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Deliverable D 4.2

Initial estimation of the KPIs

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1 Executive summary

The following deliverable shows the results of the first rough estimation of the Key Performance Indicators (KPIs) carried out with the simplified model fed by rough low-level KPIs of the Technical Demonstrators (TDs). This deliverable combined with the deliverable D4.1 “Initial quantitative KPI model“ documents the first version of the KPI model developed within IMPACT-2.

The results are estimated while taking a lot of assumptions and restrictions not only for the KPI model but also for the input data into account, therefore the shown results should be read and interpreted with care.

Also it was recognised, that results per Innovation Program (IP) can only give usable information, if they are calculated on the basis of the areas, the IPs are working on. A calculation to the overall basis skews the results and will hence lead to wrong impressions.

The results displayed in this document give a first indication on which results could be expected in the future. Further a couple of areas could be identified, which need to be worked on, before reliable results can be estimated for the impact of the innovations of Shift2Rail (S2R) on the Life-Cycle Cost (LCC), Reliability & Punctuality and Capacity of the railway system.

Therefore the results should only be considered for a rough orientation not as given solutions.

2 Abbreviations and acronyms

Abbreviation / acronym	Description
CA	Collaboration Agreement
CCA	Cross-Cutting Activities
CCS	Control Command and Signaling
GA	Grant Agreement
IMPACT-1	Indicator Monitoring for a new railway PAradigm in seamlessly integrated Cross modal Transport chains – Phase 1
IMPACT-2	Indicator Monitoring for a new railway PAradigm in seamlessly integrated Cross modal Transport chains – Phase 2
FINE1	Future Improvement for Energy and Noise – Phase 1
OPEUS	Modelling and strategies for the assessment and OPtimisation of Energy USage aspects of rail innovation
IP	Innovation Program
JU	Joint Undertaking
KPI	Key Performance Indicator
LCC	Life-Cycle Cost
R&I	Research and Innovation
S2R	Shift2Rail
SPD	System Platform Demonstrator
TD	Technical Demonstrator
WA	Work Area
WP	Work Package

3 Background

The present document constitutes the Deliverable D4.2 “Initial estimation of the KPIs” in the framework of the WA2 “KPI method development and integrated assessment” (see figure 1), task 2, task 3 and task 6 of CCA defined in the Multi-Annual Action Plan at the time of the start of IMPACT-2 (September 2017) [6].

