element in the planning area.
- Amendment of alignment of existing railway line
  Modification of existing railway line – to increase travel speed.
- Doubling or quadrupling of existing railway line
  Expansion of existing railway line – to increase capacity.
- Upgrading of existing station, hub or marshalling yard
  Renewal or expansion of railway infrastructure at an existing site.

4. Relevant topics in an early project stage

The following topics have to be addressed from the very beginning in any rail project:

- Technical aspects
- Environmental impact
- Cost issues
- Public acceptance

This paper is focussing on environmental impact, cost and public acceptance; technical aspects are only addressed as required for the other topics.

4.1 Environmental impact

The environmental impact of a rail project shall be addressed by a broad multidisciplinary approach, which shall be established at the beginning of the conceptual design phase. This approach shall be structured according to the different environmental disciplines (like anthroposphere, in particular effects on residents like noise, wild life habitats, water, in particular groundwater, landscape etc.) It is essential to establish the basic structure at the beginning and to follow it consistently throughout all project phases.

In the **conceptual design phase**, a screening and scoping process shall take place in order to identify the most relevant aspects with respect to the goals of this phase and to eliminate other aspects which are not contributing to this task. Furthermore a definition and a rough analysis of the area potentially covered by the project must be carried out. In this phase availability and management of basic data is crucial, because the study may have to cover a big area and in most cases it is not feasible with respect to time and financial resources to do comprehensive field investigations. Hence in this phase the analysis relies on existing data and potential conflict zones of highest priority, like for instance densely populated areas, or established protective areas.

The main goals in this phase with respect to environmental impact are [1]:

- Identify problems, which may hamper the acceptability of a project with respect to impact on environment and discuss the consequences on the general project layout and objectives.
- Identify the key aspects, to be able to adjust the focus for the investigations in the next step.
- Reduce and shape the space to be covered by environmental investigations in the next phase in order to assure a time and cost efficient procedure.

In the **study of alternatives** phase, the results of the previous phase shall be taken as input for the draft of route (or site) alternatives, aiming to avoid critical conflicts from the very beginning. In densely populated and / or intensely used areas there are always conflicting interest, which are more or less effected by a new rail infrastructure project. Hence it is essential to draft a set of alternatives, which are different in terms of meeting the project targets as well as in terms of their impact on natural resources and human interests. It is essential, that the set of alternatives on the one hand sufficiently covers the basic design options available in the planning area, but that on the other hand only a limited number of clearly arranged alternatives are addressed in the first step. These alternatives are the starting point in a systematic elimination and optimisation process.

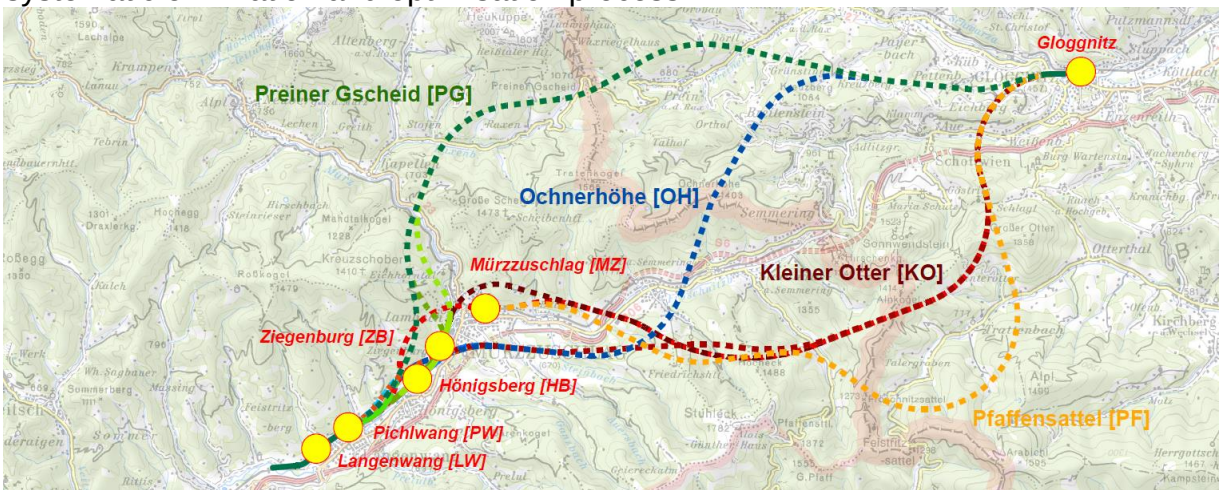

Figure 3 – Semmering base tunnel: route alternatives and different locations of portal station in Styria

The main goals in this phase with respect to impact on environment are [1]:

- Clearly identify risks, which may cause unacceptability of a project in the permit application process; eliminate such alternatives, if acceptable other alternatives without such risks are available. If no such alternatives are available it may be required to intensify the study with respect to these

specific risks to find out, whether an acceptable solution can be elaborated. This step may demand a much higher level of detail than normally required in this phase. In such a case it may even be required to go back to the project preparation phase and modify the basic project layout.

