The transport infrastructure planning process in Canton Zürich

With examples of planning infrastructure in Dübendorf-Hinwil corridor

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Summary

This report investigates how transport infrastructure, like roads and railways, is planned in the canton of Zurich from the perspective of the stakeholders responsible for shaping the planning outcomes, e.g., Federal offices of Road and Transport. This is important because the presence and quality of transport infrastructure affects how easily and safely people can travel and how freight can be transported effectively. The effectiveness of infrastructure to meet its purpose depends on the effectiveness and efficiency of planning processes. This report discusses how the planning procedure could be improved, with a particular focus on the canton of Zürich, Switzerland. The mapping and discussion of the planning institutions and procedures explains which stakeholder groups are involved and how they collaborate. Based on a critical review of the process, viable approaches to improve the planning process are provided. This includes utilising varied sources of data and comprehensive analytical and planning decision tools. Mapping this planning process in Switzerland is novel and could contribute to a more effective and efficient planning decision making process in Switzerland and to a wide range of institutes involved in the process. 'Effective planning' would result in the desired outcomes being achieved to a high extent and 'efficient planning' would result in the desired outcomes being achieved effectively in relation to the time and/or effort required to achieve it.

The following paragraphs highlight the challenges that have been identified through the investigation, and outline recommendations, based on the specific findings related to the canton of Zurich, discussed in this document:

Challenges Identified:

Challenge 1: Society has conflicting needs

- Society consists of many stakeholders. Stakeholders have conflicting needs, for example, users want to travel with high speed whereas residents want lower speed in interest of noise reduction. Ideally, all societal needs are considered and accommodated during the planning process. Meanwhile, planners remain mindful of the power of the direct democracy in Switzerland.
- The planning process requires both generating, developing and progressing intervention projects to accommodate needs and at the same time building consensus of stakeholders in society, convincing society that the projects, in fact, accommodate the needs that were to be addressed during the planning process.
- The right level of detail is crucial to facilitate a balance between effective and efficient decision-making throughout the planning process. This means planning to an aggregated level of detail in early stages and using appropriate decision-support tools, with both planning outcomes and supporting tools increasing in detail downstream in the planning process.

Challenge 2: Multiple organisations are involved in the planning process.

- Various organisations which represent different and sometimes overlapping stakeholder interests, are involved in infrastructure planning, for example, but not limited to, cantons are tasked with coordinating the spatial order concept within the canton whereas FEDRO is tasked with planning, constructing and maintaining road infrastructure. While these organisations do these tasks in alignment with societal needs, the different stakeholders are differently considered by the different organisations in the different stages of the planning process.
- Federal offices and cantons planning entities may have dissimilar objectives and different planning horizons. The lack of synchronisation between these entities may lead to delays, i.e., delivering infrastructure later than society expects.
- The effective and efficient planning of infrastructure is strongly dependent on the coordination of planning organisations, the planned outcomes and other stakeholders.

Challenge 3: Change is inevitable over the long duration of the planning process

- The planning process could last years, and societal needs change over that time.
- Stakeholders become cautious about making assumptions or decisions for the reason that such decisions may become suboptimal or even obsolete over the long planning process.

- Comparison with state-of-the-art methods shows that there is potential to enhance the robustness of the planning process outcomes.

Challenge 4: The iterative nature of the planning process

- Extensive deliberation is needed for stakeholders to agree on interventions.
- Prolonged planning leads to benefits but also incurs stakeholder costs.
- The added benefit of changing the planning process's duration is not explicitly quantified, impacting the responsiveness of planning process.

Recommendations:

- Coordinate early: Integrated planning of mobility, infrastructure and land use in the early stages of planning, coordinating federal offices and cantonal offices for effective and efficient planning. This can become the responsibility of a new planning organisation, or a department within the Federal Office for Spatial Development.
- Embrace adaptive planning: Embrace adaptive planning to make improved decisions under uncertainty, ensuring robustness to changing needs. Many decision-makers use some sort of adaptive planning already, but there is potential to fully utilise the decision-support tools available to them.
- Quantify the value of planning duration: Develop a framework to quantify the benefits of the planning process's duration, balancing it against stakeholder costs. This can lead to improvements in the responsiveness of planning processes and positively impact societal net benefit.
- Ensure right amount of detail at the right time: It may be problematic to define a narrow scope of possible futures in the early stages of planning, e.g., 20-25 years before a new infrastructure is put in operation. To allow for a range of possible futures in the early stages it can be useful to facilitate a balance between effective and efficient decision-making throughout the planning process, e.g., the use of quantitative decision-support considering uncertainty at an aggregated level of detail could enable faster early-planning resource allocation.

In essence, the report suggests the implementation of a coordinating organisation with a strategic governance approach strongly anchored in practice facilitating early coordination, and adaptive planning to address these challenges in the right amount of detail at the right time, ensuring transport infrastructure aligns with societal needs effectively.

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Table of Abbreviations

Abbreviation	Abbreviated name
AP	Execution project in FEDRO‘s project pipeline
ARE	Federal office for spatial development
BIF	Rail infrastructure fund (d. Bahninfrastrukturfonds)
CS	Concept study in SBB‘s project pipeline
C-ARE	Cantonal office for spatial development
DP	Detailed project in FEDRO‘s project pipeline
EIA	Environmental impact assessment
FC	Federal Council (executive branch)
FEDRO	Federal Roads Office (a.k.a., ASTRA)
FOT	Federal Office of Transport (a.k.a., BAV)
FP	Federal Parliament (legislative branch, incl. Senate and Representatives)
GP	General project in FEDRO‘s project pipeline
KEVU	Cantonal commission for Energy, Transport and Environment
KVF	Federal Parliament‘s Committee for Transport and Communications
MP	SBB‘s regional infrastructure development Masterplan
NAF	National road and agglomeration fund
NIBA	Appraisal framework for national rail infrastructure projects
NISTRA	Appraisal framework for national road infrastructure projects
NP	The department of Network planning within FEDRO
SBB	Swiss Federal Railways
SI	The department of Road infrastructure within FEDRO
STEP	Federal strategic development program
TBA	Civil engineering office (d. Tiefbauaumt)
UVEK	Department of Environment, Transport, Energy and Communications
VBZ	Zurich public transport operator (d. Zürcher Verkehrsbetriebe)
ZVV	Zurich public transport agency (d. Zürcher Verkehrsverband)

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1 Introduction

Effective and efficient infrastructure planning requires foresight to accommodate changing societal needs. Societal needs can be as diverse as the people and organisations that compose society. The societal needs are often conflicting, e.g., a user's wish to travel in peak hour without travel delay, as opposed to an owner's wish to keep operating costs low, and consequently keep the number of highway lanes, as few as necessary. Additionally, the societal needs change over time.

To accommodate ever-changing societal needs, planners in infrastructure planning organisations, e.g., the Canton, Federal Roads office (FEDRO) or Federal Office of Transport (FOT), plan infrastructure. Infrastructure planning, which involves many organisations, happens over a long period of time and is highly iterative. The results of infrastructure planning are projects to create and modify transport infrastructure to accommodate the changing needs of society in alignment with society's strategic objectives.

The ability to accommodate societal needs is directly linked with the availability of infrastructure to facilitate demanded activities, e.g., highways or railways to enable the quick and safe travel of persons and trade of goods. It is therefore in society's interest that the planning process be both efficient and effective, i.e., transport infrastructure is continually constructed and modified at the right time with the right level of involvement of all societal stakeholders so that their stakeholder needs can be accommodated quickly and to their satisfaction. 'Effective planning' would result in the desired outcomes being achieved to a high extent, e.g., meeting net zero climate objectives by the set deadline. 'Efficient planning' results in the desired outcomes being achieved effectively in relation to the time and/or effort required to achieve it, e.g. reducing the duration until the net zero climate objectives can be met or the effort required to do so.

For the process to be efficient and effective it is beneficial to be able to answer the following questions regularly and clearly:

(1) How are societal transport needs likely to change over time?, e.g., Will more or less people want to travel between Dübendorf to Hinwil 10, 25, 60 years from now and how long will people expect the travel to take?
(2) How well could the current transport infrastructure accommodate the likely societal needs if no changes are made?, e.g., Can the current highways and railways connecting Dübendorf and Hinwil accommodate the likely numbers of people who want to travel between Dübendorf and Hinwil 10, 25, 60 years from now as desired? And if not, when is this likely not to be the case?
(3) If it is likely that creation or modification of the current transport infrastructure will be required, e.g., widening the highway to three lanes or building an additional railway line, can the best solution be selected and approved within appropriate amounts of time with appropriate amounts of effort?, e.g., assuming that significantly more people would travel between Dübendorf and Hinwil in the next 60 years, can the best modification be selected to accommodate for societal needs and approved within a short amount of time (e.g., 2 years) with reasonable amounts of effort invested by each involved organisation and their consultants.

Answering these questions requires the use of data and analytic tools to facilitate the decision making within the planning process. Answering these questions regularly and clearly requires the coordinated use of all stakeholders of appropriate data and appropriate analytics at the right times in the process, and appropriate ways to present the information to facilitate stakeholder discussions.

As a precursor to making specific suggestions as to how the planning process may be made more effective and more efficient, this report describes for the first time the transport infrastructure planning process in Switzerland, with a special focus on the creation and modification of transport infrastructure in the canton of Zürich. Mapping this process includes explanation of the diverse set of stakeholders involved and the interactions between them.

This report describes at a high level the infrastructure planning process, identifies challenges related to the planning process and proposes the use of available opportunities to address said challenges. While the process is possibly similar across cantons, the planning process described in this report is defined specifically for the canton of Zurich as there may be some variability between Cantons.

The remainder of this report is organised as follows. Section 2 outlines the stakeholders involved in the infrastructure planning process. In section 3 the entire process is illustrated and then subsequently dissected into different segments that compose various phases of the planning process. In section 4, reasons that the process is perhaps not as effective or efficient as it could be are identified, along with potential ways to improve the process, referred to in the text as challenges and opportunities. The challenges and opportunities are elaborated using examples from the infrastructure corridor Dübendorf-Hinwil. Section 5 concludes the work and reports on the future outlook based on this report's findings.

2 Stakeholders

Addressing the accommodation of societal needs is the main objective of planners carrying out the infrastructure planning process. The societal needs are based on needs of stakeholders within society. Within society, there are many different stakeholders. These stakeholders are involved in or affected by changes proposed during the planning process. Stakeholders are defined as individuals, groups or organisations that are either (i) affected by change to infrastructure, e.g., users, or (ii) those that are involved in the process of modifying the infrastructure, e.g., public transport agencies (Adey, 2019).

Stakeholders may have conflicting needs, e.g., a user may want to travel on a road safely without delay, whereas residents, living next to a road, expect not to hear excessive noise caused by thoroughfare traffic. As a foundation for any planning decision aimed to improve societal welfare, planners must identify the stakeholders relevant to their decisions, define their needs and be cognizant of how the needs may change over time.

Stakeholders may be categorised into "shaping" stakeholders, "approving" stakeholders, "participating" stakeholders and "controlling" stakeholders:

- shaping stakeholders are those who actively shape the planning outcomes and the related projects, e.g., the ARE, FEDRO, FOT and cantonal offices for spatial development, mobility and civil engineering,
- approving stakeholders are those who approve the projects to achieve the planned outcomes and bear their costs, e.g., the federal parliament or the general population through the Plan approval process,
- participating stakeholders are those who participate in the planning tasks to develop projects, e.g., rail service operators, rail infrastructure operators and road operators,
- controlling stakeholders are those who control whether the planning process and outcome meets their needs and requirements, e.g., rail regulator, planning regulator, residents, users, transport policy groups, nature preservation groups and others.

It should be noted that in reality boundaries between these four categories are not always clear. For example, the general population is both a policy-maker and a policy-addressee. The veto power held by the general population incentivises the shaping stakeholders to actively encourage the participation of the general population in the planning process of infrastructure to elicit stakeholder needs, build consensus and increase the likelihood of their approval (Adey et al., 2020). In some cases the planning process cannot be completed because the decision to finance some infrastructure projects is being questioned by the public through a referendum, whereby passed bills must be presented to the general public and the bill must pass a public majority as well. An example of this is the November 2024 referendum to ask for the public's decision on the Expansion step 2023 (Swiss Federal Council, 2024).

Figure 1 shows the multiple stakeholders and their relations in the infrastructure planning process. The shaping stakeholders are not explicitly shown on the figure, but they are embedded in the planning processes in the centre of the figure. The approving stakeholders are shown in white, the participating stakeholders on the right and the controlling stakeholders in slightly lighter gray color on the left. The figure shows the financial instruments available to the approving stakeholders. Not all funds are available for all types of infrastructure. A disentangling overview of the origin and usage of financial resources in the year of 2022 for national infrastructure through the instruments BIF and NAF can be found in the appendix, Section 7.5. Furthermore, all stakeholders are summarised in tabular form in Table 1 in reference to the above-mentioned categorisation.

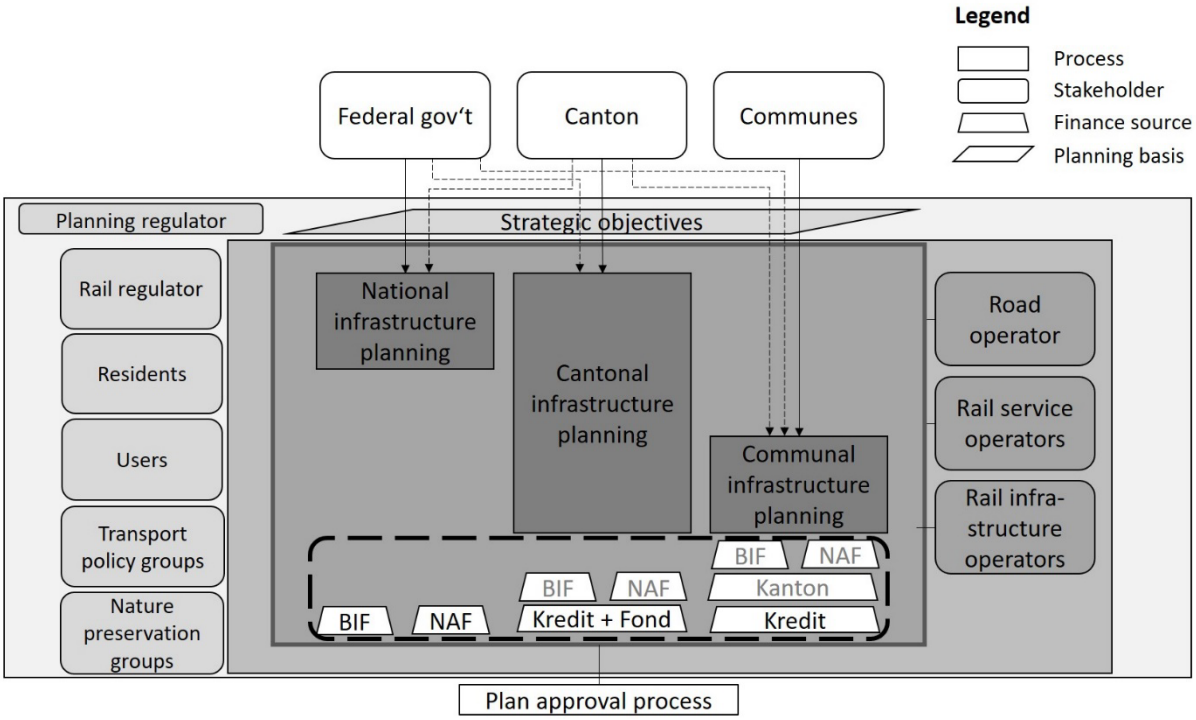

Figure 1: Stakeholder map for transport infrastructure planning in Switzerland. The shaping stakeholders are not explicitly shown on the figure, but they are embedded in the darkest grey processes in the centre of the figure.

In the following sections, and for the rest of this report, the focus is on the shaping stakeholders that actively shape the planning outcomes and the related projects, e.g., the FEDRO, FOT and cantonal civil engineering offices. The process in the following section 3 is therefore built around these shaping stakeholders but refers to the other stakeholders when they are involved.

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Table 1: Stakeholders by role in the infrastructure planning process

Role	Description	Stakeholder	Stakeholder description with example related to Canton Zürich, when applicable
Shaping	actively shape the planning outcomes and the related projects, e.g., the FEDRO, FOT and cantonal civil engineering offices	National road planning organisation	FEDRO is responsible for the infrastructure planning process for roads on the national level. FEDRO defines the long term perspectives related to the road network development in Switzerland. Those long term perspectives are reported in the federal sectoral plan. FEDRO then plans, constructs, operates and maintains the national road infrastructure. FEDRO's department of network planning (NP) is responsible for planning road networks. Its department of road infrastructure (SI) is generally responsible for preparing their construction, while operation and maintenance is in the hands of regional units (d. Gebietseinheit) and the five geographically separated subsidiaries (d. Filiale), respectively.
		National rail planning organisation	FOT is responsible for the infrastructure planning process for rail on both the national and regional level, more specifically leading the development process, national service, freight traffic and all railway infrastructure projects. FOT defines the long term perspectives of the railway system in Switzerland. Those long term perspectives are reported in the federal sectoral plan. FOT then coordinates the definition of the necessary infrastructure to be planned and constructed through its planning process with support from the cantons and rail service operators (i.e., SBB). However, the construction, maintenance and operation of the infrastructure is in the hands of the infrastructure operator, e.g., SBB.
		Cantonal road and rail planning organisation	The canton is responsible for the following tasks: (A) the infrastructure that it owns and operates and (B) coordinating transport operators in its regions. The canton also (C) represents the interests of all sides, sheds light on and mediates the views of different stakeholders to find a good solution for a region. In some cantons, for example the canton of Zürich, an office for mobility takes over the responsibilities related to the planning to separate the system-oriented development planning from the conventionally asset-oriented construction and maintenance. The cantonal structural plan is the instrument used to define strategic development objectives within the space of the Canton and propose interventions to better meet those objectives. See more on this in appendix 7.4. The canton is generally responsible for representing communes, regions and agglomerations in the process of developing agglomeration programs, which are (when the application is successful) partially funded by the federal government.

Role	Description	Stakeholder	Stakeholder description with example related to Canton Zürich, when applicable
		Communal planning organisation	The communes plan their own transport infrastructure, but have limited influence on the regional development by the federal state and the canton. However, when communal infrastructure is of regional importance, it may be more complex to negotiate how funds should be allocated, and who will have the planning mandate. Communes and groups of communes, forming regions, can submit proposals for agglomeration programs to the ARE for approval and financing. Agglomeration programs are devised with the goal to coordinate the transport and urban development between regions and communes and thus contributing to sustainable regional development. They ensure smooth and efficient transport operates through regional corridors and that regional links are optimally connected to federal road network. These efforts are generally coordinated by cantons. Furthermore, communal interests are represented in the regional public transport conferences through local public transport agencies, e.g., the Zurich Transport Agency (ZVV). Otherwise, communal-level stakeholders are generally represented for regional infrastructure at the Cantonal Civil Engineering Office (d. Tiefbauamt).
Approving	approve the projects to achieve the planned outcomes and bear their costs, e.g., the federal parliament or the general population	Federal Parliament	For both national roads and rail, the federal government prioritises the projects through budgeting using the financial instruments available to them using funds such as BIF and NAF, see appendix 7.5. They do this through the strategic development program for road and rail. The federal government assumes this role as they own the national roads and most of the rail infrastructure through SBB. The federal government may also be financially involved in cantonal projects, e.g., through project-specific agreements and communal projects, e.g., through Agglomeration programs.
		Cantonal parliament	Rail infrastructure may also be owned by cantonal transport agencies, e.g., ZVV or communal transport operators, e.g., VBZ. Cantonal authorities also get involved in communal and national planning efforts and may participate in costs of the infrastructure based on constraints set, on a case-by-case basis.
		Communal parliament	Costs related to the infrastructure construction, maintenance and operation (and of course deconstruction) are generally not fully covered by the organisation‘s revenues and is covered by communal, cantonal and national financial instruments.
		General population	Projects must be placed under public scrutiny through formal approval processes. If any of the affected stakeholders feel their needs are not adequately met throughout the planning process, they can direct their

Role	Description	Stakeholder	Stakeholder description with example related to Canton Zürich, when applicable
			grievances to the Department for Environment, Transport and Communications (abbrev. UVEK), the Federal Administrative Court during the Plan Approval Process or ultimately the Federal Supreme Court. In the interest of earning popular approval, planning organisations often encourage active participation of the local population to elicit and address their stakeholder needs.
Participating	participate in the planning tasks to develop projects, e.g., rail service operators, rail infrastructure operators	Rail infrastructure operator	SBB constructs, maintains and operates rail infrastructure. They participate in the planning process through clear operative requirements and ability to accommodate future societal needs.
		Rail service operators	SBB and others provide a service on the infrastructure, e.g., regional S-Bahn lines. They are in close relations with the communes and cantons who are generally the purchasers of the service provided to the users. They will participate in the planning process through clear operative requirements and ability to accommodate future societal needs. A rail (public transport) regulator will then control their performances and put the provided mobility service in context of the infrastructure supplied.
		Road operators	The regional operation units, (d. Gebietseinheite) are collaborations between the state and the cantons. They will participate in the planning process through clear operative requirements and ability to accommodate future societal needs.
Controlling	control whether the planning process and outcome meets their needs and requirements	Planning regulators	The Federal Office for Spatial Development (ARE) ensures that strategic objectives are met. Cantonal structural plans and national development plans are approved by the ARE. Earlier in the process, the ARE coordinates the setting of federal strategic objectives, controlling and ensuring that strategic objectives are met. Similarly, the Cantonal Office for Spatial Development (C-ARE) controls that communes meet strategic objectives. On the cantonal level, the office for mobility is also tasked to strategically balance the investments and incentives between different modes according to cantonal and national strategic objectives.
		Rail regulator	Controlling and ensuring that the agreed service provision is met to an adequate level, e.g., by FOT or Cantonal public transport agencies, e.g., ZVV. Road services are generally provided by the users themselves and are therefore not regulated through a separate organisation.

