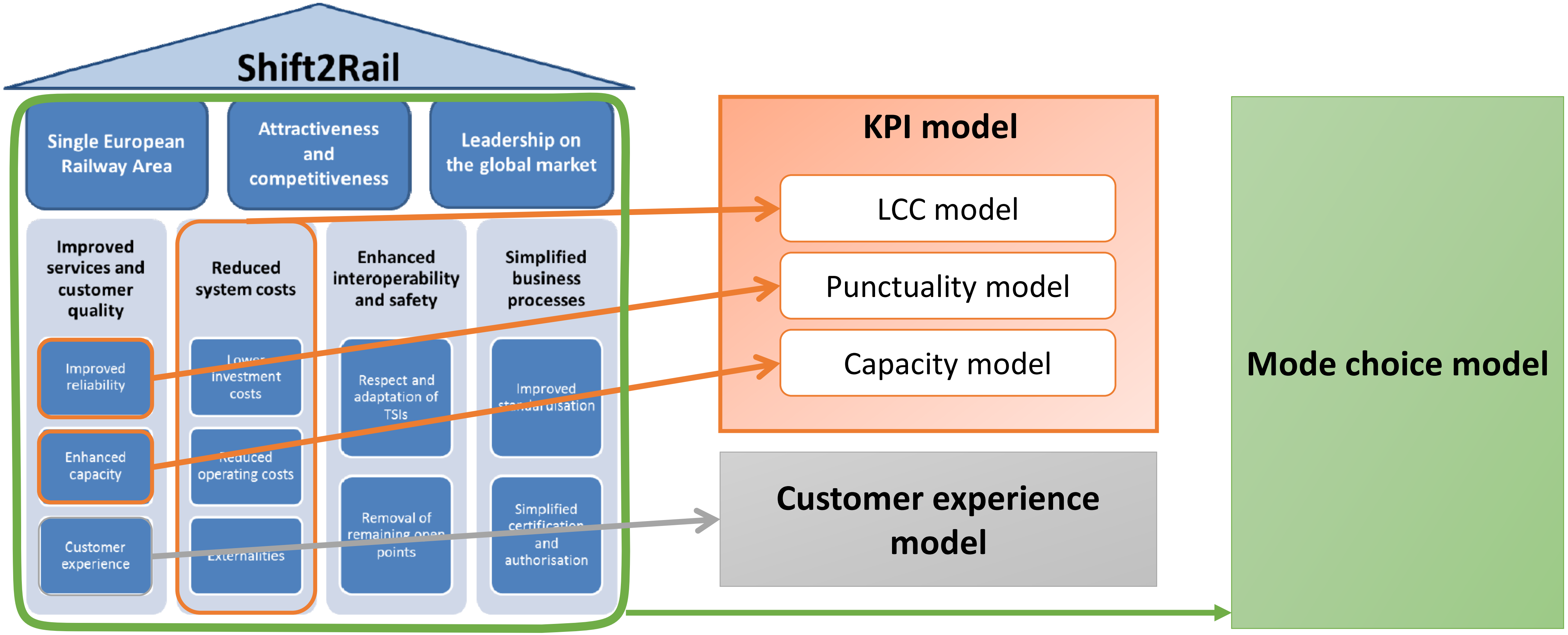
Flex-Rail Final Results Dissemination Webinar