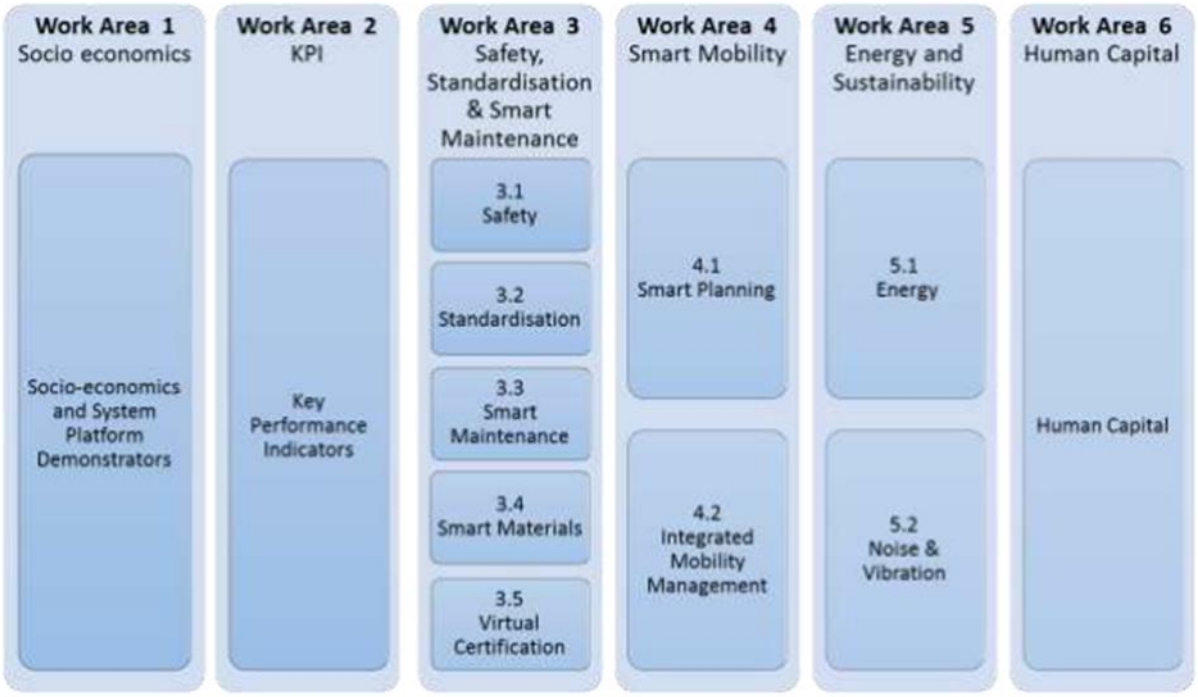

Figure 1: Overview Work Areas

IMPACT-2 constitutes of nine Work Packages (WPs) (see Table 1). The work reported in this deliverable has been performed within WP4 “KPI”.

Table 1: Work packages within IMPACT-2

WP	**Name**
WP1	Project management
WP2	Socio-economic impact
WP3	SPD implementation
WP4	**KPI**
WP5	Standardisation
WP6	Smart Maintenance
WP7	Integrated Mobility
WP8	Human Capital
WP9	Dissemination

4 Objectives/aims

This document has been prepared to provide a summary of the results of the first rough estimation of the KPIs carried out with the simplified model fed by rough low-level KPIs of the TDs. Those results should give a first indication on which results could be expected in the future. Nevertheless, the results are estimated while taking a lot of assumptions and restrictions not only for the KPI model but also for the input data into account and should therefore only be considered for a rough orientation not as given solutions.

5 Initial estimation of the KPIs

The initial estimations, which are the result of the initial quantitative KPI model of IMPACT-2 [5], are supposed to give a first indication on what impact the main improvements of the innovations developed within Shift2Rail can have on important KPIs of the railway system.

5.1 Results of the first estimation

5.1.1 Results of the overall Shift2Rail Programme

The first quantitative KPI model estimates results for the KPIs LCC, Reliability & Punctuality (namely the punctuality of the running trains) and Capacity (namely the maximum possible capacity). These KPIs are issued for the three passenger SPDs high-speed trains, regional trains and metro and for one freight SPD [2]. For these four SPDs there have been scenarios defined, which build the baseline of the estimations for the initial model (see Deliverable D4.1 “Reference Scenario” of IMPACT-1 [3]). The precise definition of the KPIs LCC, Reliability & Punctuality and Capacity are described in the deliverable D4.2 “Subsystem structure and Sublevel KPIs” of IMPACT-1 [4].

These following results (Table 2 – Table 5) are only rough primarily estimations. To calculate these first indications, there had to have been made a couple of assumptions and therefore there are some restrictions to the results. The main restrictions and assumptions to the here shown results are descripted in Chapter 4.2.

SPD 1 – High-Speed	
LCC reduction	-17 %
Reliability & Punctuality increase	19 %
Capacity increase	74 %

Table 2: KPI results for High-Speed

SPD 2 – Regional	
LCC reduction	-25 %
Reliability & Punctuality increase	15 %
Capacity increase	49 %

Table 3: KPI results for Regional

SPD 3 – Metro	
LCC reduction	-9 %
Reliability & Punctuality increase	11 %
Capacity increase	26 %

Table 4: KPI results for Metro

In general the definitions and calculations for passenger transport and freight transport are similar but not always the same. Especially for the KPI Capacity, there is an important difference in the definition. While the capacity for passenger transport is calculated for the peak hour, the capacity for freight is calculated over the period of one day. This is because of the demand in the transport systems. While for passenger trains capacity usually is critical for certain hours of the day (rush hours), for freight transport the capacity bottleneck is more dependent on the available routes in a certain segment of the line in a certain time and therefore not so much depending on specific hours.

