FinEst Link Risk report

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1. General

a. Purpose of the document

This document is a report about risk management for the feasibility study phase of the FinEst Link project. This risk report gives a general view of the risk management process and the risks in the FinEst Link project in the feasibility phase. The risks described in this document are focused on the risks that may affect the feasibility study phase project or the results of the feasibility study. Risk management concerns also some risks related to future phases and has been reported in the hazard logs for the use of the next phases of the project. The risk management also includes the necessary risk reduction measures and the means to monitor the risks in order to manage and decrease them.

This risk report is based on the risk management plan and hazard logs that have been done during the project's feasibility phase in 2016–2017. The hazard logs are managed by the partners after the feasibility study is finished.

b. Project scope

The FinEst Link project explores the development needs in transport between Helsinki and Tallinn in a long-term perspective. The project carries out a feasibility study that analyses from an economic and technical standpoint whether it is cost-effective to construct a sub-sea railway tunnel between the two cities ("Tunnel alternative"). Different options and technical solutions have been considered in order to find an optimal choice for the tunnel. As an alternative for the tunnel, the project analyses how the existing fast ferry services and connections could serve the increasing traffic volumes between the ports of Helsinki and Tallinn ("Alternative 0+").

c. Stakeholders

The partner organizations of the FinEst Link project are: Helsinki-Uusimaa Regional Council, City of Helsinki, Finnish Transport Agency, Estonian Ministry of Economic Affairs and Communications, City of Tallinn and Harju County Government.

Work packages WP 2 (traffic models and calculations of the cost-effectiveness) and WP 3 (technical solutions, design of the tunnel and the safety concept) have also been actively involved in the risk management process.

Sito Oy is the consultant in the risk management of the feasibility study phase.

2. Implementation of risk management

a. Guidelines used for risk management

The risk assessment in the FinEst Link feasibility study phase has been made applying the risk assessment guidelines of the Finnish Transport Agency (FTA). The FTA guidelines are well-established and widely used in Finnish railway projects. The methods are mostly in compliance with the EU's Common Safety Method (CSM) risk assessment regulation (402/2013/EC) as well. The risk management process has been tailored to serve the purposes of this project and especially it's feasibility study phase.

The Finnish Transport Guidelines that were used where applicable, are:

- Risk management in transportation infrastructure (LO 28/2015, new version from 1.1.2018 LO 39/2017)
- Guidelines for risk management methods (31.10.2011, new version from 1.1.2018 LO 40/2017)
- Risk management in track design (LO 10/2010, new version from 1.1.2018)
- Risk management according to CSM regulation in railway system (15.12.2016)

b. Risk management process

Risk assessment for FinEst Link has been done as "a comprehensive risk management" according to the Finnish Transport Agency guidelines. The risk management process has involved the whole project from preliminary study phase to maintenance phase and has taken into account the different alternatives of the project. In the end of the project, the risk management process and risks have been evaluated to give an overview and starting point for the risk management in the next planning phase. The risk assessment material produced in the feasibility phase can be exploited also in the next phases of the FinEst Link project.

Risk management process included several phases:

1) Defining the risk management process and the scope of the risk management within FinEst Link project (Risk identification → Risk Analysis → Risk evaluation)
2) Defining the methods of the risk assessment
3) Brainstorming the risks with Potential Problem Analysis
4) Documentation of the risks
5) Evaluating the risks in expert workshops
6) Evaluating the acceptability of the risks
7) Defining the risk mitigation measures to all risks that are not acceptable and to some acceptable risks
8) Follow-up of the risks, updating the evaluation and the mitigation measures, when needed
9) Overview to the project risks and risk management in the end of the project

In the very beginning the scope of the risk management was discussed in detail. It was decided that the focus of the risk management needs to be in the feasibility phase. This was concluded, as the next phases including planning, construction and operation are so far in future, the decision of the continuation of the project has not been done and the technical design is done only at the level required by the feasibility study. The risk management needs to be done in detail in the next planning phases, as the planning proceeds and more information is available.

c. Methods of risk assessment

The risks have been identified and evaluated in the risk workshops and in the project meetings. The risks have been collected into two "hazard log" Excel sheets – one is for the risks of Alternative 0+ and the other for the risks of the tunnel alternative – so that same risk may be included in both hazard logs. The goal has been to list all possible risks that come to the project personnel's minds, even though some of the risks would eventually be evaluated insignificant or transferred to the next planning phase risks. In the beginning, to brainstorm all related risks, the Potential Problem Analysis has been used in the workshops.