The IMPACT-2 model for Shift2Rail

Michael Meyer zu Hörste, DLR
Ida Kristoffersson, VTI
Filiz Kurt, DLR

30th June 2021

Overview of the IMPACT-2 model of Shift2Rail

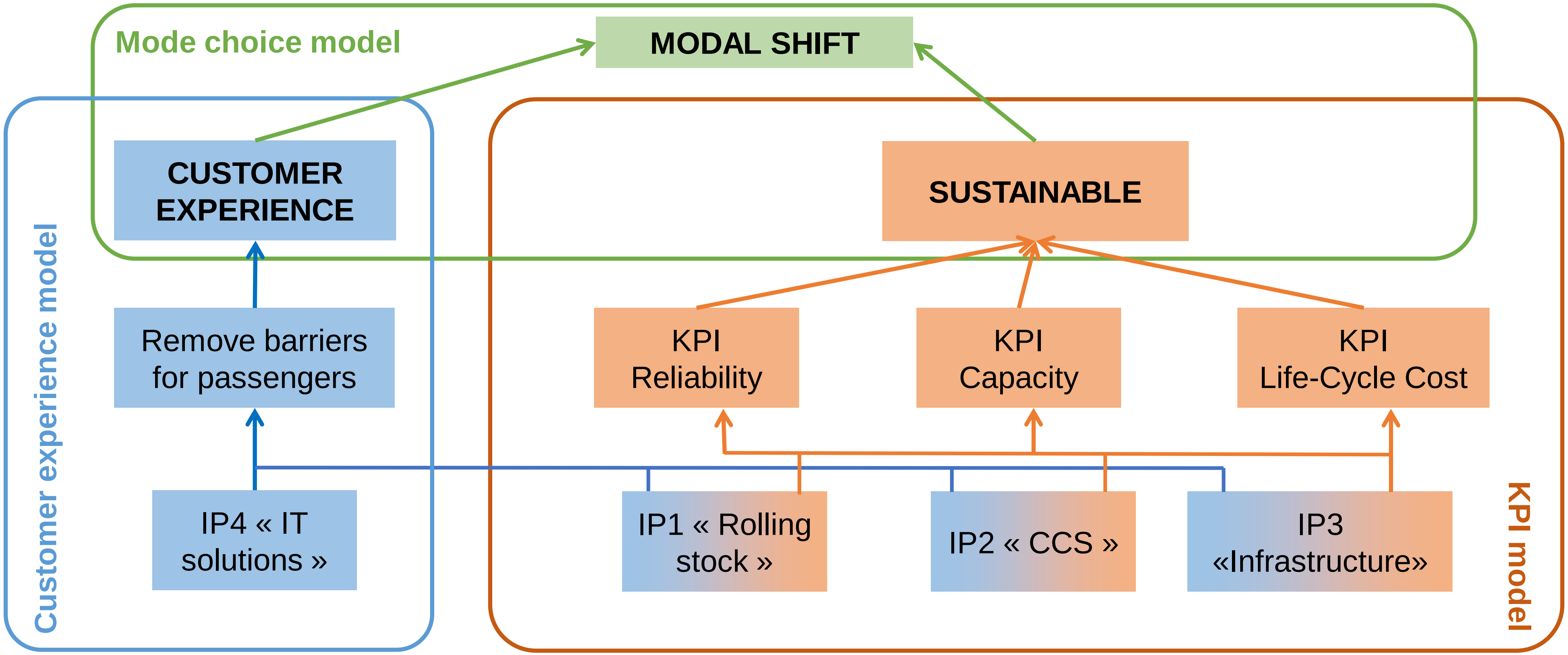


Source: www.shift2rail.org

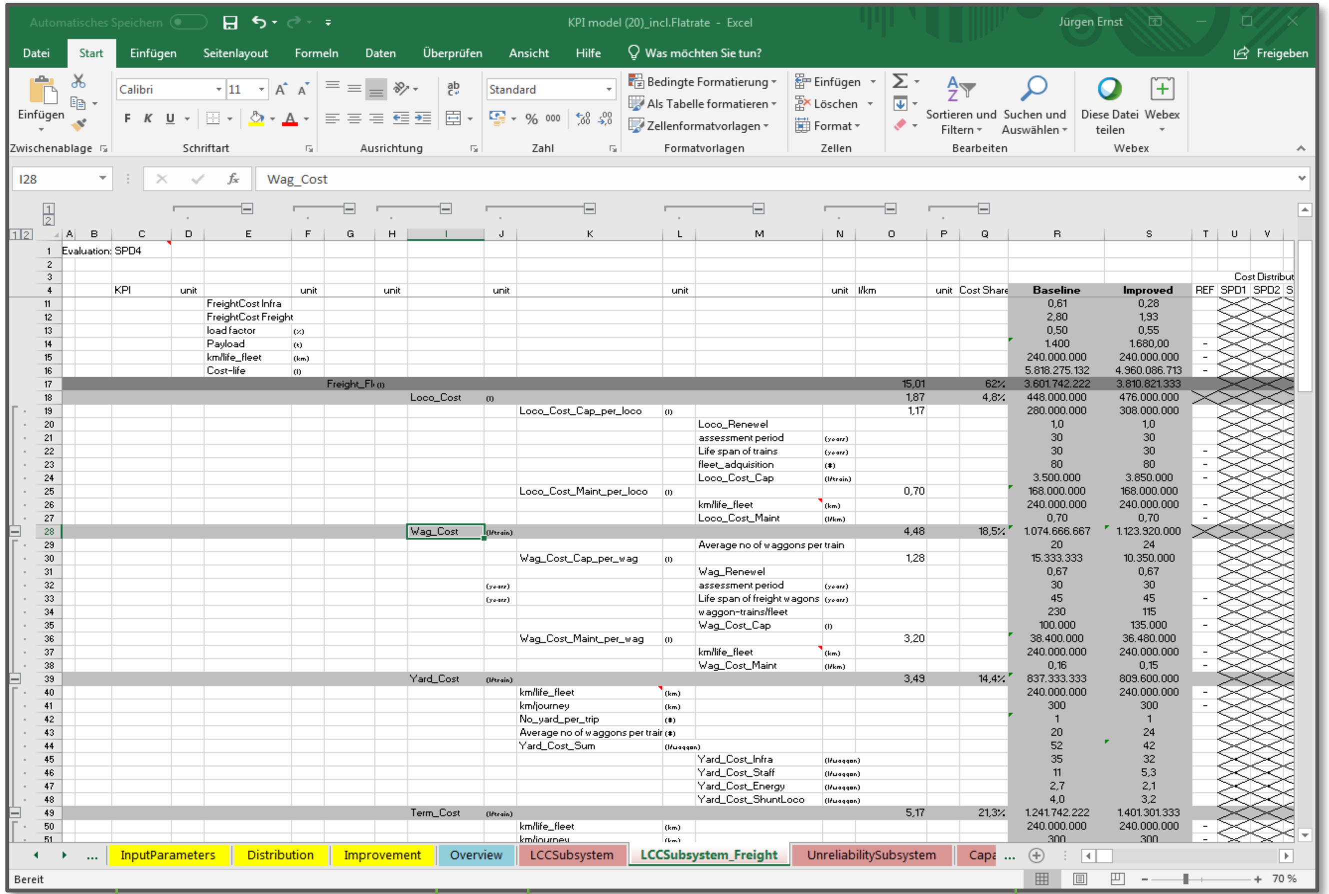
Overview of the IMPACT-2 model of Shift2Rail

1. **Quantitative KPI model**
    - Strict focus on technological innovations
    - Consequent percentages used
    - Target is the maximum achievable improvement as a priority for the respective KPI
    - Based on generic scenarios
2. **Customer Experience**
    - Focus on Areas of Major Potential for Improvement i.e. improving attractivity of the Rail System
    - Based on feedback from customers
3. **Mode-Choice model**
    - Focus on the increased use of the Rail System
    - Based on real Scenarios