SPD 4 – Freight	
LCC reduction	-36 %
Reliability & Punctuality increase	71%
Capacity increase	82%

Table 5: KPI results for Freight

5.1.2 Results for specific parts of the railway system

Besides the results for the whole railway system, the first initial models are also able to show results individually for the IPs of Shift2Rail. During the process of developing the model, it was figured, that the baseline, to which the improvements are measured has a high influence on the impression that is given by the results. An example for this effect is the LCC for signalling. When the improvements in cost by IP2 were shown on basis of the cost of the whole railway system, there could only a very small improvement been seen. Even if the cost of IP2 were cut complete, this had only a minor impact on the results. This is because IP2 has only a small contribution to the whole costs of the railway system (in average less than 5%). Therefore even a big improvement in cost reduction of Signalling is shown as a marginal reduction compared to the cost of the railway system.

As this effect has the potential to create the wrong impression on the efficiency of single IPs, it was decided to show the improvements for every IP on the bases on which the IPs really can have an influence at. This means that for example the reduction of costs for Signalling is compared to the overall costs of the Signalling system.

In Table 6 - Table 9 the results for every IP per SPD is shown. Thereby IP5 Freight traffic is not reflected in SPD1, SPD2 and SPD3, as these are passenger transport scenarios and IP1 Rolling stock is not reflected in SPD4 as the IP is focusing on passenger trains. Further there are no results for the Capacity improvement of IP3 Infrastructure for the passenger transport SPDs. This is because the Capacity for the passenger SPDs is measured per peak hour. The main influence IP3 has on Capacity is concerning maintenance and failure fixing. The relation between peak hour Capacity and maintenance / failure fixing is not trivial and therefore could not be included in the initial KPI model. This is one of the improvements of the model, which is foreseen for the next involved version of the models.

SPD 1 – High-Speed	Vehicle / IP1	Signalling / IP2	Infrastructure / IP3
LCC reduction	-5 %	-38 %	-39 %
Reliability & Punctuality increase	11 %	24 %	42 %
Capacity increase	16 %	50 %	[1]

Table 6: KPI results for High-Speed per IP

SPD 2 – Regional	Vehicle / IP1	Signalling / IP2	Infrastructure / IP3
LCC reduction	-9 %	-48 %	-39 %
Reliability & Punctuality increase	15 %	12 %	45 %
Capacity increase	14 %	30 %	[1]

Table 7: KPI results for Regional per IP

SPD 3 – Metro	Vehicle / IP1	Signalling / IP2	Infrastructure / IP3
LCC reduction	-6 %	-58 %	-38 %
Reliability & Punctuality increase	15 %	5 %	45 %
Capacity increase	5 %	20 %	[1]

Table 8: KPI results for Metro per IP

SPD 4 – Freight	Freight / IP5	Signalling / IP2	Infrastructure / IP3
LCC reduction	-11 %	-20 %	-40 %
Reliability & Punctuality increase	81 %	28 %	45 %
Capacity increase	21 %	50 %	5 %

Table 9: KPI results for Freight per IP

It was also discussed to show the improvements in LCC, Reliability & Punctuality and Capacity per Technical Demonstrator (TD). It was decided that the results are not shown per TD and furthermore will not be shown in future versions of the model. This is because there are numerous interrelations and interactions between the TDs, which do effect the improvements of the KPIs. Some TDs are not contributing very much to the KPIs, but are necessary so other TDs can rise to their full potential. In some cases there are even TDs, which only work together and would have no effect separately (e.g. TD3.6, TD3.7 and TD3.8,

[1] Major impact on Capacity per day but not on Capacity at Peak Hour

which build together the Intelligent Asset Management). Therefore splitting up the improvements into the influences of single TDs to the system could not reflect their importance suitably and often would lead to almost philosophical debates more than it would bring any usable information.

