- FORESEE -

Future proofing strategies FOr RESilient transport networks against Extreme Events

– Deliverable *1.3* –

Examples of using Levels of Service and resilience in governance.

Project reference no.	769373
Deliverable no:	1.3
Work Package no:	1
Status	Final
Version:	04
Author:	UC (Mª Antonia Pérez Hernando, Luis Acebes Escudero, Javier Torres Ruiz, Miguel Cuartas Hernández, Tania Ivanova Ivanova). wsp (Ignacio Robles), TEC (David Garcia Sánchez).
Date:	31/07/20
Nature:	Report
Dissemination level:	Public

	Participant Legal Name	**Country**
1	FUNDACION TECNALIA RESEARCH & INNOVATION (TEC)	Spain
2	RINA CONSULTING SPA (RINA-C)	Italy
3	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V. (FRAUNHOFER)	Germany
4	UNIVERSIDAD DE CANTABRIA (UC)	Spain
5	FUTURE ANALYTICS CONSULTING LIMITED (FAC)	Ireland
6	FERROVIAL AGROMAN SA (FERR)	Spain
7	UNIVERSITY OF BATH (BATH)	United Kingdom
8	CENTRO DE ESTUDIOS DE MATERIALES Y CONTROL DE OBRA SA (CEMOSA)	Spain
9	LOUIS BERGER SPAIN SA (LB)	Spain
10	INGENIERÍA Y CONSERVACIÓN CONTRAINCENDIOS, S.L. (ICC)	Spain
11	INFRAESTRUTURAS DE PORTUGAL SA (IP)	Portugal
12	AISCAT SERVIZI SRL (AIS)	Italy
13	Autostrade per l'Italia S.p.A. (ASPI)	Italy
14	EUROPEAN UNION ROAD FEDERATION (ERF)	Belgium
15	EIDGENOESSISCHE TECHNISCHE HOCHSCHULE ZUERICH (ETH Zürich)	Switzerland
16	TELESPAZIO VEGA UK LIMITED (TVUK)	United Kingdom
17	THE UNIVERSITY OF EDINBURGH (UEDIN)	United Kingdom
18	Ingenieurgesellschaft für Verkehrs- und Eisenbahnwesen mbH (IVE)	Germany

Authors list		
Reviewer: Name, surname	Organisation	email
Mª Antonia Pérez Hernando, Luis Acebes Escudero Javier Torres Ruiz Miguel Cuartas Hernández Tania Ivanova Ivanova.	Universidad de Cantabria **UC**	antonia.perez@unican.es luis.acebes@unican.es javier.torres@unican.es miguel.cuartas@unican.es tivanova@transmodalbots.com
David Garcia Sánchez	Tecnalia **TEC**	david.garciasanchez@tecnalia.com
Ignacio Robles Urquijo	LOUIS BERGER **LB**	Ignacio.Roble@wsp.com
David Delgado	Ferrovial **FERR**	david.delgado@ferrovial.com
André Costa	Infraestructuras de Portugal **IP**	andre.costa@infraestruturasdeportugal.pt
Jose Díez	EUROPEAN UNION ROAD FEDERATION / UNE	j.diez@erf.be

Document History			
Version	**Date**	**Comments**	**Author**
01	01/06/2019	Draft 1	Mª Antonia Pérez Hernando
02	08/10/2019	Draft 2	Ignacio Robles Urquijo
03	31/10/2019	Draft 3	Mª Antonia Pérez Hernando
04	22/11/2019	Draft 4	Mª Antonia Pérez Hernando
05	26/11/2019	Draft 5	Mª Antonia Pérez Hernando David Garcia Sánchez Ignacio Robles Urquijo David Delgado Zaldívar André Costa
06	13/05/2020	FINAL	Mª Antonia Pérez Hernando David Garcia Sánchez Ignacio Robles Urquijo David Delgado Zaldívar André Costa José Diez
07	31/07/20	FINAL	Mª Antonia Pérez Hernando David Garcia Sánchez

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

1 EXECUTIVE SUMMARY.

The overall objective of the project FORESEE is to develop, demonstrate and validate a set of reliable and easily implemented tools, in order to provide short and long-term resilience measures in rail corridors, roads and multimodal terminals in the face of disruptive and / or extreme events.

In order to apply these measures, it is necessary to introduce and evaluate in the general infrastructure governance processes, the service level and resilience measures in the case of extreme events.

Thus, the particular objective of the Task 1.3 "Integration of Level of Service and resilience measures for governance" (M1-M15), is to integrate to the infrastructure governance decision-making, service level and resilience considerations, in the case of disruptive and / or extreme events, so that they can be used by the different organizations in their management mechanisms throughout the entire life cycle.

To achieve this goal, this proposal uses the governance tool developed in the H2020 RAGTIME[1] (Annex 1) project, based on simple management principles, in which the service level and resilience measures are introduced, through its expression with indicators and targets, defined in the deliverables D1.1. and D1.2. It will be later in the project implemented in the platform "FORESEE Response, Mitigation and Adaptation Toolkit", to be developed in WP5 and it will be validated with the different case studies to present in WP6. Prior to exhaustive study of current management systems and governance models.

2 INTRODUCTION.

This deliverable is based on D1.1 and D1.2, integrates the concepts of resilience and level of service in the case of disruptive and / or extreme events, in infrastructure governance, using a decision-making methodology, which includes the resilience indicators defined in D1.1 and the targets defined in D1.2[1], based on the defined concepts of service and resilience.

Only recommendations proposed by the OECD on the inclusion of resilience and service level concepts in infrastructure governance have been found from the state of the art, without specifying methodology or tool development specifications. With the exception of the governance tool resulting from the H2020 RAGTIME Project, which allows to include all kinds of concepts in governance.

Thus to achieve the objective of the Foresee Project, develop a governance model adapted to infrastructure managers in which the concepts of resilience and level of service of infrastructure are integrated, is based on the results obtained in the H2020 RAGTIME Project, since it has been the only result obtained after the exploration and comparison carried out , complementing the specific indicators of governance, with those of resilience and service level, to compare and

[1] D1.2 only defines targets for the indicators (Annex 2) required in life cycle O&M. D1.3 determine targets for the indicators required throughout the life cycle, (Annex 3 marked in yellow).

evaluate the different technical solutions that solve the process and the selection of external contractors involved in the same

Making use of this methodology by integrating the concepts of governance and those of service and resilience, complements governance by making it automatic, simple and transparent, for all stakeholders, and provides a rapid response of mitigation actions to disruptive and / or extreme events (even after the event), in addition to providing capabilities to all stakeholders, in all phases of the infrastructure life cycle.

This deliverable has been carried out with the collaboration of the different stakeholders (Project´s Infra Managers[2]), who are involved in the different phases of the project life cycle, and therefore in the governance, contributing criticism and reality to the content proposal.

- INVESTIGATION: Universidad de Cantabria **UC**.
- STANDARDIZATION COMPANY: European Union Road Federation **ERF** / **UNE**
- OWNER: Infraestructuras de Portugal **IP**.
- CONTRACTS (Specialist Designer): **ETH** Zurich. NO Participation D1.3.
- CONTRACTS (Designer): Louis Berger **LB**.
- CONTRACTS (Concessioner): **AISCAT** SERVIZI. NO Participation D1.3.
- CONTRACTS (Builder): Ferrovial **FERR**

2.1 SCOPE OF THIS DELIVERABLE.

The scope of this deliverable is to integrate the level of objective service and the resilience of the infrastructure defined in D1.1 and D1.2, in infrastructure governance tools based on simple management principles and formulated through open standards, which allow great data exchange capacity, to ensure the integrity of these assets against disruptive and / or extreme events. The output of this task will feed the platform, "FORESEE Response, Mitigation and Adaptation Toolkit", to be developed in WP5.

2.2 DELIVERABLE STRUCTURE.

The deliverable is structured in the following sections:

- Section 1 contains the executive summary of the deliverable.
- Section 2 presents the introduction of this deliverable, where the main objectives, purpose and structure of the same are described.
- Section 3 defines the problem and the state of the art, which involves introducing the terms of service and resilience, in the face of disruptive and / or extreme events, in governance decision-making measures, also proposes solutions to the problem, and concludes with the selection of a governance tool.

[2] All kinds of participants in the governance of infrastructures have been contacted, with the aim of knowing the tools in use, obtaining as a result only the increase of offers through websites to use. For example, that of the Spanish Government, which consists of web exhibition of contracts including those of infrastructures, based on database, with exposure and upload of pdf files. https://contrataciondelestado.es/wps/portal/plataforma.

- Section 4 integrates the terms of service and resilience in the governance tool FORESEE, through the indicators and targets defined in D1.1 and D1.2.
- Section 5 implements the governance tool FORESEE in the case studies of the FORESEE project and in detail in case of study 3 Montabliz Viaduct, checking their resilience and level of service, in extreme and / or disruptive events throughout their life cycle.
- Section 6 shows the conclusions drawn from this deliverable.
- Section 7 provides additional information that complements the main body of the deliverable, through Annexes.
- And the last section indicates the base references, used in this deliverable.

3 SERVICE LEVEL AND RESILIENCE IN INFRASTRUCTURE GOVERNANCE.

Considering that present and future investments in transport infrastructure are one of the priorities of larger investment and longer life cycle of our societies, it is essential to provide them with resilience, capacity to prevent, absorb, withstand and recover from the negative effects caused by different disruptive and / or extreme events and maintain the level of service as much as possible.

And according to the definitions of service and resilience, given in D1.1 and D1.2, it can be said that these terms are taken into account in the governance of current infrastructure, in two very specific actions.

- In **Decision Making** by the owner and / or contractors and suppliers, to select the most appropriate technical solutions, in terms of fulfilling the required service levels and resilience, in the face of disruptive and / or extreme events.
- In the **Decision Making** by the owner, to select the experts, who can carry out the realization of the infrastructure, based on the required service levels and resilience, of the infrastructures made throughout their professional experience in the face of disruptive and / or extreme events.

But these terms of service and resilience:

- Are not used in a related way, are not related to disruptive events specifically, and are not evaluated in combination with each other.
- Are not used throughout the infrastructure life cycle, **they are only used in the operation and maintenance phase, without an specific name and relationship**.

However, if the concept of resilience were incorporated into the different phases of infrastructure governance, it would be expected that the impacts would decrease. For example, if emergency traffic routes are not blocked due to a disruptive event, collateral risks may be reduced or their restoration time may be shorter.

Therefore, **Resilience and Service Level** by **Decision Making**, versus **Extreme Events**, must be included in governance throughout the lifecycle.

3.1 STATE OF THE ART AND CONSIDERATIONS REGARDING GOVERNANCE MODELS

Different international entities make recommendations on how to include resilience against extreme events in governance:

OCDE.

- Framework for the Governance of Infrastructure.
  - Presents the 10 dimensions of the framework for the governance of public infrastructure. The dimensions relate to how governments prioritise, plan, budget, deliver, regulate and evaluate infrastructure investment. Each area covers the principal objective of policy in each area, followed by key questions decision makers need to address and indicators identifying the enabling factors.

Vision	Integrity	Delivery	Regulation	Consultation
Establish a national long-term strategic vision to address service needs. Vision	A whole of government approach is essential to address related integrity risks. Integrity	Balancing the political, sectoral, economic, and strategic aspects. Delivery	Regulation is necessary to ensure sustainable and affordable infrastructure. Regulation	The consultation should take account of public interest and stakeholders views. Consultation
Coordination	**Value**	**Data**	**Performance**	**Resilience**
Robust co-ordination mechanisms within and across levels of government. Coordination	Governments must ensure that infrastructure projects are affordable. Value	Infrastructure policy should be based on data and disclosed to the public. Data	Ensure asset performance through monitoring systems and institutions. Performance	Infrastructure systems should be resilient and adaptable to future circumstances. Resilience

Table 1. Oecd framework - The 10 main Governance challenges and policy options

- Public infrastructure needs to be resilient.
  - Multiple disasters in recent years have demonstrated the significant socio-economic impacts of these events.
  - Disruptions to critical systems spread the social hardships of disasters by cutting-off access to basic life lines (health services, food, fuel, payment systems), and produce large economic impacts by preventing the mobility of labour and inventory.
  - A governance framework that ensures resilience measures are applied to multiple critical infrastructure sectors is essential.
  - Functional dependencies and inter dependencies between different sectors of critical infrastructure. Damages to one asset, for example electricity distribution, could result in downstream disruptions to various sectors, e.g. water purification.

- The high share of critical infrastructure that is privately owned or operated implies the need for governments to partner with the private sector.

➢ Recommendation on the Governance of Critical Risks.
- Identification and assessment of risks takes interlinkages and knock on effects into account. This helps set priorities and inform allocation of resources.
- More investment in risk prevention and mitigation such as investments in protective infrastructure, but also non-structural policies such as land use planning.
- Flexible capacities for preparedness, response and recovery help manage unanticipated and novel types of crises
- Good risk governance- transparent and accountable risk management systems that lean continuously and systematically from experience and research.

➢ Good Governance for Critical Infrastructure Resilience[2]
- This report takes stock of the changing contexts for boosting resilience across OECD countries, and discusses the policy options and governance models that favour upfront investment in resilience.
- Finally, a Policy Toolkit for Governance of Critical Infrastructure Resilience identifies important steps in designing an appropriate governance model for today's critical infrastructure resilience challenges. This Toolkit complements the OECD Recommendation on the Governance of Critical Risks, contributes to international discussions in the G20 on quality infrastructure, and supports the implementation of the Sendai Framework for Disaster Risk Reduction.
- The Toolkit is designed to support governments' efforts to renew critical infrastructure policies. Going forward, the OECD will work with governments to develop benchmark indicators and conduct case studies to compare progress and improve cross-country learning in this crucial area.

➢ Governance challenges for critical infrastructure resilience

Adopting a system's approach to critical infrastructure resilience:
- The shift from critical infrastructure protection to resilience aims to address key changes of the risk landscape, marked by increased uncertainties. In order to better integrate the complexity, interdependencies and interconnectedness of critical infrastructure, adopting a systemic approach to critical infrastructure resilience provides complementary perspectives.
- Barami (2013) emphasises the complex and multi-faceted nature of critical infrastructure resilience. Barami applies a risk-based and layered approach accounting for complex infrastructures interdependencies, while considering potential solutions applicable through the infrastructure system lifecycle (i.e., design, construction, and operation). Resilience is therefore defined not as a single outcome or an exclusively post-disaster recovery capability but rather as a dynamic process that applies a risk and lifecycle-based method for addressing the vulnerabilities of critical infrastructure systems, making systems more fault-tolerant, more efficient, smarter, and better able to adapt to unexpected challenges (Barami, 2013[36]).
- The OECD High-Level Risk Forum workshop on "System-thinking for Critical Infrastructure resilience" (OECD and EU JRC, 2018[41]), extended this notion of system approach applied to critical infrastructure resilience, and proposed a series of key attributes that public policies should consider in this area:
- All-hazards and threats: Single-hazard policies are not sufficient to build infrastructure resilience. The critical infrastructure impacts of Superstorm Sandy in New York, which had engaged in substantial protection activities following 9/11 demonstrated that protective activities alone are not sufficient to address the range of potential critical infrastructure disruptions and associated cascading risks. Adopting an all-hazard and threat approach to critical infrastructure

resilience enables policy makers and operators to better prepare for the unexpected.