Role	Description	Stakeholder	Stakeholder description with example related to Canton Zürich, when applicable
		Users	Participate in public processes during the planning process and voice their (dis)satisfaction during operation.
		Residents	Participate in public processes during the planning process and voice their (dis)satisfaction during operation.
		Transportist policy groups	Participate in public processes during the planning process and voice their (dis)satisfaction during operation, e.g., Swiss Automobile Club (www.acs.ch), Swiss Touring Club (www.tcs.ch), Union of Public Transport Operators (www.voev.ch),
		Nature preservation groups	Participate in public processes during the planning process and voice their (dis)satisfaction during operation.

3 Process

3.1 Overview

The road and rail infrastructure planning process has been modelled for three levels of infrastructure: national road, national rail and cantonal infrastructure (road and rail). The road and rail infrastructure planning process comprises of separate planning processes for each level as different organisations lead the process for each, i.e., The Federal Road Office for national roads, The Federal Office of Transport for national rail and the Cantonal Office for Spatial Development, in lead, for cantonal infrastructure. The process has been modelled based on semi-structured interviews with members of, and based on grey literature published by, infrastructure planning organisations, e.g., FEDRO's guideline for developing general projects (ASTRA, 2014). The reported process is the authors' understanding of the process. It is based on public, and official documents and expanded and validated through semi-structured interviews with the shaping stakeholders. It is furthermore reported sufficiently detailed to clearly specify the tasks of the process but sufficiently general to retain the big picture of the planning process as a whole.

The objective of this section is to clarify the infrastructure planning process and the purpose of each planning task. The process, as illustrated in Figure 2, is mapped using Business Process Modelling Notation 2.0 (BPMN) shown for the canton of Zürich based on the information acquired through interviews and public documents on infrastructure development (see Appendix section 7.1). Each task is placed in the context of the infrastructure planning process as a whole.

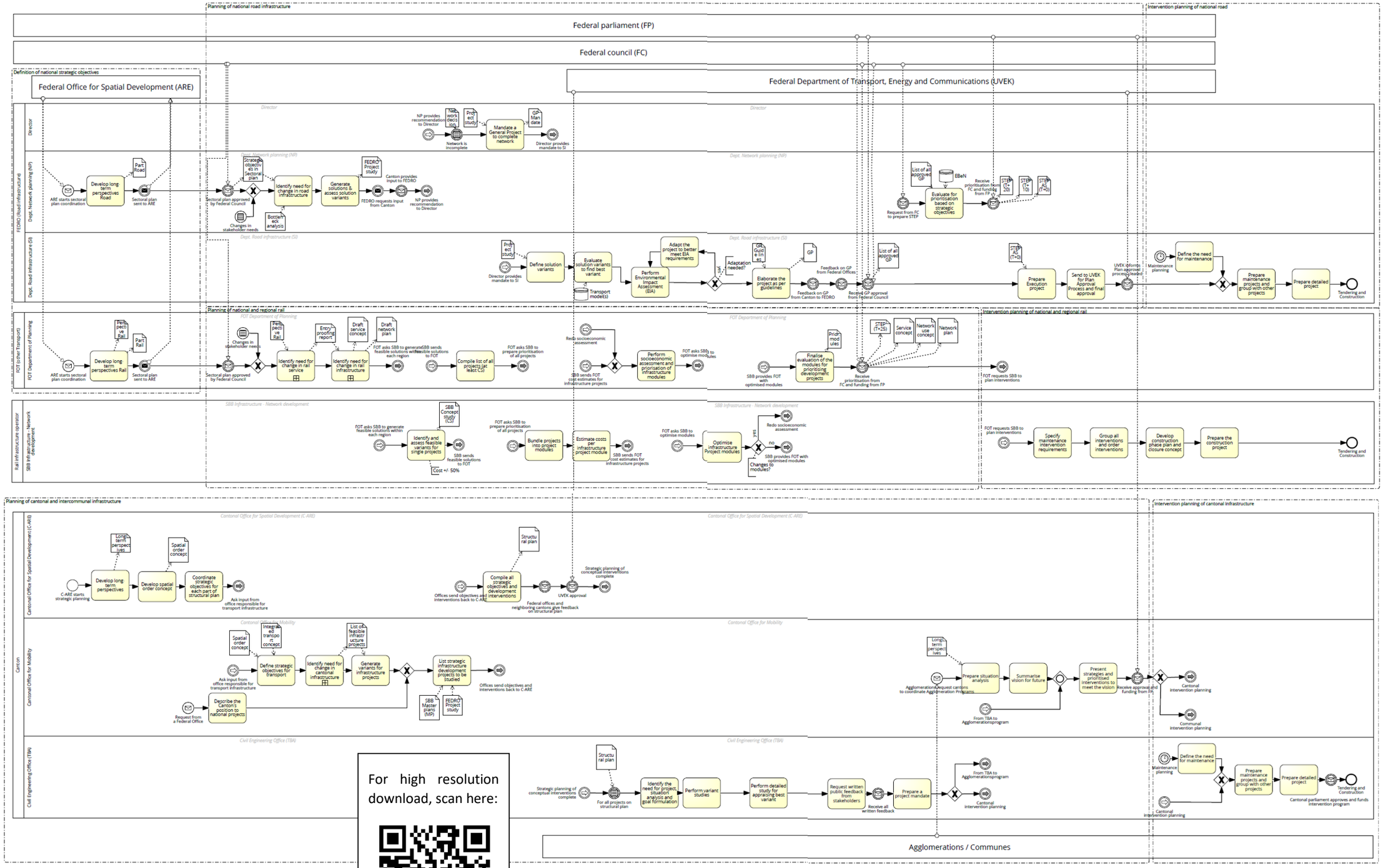

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Figure 2: Infrastructure planning process for the canton of Zürich

Throughout the process, stakeholders are involved to a differing extent and the process can be thematically split into four parts based on the separation of planning responsibility, i.e., based on the timing within the planning process and type of infrastructure. Figure 3 demonstrates the way that the general planning process has been split into these four parts. For each type, different shaping stakeholders are predominantly involved, e.g., FEDRO for national road and FOT for national rail.

Accordingly, these four parts are each illustrated in more detail in sub-sections 3.2-3.5. First, (1) the definition of national strategic planning objectives is specified, which applies to the sectoral plan coordination across all types of infrastructure over the whole of Switzerland (see section 3.2). While the strategic objectives are defined by federal offices, the objectives also apply to the cantonal and communal planning stakeholders. Then, the infrastructure planning process is broken down by their distinctive types and functions: (2) national road (see section 3.3), (3) national/regional rail (see section 3.4), (4) cantonal and intercommunal infrastructure (see section 3.5). The national infrastructure primarily serves international, national and interregional transport needs whereas cantonal and intercommunal infrastructure serve primarily intraregional needs. The faintly colored parts of the process diagram are those belonging to intervention planning and construction, i.e., after the infrastructure planning process. They are included in the figures, but are not within the scope of this report. A more detailed overview of the national infrastructure intervention planning processes can be found within the research projects MINERVA (for FEDRO, see (Hässig et al., 2024)) and STABILITY (for rail / SBB, see (Chuo et al., 2022, 2024; Mehranfar et al., 2023)).

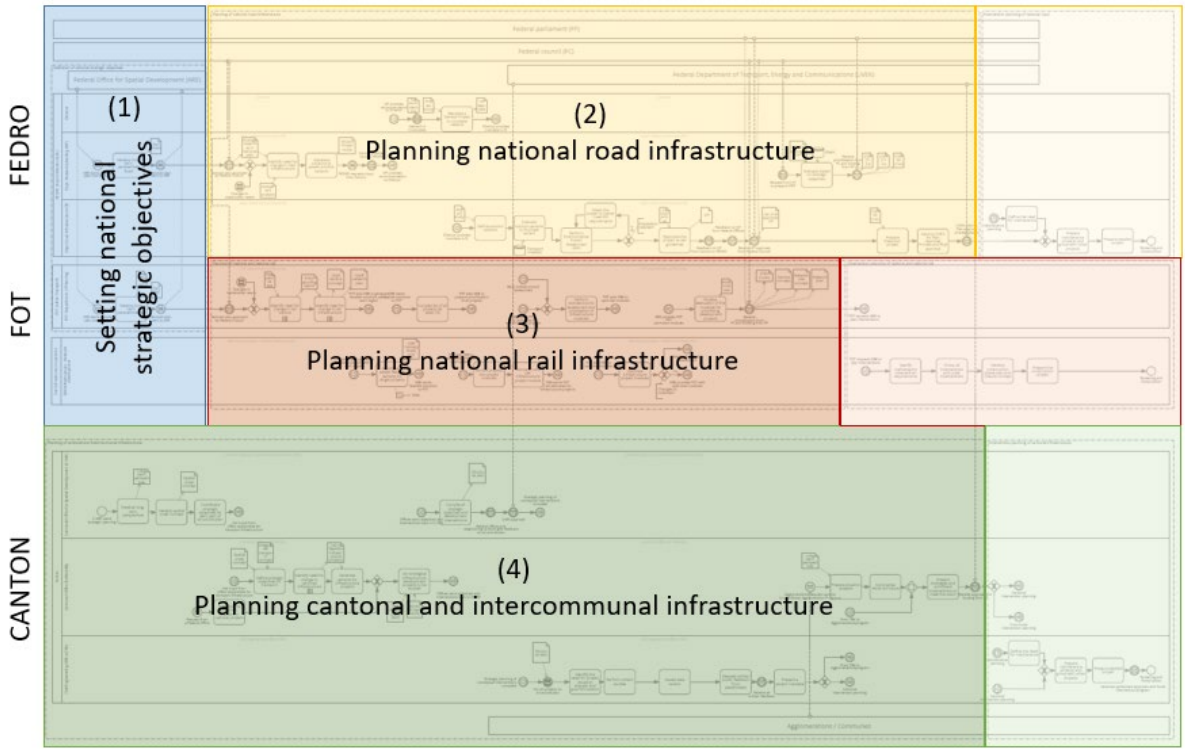

Figure 3: A visualisation of the thematic split within the infrastructure planning process. The more transparent area indicates the part of the same colored process that is allocated to intervention planning and construction, which is beyond the scope of this report and only generally reported

In the following sub-sections, each infrastructure type is addressed by providing a close-up of the part of the process that the sub-section is highlighting and then by describing each task using a standardised table, from now on called 'task description panel' or 'panel' for short. Within each panel describing a task in the infrastructure planning process, information is provided regarding the task's description and duration. The

granularity chosen is considered to be sufficiently high to have a general idea of how the process works and identify challenges and opportunities for the process, and sufficiently low to have a complete overview of the whole process. In situations where there are multiple stakeholders involved in a task, it is assumed that the stakeholder requesting information from others is the one that coordinates the sub-tasks of all stakeholders involved.

When describing the process tasks, a particular focus is placed on the planning-support tools used in order to find out how and where the process is already supported. For each panel, there is a corresponding figure that places the task in the context of the entire process and the information flow. The individual process steps highlighted by the documents and discussions are explained in more detail in this report using the following description categories shown in the panel (see Table 2). Note that, figures dedicated to the corresponding sub-sections are a close-up of a certain part of the overall process, so that the tasks can be discussed systematically.

While the tables and figures presented in this section represent the current understanding of the infrastructure planning process, there are some gaps which require further clarifications from planners. The reported understanding of the process should not be considered as an official version of the process, albeit being based on public, and official documents. It is furthermore reported sufficiently detailed to specify the necessary detail to meet the objectives of the report but sufficiently general to see the big picture of the planning process as a whole.

Table 2: Explanation for the single categories of the panels explaining each process task.

Category	**Explanation**
Process task	The name of the process task that corresponds to the name written in the process itself.
Description	The description of the process task and the underlying steps taken.
Responsible	The stakeholder organisation, and possible position within the organisation, that is responsible for the task being performed.
Other stakeholders involved	List of the participating stakeholders, although they are themselves not responsible.
Input	A list of documents used or considered for the execution of the task.
Supporting tools	Software, documents or templates used for the execution of the task.
Output	Documents resulting from the process task.
Process task duration	The duration of the process task.
Timing	The approximate timing of the task in relation to the construction of a resulting project.

Although not within the scope of the process, it is of interest to report on the input related to how the process is initiated and how the resulting output gets used for infrastructure construction or modification. An instance of the planning process may be initiated in various ways. For example, the process could be initiated with the first serious effort to include a project idea in an official planning document which may only be produced or updated at a regular interval (e.g., every 10 years for a cantonal structural plan). It could also be started with a revision of strategic objectives, either because of changing societal objectives (e.g., due to climate change and internationally aspired net-zero objectives) or technological developments providing a new understanding for how stakeholder needs may change (e.g., a development of technological readiness of connected electric automated vehicles). After a list of interventions has been defined for a certain budget period, the

interventions are then planned in detail. Afterwards, the construction and modification projects are granted permits to begin. Lastly, the interventions are tendered and executed by contractors. Only after the intervention projects are completed does society benefit from the infrastructure planning performed in earlier stages. The planning process is mapped until construction. However, the focus of this paper is on the planning process until a list of interventions has been defined for a certain budget period.

3.2 Setting strategic planning objectives

The first part of the infrastructure planning process includes setting up the national strategic objectives. This task is coordinated across multiple sectors by the federal office for spatial development, the objectives for each sector as well are proposed by each shaping stakeholder and then the sectoral plans are approved and published by the federal council. The close-up for this part of the process is shown in Figure 4 and the tasks are described in the panel in Table 3.

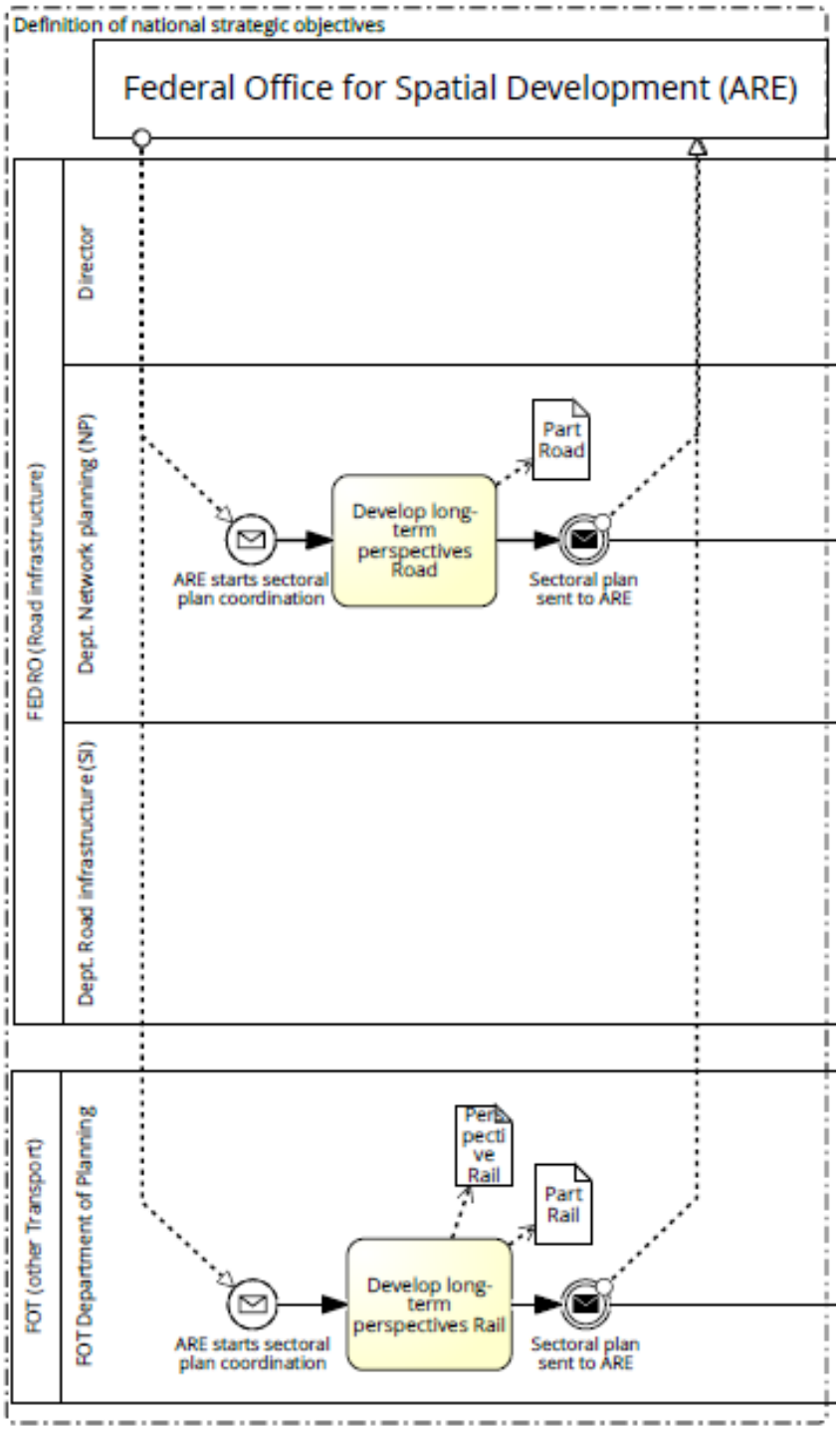

Figure 4: Close-up of process for defining national strategic planning objectives

Table 3: Process task explanation for developing long-term perspectives for either road or rail

Category	Explanation
Process task	Develop long-term perspectives (Road or Rail)
Description	As planning is performed for an uncertain future, planners make reasonable estimates related to how societal needs could change over time and how such needs are accommodated given possible futures. By making these predictions related to the future, it enables planners to identify robust solutions that accommodate needs in multiple futures. The federal office for spatial development (ARE) will initiate the sectoral plan coordination and ask the responsible Federal offices to contribute their long-term perspectives, sectoral sub-strategies and strategic objectives that become part of the federal Sectoral Plan. ARE influences the development of infrastructure through these strategic objectives in formulating the sectoral plans and through their approval of the cantonal structural plans in alignment with federal strategic objectives. Here it is possible to set ambitious goals, and definitive population growth estimations to steer the infrastructure planning and development of federal offices and cantons. A sectoral plan is then approved by federal council as an output of this process. The objectives of the partial transport related sectoral plans is to: • Provide information to the public regarding the objectives, basic assumptions and priorities of the federal state related to the national infrastructure • The coordination of the national infrastructure interventions with different transportation modes • The definition of the further procedure of the national infrastructure planning on a federal level • The definition of the spatial information and coordination instructions for the national infrastructure.
Responsible	Network Planning department of FEDRO for Road and Planning department of FOT for Rail
Other stakeholders involved	ARE and Federal Council
Input	-
Supporting tools	-
Output	Strategic objectives, long-term perspectives and sectoral plan parts for the Road or Rail infrastructure network
Process task duration	~1-4 years (1-2 years for road, 3-4 years for rail)
Timing	25 years prior to planning horizon for rail and 5-20 years prior to intervention for road

3.3 Planning national road infrastructure

3.3.1 A close-up of the process for national road infrastructure planning

The second part of the infrastructure planning process describes the planning for national roads according to the national strategic objectives defined in the sectoral plan. This task requires coordination with the affected canton(s), other federal offices and the general public and is completed when the federal parliament allocates funds to the strategic development program. The close-up for this part of the process is shown in Figure 5 and the tasks are described in the panels in Table 4 - Table 14.

