Definition of the KPI Model for the EU-Rail Programme

KPI Cards

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Support to Europe's Rail Joint Undertaking | Framework Contract S2R.19.OP.02
LOT 1 - Strategy Advice

Building a better working world

Widely used parameters

Parameter	Definition	Data source
$TC_{i,p}[-]$	**Time coefficient:** Binary coefficient becoming 1 from the moment the new technology enters market	• Societal KPI Model – input project-by-project
$CF_{i,p}[\%]$	**Confidence factor:** Probability of the technology reaching market deployment, meaning that more mature technologies will have higher confidence factor in terms of reaching the market. Calculated as follows: $\frac{TRL[-]}{9} \times 100\%$	• $TRL[-]$ is calculated from reported TRLs for each project, reported by the project implementers.
$DC_{i,p}[\%]$	**Deployment coefficient:** Assumed market penetration of the technology (100% meaning that every asset is retrofitted/replaced)	• Societal KPI Model – predefined
$f_{i,m,t}^{shift}[\%]$	**Modal shift amount factor:** Percentage change for each mode in terms of the pkm or tkm as the modal shift occurs	• Societal KPI Model (with demand shock methodology) • 2022 report on Railway Safety and Interoperability in the EU
$P_{i,m,t}^{traff}[du]$	**Transport traffic forecast**	• JRC, PRIMES (Tremove)
$TRL[-]$	Technology readiness level of the FA	• $TRL_{i,n}^{impact}[-]$ is the monitored TRL and thus sourced from project implementers • $TRL_{i,n}^{baseline}[-]$ is the initial TRL for each technology which is thus sourced from MAWP and/or project implementers
$W_{FA}^{impact}[\%]$	Weighted impact of the respective Flagship Area on the modal shift according to the demand shock methodology developed as part of this study	• Societal KPI Model – predefined for each FA
$CAP\ [du]$	Capacity of the network is widely used as a conditional for modal share increase. Due to the current constraints on the network, any major modal shift to rail is not possible without an increase in capacity, which Flagship Area 1 addressed. The formula uses a technical KPI from FA1 as follows: $CAP\ [du] = KPI_{FA1}\left[\frac{\#\text{ of trains}}{km_{line}*year}\right] \times OCC\left[\frac{pax\ or\ t}{train}\right] \times \frac{km_{network}}{km_{line}}[-]$	• $KPI_{FA1}\left[\frac{\#\text{ of trains}}{km_{line}*year}\right]$ is the technical KPI sourced by project implementers • $OCC\left[\frac{pax\ or\ t}{train}\right]$ Data taken and derived from Eurostat (divide total number of pkm or tkm by total number of train-km) • $km_{network}$ sourced from Eurostat (dividing pkm by pax) • km_{line} sourced from the project implementer

[du] denotes unit of demand for use case i (pkm/tkm)

EY

Societal KPI card - Energy Savings in Transport (1/2)

KPI name: Energy Savings in Transport

Symbol and unit	Impactful/Relevant Flagship Areas
$E^{savings}$ $[MWh]$	Direct impact in rail: **FA1, FA2, FA4, FA5** Modal shift impact: **FA1, FA2, FA3, FA4, FA5, FA6**

Impact Analysis

One of the main goals of the projects is to contribute to improving the energy efficiency throughout the transport sector. Savings in energy consumption can be tackled throughout different steps and areas in the whole transport service (from power/fuel supply to maintenance or infrastructure), all of which are, to a certain extent, influenced by the projects of the different Flagship Areas.

Hence, this KPI aims to generally measure the energy consumption savings in transport. It thereby considers the consumption reduction due to the introduction of the more efficient innovative technologies E^{rail}, as well as the decrease E^{MS} due to the shift from alternative transport modes (road, aviation, etc.) to the less energy intensive sector rail. $E^{savings}$ thus indicates by how many megawatt-hour the total energy consumption in transport has decreased (i.e. savings) compared to the baseline scenario $E^{baseline}$. The generic consumption E^{rail} considers the sector relevant and specific energy consumption components of "power/fuel", "maintenance", "stations" and "signaling infrastructures".

Each of these are calculated with existing/proposed technical KPIs and further parameters from literature. Some of these might apply to a different extent depending on the segment/mode considered, which is why differently indexed parameters provide the relevant data for each use case.