- Give input to the optimisation of alternatives – in order to minimise environmental impact as much as possible.
- Systematically analyse the effects of the alternatives on the various environmental disciplines (following the structure already defined in the conceptual phase) and identify relevant relative differences to give input to the multidisciplinary route selection process.
- Identify protection measures on a conceptual level which are able to significantly minimise impact on environment and which are considered as necessary for the implementation of the project. Such measures have to be taken into account with respect to the evaluation of environmental impact as well as the estimation of project cost.

At the end of this phase one alternative is selected on the basis of a systematic methodical approach which is the basis for the next step in the preliminary design phase.

The objective of the **preliminary design phase** is to elaborate a stable overall project which contains all secondary structures (like modification of existing infrastructure, dewatering facilities, all kinds of buildings and structures required for the project) as well as protection measures (like noise protection measures, groundwater protection measures, measures for integration in landscape and natural

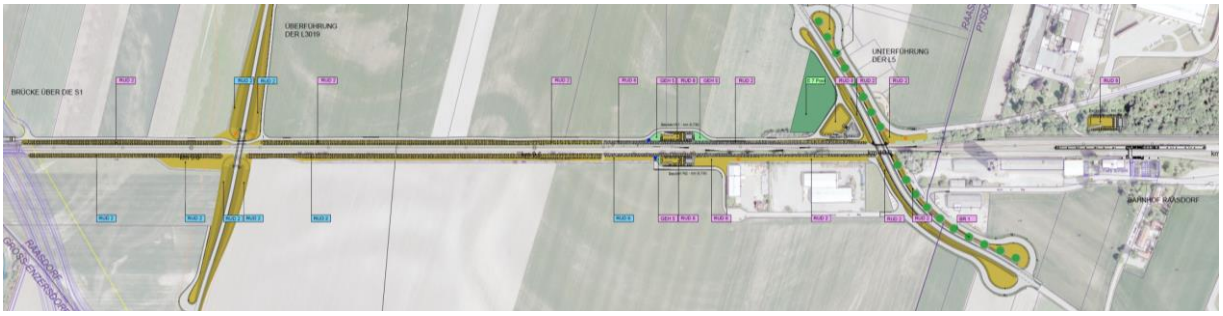

Figure 4 – Doubling of Stadlau-Marchegg railway line: secondary structures and protection and compensation measures

habitats etc.). The integrated project elaborated in this phase is the basis for the preparation of the permit application documents.

At the beginning of this phase, another optimisation process is required. Input to this process is provided from two sides:

- The findings of the evaluation of alternatives in all disciplines may bring up ideas for the improvement of the project in terms of final (small) adjustments of the alignment as well as in terms of a refinement of the concept of protective measures.
- The same may happen in the public discussion process carried out in parallel to the decision on alternatives (see chapter 4.3).

4.2 Cost issues

To find the right balance between cost, benefit and (negative) impact on residents and environment is one of the key tasks in the early design phases of a

traffic infrastructure project. However, two major challenges have to be mastered with respect to costs:

- On the one hand the definition of the project is still incomplete and parts relevant for a cost estimate are still missing.
- On the other hand the level of detail of the design is such, that a cost-estimate on only be based on roughly structured basic cost elements.

This facts cause a rather high level of uncertainty in particular with respect to absolute cost estimates. To handle this problem a cost-estimate approach according to ÖGG guideline on Cost Estimates for Traffic Infrastructure **Fehler! Verweisquelle konnte nicht gefunden werden.** can be applied: Depending on the current design phase and the complexity and difficulty of boundary conditions of the project additions are applied on the basic costs at several levels of the cost-estimate process to cover the identified risks. In the later design phases, these additions can be reduced according to the increased knowledge of the project and its conditions of implementation. Another addition has to be applied to cover the involvement of cost with respect to time. Figure 5 shows how the project costs are developing from the early phase towards realisation: at the beginning the basic costs-estimated on the basis of the project design in this phase – are only a minor part of the overall project costs; the difference has to be compensated by adequate additions to the basic costs; at the end – in the procurement phase – the project is well known and the remaining risks refer to other spheres.

