FORESEE: Processes and methods to define metrics and targets of levels of service, risk and resilience

H2020-MG-7-1-2017: Resilience to extreme (natural and man made events)

Presented to:

ECE: Inland Transport Committee: Working Party on Transport Trends and Economics

Group of Experts on Assessment of Climate Change Impacts and Adaptation for Inland Transport

Presented on 02.09.2021 by: Prof. Dr. Bryan T. Adey,
Head of the Infrastructure Management Group, ETHZ

FORE
SEE
PROJECT

Deliverables

- D1.1 Guideline to measure levels of service provided by, and resilience of, transport infrastructure

- D1.2 Guideline to set the target levels of service provided, by and resilience of, transport infrastructure

- CEN/CLC/WS 018 "Assessment of the resilience of transport infrastructure to potentially disruptive events"

https://www.climatechangepost.com/news/2014/5/26/extreme-weather-and-climate-change-impacts-inland-/

2

FORE SEE PROJECT

Main points

- With a changing climate, decision makers need to have a systematic way to evaluate the resilience of transport systems, whether they are roads, rails, inland water ways or combinations of these

- This requires systematic assessments for the system(s) being assessed that have
    - clear definitions of the system(s) being considered,
    - clear definitions of the service being provided, and
    - consistent assessment of the intervention costs and reductions in service expected if potentially disruptive events occur

- With these systematic assessments, decision makers can devise «stress tests» that should be used in the assessments so they obtain clarity on
    - the resilience of the system(s),
    - the parts of the system(s) that are leading to a lower than desired resilience,
    - the parts of the system(s) that could be improved to improve resilience, and
    - the resilience targets to be set.

3

FORE
SEE
PROJECT

D1.1 Guideline to measure

1. Introduction (General, Service, Resilience, Conclusion)

2. The guideline (General, Definition of service, Definition of resilience, Measuring service, Measuring resilience)

3. Define transport system

4. Measure service (Define service, Determine how to measure service, Measure service)

5. Measure resilience (General, Identify resilience relevant parts of transport system, Determine how resilience is to be measured, Measure resilience directly using lost service and intervention costs, Measure resilience using indicators, Estimate percentage of fulfilment of resilience indicators)
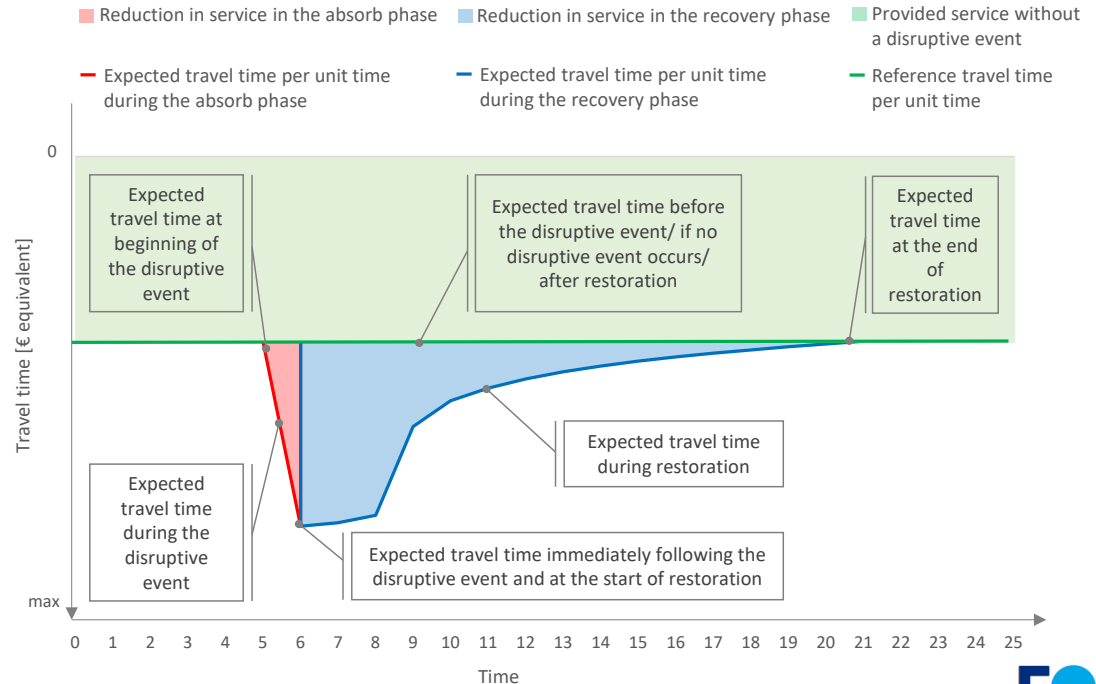
6. Conclusion