Societal KPI card - Energy Savings in Transport (2/2)

Formula

$$E^{savings} = \sum E^{cons,baseline}_{i,m} - \sum (E^{rail} + E^{MS})$$

$$E^{rail}\,[MWh] = \left(e_k^{\frac{power}{fuel}} \left[\frac{MWh}{du}\right] \times P^{traff}_{i,m,t}[du] + e^{maintenance} \left[\frac{MWh}{du}\right] \times P^{traff}_{i,m,t}[du] + e^{stations} \left[\frac{MWh}{m^2}\right] \times A^{station}[m^2] + e^{signaling} \left[\frac{MWh}{km}\right] \times l^{rail}[km] \right) \times TC_{i,p}[-] \times CF_{i,p}[\%] \times DC_{i,p}[\%]$$

$$E^{MS}\,[MWh] = \sum E^{cons}_m [MWh] \times f^{shift}_{i,m,t}[\%] \times \sum \left(\frac{\Delta TRL^{average}_{FA}[-]}{9} \times W^{impact}_{FA}[\%] \right) \times TC_{i,p}[-] \times CF_{i,p}[\%] \times DC_{i,p}[\%], \text{while } P^{traff}_{rail}[du] \leq \text{CAP}[du]$$

Indexing

- i: use case
- p: project
- m: mode
- t: year

Parameter	Definition	Data source
$E^{cons,baseline}_{i,m}[MWh]$	Baseline energy consumption in transport	EEA: Final energy consumption by transport mode
$E^{cons}_m[MWh]$	Energy consumption of the portion of alternative modes shifting to rail	E^{cons}_m: EEA: Final energy consumption by transport mode
$e_k^{power/fuel}\left[\frac{MWh}{du}\right] \times P^{traff}_{i,m,t}[du]$	Energy consumption related to the fuel/power demand of the transport method	$e_k^{power/fuel}$: Technical KPIs 2.2, 4.2 and 6.3
$e^{maintenance}\left[\frac{MWh}{du}\right] \times P^{traff}_{i,m,t}[du]$	Energy consumption of transport related maintenance work	$e^{maintenance}$: Proposed technical KPI (FA1)
$e^{stations}\left[\frac{MWh}{m^2}\right] \times A^{station}[m^2]$	Energy consumption of stations (including peripheral facilities and infrastructure)	• $e^{stations}$: Technical KPI 4.2 • $A^{station}$: RRG GIS Database
$e^{signaling}\left[\frac{MWh}{km}\right] \times l^{rail}[km]$	Energy consumption of the signaling system	• $E^{signaling}$: Proposed technical KPI (FA5) • l^{rail}: Eurostat lenghts of tracks

[du] denotes unit of demand for use case i (pkm/tkm)

EY

Societal KPI card – Greenhouse Gas Emissions Savings in Transport (1/2)

KPI name: GHG Savings in Transport

Symbol and unit	Impactful/Relevant Flagship Areas
$\boldsymbol{EM^{savings}}\ [t\ CO_2e]$	Direct impact in rail: **FA4** Modal shift impact: **FA1, FA2, FA3, FA4, FA5, FA6**

Impact Analysis

Emissions from the transport sector account for 27% of total EU greenhouse gas emissions[1]. Any systemic decarbonisation developments in transport therefore significantly contribute to the societal benefits. In this regard, Europe's Rail programme not only impacts the decarbonisation of the rail transportation, but also it significantly contributes to the decarbonisation of the overall transport sector as it is making rail a more attractive alternative to air and road travel. Since the latter two modes are notably more carbon intensive, the shift (also called modal shift) between them allows for net savings in emissions.

The Flagship Area primarily targeting the "greenness" of rail (FA4) also contains useful parameters for measuring the project impact on the rail's carbon intensity, which further enables net savings in emissions (in terms of the modal shift as well as internal rail improvements). Hence, the formula for the overall CO_2 savings consists of both rail improvements as well as the modal shift. The two channels of savings have the same unit (tCO_2eq) and are thus added together to form an aggregate saving value. The part of the formula referring to rail improvement is measured through a technical KPI listed under Flagship Area 4 in the MAWP. More precisely, it is the KPI that measures physical CO_2 equivalent emissions' intensity linked to new propulsion systems, stations and infrastructure using life-cycle assessment of assets involved. Life-cycle assessment is a robust methodology for estimating the true impact of an activity through calculating the overall emissions from assets and normalising it per unit of demand (either passenger-kilometre or tonne-kilometre). Hence the improvements of rail's CO_2 intensity are materialised through decarbonising the entirety of the value chain of rail service provision.