- System-level: Initially, critical infrastructure protection policies focused primarily on setting up protection measures at asset-level. However infrastructure assets are usually only the components of a wider complex system, which should be considered in its entirety in a comprehensive resilience strategy. Some of the system's assets are more critical than others, because of dependencies or (non)-existing redundancies for instance. A system approach allows for prioritising the most critical components, through dependency modelling and criticality assessments, as well as to address weak points that otherwise create critical vulnerabilities for the entire system.
- Multi sectoral: Addressing interdependencies requires policy makers and operators to go beyond a system-level approach and to target the critical infrastructure sectors together in a comprehensive resilience policy. While infrastructure operators tend to be well aware of their own dependencies upon critical sectors (e.g.: electricity, payment systems), they may not be as conscious of the dependencies others have upon their own services. From interdependency mapping to developing shared business continuity objectives, a multi-sectoral approach is essential to a comprehensive critical infrastructure resilience policy.
- Transboundary dimension: Similarly, interdependencies and interconnectedness cannot be fully understood without incorporating their international dimension. Hazards and threats do not stop at national borders. In some cases, critical infrastructure systems cross borders, providing services in multiple countries. Infrastructure operators can also manage critical infrastructure in several countries. This makes it more compelling to integrate international cooperation in critical infrastructure resilience policies. Sharing good practices, adopting common approaches, developing joint standards in critical infrastructure resilience are among the policy options that can foster international cooperation in this area.
- Life cycle approach: Different resilience and security measures can apply to the different phases of the infrastructure life-cycle: integrating robustness and redundancies requires investments in the design phase, while developing business continuity planning pertains more to the operation phase and adaptability can be based on infrastructure retrofitting. Thus, it is important to set-up a comprehensive policy that enables resilience throughout the life cycle of critical infrastructures, with applications from the design phase to its operations and maintenance, and retrofitting.
- Entire risk management cycle: A comprehensive resilience policy should incorporate measures throughout the entire disaster risk management cycle, from risk assessment, over risk prevention, emergency preparedness and response, to recovery and reconstruction (Moteff, 2012[42]). Critical infrastructure resilience has specificities in each of these phases. Risk assessment should incorporate dependencies and criticality assessment. Risk prevention includes robustness measures in the design phase as well as dedicated awareness raising dialogues with infrastructure operators. Emergency preparedness and response required tailored warning systems, business continuity measures and back-ups, and dedicated emergency teams and capabilities. The recovery and reconstruction phase should integrate degraded mode, rapid restoration plans as well as dedicated financing schemes, including for building back better.
- Risk-based and layered approach: Given the considerable degree of uncertainty about the intensity and the complexity of future disasters, the manifold dimensions of vulnerability of infrastructure systems, and all the interrelationships between these systems, the prioritisation of resilience measures is essential. Only a risk-based and layered approach can account for complex infrastructures interdependencies, while considering potential solutions

applicable through the infrastructure systems across the life-cycle (Barami, 2013[36]).

- Policy Toolkit on Governance of Critical Infrastructure Resilience.

IDB.

- Policy Evaluation Framework on the Governance of Resilient Critical Infrastructure in Latin America Policy Evaluation Framework on The Governance of Critical Infrastructure Resilience in Latin America
  - **Critical Infrastructure Modelling Simulation (CIMS).** Used by Idaho National Laboratory, the CIMS approach was developed policy and decision makers at the city or county level to enable swift decision making and emergency response in the recovery phase. It provides visualization of infrastructure interoperability and can develop models in real time using open source information (e.g. simple maps or aerial photos combined with information at a high level of aggregation). CIMS is inherently cross-sectoral given its focused on interdependencies, albeit at a high level of abstraction, and should be viewed as an interdependency and impact assessment tool with a focus on societal resilience

- Towards resilient and sustainable infrastructure: A case study of Governance of Critical Infrastructure Resilience in Costa Rica

EUROPEAN COMISSION.

- White Paper on Resilience Management Guidelines for Critical Infrastructures. From theory to practice by engaging end-users: concepts, interventions, tools and methods.

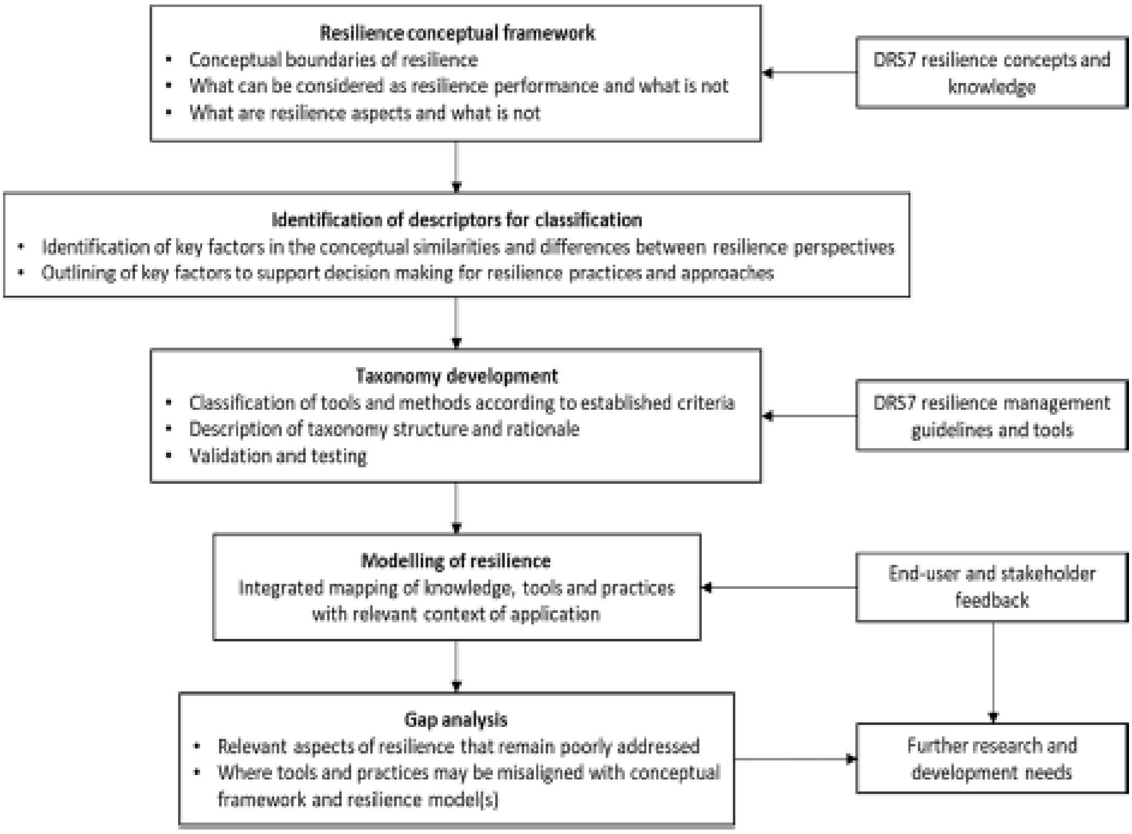


Figure 1. Resilience Roadmap Approach.

➢ Ragtime Tool Governance System Infrastructures.

– **RAGTIME governance management tool** is a risk-based approach for multimodal Transport Infrastructure Asset Management. The governance tool implements a whole system planning software platform able to facilitate a holistic management throughout the entire lifecycle of infrastructures. The development is based on multi-scale data model that uses a risk-based approach, incorporating resilient concepts and mitigation actions to support infrastructure stakeholders during its whole life-cycle by fostering an electronic Tender Process procurement mechanism that promotes the transparency and efficiency, while reducing the risks of the process.

Of all the recommendations presented, only RAGTIME, it develops a tool that includes all kinds of terms of the infrastructure through indicators, against the risks inherent, **(Annex 1)**.

❖ Structures infrastructure governance, throughout the life cycle (Evaluation & Decision), (Design and Construction) and (Operation and Maintenance) based on risks Indicators.
   – Risk External:
      • Natural.
      • Artificial.

– Risk Internal:
  - Governance.
  - Technical (all risk technical, including, **Resilience & Service Level).**
  - Financial.
- Decision-making using Multicriteria Analysis based on risk indicators.
- All based on the flow of the infrastructure governance lifecycle phases.

MINISTERIO FOMENTO SPAIN.

- Contracts for the procurement of road operation and maintenance public works.

In the public works concession contracts for the conservation and exploitation of infrastructure management, it incorporates in its “technical specification” the next points:

- *General terms and conditions of the contract (regulations, concession period, asset operation, insurance)*
- *Rights and obligations of the concessionaire (general, operational and during operation)*
- *Development and monitoring of the execution of the contract (checks, works, operating management, head of operation, suspensions)*
- *Operational phase (check of works and facilities, receipt of infrastructure, warranty period)*
- *Contract regime (remuneration, regulation, variables: number of vehicles-kilometres, vehicle types, rates and indexation, Service level and correction of the Canon's annual amount, deductions for the state of the infrastructure and the quality of the quality of the amount serviced, calculation of the annual payment amount and payment procedure to the concessionaire,*
- *Termination of the contract (Causes of termination, delivery, receipt, warranty period)*
- *Development of projects, construction and conservation works*
- *Construction projects (projects, responsibilities, delay penalties, responsibilities)*
- *Construction of works (plans, deadlines, verification and settlement)*
- *Traffic measurement system (tramification, systems, operation and maintenance of equipment)*
- *Plan for the Conservation and Exploitation of infrastructures (scopes, conservation work, development of conservation work, routine maintenance and localized repairs, replenishment actions and major repairs, reinforcement of pavement, horizontal signage, conservation and replenishment of vertical signage, beaconing, barrier and fencing, signalling and support in case of accidents, surveillance, winter road plan, quality assurance plan (QAP)*
- *Penalties for conservation agreements, total or brown decrease in the traffic capacity of the Highway, damage and auxiliary)*
- *Dealer organization (Centre for Traffic Control and Conservation, personnel, machinery and auxiliary media, computer applications, other facilities, inventory of the elements of the Highway, risks of prevention of occupational prevention)*

ANNEX 5 STATE AND QUALITY INDICATORS OF SERVICE:

As mentioned, it will be the obligation of the Dealer to maintain the conditions of road, safety, comfort, environmental respect, and survival that are typical of the type of roads that are the subject of the contract. In this sense some elements and some activities will be characterized by indicators that determine the degree of quality achieved by the Dealer

Indicators are the parameters defined and set objectively so that different elements of the road network can meet the optimum road conditions and service during the duration of the Contract. Regardless of the fulfilment of these indicators throughout the contract, the works carried out on the roads (first establishment and refurbishments, as well as those of replacement and major maintenance) must be delivered in compliance with the requirements of the Private Technical Requirements of the corresponding construction project, the corresponding PG-3, and all current regulations, circular orders or recommendations governing the conditions of the work.

Thresholds are set for each indicator to be met over the duration of the Contract, and which, if not satisfied, must be acted upon before the expiry of the maximum period of action defined in the indicator itself.

In some of the indicators, the downward or upward corrections resulting from the deviation from the thresholds defined for each indicator are also reflected, deviations that reflect the degree of quality or level of compliance.
On a monthly basis, all correction factors, faith, obtained from the indicators in this Annex, will be calculated and the total correction factor, Ft, will be obtained from the base rate of the year as follows:
The corrected rate for the corresponding month will be obtained as follows:

$$Ft = 1 + \sum_{1}^{n} \frac{fci}{100}$$

Corrected rate = Base rate of the year x Ft
The Dealer is obliged to carry out all the activities that allow to obtain these indicators (auscultation, inspection, measurements, etc.) having any means necessary to undertake their obtaining within the indicated time and time.
Measurements shall be carried out with equipment approved by the GCC or by the contracting authority.
In order to carry out the measures, in cases where there are NLT standards or UNE standards, the methodologies described in them will be followed, complying with the indications of the standards that are currently in force. In the absence of an NL T or UNE standard, the GCC Folds that are in force and applicable shall be followed.
Each indicator describes the procedure for calculating up or down corrections and when penalty is incurred.

I1.	Pavement. Resistance to time	I21.	Marche Vials. Retroreflection
I2.	Pavement. Macrotexture	I22.	Marche Vials. Resistance to time
I3.	Pavement. Longitudinal application	I23.	Horizontal signage. Luminance
I4.	Pavement. Structural capacity	I24.	Vertical signage
I5.	Pavement. Transverse etc.	I25.	Cleaning margins and rest areas
I6.	Pavement. Cracking and fatigue	I26.	Cleaning and repairing drainage
I7.	Pavement. Concrete cracking	I27.	Lighting
I8.	Pavement. Load transfer	I28.	Tunnels. Structural elements
I9.	Pavement. Settlement	I29.	Tunnels. Finishes
I10.	Pavement. Bumps	I30.	Tunnels. Lighting
I11.	Pavement. Cleaning of firm draining	I31.	Tunnels. Ventilation
I12.	Slopes	I32.	Tunnels. Fire fighting systems
I13.	Mowing, pruning and clearing	I33.	Tunnels. Electric Installation
I14.	Plantation maintenance	I34.	Tunnels. communication System
I15.	Cleaning of roads and debris	I35.	Tunnels. surveillance System
I16.	Bridges	I36.	Tunnels. Clear emergency zones
I17.	Winter road	I37.	Barriers and containment elements
I18.	Safety. Endangerment	I38.	Attention to incidents and accidents
I19.	Safety. Mortality	I39.	Lane occupancy
I20.	Safety. Performances at TCA	I40.	Level of service
		I41.	Surveillance

Among the contract offers, the local government selected the construction and operation proposals that offered better value for money. Among the parameters that were considered in value for money, and in terms of governance with resilience considerations, the following sections were noteworthy:

- *"Rate deductions based on infrastructure status and quality of service"*
- *"Penalties and damages for total or partial reduction in the traffic capacity of the highway"*

Tariff deductions are a reduction in the amount to be collected by the infrastructure operator under certain indicators of infrastructure status and quality of service. Deductions are applied when the following indicators are below the reference values or when they are placed in inadmissible values for a certain period of time. The indicators used are:

- *Surface regularity index (IRI)*
- *Cross-friction coefficient (CRT)*
- *bearing capacity (deflections)*
- *Cleaning of firm draining*
- *Horizontal signalling retroreflective index*
- *Quality of vertical signage*
- *State of enclosures*
- *Road safety and accident*
- *Attention to incidents and accidents*

On the other hand, the total or partial decrease in the traffic capacity of the highway is considered when one or more lanes of the track or its links (entrances/exits) are closed to traffic. The causes of capacity reduction can be characterized as due to conservation efforts, causes attributable to national, regional or local government, weather causes or catastrophes *of impossible foresight, traffic accidents or causes attributable to the dealer. Planned penalties will only affect in the latter case, i.e. when traffic restrictions are arising from infrastructure failures or failures in the conservation service. Delay in the reopening of traffic from lanes or branches subject to conservation and maintenance works whose execution time exceeds the provisions of the Conservation Plan is also penalized. The economic sanctions envisaged are proportional to the IMD, the hours of capacity reduction and an economic rate described in the contract.*

As seen in most cases, disruptive or extreme events belong to a specific scope, but the trigger causes are multiple and complex. There are many ways to make an infrastructure more resilient to risk, avoiding the cascading effect on conditions, but how to predict its optimization can be complicated if you also want to evaluate multiple risks at once.

Having presented all the proposals for the inclusion of resilience and the level of service in governance it is concluded that, the only methodology and tool currently existing is that developed in the H2020 RAGTIME project and will therefore be used to define FORESEE governance.

3.2 DECISION MAKING BY SIMPLE MANAGEMENT PRINCIPLES.

Thus, once the problem has been defined and verified in the above example, it is concluded that the terms of service and resilience are not used in combination and much less throughout the life cycle of the infrastructure, nor for the whole of all events, but they are only raised for the operation and maintenance phase, and in the specific case of contracting through concession.

Therefore it is necessary to consider a form of integration and as it is indicated in the "Description of work and role of partners", it must be done through simple management principles.

To do this, **first of all**, the general flowchart of the FORESEE project has to be established, than to determine resilient infrastructure typologies, based on criteria of maintaining the level of service as much as possible, in the face of disruptive and / or extreme events, with governance being the one to make these decisions, among the possible responses, handling a multitude of variables, analysis, calculations and simulations, to provide the most appropriate solution.