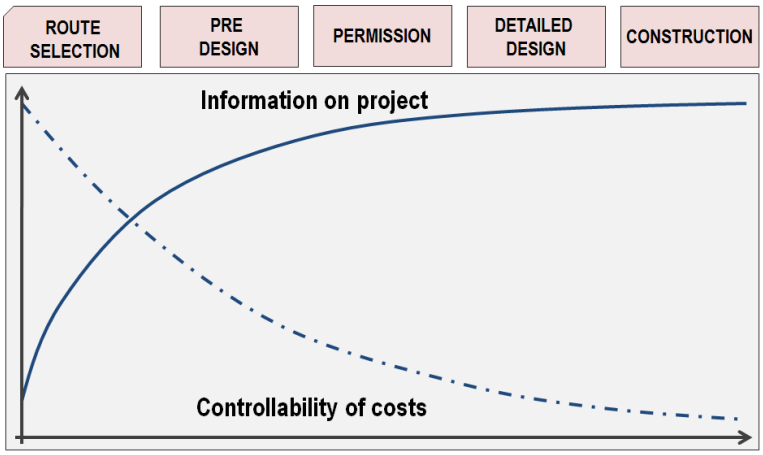

Figure 5 – Evolution of controllability of project costs over time

However, owners and designers should be aware, that the most relevant decisions with respect to the costs of a traffic infrastructure project are taken in the early design phases (see figure 6):

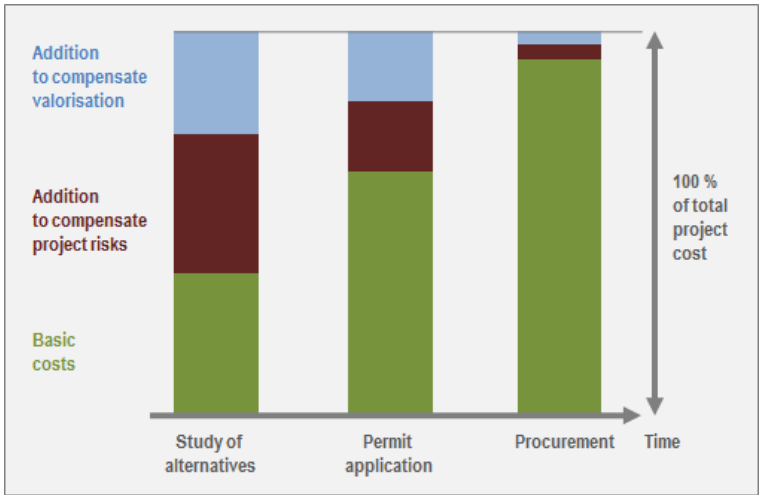

Figure 6 – Evolution of project costs over time

- During the process of selection of alternatives: costs shall be implemented in the decision making process by applying a cost-benefit approach; the costs of an alternative shall be balanced against its positive effects (project quality – with respect to the objectives defined earlier) as well as its negative consequences (impact on residents and environment) in many cases the situation for decision making is quite complex in this

phase; however, different methods are available which can be applied to support the decision making process.

- For some decisions of the project optimisation in the preliminary design phase cost factors may have a relevant influence as well; for instance, if the protective measures under discussion include expensive structures like a tunnel which is required as noise barrier only (and not for technical reasons); however, during project optimisation decision making is less complex, because it often refers to local problems with a limited number of subjects involved.

4.3 Public acceptance

The intention to implement a new traffic infrastructure into a region may cause big conflicts. As a consequence, projects are often delayed, costs are increased, and disputes during the permit procedure may arise. Some projects may have to undergo substantial modifications or are even abandoned at the end of long discussions. Obviously, there is no easy solution to this problems, but the experience of many traffic infrastructure projects of the past 15 – 20 years in Austria show that there are strategies to cope with this situation in a good manner.

The core element of these strategies is to establish a structured discussion process with the relevant interest groups and stakeholders (figure 7). This communication process shall be organized according to the representative principle and should be based on existing structures, e.g. at the level of the municipalities affected by the project. It shall actively be planned, controlled and documented and it is essential to coordinate it with the design process in a way that results of individual design steps are discussed with the representatives of the involved interest groups on a regular basis (figure 8). It is essential to explain why the project is needed, what are the objectives and basic requirements of the project and how, to what extent and at which stage the interests of people affected by the project are taken into account; the process shall include elements, where the interest groups involved can contribute actively by bringing in own proposals (for additional route alternatives, for instance, or for protective measures), which – of course – must be handled and addressed in the same way as the proposals prepared by the project team.