[1] EEA, 2019: https://www.eea.europa.eu/data-and-maps/daviz/ghg-emissions-by-aggregated-sector-5#tab-dashboard-02

EY

Societal KPI card - Greenhouse Gas Emissions Savings in Transport (2/2)

Formula

$$EM^{savings} = \Delta EM^{rail} + \Delta EM^{MS}$$

$$\Delta EM^{rail}\,[t\,CO_2e] = \left(CI_{i,k}^{baseline}\left[\frac{t\,CO_2e}{du_i}\right] - KPI_{FA4}\left[\frac{t\,CO_2e}{du_i}\right]\right) \times P_{i,t}^{traff,rail}[du_i] \times TC_{i,p}[-] \times CF_{i,p}[\%] \times DC_{i,p}[\%]$$

$$\Delta EM^{MS}[t\,CO_2e] = \frac{\Delta TRL[-]}{9} \times W_{FA}^{impact}[\%] \times \sum \Delta CI_{m,k}\left[\frac{t\,CO_2e}{du_i}\right] \times P_{m,t}^{traff,alt}[du_i] \times f_{i,m,t}^{shift}[\%] \times TC_{i,p}[-] \times CF_{i,p}[\%] \times DC_{i,p}[\%],$$

$$\text{while } P_{rail}^{traff}[du] \leq \text{CAP}[du]$$

Indexing

i: use case

p: project

m: mode

t: year

Parameter	Definition	Data source
$CI_{i,k}^{baseline}\left[\frac{t\,CO_2e}{du_i}\right]$	Baseline physical CO_2 equivalent emissions' intensity (LCA) linked to new propulsion systems, stations and infrastructure for rail.	https://www.researchgate.net/publication/324638466_Life_Cycle_Assessment_of_a_Hybrid_Train_-_Comparison_of_Different_Propulsion_Systems
$W_{FA}^{impact}[\%]$	Weighted according to the FA's impact on the modal shift	Demand shock methodology as part of the Societal KPI Model
$KPI_{FA4}\left[\frac{t\,CO_2e}{du_i}\right]$	Physical CO_2 equivalent emissions' intensity (LCA) linked to new propulsion systems, stations and infrastructure as per the project data.	Project implementer: FA4
$\Delta CI_{m,k}\left[\frac{t\,CO_2e}{du_i}\right]$	Difference in CO_2 equivalent emissions' intensity for the corresponding modes that have shifted. Expressed per demand unit.	https://ourworldindata.org/co2-emissions-from-transport

[du] denotes unit of demand for use case i (pkm/tkm)

Societal KPI card - Congestion Savings in Overall Transport (1/2)

KPI name: Congestion Savings in Transport

Symbol and unit
$CON^{savings}$ [€]

Impactful/Relevant Flagship Areas
Direct impact in rail: **FA2**
Modal shift impact: **FA1, FA2, FA3, FA4, FA5, FA6**

Impact Analysis

Savings in congestion cost primarily stem from the reduction in travel time (following the monetary value of time for the society). This valuation for different modes is encompassed in the EU Handbook of External Costs of Transport [1].

Rail, similarly to many other external costs, is the least costly per demand unit. Hence the modal shift to rail from more congested modes acquires net savings in monetary terms. In the formula, congestion is therefore calculated as the sum of the reduction in congestion cost per demand unit arising from the shift from alternative transport modes to rail, traffic forecasts and the modal shift factor. The modal shift, however, is limited by the infrastructural capacity of the rail network, which emphasizes the importance of Flagship Area 1 in facilitating the modal shift.

One of the key KPIs from this flagship area that regards capacity is the one that measures the count of trains per reference day on a demonstration line. Hence, this societal KPI uses any percentage improvement of this technical KPI as a maximum percentage increase in the modal share of rail, which in turn drives the societal benefits.