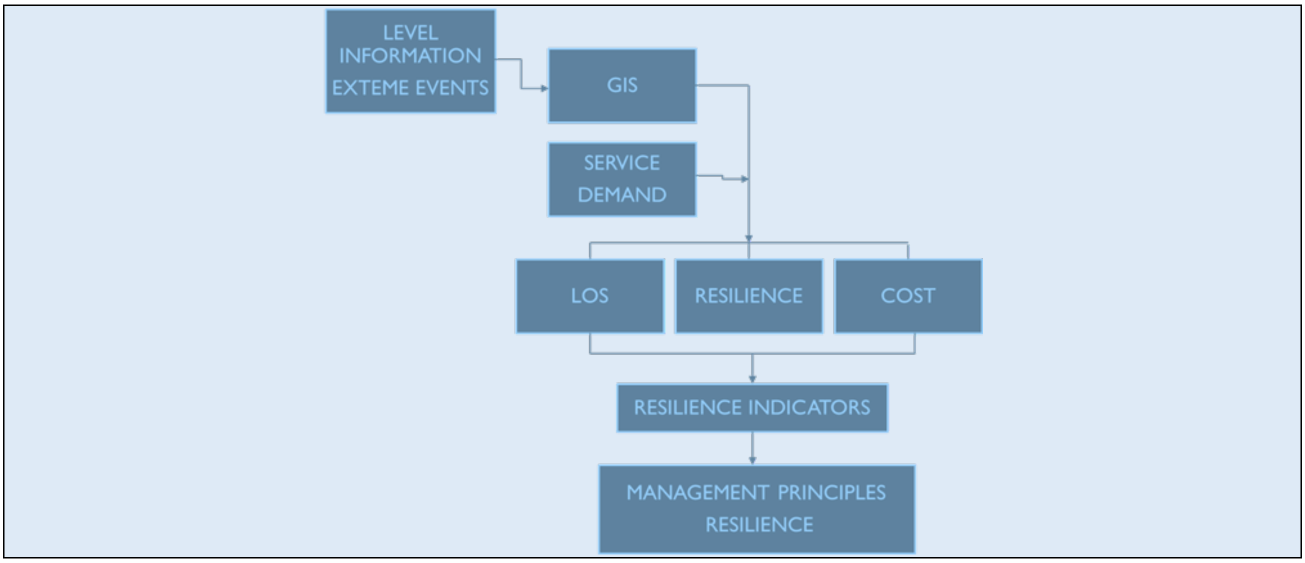


Figure 2. FORESEE Project Flow.

Secondly, it is necessary to consider which possible solutions (based on simple management principles) are capable of adding a multitude of variables, analysis, calculations and simulations, to support the decision-making process. At present the principles of simple management that are handled are:

- QUALITATIVE: Expert Judgment - the expert judgment is currently used, justified by the selection of experts outside the owner through the legal framework defined by the EU, public procurement or concession,
- QUANTITATIVE: Based on multicriteria analysis against multiple risks or "multi-risk", both for the selection of experts and for technical decision making. Or in the future based on empirical techniques and statistics fed with historical data such as Neural Networks, Machine Learning, which learn from unstructured historical data difficult to gather in assets, with a life cycle as long as infrastructure, and more in the future that must predict new scenarios, which face the performance after extreme events affected by changes, such as climate change.

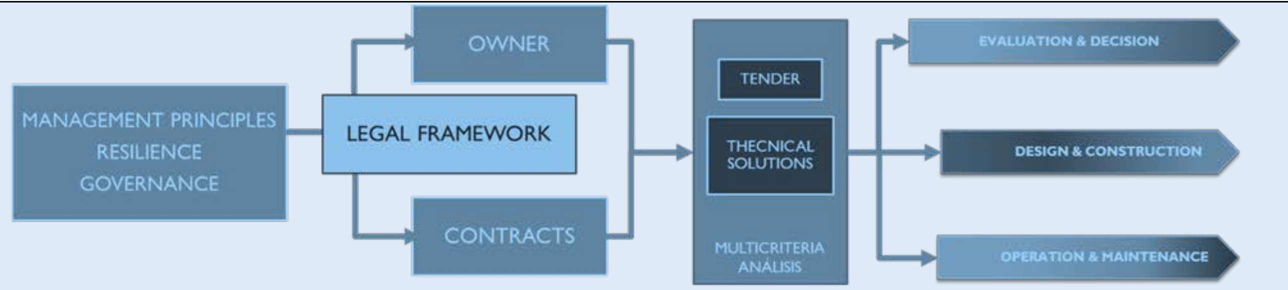


Figure 3. Governance Flow by simple management principles.

And finally, it is decided that the most useful tool may be the one based on multicriteria, multi-risk analysis, the conclusion reached to solve the RAGTIME[3] Project's governance module, previous digitalization through indicators of the multitude of variables, analysis, calculations and simulations, which implies governance, in this case to represent the service and resilience in the face of extreme events, which has already been carried out in D1.1 and D1.2, establishing the relationship between both terms and their influence with disruptive and / or extreme events independently, for each type of event. (Annex 2).

Therefore, the solution is to adapt RAGTIME governance to Foresee governance, introducing the concepts of service and resilience in multi-risk decision-making, in the face of disruptive and / or extreme events, jointly, through the indicators defined in D1.1 and D1.2.

4 INTEGRATION OF LEVEL OF SERVICE AND RESILIENCE MEASURES FOR GOVERNANCE.

The way to integrate the terms of service level objective and resilience, in the face of disruptive / extreme events, and constitute FORESEE governance, based on the RAGTIME governance model that manages infrastructures according to the following terms (Annex1):

- Include all kinds of risks in infrastructure governance.
- Represent risks through indicators.
- Make governance decisions through multicriteria analysis, TOOL RAGTIME.
- Decide technical solutions.
- Include all participants in infrastructure management, along life cycle.

Thus the application of the Ragtime model to create FORESEE Governance, is done through the following steps:

First, specify at what moments in the infrastructure life cycle it is necessary to use these terms in decision making and in which technical documents are to be used.

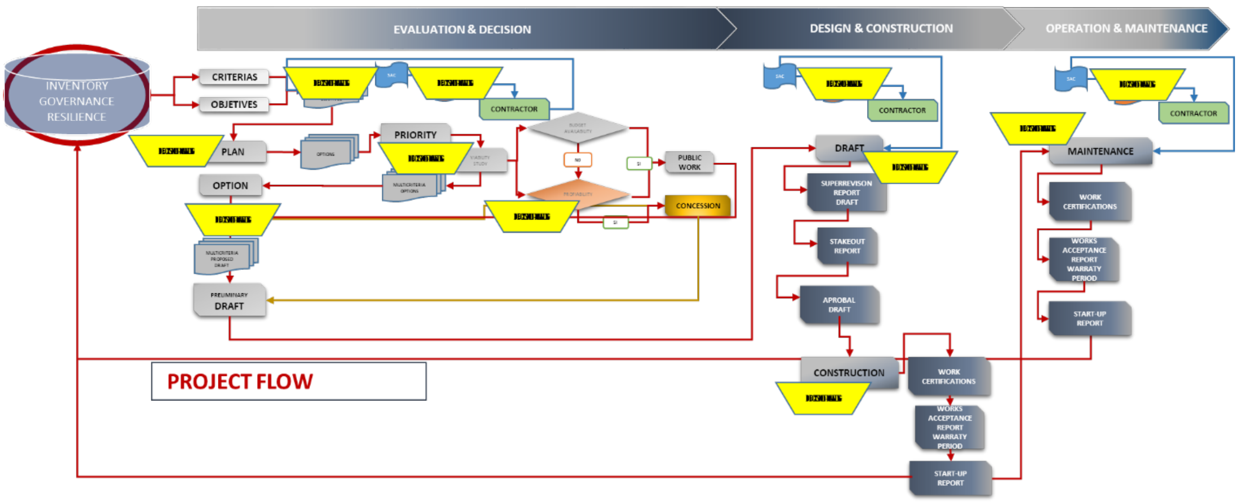


Figure 4. Management principles, life cycle assets infrastructure.

- In the Decision making and Evaluation phase, they are used to define resilient infrastructure necessary for citizens, based on disruptive / extreme events and the level of long-term and regional objective service. These levels are specified in the Plans, Feasibility Studies and Preliminary Designs.
- In the Design, Project and Construction phase, specifying solutions, typologies and constructive methodologies, which materialize the resilience of the infrastructure, compared to requests produced by these events, for an objective level of service and to a detail scale. These phases are specified in the Projects and in the construction itself.
- In the Operation and Maintenance Phase, where the conditions of service and resilience must be maintained, in the case of disruptive / extreme events, defined in the project and if altered, have alternatives that mitigate the damage and continue to provide service. The

documents used are the operation and maintenance plans, winter maintenance plans and action protocols.

- And of course in all the selection processes, competitions of expert contractors, for the realization of these actions, either through Public Procurement or Concession

Second, articulate resilience indicators D1.1 with phases and documents. (Annex 2).

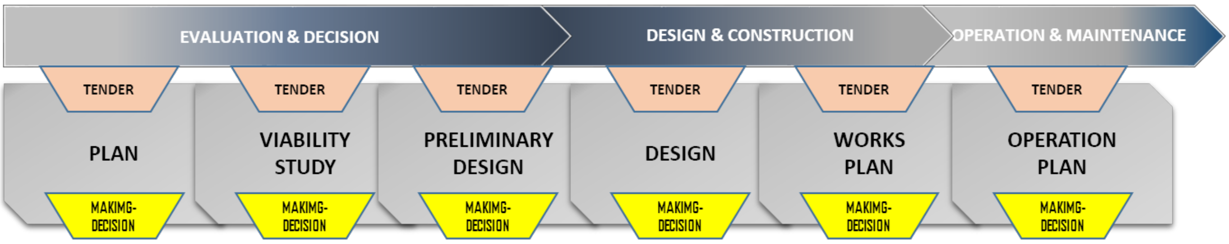


Figure 5. Documents & Phases of the Project, with Tender & Decision Making.

Third, set weights, service level targets for each D1.2 indicator, either qualitative targets or quantitative targets. (Annex 3).

Fourth, create the FORESEE Governance tool, http://foresee.transmodalbots.com/[4]

And **fifth**, introduce indicators and targets for service and resilience decisions against disruptive and / or extreme events, jointly.

All this is checked in the following section, for the case studies that are handled in this project[5].

5 FORESEE GOVERNANCE. APLICATION AND RESULTS.

5.1 Aplication: CASE STUDY 3 MONTABLIZ VIADUCT.

In this section, the different indicators and targets are implemented, for the entire life cycle of case study 3, Montabliz Viaduct, in order to check the operation of the proposed tool, with the conditions marked for it.

FEATURES MONTABLIZ VIADUCT: Short description of the pilot/case study		
Case Study Data Sheet	*Location*: A-67 Highway. Cantabria. Spain. *Name*: Montabliz Viaduct *Pilot Owner:* Ministerio de Fomento Government of Spain	*Description*: This viaduct saves the big valley formed by a river in Cantabria Spain. It has a length of 721 m distributed in 5 spans (11 + 155 + 175 + 155 + 126), maximum light 175.00 m, radius of curvature in plant 700 m. Continuous board, formed by a monocellular drawer of prestressed concrete of variable edge between 4.30 and 11.00 m supported on single pile. The maximum height of the pile is 128.60 m, the highest in Spain and among the 6 largest in Europe (year 2008). The board has been built by the voussoirs system concreted "in situ" by cantilevered forward.

		
Significant aspects	*Criticalities and problems of the pilot*	Regional situation with adverse winter weather Very special typology
	Extreme events	**WIND** **FOG** **SNOW**
	Replication	
Technical information		
Monitoring Data		YES
Maintenance Data		YES
Usage conditions		Data storage
Test		
Data Availability		Pier Movement Layout Design, Maintenance Plan, Shop drawing, Traffic data, SHM data
Infrastructure Peculiarities		
Preferred Time for testing activities (e.g. due to specific conditions)		Night
Data Collection & Privacy Issues		Owner Ministerio Fomento Government of Spain

Table 2. Case Study 3 MONTABLIZ Viaduct. FEATURES.

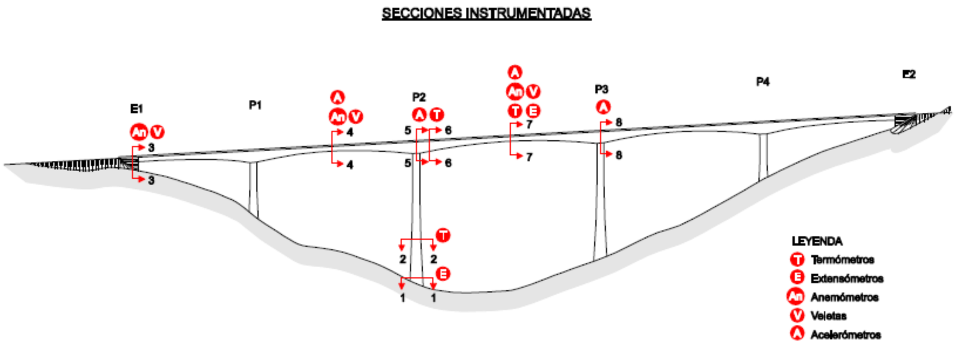


Figure 6. Case Study 3 MONTABLIZ Viaduct. Scheme.

In addition, from the application of Foresee Governance to CS3 you get as results, the foresee governance scheme, the Foresee Governance line.

5.1.1 PHASE: EVALUATION & DECISION.

- DOCUMENT: **EVALUATION & DECISION**
- MAIKING DECISION: **PREVIOUS DRAFT ALTERNATIVES**

– STAKEHOLDER: **DESIGNER**

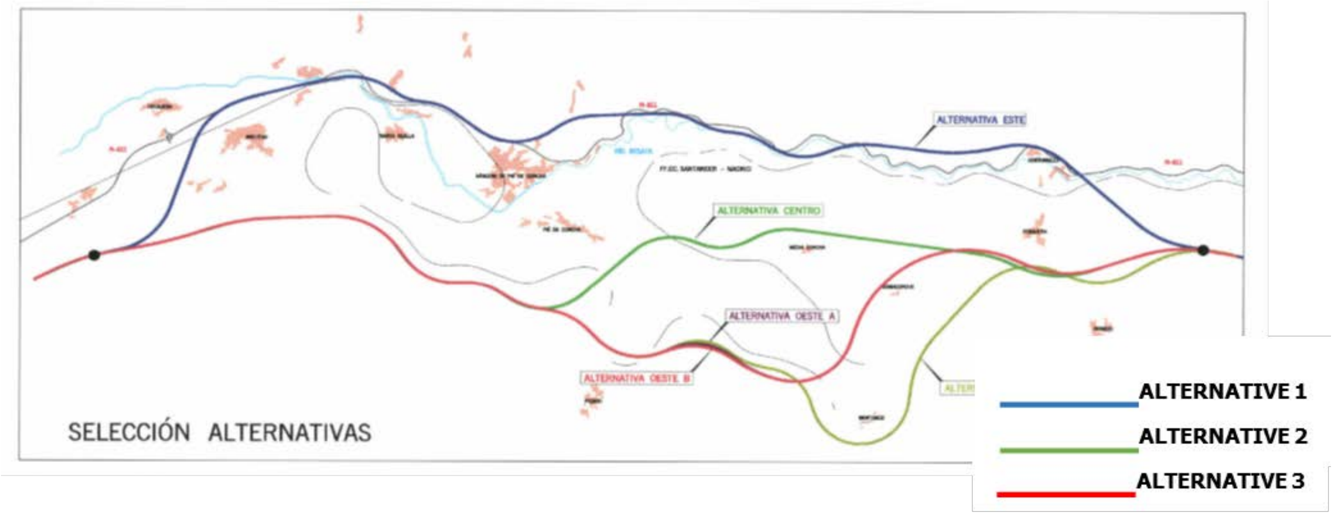


Figure 7. Case Study 3 MONTABLIZ Viaduct. Draft Alternatives.