Relation of the IMPACT-2 model of Shift2Rail



Internal structure of the KPI model



Input parameters

Results

Models for LCC, punctuality & capacity

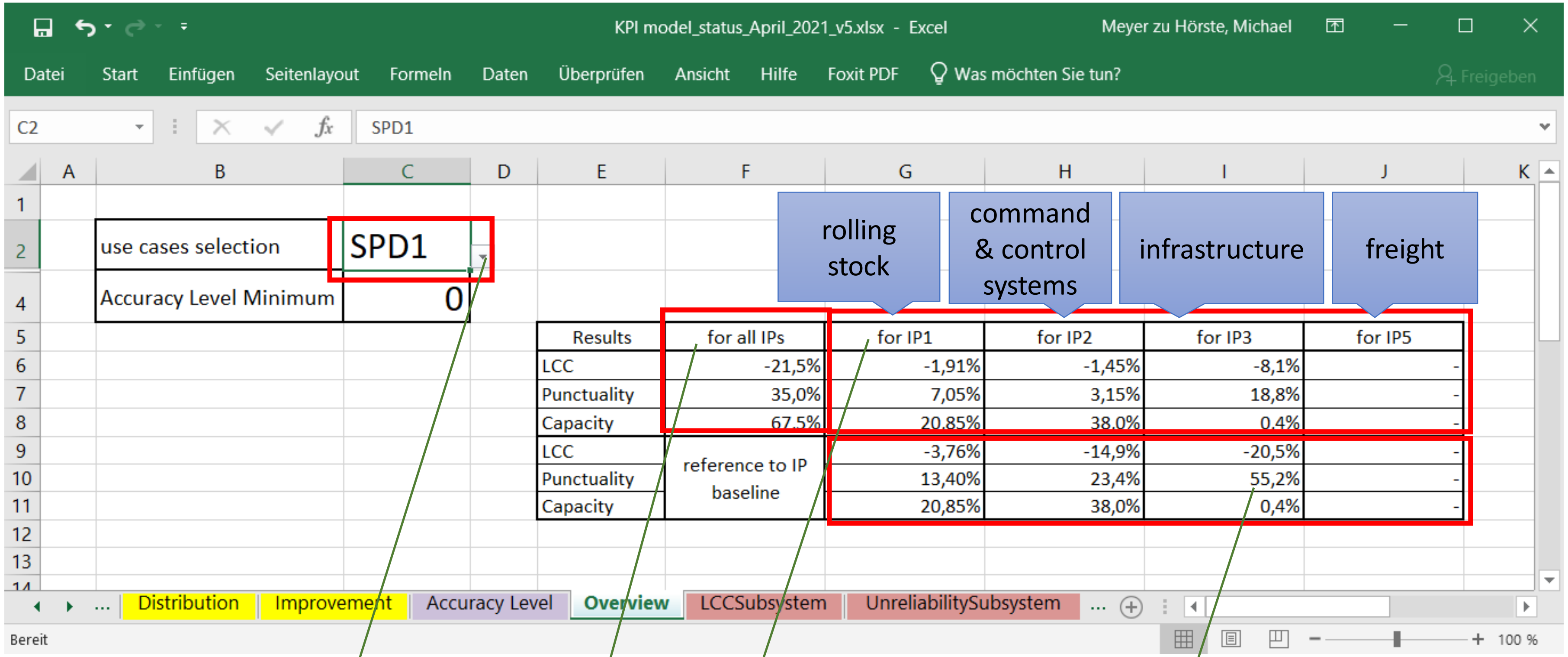
Sheet 3: InputParameters
Sheet 4: Distribution
Sheet 5: Improvements

Sheet 7: LCCSubsystem
Sheet 8: UnreliabilitySubsystem
Sheet 9: Capacity_Subsystem
Sheet 10: LCCSubsystem_Freight
Sheet 11: Unreliability_Freight
Sheet 12: Capacity_Freight

Sheet 6: Overview

Sheet 1: Cover & History
Sheet 2: SPDParameters
Sheet 13: Decisions
Sheet 14: Sources

Internal structure of the KPI model



use cases selection	SPD1
Accuracy Level Minimum	0

Results	for all IPs	for IP1	for IP2	for IP3	for IP5
LCC	-21,5%	-1,91%	-1,45%	-8,1%	-
Punctuality	35,0%	7,05%	3,15%	18,8%	-
Capacity	67,5%	20,85%	38,0%	0,4%	-
LCC	reference to IP baseline	-3,76%	-14,9%	-20,5%	-
Punctuality		13,40%	23,4%	55,2%	-
Capacity		20,85%	38,0%	0,4%	-