[1] DG MOVE, EU Handbook on External Costs of Transport, Available at: https://op.europa.eu/en/publication-detail/-/publication/9781f65f-8448-11ea-bf12-01aa75ed71a1

Societal KPI card - Congestion Savings in Overall Transport (2/2)

Formula

$$CON^{savings} = \Delta CON^{MS}$$

$$\Delta CON^{MS}[€] = \frac{\Delta TRL[-]}{9} \times W_{FA}^{impact}[\%] \times \sum \left(\Delta CS_{i,m} \left[\frac{€}{du}\right] \times P_{m,t}^{traff}[du] \times f_{i,m,t}^{shift}[\%] \right) \times TC_{i,p}[-] \times CF_{i,p}[\%] \times DC_{i,p}[\%],$$

$$\text{while } P_{rail}^{traff}[du] \leq \text{CAP}[du]$$

Indexing

- i: use case
- p: project
- m: mode
- t: year

Parameter	Definition	Data source
$CS_{i,m}^{difference}\left[\frac{€}{du}\right]$	Difference in congestion cost for the corresponding modes that are being shifted. Expressed per demand unit. Captured in euros per demand unit.	DG MOVE - EU Handbook of External costs of Transport (p. 111 - 114)
$\frac{km_{network}}{km_{line}}[-]$	Total number of km per network and line	KPI Model (calculated using demand shock methodology)

[du] denotes unit of demand for use case i (pkm/tkm)

EY

Societal KPI card – Rail Affordability

KPI name: Rail Affordability

Symbol and unit	Impactful/Relevant Flagship Areas
$\boldsymbol{SAI}$ [%]	Direct impact in rail: **FA2, FA3, FA4, FA6**

Impact Analysis

The objective of this KPI is to yield the impact of the cost reductions achieved through technology innovations of the projects on society. We therefore introduce the Societal Affordability Index SAI and a qualitative approach to withdraw conclusions. SAI is represented as a dimensionless ratio of the total reduced absolute costs to the average income of population $I^{average}$.

The total reduced absolute costs can be obtained from the total cost reduction $\Delta C^{reduction}$ per demand unit ($\left[\frac{€}{du}\right]$). This entails reductions throughout a representative selection of cost components in rail transport, that is **energy**, **maintenance**, **staff**, **safety** or **other** costs. Instead of considering absolute values for these, we assign percentages of the total cost reduction $\Delta C^{reduction}$ to each cost component. $\Delta C^{reduction}$ is then further multiplied by the traffic factor $P_{i,t}^{traff,rail}$ as well as the generic factors $TC_{i,p}$, $CF_{i,p}$ and $DC_{i,p}$. With the formula, the data sources included and assumptions based on the project implementer data, an estimation of the percentage value of the SAI can be calculated. Comparing these with the value ranges (for HSR, freight and reginal rail) we provide, a qualitative assessment to evaluate the impact of the projects on societal Rail Affordability can be conducted. This helps extracting conclusions through this qualitative societal KPI, for example, the higher the SAI, the more impactful projects are in reducing rail costs for society.

$[du]$ $denotes\ unit\ of\ demand\ for\ use\ case\ i\ (pkm/tkm)$

Societal KPI card - Rail Affordability (2/2)

Formula

$$SAI = \frac{\Delta C^{reduction}\left[\frac{€}{du}\right] \times P_{i,t}^{traff,rail}[du] \times TC_i[-] \times CF_i[\%] \times DC_i[\%]}{I^{average}[€]}$$

Indexing

i: use case

p: project

m: mode

Suggested SAI ranges:

	HSR	Freight	Regional
High	0.2% - 1.0%	0.5% - 1.5%	0.5% - 1.5%
Moderate	0.1% - 0.2%	0.3% - 0.5%	0.3% - 0.5%
Low	0% - 0.1%	0% - 0.3%	0% - 0.3%

Component breakdown of: $\Delta C^{reduction}$

Cost component	Percentage of total costs	Future tendency
Energy	20-30%	Likely to decrease
Maintenance	15-25%	Likely to decrease
Staff	25-35%	Little influence
Safety	5-15%	Likely to decrease
Other	5-15%	Little influence