FORE SEE
PROJECT

Definitions

- **Service** is defined as

  - **the ability to perform an activity in a certain way**.

- Service, with this definition, can be operationalised, for example, as the ability to transport from A to B,
- goods and persons within a specific amount of time, and
- goods without being damaged and persons without being hurt or losing their lives.

- **Resilience** is defined as

  - **the ability to continue to provide service if a hazard event occurs**.

- Resilience, with this definition, is operationalised, using
- each measure of service deemed relevant, in order to assess how service is being affected, and
- the cost of the interventions required to ensure that the infrastructure once again provides and adequate service.
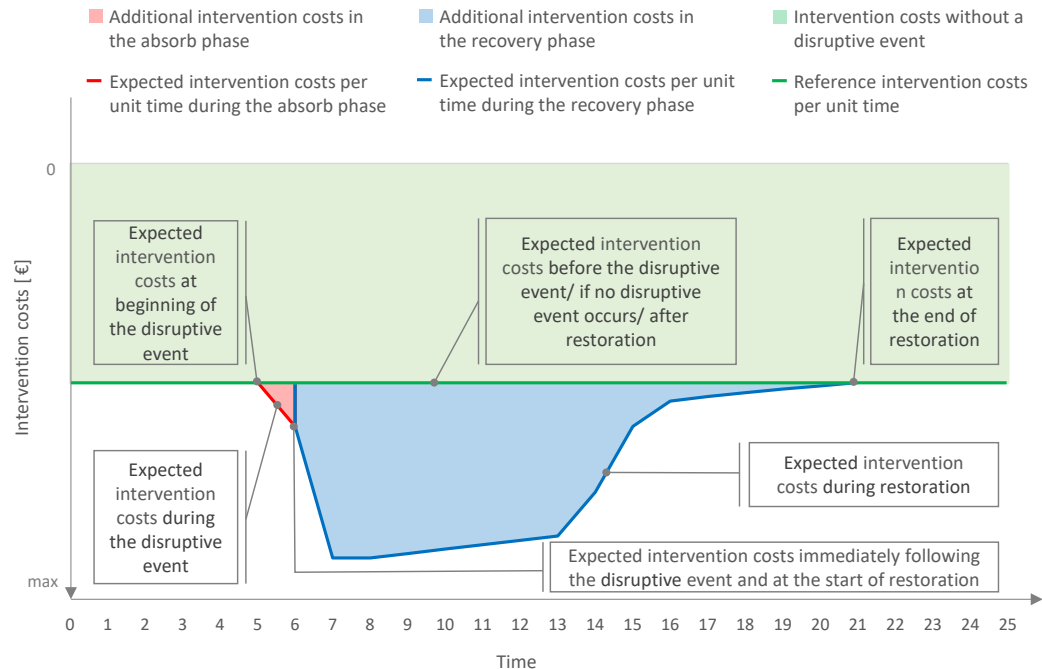
FORE SEE PROJECT