Selection of SPD

Overall results

Results w.r.t. to the IP part of the overall baseline

Results w.r.t. to the IP-specific part of the baseline

SPD1: High Speed

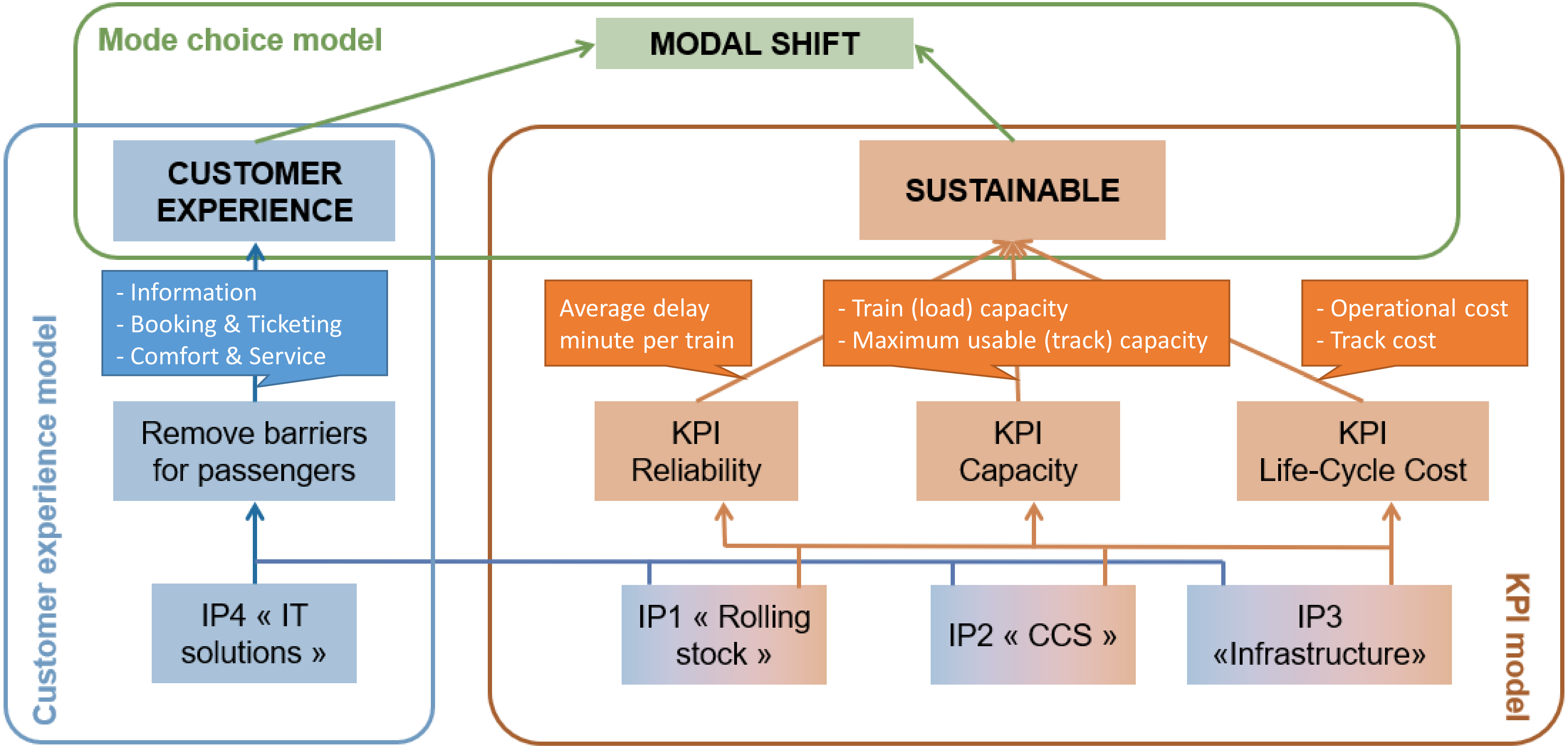
SPD2: Regional

SPD3: Metro

SPD4: Freight

Source: www.pixabay.com

KPI-Input for Mode choice model



IMPACT-2 Mode choice modelling and results

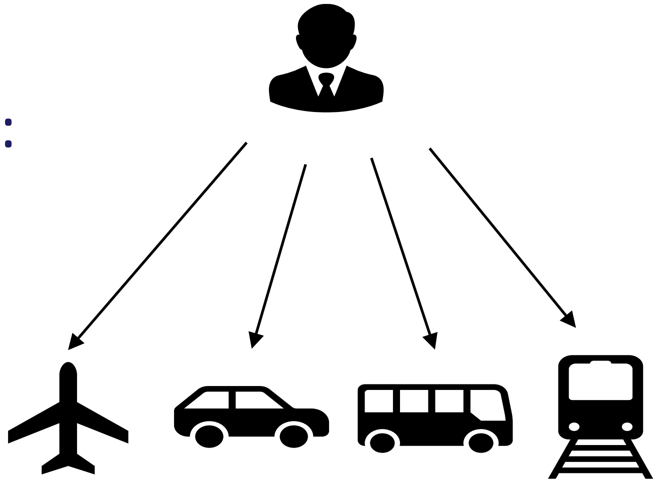
Passenger mode choice models are based on theory of discrete choice

- Predefined set of alternatives: e.g. air, car, bus, rail
- Preference of an alternative quantified in the utility function:

$$U_{rail} = V_{rail} + \varepsilon_{rail}$$
$$= ASC_{rail} + \beta_{rail} InVehicleTime_{rail} + \gamma_{rail} TravelCost_{rail} + \cdots + \varepsilon_{rail}$$

$$U_{car} = V_{car} + \varepsilon_{car}$$
$$= ASC_{car} + \beta_{car} TravelTime_{car} + \gamma_{car} TravelCost_{car} + \cdots + \varepsilon_{car}$$

…



- Assuming ε follows Gumbel distribution → Multinomial Logit model

$$P_{car} = \frac{e^{V_{car}}}{e^{V_{car}} + e^{V_{bus}} + e^{V_{rail}} + e^{V_{air}}}$$

Assumptions

- Only the end situation when all Shift2Rail innovations are realized is modelled – not the implementation path
- Changes in population development, income etc. are not considered – the innovations are applied to today's situation to isolate the effects of innovations
- Only one corridor per SPD is considered
- Only demand in the peak hour is modelled
- Only one type of traveller is considered: an ”average” traveller
- Total number of travellers (for all modes) is assumed to be constant
- Congestion on the road network is not taken into account

Source: www.pixabay.com

Baseline mode choice models

- To build the baseline mode choice models, we need:
  - Baseline demand
  - Service attributes: travel time, travel cost, average delay, customer experience variables (Booking & ticketing, information, comfort) etc.
  - Passenger valuations: value of time (Swedish, French and EEU Value of time sets), value of customer experience

Supply constraints

- There exists supply constraints
  - Number of trains per hour is limited by the maximum usable track capacity
  - Number of passengers per train is limited by train seat capacity
  - Negative effects of crowding are captured by a discomfort factor (based on the load factor)

Optimisation

We assume operators will only adjust ticket cost and frequency:

- High-speed: operators maximize profit both in baseline and in future scenarios

- Regional and metro: Producer surplus is kept as in baseline and profit above that is used to decrease ticket prices and/or increase frequency

SPD High-speed passenger rail

Important characteristics of the studied corridor

- Busy corridor in a high-density area
- Maximum usable track capacity reached already in baseline (12 trains/h)
- Large share of long-distance rail already in baseline (24%)
- Average delay small compared to corridor travel time
- Main competing mode is private car