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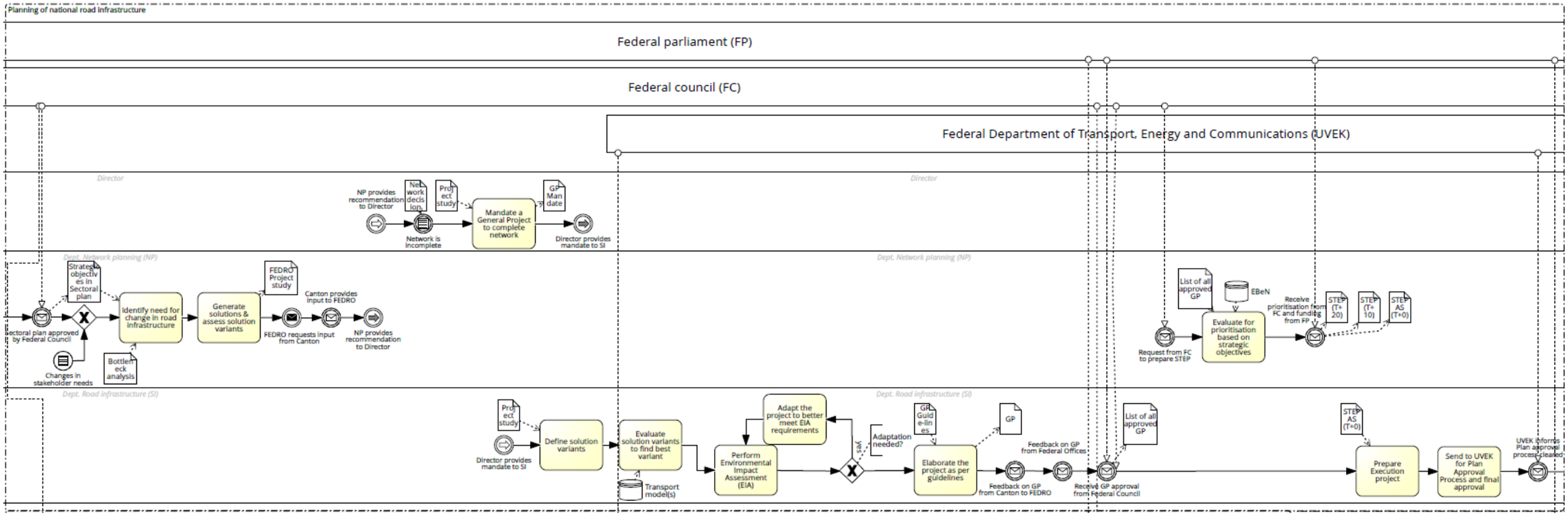

Figure 5: Close-up of process for planning national road infrastructure

Table 4: Process task explanation for identifying need for change in national road infrastructure

Category	Explanation
Process task	Identify the need for change in road infrastructure
Description	This process commences if a new sectoral plan approved by federal council or there are changes in stakeholder needs. The need for change is based on the comparison of the long-term perspectives and strategic goals defined by the Federal Council's Sectoral plans, originally prepared by FEDRO. Key indicators are based on objectives defined by the federal council and UVEK, originally in the 2006 Sectoral Plan. Since then, the eighth objective has been added to the top of the list They are designed to monitor FEDRO's ability to meet the following eight societal objectives: • Contribute to achieving the goals of the Paris Climate Agreement and CO2 reduction. • Maintain functionality of the transport infrastructure for society and economy. • Improve the quality of the connections between agglomeration and urban centres. • Guarantee accessibility to rural space and tourist regions as well as ensure a basic provision of services. • Foster inwards spatial development and improve the quality of urban spaces. • Make transport safe. • Relieve environmental burdens and improve natural quality of life. • Provide an attractive cost-benefit-ratio and keep public expenses feasible. Every four years, FEDRO provides an overview to the federal government of the performance of the network in terms of a bottleneck analysis (d. Engpassanalyse). This provides the main argument for development expansions in the Strategic development program. A project study is done if there is a clear bottleneck or weakness in the network is identified that must be solved (d. Engpassbeseitigung oder Schwachstelle). This task is the first step of preparing a project study.
Responsible	Network Planning department of FEDRO
Other stakeholders involved	Federal government
Input	Strategic objectives, long-term perspectives and bottleneck analysis
Supporting tools	-
Output	-
Process task duration	1 year
Timing	10-20 years prior to intervention

Table 5: Process task explanation for generating solutions & assessing solution variants

Category	Explanation
Process task	Generate solutions and assess solution variants
Description	This task aims to generate solution variants, the necessary costs to implement it and assess the impact the variant will have on the infrastructure system. In Switzerland, a project study is performed for any project that impacts the network capacity or performance. A project study sets the framework of what is to be projected in a General Project, evaluates if the proposed measures meet the aspired objectives, and if additional environmental considerations are necessary based on the legislation. Once a network bottleneck or weakness are identified through the project study phase, they are likely to be solved within the studied variants. The general procedure includes a report on this matter, a request of feedback from affected Cantons and Federal Offices. The final step is to prepare a summary of the variants and a recommendation to FEDRO's director to make a decision on whether to move forward with this project.
Responsible	Network Planning department of FEDRO
Other stakeholders involved	Affected cantons and federal offices, FEDRO Director
Input	Bottleneck analysis
Supporting tools	EbeN Handbook
Output	FEDRO project study
Process task duration	2-3 years
Timing	5-15 years prior to intervention.

Table 6: Process task explanation for mandating a general project to complete network

Category	Explanation
Process task	Mandate a General Project to complete network
Description	The National government defines an aspired network and network functionality through a document named 'Network Decision' (d. Netzbeschluss). Such a document will not define the exact location of a road, but instead that there are two nodes in a network that should be connected with a certain type of a road. The FEDRO's task is to plan, construct and maintain the network decided in the network decision. If the infrastructure network does not correspond to the 'network decision', the director of the FEDRO may mandate its office, more specifically the department for road infrastructure, to start to prepare a general project based on the studied variants. A general project is a specified term in the law for national roads. The descriptor "general" refers to the level of detail aspired. It should be noted, that any project of the federal government that has a wider impact on the transport system, e.g., that additional capacity on a road link has network effects, must also be a part of the cantonal structural plan, which is the canton's responsibility.
Responsible	FEDRO Director
Other stakeholders involved	Department of road infrastructure, cantons
Input	Project study
Supporting tools	-
Output	General Project Mandate (GP Mandate)
Process task duration	< 1 year
Timing	5-15 years prior to intervention

Table 7: Process task explanation for defining solution variants

Category	Explanation
Process task	Define solution variants
Description	A general project will set up variants as per the director's mandate. Based on the results of a project study and the input from the canton and federal offices. Following steps are defined to be fed into the NISTRA appraisal framework
Responsible	FEDRO road infrastructure
Other stakeholders involved	-
Input	GP Mandate, project study
Supporting tools	EBeN Guideline
Output	-
Process task duration	1-2 years
Timing	5-15 years prior to intervention

Table 8: Process task explanation for evaluating solution variants to find a best variant

Category	Explanation
Process task	Evaluate solution variants to find best variant
Description	To evaluate the solution variants, a transport model is set up for each variant.
Responsible	FEDRO road infrastructure
Other stakeholders involved	-
Input	-
Supporting tools	A transport model
Output	A best variant
Process task duration	1-2 years
Timing	5-15 years prior to intervention

Table 9: Process task explanation for performing an environmental impact assessment (EIA)

Category	Explanation
Process task	Perform Environmental Impact Assessment (EIA)
Description	For a previously defined best variant, an environmental impact assessment is performed to fulfill the requirements of a general project.
Responsible	FEDRO road infrastructure
Other stakeholders involved	-
Input	-
Supporting tools	-
Output	Environmental impact assessment
Process task duration	2-4 years
Timing	3-10 years prior to intervention

Table 10: Process task explanation for adapting the project to better meet EIA requirements

Category	Explanation
Process task	Adapt the project to better meet EIA requirements
Description	If the project requires adaptations, then adaptations are made and the EIA is revised to accommodate the adaptations made.
Responsible	FEDRO road infrastructure
Other stakeholders involved	-
Input	-
Supporting tools	-
Output	-
Process task duration	1-2 years
Timing	3-10 years prior to intervention

Table 11: Process task explanation for elaborating the project as per guidelines

Category	Explanation
Process task	Elaborate the project as per guidelines
Description	The objective is to make an informed decision on an appropriate variant in consensus with the responsible accompanying committee (d. Begleitkommission), neighboring cantons and federal offices. This includes the technical project work: The general project defines the road path, connection to current network, intersection structures and the number of lanes. General projects can be included on the strategic development programme (STEP) for Road. However, only approved general projects can be included on the STEP expansion step for road. The "Expansion step" is the category of highest priority to be built in the next 5 years. The affected cantons and other federal offices are provided the opportunity to express their concerns for the planned project. Lastly, the federal council approves the GP.
Responsible	FEDRO Road infrastructure
Other stakeholders involved	Cantons, federal offices, federal council
Input	GP guidelines
Supporting tools	-
Output	GP
Process task duration	2-5 years
Timing	3-10 years prior to intervention

Table 12: Process task explanation for evaluating projects for prioritisation based on strategic objectives

Category	Explanation
Process task	Evaluate for prioritisation based on strategic objectives
Description	FEDRO prepares the evaluations for the basis on which the federal council prioritises the projects. For a project to be realised, it must not only be deemed most urgent and most beneficial, but also be prepared to an adequate level of detail ready for tendering. This is why the elaboration of the project to an execution project and its approval runs in parallel, yet independent, from the evaluation of the many projects on a strategic level. As a result, the federal council‘s prioritisation in addition to the budget allocated by the federal parliament make up the strategic development programme (STEP). The STEP is the national program of infrastructure development projects. If the projects have been approved as general projects, they may, be considered in the STEP’s following expansion step. It should be noted that any project of the federal government that has a wider impact on the transport system, e.g., that additional capacity on a road link has network effects, must also be a part of the cantonal structural plan, which is the canton‘s responsibility.
Responsible	FEDRO Network planning
Other stakeholders involved	Federal council and federal parliament, cantons
Input	List of all projects at least with a GP mandate
Supporting tools	EBeN
Output	A decision from the federal council and federal parliament on the STEP for the immediate time period (T+5) and then those lower prioritised/less ready projects in time horizons (T+15) and (T+25).
Process task duration	2-4 years
Timing	3-8 years prior to intervention

Table 13: Process task explanation for preparing execution project

Category	Explanation
Process task	Prepare execution project
Description	FEDRO will prepare the project in a high level of detail according to standards. The execution project (d. Ausführungsprojekt) includes detailed technical drawings, major details on the engineering structures, technical report on mitigating interventions, environmental aspects, and relations to other modes. Execution projects are ready for tendering. Particular parts of the execution project, e.g., tunnels, galleries or special constructions, can be further elaborated in a detail project prior to tendering, but do not require further approval. This project is then sent to UVEK for approval.
Responsible	FEDRO road infrastructure
Other stakeholders involved	-
Input	Approved GP which is on a STEP expansion step
Supporting tools	-
Output	-
Process task duration	1-3 years
Timing	3-8 years prior to intervention

Table 14: Process task explanation for sending project to UVEK for plan approval process and final approval

Category	Explanation
Process task	Send to UVEK for Plan Approval Process and final approval
Description	The next step includes the Plan Approval Process, incorporating public participation, whereby cantons, communes and private individuals can send in their comments. UVEK puts the project on public display for cantons, communes and the general public to voice any concern they may have and participate in the project preparations. These comments must be addressed by UVEK. If stakeholders are dissatisfied with how their comments were handled, they may send a complaint through the judicial system. When all comments are addressed and all court complaints are cleared up, the project can be approved and consequently, realised. After the plan is approved, land acquisition can be carried through and all plans be prepared in detail for tendering for construction.
Responsible	FEDRO Road infrastructure
Other stakeholders involved	UVEK, cantons, communes, general public
Input	Execution project
Supporting tools	-
Output	An approved execution project
Process task duration	< 1 year
Timing	2-5 years prior to intervention

3.3.2 A general overview of the process related to planninginterventions for national road

The subsequent intervention planning process is generally visualised in Figure 6 and described in

Table 15.

Table 15: General explanation for three tasks shown related to national road intervention planning

Category	Explanation
Process task	National road intervention planning: Define the need for maintenance, prepare maintenance projects and group with other projects, prepare detailed project as shown in the following Figure 6.
Description	Describing the intervention planning and construction processes is not within the scope of this report. It is nevertheless included in aggregated form. After the maintenance managers define the need for maintenance, maintenance projects are prepared and combined with development projects if it is suitable, i.e., they are nearby or provide some other synergies. Lastly, the detailed project is finalised by FEDRO and sent for tendering and subsequent construction.
Responsible	FEDRO road infrastructure
Other stakeholders involved	FEDRO subsidiaries and Regional operational units
Input	Approved execution project
Supporting tools	-
Output	A project ready for tendering and construction
Process task duration	5-7 years
Timing	About 1-15 years prior to intervention.

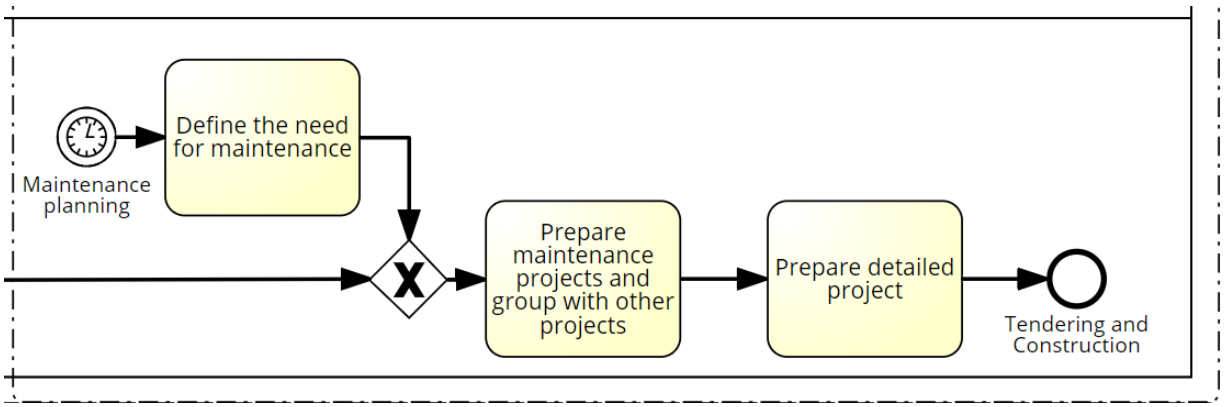

Figure 6: Generalised intervention planning tasks for national road

3.4 Planning national rail infrastructure

3.4.1 A close-up of the process for national rail infrastructure planning

The third part of the infrastructure planning process describes the planning for national rail according to the national strategic objectives defined in the sectoral plan. This task requires coordination with the affected canton(s), other federal offices and the general public and is completed when the federal parliament allocates funds to the strategic development program. The close-up for this part of the process is shown in Figure 7 and the tasks are described in the panels in Table 16 - Table 32. The hierarchical expansion of the tasks “Identify need for change in rail service” and “Identify need for change in rail infrastructure” are shown in Figure 8 and Figure 9, respectively.

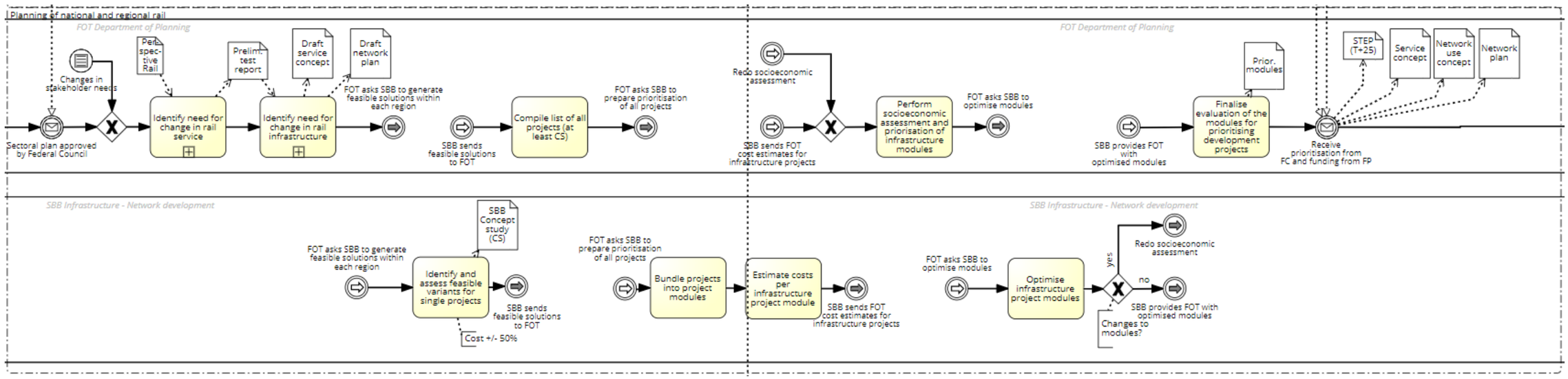

Figure 7: Close-up of process for planning national rail infrastructure

Table 16: Process task explanation for identifying need for change in rail service

Category	Explanation
Process task	Identify need for change in rail service
Description	This process will start every 4 to 8 years as per the Railway Law if there is a new sectoral plan approved by federal council or there are changes in stakeholder needs, bearing in mind the long-term perspectives. The need for change is based on the strategic goals defined by the federal council's sectoral plans, originally prepared by FOT. The key indicators are based on objectives defined by the federal council and UVEK in the long term perspectives, e.g., the document "Perspektive BAHN 2050" from 2023. They are designed to monitor FOT's ability to meet the following 6 strategic objectives: • Rail development is coordinated with the objectives of spatial development. • Rail services are part of integrated mobility. It is flexible and optimally interlinked with other transport services and modes. • The rail share of the modal split in passenger and freight transport increases noticeably. • Rail operations are climate-neutral and new rail infrastructure is designed to conserve land and resources and is well integrated into the landscape and settlements. • Rail operations are safe, punctual, reliable and flexible. • Efficiency gains through automation and new technologies are effectively utilized. The task is shown as a collapsed task – a more detailed explanation of the task as it is broken into its sub-tasks illustrated in Figure 8. This visualisation shows clearly the interactions between the involved stakeholders.
Responsible	Planning department of FOT
Other stakeholders involved	SBB, canton, regional public transport conferences
Input	Strategic objectives
Supporting tools	-
Output	Service concept & network plan drafts
Process task duration	3-5 years
Timing	20 years before planned completion

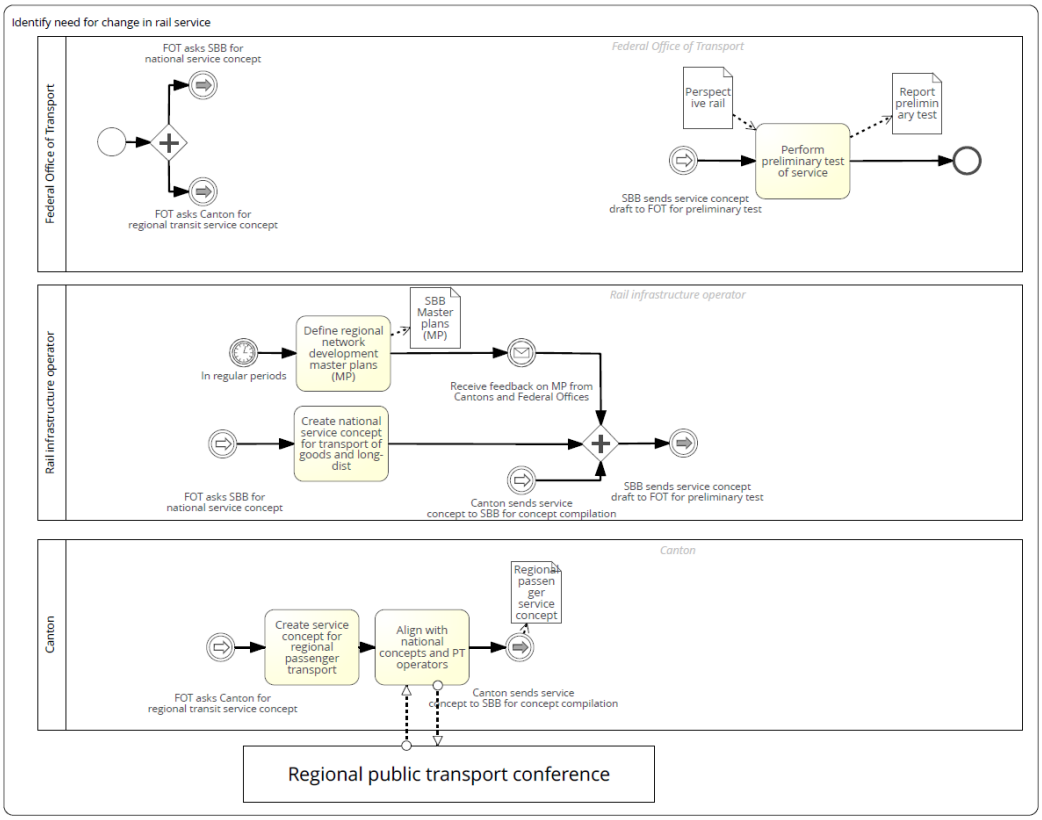

Figure 8: Hierarchical expansion of identifying need for change in rail service from Figure 7

Table 17: Process task explanation for defining regional network development master plans

Category	**Explanation**
Process task	*Identify need for change in rail service* as seen on Figure 7
Sub-process task	Define regional network development master plans (MP)
Description	SBB generates feasible solutions within each region to complete the network plan. It requires expressing the spatially explicit requirements for infrastructure. This is done through a regional network development master plan for every region. This master plan is to be subject to consultation feedback from the cantons and relevant federal offices.
Responsible	SBB
Other stakeholders involved	FOT, cantons, other federal offices
Input	-
Supporting tools	-
Output	SBB regional master plans
Process task duration	-
Timing	20 years ahead of planned completion

Table 18: Sub-process task explanation for creating national service concept for transport of goods and long-distance

Category	**Explanation**
Process task	*Identify need for change in rail service* as seen on Figure 7
Sub-process task	Create national service concept for transport of goods and long-distance
Description	In order to identify the need for change in rail infrastructure, the FOT starts by (1) asking SBB to provide a national service concept for transport of passengers and goods and (2) asking the canton to provide a service concept for the regional services of passenger transit. The service concept provides a definition of the demand anticipated for both goods and personal transport on each stretch. For the national concepts, the rail infrastructure operator is responsible.
Responsible	SBB
Other stakeholders involved	FOT
Input	A request from FOT
Supporting tools	-
Output	-
Process task duration	6-12 months
Timing	20 years before planned completion

Table 19: Sub-process task explanation for creating a national service concept for regional passenger transport

Category	**Explanation**
Process task	*Identify need for change in rail service* as seen on Figure 7
Sub-process task	Create national service concept for regional passenger transport
Description	In order to identify the need for change in rail infrastructure, the FOT will start by (1) asking SBB to provide a national service concept for transport of passengers and goods and (2) asking the Canton to provide a service concept for the regional services of passenger transit. The service concept provides a definition of the demand anticipated for both goods and personal transport on each stretch. For the regional concepts for passenger transport, the canton is responsible and then sends their concept to the FOT for an initial proofing.
Responsible	Canton
Other stakeholders involved	FOT
Input	A request from FOT
Supporting tools	-
Output	-
Process task duration	6-12 months
Timing	20 years ahead of planned completion

Table 20: Sub-process task explanation for aligning with national concepts and public transit operators

Category	**Explanation**
Process task	*Identify need for change in rail service* as seen on Figure 7
Sub-process task	Align with national concepts and public transit operators
Description	The canton will keep all transit operators in the relevant regions informed and build consensus with any of their needs as they are the operators that will have to realise the service concept in the future. The regional public transit conference is a consortium of planners, policy-makers and service providers to ensure an understanding for the needs of each other. Afterwards, the canton forwards the regional passenger service concept to FOT.
Responsible	Canton
Other stakeholders involved	Regional public transit conference
Input	-
Supporting tools	-
Output	-
Process task duration	-
Timing	-

Table 21: Sub-process task explanation for performing preliminary test of service

Category	**Explanation**
Process task	*Identify need for change in rail service* as seen on Figure 7
Sub-process task	Perform preliminary test of service
Description	The federal office of transport (FOT) receives the service concept draft considering the requested changes in service for the planning horizon. The preliminary test is used to verify that the service changes fulfil certain requirements and are in alignment with the Federal objectives. Afterwards, the FOT reports their findings in a preliminary test result report.
Responsible	Federal office of transport
Other stakeholders involved	-
Input	
Supporting tools	-
Output	Report preliminary test
Process task duration	3 months
Timing	Describes the approximate timing of the task in relation to the construction of a resulting project.