– INPUTS:

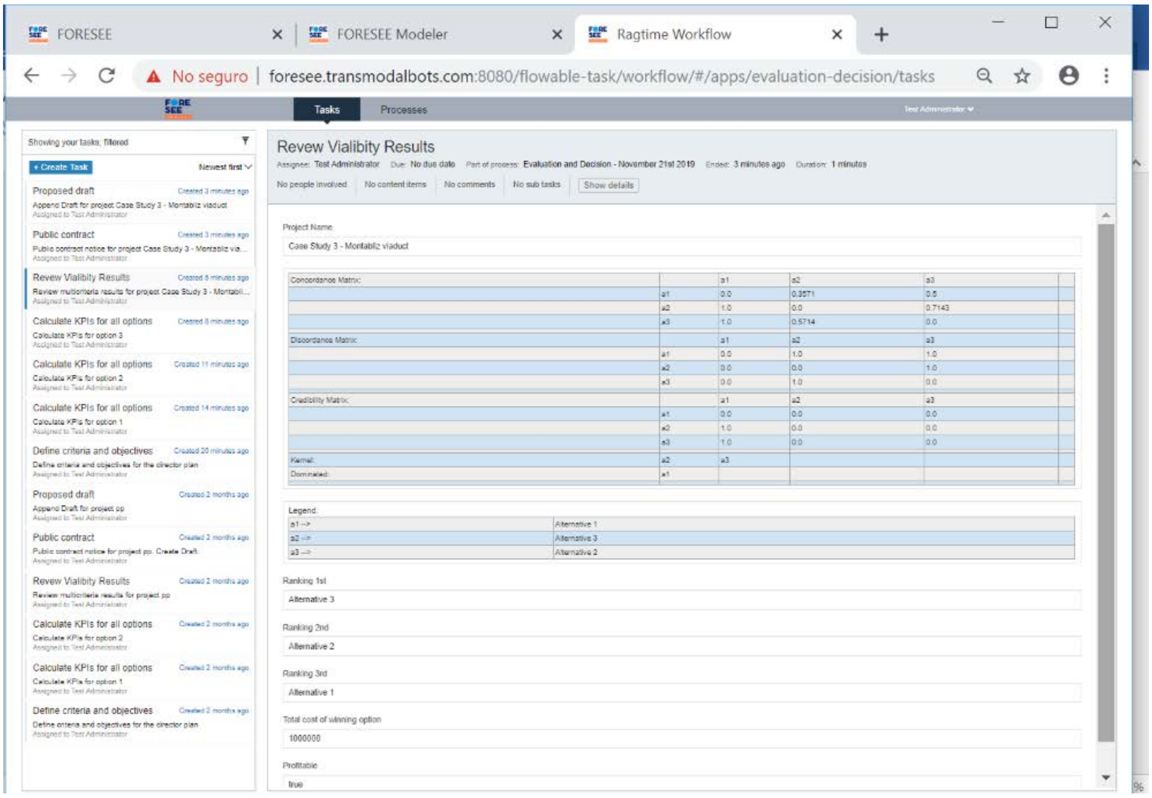
	E&D
DOCUMENT:	PREVIOUS DRAFT
MAIKING DECISION:	PREVIOUS DRAFT ALTERNATIVE
SATKEHOLDER	OWNER

CASE STUDY 3

RISK	ID	Indicator	Number of possible values		Number of possible values Possible values and meaning		Target.indic._BC	%	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
WIND	W										
	W1.2.2	The number of possible existing alternative ways to deviate vehicles	2		0/2	No alternative ways	2	100%	2	2	3
					1/2	1 alternative way					
					2/2	Multiple alternative ways					
	W.2.1.2	Frequency of past hazards	3		0/3	> 10 events per year	0	25%	4	4	2
					1/3	> 7, < 10 events per year					
					2/3	> 3, < 7 events per year					
					3/3	< 3 events per year					
	W.2.1.4	Frequency of future hazards	3		0/3	2 weeks	0	25%	3	3	2
					1/3	1-2 weeks					
					2/3	1 day- 1 week					
					3/3	0 days					
	W.2.1.8	Traffic*	3		0/3	< 20% of capacity	3	100%	2	3	2
					1/3	> 20%,< 50% of capacity					
					2/3	> 50%,< 80% of capacity					
					3/3	> 80% of capacity					
	W.2.1.9	Hazards goods traffic*	2		0/2	Frequent dangerous goods	2	100%	3	2	1
					1/2	Rare dangerous goods					
					2/2	No dangerous goods					
FOG	H										
	F1.2.2	The number of possible existing alternative ways to deviate vehicles	2		0/2	No alternative ways	2	100%	2	2	3
					1/2	1 alternative way					
					2/2	Multiple alternative ways					
	F.2.1.2	Frequency of past hazards	3		0/3	> 10 events per year	0	33%	2	1	2
					1/3	> 7, < 10 events per year					
					2/3	> 3, < 7 events per year					
					3/3	< 3 events per year					
	F.2.1.4	Frequency of future hazards	3		0/3	2 weeks	0	33%	3	3	3
					1/3	1-2 weeks					
					2/3	1 day- 1 week					
					3/3	0 days					
	F.2.1.7	Traffic*	3		0/3	< 20% of capacity	1	50%	2	3	2
					1/3	> 20%,< 50% of capacity					
					2/3	> 50%,< 80% of capacity					
					3/3	> 80% of capacity					
	F.2.1.8	Hazards goods traffic*	2		0/2	Frequent dangerous goods	2	100%	2	2	3
					1/2	Rare dangerous goods					
					2/2	No dangerous goods					
SNOWFALL	S										
	S.1.2.2	The number of possible existing alternative ways to deviate vehicles	2	3	0/2	No alternative ways	2	100%	2	2	3
					1/2	1 alternative way					
					2/2	Multiple alternative ways					
	S.2.1.2	Frequency of past hazards	3	4	0/3	> 5 events per year	1	50%	1	3	2
					1/3	> 2, < 5 events per year					
					2/3	> 1, < 2 events per year					
					3/3	1 events per year					
	S.2.1.4	Frequency of future hazards	3	4	0/3	2 weeks	0	25%	1	2	1
					1/3	1-2 weeks					
					2/3	1 day- 1 week					
					3/3	0 days					
	S.2.1.7	Traffic*	3	4	0/3	< 20% of capacity	3	100%	1	3	2
					1/3	> 20%,< 50% of capacity					
					2/3	> 50%,< 80% of capacity					
					3/3	> 80% of capacity					
	S.2.1.8	Hazards goods traffic*	2	3	0/2	Frequent dangerous goods	2	100%	2	3	3
					1/2	Rare dangerous goods					
					2/2	No dangerous goods					

Table 3. Case Study 3 Index-Targets. E&D

– OUTPUTS:



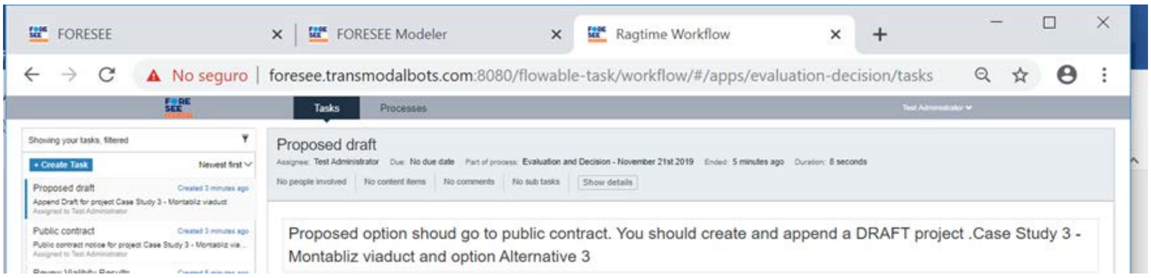


Table 4. Case Study 3. Results Draft Alternatives E&D

5.1.2 PHASE: DESIGN & CONSTRUCTION.

- DOCUMENT: **DESIGN & CONTRUCTION**
- MAIKING DECISION: **SOLUTIONS DESIGN**
- STAKEHOLDER: **DESIGNER & CONSTRUCTOR**
- INPUTS:

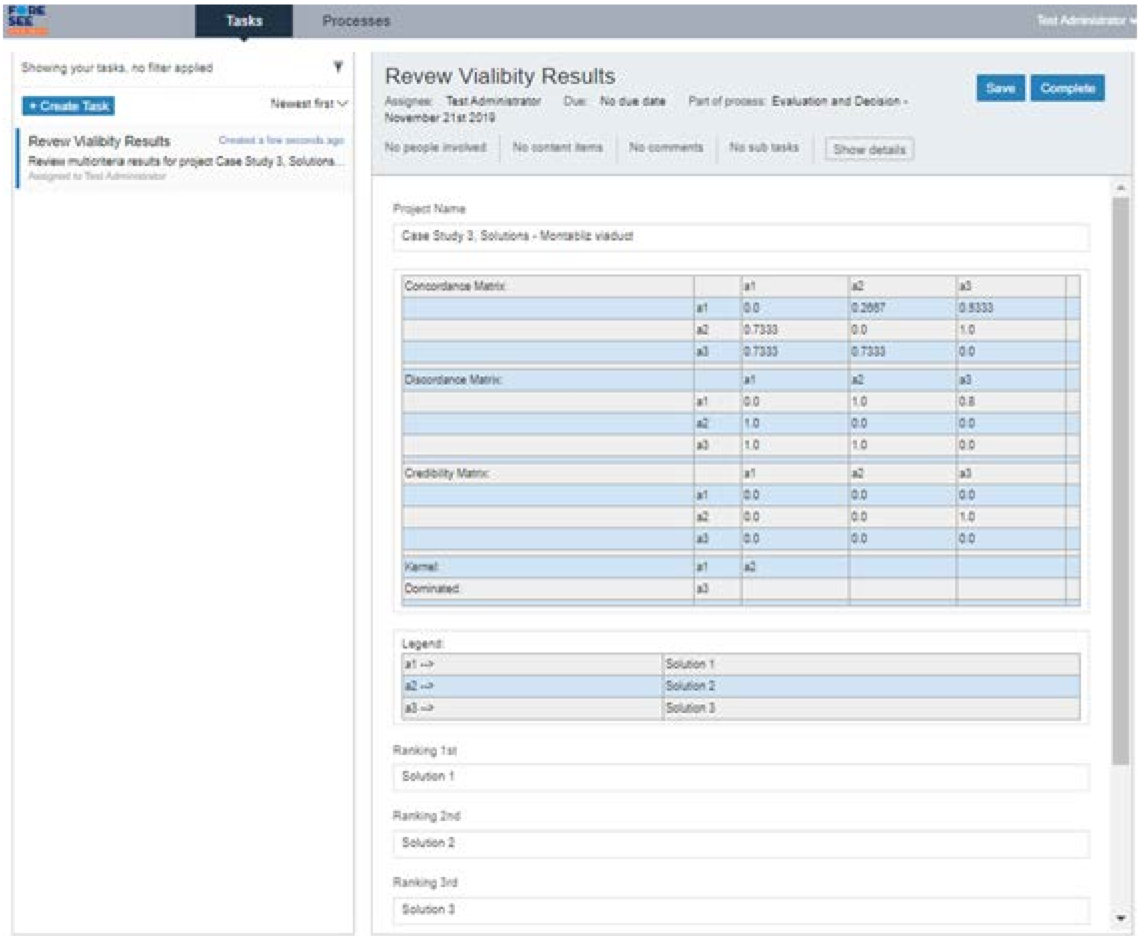
	D&C
DOCUMENT:	DESIGN & CONSTRUCTION
MAIKING DECISION:	SOLUTIONS DESIGN
SATKEHOLDER	DESIGNER & CONSTRUCTOR

CASE STUDY 3

RISK	ID	Indicator	Number of possible values		Number of possible values Possible values and meaning		Target.indic._BC	%	SOLUTION 1	SOLUTION 2	SOLUTION 3
WIND	W										
	W1.3.1	Adequacy of hazard effect reduction system (barriers to wind)	1		0/1	Not adequate	1	100%	1	2	1
					1/1	Adequate					
	W.2.1.2	Frequency of past hazards	3		0/3	> 10 events per year	0	25%	1	2	1
					1/3	> 7, < 10 events per year					
					2/3	> 3, < 7 events per year					
					3/3	< 3 events per year					
	W.2.1.4	Frequency of future hazards	3		0/3	2 weeks	0	25%	1	1	2
					1/3	1-2 weeks					
					2/3	1 day- 1 week					
					3/3	0 days					
	W.2.1.5	Severity of future hazards	3		0/3	Strong increase	2	75%	2	1	1
					1/3	Soft increase					
					2/3	Soft decrease					
					3/3	Strong decrease					
	W.2.1.8	Traffic*	3		0/3	< 20% of capacity	3	100%	2	1	1
					1/3	> 20%,< 50% of capacity					
					2/3	> 50%,< 80% of capacity					
					3/3	> 80% of capacity					
FOG	H										
	F1.3.1	Adequacy of hazard effect reduction system (pavement lines and visibility sticks)	1		0/1	Not adequate		50%	1	2	2
					1/1	Adequate					
	F.2.1.2	Frequency of past hazards	3		0/3	> 10 events per year	0	33%	3	3	4
					1/3	> 7, < 10 events per year					
					2/3	> 3, < 7 events per year					
					3/3	< 3 events per year					
	F.2.1.4	Frequency of future hazards	3		0/3	2 weeks	0	33%	1	2	2
					1/3	1-2 weeks					
					2/3	1 day- 1 week					
					3/3	0 days					
	F.2.1.5	Severity of future hazards	3		0/3	Strong increase	2	100%	1	2	2
					1/3	Soft increase					
					2/3	Soft decrease					
					3/3	Strong decrease					
	F.2.1.7	Traffic*	3		0/3	< 20% of capacity	1	50%	2	3	3
					1/3	> 20%,< 50% of capacity					
					2/3	> 50%,< 80% of capacity					
					3/3	> 80% of capacity					
SNOWFALL	S										
	S.1.3.1	Adequacy of hazard effect reduction system (barriers to snow)	1	2	0/1	Not adequate	1	100%	1	2	1
					1/1	Adequate					
	S.2.1.2	Frequency of past hazards	3	4	0/3	> 5 events per year	1	50%	2	2	1
					1/3	> 2, < 5 events per year					
					2/3	> 1, < 2 events per year					
					3/3	1 events per year					
	S.2.1.4	Frequency of future hazards	3	4	0/3	2 weeks	0	25%	1	1	2
					1/3	1-2 weeks					
					2/3	1 day- 1 week					
					3/3	0 days					
	S.2.1.5	Severity of future hazards	3	4	0/3	Strong increase	0	25%	1	2	2
					1/3	Soft increase					
					2/3	Soft decrease					
					3/3	Strong decrease					
	S.2.1.7	Traffic*	3	4	0/3	< 20% of capacity	3	100%	1	2	2
					1/3	> 20%,< 50% of capacity					
					2/3	> 50%,< 80% of capacity					
					3/3	> 80% of capacity					

Table 5. Case Study 3 Index-Targets. D&C

– OUTPUTS:



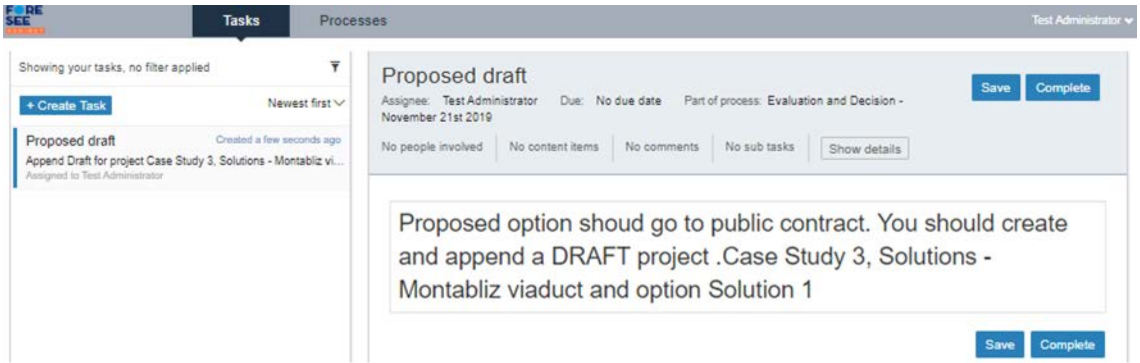


Table 6. Case Study 3 Results Solutions Draft D&C

5.1.3 PHASE: OPERATION & MAINTENANCE.

- DOCUMENT: **TENDER OPERATOR**
- MAIKING DECISION: **OPERATION & MAINTENANCE**
- STAKEHOLDER: **OWNER / OPERATORS (Ci)**
- INPUTS:

	O&M
DOCUMENT:	**Tender OPERATOR**
MAIKING DECISION:	**OPERATION & MAINTENANCE A**
SATKEHOLDER	**OPERATOR**

CASE STUDY 3

RISK	ID	Indicator	Number of possible values		Number of possible values Possible values and meaning		Target.indic._BC	%	c1	c2	c3
WIND	W										
	W.2.1.5	Severity of future hazards	3		0/3	Strong increase	2	75%	1	1	2
					1/3	Soft increase					
					2/3	Soft decrease					
					3/3	Strong decrease					
	W.2.1.8	Traffic*	3		0/3	< 20% of capacity	3	100%	1	2	1
					1/3	> 20%,< 50% of capacity					
					2/3	> 50%,< 80% of capacity					
					3/3	> 80% of capacity					
	W.3.1.1	The presence of an emergency plan	2		0/2	No plan	1		2	2	2
					1/2	Generic plan					
					2/2	Operative plan (with tasks, resources, ...)					
	W.3.1.2	Practice of the emergency plan	4		0/4	No exercise	0		1	3	3
					1/4	1 exercise every > than 2 years					
					2/4	1 exercise every 2 years					
					3/4	1 exercise every year					
					4/4	1 exercise every 6 months					
	W.3.1.3	Review/update of the emergency plan	2		0/2	< 2 years ago	0		2	2	3
					1/2	< 5 years ago					
					2/2	> 5 years ago					
FOG	H										
	F.2.1.5	Severity of future hazards	3		0/3	Strong increase	2	100%	1	2	2
					1/3	Soft increase					
					2/3	Soft decrease					
					3/3	Strong decrease					
	F.2.1.7	Traffic*	3		0/3	< 20% of capacity	1	50%	3	3	4
					1/3	> 20%,< 50% of capacity					
					2/3	> 50%,< 80% of capacity					
					3/3	> 80% of capacity					
	F.3.1.1	The presence of an emergency plan	2		0/2	No plan	2		1	2	1
					1/2	Generic plan					
					2/2	Operative plan (with tasks, resources, ...)					
	F.3.1.2	Practice of the emergency plan	4		0/4	No exercise	1		2	3	3
					1/4	1 exercise every > than 2 years					
					2/4	1 exercise every 2 years					
					3/4	1 exercise every year					
					4/4	1 exercise every 6 months					
	F.3.1.3	Review/update of the emergency plan	2		0/2	< 2 years ago	0		1	2	3
					1/2	< 5 years ago					
					2/2	> 5 years ago					
SNOWFALL	S										
	S.2.1.5	Severity of future hazards	3	4	0/3	Strong increase	0	25%	1	2	1
					1/3	Soft increase					
					2/3	Soft decrease					
					3/3	Strong decrease					
	S.2.1.7	Traffic*	3	4	0/3	< 20% of capacity	3	100%	3	2	2
					1/3	> 20%,< 50% of capacity					
					2/3	> 50%,< 80% of capacity					
					3/3	> 80% of capacity					
	S3.1.3	The extent of interventions executed prior to the event	2	3	0/2	No interventions	2	100%	1	2	3
					1/2	Partial interventions					
					2/2	Full interventions					
	S3.1.5	Practice of the emergency plan	4	5	0/4	No exercise	1		2	3	3
					1/4	1 exercise every > than 2 years					
					2/4	1 exercise every 2 years					
					3/4	1 exercise every year					
					4/4	1 exercise every 6 months					
	S3.1.6	Review/update of the emergency plan	2	3	0/2	> 5 years ago	1		1	2	3
					1/2	< 5 years ago					
					2/2	< 2 years ago					

Table 7. Case Study 3 Index-Targets O&M

– OUTPUTS:

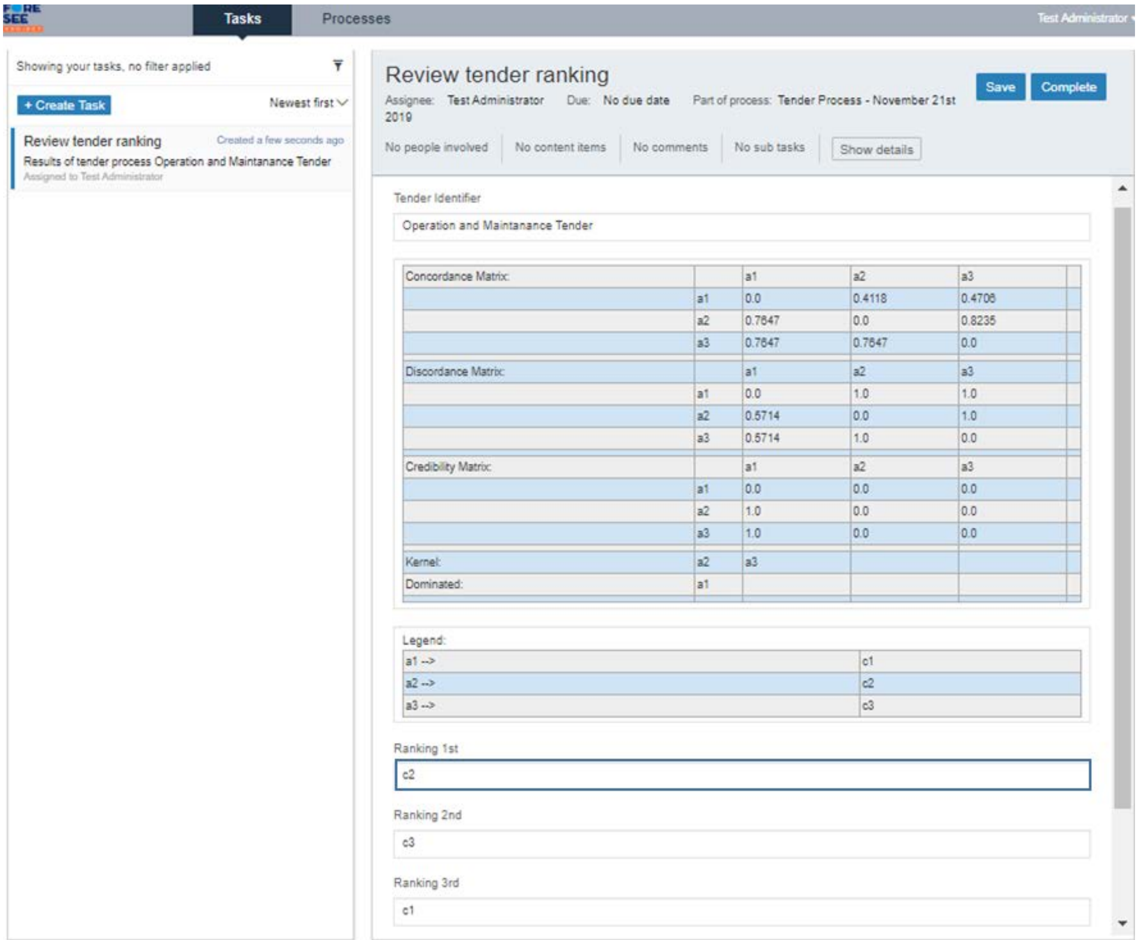


Table 8. Case Study 3 Results Tender Operator O&M

5.2 RESULTS. FORESEE GOVERNANCE.

5.2.1 Results CS3 MONTABLIZ Extreme Events (EE).

The implementation of Foresee governance in the CS3 Montabliz Viaduct provides the following results, shown in the graph:

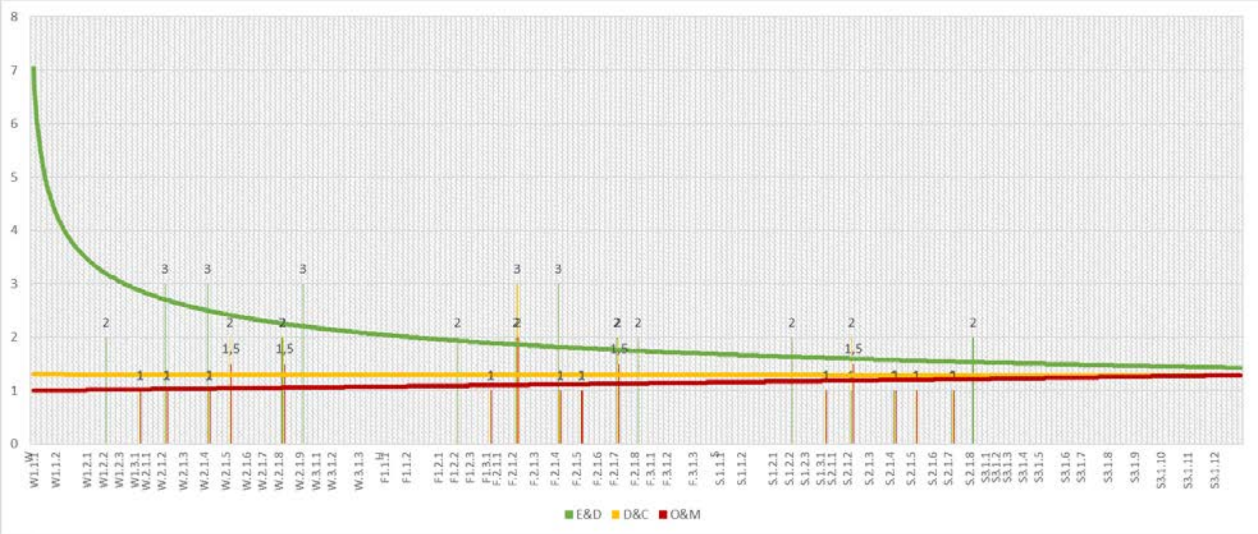


Figure 8. FORESEE Governance Line

This graph represents the resilience of the CS3 Montabliz Viaduct to the EE, specific to the infrastructure, through the resilience indicators & LOS, and throughout its life cycle,

And, from it you can obtain an average or normal resilience value of resilience, which represents the Resilience of the infrastructure versus its EE. The Foresee de Governance line versus EE.

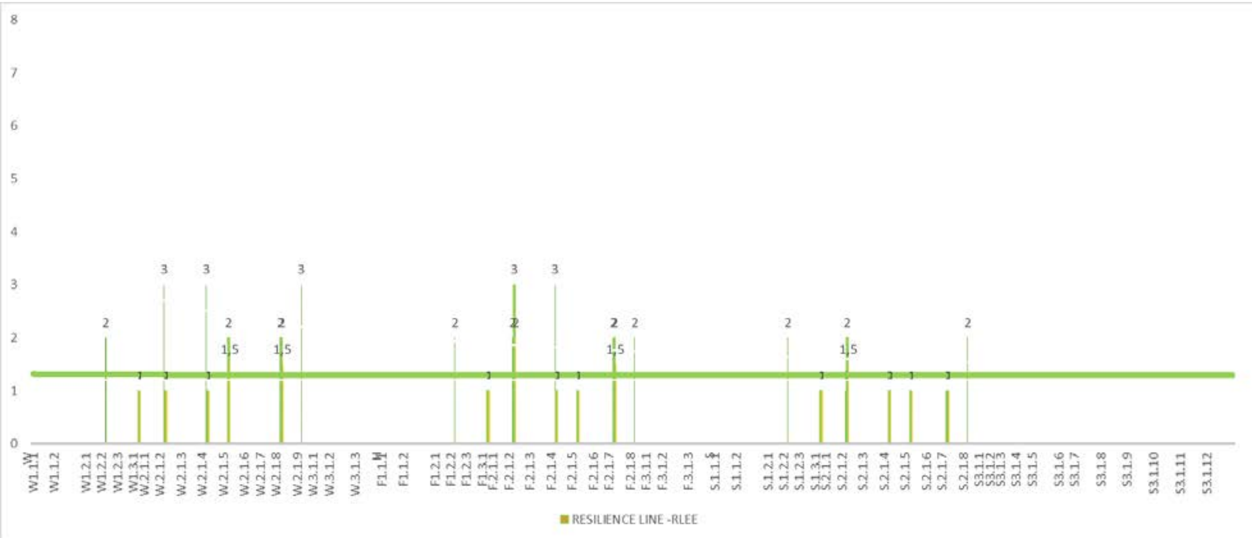


Figure 9. FORESEE Resilience Line Governance EE – RLEE CS3 Montabliz Viaduct.

5.2.2 Resilience Governance Methodology, in Infrastructure Projects. FORESEE GOVERNANCE.

The results of the CS3 Montabliz viaduct, allow through the use of Reverse Engineering to define the methodology of using Resilience Governance in Infrastructure Projects vs. Extreme Events (EE), which constitutes the methodology for the application of **GOVERNANZA FORESEE**.

EVALUATION & DECISION. (RESILIENT).

1. Relationship of EE, which can affect infrastructure, in the territory to study. D1.1.
2. Definition and calibration of Indicators (Resilience & LOS), based on EE, D1.1.
3. Definition of rLEE resilient line, as a potential trend line obtained from indicators. Optimal state of use of the Project in the face of extreme events.
4. Proposal Infrastructure Solutions, which avoid if possible, the EE.
5. Selection of resilient infrastructure against extreme events, through indicator-based multi-criteria analysis decision-making [6].

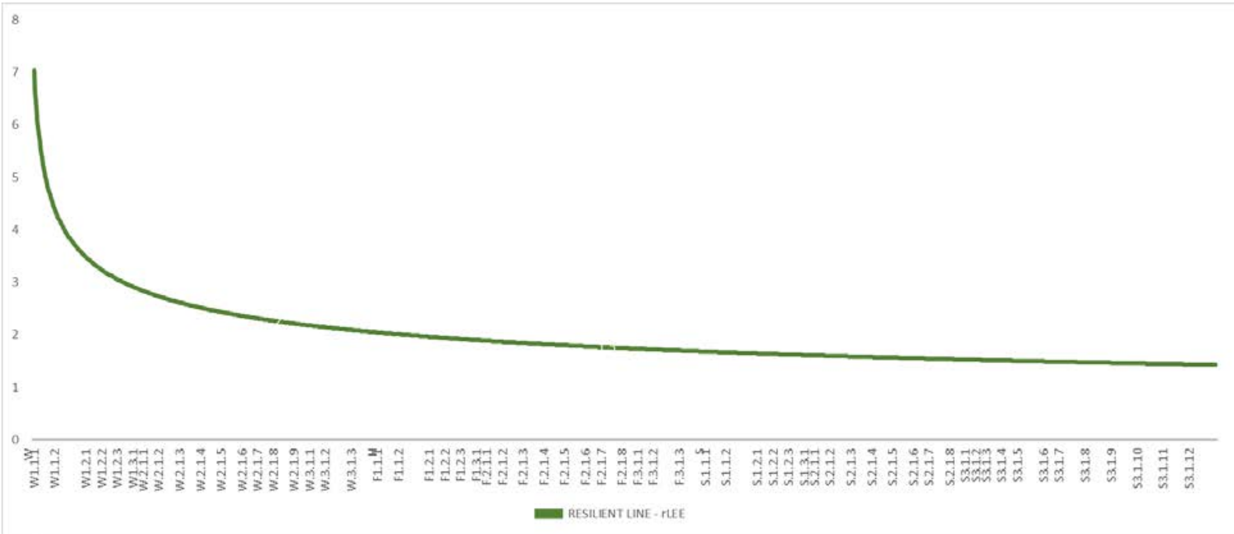


Figure 10. Resilient Line, rLEE.