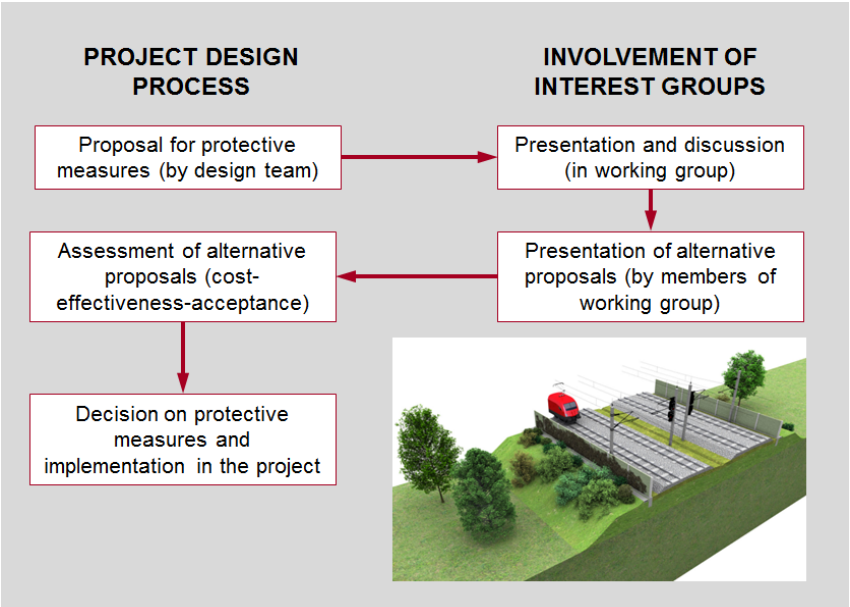

Figure 7 – Example for involving affected interest groups in the preliminary phase

Of course this process requires a lot of time and also financial resources, but experience shows, that it opens the realistic chance to reduce the conflict potential a lot. It is recommended to start this process – if possible – before the study of alternatives is starting. At any case, the basic project layout shall be established and the objectives shall be defined. Before the big advantage of starting the communication process before alternatives are on the table is, that at this moment there is not yet a conflict. Experience has proven that it is much easier to establish a good communication culture in a faithful atmosphere in this situation than later in the project. In an early project stage – before all details of the project are fixed and before even the route has been chosen – it is much easier to avoid or mitigate conflicts or to take advantage of win-win situations. It should not be neglected, that people living in the project region use to have a very good knowledge of their environment and that they are able to bring in good ideas and valuable and specific information into the design process. Of course, this discussion process also includes risks, for instance with respect to project costs. It also requires an active management and a high flexibility of the design process as well as a high personal engagement of the design team members involved. However, experience shows – that – if well done – this process may reduce the frequency and intensity of conflicts a lot and time and money invested in such activities in the early phases, are paid off at a later stage of the project.

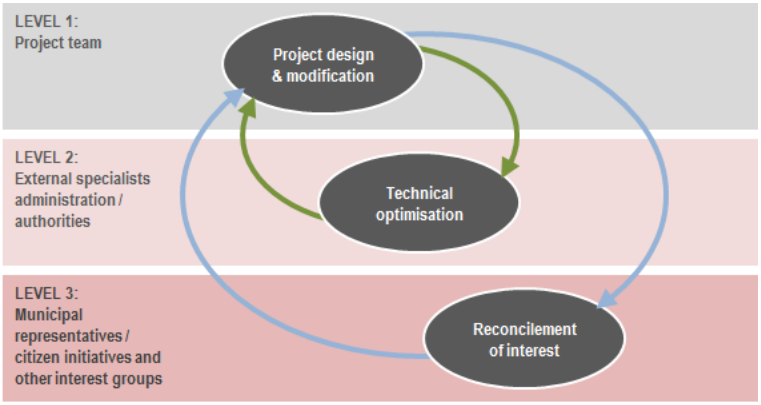

Figure 8 – Interactive process for project optimisation

Literature

[1] RVS 04.01.11, Environmental Impact Studies, Austria Society for the Research on Road-Rail-Transport, draft December 2013

[2] ÖGG Guideline, “Cost Estimates for Traffic Infrastructure Projects”, Österreichische Gesellschaft für Geomechanik