Table 22: Process task explanation for identifying need for change in national rail infrastructure

Category	Explanation
Process task	Identify need for change in rail infrastructure
Description	The need for change in infrastructure is based on the difference between the demand expressed through the service concept and the available infrastructure supply. The supply has been aggregately tested for feasibility and certain conditions through the preliminary test. The task is shown as a collapsed task – a more detailed explanation of the task as it is broken into its sub-tasks illustrated in Figure 9. This visualisation shows clearly the interactions between the involved stakeholders.
Responsible	Planning department of FOT
Other stakeholders involved	SBB, canton, regional public transport conferences
Input	Strategic objectives
Supporting tools	-
Output	Service concept & Network plan drafts
Process task duration	3-5 years
Timing	20 years before planned completion

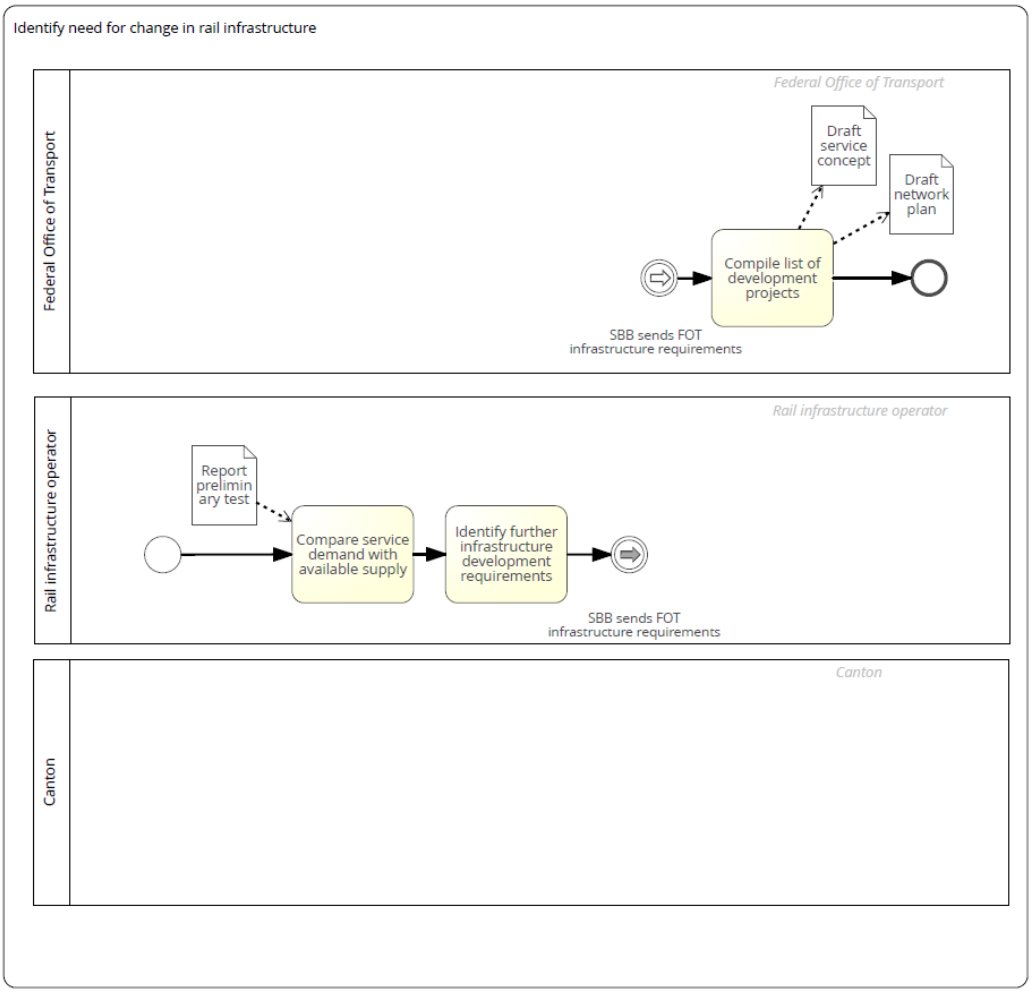

Figure 9: Hierarchical expansion of identifying need for change in rail infrastructure from Figure 7

Table 23: Sub-process task explanation for comparing service demand with available supply

Category	**Explanation**
Process task	*Identify need for change in rail infrastructure* as seen on Figure 7
Sub-process task	Compare service demand with available supply
Description	Based on the service demand from both service concepts, SBB identifies the need for additional infrastructure supply.
Responsible	SBB
Other stakeholders involved	FOT
Input	A request from FOT, report on preliminary tests
Supporting tools	-
Output	-
Process task duration	3-4 months
Timing	20 years ahead of planned completion

Table 24: Sub-process task explanation for identifying further infrastructure requirements

Category	Explanation
Process task	*Identify need for change in rail infrastructure* as seen on Figure 7
Sub-process task	Identify further infrastructure development requirements
Description	By comparing the supply of infrastructure and the demand expressed in the service concepts, SBB can show where the infrastructure supply is lacking. Furthermore, the infrastructure operator could demonstrate scenarios of growth to accommodate the needs of other decision makers.
Responsible	SBB
Other stakeholders involved	FOT
Input	A request from FOT
Supporting tools	-
Output	-
Process task duration	3-4 months
Timing	20 years ahead of planned completion

Table 25: Sub-process task explanation for compiling list of development projects

Category	Explanation
Process task	*Identify need for change in rail infrastructure* as seen on Figure 7
Sub-process task	Compile list of development projects
Description	As a result of identifying the infrastructure requirements needed, the FOT will compile a list of necessary development projects to expand the network so as to accommodate the aspired needs until a certain time. For instance, this is expressed through a draft of the “network plan” for the planned year of completion, e.g., year 2050 for the expansion step 2050. The corresponding service concept for different services follows.
Responsible	SBB
Other stakeholders involved	FOT
Input	A request from FOT
Supporting tools	-
Output	Drafts for the service concept and network plan
Process task duration	3-4 months
Timing	20 years ahead of planned completion

Table 26: Process task explanation for identifying and assessing feasible variants for single rail projects

Category	Explanation
Process task	Identify and assess feasible variants for single rail projects
Description	Based on the regional master plans, the SBB selects feasible and suitable solution variants for single projects. These are expressed in so-called concept studies at a level of detail that corresponds to +/-50% cost estimate accuracy.
Responsible	SBB
Other stakeholders involved	-
Input	-
Supporting tools	-
Output	Concept study (CS)
Process task duration	3-9 months
Timing	15-20 years ahead of planned completion

Table 27: Process task explanation for compiling list of all projects

Category	Explanation
Process task	Compile list of all projects (at least CS)
Description	In this task, a basis to the prioritisation of development projects is prepared. All development projects that have been projected to the level of detail of CS are included.
Responsible	FOT
Other stakeholders involved	
Input	SBB Concept studies, preliminary studies and pre-projects
Supporting tools	-
Output	A list of project to be prioritised.
Process task duration	1 month
Timing	15-20 years ahead of planned completion

Table 28: Process task explanation for bundling projects into project modules

Category	Explanation
Process task	Bundle projects into project modules
Description	When realised, interventions will be grouped by SBB. This brings economic savings. Hence, the cost estimates used for prioritisation should also be based on the project modules created by the grouped projects. In this task the projects are bundled into modules.
Responsible	SBB
Other stakeholders involved	-
Input	-
Supporting tools	-
Output	-
Process task duration	2 months
Timing	15-20 years ahead of planned completion

Table 29: Process task explanation for estimating costs per infrastructure project module

Category	Explanation
Process task	Estimating costs per infrastructure project module
Description	The cost estimates are made based on the infrastructure project modules defined. These cost estimates are then used for a sociodemographic assessment of infrastructure projects.
Responsible	SBB
Other stakeholders involved	-
Input	-
Supporting tools	NIBA handbook
Output	Cost estimates
Process task duration	3 months
Timing	15-20 years ahead of time

Table 30: Process task explanation for performing socioeconomic assessment and prioritisation of infrastructure modules

Category	Explanation
Process task	Perform socioeconomic assessment and prioritisation of infrastructure modules
Description	Based on the cost estimates made of the infrastructure project modules, the next step includes a socioeconomic assessment, including the time savings and service loss reduction made through the infrastructure project modules.
Responsible	Planning department of FOT
Other stakeholders involved	-
Input	Cost estimates
Supporting tools	NIBA, Spatial effect and environmental impact assessment
Output	Socioeconomic assessment
Process task duration	4 months
Timing	15-20 years prior to planned completion

Table 31: Process task explanation for optimising infrastructure project modules

Category	Explanation
Process task	Optimise infrastructure project modules
Description	FOT asks SBB to optimise the infrastructure project modules to ensure the best return on investment. If the optimisation leads to a change in the modules, the previous step of socioeconomic assessment and prioritisation of infrastructure projects is repeated. This may require a few steps of iteration. If not, then the prioritised modules are passed on to FOT.
Responsible	SBB
Other stakeholders involved	-
Input	-
Supporting tools	Optimisation algorithms
Output	-
Process task duration	1 year
Timing	15-20 years prior to planned completion

Table 32: Process task explanation for finalising evaluation of the modules for prioritising development projects

Category	Explanation
Process task	Finalise evaluation of the modules for prioritising development projects
Description	FOT will prepare the evaluations for the basis on which the Federal Council will prioritise the projects. For a project to be realised, it must not only be deemed most urgent, most beneficial but also be prepared to an adequate level of detail. The strategic development programme (STEP) for rail is set up with an expansion step for about 15 years ahead of time. This is (at least) the time required for the necessary projecting and intervention planning. As a result, the federal council‘s prioritisation in addition to the budget allocated by the federal parliament make up the strategic development programme (STEP). It should be noted, that any project of the federal government that has a wider impact on the transportation system, e.g., that additional capacity on a road link has network effects, must also be a part of the cantonal structural plan, which is the canton‘s responsibility.
Responsible	Planning department of FOT
Other stakeholders involved	Federal council and federal parliament
Input	-
Supporting tools	STEP (T+15)
Output	A list of prioritised modules
Process task duration	approx. 2 years
Timing	about 15 years before planned completion

3.4.2 A general overview of the process related to planning interventions for national rail

The subsequent intervention planning process is generally visualised in Figure 10 and described in Table 33.

Table 33: General explanation for four tasks shown related to national rail intervention planning

Category	Explanation
Process task	National rail intervention planning: specify maintenance intervention requirements, group all interventions and order interventions, develop construction phase plan and closure concept, prepare construction project as shown in the following Figure 10
Description	Describing the intervention planning and construction processes is not within the scope of this report. It is nevertheless included in aggregated form. Within the SBB, different roles address different tasks within the intervention process. The roles include network developers, maintenance planners, network coordinators, production and project planners and capacity planners. The construction is then carried out by project managers. The construction project is finalised by SBB and sent for tendering and subsequent construction.
Responsible	SBB
Other stakeholders involved	FOT
Input	Approved projects on STEP, concept studies
Supporting tools	-
Output	A project ready for tendering and construction
Process task duration	12-15 years
Timing	About 1-25 years prior to intervention.

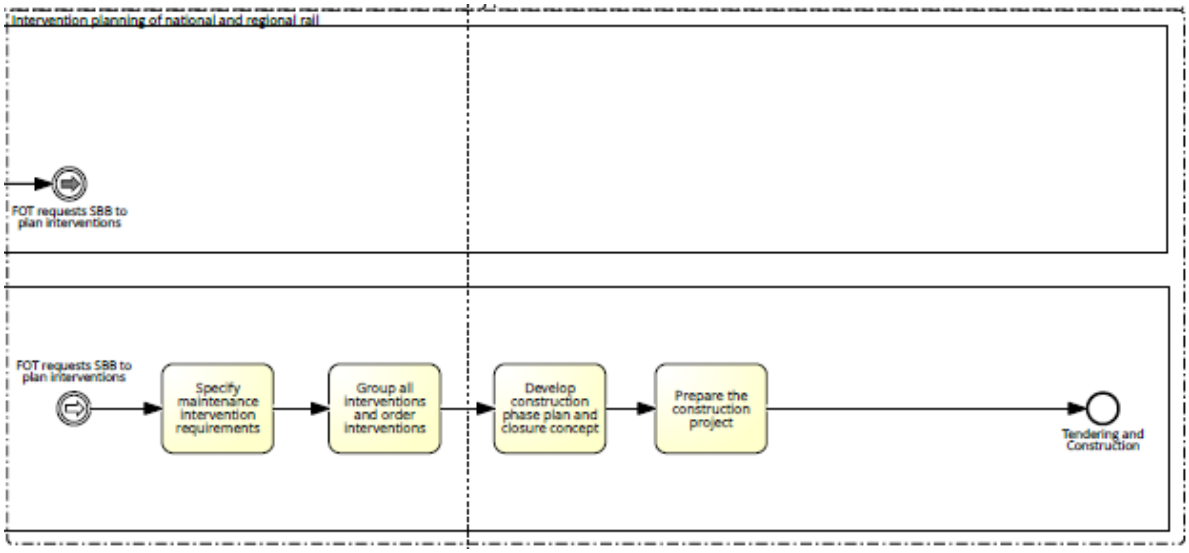

Figure 10: Generalised intervention planning tasks for national rail

3.5 Planning cantonal and intercommunal infrastructure

3.5.1 A close-up of the process for national rail infrastructure planning

The fourth part of the infrastructure planning process describes the planning for cantonal road and rail infrastructure according to the cantonal strategic objectives defined within the process. This task requires coordination with the affected federal offices, communes and the general public and then the federal office for spatial development when setting up agglomeration program. The planning process is completed when it becomes clear which projects are funded by the executive council via the canton's construction program and which projects are funded by the federal government via an agglomeration program. The close-up for this part of the process is shown in Figure 11 and the tasks are described in the panels in Table 34- Table 51 for cantonal infrastructure and Table 52 - Table 54 for cantonal infrastructure of intercommunal and regional importance making the infrastructure projects suitable for inclusion on the federally funded agglomeration programs. The hierarchical expansion of the task "Identify need for change in cantonal infrastructure" is shown in Figure 12.

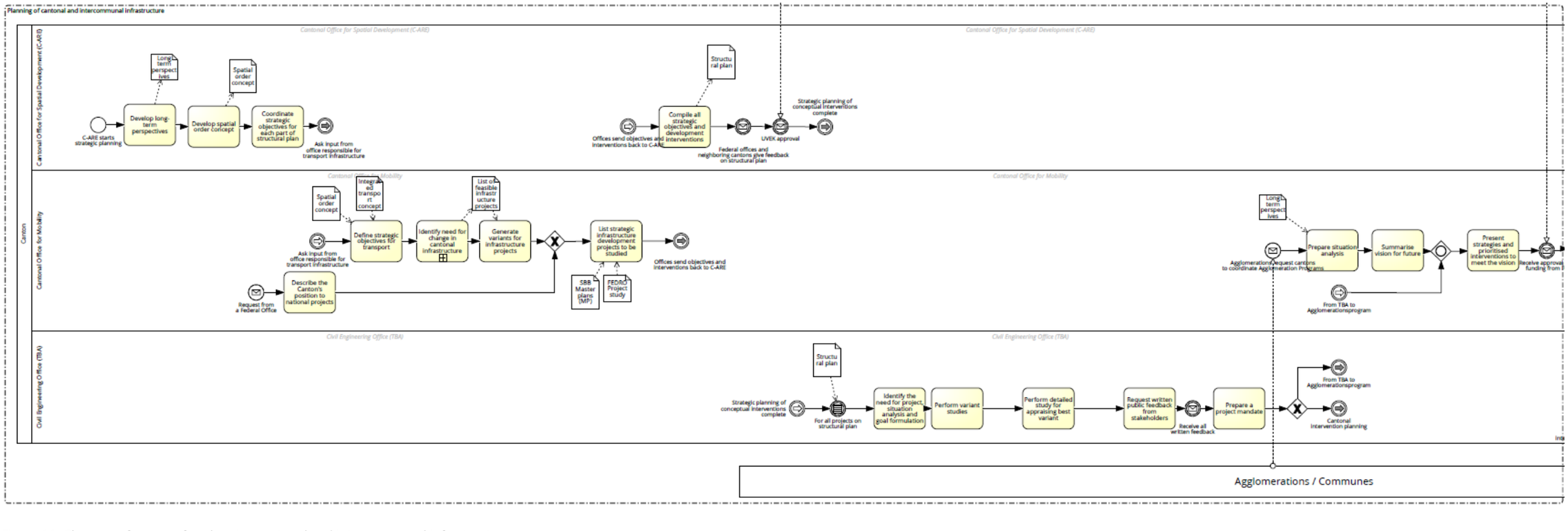

Figure 11: Close-up of process for planning cantonal and intercommunal infrastructure

Table 34: Process task explanation for developing long-term perspectives

Category	Explanation
Process task	Develop long-term perspectives
Description	The first step of the strategic planning is to map the trends and how the canton will develop within the planning horizon.
Responsible	Cantonal office for spatial development
Other stakeholders involved	-
Input	-
Supporting tools	-
Output	Long-term perspectives
Process task duration	1 year
Timing	About 25 years prior to intervention

Table 35: Process task explanation for developing spatial-order concept

Category	Explanation
Process task	Develop spatial order concept
Description	The canton will conceptually order the space available to it as per its strategic objectives.
Responsible	Cantonal office for spatial development
Other stakeholders involved	-
Input	-
Supporting tools	-
Output	Spatial order concept
Process task duration	2 year
Timing	About 25 years prior to intervention

Table 36: Process task explanation for coordinating strategic objectives for each part of structural plan

Category	Explanation
Process task	Coordinate strategic objectives for each part of structural plan
Description	In continuing its strategic planning process, C-ARE will ask all relevant offices for more specific objectives and concepts on different topics that are spatially explicit, like transport. In the following steps, only the steps within the cantonal office for mobility are considered.
Responsible	Cantonal office for spatial development
Other stakeholders involved	-
Input	-
Supporting tools	-
Output	-
Process task duration	2 year
Timing	About 25 years prior to intervention

Table 37: Process task explanation for defining strategic objectives for transport

Category	Explanation
Process task	Define strategic objectives for transport
Description	Based on the spatial order concept and the integrated transport concept the planners will come up with strategic objectives to report in the structural plan, upon which the proposed interventions will base.
Responsible	Cantonal office for mobility
Other stakeholders involved	-
Input	Spatial order concept, integrated transport concept
Supporting tools	-
Output	-
Process task duration	1 year
Timing	About 25 years prior to intervention

Table 38: Process task explanation for identifying need for change in cantonal infrastructure

Category	Explanation
Process task	Identify need for change in cantonal infrastructure
Description	There are multiple ways to identify the need for change in infrastructure. From inside the cantonal institution, the planning projects to meet the strategic objectives may be proposed by either planners or the politicians. The office collects proposals. This task is collapsed. Its hierarchical expansion is shown in Figure 12.
Responsible	Cantonal office for mobility
Other stakeholders involved	Cantonal government
Input	Integrated mobility concepts (cantonal and regional), long term perspectives
Supporting tools	-
Output	List of feasible infrastructure projects
Process task duration	6-9 months
Timing	About 20 years prior to intervention