Illustration of resilience, using the measure of service expected yearly cumulative travel time, of infrastructure enabling the transport of goods and persons from A to B for a scenario, where a single hazard event occurs and the infrastructure is restored so that it provides that same level of service as it did before the hazard event
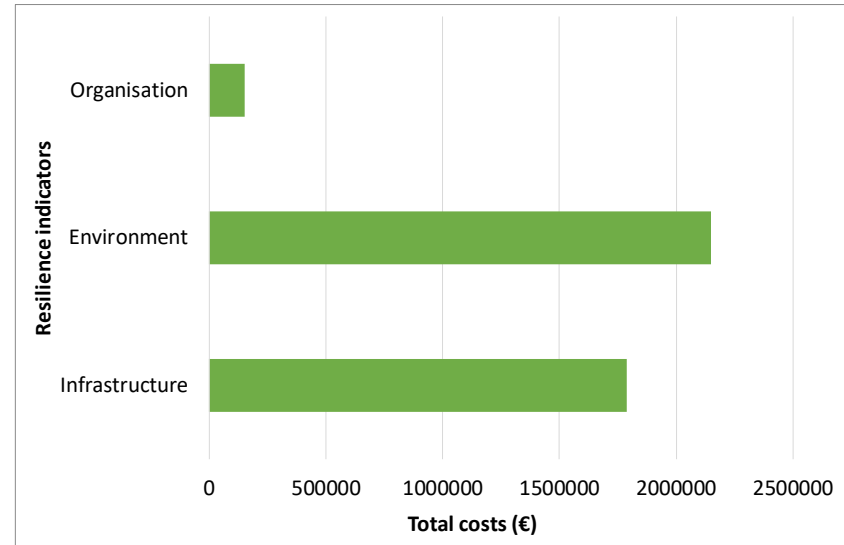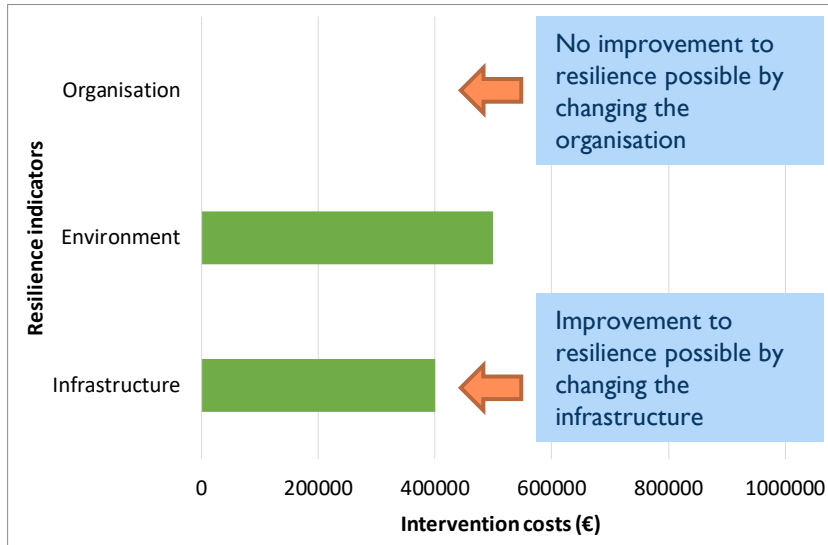

Legend:
- Reduction in service in the absorb phase
- Reduction in service in the recovery phase
- Provided service without a disruptive event
- Expected travel time per unit time during the absorb phase
- Expected travel time per unit time during the recovery phase
- Reference travel time per unit time

Chart labels:
- Expected travel time at beginning of the disruptive event
- Expected travel time before the disruptive event/ if no disruptive event occurs/ after restoration
- Expected travel time at the end of restoration
- Expected travel time during the disruptive event
- Expected travel time during restoration
- Expected travel time immediately following the disruptive event and at the start of restoration

Axis labels: Travel time [€ equivalent]; Time

FORE SEE PROJECT

Illustration of resilience, using intervention costs, of infrastructure enabling the transport of goods and persons from A to B for a scenario, where a single hazard event occurs and the infrastructure is restored so that it provides that same level of service as it did before the event