Some methods and tools have been developed only for the FinEst Link project, as risk management has been considered as a special tool to ensure the quality of the feasibility study and it may be used to follow up the planning process. The FinEst Link project the identified risks have been listed in 5 categories that are based on the different phases of the project. Each risk may exist in many categories. The categories are (Figure 1):

- Feasibility study, internal (FSI): These risks and their mitigation measures can be affected by the FinEst Link project organization, e.g. the communication in the project between the work packages.
- Feasibility study, external (FSE): These risks are something that come from outside of the project, e.g. political changes in Finland or Estonia, and can't be affected by the FinEst Link project organization. These risks have been listed and evaluated, but are not considered in detail in the risk management process.
- Design and construction (DC): These risks are listed but only the risks that may affect the feasibility study, e.g. logistics during the construction, are considered.

- Impact (IM): This category contains the FinEst Link impact risks, e.g. pollution of the ground water in Tallinn, that significant enough to be considered in the feasibility study.
- Operation (OP): This category contains the risks related to operation, e.g. the goal for the half-an-hour travel time is not realized. Only the risks being significant enough to be considered in the feasibility phase are listed.

Figure 1: Risk categories in the FinEst Link feasibility study

All the identified risks have been evaluated by experts in order to define the probability and severity of the risk. The evaluation has been made as an expert assessment using a special table for recognizing the probability and severity of the consequences. The table comes from is in the FTA guidelines, but has been slightly adjusted to include the feasibility phase in detail.

Risk probability contains five categories from 1 to 5, where 1 is very rare and 5 is very common (Table 1).

Table 1: Risk probability evaluation

Risk probability
5 Very common Occurs at least 10 times per year or the probability for the feasibility study is over 90 %
4 Common Occurs at least once per year or the probability for the feasibility study is over 60 %
3 Occasional Occurs at least once per 10 years or occurs at least once during the implementation of the project or the probability for the feasibility study is over 40 %
2 Rare Occurs at least once per 100 years or occurs at least once during the operation of the project or the probability for the feasibility study is over 10 %
1 Very rare Occurs more rarely than once every 100 years Theoretical, not known to have occurred during construction or operation or the probability for the feasibility study is less than 10 %

Risk probability affects the risk evaluation together with the severity of the consequences (Tables 2 and 3).

Table 2 Severity assessment of the risks

	Severity of the consequences				
Project risks	**1 Very slight/minor consequences**	**2 Slight/minor**	**3 Severe/significant**	**4 Major**	**5 Very major**
Project risks for feasibility phase	Very minor effect on feasibility study results	Minor effect on feasibility study results but does not affect the decision based on feasibility study	Significant effect on feasibility study results and may affect the decision based on feasibility study	Major effect on feasibility study results affecting the decision based on feasibility study.	Very major effect on feasibility study changing the decision based on the feasibility study
Personal injury	Very slight injuries	Slight injuries, sick leave under 14 days	Severe injuries, sick leave more than 14 days	Deaths	Multiple deaths
Property damage	Very little property or business damage	Slight property or business damage	Significant property or business damage	Major property or business damage	Very major property or business damage
Operational harm	Very slight impact on planning/ contract schedules No claims	Interferes with the realisation of planning/contracts Minor claims	Interferes with the realisation of planning/contracts Severe claims	Project is delayed by a month Major claims	Project is delayed by several months Very major claims
Traffic damage	Very slight traffic damage, only traffic disturbance	Minor traffic damage	Significant traffic damage	Major traffic damage	Very major traffic damage
Environmental damage	Very slight environmental harm.	Minor environmental damage, slight harm, easily rectified	Significant environmental damage, moderate harm, can be rectified	Major environmental damage, considerable and extensive harm, can be rectified	Very major environmental damage, severe long-term harm, difficult to rectify

The row "Project risks for feasibility phase" (marked with green in Table 2) is completely tailored for the FinEst Link project's feasibility phase. The profound assessment of the feasibility phase project risks has been made using another table that is presented in Table 3.