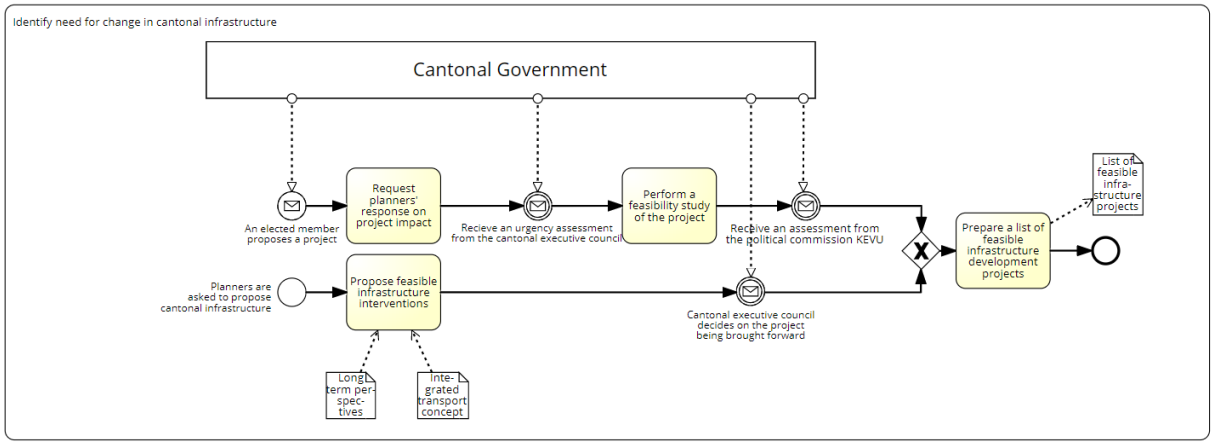

Figure 12: Hierarchical expansion of process task identifying need for change in cantonal infrastructure

Table 39: Sub-process task explanation for identifying need for requesting planner's response on elected member's project proposal's impact

Category	Explanation
Process task	*Identify need for change in cantonal infrastructure* as seen on Figure 12
Sub-process task	Request planner's response on elected member's project proposal's impact
Description	Elected members may also propose projects based on a need for change that they have identified. In this condition, planners are asked to provide a response to the expected impact of the project to accommodate the need that is to be addressed as well as the cantonal strategic objectives. Now the cantonal executive council is asked to assess the urgency of the project to mandate further studying of the project.
Responsible	Cantonal office for mobility
Other stakeholders involved	Cantonal executive council
Input	-
Supporting tools	-
Output	-
Process task duration	6 months
Timing	About 20 years prior to intervention

Table 40: Sub-process task explanation for performing a feasibility study of the project

Category	Explanation
Process task	*Identify need for change in cantonal infrastructure* as seen on Figure 12
Sub-process task	Perform a feasibility study of the project
Description	Once mandated by the cantonal executive council, planners conduct a feasibility study of the project. This study receives an assessment from a political commission on transport related issues to carry further into the strategic development of the cantonal infrastructure.
Responsible	Cantonal office for mobility
Other stakeholders involved	Cantonal committee on communication, energy and environment (KEVU).
Input	-
Supporting tools	-
Output	Feasibility study with variants
Process task duration	1 year
Timing	About 20 years prior to intervention

Table 41: Sub-process task explanation for proposing feasible infrastructure interventions

Category	Explanation
Process task	*Identify need for change in cantonal infrastructure* as seen on Figure 12
Sub-process task	Propose feasible infrastructure interventions
Description	Regularly, the cantonal planning staff are asked to contribute feasible infrastructure interventions. As a part of this task, planners are to provide a feasibility study of an intervention including possible variants generated by planners. Examples of variants for a project connecting highway node A and node B can be to go from A to B via either town C or via forest D. The feasibility study is based on the long term perspectives and cantonal integrated transport concept. Upstream to this task, the existing version of the cantonal structural plan places requirements on the regional integrated transport concepts to not only assess the interventions within the cantonal structural plan, but also to generate need for improvement for road, transit, cycling, pedestrians and parking infrastructure. The needs generated through this process feed into this task.
Responsible	Cantonal office for mobility
Other stakeholders involved	-
Input	Long term perspectives, integrated transport concept (both cantonal and regional)
Supporting tools	-
Output	-
Process task duration	6 months
Timing	About 20 years prior to intervention

Table 42: Sub-process task explanation for preparing a list of feasible infrastructure development projects

Category	Explanation
Process task	*Identify need for change in cantonal infrastructure* as seen on Figure 12
Sub-process task	Prepare a list of feasible infrastructure development projects
Description	Based on the assessment from the cantonal committee on communication, energy and environment (KEVU) of the politician-proposed tasks and the cantonal executive council decision on planner-proposed task, a list of feasible infrastructure development projects is prepared by the cantonal office for mobility.
Responsible	Cantonal office for mobility
Other stakeholders involved	-
Input	-
Supporting tools	-
Output	List of feasible infrastructure projects
Process task duration	3 months
Timing	About 20 years prior to intervention

Table 43: Process task explanation for generating variants for infrastructure projects

Category	Explanation
Process task	Generate variants for infrastructure projects
Description	For the infrastructure projects listed, a number of feasible variants to be studied are generated.
Responsible	Cantonal office for mobility
Other stakeholders involved	-
Input	List of feasible infrastructure projects
Supporting tools	-
Output	-
Process task duration	1 year
Timing	About 20 years prior to intervention

Table 44: Process task explanation for describing the canton‘s position to national projects

Category	Explanation
Process task	Describe the canton‘s position to national projects
Description	Federal offices will reach out to cantons to ask the cantons to describe their position related to the infrastructure intervention project proposals from federal offices. National infrastructure projects can only be realised in cantons if the cantons are in favor of the construction. The canton will therefore provide a thorough analysis of the interests to be addressed in the project as well as facilitate the planning of beneficial infrastructure, e.g., by including the infrastructure on its structural plan.
Responsible	Cantonal office for mobility
Other stakeholders involved	Federal offices
Input	-
Supporting tools	-
Output	-
Process task duration	3 months
Timing	About 25 years prior to intervention

Table 45: Process task explanation for listing strategic infrastructure development projects to be studied

Category	Explanation
Process task	List strategic infrastructure development projects to be studied
Description	Projects from both inside the cantonal organisation as well as from the national authorities are compiled to a list of projects for further studying.
Responsible	Cantonal office for mobility
Other stakeholders involved	-
Input	List of feasible infrastructure projects, SBB network development master plans and FEDRO project studies
Supporting tools	-
Output	List sent to C-ARE
Process task duration	1-2 months
Timing	About 25 years prior to intervention

Table 46: Process task explanation for compiling all strategic objectives and development interventions

Category	Explanation
Process task	Compile all strategic objectives and development interventions
Description	The structural plan is made by the strategic objectives, their development interventions and the related maps. These plans provide the mandate for any projecting made by the canton from the moment of approving the plan. The structural plan is subject to consultation feedback from neighboring cantons and federal offices before being submitted to UVEK for approval. The structural plan has a three-fold purpose: • Coordinate any physical interventions with spatial effect • Canton guarantees financing for interventions listed • Reach an explicit agreement with federal level (and other cantons) on which interventions to prioritise and in what way
Responsible	Cantonal office for spatial development
Other stakeholders involved	Neighboring cantons, federal offices, UVEK
Input	-
Supporting tools	-
Output	Structural plan
Process task duration	2 year
Timing	About 20 years prior to intervention

Table 47: Process task explanation for identifying the need for project, situation analysis and goal formulation

Category	Explanation
Process task	Identify the need for project, situation analysis and goal formulation
Description	For all projects on a structural plan, a mandate has been provided to further project it. Once the need for the project becomes clear, the analysis of the situation is made clear and the goal formulation that adequately address the need for the project.
Responsible	Cantonal civil engineering office (d. Tiefbauamt)
Other stakeholders involved	-
Input	-
Supporting tools	-
Output	-
Process task duration	6 months
Timing	About 15 years prior to intervention

Table 48: Process task explanation for performing variant studies

Category	Explanation
Process task	Perform variant studies
Description	The planners within the cantonal civil engineering office generate variants and discuss them with stakeholders in a workshop
Responsible	Cantonal civil engineering office
Other stakeholders involved	Project stakeholders
Input	-
Supporting tools	-
Output	Advantages and disadvantages of each variant
Process task duration	6 months
Timing	About 15 years prior to intervention

Table 49: Process task explanation for performing a detailed study for appraising best variant

Category	Explanation
Process task	Perform detailed study for appraising best variant
Description	Within this task the best variant is identified, based on previous results, and arguments are prepared in favor of the variant. The discussion of the best variant, e.g., in workshops, is important to firstly communicate the results of the process, but also to elicit reactions from stakeholders.
Responsible	Cantonal civil engineering office
Other stakeholders involved	-
Input	-
Supporting tools	Appraisal tools
Output	-
Process task duration	1 year
Timing	About 15 years prior to intervention

Table 50: Process task explanation for requesting written public feedback from stakeholders

Category	Explanation
Process task	Request written public feedback from stakeholders
Description	Through a public consultation, the cantonal office ensures that all feedback comes across and is addressed to the utmost extent in the final project.
Responsible	Cantonal civil engineering office
Other stakeholders involved	General public, federal offices, communes, non-profit organisations
Input	-
Supporting tools	-
Output	-
Process task duration	3-12 months
Timing	About 15 years prior to intervention

Table 51: Process task explanation for preparing a project mandate

Category	Explanation
Process task	Prepare a project mandate
Description	Based on all written feedback and any adaptation made to the variants, a project mandate is prepared with cost estimates for the entire projecting phase until the end of construction. The project mandate is handed to the cantonal intervention planning unless the project is suitable to be included in an agglomerations program.
Responsible	Cantonal civil engineering office
Other stakeholders involved	Communes, agglomerations
Input	-
Supporting tools	-
Output	Project mandate
Process task duration	3 months
Timing	About 15 years prior to intervention

Table 52: Process task explanation for preparing a situation analysis

Category	Explanation
Process task	Prepare situation analysis
Description	Each commune plans their own infrastructure. For those projects where communal infrastructure is of regional importance, it may be more complex to negotiate how funds should be allocated, and where the planning mandate will lay. In Switzerland, agglomeration programs are used to address this. The related criteria to determine this is defined by the Federal office for spatial development. Agglomeration programs are intervention programs compiled by groups of communes, agglomeration regions, and are submitted by cantons on their behalf to the federal government for funding. This is an instrument used to coordinate the transport and urban development between communes, agglomerations and even cantons and thus contributing to sustainable regional development. Based on an agglomeration's request for the canton to coordinate the agglomeration program, the first step is an assessment of the situation.
Responsible	Cantonal office for mobility
Other stakeholders involved	Agglomerations
Input	Long term perspectives
Supporting tools	Guideline for agglomeration programs
Output	-
Process task duration	6 months
Timing	About 10-20 years prior to intervention

Table 53: Process task explanation for summarising vision for future

Category	Explanation
Process task	Summarise vision for future
Description	The agglomerations are expected to present a future vision where they improve the sustainable development of settlement and transport.
Responsible	Cantonal office for mobility
Other stakeholders involved	Agglomerations
Input	-
Supporting tools	-
Output	-
Process task duration	6 months
Timing	About 10-20 years prior to intervention

Table 54: Process task explanation for presenting strategies and prioritised interventions to meet the vision

Category	Explanation
Process task	Present strategies and prioritised interventions to meet the vision
Description	The strategies incorporate a way to meet the set objectives and the vision through interventions. These include the interventions generated by setting a vision and those passed on by the cantonal office for civil engineering (d. Tiefbauamt). The agglomeration program is sent to the federal government that scores the proposal and finances it in accordance with its findings. If approved, the projects then get handed to the cantonal or communal intervention planning teams.
Responsible	Cantonal office for mobility
Other stakeholders involved	-
Input	-
Supporting tools	-
Output	-
Process task duration	6 months
Timing	About 10-20 years prior to intervention

3.5.2 A general overview of the process related to planning interventions for cantonal road and rail infrastructure

The subsequent intervention planning process is generally visualised in Figure 13 and described in Table 55.

Table 55: Explanation for cantonal intervention planning

Category	Explanation
Process task	Cantonal road intervention planning: Define the need for maintenance, prepare maintenance projects and group with other projects, prepare detailed project as shown in the following Figure 13
Description	Describing the intervention planning and construction processes is not within the scope of this report. It is nevertheless included in aggregated form. After the maintenance managers define the need for maintenance, maintenance projects are prepared and combined with development projects if it is suitable, i.e., they are nearby or provide some other synergies. Lastly, the detailed project is finalised by the Civil engineering office, approved with budget by the cantonal parliament and then sent for tendering and subsequent construction.
Responsible	Cantonal civil engineering office

Other stakeholders involved	Cantonal parliament
Input	Cantonal projects
Supporting tools	-
Output	A project ready for tendering and construction
Process task duration	1-4 years
Timing	About 1-6 years prior to intervention.

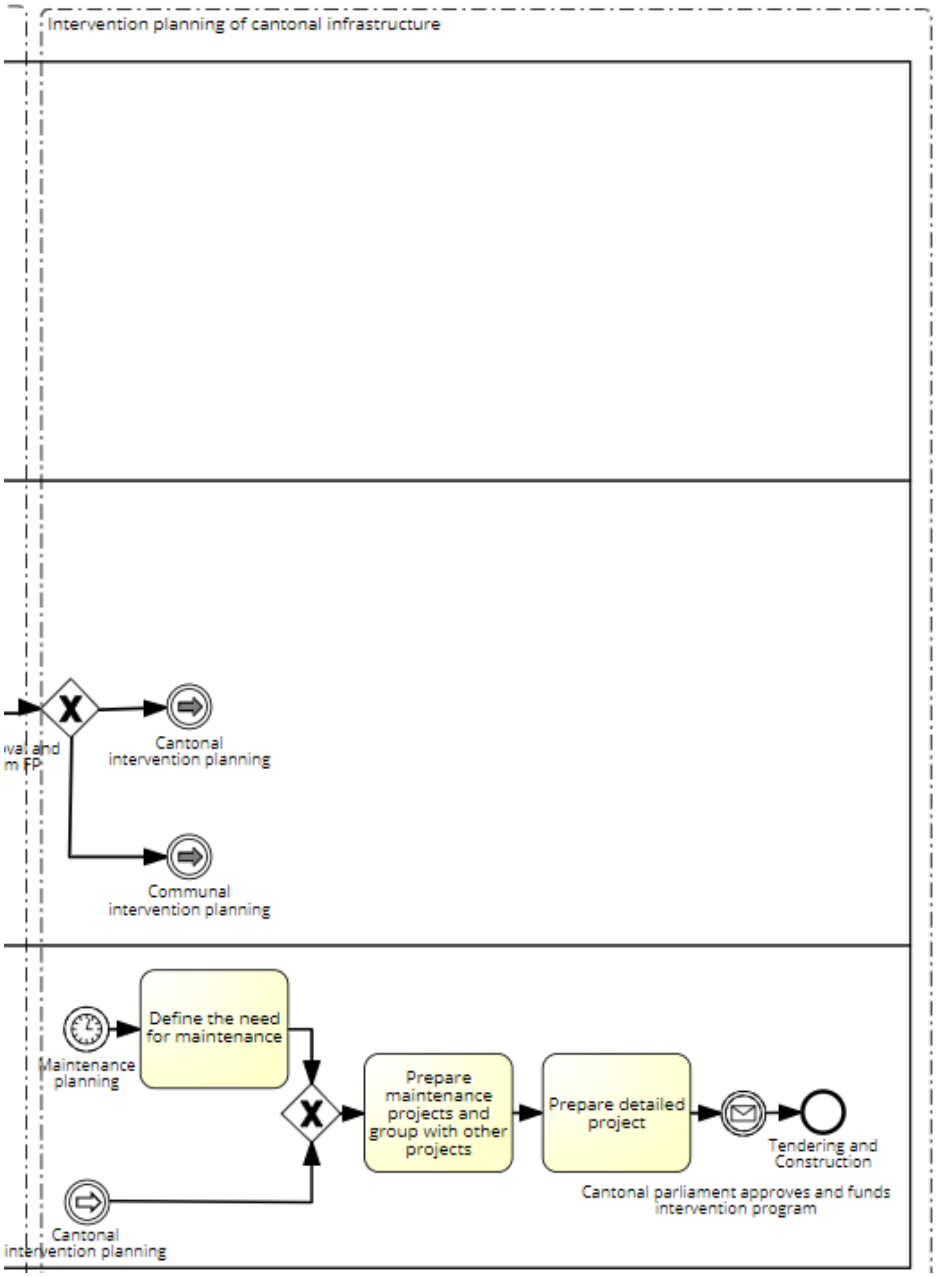

Figure 13: Generalised intervention planning tasks for cantonal infrastructure

4 Challenges and opportunities

4.1 Connecting the process attributes with its efficiency and effectiveness

At the end of the planning process, a decision is made to either intervene (i.e., build or modify) or not to intervene. Carrying out the planning process is the prerequisite to any such a decision. The tasks within the Swiss road and rail infrastructure planning process and its governance structures are defined by policymakers in the Federal Council, Parliament and Council of States. Policymakers strive to define these tasks in such a way so that the infrastructure planning processes are effective in accommodating societal needs and can be performed efficiently. The allocation of financial resources to the specific projects at the end of the planning process is not only based on technical 'performance' of the projects, but also based on political processes related to the financial allocation as well as the stakeholder consensus built around the project (Pagano et al., 2004; Velde et al., 2013). To make that decision is a binding commitment, and sometimes decision-makers defer or refrain from decision.

It is in society's interest that the process to create and modify infrastructure is both efficient and effective, i.e., transport infrastructure is continually modified at the right time with the right level of involvement of stakeholders. The refrain to decide to intervene or proceed with the project at any time postpones the decision, enabling further unforeseen changes to factors impacting societal needs. The inability to decide for a project at the end of a planning process can be, for example due to lack of consensus in society, and ultimately postpones the decision to intervene to a later date, once certain tasks have been completed or there is a more favourable decision-making environment. For example, regardless of how methodical and meticulous the planning outcome has been planned, the expectation that the planning outcome will not accommodate societal needs can lead to further postponement of the intervention. Consequently, one may experience either (i) a further deviation of the societal needs expected at time of decision compared to the expected societal needs at the time of planning, (ii) additional costs or disbenefits related to the postponement of a decision leading to a project being realised later than stakeholders had anticipated or (iii) both.

Since decisions are not solely based on performance, it is valuable to explain what other factors play a role in the process. An understanding of this is necessary to make reasonable improvement proposals in favor of the efficiency of infrastructure planning. The relationship between the factors facilitating decision-making to allocating funds are visually summarised in the causal loop diagram in Figure 14 with an arrow showing a causal relationship from the originating factor to the destining factor. The factors and their causes are then discussed one-by-one as follows with references to the numbering in Figure 14. This is a way to map out the root causes of a decision being made or not being made.

(1) When funds are to be allocated to achieve a planning outcome through an explicit decision, denoted with a diamond (labelled 1) in Figure 14, the decision is made only if following three conditions are fulfilled: the planning outcome is technically ready for the next step in the process (labelled 3 in Figure 14), the planning outcome will be prioritized over other projects (labelled 2 in Figure 14) and there is consensus that the planning outcome will adequately accommodate societal needs (i.e., the three factors denoted with a box in Figure 14(labelled 4-6)). One can imagine that in the context of the A15, such a decision is made when the project is allocated funding in the Expansion step of the Strategic development program (Schweizerische Bundesrat, 2018a, 2018b).

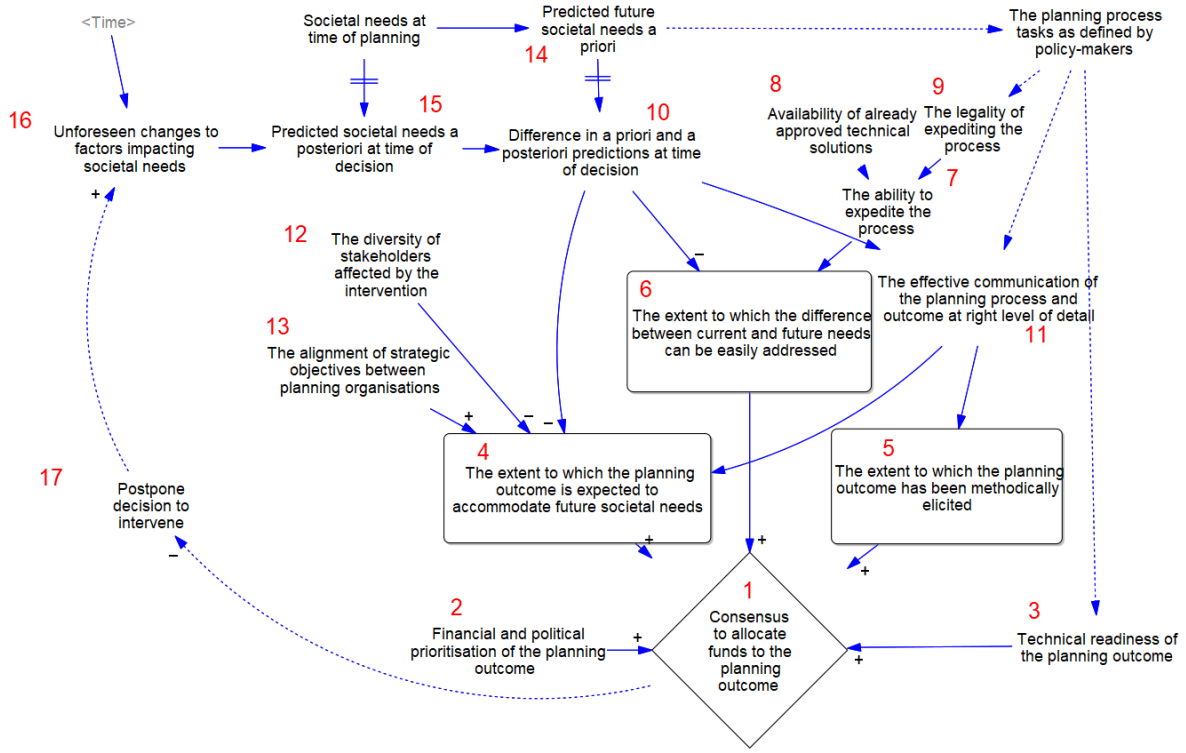

Figure 14: Causal loop diagram explaining the role of the planning process in facilitating a decision to intervene

(2) The willingness and ability to prioritise the planned outcome over other projects is related to the fact that financial resources are scarce and the political allocation of funds to projects requires a majority vote. In the case of the A15, the decision-makers must be able and willing to build a majority vote around including the highway on the strategic development program. This is based on, for example, the political prioritization to build the A15 instead of allocating scarce financial resources to other regions. In 1970, it was decided to build the A15 in phases to be able to more evenly prioritise other regions.

