- FORESEE -

Future proofing strategies FOr RESilient transport networks against Extreme Events

– Deliverable *1.3* –

Examples of using Levels of Service and resilience in governance

Integration of Level of Service and resilience measures for governance.

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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 RAGTIME[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.

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.

To achieve this objective, the governance bases defined in the RAGTIME project are used, where the indicators and governance targets are complemented with those of service and resilience, establishing preference criteria, to compare and evaluate both the different technical solutions that solve the process, and the selection of external contractors involved in it.

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.

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

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.
- 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.

However, many of the governance objectives, in terms of making infrastructure more resilient, are based on information obtained from past experiences with failed / affected infrastructure, such failures are not statistically numerous, and the causes are varied. In order to determine the optimal actions that should be undertaken when infrastructures are exposed to different risks, it is necessary to evaluate the different contributing factors in a combined manner. (Annex 1).

3.1 EXAMPLES OF RESILIENCE USE IN GOVERNANCE - LESSONS FROM THE PAST.

The following example shows the use of the concepts of service and resilience in governance:

EXAMPLE - 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.

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 al**l, 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.

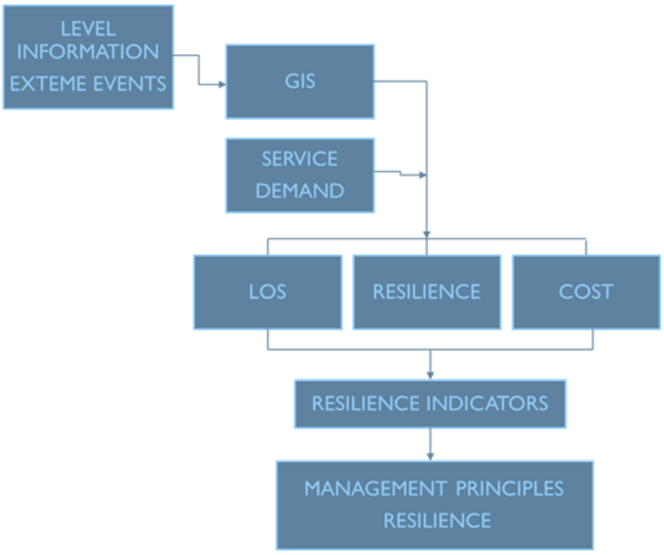


Figure 1. FORESEE Project Flow.

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.

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[2] 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 1).

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.

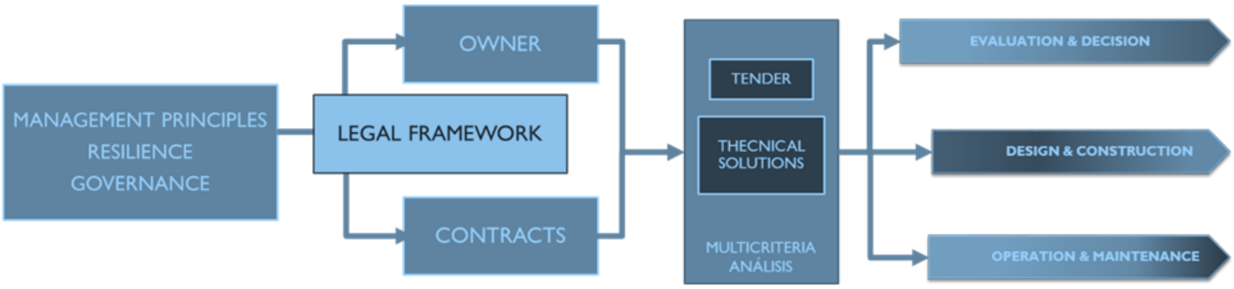


Figure 2. Governance Flow by simple management principles.

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 is:

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.