Table 3: Severity assessment in the feasibility phase

	Severity of the consequences				
Project risks for feasibility phase	**1 Very minor effect on feasibility study results**	**2 Minor effect on feasibility study results but does not affect the decision based on feasibility study**	**3 Significant effect on feasibility study results and may affect the decision based on feasibility study**	**4 Major effect on feasibility study results affecting the decision based on feasibility study.**	**5 Very major effect on feasibility study changing the decision based on the feasibility study**
Process (e.g. schedule, management, responsibilities, acceptance)	Only minor problems in process that do not affect the study and do not need actions	Problem in project process that can be solved easily not affecting much the quality or results of the study	Problem in process that cannot be solved in time affecting the quality of the study	Major problem in process that cannot be solved affecting the quality and results of the study	Very major problem or many major problems in process affecting the quality and results of the study
Level and quality of the information (e.g. background information, assumptions)	Only minor problems or uncertainty in information that do not affect the study and do not need actions	Problem in information that can be solved easily or uncertainty in information not affecting much the quality or results of the study	Problem in information that cannot be solved in time or uncertainty in information affecting the quality of the study	Major problem in information or uncertainty in information that cannot be solved affecting the quality and results of the study	Very major problem or many major problems in information affecting the quality and results of the study
Resources (e.g. knowledge, number of experts, use of the experts)	Only minor problems in resources that do not affect the study and do not need actions	Problem in resources that can be solved easily not affecting much the quality or results of the study	Problem in resources that cannot be solved in time affecting the quality of the study	Major problem in resources that cannot be solved affecting the quality and results of the study	Very major problem or many major problems in resources affecting the quality and results of the study
Communication (e.g. communication in the project, stakeholders, social media)	Only minor problems in communication that do not affect the study and do not need actions	Problem in communication that can be solved easily not affecting much the quality or results of the study	Problem in communication that cannot be solved in time affecting the quality of the study	Major problem in communication that cannot be solved affecting the quality and results of the study	Very major problem or many major problems in communication affecting the quality and results of the study
Solution acceptability (e.g. technical and design solutions technically, economically or environmentally acceptable)	Only minor problems in solution acceptability that do not affect the acceptability of the study and do not need actions	Problem in solution acceptability that can be solved easily not affecting much the acceptability of the study	Problem in solution acceptability that cannot be solved in time delaying the acceptance of the study	Major problem in solution acceptability that cannot be solved so that only part of the study is accepted and some solutions are left open	Very major problem or many major problems in solution acceptability preventing the acceptance of the study

The severity together with the probability of the risk constitute the magnitude of the risk according to a 5-level risk matrix. This is a widely-used evaluation method and is also required in the FTA guidelines.

Table 3 The 5-level risk matrix used in this project:

	No consequences	Slight/minor	Severe/ significant	Major	Very major
5 Very common Occurs at least 10 times per year or the probability for the feasibility study is over 90 %	Minor	Moderate	Significant	Intolerable	Intolerable
4 Common Occurs at least once per year or the probability for the feasibility study is over 60 %	Insignificant	Minor	Moderate	Significant	Intolerable
3 Occasional Occurs at least once per 10 years or occurs at least once during the implementation of the project or the probability for the feasibility study is over 40 %	Insignificant	Minor	Moderate	Moderate	Significant
2 Rare Occurs at least once per 100 years or occurs at least once during the operation of the project or the probability for the feasibility study is over 10 %	Insignificant	Insignificant	Minor	Moderate	Significant
1 Very rare Occurs more rarely than once every 100 years Theoretical, not known to have occurred during construction or operation or the probability for the feasibility study is less than 10 %	Insignificant	Insignificant	Insignificant	Minor	Moderate

After the risks have been identified and evaluated, risk mitigation measures have been defined in order to manage and decrease the risks, when they can be affected by the FinEst Link project. The mitigation measures are defined for at least all the risks that have a magnitude of “Moderate” or higher, but they can be planned also for the less significant risks. The risks that have a magnitude of “Minor” also need to be followed up even if no reduction measures had been planned.