(3) By "technically ready", it is meant that the project would fulfil the technical specifications for the next phase in the planning process. Infrastructure planners work towards advancing the planning projects that will lead to societal benefits, generally through well established organizational processes, e.g., the Federal Road Offices project guidelines (ASTRA, 2014). By doing this, the projects will be technically ready for implementation. The current project for the A15 is not yet technically ready as it has not been elaborated to a General Project (ASTRA, 2023). In 1989, it was technically ready fulfilling the requirements at the time, however, after the Rothenturm initiative, providing constitutional protection of wetlands, the infrastructure project was no longer compliant with the regulations and requirements of the planning process (Eidgenossenschaft, 2024).

The consensus related to the planning outcome being able to facilitate accommodating societal needs depends on the following three factors:

(4) *"The extent to which the planning outcome is expected to accommodate future societal needs*" is related to the effectiveness of the planning outcome. Are the decision-makers convinced that the planning outcome in questions addresses future needs? In its current constellation, the railway network is being expanded, through the double track between Uster and Aathal, to enable improved transit service in the region. This is done before the highway is constructed, in alignment with the integrated mobility objectives of the Canton Zürich (Kanton Zürich, 2018).

(5) "*The extent to which the planning outcome has been methodically elicited*" is important to safeguard consensus. Any sentiment of oversight or negligence during the process can cast shade on the process and create resistance to a decision being made, leading to its postponement. In the case of the A15, the municipalities of Gossau, Hinwil and Wetzikon believe that the structural plan variant is inadequate and that a tunnel variant will better accommodate societal needs. In fact, they claim that this variant has not been studied before and cannot be left out (ASTRA, 2023). This depends on the planning process being performed according to law, regulation and norms and that the planning process and results are appropriately communicated at the right level of detail to those affected by the infrastructure (see (11) below).

(6) "T*he extent to which the difference between predicted and current needs can be easily addressed"* is important. For example, if a problem is identified that can be solved with a very minor adjustment, requiring no permit and no costs – then it is obvious that it is easy to build consensus about the planning outcome in comparison to something requiring a long planning time and will cost a large amount of public resources and affect stakeholders in various ways. To positively influence the easiness of addressing the difference between predicted and current needs, one may facilitate the (7) ability to expedite the process which is contingent on two things: First, (8) available technical solutions ready for implementation, for example through the anticipated adaptiveness in infrastructure design of already built infrastructure (Neufville & Scholtes, 2011) or the anticipated early land acquisition for not yet built infrastructure. Second, whichever measures are used, the infrastructure planning organisations must have (9) a legal mandate to implement them, e.g., a legally anchored process to reactivate existing rail tracks (ARL, 2024).

(6) also depends on (10), the difference in predicted and current needs at the time of decision. This difference occurs when planners make assumptions about the future that do not materialise. If there is a large difference in the predicted and current needs at the time of decision, there is a larger gap to fill with the planning outcome or other readily available solutions, e.g., if the A15 were planned to have a peak hour capacity of 4000 vehicles per hour, but increased population growth has changed those estimates to require 6000 vehicles per hour.

(11) The effective communication by planners to all other stakeholders of both the planning process and outcome at the right level of detail at the right time is crucial. For example, not studying the planning outcome's impact on societal benefits in enough detail prior to decision to construct will leave stakeholders with the question whether it was the right decision as the analysis did not study the impact in sufficient detail to ensure the effectiveness of the planning outcome. Similarly, if studying the planning outcome impact on societal benefits in too much detail in the early planning stages, this will raise questions regarding the level of certainty the planner is presuming for a highly uncertain future. The importance of communication of the trade-off of societal needs has been addressed in the field of intervention planning, (e.g., (Adey et al., 2019)). Hypothetically, as a simplified example, if the A15 project would have to be adapted to have three lanes instead of two, the cost of not having three lanes must be communicated at the same time as the increased cost of the project to put the change into perspective.

(4) "the extent to which the planning outcome is expected to accommodate future societal needs" not only depends on the aforementioned (10) "difference in predicted and current needs at time of decision" and (11) "the effective communication of the planning process and planning outcome at the right level of detail", but is also impacted by two more factors: First, (12) the diversity in stakeholders affected by a planning decision, for example, a planned project on land owned by the federal state is comparatively easier to build consensus for than planning on land owned by multiple private landowners. The more stakeholders are affected by the decision, the larger the difference in needs that must be reconciled. This is particularly related to transport infrastructure. Second, (13) the alignment of strategic objectives between involved planning organisations also affects the broadness of the views that must be reconciled during the process. The large diversity of interests

can also become apparent through any misalignment that there may persist in the strategic objectives of different planning organisations, e.g., between FEDRO, FOT and/or the Canton. One fictive example could be that, FEDRO and FOT would like to widen highways and add rail lines on unbuilt land, but the Canton has so far planned to continue to use this land for agricultural purposes.

The difference in predicted and current needs (10) can, and will, be reassessed at the time of decision. If difference is larger than anticipated, the intervention project may not be the right project to best accommodate societal needs. Similarly, if the difference is smaller than anticipated, it may be that the intervention project may be overdesigned and turn out to be less cost-effective. (14) At the time of decision-making, time will have passed since the planning took place and decision-makers have more information than planners had had in the early stage of their planning once they made a prediction (15), e.g., when originally planning the A15 between Uster and Betzholz, the importance of the wetlands was underestimated. In fact, this is an example of (16), "unforeseen changes to factors impacting societal needs". In the absence of planning considering uncertainty, there is a higher likelihood of unforeseen changes impacting societal needs related to the planning decisions. Further contributing to unforeseen changes is a) more time passing in b) the absence of a decision being made.

This section reports on the challenges related to the process and opportunities identified to address them. Based on the causal loop diagram that is a basis for a connection between the process attributes and its effectiveness and efficiency, one finds possible reasons that the process is perhaps not as effective or efficient as it could be. Potential opportunities are identified to address the identified challenges. Each opportunity is argued to address a component of the causal loop diagram related to the consensus-building of infrastructure planning shown in Figure 14 and consequently improve the effectiveness and efficiency of the infrastructure planning process. These challenges, which may overlap, and opportunities to address them are summarized in the following sub-sections. Furthermore, the challenges and opportunities are visually summarised in Figure 15 and summarised more elaborately in the appendix section 7.7.

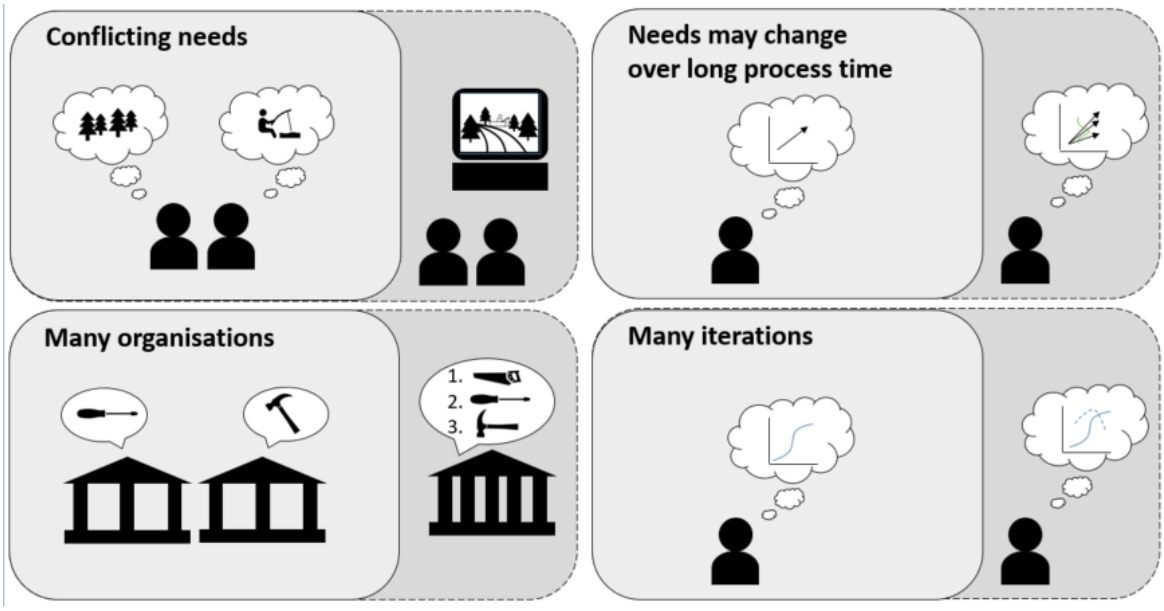

Figure 15: Visual summary of the challenges and opportunities related to the infrastructure planning process

4.2 Challenge 1: Society has conflicting needs

Challenge

Society is composed of many different stakeholders. These stakeholders have diverse, sometimes conflicting needs. Some stakeholders may have needs that have to be traded off with other stakeholder needs. To adequately address the conflicting needs and find the necessary trade-offs between all the different stakeholder needs in society, it is important to plan at the right level of detail at the right time in the planning process and communicate it effectively. This will impact the extent to which the planning outcome is expected to accommodate future societal needs and facilitate a further discussion of how the solution can be improved to better accommodate future societal needs. At any point in the planning process, the task will be performed dependent on the answer to the following questions:

i. What is the expected accuracy of the planning outcome?, e.g., are benefits to be estimated with an error margin of 10% or 50%?
ii. What are the resources available?, e.g., the man-hours or budget available for solving the task,
iii. What is the amount of iterative deliberations required?, e.g., how many variants and how elaborate should they be when presented in any upcoming deliberations,
iv. What are the planning support tools available?, e.g., do the tools available provide analysis in the required level of detail

Currently, in the early stages of the planning process for highway infrastructure, a preliminary appraisal tool, based on cost-benefit analysis methods is used using the results of a calibrated transport model, a relatively high level of detail. For rail infrastructure, regional master plans are set up to qualitatively assess the spatially explicit impacts from the planning of infrastructure, a relatively low level of detail. A decision-support tool that can assist in evaluating qualitative regional master plans, providing an assessment of the impact of wide range of potential infrastructure developments across an ensemble of future scenarios can be beneficial.

Opportunity

A network-benefit appraising framework to compute different variants under many future scenarios to a suitable level-of-detail could be a useful tool to better estimate network-wide benefits of projects across all infrastructure types under uncertainty. For example, a generative predicting algorithm for different types of infrastructure development can provide infrastructure planners with a quick, yet transparent overview of the possibilities with a first estimate showing how planners should spend their time and allocate scarce resources.

This will enable planners to effectively address different, sometimes competing societal needs, offering the right-level-of-detail at the right time. This balance is important since a finer level of detail in planning requires a larger number of assumptions regarding the future. At the same time, when planning transport infrastructure, it is necessary to consider system-wide impacts. Nevertheless, modelling such system-wide impacts in a simple and parsimonious way is a challenging task. Such a tool can provide support to planner expert opinions and intuitions and support them in making objectively the best decisions. Furthermore, this would improve the effective communication of the planning process and outcome at the right level of detail.

An example of such a tool is a prototype that was developed for investigating the future development of the infrastructure corridor from Dübendorf-Hinwil.One possible concrete output of such a tool could be to indicate that for many scenarios, large societal benefits can be achieved if infrastructure, e.g., highways, is extended to a certain area, e.g., the north of Lake Pfäffikon providing people with more access at a reasonable cost of infrastructure investment (A. Elvarsson et al., 2024). As follows, regional planners could explore if this were a wise development and a wise investment and consequently study it further. A prototype for such a regional infrastructure planning-support tool is in development and an output for one scenario of population

development is shown in Figure 19 in appendix section 7.6. Due to its prototypical nature, the results are to be read with a reasonable amount of doubt.

4.3 Challenge 2: Many organisations are involved

Challenge

The creation and modification of transport infrastructure requires the involvement of different levels of road authorities, rail authorities, spatial development organisations, politicians, customer representation organisations, environmental protection organisations, etc. Some of these organisations may be on a federal level, others on cantonal level and some on regional level, all with different amount of resources allocated to them. They all have their respective planning objectives, interests and concerns that need to be reconciled in the process.

It can be identified that in the Swiss context, different federal offices are responsible for the different types of infrastructure, e.g., FEDRO for national road, FOT for national rail. In planning infrastructure, these offices rely on coordination with other federal offices, cantons and deliberations with the public. This ensures benefits of specialisation within each office, albeit reinforces a separation of responsibilities. At least two symptoms of this diffuse allocation of responsibility can be identified.

First, as each office will generate projects to better accommodate societal needs, the office focused on one type of infrastructure may be incognizant of the impacts that improvements in infrastructure for their type of infrastructure have on other types of infrastructure. Since infrastructure developments are then to be prioritised by cantons through their structural plan, this places the cantons into the position to delay certain developments to better address their own more local interests, or interests differing from those addressed by the federal office. Any delay resulting from this would be contrary to the expectation of the stakeholders. This means that the canton, located downstream in the process, is perceived to slow down an otherwise streamlined process. A canton may have their own strategic objectives, for example those described in the example in appendix section 7.2.3 where the objective was to strengthen the rail corridor between Zurich and Rapperswil through Dübendorf, Uster and Wetzikon and not necessarily other modes. One may imagine that, for example, the construction of a highway extending through the corridor may act as counter-productive, all else unchanged. While the sectoral plans should have a prioritising and coordinating role, it was understood in interviews with federal offices that this is not a well established process in practice. Furthermore, the sectoral plan process should both include cantonal structural plan projects and be the basis upon which cantonal structural plan projects are assessed, creating a feedback loop. The same feedback loop has been reported to exist for federal projects. The sectoral plan would ideally include the larger projects of larger importance to set a preliminary strategic direction (d. “Vororientierung“). However, it may be counter-productive for it to include all projects from the Strategic Development Program (STEP) and cantonal structural plans, which is downstream from the sectoral plan in the process. In this case it may create unnecessary feedback loops within the process affecting its efficiency.

Second, and related to the first, is that strategic development across different infrastructure types is not synchronised in time. The strategic development of the Swiss infrastructure networks culminates in the preparation of the STEP. Projects already accepted as General Projects for roads or Concept Studies for rail may be entered onto the respective STEP. In the “Expansion step” which is the category of highest priority to be built in the next five years, the road projects have already been prepared to an advanced level of detail. Rail projects on the other hand generally become a part of the STEP in the study phase, with the “expansion step” generally being set out for the next 15 years. A good example of how development has been

synchronised by the canton is the expansion case of the Uster-Aathal rail track, described in Appendix section 7.2.2. In this case, it has been set up aligned with the expansion of the A15 highway, described in Appendix section 7.2.1 to meet strategic objectives. At point of writing, the rail track expansion to two-tracks instead of one between Uster-Hinwil is expected by 2035 and the highway extension from Uster-Hinwil in planning horizon 2040.

Another summarising, yet fictional example, is if FEDRO plans to widen a highway between two large cities, but the land required to do so is used for agriculture, and thus does not fit within the canton‘s spatial order concept. This requires negotiations and then the execution of the necessary planning steps to align the strategic objectives between the different planning organisations.

Opportunity

To address this challenge, it seems appropriate to coordinate the infrastructure developments at an early stage, align the strategic objectives of all planning organisations and feed the federal offices and cantonal offices with information as to where infrastructure developments would be useful to better accommodate changing societal needs. Such coordination would take into consideration the planning process timeline for the different type of infrastructure and the impacts between the different infrastructure systems. The current structural plan process can be better anchored in using an integrated mobility planning approach, as has been taken up within many cantons, (e.g., Canton Zürich’s Office for Mobility). This would potentially better align the strategic objectives between the planning organisations and define the coordination needs between them (see section 7.2.3).

The coordination of integrated mobility needs is demanding. While many of the aspects that require coordination may come through coordination and deliberation built in the process followed by FOT and FEDRO, the planning process may benefit in terms of effectiveness and efficiency by mandating an organisation with the identification and facilitation of the developments that most benefit society as a whole.

These suggestions may be seen as opportunities to address the challenges related to the sectoral planning. Alternatively, it would seem logical to propose either a Federal office for Mobility or a specialised section inside the Federal Office for spatial development to be mandated with these responsibilities and ensure that the many organisations involved in the infrastructure planning process are planning with aligned interests and coordinated time schedules to ensure an effective and efficient planning process.

4.4 Challenge 3: The long duration of the planning process means needs and individuals change during the process

Challenge

As the process takes years, if not decades, the needs of society and the individuals in the organisations change, complicating the tasks of ensuring proposed changes to infrastructure match the societal needs. There are two symptoms of this challenge:

First, during the planning process, stakeholders are mindful that the needs may change after the infrastructure is constructed. Therefore, if stakeholders believe that needs may change, they may opt to refrain from making any decision that cannot be easily adapted after construction.

Second, with that in mind that the needs may change after the infrastructure is constructed, the stakeholders are cautious in making any definitive decisions during the planning process as assumptions made upstream in the planning process must be revisited if they were incorrect or deemed obsolete at a later stage during the

planning process. This in turn can further slow down the planning process as it will enforce the impact on changing needs.

In both cases, the stakeholder concerns would be justified. Making decisions under assumed certainty will with certainty lead to the incorrect outcome. This is because the future never turns out as assumed, ex ante. However, the inability to make decisions can be more costly.

Currently, the canton of Zurich sets long-term perspectives for the population and employment growth per district. Each district is provided a number, allocating the assumed growth in each district. E.g., if the region of Hinwil is assumed to expect 30% growth until 2050, it is then up to the region and communes, in collaboration with the Canton, to fit that growth within the region. In turn, there remains the possibility that overestimated population growth will lead to inflated requirements for growth in infrastructure, resulting in a robust solution. This would mean, for example, the users will not experience the same amount of delays because of an overestimated demand for more roads. It may be, however, that this was a suboptimal allocation of public funds. In other words, the decision was less robust considering the needs of the infrastructure owner.

Opportunity

Current state-of-the-art decision-support tools rely on the adaptive planning paradigm which maximises the opportunities of a manager and minimises the impacts of threats. Adaptiveness (also used here synonymously with flexibility) is the characteristic or quality of being able to adapt to new conditions. Adaptive planning is a long-term planning paradigm addressing the significant uncertainties with which decision makers are confronted. When the planner subjects the planned future to many possible future scenarios, planners cannot devise a single optimal fixed set of actions for the long term, but must remain adaptive, or flexible to change within their strategy to fit the planned entity, e.g., infrastructure, to the new setting. This would require a decision-maker to make a decision under uncertainty, instead of a decision under assumed certainty. The implementation of adaptive planning would make both the process of planning and the planned outcome more robust to uncertain changes in future using transparent and evidence-based decision-making. Adaptive planning tools have the potential to support decision makers in reducing the difference in predicted and current needs at the time of decision, better facilitating the availability of already approved technical solutions and improving the extent to which the planning outcome will be perceived to accommodate future societal needs (see section 7.2.2).

4.5 Challenge 4: The iterative nature of the planning process

Challenge

Proposing and selecting interventions that can accommodate changing societal needs requires that many organisations and many, if not all, of the members of a diverse group of stakeholders ideally reach an agreement. This requires extensive deliberation and engagement with all stakeholders leading to proposals being presented, reworked, and then presented again and again reworked until agreement is obtained.

This amount of iterative deliberations also leads to prolonged process duration. The long planning process duration leads to some benefits as the project's effectiveness can improve with more discussions and deliberations. However, the longer the planning process takes, the more stakeholders' costs may be experienced, e.g., the growth in car users leading to the potential increase in delay, while no agreement can be reached by decision-makers. These costs incurred during the planning process are not quantified for decision-related appraisals, and consequently little incentive remains to reduce any planning time used less efficiently, except for the planner's sheer will to work in favor of the greater good.

Opportunity

Policymakers who are mindful of the time required for the planning process and the added benefit of the added duration are well equipped to define the planning process in such a way that the infrastructure is planned to best accommodate societal needs. A framework to quantify the added benefit of the longer duration of the planning process and trade it off with the added benefit of shorter duration of the planning process can be useful to support the policymaker responsible with defining the planning process. This could allow for the costs and benefits experienced by stakeholders over the time prior to construction to be considered, e.g., such a framework can enable decision-makers to make statements such as "the shortening of a planning process by two years could provide societal benefits of at least 2 million CHF." A similar, fictive but still realistic, case study was implemented based on the hypothetical reduced planning duration of the A15 in the infrastructure corridor Dübendorf-Hinwil (A. B. Elvarsson et al., 2023). While the time reduction of planning processes is generally supported in Europe and elsewhere, the costs and benefits related to the duration of planning processes are currently not explicitly considered in the shaping of planning processes, anywhere in the world, to our knowledge. Its development and inclusion would address the ability to expedite the process in a transparent and evidence-based manner (see section 7.2.1).