Legend:
- Additional intervention costs in the absorb phase
- Additional intervention costs in the recovery phase
- Intervention costs without a disruptive event
- Expected intervention costs per unit time during the absorb phase
- Expected intervention costs per unit time during the recovery phase
- Reference intervention costs per unit time

Expected intervention costs at beginning of the disruptive event

Expected intervention costs before the disruptive event/ if no disruptive event occurs/ after restoration

Expected intervention costs at the end of restoration

Expected intervention costs during the disruptive event

Expected intervention costs during restoration

Expected intervention costs immediately following the disruptive event and at the start of restoration

Intervention costs [€]

Time

FORE SEE PROJECT

D1.1 Guideline: Measure Resilience

Results of resilience measured using transport systems parts and differentiated weights,
a) intervention costs, c) travel time costs.

D1.2 Guideline to set targets

1. The guideline (General, Definition of target, Target types)
2. Setting targets (General, Tasks)
3. Task 1: Gather all relevant stakeholders
4. Task 2: Determine legal requirements
5. Task 3: Determine stakeholder requirements
6. Task 4: Set targets
   1. Service and resilience targets without cost-benefit analysis
   2. Resilience indicator targets without cost-benefit analysis
   3. Service and resilience targets with cost-benefit analysis
   4. Resilience indicator targets with cost-benefit analysis
7. Conclusion

https://www.eib.org/photos/download.do?documentId=a67696b2-5d64-404b-b75e-b5d6b792fa1d&binaryType=largeprvw

FORE SEE PROJECT

D1.2 Guideline: Target

Target is defined as

A level of service or resilience that stakeholders consider acceptable and for which they are willing to take due actions.

The choice of target, and target setting method, depends on, among other things
- the specific problem to be addressed
- the time frame at disposition
- the expertise available
- the availability of data, and
- how the level of service and resilience are measured.

FORE SEE PROJECT

D1.2 Guideline: Target

Illustration of resilience using the measure of service travel time showing the various types of targets, i.e. maximum decrease in service, shape of decrease in service, shape of service curve during restoration, service restoration time and total reduction in service.
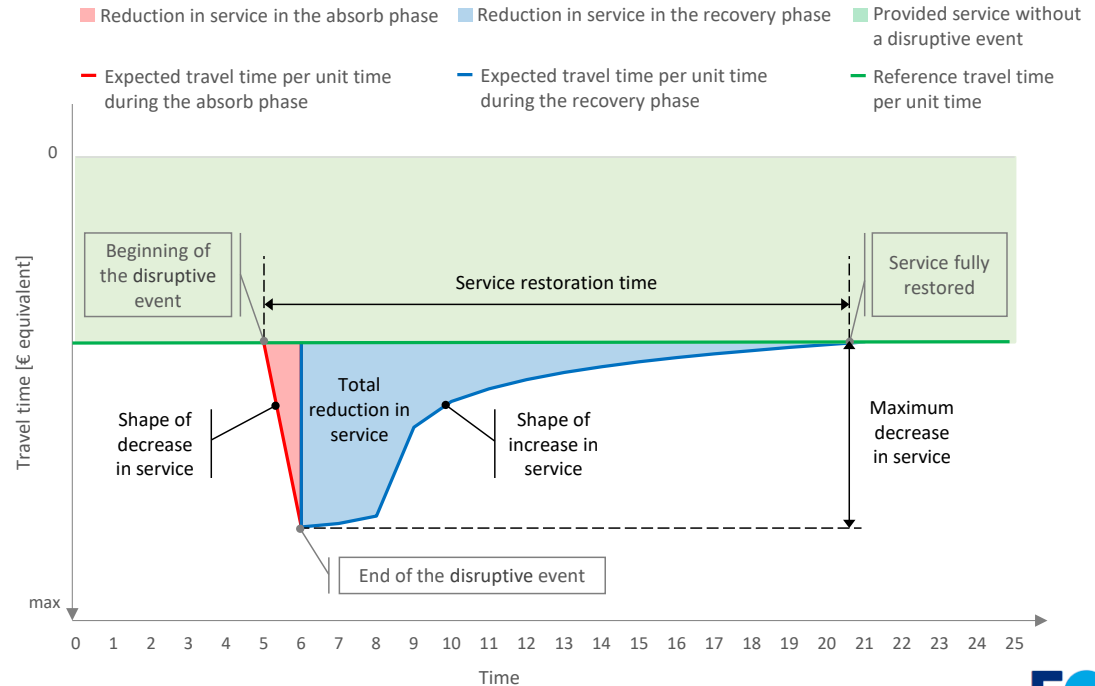
D1.2 Guideline: Setting targets