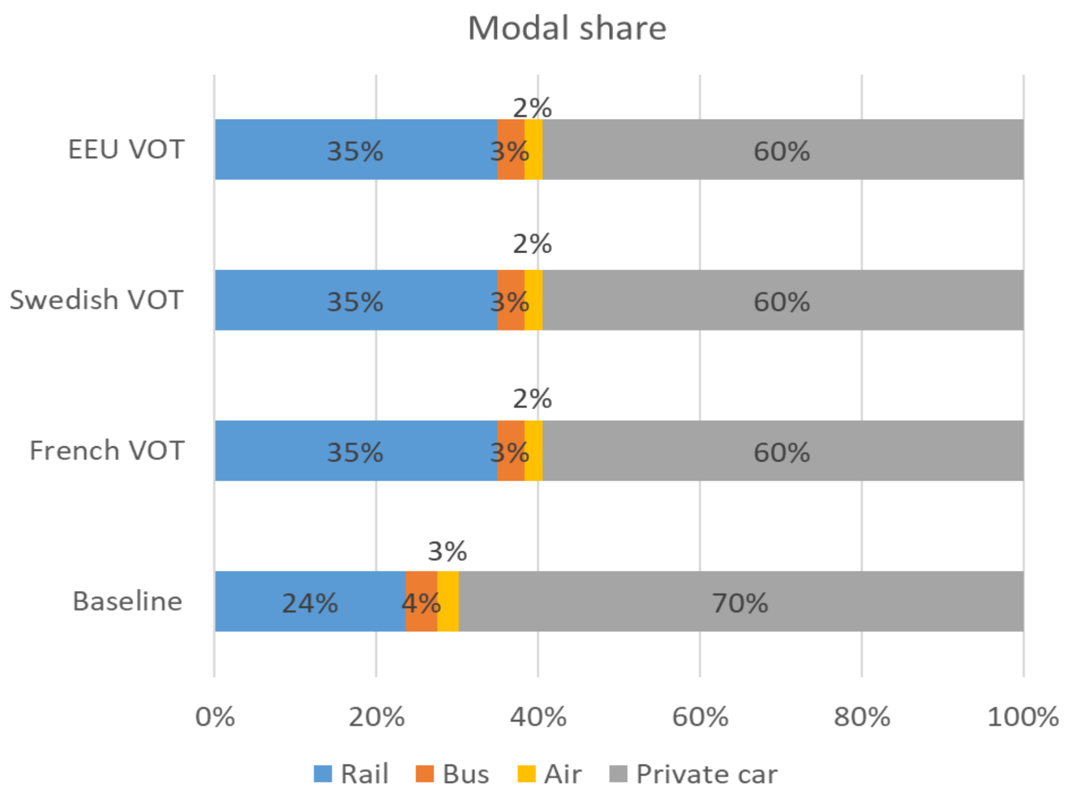
Improvements in S2R impact scenario – High-speed

- Maximum usable track capacity increases substantially → important for operator's decision regarding train frequency (running at full capacity in baseline)
- Full deployment of high-speed S2R customer experience improvements assumed (100%)
- Substantial reduction of average delay minutes (-35%) but delay minutes are small compared to in-vehicle travel time for the corridor

Input data item	Unit	Percentage difference
Average delay minute per train	min	-35%
Train capacity	seats/train	+11%
Maximum usable track capacity	trains/h	+33%
Operational cost	€/train	-6%
Track cost	€/train	-16%
Customer experience variables	Normalized to 1	+100 %