From outside the FTA risk management guidelines, as a part of the risk identification process, the worst-case-scenario costs of the realization of each risk were supposed to be estimated. This was meant to help the work packages to take into account the risks and their possibilities in the cost-effective analysis. The positive possibilities of the risks were supposed to be estimated as well, even though the focus in risk management is in evaluating the magnitude and mitigating the consequences of the risks. However, it was noticed that it is too early to estimate the monetary costs and benefits of the risks in the feasibility phase, as there is not enough data about the future planning solutions available yet and as the design is at a very rough level.

d. Workshops and participants

A total of five (5) risk management workshops have been organized during the feasibility study phase. The participants have represented wide knowledge from the field and both the customer (partners) and the consultants (work packages WP2 and WP3) have been well represented. In addition to the workshops, several meetings for the follow-up of the risk management have been held.

1. **Risk workshop 22.11.2016, Helsinki, Hotel Katajanokka**

The workshop was held together with the risk management kick-off meeting. The workshop focused on the methods that would be used in the risk management.

Participants: Heidi Mäenpää (Finnish Transport Agency), Olli Keinänen (Helsinki-Uusimaa Regional Council), Kari Ruohonen (FinEst Link), Malla Paajanen (Helsinki-Uusimaa Regional Council), Anni Rimpiläinen (Finnish Transport Agency), Ulla Tapaninen (City of Helsinki), Kaarel Koose (Harju CG), Eva Unt (Ministry of Economic Affairs and Infrastructure, Estonia), Liivar Luts (City of Tallinn), Jaak Simon (Estonian Technical Surveillance Authority), Laura Järvinen (Sito Oy, risk management)

2. **Risk workshop 10.2.2017, Helsinki**

The workshop focused on listing the risks and evaluating them. The method used was Potential Problem Analysis.

Participants: Heidi Mäenpää (Finnish Transport Agency), Kari Ruohonen (FinEst Link), Laura Järvinen (Sito Oy, risk management), Sakari Grönlund (Sito Oy, WP2), Juho Siipo (Sweco Oy, WP3)

3. **Risk workshop 14.2.2017, Tallinn**

The workshop focused on discussing the mitigation measures and responsibilities.

Participants: Heidi Mäenpää (Finnish Transport Agency), Olli Keinänen (Helsinki-Uusimaa Regional Council), Kari Ruohonen (FinEst Link), Malla Paajanen (Helsinki-Uusimaa Regional Council), Anni Rimpiläinen (Finnish Transport Agency), Ulla Tapaninen (City of Helsinki), Kaarel Koose (Harju CG), Eva Unt (Ministry of Economic Affairs and Infrastructure, Estonia), Liivar Luts (City of Tallinn), Jaak Simon (Estonian Technical Surveillance Authority), Laura Järvinen (Sito Oy, risk management), Sakari Grönlund (Sito Oy, WP2), Juho Siipo (Sweco Oy, WP3)

4. **Risk workshop 10./11.5.2017, Tallinn**

The workshop focused on the mitigation measures and follow up of the measures.

Participants: Heidi Mäenpää (Finnish Transport Agency), Olli Keinänen (Helsinki-Uusimaa Regional Council), Kari Ruohonen (FinEst Link), Malla Paajanen (Helsinki-Uusimaa Regional Council), Anni Rimpiläinen (Finnish Transport Agency), Ulla Tapaninen (City of Helsinki), Kaarel Koose (Harju CG), Eva Unt (Ministry of Economic Affairs and Infrastructure, Estonia), Liivar Luts (City of Tallinn), Jaak Simon(Estonian Technical Surveillance Authority), Laura Järvinen (Sito Oy, risk management), Juho Siipo (Sweco Oy, WP3), Jaak Järvekülg (Hendrikson & Ko)

5. **Risk workshop 15.12.2017, Helsinki-Tallinn ferry**

The workshop focused on the essential risks and the mitigation measures, as well as the lessons learned for the next phases.