5 Conclusions

In this report, a mapping of the high level regional road and rail infrastructure planning process in Switzerland is reported. The stakeholders involved in the process have been interviewed to map the actual process accurately and in its entirety. The mapped process provides a clear overview of what planning organisation is responsible for each task with clear process tasks for each type of infrastructure. Societies and the responsible planning organisations strive for their processes to be shaped in such a way that it effectively and efficiently supports planners in asking and communicating the answers of the three key questions related to infrastructure planning: (1) *How are societal needs likely to change in the future*?, (2) *How well could the current infrastructure accommodate societal needs in the future if no changes to infrastructure are made*?, (3) *If it is likely that creation or modifications to infrastructure will be required, can the best intervention be selected in an effective and efficient manner*?

The report analyses the reasons for why societies may experience deferrals in decision-making related to the planning of infrastructure, which results in four challenges of the planning process being identified. For each of them, potential opportunities to address the challenges have been listed and discussed. These opportunities are provided as ideas as to how the planning process could be improved to make the planning process more effective and efficient.

If all proposed suggestions were to be accepted for inclusion in the road and rail infrastructure planning process, then (1) a national organisation, e.g., a specialised section within the Federal Office for Spatial Development or a new Federal Office, would be responsible for identifying ways that changing societal needs can be better accommodated in an integrated way. This would be done in alignment with strategic objectives of the stakeholders involved in shaping the planning outcomes. (2) Such an organisation would be well equipped with decision-support tools that would better estimate network-wide benefits of projects across all infrastructure types and consider multiple future scenarios. (3) All decision-support tools downstream of this initial planning task would also consider future uncertainty not only to make planning outcomes more robust to any future that could unfold, but also to facilitate transparent decision-making based on the best possible information. (4) Finally, decision-makers and those responsible with shaping planning processes would use suitable frameworks to support them in critically reflecting on the added value of the planning tasks that require considerable time and provide evidence for shaping the planning process in such a way that it meets

planning objectives effectively and efficiently, e.g., accelerating planning processes and reducing their duration, where it is beneficial to do so.

The proposed opportunities capitalise on using the right data, the right analytics, and the right visualisations at the right times in the process to help organisations reach agreement quicker than they otherwise would have and provide means to evaluate the value of reaching agreement quicker. This, in turn, may reduce the number of iterations required in the process. The opportunities identified seems to be a promising set of steps to make the planning process more effective and more efficient than otherwise. Each opportunity is argued to address a component of the causal loop diagram related to connecting the planning process to its effectieveness and efficiency. Acting on those opportunities is therefore argued to consequently improve the effectiveness and efficiency of the infrastructure planning process.

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7 Appendix

7.1 Documents and Interviews

The infrastructure planning process for the canton of Zürich was modelled using information gathered through public documents and interviews with relevant stakeholders. The following Table 56 lists multiple documents used to acquire the necessary information to describe the process. The review was more extensive, the table is not exhaustive and the documents are not listed in any particular order.

Table 56: List of documents used in summarising the process

Original document title	Author	Description	Citation
Erarbeitung von generellen Projekten der Nationalastrassen	FEDRO	A guideline for preparing General Projects	(ASTRA, 2014)
Botschaft zum Ausbauschritt 2035 des strategischen Entwicklungsprogramms Eisenbahninfrastruktur	FC	A report on the making of the strategic development program for rail for the expansion step of 2035 and beyond	(Schweizerische Bundesrat, 2018a)
Botschaft zum Zahlungsrahmen Nationalstrassen 2020 – 2023, zum Ausbauschritt 2019 für die Nationalstrassen und zum Verpflichtungskredit	FC	A report on the making of the strategic development program for road for the expansion step of 2019 and the budget frame for 2020-2023	(Schweizerische Bundesrat, 2018b)
Netznutzungskonzept zum Ausbauschritt 2025 der Eisenbahninfrastruktur	FOT	Network use concept for the expansion step of 2025 for rail infrastructure	(Bundesamt für Verkehr (BAV), 2017)
Leitfaden für die Kantonale Richtplanung	ARE	A guideline on cantonal structural planning	(Bundesamt für Raumentwicklung (ARE), 1997)
Richtlinien Programm Agglomerationsverkehr (RPAV)	ARE	A guideline on Agglomeration programs	(Bundesamt für Raumentwicklung (ARE), 2020)
Kantonaler Richtplan	Canton Zürich	The cantonal structural plan for Canton Zürich	(Kanton Zürich, 2022b)
Gesamtverkehrskonzept	Canton Zürich	The cantonal integrated transport concept	(Kanton Zürich, 2018)
«Netzhierarchien, Strassenfunktionen und Geschwindigkeiten – Erfahrungen und Herausforderungen »	Cantonal office for mobility	Slide deck from a presentation made by head of Office for mobility on the Cantonal infrastructure projecting process	(Traber, 2015)
Infrastrukturkosten Bahn: Leitfaden zur Ermittlung der Kosten von Ausbauvorhaben	FOT	Guidelines on the estimating of costs for each project phase in rail infrastructure	(Bundesamt für Verkehr (BAV), 2016)

Importantly, interviews with stakeholders helped provide added context to the information acquired. There were three sets of interviews. The first set of semi-structured interviews was in December 2022 and January 2023 with the canton of Zürich and City of Dübendorf and was used to build an initial impression of the infrastructure planning process. The Federal Office of Transport was a key contributor in the early stages, but was less formal. The second set was held with FEDRO in a more formal setting to ask more detailed questions regarding specific tasks and interconnectedness of stakeholders between July and August 2023. A final validation round was held in April and May 2024, where partners were asked to verify the correctness of the process. The partners were asked to be critical, yet lenient in terms of specificity, as the language of this report is chosen to be general enough for a more general reader and comparability across different stakeholders.

An overview of the interviewed stakeholders is shown in Table 57. The German description of function is added alongside the English description of function for additional clarity. Each interviewee was chosen specifically for their function in the infrastructure planning process and their knowledge of the associated tasks. The selection process of interviewees was made to ensure a holistic overview of the planning process for the aspired level of detail. During the initial set of interviews, questions were asked regarding their understanding of the process, including i) the tasks required and ii) the information and interaction required from other stakeholders within the process. Later, after the process was constructed, the interviewees were asked to estimate the time frames for each task.

Table 57: An overview of the stakeholders involved in interviews for information collection

Stakeholder		**Relevant department**	**Interviewee function (English)**	**Interviewee function (German)**	**Interviewee name**
Federal Office for Spatial Development	ARE	Bundesplanungen	Deputy head of Federal planning	Stellvertretender Leiter Sektion Bundesplanungen	Martin Tschopp
		Agglomerationsverkehr	Deputy head of Agglomeration mobility	Stellvertretende Leiterin Sektion Agglomerationsverkehr	Regina Witter
Federal Office of Transport	FOT	Planung	Project Manager in Planning	Projektleiter Angebotsplanung	Marcel Burkhalter
Federal Roads Office	FEDRO	Netzplanung	Head of network planning	Bereichsleiter Netzplanung	Jean-Luc Poffet
Canton	Zürich	Amt für Raum-entwicklung (C-ARE)	Director of office for spatial planning	Amtschef für Raumentwicklung	Wilhelm Natrup
		Amt für Mobilität (AFM)	Head of Integrated Mobility	Bereichsleiter Gesamtmobilität	Wilfried Anreiter
		Tiefbauamt (TBA)	Project developer	Projektentwickler	Francesco Paganini
Commune	Dübendorf	Verkehrs-planung	Head of City planning	Leiter Stadtplanung	Reto Lorenzi
	Wetzikon	Verkehrs-planung	Head of Civil Engineering	Bereichsleiter Tiefbau	Dario Erismann

An overview of when the interviewees were interviewed during the creation of the process is shown in Table 58.

Table 58: Interviewee per interview round

	Round 1	Round 2	Round 3
ARE			X
FOT	X		X
FEDRO		X	X
Canton – C-ARE	X		*
Canton – AFM		X	X
Canton – TBA			X
Dübendorf	X		*
Wetzikon		X	X

The interviews in the first round were informal semi-structured interviews. The guiding questions used differed for each stakeholder depending on their function within the process. There was no standardised way of asking the questions as it depended on the natural flow of conversation during the interview. The focus on the question related to the description of the process from their point of view, how they viewed other stakeholder inputs and description of how the coordination and collaboration between stakeholders took place. Examples of these question lists are found in Table 59.

Table 59: Example question lists for semi-structured interviews

Cantonal Office for Spatial Development	Questions/Topics to be covered during the interview
Introduction	• What is the motivation for planning infrastructure? What are the main points? How binding is it? • Why is there a need for the planning of infrastructure? How does the Canton's process meet that need? • What are hindrances to meeting that need? • How does the Canton see its responsibility in contrast to those of Federal state, Regions and Communes?
Planning in a complex system	• How do you coordinate the needs of the canton and communes? And those of the federal state? • To what extent do you consider transit and road together for your strategic decisions?
Designing the planning process	• How do you identify an inadequate performance of your infrastructure? • If you identify stakeholder needs that are not being accommodated and the ideal solution is not within the cantonal structural plan. How do you proceed? • What are the advantages and disadvantages to your approach? What are the criteria upon which you classify a good planning process?
Responsiveness	• How important is an effective solution? • How important is a quickly implemented solution? • How would you trade these off?
Assessing infrastructure	• For a planning decision, how do you decide which is the best alternative given uncertainty? • Do you set different requirements for cantonal infrastructure (e.g., roads) in rural and in urban environment?
Federal Roads Office	**Questions/Topics to be covered during the interview**
Introduction	• what does the strategic planning process for the national road network look like? What challenges do you see? • how actively is FEDRO planning changes to the existing network decision? How was the need for the new NEB in 2020 determined? • what criteria lays the basis for planners to identify that a network development, modification or adaptation is required? ○ Which stakeholder needs does FEDRO consider most important? ○ What role does the canton play in deciding that there is a need for measures?
Definition of variants	• how do you identify variants? Is this done by FEDRO or externally? • what level of detail do the projects have for parliamentary approval?
Hindrances to planning	• what obstacles stand in your way of implementing the planned network as quickly as possible today? ○ To what extent does the planning process take longer if an amendment to the structure plan is required?

	• uncertainty and long-term prospects. Do you apply the scenarios of the sectoral plan, or also others? Do you also evaluate the network extensions with different scenarios?
Evaluation	• how do you evaluate the network extensions? Who carries out the evaluation, if not FEDRO?
Communes	Questions/Topics to be covered during the interview
Need for change	• how do you determine the need for infrastructure measures (infrastructure expansion/adaptation/deconstruction) for transportation infrastructure? Is your commune also responsible for this needs assessment for cantonal and national roads that run through or touch the city?
Definition of variants	• once the need for the measure has been identified, how is the procedure followed to ensure that users or other stakeholders are satisfied?
Evaluation	• how are the plans evaluated and categorized? Who is ultimately responsible for the decision on the measure for regional infrastructure measures?

7.2 Examples referred to in text

7.2.1 National infrastructure planning: A15 between Brüttisellen and Reichenburg

The A15 is a national road connecting the A1 at junction Brüttisellen and the A3 at junction Reichenburg. In between those two junctions the highway provides access to the communes of Dübendorf, Uster, Hinwil and Rapperswil among others. It is a dual carriageway, four-lane highway from Brüttisellen to the Uster East junction, a single carriageway two-lane national road to Betzholz (named H340) and again a dual carriageway, four-lane highway to Reichenburg (see Figure 16). The highway was originally planned in 1965. The first, second, and third sections were completed in 1970, 1983 and 1989 (as labeled on Figure 16). The fourth section, which is between Uster East and Hinwil, could however not be completed, because the construction permit application was withdrawn in 1987. It was withdrawn following the passing by national referendum of the Moor Protection Initiative because the highway was to run through a wetland.

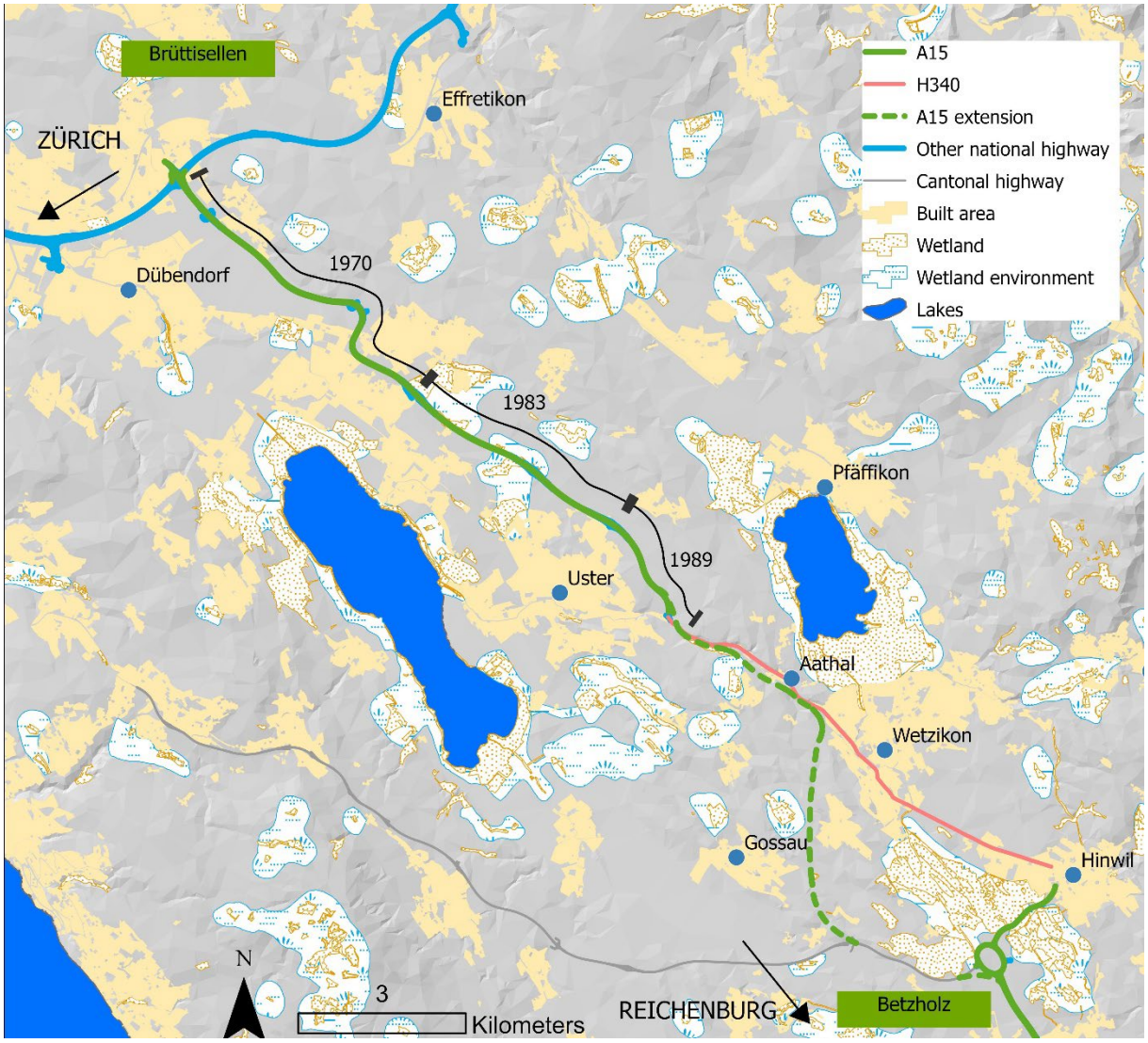


Figure 16: An overview of the development of the A15 highway

Currently, the H340 goes through Aathal, Wetzikon and Hinwil, leading heavy truck traffic through urban centers. This leads to large travel delays in the peak hour. Therefore, stakeholder needs could be better met through the construction of the A15 extension from Uster East to Betzholz and would be well aligned with the following strategic objectives set in the sectoral plan:

- Maintain functionality of the transport infrastructure for society and economy
- Improve the quality of the connections between agglomeration and urban centres
- Foster inwards spatial development and improve the quality of urban spaces
- Relieve environmental burdens and improve natural quality of life.

Many different variants were explored by the Canton already and this study lays the foundation for the variant in place in the cantonal structural plan, shown in Figure 16. One more variant is to be studied on request of neighbouring communes with a more direct tunnel solution. This line would be similar between Uster and Aathal, but then lay more north of the current line between Gossau and Wetzikon, then under the wetlands directly linking to Betzholz. A result of that Variant study is expected 2025 and an approval of the General Project is anticipated in 2027, with construction only commencing no earlier than 2038. The project is currently included in the STEP with a "realisation horizont" of 2040. Only with an approved general project can it be prioritised in the STEP to the next expansion step and allocated funds. Prior to being realised, the finished Execution Project must go through the Planning Approval Process. During this process, the project is put out on display to public. The public and affected communes and cantons will have the chance to express their comments on the project.

7.2.2 National/regional rail planning: Expansion of rail tracks between Uster and Aathal

The rail service in the corridor between Dübendorf and Hinwil connects people of the Glattal region to Zürich, the main regional hub. The corridor is connected to Zurich through the north via Wallisellen to Zürich-Oerlikon and through the East via tunnel through Stettbach to Zürich-Stadelhofen. The railway corridor is illustrated in Figure 17.

The provision of rail service to meet the growing demand in the region is currently hampered by rail network bottlenecks, i.e., the limited supply of infrastructure, specifically due to a 4 km long single-track segment between Uster and Aathal.

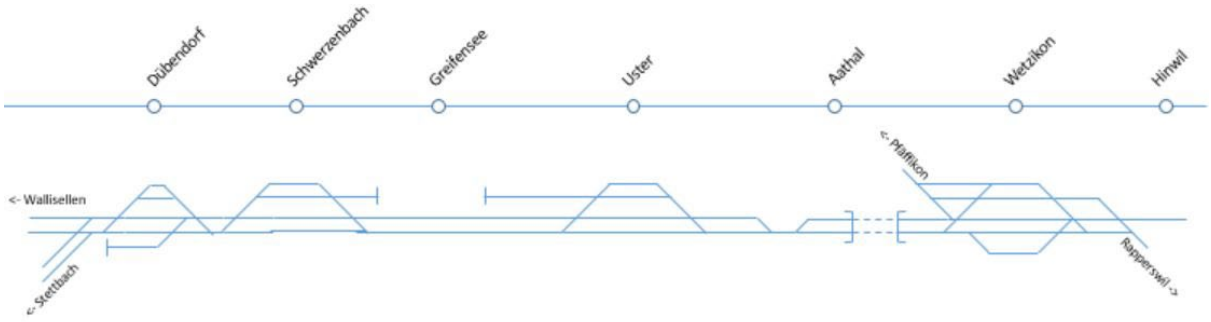


Figure 17: An illustration of the railway network between Dübendorf and Hinwil. Not to scale

The built infrastructure defines the capacity of the service, e.g., the number of trains able to use the rail corridor per hour. The railway service on the infrastructure is provided by the Federal Railway Company (SBB) and the Zurich Transportation Agency (ZVV). The FOT asks the canton to set up a service concept. The canton passes on that concept to SBB that defines infrastructure requirements. The capacity is defined by the service planned given the available infrastructure. The need for further infrastructure bases on the fact that only after the track expansion, an improved service can be provided (Schweizerische Bundesrat, 2018a; Stadtrat Uster, 2019).

The Uster-Aathal project is currently in the strategic development programme with the realisation horizon of 2035, but is not yet considered in the next expansion step and has therefore not been allocated funds. The construction of a second track on the 4 km long stretch between Uster and Aathal is currently estimated at 180 million CHF (Schweizerische Bundesrat, 2018a, 2018c).

7.2.3 Cantonal rail planning: Development of rail service, S5

The S5 was a peripheral train connecting Rapperswil to Zürich main station with an express connection from Zürich Stadelhofen to Uster and Wetzikon. It was first placed in service in 1990 with the introduction of the S-Bahn network. Today, after a few modifications to the timeplan, the S5 line extends from Zug to Pfäffikon SZ and thus connects four cantons, Zug, Zürich, St. Gallen and Schwyz. Since the S15 was put in operation in 2006, the S5 and S15 together serve Zürich-Uster-Wetzikon-Rapperswil corridor every 15 minutes. These lines thus served an area with about 300’000 residents from Zürich Stadelhofen to Rapperswil, which became the focus of a 2006-2011 research project (s5-stadt.ch). Today, the string of settlements from Dübendorf-Rapperswil includes about 160’000 residents, whereby 90’000 of these reside from Dübendorf-Uster and 70’000 after Uster to Rapperswil, with increasing growth expected by the Canton (Kanton Zürich, 2022a).

Identifying this potential, communal and cantonal planners in Canton Zürich have gradually been strengthening the accessibility between the City of Zurich and the Zurich Highlands, providing a larger choice set of travel alternatives for people in the extended agglomeration. The cantonal structural plan and the transit agency’s, ZVV’s, plans include an improvement of the service to the region, requiring the infrastructure development of a double track between Uster and Aathal, like discussed in section 7.2.2. That is an example of national infrastructure development and therefore requires coordination with the FOT and SBB. An instrument to facilitate such projects is the Agglomeration program, which is a result of intercommunal infrastructure planning, discussed in the following section 7.2.4. Furthermore, the canton has recently included the A15 in their cantonal structural plan allowing for improved road accessibility to the region.

7.2.4 Agglomeration program Zürich Highlands

The largest communes within the Zürich Highlands region are Uster (35'000) and Wetzikon (25'000) as well as Pfäffikon (ZH), Rüti (ZH), Gossau (ZH) and Hinwil. Agglomeration programs are created by regions, in close collaboration with the cantons. Regions are informal administrative entities and are generally collaborative organisations between neighboring communes. Based on an extensive analysis of the situation and a vision of the cantons and communes, regions put together a list of necessary interventions with the primary objective of collaborative coordination of transport and settlement planning in agglomerations for a sustainable settlement development across communal, cantonal and national borders. The agglomeration program is now in the 4th generation and already many projects have been finished with the financial support of the federal government.