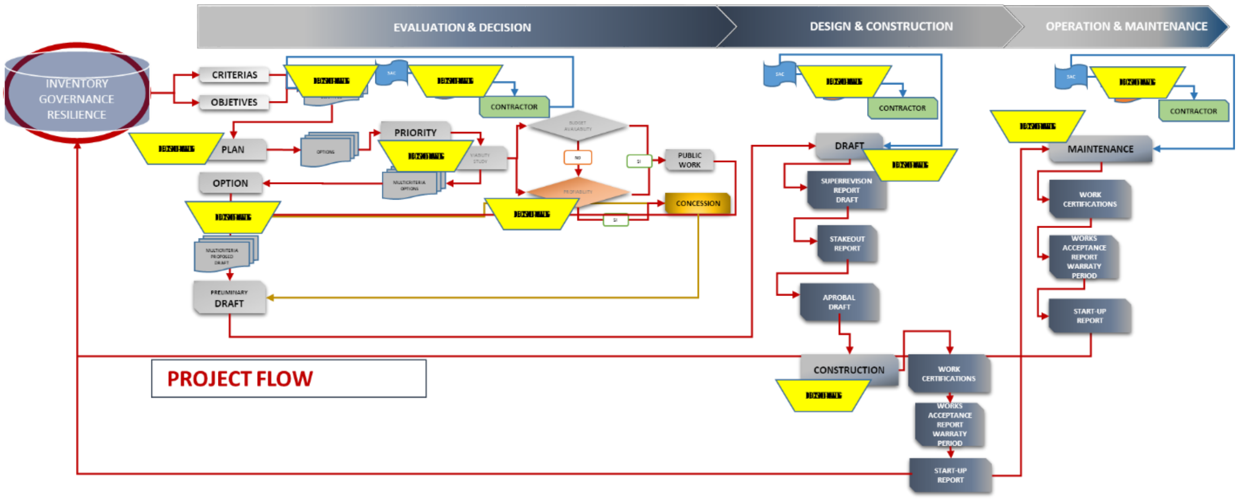


Figure 3. Management principles, life cycle assets infrastructure.

- 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 1).

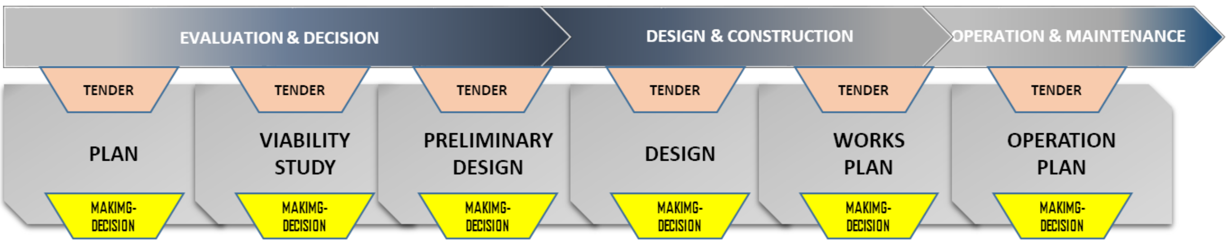


Figure 4. Documents & Phases of the Project, with Tender & Decision Making.

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

Fourth, create the FORESEE Governance tool, http://foresee.transmodalbots.com/[3]

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[4].

5 IMPLEMENTATION EXAMPLE OF FORESEE GOVERNANCE. METHODOLOGIES TO 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 1. Case Study 3 MONTABLIZ Viaduct. FEATURES.

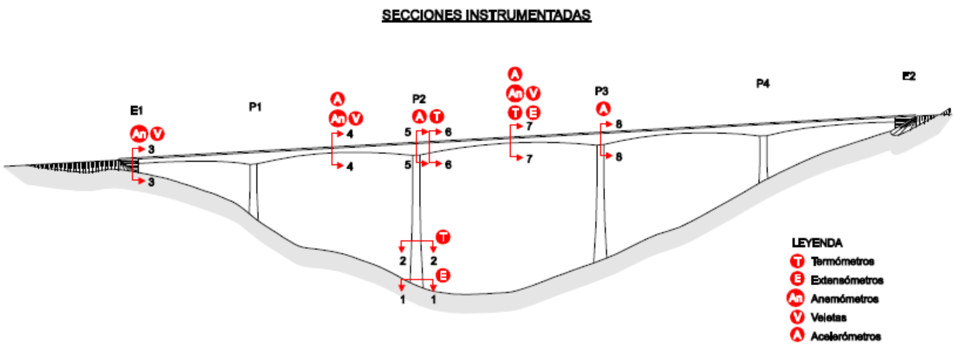


Figure 5. Case Study 3 MONTABLIZ Viaduct. Scheme.