Parameter	Definition	Data source
$\Delta C^{reduction}\left[\frac{€}{du}\right]$	Total cost reduction after innovation projects	To be assessed from project implementer individually
$I^{average}[€]$	Average income of population	Population income in the EU

$[du]$ *denotes unit of demand for use case i (pkm/tkm)*

Societal KPI card - Rail Connectivity (1/2)

KPI name: Rail Connectivity

Symbol and unit	Impactful/Relevant Flagship Areas
$\boldsymbol{RC}\ [du]$	Direct impact in rail: **FA1, FA2, FA5, FA6**

Impact Analysis

Rail connectivity refers to the availability and accessibility of rail services for an area or region. Its societal impact can be measured looking at the ability of population to use the railway system to travel to different locations, and the level of integration between different modes of transport. Enhancing general mobility, it should, ultimately, lead to overall economic development. Rail connectivity in rail transport can be affected by different factors, such as network density, accessibility, intermodal connectivity, service frequency, journey time, reliability or passenger satisfaction. Combining all of these in one single indicator would result into a complex, hardly quantifiable and unitless dimension. Therefore, we propose a KPI focusing on connectivity capacity (train speed, stop time, length of train) and reliability (on-time trains).

The whole KPI RC is calculated as a product of the capacity improvements ΔCap_i [du] (total number of passengers transported by the rail network) and the percentage of on-time trains OTT [%], describing the reliability of the networks and the service. The capacity improvements are calculated as a difference between a baseline scenario $Cap_i^{baseline}$ and the capacity after the improvements Cap_i^{new}, which is directly proportional to the new minimum headway $s_i^{min,head}$ of the trains. The minimum headway $s_i^{min,head}$ is proposed as a new technical KPI for the projects.

In general, this KPI provides a single measure of the overall performance of the rail network, taking into account both capacity and reliability. A high value of the KPI indicates a well-functioning rail network with high capacity and high reliability, while a low value indicates low performance in one or both components.

Societal KPI card - Rail Connectivity (2/2)

Formula

$$\boldsymbol{RC} = \sum\left(Cap_i^{baseline} - Cap_i^{new}\right) \times OTT$$

$$Cap_i^{new}[du] = \sum\left(\frac{t_i^{op}\,[h]}{s_i^{min,head}\,[h]} \times Cap_i^{average,train}\left[\frac{du}{-}\right] \times n^{trains}[-]\right) \times TC_{i,p}[-] \times CF_{i,p}[\%] \times DC_{i,p}[\%]$$

$$s_i^{min,head}[h] \sim \frac{\left(v_i\left[\frac{m}{s}\right], a_i^{break}\left[\frac{m}{s^2}\right], l_i^{train}[m], t_i^{stop}[s]\right)}{3600\left[\frac{s}{h}\right]}$$

Indexing

i: use case

p: project

Parameter	Definition	Data source
$Cap_i^{baseline}[du]$	Baseline rail network capacity	• Capacity of infrastructure networks
$s_i^{min,head}[h]$	Minimum headway distance between trains	• Proposed technical KPI
$Cap_i^{average,train}\left[\frac{du}{-}\right] \times n^{trains}[-]$	Average capacity per train	• $Cap_i^{average}$: Monitoring report on the development of the rail market • n^{trains}: Technical KPI 1.1
$OTT\ [\%]$	Percentage of on-time trains during a defined period	• Technical KPI FA4/6
$t_i^{op}\ [h], v_i\left[\frac{m}{s}\right], a_i^{break}\left[\frac{m}{s^2}\right], l_i^{train}[m], t_i^{stop}[s]$	Accompanying, train operation dependent factors: operational time, speed, breaking rate, train length, stops time	• t_i^{op}, a_i^{break} proposed technical KPIs (FA5) • v_i: Technical KPI (FA1.1, FA2.1, FA5.3) • l_i^{train}: Technical KPI (FA5.2) • t_i^{stop}: Technical KPI (FA2.4, FA5.1, FA5.4)

[du] denotes unit of demand for use case i (pkm/tkm)

EY

Societal KPI card - EU Rail Sector Competitiveness (1/2)

KPI name: EU Rail Sector Competitiveness

Symbol and unit	Impactful/Relevant Flagship Areas
$COMP$ $[-]$	Direct impact in rail: **FA1, FA2, FA3, FA4, FA5, FA6**

Definition

Competitiveness of an industry strongly depends on the level of innovation and research within an industry, which is the core value of Europe's Rail programme. Increased capacity for innovation inevitably leads to higher competitiveness.