7.3 Historical account for infrastructure development

7.3.1 Rail

The rail network is a result of a decentralised effort that was later centralised due to a lack in profitability. The first 24 km long rail line between Zürich and Baden connected Zürich to a new market in 1847 by initiative of Zürich's trading organisation. The original intention was to extend the line to Basel's Franco-German border, but this was not completed until later. Rail infrastructure was planned originally via the cantonal council's railway commission as mandated by the Law for Railway dated 1852.

The planning and construction of rail infrastructure was defined as task of the private industry. The cantons had the option of supporting projects financially and the federal state had the right to veto projects for reasons of military defense. This competition lead to swift growth in the rail network to over 300 km by 1856 and over 1300 km by 1866.

In 1862, the Federal President Stämpfli wrote a report expressing his concerns for the financial standing of four-fifths of the operating rail companies. An 1898 referendum voted in favour of a state-owned railway company. The nationalisation took place in phases, mainly between 1901-1903, after which a large effort was made in electrifying the track lines. Since then the Swiss Federal Railways, (abbrev. SBB) was changed to a limited company in 1999, with the Federal State owning 100% of the shares.

7.3.2 Road

7.3.2.1 General

The original federal bill on national roads was passed into law (d. Bundesgesetz über die Nationalstrassen) on March 8, 1960. At this time, the classification of national roads was simply a legal one and did not yet set any technical requirements. The federal state was, per law, expected to set the minimum requirements for the road, define the network, determine an intervention program and classify the roads. The cantons, on the other hand, were responsible for the construction and maintenance of these roads.

The technical requirements were set in the network definition, (d. Netzbeschluss) first defined on June 21, 1960. The technical details dependent on the classification of the roads into first, second or third class. The first class were to be designed similar to an „Autobahn" with separate lanes per direction, the second class was more like a „Landesstrasse" with non-separated lanes and the third class all other roads, also for non-motorised vehicles, that belonged to the national network. The technical requirements defined were the result of the findings of a planning commission.

Swiss national roads were constructed later than those in Germany or Italy, partly due to the main interest of cantons to build and maintain roads within their own entities and not necessarily across the entire country (Kammann, 1990). The national roads had the purpose of serving long-distance transit. Understandably, this was only peripheral to the canton's interests. While the Federal council had already shaped a draft of how a main road network may look like already in 1950, they had no way of realising this without the support of the cantons. The Federal Inspectorate of Ground Construction (d. Eidgenössische Oberbauinspektorat) had been founded in the 19th century and had the mandate to oversee the construction of riverways, motorways and bridges (Ruckli, 1960). One may have expected them to represent these inter-cantonal interests, but lacked the instruments to do so (Kammann, 1990).

7.3.2.2 Planning National roads before 1950

Prior to the 1950s, there had been different efforts to organise the long-distance automobile travel within Switzerland. In 1920, the Swiss VSS proposed a through-fare road network, whereby the first-mentioned

objective was the elimination of dust in urban environments (Nyffeler, 1929). In the late 20s, a political initiative was written out to set in law the necessity of the cantons to pay some of the ear-marked gasoline taxes to the federation, so the federal government could assume the construction and maintenance of these roads. This was rejected. Then in 1929, an organisation was formed with the name Swiss Auto-road Organisation (d. Schweizerische Autostrassen Verein (SAV)). Its chairperson, Fritz Steiner, had suggested a network, similar to the one from VSS, with optimal international connections through larger cities (Nyffeler, 1929).

In 1937, plans for a ‚road crossing' of constructing two national highways from Geneva to St. Gallen and Basel to Chiasso was discussed in the Council of States (d. Ständerat). While the arguments in favor did manifest themselves, the arguments against were considered more important at the time. Those arguments were:

- Negative impact of external traffic demand and defensive ability of our country
- Financial standing of the Swiss state
- The bill would include a centralisation of tasks, which should be tasks of the cantons.

In 1941, Federal Inspectorate of Ground Construction put in place a commission on the topic of studying the development of the Swiss main road network for the generation of jobs. This resulted in a map of the main road network to be developed in 1942.

This work, supported by a report by Robert Ruckli in 1945, lead to a collaborative effort between cantons and the federal state to decide on a construction program of developing the road network between 1950 and 1952. In the end of 1952, there was a general consensus among SAV experts, that new highways were cheaper in realisation than the development of existing structures.

7.3.2.3 The planning commission and planning process

On May 26, 1954, a group of experts requested to form a Study commission for the development of Main roads across Switzerland. The main reasons were listed as the growing traffic demand and lack of coordination among the cantons (Kammann, 1990). The commission first met on November 16 in the same year and was given the official name „Commission for the Planning of the Main road network". This commission was tasked to answer the following questions:

- On which national connections drafted by the Federal council are highways and highway-like designs necessary?
- How should such road designs be placed in the landscape and how should they be connected the rest of the road network, particularly in urban environments?
- To what extent do the norms in place require enhancements or amendments?
- How should the construction program be executed, considering time and space?
- Where is the consideration of road tunnels possible in order to provide safe transportation from north to south and back?
- Is there a change in legislation necessary for the construction of such roads in Switzerland?
- How shall the new roads be financed?
- Must the Swiss road system be re-structured to answer the above-mentioned questions?

Originally, the commission planned to finish the task in just under a year. The final reports were submitted in 1958. The commission consisted of 33 members, split in thematic groups and local working groups, where technical decisions were made. All decisions were then agreed upon in plenum. There was general consensus in society that these constructions were necessary and the planning committee's work was expedited accordingly.

Half a year into the planning, in July 1955, the road network is set out to be 500-600 km long. Seven projects were drawn up in scale of 1:25‘000. A criteria list was set up to discuss and eliminate potential projects. The criteria groups were:

- Advantages and disadvantages for traffic
- Advantages and disadvantages for the accessed and through-passed regions
- Technical questions
- Costs
- Arguments for the defensive military protection of the country

Furthermore, the planning was to be made to be complete in the year 1980 with an expected number of vehicles being 800‘000. Just under 2 years later, in early year of 1957, the vehicle estimations were updated to 800‘000 cars and 200‘000 motorcycles. To serve those vehicles, the road network was now expected to be 1‘451 km long by year 1980. When finalising the report in November 1958, the total length of the network was set to be 1‘811 km long.

The commission worked under a high time pressure. This was not only due to the overly optimistic time schedule they set themselves, but also political pressure from the Touring Club Suisse that collected over 200‘000 signatures to force the state to show what they were planning. As a result, the commission focused heavily on those questions that it could indeed answer, left the more difficult questions for cantons to answer themselves. With local interests at heart, commission delegates, appointed by cantons, asked for national road network to extend to their cantons and regionally important places. This lead to expansion of the planned road network from 500-600 km to 1‘811 km (Kammann, 1990).

In May 1957, a matrix of criteria was suggested to justify the concept of the national road development, including:

1. Connections of cities
2. Connections of different regions
3. The important transit lines
4. The connection to European highways.

To halt any further expansion of the planned road network, a commission member Robert Ruckli, later the Head of the Office for Road and River Construction (successor of Federal Inspectorate of Ground Construction), proposed new criteria in the following meeting, June 1957,

1. To ensure the provision of good connection between the main trade centers of the country
2. To ensure the purpose-oriented connection to the continental transit road network.

With the consideration of these criteria, he successfully proposed to remove some minor pass roads, which would have borne high costs, e.g., Brünig-Thun and Brig-Andermatt-Chur (Ackermann, 1991)

7.4 A few words on the use of structural plans to align the interest of the many stakeholders

The infrastructure planning process involves multiple stakeholders, takes time and requires appropriate decision-support tools along the way. A result of this planning process as a whole is a strategic document listing the strategic development steps based on the strategic objectives of the planning organisation. Each infrastructure planning organisation has their own strategic documents, e.g., a master plan that both shapes and constrains infrastructure development to a differing extent. For example, in Switzerland, infrastructure planning organisations at all levels of government explicitly define strategic objectives and strategic infrastructure development as follows:

- national planning organisations (e.g., Federal Roads Office) create sectoral plans coordinated by the national planning regulator (Federal Office for Spatial development) (Schweizerische Bundesrat, 2022). These sectoral plans define the strategy of the federal government. Infrastructure development projects for national infrastructure, financed by the federal government, such as those for road and rail, are then listed by federal offices in Strategic Development Programs (Schweizerische Bundesrat, 2018a).
- cantonal planning organisations set structural plans that are more definitive, set clear objectives and outline infrastructure development projects that meet the objectives in a balanced manner (Schweizerische Bundesrat, 2022; Zürich, 1975). For a definitive program of projects to be realised in the short-term, cantonal civil engineering offices like Canton Zürich's Tiefbauamt are responsible for making construction programs (d. Bauprogramm).
- communal planning organisations also set structural plans including their objectives and further specify the strategic development explained in cantonal planning documents (Zürich, 1975).

In Switzerland, all levels of planning must be aligned. The system imposes checks and balances to ensure the alignment of infrastructure planning outcomes, e.g., the national planning outcomes such as the strategic development program for road does not propose projects that are not included in cantonal structural plans. Similarly, Cantonal structural plans are approved by the Federal office for spatial development (ARE) and communal structural plans are approved by the cantons.

This makes the canton‘s structural plan an effective tool for planning infrastructure. Infrastructure planned on a national level by the federal offices, must also be a part of the canton‘s structural plan, providing the canton a say in the decision-making process. For example, the Federal office of Transport will not propose a large railway project in its development plans, unless the project is included in the cantonal structural plan and vice versa. Different authorities (e.g., national and cantonal) therefore coordinate with each other to find out a feasible solution that works within the constraints defined by the planning organisation.

While the master plans provide the legal basis to build infrastructure in space, the infrastructure projects must be approved and financed individually. On a national level, the strategic development programs are used to finance programs, dependent on the prioritisation, in the upcoming budget period or list the expected developments in the budget periods thereafter. On a cantonal level, the projects get funded through their own investment programs, e.g., Kanton Zürich's Bauprogramm. On a communal level, each commune has their own programs. However, some projects may be applicable for funding from the cantonal or national authorities.

7.5 The financing of infrastructure from the national fonds

The rail infrastructure fond (d. Bahn Infrastrukturen Fond (abbrev. BIF)) has the purpose of allocating funds to projects related to operations, maintenance, development and research of railways in Switzerland (Bundesversammlung, 2013). The National road and agglomeration transport fond (d. Nationalstrassen- und Agglomerationsverkehrsfond (abbrev. NAF)) has the purpose of allocating funds to operations, maintenance, bottleneck removal and completion of national roads (Bundesversammlung, 2016). NAF is also used to support agglomerations through intercommunal projects, listed in the national Agglomeration programs for roads, walking and cycling paths as well as bus and tram projects (Bundesamt für Raumentwicklung (ARE), 2020). Agglomerations are defined by the Federal Office for Statistics to enable a comparison between urban areas (BFS, 2014). They generally consist of two or more communes, which urban settlement areas have grown together over time, making intercommunal planning grow in importance. Cantons and communes generally finance their infrastructure projects with loans, but some cantons have transport fonds to support their transportation infrastructure development, e.g., Canton Zürich.

ARE has put together the following graphic to visualise the flow from one financial source to the federal transport investment funds and from there to related projects. Figure 18 is based on data from the Federal office of Finance.

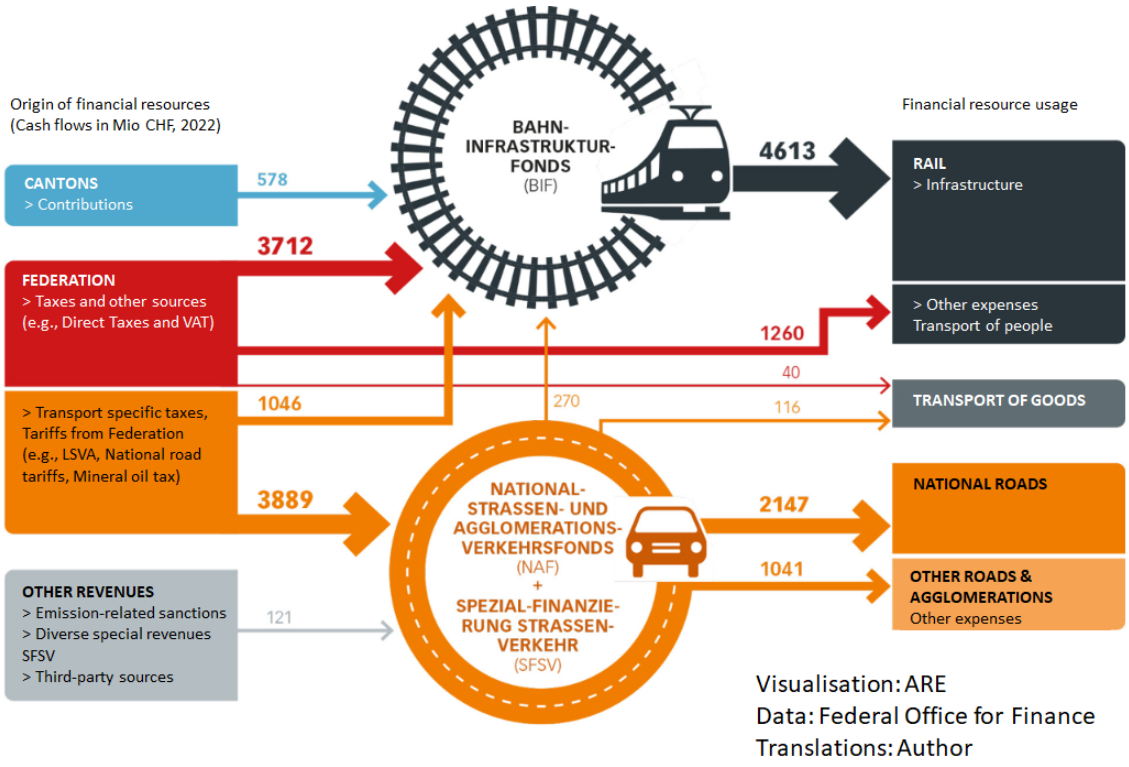


Figure 18: Visualisation of finances for national infrastructure investment in Switzerland

7.6 Example output of an early-planning scanning tool

The following Figure 19 shows an example visualisation of an earl-planning scanning tool, useful for addressing questions such as, “Where are the potential bottlenecks in the transportation network in the mid- and long-term?” and “how can spatial development be directed to enable the use of existing transport network capacity reserves and, as possible, steer away from the formation of traffic bottlenecks?”. It scans a region for infrastructure development potential considering uncertain land use development and resulting changes in mobility demand. This potential is illustrated through the quantified net benefits shown through color, with red being negative and blue being positive. In this figure, depicting one possible future scenario of studying only studying a highway network expansion through the addition of a single highway access point. This image is a result of the student work in (Marggi, 2024).

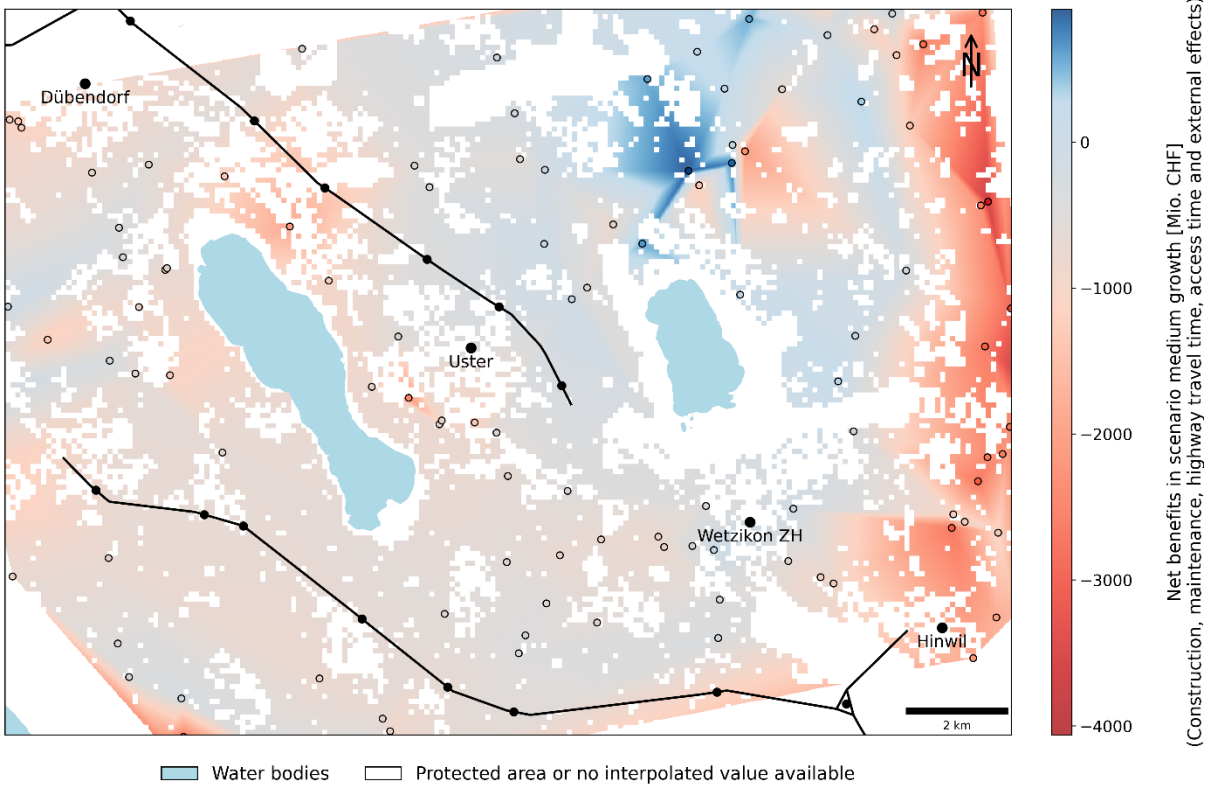
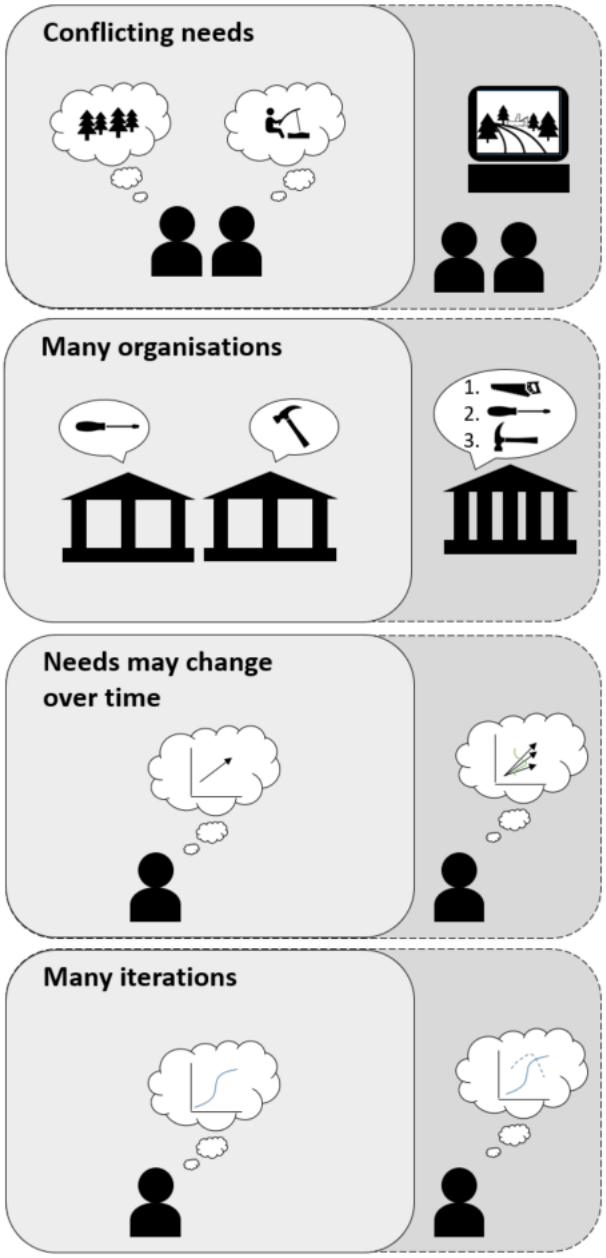


Figure 19: A possible output of infrastructure development generation impacts in one scenario of population distribution showing high potential to extend highway to the north of Lake Pfäffikon

7.7 Visual summary of the findings

The challenges elaborated in section **Error! Reference source not found.** are visually summarised in Figure 15 in the same section. Figure 20 below shows the same figure with a text summary related to each challenge and the recommendation.



- Society consists of different stakeholders with diverse needs
- Planning accommodates needs through infrastructure projects in alignment with strategic objectives
- *Project development tool at right level of detail*

- Organisations involved in the planning may focus on different interests
- Lack of alignment and synchronisation of projects leads to delays and conflicting objectives
- *Propose new organisation to foster early coordination*

- Societal needs may change during long planning process
- Stakeholders become cautious to make definitive decisions
- *Considering the adaptive planning paradigm to make the process and outcome effectiveness more robust to many futures*

- Extensive deliberation is required for stakeholders to agree, particularly when upstream decisions must be re-visited
- Prolonged planning leads to benefits but also incurs stakeholder costs
- *A framework to quantify the added benefit more responsive planning processes*

Figure 20: Visual summary of the challenges found by analysing the infrastructure planning process including a list of the descriptors of the challenges and the related recommendation italicized