Participants: Heidi Mäenpää (Finnish Transport Agency), Kari Ruohonen (FinEst Link), Malla Paajanen (Helsinki-Uusimaa Regional Council), Anni Rimpiläinen (Finnish Transport Agency), Laura Järvinen (Sito Oy, risk management), Mikko Raninen (Sweco Oy, WP3), Antti Korhonen (Ramboll Finland Oy, WP2)

3. Risks threatening the project

a. Risks mutual to all alternatives

Many of the risks concerning the feasibility phase are mutual to alternative 0+ and the tunnel alternative. The mutual risks concern mostly project management, responsibilities, quality of background information, resources and communication.

Some of the risks have already been realized. The most important risks that have at least partly been realized during the feasibility phase are:

- The resources on the partners' side have been insufficient at times, as the partners' personnel are not working for the FinEst Link full time.
- The risk management has not worked in the Work packages as well as planned, since there haven't been enough hours reserved for risk management in the work packages' assignment. However, the risk-oriented working method in general has worked well, and the risk management results can be considered sufficient.
- Project milestones have not been finished as planned, mostly because the original alignment option were found unsuitable, and there was no time for an additional planning phase in the schedule
- Co-operation between work packages has mainly been good, but there have been incidents where outdated source material has been used in a WP's work.

Some important risks that have not been realized so far:

- There has not been a lack of resources in the consultants' work.
- The project personnel have not been concentrating on too detailed design, but have been focusing on the important questions.
- There have not been problems with a "no-turning-back-point" in planning when there has been need to change plans radically. This shows well with the fact that the original alignment options were disqualified even after the feasibility study had started.
- There have not been unexpected changes in regulations that would cause problems with the FinEst Link project.

Many of the risks considered in the risk management have been taken into account in the feasibility study itself. The concerns were about the quality of the feasibility study and that all possible matters affecting the results need to be considered. These risks concerned for example:

- Increasing of the project costs
- Pay level changes
- Traffic analyses
- Operator risks
- Urban development risks
- Maintenance risks
- Ground water level
- Acceptance of the project and its solutions.

All the risks are presented more profoundly in the hazard logs.

b. Alternative 0+

A total of 100 risks have been identified and evaluated for the alternative 0+. None of them are considered intolerable, and three are considered significant risks in the end of the feasibility study phase. These numbers include the risks that are mutual for both alternatives.

The significant risks and the mitigation measures are the following:

- Describing the WP2 study methods and calculations to public fails, which leads into the public opposition. In order to minimize the risk, there needs to be open communication, results need to be transparent and easily understandable to the media. (Same risk in tunnel option)
- Standard solution of the impact assessment method does not exist, which leads into the lower acceptability of the wider impact analysis due to the lack of standardization. In order to minimize the risk, the background materials need to be open.
- There happens a catastrophe in the Baltic Sea leading to an environmental catastrophe. This is a risk that can't be minimized within the feasibility study, but needs to be considered in the analysis.

None of the risks that are specific to Alternative 0+ have been realized yet.

In addition to the 100 risks evaluated in this phase, there have been 9 risks that have been identified, but since they concern only the construction or the operation phase and do not affect the feasibility study, their evaluation will be carried out in the later phases of the project. There have also been 20 omitted risks that were found irrelevant.

The risks are presented more profoundly in the hazard log.

c. Tunnel alternative

A total of 175 risks have been identified for the tunnel alternative. None of them have been considered intolerable, and 10 are considered significant in the end of the feasibility study phase. These numbers include the risks that are mutual for both alternatives.

The significant risks and the mitigation measures are following:

- **EU funding will not be given**, which affects the schedule of the FinEst Link project and the costs in the end will be higher. The project may be cancelled due to the lack of funding. In order to minimize the risk, the feasibility study needs to meet the criteria of the funding application and the reporting needs to be done on schedule.
- **Describing the WP2 study methods and calculations to public fails**, which leads into the public opposition. In order to minimize the risk, there needs to be open communication, results need to be transparent and easily understandable to the media. (Same risk in 0+ option)
- **Society is not willing to accept the artificial islands** even if they are found necessary in the feasibility study. This results into longer construction time and higher costs. In addition, the safety concept needs to be reconsidered, which may lead to increasing costs. In order to minimize the risk, there needs to be open information and communications. Knock-out criteria needs to be addressed in a very early phase of the

project. Attractive post-construction usage of the artificial island needs to be studied to raise the level of the acceptance.