Hence, an overarching KPI is taken as a technical KPI used for monitoring advancements in competitiveness is the same KPI that is universally considered as the KPI of general ER JU programme's progress, which is Technology Readiness Level. The KPI can be measured as an average of Technology Reediness Level (TRL) improvements across the entire portfolio of projects $n^{projects}$ in each use case. Higher 'delta' (i.e. difference) between the starting TRL and the observed TRL represents higher pace of innovation and thus higher capacity for innovation.

Societal KPI card - EU Rail Sector Competitiveness (2/2)

Formula

$$COMP = \Delta TRL_{average}$$

$$\Delta TRL_{average}\,[-] = \frac{1}{n^{Projects}[-]} \times \sum \left(TRL_{i,n}^{impact}[-] - TRL_{i,n}^{baseline}[-]\right) \times TC_{i,p}[-] \times CF_{i,p}[\%] \times DC_{i,p}[\%]$$

Indexing

i: use case

p: project

n: number of project

Parameter	Definition	Data source
$n^{projects}[-]$	Number of projects inside the portfolio	Europe's Rail JU
$TRL_{i,n}^{baseline}[-]$	Baseline average TRL across the project portfolio	Europe's Rail JU (MAWP)
$TRL_{i,n}^{impact}[-]$	Measured average TRL across the project portfolio	Project demonstrators

EY

Societal KPI card - Occupational Safety in Rail (1/2)

KPI name: Occupational Safety in Rail

Symbol and unit	Impactful/Relevant Flagship Areas
OS [light injuries, serious injuries & fatalities]	Direct impact in rail: **FA1, FA2, FA3, FA5**

Impact Analysis

This societal KPI measures occupational safety costs in transport. It considers the savings due to improved workplace safety measures. One of the most important Europe's Rail JU's projects currently affecting the occupational safety in marshalling, maintenance and inspection of freight trains is the Digital Automatic Coupling (FA5). The preparation of freight trains for their departure is a hazardous procedure as it involves many coupling & decoupling repetitions (each multiplying the risk of injury). The safety cost (measured in $light\ injuries$,$serious\ injuries$ and $fatalities$) is therefore calculated as a multiple of total number of manual train preparation, harm rate per preparation, and accident cost per employee. This is only applicable to the freight use case while the other variable in the formula is applicable to all rail transport and it regards the number of incidents per 10k train-km of travel.

Using data from Eurostat on the number of light injuries, serious injuries and fatalities per incident, the incident number can directly result in the number of injuries and fatalities per km. Each of these are calculated with existing/proposed technical KPIs and additional parameters from literature.

EY

Societal KPI card - Occupational Safety in Rail (2/2)

Formula

$$OS = \Delta SC^{rail}$$

$$\Delta SC^{rail}\ [li, si, fatalities] = [KPI_{FA5}[\#of\ manual\ shunting\ procedures\ per\ 10k\ train.km] \times Harm^{rate}[li, si, fatalities\ per\ manual\ shunting\ procedure] + KPI_{FA2}\ [\#of\ incidents\ per\ 10k\ train.km] \times Harm^{rate}\ [li, si, fatalities\ per\ incident]] \times TC_{i,p}[-] \times CF_{i,p}[\%] \times DC_{i,p}[\%] \times Acc^{cost}\left[\frac{M€}{light\ injury, serious\ injury\ and/or\ fatality}\right]$$

Optional

Indexing

p: project

Parameter	Definition	Data source
$KPI_{FA5}[\#of\ manual\ shunting\ procedures\ per\ 10k\ train.km]$	The expected number of manual train preparation and shunting operations per 10k train.km	Project demonstators (FA5)
$Harm^{rate}[li, si, fatalities\ per\ manual\ shunting\ procedure]$	The (reduced) rate of accident (harm) per train prepations/shunting/other	DAC CBA
$KPI_{FA2}\left[\frac{\#\ of incidents}{10k\ train.km}\right]\ or\ \left[\frac{\#\ of incidents}{10k\ pkm}\right]$	Number of incidents that occur per 10k train-km or 10k passenger-km	Project demonstators (FA2)
$Harm^{rate}\ [li, si, fatalities\ per\ incident]$	The rate of light injuries, serious injuries and fatalities of personnel per train incident	Eurostat
$Acc^{cost}\left[\frac{M€}{light\ injury, serious\ injury\ and/or\ fatality}\right]$	The cost (million euros) due to light injury, seious injury and/or fatality	DG MOVE - EU Handbook of External costs of Transport p. 44