5.2 Restrictions and Assumptions for the results of the initial estimation

As already mentioned before due to its preliminary character, there are a couple of assumptions and restrictions to the initial KPI model, which results are discussed in this deliverable. In the following the most important restrictions and assumptions of the models are descript. Further the assumptions and restrictions which were identified for the qualitative structure on which the initial KPI model is based on apply here as well (see Deliverable D4.2 of IMPACT-2 [4]).

Evolutionary development: A basic assumption behind all scenarios is that the overall development is evolutionary and not disruptive. The world around the rail sector is assumed developing in a predictive way, e.g. the demand continues to develop as in the past decade and not disruptive political decisions as e.g. a complete ban of individual cars is happening. This assumption will also be valid for more advanced models developed in IMPACT-2.

Optimisation of KPIs: A restriction to the here shown results is that the KPIs are calculated independently. This means, that when e. g. calculating the LCC for High Speed, there is no influence of on Capacity or Reliability & Punctuality taken into account. Down the road this means, that there is no optimisation between the three KPIs done for these first initial results. A full optimisation will also not be possible in the future as this is an exceptional mathematical problem, which cannot be solved within this project. Nevertheless, for the future version of the KPI model, there are some measures foreseen, which will take the interdependencies between LCC, Capacity and Reliability & Punctuality at least in a simplified way into account, e. g. by introducing a minimum requirement of reliability when measuring the capacity.

Discounting: As the LCC model calculates costs over several decades, for economical correctness, future cash flows should be discounted. This praxis is common in economics to take common economic developments such as inflation into account. For the initial estimations a discount rate of three percent was used. Nevertheless, to keep the complexity of the initial model on a manageable level, the discounting was done outside of the model. This means, that the input values, for which discounting was necessary already were discounted when put in the model. For the advances model it is planned to include the discounting in the model, so coherence can be ensured.

Labour cost: Due to innovations the structure and quantity of labour can be influenced. Although this can have an influence on all sorts of labour, the initial KPI model is taking two kind of labour cost into account: labour cost for maintenance activities and labour cost for the train driver. Thereby only the labour cost for the train driver is pointed out in a dedicated *labour cost* part of the model. The labour cost for maintenance activities (corrective as well as preventive) are directly via the maintenance cost taking into account,

what means, that the named maintenance cost for parts include besides material, tools etc. the personal cost for the technician. This applies only to the labour cost, which result from the actual maintenance activity. Labour costs for planning, coordinating etc. of the maintenance are not included. The labour cost for the train driver is shown in a dedicated *labour cost* part as part of the *operation costs* in the model. Other labour cost for e.g. personal in the communication centre or train attendants will be considered for the advanced LCC model and if applicable included.

Energy cost: The initial KPI model is taking into account the energy costs for rolling stock (traction system and other consumers). In addition, the energy cost takes into account: annual travelled distance (km/year), the journey energy usage (kWh/km) and the energy price (€/kWh). The annual travelled distance is unique for each SPD, and is defined in IMPACT-1 D4.1 "Reference Scenario" [2]. Journey energy usage is initially obtained from IMPACT1 - D4.1 "Reference Scenario" [2], although in following versions will be updated with the data provided by FINE1 and OPEUS projects due to S2R improvements. These projects take also into account the energy feedback into the overhead line (recovery). Regarding energy price, which is the price that railway operators have to pay to infrastructure managers, the initial values are unique for each SPD, and are defined by FINE1 – D3.1 "Energy Baseline" [1]. Moreover, the energy prices depend on the supply system AC (16.7Hz and 50Hz) or DC, and the direction of current flow (supply or recovery).The evolution of energy prices [/kWh] should also be considered in the future updates of the KPI models. Finally, it shall be noted that full energy recovery is considered for all SPD's.