DESIGN & CONSTRUCTION. (RESISTANT).

1. Design of the Infrastructure based on the resilient line, rLEE, through indicator-based multi-criteria analysis decision-making [7].
2. Definition of RRLEE resistant line, as a potential trend line obtained from resistant indicators of solution. Realistic line state of use of the Project in the face of extreme events, and RRRLEE rupture line, as a potential trend line obtained from collapse resistant limit indicators.
3. Construction Plan according to the resistant line RRLEE. Defined Emergency Plan of Construction based of RRLEE and RRRLEE.

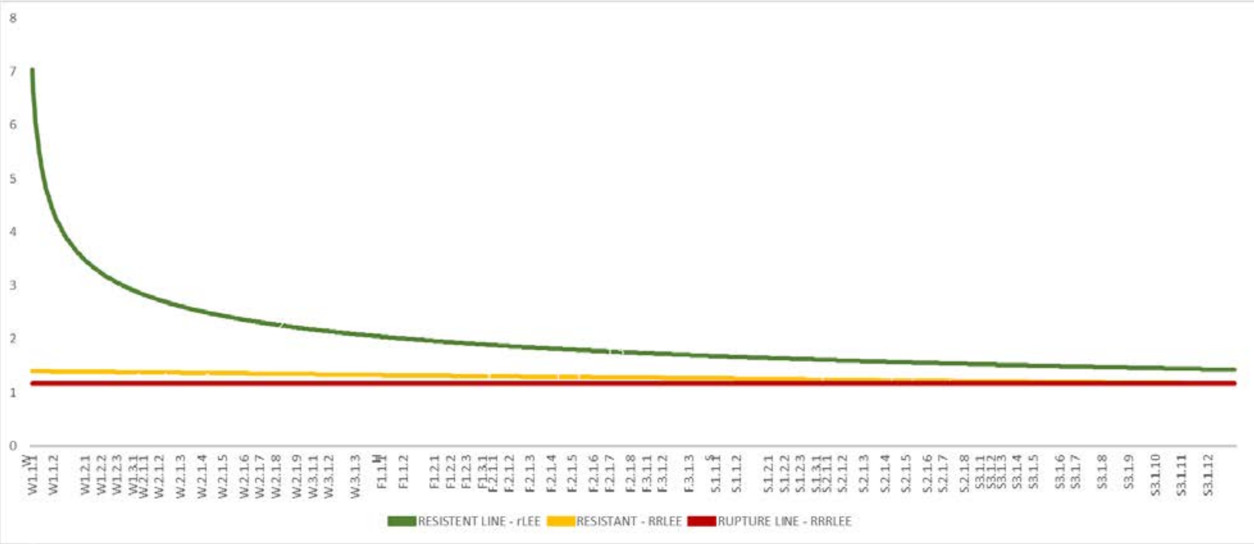


Figure 11. Resistant Line - RRLEE and Rupture Line - RRRLEE.

OPERATION & MANTENIMIENTO. (RESILIENCE).

1. Definition of **Resilience Line RLEE**, trend line defined from the three lines rLEE, RRLEE, RRRLEE.
2. Definition Operation Plan based on RLEE Resilience line.
3. Definition Emergency Plan based on RLEE and RRRLEE, which can be obtained, as a trend line for the fragility indices defined in WP3.

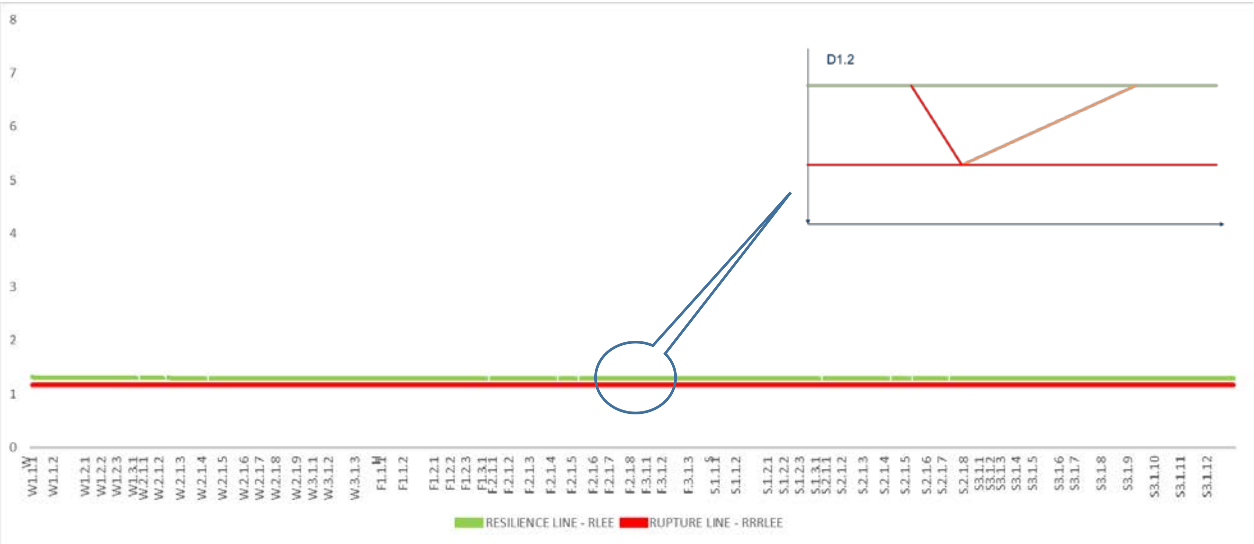


Figure 12. Resilience Line RLEE.

And, as a last result, we get the definition of the target lines proposed in D1.2.

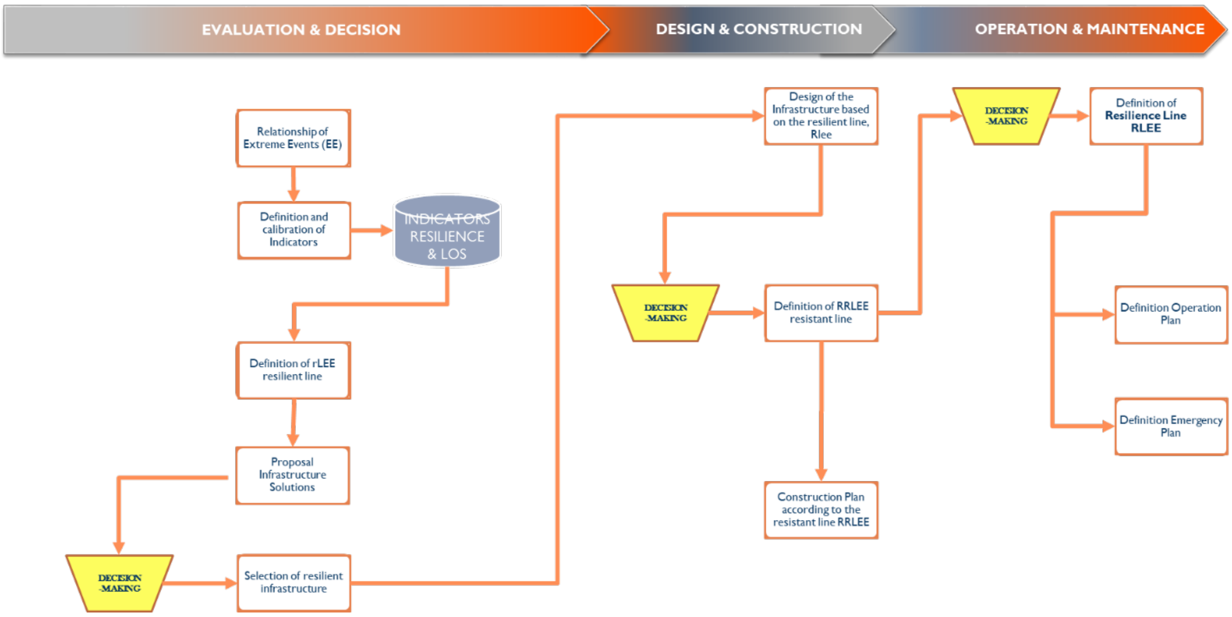


Figure 13. Actions Plan FORESEE Governance.

In short, FORESEE governance is based on:

- (Resilience & LOS) indicators and their specific calibration for each infrastructure and its territory.
- The most suitable trend lines specific to each infrastructure and the (Resilience & LOS) indicators.
- And, Multicriteria Analysis Ragtime for Making Decision.

The FORESEE governance methodology is part of the RAGTIME governance methodology, worked on the specific resilience risk indicators obtained in WP1, Tasks 1.1 and 1.2, to select technical solutions, or contractors, by purely resilient criteria. From the Foresee resilience lines **WP1** and **WP3**.

It is implemented in the FORESEE **WP5** TOOL Kit, as a standalone module, FORESEE Governance module, being possible, since the RAGTIME Governance module is a development methodology of interest to UC, and software offered as a service physically located on TEC (TECNALIA) servers.

And, includes a great contribution, the resilience line of Foresee Governance, which activates the code, protocols, and intervention plans, which are developed in the **WP7**, defined from the results of Tasks 1.1, 1.2, constituting the high-level control line for infrastructure resilience management.

5.2.3 Implementation. FORESEE Governance.

Define of resilience and rupture lines, based on the resilience and service level indicators of infrastructure, simplifies and helps decision-making processes, quickly, justified and simple, throughout the life cycle, which constitute the Foresee Governance.

Implement the use of FORESEE governance, unifies the Project constituting the base reference of the project.

Get approval from the different properties of the infrastructures, case studies, of the FORESEE governance, is a specific challenge that will be carried out, if it is of interest in the WP6 and WP7, in order to consolidate indicators and lines of Governance

Finally, we can become the basis of a future NORMALIZATION of the governance of the infrastructures for extreme events, based on indicators.

6 CONCLUSIONS.

It can therefore be concluded that this deliverable describes how to include resilience and the level of service in the governance of infrastructure assets, in the case of different extreme events, by including the resilience indicators defined in D1.1 and D1.2, in a multi-risk (multi-criteria) methodology, which facilitates the inclusion of such considerations in governance procedures and is resolved by adapting the governance tool developed in the RAGTIME project.

The application of this methodology is implemented in the case studies of FORESEE, and is specified in particular for case 3 Montabliz Viaduct, by using the online solution that serves to help infrastructure owners and contractors incorporate resilience in the management of infrastructure assets throughout the life cycle, introducing these concepts through specific indicators, that would be completed in reality with governance indicators.

The integration of these concepts in governance, improves performance of th infrastructure, as a tool is provided in order to prevent the behaviour and use of infrastructure, from its planning, to the operation and maintenance of the same, through its definition and construction, and possible subsequent actions against extreme events, and it is concluded that:

- The level of objective service and resilience to extreme / disruptive events have been integrated into the governance of infrastructure assets.
- D1.1 and D1.2 definitions and indicators of infrastructure resilience and target service level have been used as input of this task.
- The place of these terms in the asset's life cycle has been identified.
- A simple management methodology that solves the combined use of these terms in governance has been selected.
- A solution methodology has been described according to the multi-criteria, multi-risk proposal for the management of infrastructure asset governance.
- The use of the tool has been verified in the case studies, especially in the 3 Montabliz Viaduct, demonstrating that its use is adequate, that it provides an effective, transparent and automatic aid to the governance of the service and resilience of infrastructures in the face of extreme events, which can be used by all stakeholders and that contemplates the complete life cycle, even at post-event cases.

And the most important thing about Governance is defined Foresee the resilience methodology of the Infrastructure Project throughout its life cycle, by defining the RESILIENCE LINE, based on the LOS, resilience indicators, and resilience targets defined, on D1.1 and D1.2.

And finally, a governance module is obtained as an output with integration of the level of service and resilience of infrastructures against disruptive and / or extreme events, to be implemented in the “WP5 FORESEE Response, Mitigation and Adaptation Toolkit”, where the FORESEE project objective will be developed, providing short and long term resilience measures in rail corridors, roads and multimodal terminals, in the face of extreme events, in addition to defining the framework for the implementation of contingency general plans for extreme events defined in “WP7 FORESEE Resilience scheme application"

"Like This, FORESEE Governance makes Resilience against Events Extreme, the centre of infrastructure governance management, defining methodology and resolution applications".

7 ANNEX.

ANNEX 1. RAGTIME RISK BASED APPROACHES FOR ASSET INTEGRITY MULTIMODAL TRANSPORT INFRASTRUCTURE.

Brief explanation of Project H2020 Ragtime according to paper:

Proceedings of 7th Transport Research Arena TRA 2018, April 16-19, 2018, Vienna, Austria
María Zalbide/ TRA2018, VIenna, Austria, April 16-19, 2018

Conclusions:
There are some important conclusions that arise from the study developed. With respect to the governance risks analysed for transport infrastructures:

- The risks identified in the Governance process are due to the decision-making process, the profitability study, the financing methods, the technical capacity of the property technicians, and the transparency of the entire management process.
- The proposed evaluation of Governance risks can be done through the experience of the property experts (administration divisions and related entities), by valuing from 0 to 1 the perceived risk. The values not exceeding 0.25 represent a low risk as far as its intrinsic value, while the values closer to 1 represent higher risks with values of the order of the infrastructure costs or higher (millions of euros).
- The legal framework significantly affects the governance risk and is considered as the main risk mitigation method to apply.
- The greater risks of governance according to the legal framework can occur in the concession contracts, where the concessionaire is involved in the planning phase of the infrastructure.
- The governance risk is greater during the decision-making and planning phase, and coincides with the legal framework of the concession.

Regarding operational risks, the state of the art performed in these months laid the foundation for the next steps of the projects. In order to fill in the gap in the literature, one of the main objective of RAGTIME is to implement a new risk-based approach on the transport infrastructure field. The specific Risk Strategy approach will be able to consider the "risk-related" aspects from planning and design, to the delivery, deployment and management of a generic transport infrastructure. This strategy will raise the awareness of the risks of the infrastructure by providing suitable instruments for addressing and managing risks. Potential cost savings on the operational losses through the implementation of a more effective analysis of the risk processes and an identification of the best measures to mitigate risk will be also studied through specific and dedicated solutions.

Finally, for the technical management of risks a proper identification of risks is crucial, as one of the first steps to be subsequently managed based on interpreted information that provides value and supports decisions of action and prioritization, is the basis of an advanced asset management system as RAGTIME intends to achieve.

The full infrastructure lifecycle perspective makes it necessary to reflect on the participating actors as well as the different phases that take place in the infrastructure, as well as the potential risks or causes of technical risks, which in a direct or indirect way affect the level of service with the social and economic consequences. Therefore, it is necessary to keep in mind at all times the triangle formed by: stakeholders, life cycle and typology of risks such as technical, which are also classified according to type and class, to ensure the level of service, whose objectives defined generally in green, cost-efficient, social / inclusive, resilient and safe / secure have their implication.

After analyzing the different considerations that are taken into account today, in the life cycle of the transport infrastructure, as well as the analysis of events collected in the past in the four transport modes, 104 causes of risks or technical risks have been identified, which has been grouped into 5 clusters depending on their nature: contractual; data; design and calculations; building and civil works and, unintentional hazards, natural disasters and intentional threats.