Targets can be set for

1. Either intervention costs or a measure of service

2. Combinations of intervention costs and measures of service

3. Multiple hazards

For example, one can concentrate only on the travel time measure of service and set a target for the maximum decrease following the beginning of the hazard event and the time until vehicles can once again travel as they could prior to the event.

For example, one can consider intervention costs and the travel time measure of service and set a target for the total intervention and travel time costs following the beginning of the hazard event.

For example, one can set the maximum additional travel time per week following the beginning of either a 500-year earthquake hazard event or a 500-year flood event.

FORE SEE
PROJECT

D1.2 Guideline: Setting targets

Steps:

1. Gather all relevant stakeholders
2. Determine legal requirements
3. Determine stakeholder requirements
4. Set targets

The specific method to be used to set targets, i.e. task 4, depends on:

- how resilience is measured, i.e. using simulations or indicators, and
- whether or not cost-benefit analysis is used.

https://www.joc.com/international-logistics/low-water-halts-all-rhine-barge-shipping-kaub-basel-stretch_20181026.html

FORE SEE PROJECT

D1.2 Task 4: Set targets (SR-CB)

Target set	Label	Des-cription	Targets per type of target		
			travel time reduction	restor-ation time	restoration intervention costs
1	No changes in service	No change in travel time given a 100-year flood	None	Not specified	Not specified
2	Legal minimum	All legal requirements are fulfilled	Largest legally allowed	Largest legally allowed	Not specified
3	Restoration budget	Available budget will be used fully, in order to maximise the service	Not specified	Not specified	Under the specified restoration budget

FORE SEE PROJECT
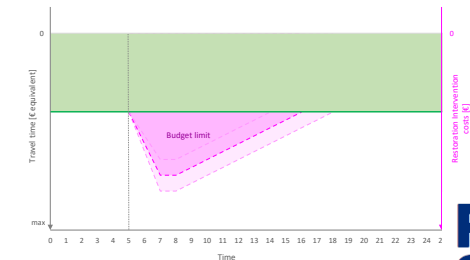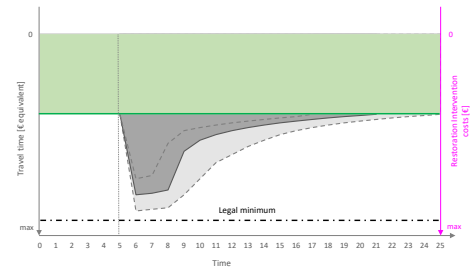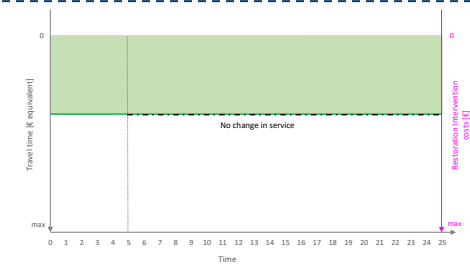
D1.2 Task 4: Set targets (RI-CB)

1. select the resilience indicators for which targets are to be set

> Example: the emergency plan resilience indicator

2. set each target to the lowest value possible

> Example: the emergency plan indicator should have a value of 2 (e.g. the emergency plan is practised every 2 years) if according to law it has to be 2

3. estimate the additional costs of each unit increase in the value of each indicator from the lowest legally allowed value