Further energy usage is not considered, especially for:

- Stations
- Switches (heating)
- Control Command and Signalling (CCS)-assets

Third party cost: In every complex system there are cost which do not result from the inherent activities of the system, but do emerge. Some of these costs are more or less independent from the innovations within the system (e. g. financial cost) whereas others interact with the system (e.g. compensations). In this initial KPI models third party cost are not included. For the advanced model it is foreseen to identify third party cost of the railway system and were applicable include them into the model.

Failure rates and delay minutes per failure: For the initial Reliability & Punctuality model there are only failure rates of the different subsystems considered. This can only lead to estimations about the punctuality when assuming, that every considered failure is leading to one delayed service. The assumption do not consider any chain effects in the system, when there is a disturbance, neither allow any gradation whether a failure leads to cancelled train or simply to a certain delay of the train. Therefore it is planned to extend the advanced Reliability & Punctuality model by introducing also the delay minutes in the system that are caused by a certain kind of failure. Thus the effects in the system of failures can be better displayed within the model.

Capacity limitations: Another restriction to the initial KPI models is regarding the Capacity model. When estimating the capacity of a railway system, there are a lot of interrelations, which influence each other in terms of capacity, which need to be considered. Some of these interrelations determine each other while for others one limits another. For the initial Capacity model the second kind of interrelation is not included yet. This means there are no limiting factors about the improvements of each single IP and TD. For example in the initial Capacity model of the passenger transport the improvements of IP1 Rolling stock lead directly to an increase of transportable passengers. But it could be, that the platforms are not able to cover the new amount of people exchanging, which would limit the number of transportable passenger again. Those factors need to be identified and were applicable introduced in the advanced Capacity model.

Mixed traffic for SPD4: As already described the definition of Capacity differs a bit for the freight scenario (SPD4) in comparison to the passenger scenarios (SPD1-3). Because the capacity is calculated for the whole day in the freight scenario, a traffic mix needs to be considered for SPD4. For the initial model, and thus for the initial results, a simplification in the scenario was assumed by sorting the traffic during the day. This means, that there is no real traffic mix, but that first all trains for one kind of traffic, e.g. high speed, and then all trains of another kind of traffic, e.g. freight traffic, are operating. This assumption simplifies the time tabling radically. Nevertheless, this assumption does not reflect the praxis in a suitable manner and will therefore be changed for the advanced model.

Interdependencies: The example for Capacity limitation could also be used as an example for interdependence between IP1 Rolling stock and IP3 Infrastructure. Interdependencies can occur on different levels within the structure of the models. As this interrelations are often quite complex and require a lot of communication between experts of the effected systems and the modeller, including interdependencies in the initial models were not feasible. For the advanced models it is foreseen to identify, discuss and if applicable model interdependencies within the railway system.

Functional structure of IP2: The Signalling System has some specifics which leads to the situation that the more technical definitions of the TDs is not suitable for the application of the KPIs. Therefore a high aggregation has been used in the first set of quantifications. This will be refined for the further issues to a functional structure which reflects more the application and use of the technology than technical subsystems.

Input data: The results of the first initial KPI models are based on the reference scenarios described in the deliverable D4.1 “Reference Scenarios” of IMPACT-1 [3]. The data for this scenarios were collected from various sources whereas usually there could only one source for each certain parameter be found. Therefore and because of the variety in European railway systems there has no coherence check been made, yet. Further some of the calculations, especially in the LCC model, are based on distribution factors, which show the distribution of a certain parameter, e. g. cost of a train, among the subsystems contributing to this parameter, here cost of doors, cost of traction etc. Introducing distribution factors

were necessary, as for some parameters there can no data be found because of confidentiality matters or other reasons. Those distribution factors are mainly based on expert judges and have to get a coherence check, too. Additionally the grad of detail of the reference scenarios is mostly in line with the grad of detail of the KPI models. When the models will advance, there might be some advances of the reference scenarios needed, too. This is foreseen to apply especially to the freight reference scenario as there are still some clarifications on the operational scenario are needed.