After the identification of the technical risks, a final analysis has been made taking into account the transport mode, life cycle phases and stakeholders as criterion, setting two and leaving one as a variable. Thus, the objective of this analysis is to evaluate and preview the relative weight of each technical risk on each of the criteria.[8]

ANNEX 2. CASE STUDY 3. Forese Governance Indicators throughout the lifecycle, according to extreme event, based on indicators defined in D1.1.

						LIFE CYCLE: EVALUATION & DECISSION			LIFE CYCLE: DESIGN & CONSTRUCTION		LIFE CYCLE: OPERATION & MAINTENANCE
RISK	ID	Indicator	Number of possible values	Number of possible values Possible values and meaning		PLAN	VIABILITY STUDY	PREVIOUS DRAFT	DRAFT	WORK PLAN	OPERATION PLAN
WIND	W										
	W1.1.1	Age / Age of replacement of the warning system	3	0/3 1/3 2/3 3/3	> 80% of the expected life time achieved** > 50%,< 80% of expected life time achieved** > 20%,< 50% of expected life time achieved** < 20% of expected life time achieved**						1
	W1.1.2	Condition state of protective structures/systems	5	0/5 1/5 2/5 3/5 4/5 5/5	Condition State 5: A condition in which it is highly likely that the systems would fail under normal traffic loads over the next 20 years I don't know. No information are available on the condition state of the infrastructure. Condition State 4: Bad (A condition in which it is moderately likely that the systems would fail under normal traffic loads over the next 20 years) Condition State 3: Good (A condition in which it is unlikely that the systems would fail under normal traffic loads over the next 20 years) Condition State 2: Very good (A condition in which it is very unlikely that the systems would fail under normal traffic loads over the next 20 years) Condition State 1: Excellent A condition in which it is extremely unlikely that the systems would fail under normal traffic loads over the next 20 years						1
	W1.2.1	The possibility of using another means to satisfy transport demand	2	0/2 1/2 2/2	No alternative means 1 alternative mean Multiple alternative means	1	1	1	1		1
	W1.2.2	The number of possible existing alternative ways to deviate vehicles	2	0/2 1/2 2/2	No alternative ways 1 alternative way Multiple alternative ways	1	1	1	1		1
	W1.2.3	The presence of a warning system	2	0/2 1/2 2/2	No warning systems 1 warning system Multiple warning systems				1	1	1
	W1.3.1	Adequacy of hazard effect reduction system (barriers to wind)	1	0/1 1/1	Not adequate Adequate				1		1
	W.2.1.1	Height*	2	0/2 1/2 2/2	> 3meters < 3meters At the same level	1	1	1	1	1	1
	W.2.1.2	Frequency of past hazards	3	0/3 1/3 2/3 3/3	> 10 events per year > 7, < 10 events per year > 3, < 7 events per year < 3 events per year	1	1	1	1	1	1
	W.2.1.3	Severity of past hazards	3	0/3 1/3 2/3 3/3	Infrastructure’s collapse Serious damage Minor damage Aesthetic damages	1	1	1	1	1	1
	W.2.1.4	Frequency of future hazards	3	0/3 1/3 2/3 3/3	2 weeks 1-2 weeks 1 day- 1 week 0 days	1	1	1	1	1	1
	W.2.1.5	Severity of future hazards	3	0/3 1/3 2/3 3/3	Strong increase Soft increase Soft decrease Strong decrease	1	1	1	1	1	1
	W.2.1.6	Extent of past damages due to hazards	2	1/3 2/3 3/3	Serious damage Minor damage Aesthetic damages	1	1	1	1	1	1
	W.2.1.7	Duration of past down time due to hazards	2	0/2 1/2 2/2	< than 1 day 1-3 days > than 3 days	1	1	1	1		1
	W.2.1.8	Traffic*	3	0/3 1/3 2/3 3/3	< 20% of capacity > 20%,< 50% of capacity > 50%,< 80% of capacity > 80% of capacity	1	1	1	1		1
	W.2.1.9	Hazards goods traffic*	2	0/2 1/2 2/2	Frequent dangerous goods Rare dangerous goods No dangerous goods	1	1	1	1		1
	W.3.1.1	The presence of an emergency plan	2	0/2 1/2 2/2	No plan Generic plan Operative plan (with tasks, resources, ...)						1
	W.3.1.2	Practice of the emergency plan	4	0/4 1/4 2/4 3/4 4/4	No exercise 1 exercise every > than 2 years 1 exercise every 2 years 1 exercise every year 1 exercise every 6 months						1
	W.3.1.3	Review/update of the emergency plan	2	0/2 1/2 2/2	< 2 years ago < 5 years ago > 5 years ago						1

Table 9. WIND Index & Life cycle Project Documents.

						LIFE CYCLE					
						EVALUATION & DECISSION			DESIGN & CONSTRUCTION		OPERATION & MAINTENANCE
RISK	ID	Indicator	Number of possible values	Number of possible values Possible values and meaning		PLAN	VIABILITY STUDY	PREVIOUS DRAFT	DRAFT	WORK PLAN	OPERATION PLAN
FOG	H										
	F1.1.1	Age / Age of replacement of the warning system	3	0/3 1/3 2/3 3/3	> 80% of the expected life time achieved** > 50%,< 80% of expected life time achieved** > 20%,< 50% of expected life time achieved** < 20% of expected life time achieved**						1
	F1.1.2	Condition state of protective structures/systems	5	0/5 1/5 2/5 3/5 4/5 5/5	Condition State 5: A condition in which it is highly likely that the systems would fail under normal traffic loads over the next 20 years I don't know. No information are available on the condition state of the infrastructure. Condition State 4: Bad (A condition in which it is moderately likely that the systems would fail under normal traffic loads over the next 20 years) Condition State 3: Good (A condition in which it is unlikely that the systems would fail under normal traffic loads over the next 20 years) Condition State 2: Very good (A condition in which it is very unlikely that the systems would fail under normal traffic loads over the next 20 years) Condition State 1: Excellent A condition in which it is extremely unlikely that the systems would fail under normal traffic loads over the next 20 years						1
	F1.2.1	The possibility of using another means to satisfy transport demand	2	0/2 1/2 2/2	No alternative means 1 alternative mean Multiple alternative means	1	1	1	1		1
	F1.2.2	The number of possible existing alternative ways to deviate vehicles	2	0/2 1/2 2/2	No alternative ways 1 alternative way Multiple alternative ways	1	1	1	1		1
	F1.2.3	The presence of a warning system	2	0/2 1/2 2/2	No warning systems 1 warning system Multiple warning systems				1	1	1
	F1.3.1	Adequacy of hazard effect reduction system (pavement lines and visibility sticks)	1	0/1 1/1	Not adequate Adequate				1		1
	F.2.1.1	Height*	2	0/2 1/2 2/2	> 3meters < 3meters At the same level	1	1	1	1		1
	F.2.1.2	Frequency of past hazards	3	0/3 1/3 2/3 3/3	> 10 events per year > 7, < 10 events per year > 3, < 7 events per year < 3 events per year	1	1	1	1	1	1
	F.2.1.3	Severity of past hazards	3	0/3 1/3 2/3 3/3	Infrastructure's collapse Serious damage Minor damage Aesthetic damages	1	1	1	1	1	1
	F.2.1.4	Frequency of future hazards	3	0/3 1/3 2/3 3/3	2 weeks 1-2 weeks 1 day- 1 week 0 days	1	1	1	1	1	1
	F.2.1.5	Severity of future hazards	3	0/3 1/3 2/3 3/3	Strong increase Soft increase Soft decrease Strong decrease	1	1	1	1	1	1
	F.2.1.6	Duration of past down time due to hazards	2	0/2 1/2 2/2	< than 1 day 1-3 days > than 3 days	1	1	1	1	1	1
	F.2.1.7	Traffic*	3	0/3 1/3 2/3 3/3	< 20% of capacity > 20%,< 50% of capacity > 50%,< 80% of capacity > 80% of capacity	1	1	1	1		1
	F.2.1.8	Hazards goods traffic*	2	0/2 1/2 2/2	Frequent dangerous goods Rare dangerous goods No dangerous goods	1	1	1	1		1
	F.3.1.1	The presence of an emergency plan	2	0/2 1/2 2/2	No plan Generic plan Operative plan (with tasks, resources, ...)						1
	F.3.1.2	Practice of the emergency plan	4	0/4 1/4 2/4 3/4 4/4	No exercise 1 exercise every > than 2 years 1 exercise every 2 years 1 exercise every year 1 exercise every 6 months						1
	F.3.1.3	Review/update of the emergency plan	2	0/2 1/2 2/2	< 2 years ago < 5 years ago > 5 years ago						1

Table 10. FOG Index & Life cycle Project Documents.

					LIFE CYCLE					
					EVALUATION & DECISSION			DESIGN & CONSTRUCTION		OPERATION & MAINTENANCE
RISK	ID	Indicator	Number of possible values	Number of possible values Possible values and meaning	PLAN	VIABILITY STUDY	PREVIOUS DRAFT	DRAFT	WORK PLAN	OPERATION PLAN
SNOWFALL	S									
	S.1.1.1	Age / Age of replacement of the warning system	3	0/3 > 80% of the expected life time achieved** 1/3 > 50%,< 80% of expected life time achieved** 2/3 > 20%,< 50% of expected life time achieved** 3/3 < 20% of expected life time achieved**						1
	S.1.1.2	Condition state of protective structures/systems	5	0/5 Condition State 5: A condition in which it is highly likely that the systems would fail under normal traffic loads over the next 20 years 1/5 I don't know. No information are available on the condition state of the infrastructure. 2/5 Condition State 4: Bad (A condition in which it is moderately likely that the systems would fail under normal traffic loads over the next 20 years) 3/5 Condition State 3: Good (A condition in which it is unlikely that the systems would fail under normal traffic loads over the next 20 years) 4/5 Condition State 2: Very good (A condition in which it is very unlikely that the systems would fail under normal traffic loads over the next 20 years) 5/5 Condition State 1: Excellent A condition in which it is extremely unlikely that the systems would fail under normal traffic loads over the next 20 years						1
	S.1.2.1	The possibility of using another means to satisfy transport demand	2	0/2 No alternative means 1/2 1 alternative mean 2/2 Multiple alternative means	1	1	1	1		1
	S.1.2.2	The number of possible existing alternative ways to deviate vehicles	2	0/2 No alternative ways 1/2 1 alternative way 2/2 Multiple alternative ways	1	1	1	1		1
	S.1.2.3	The presence of a warning system	2	0/2 No warning systems 1/2 1 warning system 2/2 Multiple warning systems				1		1
	S.1.3.1	Adequacy of hazard effect reduction system (barriers to snow)	1	0/1 Not adequate 1/1 Adequate				1		1
	S.2.1.1	Height*	2	0/2 >3meters 1/2 <3meters 2/2 At the same level	1	1	1	1		1
	S.2.1.2	Frequency of past hazards	3	0/3 > 5 events per year 1/3 > 2, < 5 events per year 2/3 > 1, < 2 events per year 3/3 1 events per year	1	1	1	1	1	1
	S.2.1.3	Severity of past hazards	3	0/3 Infrastructure's collapse 1/3 Serious damage 2/3 Minor damage 3/3 Aesthetic damages	1	1	1	1	1	1
	S.2.1.4	Frequency of future hazards	3	0/3 2 weeks 1/3 1-2 weeks 2/3 1 day- 1 week 3/3 0 days	1	1	1	1	1	1
	S.2.1.5	Severity of future hazards	3	0/3 Strong increase 1/3 Soft increase 2/3 Soft decrease 3/3 Strong decrease	1	1	1	1	1	1
	S.2.1.6	Duration of past down time due to hazards	2	0/2 < than 1 day 1/2 1-3 days 2/2 > than 3 days	1	1	1	1	1	1
	S.2.1.7	Traffic*	3	0/3 < 20% of capacity 1/3 > 20%,< 50% of capacity 2/3 > 50%,< 80% of capacity 3/3 > 80% of capacity	1	1	1	1		1
	S.2.1.8	Hazards goods traffic*	2	0/2 Frequent dangerous goods 1/2 Rare dangerous goods 2/2 No dangerous goods	1	1	1	1		1
	S3.1.1	The presence of a monitoring strategy	1	0/1 No strategy 1/1 Presence of a strategy				1	1	1
	S3.1.2	The presence of an maintenance strategy	1	0/1 No strategy 1/1 Presence of a strategy				1		1
	S3.1.3	The extent of interventions executed prior to the event	2	0/2 No interventions 1/2 Partial interventions 2/2 Full interventions						1
	S3.1.4	The presence of an emergency plan	2	0/2 No plan 1/2 Generic plan 2/2 Operative plan (with tasks, resources, ...)						1
	S3.1.5	Practice of the emergency plan	4	0/4 No exercise 1/4 1 exercise every > than 2 years 2/4 1 exercise every 2 years 3/4 1 exercise every year 4/4 1 exercise every 6 months						1
	S3.1.6	Review/update of the emergency plan	2	0/2 > 5 years ago 1/2 < 5 years ago 2/2 < 2 years ago						1
	S3.1.7	Availability of appropriate labour force	4	0/4 No redundancy 1/4 Redundancy <20% of work forces 2/4 Redundancy >20%, <50% of work forces 3/4 Redundancy >50%, <80% of work forces 4/4 Redundancy >80% of work forces						1
	S3.1.8	Flexibility in hiring appropriate work force	4	0/4 No possibility to hire 1/4 >80% of the estimated time to repair (ETTR) to hire 2/4 >80% of ETTR to hire 3/4 >50%, <80% of ETTR to hire 4/4 < than 20% of ETTR to hire						1
	S3.1.9	Availability of materials	4	0/4 No redundancy 1/4 Redundancy <20% of material 2/4 Redundancy >20%, <50% of material 3/4 Redundancy >50%, <80% of material 4/4 Redundancy >80% of material						1
	S3.1.10	Expected time for material delivery	4	0/4 No possibility to order 1/4 >80% of the estimated time to repair (ETTR) to hire 2/4 >80% of ETTR to order 3/4 >50%, <80% of ETTR to order 4/4 < than 20% of ETTR to order						1
	S3.1.11	Availability of construction equipment	4	0/4 No redundancy 1/4 Redundancy <20% of equipment 2/4 Redundancy >20%, <50% of equipment 3/4 Redundancy >50%, <80% of equipment 4/4 Redundancy >80% of work equipment						1
	S3.1.12	Expected time for construction equipment delivery	4	0/4 No possibility to rent 1/4 >80% of the estimated time to repair (ETTR) to hire 2/4 >80% of ETTR to rent 3/4 >50%, <80% of ETTR to rent 4/4 < than 20% of ETTR to rent						1

Table 11. SNOWFALL Index & Life cycle Project Documents.

ANNEX 3. CASE STUDY 3. Targets for the indicators by Operation & Maintenance, as D1.2.