1.1 PHASE: EVALUATION & DECISION.

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

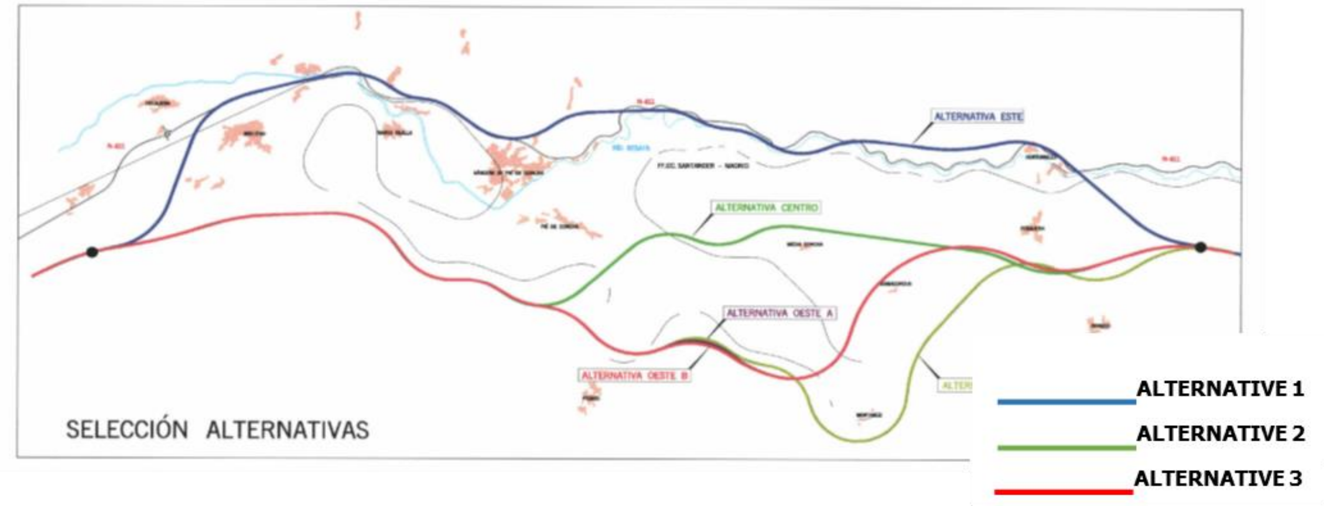


Figure 6. Case Study 3 MONTABLIZ Viaduct. Draft Alternatives.

– INPUTS:

								E&D		
						DOCUMENT:		PREVIOUS DRAFT		
						MAIKING DECISION:		PREVIOUS DRAFT ALTERNATIVE		
						SATKEHOLDER		OWNER		
						CASE STUDY 3		ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 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 2. Case Study 3 Index-Targets. E&D

– OUTPUTS:

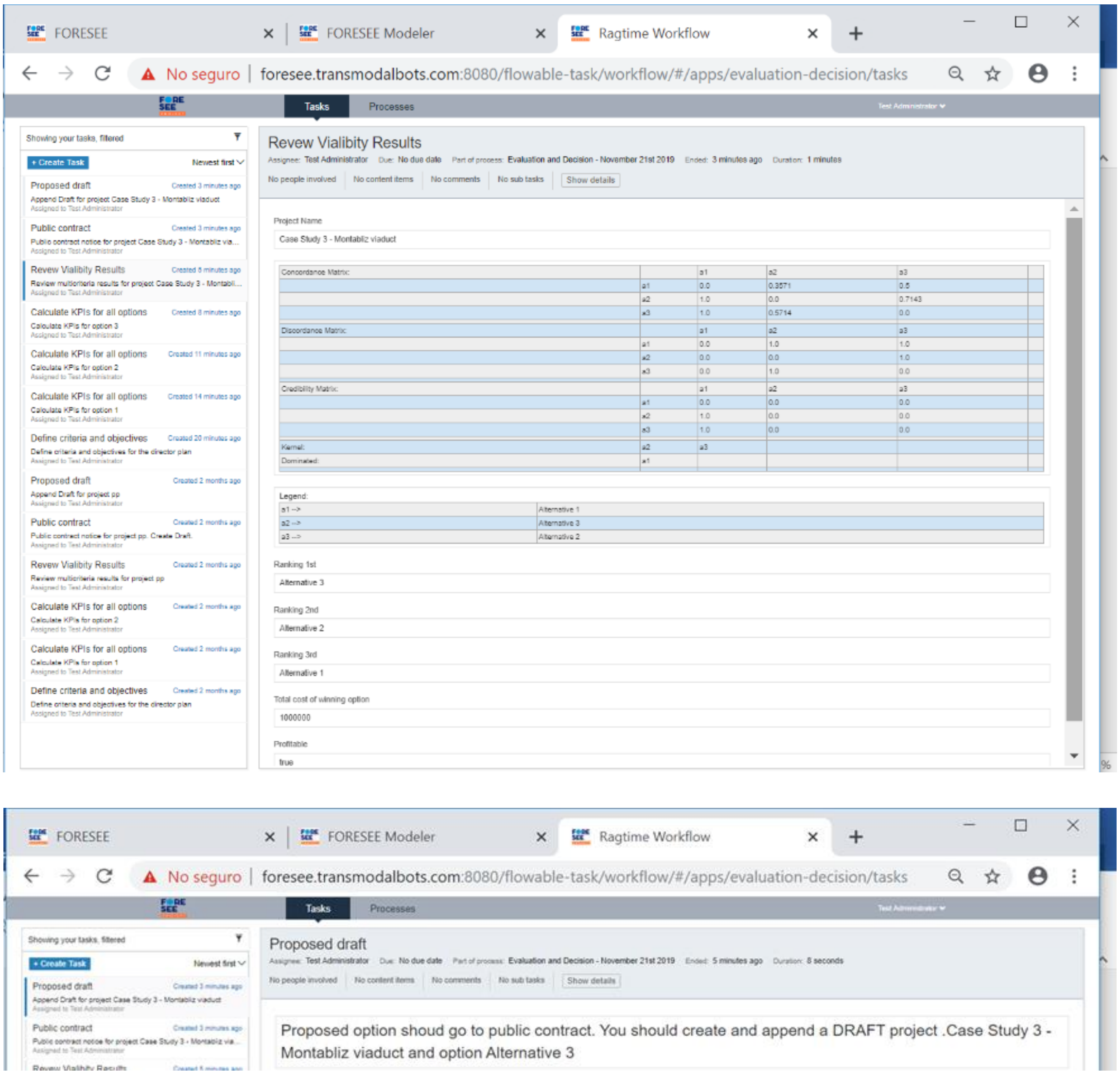


Table 3. Case Study 3. Results Draft Alternatives E&D

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 4. Case Study 3 Index-Targets. D&C

– OUTPUTS:

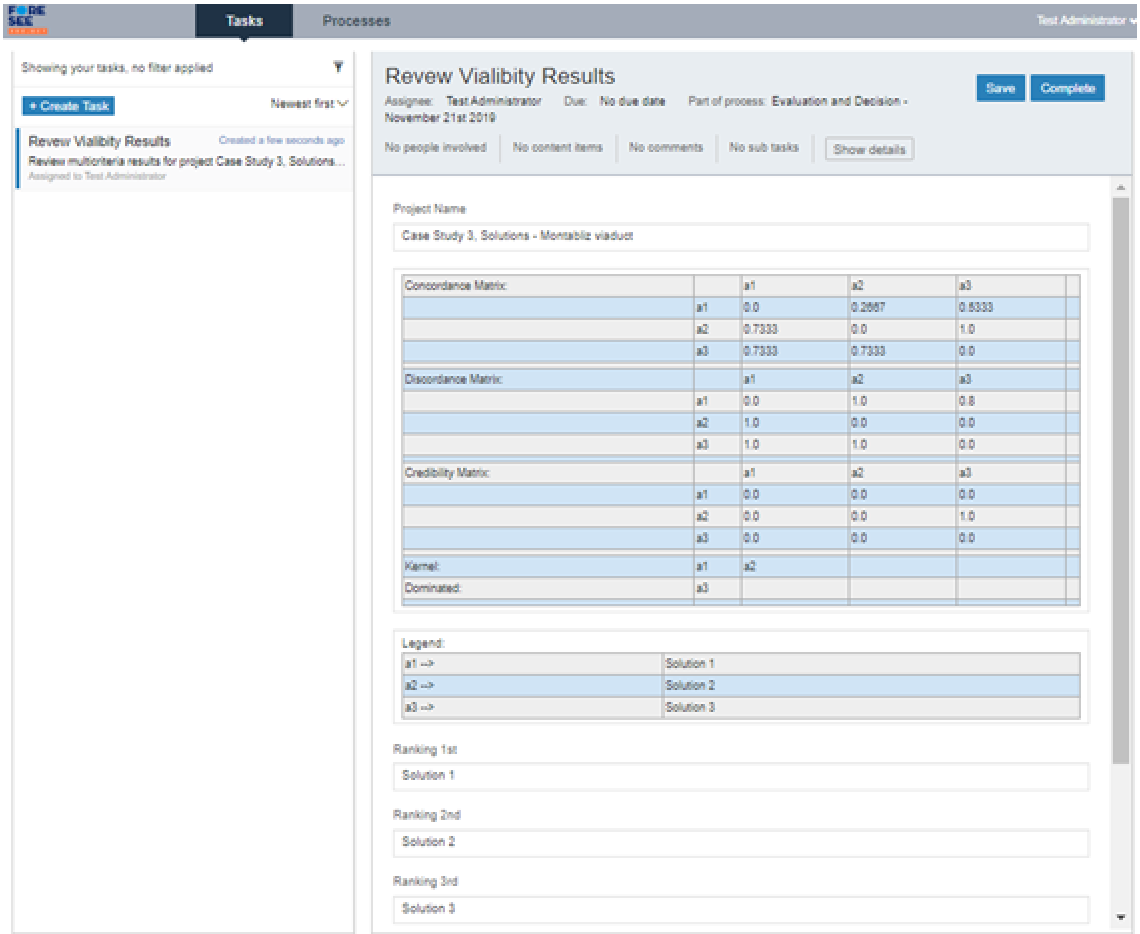


Table 5. Case Study 3 Results Solutions Draft D&C

1.3 PHASE: OPERATION & MAINTENANCE.

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

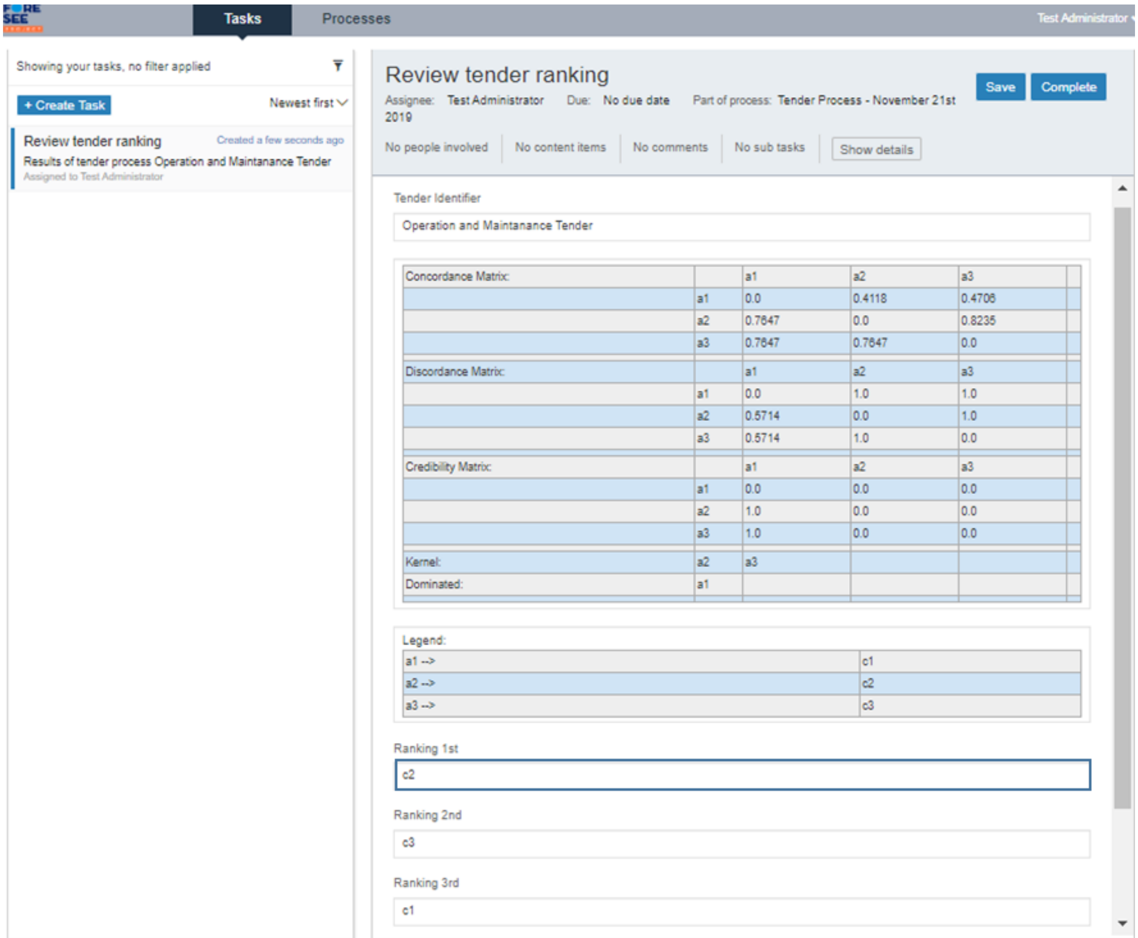
	O&M
DOCUMENT:	Tender OPERATOR
MAIKING DECISION:	OPERATION & MAINTENANCE A
SATKEHOLDER	OPERATOR

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 6. Case Study 3 Index-Targets O&M

– OUTPUTS:



Concordance Matrix:		a1	a2	a3
	a1	0.0	0.4118	0.4706
	a2	0.7647	0.0	0.8235
	a3	0.7647	0.7647	0.0
Discordance Matrix:		a1	a2	a3
	a1	0.0	1.0	1.0
	a2	0.5714	0.0	1.0
	a3	0.5714	1.0	0.0
Credibility Matrix:		a1	a2	a3
	a1	0.0	0.0	0.0
	a2	1.0	0.0	0.0
	a3	1.0	0.0	0.0
Kernel:	a2	a3		
Dominated:	a1			

Table 7. Case Study 3 Results Tender Operator O&M

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 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.

All this given that the FORESEE project, which studies in detail the influence of extreme events, (external risks: natural and man-made), on the resilience and level of service of the infrastructures, is a complement to the overall project of infrastructure management that is the RAGTIME project, therefore FORESEE, should be based on the overall structure of the RAGTIME project.

7 ANNEX.

7.1 ANNEX 1

						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
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 8. WIND Index & Life cycle Project Documents.