6 Conclusions

The conclusions reached at this stage of the R&I and highlighted in this report are that because of simplifications and assumptions first results for orientation were possible to provide. However these results were only achievable by now, because of a noteworthy number of assumptions and restrictions not only for the model, but also for the data basis and the defined scenarios. Therefore the shown results should be read and interpreted with care.

Further it was identified, that results per IP can only give usable information, if they are calculated on the basis of the areas, the IPs are working on. A calculation to the overall basis skews the results and will hence lead to wrong impressions.

In conclusion there are a couple of areas identified, which need to be worked on, before reliable results can be estimated, which will allow a profound assertion about the impact of the innovations of Shift2Rail on the LCC, Reliability & Punctuality and Capacity of the railway system.

7 References

[1] FINE1 – *D3.1 "Energy Baseline"* – 2017, Vol. 1

[2] IMPACT-1 – *D3.3 "Use cases for SPDs"* – 2017, Vol. 1

[3] IMPACT-1 – *D4.1 "Reference Scenario"* – 2018, Vol. 1

[4] IMPACT-1 – *D4.2 "Subsystem structure and Sublevel KPIs"* – 2018, Vol. 1

[5] IMPACT-2 – *D4.1 "Initial quantitative KPI model"* – 2018, Vol. 1

[6] Shift2Rail - *Shift2Rail Multi-Annual Action Plan (MAAP)* – 2015

8 Annexes

No content

9 Antitrust Statement

While some activities among competitors are both legal and beneficial to the industry, group activities of competitors are inherently suspect under the antitrust/ competition laws of the countries in which our companies do business.
Agreements between or among competitors need not be formal to raise questions under antitrust laws. They may include any kind of understanding, formal or informal, secretive or public, under which each of the participants can reasonably expect that another will follow a particular course of action or conduct. Each of the participants in this initiative is responsible for seeing that topics which may give an appearance of an agreement that would violate the antitrust laws are not discussed. It is the responsibility of each participant in the first instance to avoid raising improper subjects for discussion, notably such as those identified below.

It is the sole purpose of any meeting of this initiative to provide a forum for expression of various points of view on topics

- (i) that are strictly related to the purpose or the execution of the initiative,
- (ii) that need to be discussed among the participants of the initiative,
- (iii) that are duly mentioned in the agenda of this meeting and
- (iv) that are extensively described in the minutes of the meeting.

Participants are strongly encouraged to adhere to the agenda. Under no circumstances shall this meeting be used as a means for competing companies to reach any understanding, expressed or implied, which restricts or tends to restrict competition, or in any way impairs or tends to impair the ability of members to exercise independent business judgment regarding matters affecting competition.

As a general rule, participants may not exchange any information about any business secret of their respective companies. In particular, participants must avoid any agreement or exchange of information on topics on the following non-exhaustive list:

1. Prices, including calculation methodologies, surcharges, fees, rebates, conditions, freight rates, marketing terms, and pricing policies in general;
2. any kind of market allocation, such as the allocation of territories, routes, product markets, customers, suppliers, and tenders;
3. production planning; marketing or investment plans; capacities; levels of production or sales; customer base; customer relationships; margins; costs in general; product development; specific R&D projects;
4. standards setting (when its purpose is to limit the availability and selection of products, limit competition, restrict entry into an industry, inhibit innovation or inhibit the ability of competitors to compete);
5. codes of ethics administered in a way that could inhibit or restrict competition;
6. group boycotts;
7. validity of patents;
8. ongoing litigations.