						CASE STUDY 3					
RISK	ID	Indicator	Number of possible values	Number of possible values Possible values and meaning		Ser&Res.Targets_no BC	Target.indic._no BC	%	Ser&Res.Targets_BC	Target.indic._BC	%
WIND	W										
	W1.1.1	Age / Age of replacement of the warning system	3	0/3	> 80% of the expected life time achieved**		2			2	
				1/3	> 50%,< 80% of expected life time achieved**						
				2/3	> 20%,< 50% of expected life time achieved**						
				3/3	< 20% of expected life time achieved**						
	W1.1.2	Condition state of protective structures/systems	5	0/5	Condition State 5: A condition in which it is highly likely that the systems would fail under normal traffic loads over the next 20 years		3			2	
				1/5	I don't know. No information are available on the condition state of the infrastructure.						
				2/5	Condition State 4: Bad (A condition in which it is moderately likely that the systems would fail under normal traffic loads over the next 20 years)						
				3/5	Condition State 3: Good (A condition in which it is unlikely that the systems would fail under normal traffic loads over the next 20 years)						
				4/5	Condition State 2: Very good (A condition in which it is very unlikely that the systems would fail under normal traffic loads over the next 20 years)						
				5/5	Condition State 1: Excellent A condition in which it is extremely unlikely that the systems would fail under normal traffic loads over the next 20 years						
	W1.2.1	The possibility of using another means to satisfy transport demand	2	0/2	No alternative means		1			2	
				1/2	1 alternative mean						
				2/2	Multiple alternative means						
	W1.2.2	The number of possible existing alternative ways to deviate vehicles	2	0/2	No alternative ways		1	67%		2	100%
				1/2	1 alternative way						
				2/2	Multiple alternative ways						
	W1.2.3	The presence of a warning system	2	0/2	No warning systems		2			1	
				1/2	1 warning system						
				2/2	Multiple warning systems						
	W1.3.1	Adequacy of hazard effect reduction system (barriers to wind)	1	0/1	Not adequate		1	100%		1	100%
				1/1	Adequate						
	W.2.1.1	Height*	2	0/2	> 3meters		0				
				1/2	< 3meters						
				2/2	At the same level						
	W.2.1.2	Frequency of past hazards	3	0/3	> 10 events per year		0	25%		0	25%
				1/3	> 7, < 10 events per year						
				2/3	> 3, < 7 events per year						
				3/3	< 3 events per year						
	W.2.1.3	Severity of past hazards	3	0/3	Infrastructure's collapse		0	25%		2	75%
				1/3	Serious damage						
				2/3	Minor damage						
				3/3	Aesthetic damages						
	W.2.1.4	Frequency of future hazards	3	0/3	2 weeks		0	25%		0	25%
				1/3	1-2 weeks						
				2/3	1 day- 1 week						
				3/3	0 days						
	W.2.1.5	Severity of future hazards	3	0/3	Strong increase		0	25%		2	75%
				1/3	Soft increase						
				2/3	Soft decrease						
				3/3	Strong decrease						
	W.2.1.6	Extent of past damages due to hazards	2	1/3	Serious damage		0				
				2/3	Minor damage						
				3/3	Aesthetic damages						
	W.2.1.7	Duration of past down time due to hazards	2	0/2	< than 1 day		0				
				1/2	1-3 days						
				2/2	> than 3 days						
	W.2.1.8	Traffic*	3	0/3	< 20% of capacity		2	75%		3	100%
				1/3	> 20%,< 50% of capacity						
				2/3	> 50%,< 80% of capacity						
				3/3	> 80% of capacity						
	W.2.1.9	Hazards goods traffic*	2	0/2	Frequent dangerous goods		1	67%		2	100%
				1/2	Rare dangerous goods						
				2/2	No dangerous goods						
	W.3.1.1	The presence of an emergency plan	2	0/2	No plan		2			1	
				1/2	Generic plan						
				2/2	Operative plan (with tasks, resources, ...)						
	W.3.1.2	Practice of the emergency plan	4	0/4	No exercise		2			0	
				1/4	1 exercise every > than 2 years						
				2/4	1 exercise every 2 years						
				3/4	1 exercise every year						
				4/4	1 exercise every 6 months						
	W.3.1.3	Review/update of the emergency plan	2	0/2	< 2 years ago		1			0	
				1/2	< 5 years ago						
				2/2	> 5 years ago						

Table 12. WIND Targets Case Study 3.

RISK	ID	Indicator	Number of possible values	Number of possible values Possible values and meaning		CASE STUDY 3 Ser&Res.Targets_no BC	Target.indic._no BC	%	Ser&Res.Targets_BC	Target.indic._BC	%
FOG	H										
	F1.1.1	Age / Age of replacement of the warning system	3	0/3	> 80% of the expected life time achieved**		1		1	1	
				1/3	> 50%,< 80% of expected life time achieved**						
				2/3	> 20%,< 50% of expected life time achieved**						
				3/3	< 20% of expected life time achieved**						
	F1.1.2	Condition state of protective structures/systems	5	0/5	Condition State 5: A condition in which it is highly likely that the systems would fail under normal traffic loads over the next 20 years		2		4	4	
				1/5	I don't know. No information are available on the condition state of the infrastructure.						
				2/5	Condition State 4: Bad (A condition in which it is moderately likely that the systems would fail under normal traffic loads over the next 20 years)						
				3/5	Condition State 3: Good (A condition in which it is unlikely that the systems would fail under normal traffic loads over the next 20 years)						
				4/5	Condition State 2: Very good (A condition in which it is very unlikely that the systems would fail under normal traffic loads over the next 20 years)						
				5/5	Condition State 1: Excellent A condition in which it is extremely unlikely that the systems would fail under normal traffic loads over the next 20 years						
	F1.2.1	The possibility of using another means to satisfy transport demand	2	0/2	No alternative means		1		3	3	
				1/2	1 alternative mean						
				2/2	Multiple alternative means						
	F1.2.2	The number of possible existing alternative ways to deviate vehicles	2	0/2	No alternative ways		1	67%	2	2	100%
				1/2	1 alternative way						
				2/2	Multiple alternative ways						
	F1.2.3	The presence of a warning system	2	0/2	No warning systems		2		2	2	
				1/2	1 warning system						
				2/2	Multiple warning systems						
	F1.3.1	Adequacy of hazard effect reduction system (pavement lines and visibility sticks)	1	0/1	Not adequate		1	50%	0		50%
				1/1	Adequate						
	F.2.1.1	Height*	2	0/2	> 3meters		0				
				1/2	< 3meters						
				2/2	At the same level						
	F.2.1.2	Frequency of past hazards	3	0/3	> 10 events per year		0	33%		0	33%
				1/3	> 7, < 10 events per year						
				2/3	> 3, < 7 events per year						
				3/3	< 3 events per year						
	F.2.1.3	Severity of past hazards	3	0/3	Infrastructure's collapse		0	25%		2	75%
				1/3	Serious damage						
				2/3	Minor damage						
				3/3	Aesthetic damages						
	F.2.1.4	Frequency of future hazards	3	0/3	2 weeks		0	33%		0	33%
				1/3	1-2 weeks						
				2/3	1 day- 1 week						
				3/3	0 days						
	F.2.1.5	Severity of future hazards	3	0/3	Strong increase		0	33%		2	100%
				1/3	Soft increase						
				2/3	Soft decrease						
				3/3	Strong decrease						
	F.2.1.6	Duration of past down time due to hazards	2	0/2	< than 1 day		0				
				1/2	1-3 days						
				2/2	> than 3 days						
	F.2.1.7	Traffic*	3	0/3	< 20% of capacity		2	75%		1	50%
				1/3	> 20%,< 50% of capacity						
				2/3	> 50%,< 80% of capacity						
				3/3	> 80% of capacity						
	F.2.1.8	Hazards goods traffic*	2	0/2	Frequent dangerous goods		1	67%		2	100%
				1/2	Rare dangerous goods						
				2/2	No dangerous goods						
	F.3.1.1	The presence of an emergency plan	2	0/2	No plan		2			2	
				1/2	Generic plan						
				2/2	Operative plan (with tasks, resources, ...)						
	F.3.1.2	Practice of the emergency plan	4	0/4	No exercise		2			1	
				1/4	1 exercise every > than 2 years						
				2/4	1 exercise every 2 years						
				3/4	1 exercise every year						
				4/4	1 exercise every 6 months						
	F.3.1.3	Review/update of the emergency plan	2	0/2	< 2 years ago		1			0	
				1/2	< 5 years ago						
				2/2	> 5 years ago						

Table 13. FOG Targets Case Study 3.

RISK	ID	Indicator	Number of possible values	Number of possible values Possible values and meaning		CASE STUDY 3 Ser&Res.Targets_no BC	Target.indic._no BC	%	Ser&Res.Targets_BC	Target.indic._BC	%
SNOWFALL	S										
	S.1.1.1	Age / Age of replacement of the warning system	3	0/3	> 80% of the expected life time achieved**		2			2	
				1/3	> 50%,< 80% of expected life time achieved**						
				2/3	> 20%,< 50% of expected life time achieved**						
				3/3	< 20% of expected life time achieved**						
	S.1.1.2	Condition state of protective structures/systems	5	0/5	Condition State 5: A condition in which it is highly likely that the systems would fail under normal traffic loads over the next 20 years		3			4	
				1/5	I don't know. No information are available on the condition state of the infrastructure.						
				2/5	Condition State 4: Bad (A condition in which it is moderately likely that the systems would fail under normal traffic loads over the next 20 years)						
				3/5	Condition State 3: Good (A condition in which it is unlikely that the systems would fail under normal traffic loads over the next 20 years)						
				4/5	Condition State 2: Very good (A condition in which it is very unlikely that the systems would fail under normal traffic loads over the next 20 years)						
				5/5	Condition State 1: Excellent A condition in which it is extremely unlikely that the systems would fail under normal traffic loads over the next 20 years						
	S.1.2.1	The possibility of using another means to satisfy transport demand	2	0/2	No alternative means		1			3	
				1/2	1 alternative mean						
				2/2	Multiple alternative means						
	S.1.2.2	The number of possible existing alternative ways to deviate vehicles	2	0/2	No alternative ways		1	67%		2	100%
				1/2	1 alternative way						
				2/2	Multiple alternative ways						
	S.1.2.3	The presence of a warning system	2	0/2	No warning systems		2			0	
				1/2	1 warning system						
				2/2	Multiple warning systems						
	S.1.3.1	Adequacy of hazard effect reduction system (barriers to snow)	1	0/1	Not adequate		1	100%		1	100%
				1/1	Adequate						
	S.2.1.1	Height*	2	0/2	>3meters						
				1/2	<3meters						
				2/2	At the same level						
	S.2.1.2	Frequency of past hazards	3	0/3	> 5 events per year			25%		1	50%
				1/3	> 2, < 5 events per year						
				2/3	> 1, < 2 events per year						
				3/3	1 events per year						
	S.2.1.3	Severity of past hazards	3	0/3	Infrastructure's collapse			25%		1	50%
				1/3	Serious damage						
				2/3	Minor damage						
				3/3	Aesthetic damages						
	S.2.1.4	Frequency of future hazards	3	0/3	2 weeks			25%		0	25%
				1/3	1-2 weeks						
				2/3	1 day- 1 week						
				3/3	0 days						
	S.2.1.5	Severity of future hazards	3	0/3	Strong increase			25%		0	25%
				1/3	Soft increase						
				2/3	Soft decrease						
				3/3	Strong decrease						
	S.2.1.6	Duration of past down time due to hazards	2	0/2	< than 1 day						
				1/2	1-3 days						
				2/2	> than 3 days						
	S.2.1.7	Traffic*	3	0/3	< 20% of capacity		2	75%		3	100%
				1/3	> 20%,< 50% of capacity						
				2/3	> 50%,< 80% of capacity						
				3/3	> 80% of capacity						
	S.2.1.8	Hazards goods traffic*	2	0/2	Frequent dangerous goods		1	67%		2	100%
				1/2	Rare dangerous goods						
				2/2	No dangerous goods						
	S3.1.1	The presence of a monitoring strategy	1	0/1	No strategy		1			1	
				1/1	Presence of a strategy						
	S3.1.2	The presence of an maintenance strategy	1	0/1	No strategy		1			1	
				1/1	Presence of a strategy						
	S3.1.3	The extent of interventions executed prior to the event	2	0/2	No interventions		2	100%		2	100%
				1/2	Partial interventions						
				2/2	Full interventions						
	S3.1.4	The presence of an emergency plan	2	0/2	No plan		2			1	
				1/2	Generic plan						
				2/2	Operative plan (with tasks, resources, ...)						
	S3.1.5	Practice of the emergency plan	4	0/4	No exercise		2			1	
				1/4	1 exercise every > than 2 years						
				2/4	1 exercise every 2 years						
				3/4	1 exercise every year						
				4/4	1 exercise every 6 months						
	S3.1.6	Review/update of the emergency plan	2	0/2	> 5 years ago		1			1	
				1/2	< 5 years ago						
				2/2	< 2 years ago						
	S3.1.7	Availability of appropriate labour force	4	0/4	No redundancy		2			0	
				1/4	Redundancy <20% of work forces						
				2/4	Redundancy >20%, <50% of work forces						
				3/4	Redundancy >50%, <80% of work forces						
				4/4	Redundancy >80% of work forces						
	S3.1.8	Flexibility in hiring appropriate work force	4	0/4	No possibility to hire		3			0	
				1/4	>80% of the estimated time to repair (ETTR) to hire						
				2/4	>80% of ETTR to hire						
				3/4	>50%, <80% of ETTR to hire						
				4/4	< than 20% of ETTR to hire						
	S3.1.9	Availability of materials	4	0/4	No redundancy		1			0	
				1/4	Redundancy <20% of material						
				2/4	Redundancy >20%, <50% of material						
				3/4	Redundancy >50%, <80% of material						
				4/4	Redundancy >80% of material						
	S3.1.10	Expected time for material delivery	4	0/4	No possibility to order		1			0	
				1/4	>80% of the estimated time to repair (ETTR) to hire						
				2/4	>80% of ETTR to order						
				3/4	>50%, <80% of ETTR to order						
				4/4	< than 20% of ETTR to order						
	S3.1.11	Availability of construction equipment	4	0/4	No redundancy		2			0	
				1/4	Redundancy <20% of equipment						
				2/4	Redundancy >20%, <50% of equipment						
				3/4	Redundancy >50%, <80% of equipment						
				4/4	Redundancy >80% of work equipment						
	S3.1.12	Expected time for construction equipment delivery	4	0/4	No possibility to rent		2			1	
				1/4	>80% of the estimated time to repair (ETTR) to hire						
				2/4	>80% of ETTR to rent						
				3/4	>50%, <80% of ETTR to rent						
				4/4	< than 20% of ETTR to rent						

Table 14. SNOWFALL Targets Case Study 3.

REFERENCES.

European Union's Horizon 2020 research and innovation programme under grant agreement No. 690660. (2019). RAGTIME Innovative Asset Management, "Risk based approaches for asset integrity multimodal transport infrastructure management".

[1] RAGTIME: Risk based approaches for Asset inteGrity multimodal Transport Infrastructure ManagEment.
[2] Good Governance for Critical Infrastructure Resilience. Critical infrastructures are the backbone of modern, interconnected economies. The disruption of key systems and essential services - such as telecommunications, energy or water supply, transportation or finance - can cause substantial economic damage. This report looks at how to boost critical infrastructure resilience in a dynamic risk landscape, and discusses policy options and governance models to promote up-front resilience investments. Based on an international survey, the report analyses the progressive shift of critical infrastructure policies from asset protection to system resilience. The findings are reflected in a proposed Policy Toolkit for the Governance of Critical Infrastructure Resilience, which can guide governments in taking a more coherent, preventive approach to protecting and sustaining essential services. Published on April 17, 2019.
[3] The governance module of the RAGTIME project was developed to mitigate internal infrastructure risks, based on governance, technical and financial indicators, FORESEE will apply this same module, but to decide the resilience and level of objective service based on indicators mitigated, external risks, disruptive events and/or extremes of a natural and/or mam-made nature.
[4] Adapted FORESEE Governance Tool, from the RAGTIME Tool.
[5] FORESEE Governance Tool conditions, 5 indexes.
[6] According to RAGTIME Governance Model.
[7] According to RAGTIME Governance Model.
[8] RAGTIME Risk based approaches for Asset inteGrity multimodal Transport Infrastructure. Tecnalia (María ZALBIDE , David GARCÍA, Jon AURTENETXE, Jose Luis IZKARA), RINA (Clemente FUGGINI), AISCAT (Federico DI GENNARO), Universidad de Cantabria (Mª Antonia PEREZ), AON (Claudia PANI)