RISK	ID	Indicator	Number of possible values	Number of possible values Possible values and meaning		PLAN (EVALUATION & DECISSION)	VIABILITY STUDY (EVALUATION & DECISSION)	PREVIOUS DRAFT (EVALUATION & DECISSION)	DRAFT (DESIGN & CONSTRUCTION)	WORK PLAN (DESIGN & CONSTRUCTION)	OPERATION PLAN (OPERATION & MAINTENANCE)
FOG	H										
	F1.1.1	Age / Age of replacement of the warning system	3	0/3	> 80% of the expected life time achieved**						1
				1/3	> 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						1
				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	1	1	1		1
				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	1	1	1		1
				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				1	1	1
				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		1
				1/1	Adequate						
	F.2.1.1	Height*	2	0/2	> 3meters	1	1	1	1		1
				1/2	< 3meters						
				2/2	At the same level						
	F.2.1.2	Frequency of past hazards	3	0/3	> 10 events per year	1	1	1	1	1	1
				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	1	1	1	1	1	1
				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	1	1	1	1	1	1
				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	1	1	1	1	1	1
				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	1	1	1	1	1	1
				1/2	1-3 days						
				2/2	> than 3 days						
	F.2.1.7	Traffic*	3	0/3	< 20% of capacity	1	1	1	1		1
				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	1	1	1		1
				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						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
				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
				1/2	< 5 years ago						
				2/2	> 5 years ago						

Table 9. 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 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
	S.1.1.2	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
	S.1.2.1	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
	S.1.2.2	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
	S.1.2.3	The presence of a warning system	2	0/2 1/2 2/2	No warning systems 1 warning system Multiple warning systems				1		1
	S.1.3.1	Adequacy of hazard effect reduction system (barriers to snow)	1	0/1 1/1	Not adequate Adequate				1		1
	S.2.1.1	Height*	2	0/2 1/2 2/2	>3meters <3meters At the same level	1	1	1	1		1
	S.2.1.2	Frequency of past hazards	3	0/3 1/3 2/3 3/3	> 5 events per year > 2, < 5 events per year > 1, < 2 events per year 1 events per year	1	1	1	1	1	1
	S.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
	S.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
	S.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
	S.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
	S.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
	S.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
	S3.1.1	The presence of a monitoring strategy	1	0/1 1/1	No strategy Presence of a strategy				1	1	1
	S3.1.2	The presence of an maintenance strategy	1	0/1 1/1	No strategy Presence of a strategy				1		1
	S3.1.3	The extent of interventions executed prior to the event	2	0/2 1/2 2/2	No interventions Partial interventions Full interventions						1
	S3.1.4	The presence of an emergency plan	2	0/2 1/2 2/2	No plan Generic plan Operative plan (with tasks, resources, ...)						1
	S3.1.5	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
	S3.1.6	Review/update of the emergency plan	2	0/2 1/2 2/2	> 5 years ago < 5 years ago < 2 years ago						1
	S3.1.7	Availability of appropriate labour force	4	0/4 1/4 2/4 3/4 4/4	No redundancy Redundancy <20% of work forces Redundancy >20%, <50% of work forces Redundancy >50%, <80% of work forces Redundancy >80% of work forces						1
	S3.1.8	Flexibility in hiring appropriate work force	4	0/4 1/4 2/4 3/4 4/4	No possibility to hire >80% of the estimated time to repair (ETTR) to hire >80% of ETTR to hire >50%, <80% of ETTR to hire < than 20% of ETTR to hire						1
	S3.1.9	Availability of materials	4	0/4 1/4 2/4 3/4 4/4	No redundancy Redundancy <20% of material Redundancy >20%, <50% of material Redundancy >50%, <80% of material Redundancy >80% of material						1
	S3.1.10	Expected time for material delivery	4	0/4 1/4 2/4 3/4 4/4	No possibility to order >80% of the estimated time to repair (ETTR) to hire >80% of ETTR to order >50%, <80% of ETTR to order < than 20% of ETTR to order						1
	S3.1.11	Availability of construction equipment	4	0/4 1/4 2/4 3/4 4/4	No redundancy Redundancy <20% of equipment Redundancy >20%, <50% of equipment Redundancy >50%, <80% of equipment Redundancy >80% of work equipment						1
	S3.1.12	Expected time for construction equipment delivery	4	0/4 1/4 2/4 3/4 4/4	No possibility to rent >80% of the estimated time to repair (ETTR) to hire >80% of ETTR to rent >50%, <80% of ETTR to rent < than 20% of ETTR to rent						1

Table 10. SNOWFALL Index & Life cycle Project Documents.

7.2 ANNEX 2

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	%
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 11. 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 12. FOG Targets Case Study 3.