> Example: the additional costs of increasing the emergency plan indicator from
> a. 2 to 3, i.e. practising the emergency plan every year instead of every two years, is € 0.8 million
> b. 3 to 4, i.e. practising the emergency plan every 6 months instead of every year, is € 2.0 million

FORE SEE PROJECT

D1.2 Task 4: Set targets (RI-CB)

4. estimate the additional benefits of each unit increase in the value of each indicator from the lowest legally allowed value

5. estimate the benefit/cost ratio for each unit increase for each indicator

6. set targets for all indicators based on the estimated benefit/cost ratios

Example: the additional benefits of increasing the emergency plan indicator, due to increases in the probability that all organisations involved in emergency actions will act as expected leading to reduced restoration times, from

a. 2 to 3, is € 1.9 million, and

b. 3 to 4, is € 1.95 million

Example: the benefit/cost ratio from

a. 2 to 3 is 1.9 / 0.80 = 2.375 $\Rightarrow$ increase indicator from 2 to 3

b. 3 to 4 is 1.9 / 1.95 = 0.975 $\Rightarrow$ leave indicator at 3

Example: the emergency plan indicator should be set to level 3

FORE SEE PROJECT

D1.2 Task 4: Set targets (RI-CB)

Indicator	Legal req.	Possible values		Increment costs	Increment benefit	Benefit / cost ratio	Net benefit
Condition state of object	-	Improvement	1	-	-	-	-
			2	€ 8'000	€ 12'913	1.61	€ 4'913
			3	€ 10'000	€ 10'505	1.05	€ 5'418
			4	€ 11'000	€ 11'121	1.01	€ 5'539
			5	€ 12'000	€ 9'900	0.83	€ 3'439
Frequency of monitoring	2	Improvement	1	-	-	-	-
			2	€ 10'000	€ 8'800	0.88	€ -1'200
			3	€ 12'000	€ 12'200	1.02	€ -1'000
			4	€ 15'000	€ 10'244	0.68	€ -5'756

FORE SEE PROJECT

Summary

- These guidelines help decision makers devise systematic ways to evaluate the resilience of transport systems, whether they are roads, rails, inland water ways or combinations of these, which include
    - clear definitions of the system(s) being considered,
    - clear definitions of the service being provided, and
    - consistent assessment of the intervention costs and reductions in service expected if potentially disruptive events occur

- With these systematic assessments, decision makers can then devise «stress tests» that enable them to obtain clarity on
    - The resilience of the system(s),
    - The parts of the system(s) that are leading to a lower than desired resilience,
    - The parts of the system(s) that could be improved to improve resilience, and
    - The resilience targets to be set.

FORE SEE PROJECT

Publications

- Adey, B.T., Martani, C., Kielhauser, C., Robles Urqulijo, I., Papathanasiou, N., Burkhalter M., (published on-line 2021), Estimating, and setting targets for, the resilience of transport infrastructure, Special Issue: Resilient infrastructure for improved disaster management, Infrastructure Asset Management, DOI: 10.1680/jinam.20.00011

- Martani, C., Adey, B.T., Robles, I., di Gennarod F., Pardi, L., Beltran-Hernando, I., Concepcion Toribio Diaz, I., Jimenez Redondo, N., Antonio Moli Díaz, A., (published on-line 2021), Estimating the resilience of, and targets for, a transport system using expert opinion, Special Issue: Resilient infrastructure for improved disaster management, Infrastructure Asset Management, DOI: 10.1680/jinam.20.00029

- Adey, B.T., Martani, C., Kielhauser, C., Robles Urqulijo, I., Papathanasiou, N., Burkhalter M., (2019), Guideline to measure levels of service and resilience in infrastructure, Deliverable 1.1, EU Grant number 769373, pages 84 pages, https://doi.org/10.3929/ethz-b-000403298

- Kielhauser, C., Martani, C., Adey, B.T., (2019), Guideline to set target levels of service to be provided by, and resilience of, transport infrastructure, Deliverable 1.2, EU Grant number 769373, 27 pages, doi.org/10.3929/ethz-b-000388318.

FORE SEE
PROJECT