- **The key persons don't have enough time**, which affects the quality of the feasibility study, as all required expertise is not available at the time when needed. In order to minimize the risk, the project management needs to ensure the resources and the expertise. Meetings, themes and required resources will be agreed well beforehand.
- **Conflict of interest of different parties**, which leads to a situation, where a planning solution beneficial to all parties can't be found. In order to minimize the risk, there needs to be done an interest group analysis and communication plan. Discussions with the land use planners and a map of possible conflict areas will be done, if needed.
- **Dangerous goods traffic will be allowed in the tunnel**, where the consequences of an accident are more severe, also the technical solutions needed increase the costs. In order to manage the risk in the feasibility phase, this needs to be considered in the risk management and in the safety concept. Also a list of possible dangerous goods allowed and not allowed in the tunnel may be needed.
- **Ground water quality will be affected by the construction**, resulting into environmental and economical problems. In the feasibility study phase, this needs to be considered in the feasibility study and needs to be addressed in the SEA report.
- **Environmental consequences of the artificial islands are high**. This risk results into solutions that are worse considering the technical and safety aspect, due to environmental reasons. This needs to be considered in the feasibility study and needs to be addressed in the SEA report.
- **These is not enough space for construction materials, machinery and other logistics**. This leads into higher construction costs than estimated, as the planned construction phase schedule is not possible. This needs to be considered in the feasibility study as a risk and in more detail in the next planning phases.
- **Power supply for the construction is not enough**, as adequate power is difficult to provide at the site. This needs to be considered in the next planning phases, also redundancy with diesel generator power units may be possible.

In the tunnel alternative, many of the consequences of the most significant risks somehow concern the schedule and budget of the project and the quality of the feasibility study. As the FinEst Link is a unique project, there have been identified several risks that can cause significant delays and cost-level rises.

Some project risks have already been realized in the feasibility phase. The risks that have at least partly been realized during the feasibility phase are:

- The risks concerning the locating of the tunnel and its stations: It has been identified that there could be significant problems when trying to find suitable locations in the already-built two cities and their city plans. This risk has been realized, as the first alignment options were found impossible to fit into the cities' transport plans especially in Finland.
- The new alignment options have resulted in the risk of inadequate ground surveys to be realized.
- There have been difficulties in the co-operation with Rail Baltic project. As an example, the cargo traffic volume estimations published in these two projects have been inconsistent.
- Radon has been found from the planning area.
- The existing railway is congested in Finland, making it more difficult to find suitable solutions for the FinEst Link connection.

In addition to the 175 risks evaluated in this phase, there have been 18 risks that have been identified, but since they concern only the construction or the operation phase and do not affect the feasibility study, their evaluation will be carried out in the later phases of the project. There have also been 6 omitted risks that were found irrelevant.

The risks are presented more profoundly in the hazard log.

4. Next planning phase

a. Research and focus recommendations

The mitigation measures for the identified risks will be developed further to decrease the risk magnitudes. The utilization of the mitigation measures will also be followed up in order to ensure that all the risks are as low as possible during the whole life cycle of the FinEst Link project.

The worst-case-scenario costs and best-case-scenario benefits of the realization/non-realization of each risk were supposed to be estimated already in the feasibility phase. However, it was noticed that it is too early to evaluate the costs and benefits of the risks in the feasibility phase in such detail. The evaluation should be made in the future phases of the project in more detail, when the planning solutions are known.

The acceptance risks can be realized in the future phases, and in order to decrease their consequences, it is important to concentrate on the public communication, especially when it comes to the artificial islands.

One solution regarding the different gauges in Estonia and Finland (1435/1524 mm) has been proposed in the feasibility phase. In the feasibility phase, planning has been made in obedience to a dual gauge, but in the future phases it should be studied in more detail.

b. Project management recommendations

In the feasibility phase, there were no partners' personnel that would have worked full time in the FinEst Link project. In the future phases, it would be important to nominate full-time workers to the project. This recommendation includes the project partners.

In the future phases, it is necessary to pay close attention to the cost-effective possibilities of accommodating the ground material. The possibilities could not be comprehensively researched in the feasibility phase, as the alignment options were changed.