$[du]$ denotes unit of demand for use case i (pkm/tkm)

EY

Societal KPI card - Passenger Safety in Overall Transport (1/2)

KPI name: Passenger Safety in Transport

Symbol and unit	Impactful/Relevant Flagship Areas
PS [light injuries, serious injuries and fatalities]	Direct impact in rail: **FA2** Modal shift impact: **FA1, FA2, FA3, FA4, FA6**

Impact Analysis

This KPI is quantified, similarly to occupational safety, in terms of light injuries, serious injuries and fatalities. However, unlike the occupational safety, this societal KPI includes the improvements within the rail operations, but also the effects of the modal shift. It is namely the sum of savings on account of increased rail service safety measures and the savings due to the shift from other modes which are less safe.

Regarding the former channel of impact, a notable technical KPI is the one incorporated in the FA3 which measures the rate of incidents per unit of demand. The potential reduction in the rate of accidents can be directly converted to the number of injuries and fatalities avoided using Eurostat's database. The effects of the modal shift, on the other hand, are calculated using the EU handbook on External Costs of Transport. Rail is significantly safer than road transport for instance, and the modal shift from latter to former can result in similarly notable societal benefits. The modal shift is calculated using the weight of each FA's contribution to the modal shift as well as the contribution of the FA project to the TRL as a ratio compared to the full process (from TRL 1 to TRL 9).

Societal KPI card - Passenger Safety in Overall Transport (2/2)

Formula

$$PS = \Delta PS^{rail} + \Delta PS^{MS}$$

$$\Delta PS^{rail}[li, si, fatalities] = \left(RI \left[\frac{\#\,of incidents}{pkm}\right] - KPI_{FA2}\left[\frac{\#\,of incidents}{pkm}\right] \right) \times D\left[\frac{li,si,fatality}{incident}\right] \times P^{traff,alt}_{m,t}[du_i] \times TC_{i,p}[-] \times CF_{i,p}[\%] \times DC_{i,p}[\%] \times \underbrace{Acc^{cost}\left[\frac{M€}{li, si, fatality}\right]}_{\text{Optional}}$$

$$\Delta PS^{MS}[li, si, fatalities] = \frac{\Delta TRL[-]}{9} \times W^{impact}_{FA}[\%] \times \sum SC^{alt}_{m}\left[\frac{li, si, fatalities}{pkm}\right] \times P^{traff,alt}_{m,t}[du] \times f^{shift}_{i,m,t}[\%] \times TC_{i,p}[-] \times CF_{i,p}[\%] \times DC_{i,p}[\%],$$

$$\text{while } P^{traff}_{rail}[du] \leq \text{CAP}[du]$$

Indexing

i: use case

p: project

m: mode

t: year

Parameter	Definition	Data source
$SC^{alt}_{m}\left[\frac{li, si, fatalities}{pkm}\right]$	Number of slight injuries, serious injuries and fatalities for the corresponding mode of transport per demand unit.	DG MOVE - EU Handbook of External costs of Transport p.45
$KPI_{FA2}\left[\frac{\#\,of incidents}{pkm}\right]$	The expected rate of incidents in Flagship Area demonstrations in passenger transport under FA2	Project demonstrator (FA2)
$RI[rate\ of\ incidents\ in\ general\ operations]$	The rate of incidents in general operations due to running of trains and other factors	Eurostat
$D\left[\frac{li,si,fatality}{incident}\right]$	Rail accidents victims by type of accident and category of persons involved	Eurostat
$Acc^{cost}\left[\frac{M€}{light\ injury, serious\ injury\ and\ fatality}\right]$	Total cost of accidents in million Euro due to light injury, serious injury and fatality	DG MOVE - EU Handbook of External costs of Transport p. 44

[du] denotes unit of demand for use case i (pkm/tkm)

EY