				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**	**%**
SNOWFALL	S										
	S.1.1.1	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**		2			2	
	S.1.1.2	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		3			4	
	S.1.2.1	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			3	
	S.1.2.2	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	67%		2	100%
	S.1.2.3	The presence of a warning system	2	0/2 1/2 2/2	No warning systems 1 warning system Multiple warning systems		2			0	
	S.1.3.1	Adequacy of hazard effect reduction system (barriers to snow)	1	0/1 1/1	Not adequate Adequate		1	100%		1	100%
	S.2.1.1	Height*	2	0/2 1/2 2/2	>3meters <3meters At the same level						
	S.2.1.2	Frequency of past hazards	3	0/3 1/3 2/3 3/3	> 5 events per year > 2, < 5 events per year > 1, < 2 events per year 1 events per year			25%		1	50%
	S.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			25%		1	50%
	S.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			25%		0	25%
	S.2.1.5	Severity of future hazards	3	0/3 1/3 2/3 3/3	Strong increase Soft increase Soft decrease Strong decrease			25%		0	25%
	S.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						
	S.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		2	75%		3	100%
	S.2.1.8	Hazards goods traffic*	2	0/2 1/2 2/2	Frequent dangerous goods Rare dangerous goods No dangerous goods		1	67%		2	100%
	S3.1.1	The presence of a monitoring strategy	1	0/1 1/1	No strategy Presence of a strategy		1			1	
	S3.1.2	The presence of an maintenance strategy	1	0/1 1/1	No strategy Presence of a strategy		1			1	
	S3.1.3	The extent of interventions executed prior to the event	2	0/2 1/2 2/2	No interventions Partial interventions Full interventions		2	100%		2	100%
	S3.1.4	The presence of an emergency plan	2	0/2 1/2 2/2	No plan Generic plan Operative plan (with tasks, resources, ...)		2			1	
	S3.1.5	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		2			1	
	S3.1.6	Review/update of the emergency plan	2	0/2 1/2 2/2	> 5 years ago < 5 years ago < 2 years ago		1			1	
	S3.1.7	Availability of appropriate labour force	4	0/4 1/4 2/4 3/4 4/4	No redundancy Redundancy <20% of work forces Redundancy >20%, <50% of work forces Redundancy >50%, <80% of work forces Redundancy >80% of work forces		2			0	
	S3.1.8	Flexibility in hiring appropriate work force	4	0/4 1/4 2/4 3/4 4/4	No possibility to hire >80% of the estimated time to repair (ETTR) to hire >80% of ETTR to hire >50%, <80% of ETTR to hire < than 20% of ETTR to hire		3			0	
	S3.1.9	Availability of materials	4	0/4 1/4 2/4 3/4 4/4	No redundancy Redundancy <20% of material Redundancy >20%, <50% of material Redundancy >50%, <80% of material Redundancy >80% of material		1			0	
	S3.1.10	Expected time for material delivery	4	0/4 1/4 2/4 3/4 4/4	No possibility to order >80% of the estimated time to repair (ETTR) to hire >80% of ETTR to order >50%, <80% of ETTR to order < than 20% of ETTR to order		1			0	
	S3.1.11	Availability of construction equipment	4	0/4 1/4 2/4 3/4 4/4	No redundancy Redundancy <20% of equipment Redundancy >20%, <50% of equipment Redundancy >50%, <80% of equipment Redundancy >80% of work equipment		2			0	
	S3.1.12	Expected time for construction equipment delivery	4	0/4 1/4 2/4 3/4 4/4	No possibility to rent >80% of the estimated time to repair (ETTR) to hire >80% of ETTR to rent >50%, <80% of ETTR to rent < than 20% of ETTR to rent		2			1	

Table 13. SNOWFALL Targets Case Study 3.

REFERENCES.

[1] RAGTIME: Risk based approaches for Asset inteGrity multimodal Transport Infrastructure ManagEment.

[2] 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.

[3] Adapted FORESEE Governance Tool, from the RAGTIME Tool.

[4] FORESEE Governance Tool conditions, 5 indexes.