One risk that has already been realized is the lack of co-operation with the Rail Baltic project. In the future phases, it is crucial to co-operate with Rail Baltic, as the projects are highly dependent of each other.

In the beginning of the next phase, it would be beneficial to have a general meeting with all the stakeholders. In the feasibility phase, such a meeting where the alignment options would have been on the table, was not held. As a result, the project was being carried out for a while without knowing that the alignment options were not implementable according to all the stakeholders.

It is important that all the project workers constantly communicate with their own organization. This will enlarge the pool of experts and ensure that all the possible know-how is available for the project.

5. Situation of risk management

Risk management will be continued in all the future phases of the project. The risk management carried out in the feasibility phase will serve as a background to the risk management of the future phases.

6. Conclusion

Risk assessment for FinEst Link has been done according to the existing risk management guidelines. Also European guidelines have been followed, where applicable. The risk management process has involved the whole project from preliminary study phase to maintenance phase and has taken into account the different alternatives of the project. The focus of the risk management is in the feasibility study phase and the risks that may be managed in this design phase. During the project, there has been co-operation with the work packages to help to concentrate the work into the significant risks related to the feasibility study. Work packages have been able to update the hazard logs in the project place during the whole project. The risks have been identified and evaluated in the risk workshops and in the project meetings. A total of five separate risk workshops have been held. The risks have been collected for the Alternative 0+ and for the tunnel alternative. Risk management has been helpful to keep the focus of the feasibility study project in the most significant risks.

A total of 100 risks have been identified and evaluated concerning alternative 0+ of the FinEst Link project and a total of 175 concerning the tunnel alternative. Some of the risks are similar or the same to both alternatives, but the magnitudes of the risks in the tunnel alternative are higher in average than the risks of the Alternative 0+. The reasons for higher risks in the tunnel alternative are that the alternative 0+ relies mostly on existing infrastructure, whereas the tunnel alternative is more likely to have a bigger influence on the transportation system and to require bigger investments, more exceptional structures and more project resources.

The biggest risks in the beginning of the project were related to technical risks and project risks of the feasibility study.

- **Technical risks** were related to designing a functional railway system in a tunnel for both passenger and freight traffic → Functional solution for the railway system was solved.
- **Project risks** were related to managing the organization consisting of many work packages and stakeholders and keeping the project entity and decision making under control during the relatively short feasibility study phase. → Results were obtained in schedule, but especially document control and management can be improved in future phases.
- **Media and social media risks** were related giving wrong information or getting people against the tunnel independent of the results. → These risks were not realized and the feasibility study could concentrate on the study itself, thanks to a competing study about the tunnel.

Further questions about the design and implementation of the tunnel option need to be solved in future phases. Considering the further design phases of the project, the biggest risks and the needed measures to keep them under control are the following:

- **Cost and impact calculations**: The details of the calculations need to be reviewed, as the planning proceeds and more detailed technical information is obtained. In addition, the charges for heavy traffic and congestion charges need to be taken into account in further studies.
- **Environmental risks**: Construction of the tunnel and the implementation of the artificial islands contain environmental risks that requires more detailed investigation. In addition, the ground water quality needs to

be ensured during the construction especially in Vimsi Peninsula, Helsinki Vantaa airport site and Päijänne water tunnel. The glycol under the Helsinki Vantaa airport needs to be considered as well.

- **Construction risks**: Construction in demanding circumstances requires more detailed analysis of possible ways to construct the tunnel. Especially material logistics and providing the power supply have been identified to be critical for construction.
- **Safety and security demands**: Tunnel length and the amount of traffic sets high requirements to the safety and security, which may differ in different countries. Co-operation with the safety authorities from both countries is needed in next phases.
- **Project risks**: Many risks were related to the project itself, both within the project and outside of the project. Risks within the project includes the risks about the personnel resources and know-how. Key resources to the project, also the partner resources, needs to reserved for the project full time. The organization model needs to planned so that the project organization includes a small client organization with know-how enough the manage the project. The steering group of the project needs to consider also other aspects related to the tunnel project, such as ticketing system and smart mobility. The financial model is also a critical aspect to the success of the project and needs to be considered in the early phase of the project.