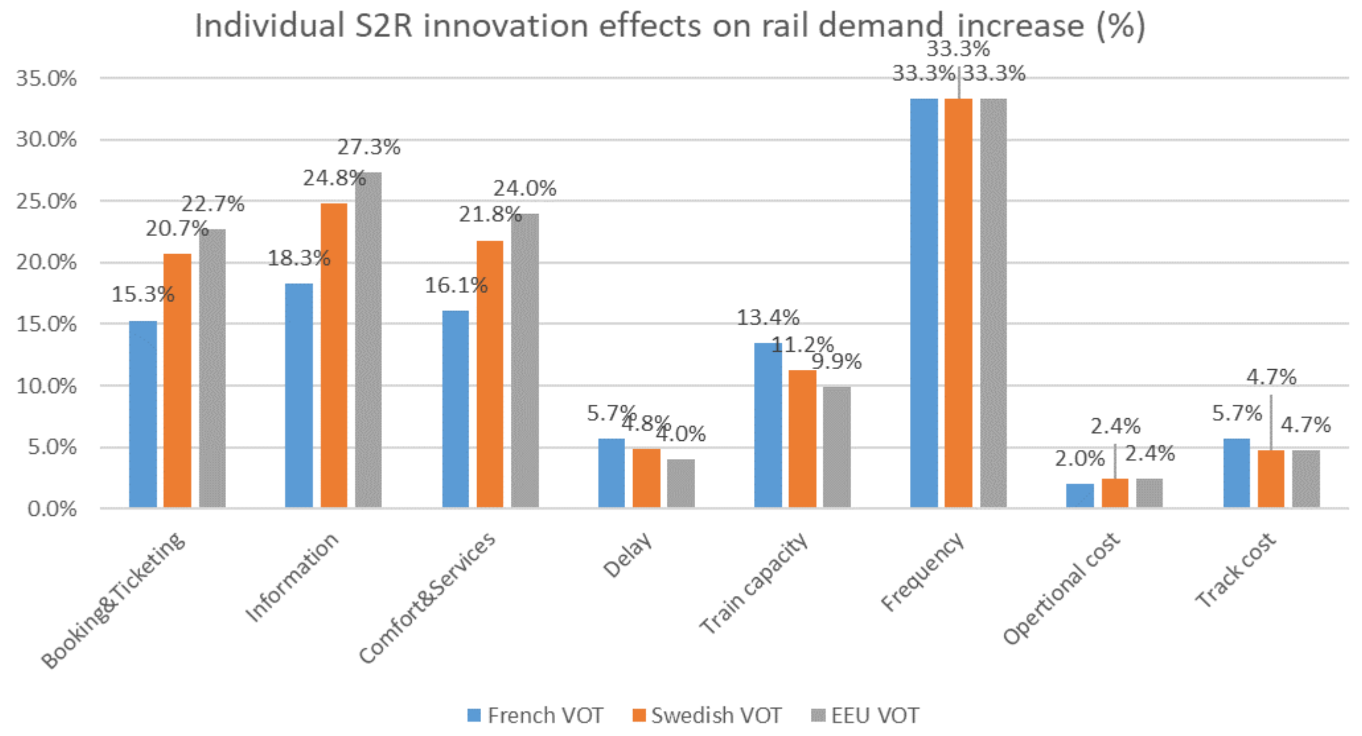
Results: High speed

- **Modal share**
  - Significant effect of S2R innovations (rail modal share increases from 24% to 35%)
  - S2R scenario rail modal share does not depend on the value of time (VOT) assumptions



High speed – Which factors contribute the most?

- **Frequency** in S2R impact scenario has reached improved maximum usable track capacity, which is the main driver (reduction of waiting time)
- **Customer experience improvements** have substantial effects, but they are constrained by the maximum usable track capacity
- Modest effects of delay reduction and reduced operational and track costs



Alternative future scenarios for AV and EV innovation

Data item	Source	Adopted values
	AV innovation	
Passenger valuations of peak hour average in-vehicle travel time for AVs	Kolarova et al. (2018) [19] ; Correia et al. (2019) [20]	Moderate 86% and Optimistic 73%
Passenger valuations of peak hour average access and egress travel time for bus	Kolarova et al. (2018) [19]	Moderate 84% and Optimistic 67%
Peak hour average access and egress travel time for bus	Near2050 D5.3 (2018) [18]; CoExist D4.2 (2020) [29]	Moderate 100.5% Optimistic 97%
Peak hour average in-vehicle travel time for AVs	Milakis et al. (2017) [22]; Near2050 D5.3 (2018) [18]; CoExist D4.2 (2020) [29]	Moderate 100.5% and Optimistic 97%
Peak hour average travel cost for AVs	Milakis et al. (2017) [22]; Near2050 D5.3 (2018) [18]; Fagnant, et al. (2015) [24]	Moderate 104% and Optimistic 75%
Market share of AVs	Milakis et al., (2017) [22]	Moderate 40% and Optimistic 100%
	Climate innovation	
Peak hour average travel cost for EVs	Jensen et al. (2017) [26]; Bösch et al., (2018) [25]; Lutsey and Nicholas (2019) [27]	Moderate 40% and Optimistic 20%
Market share of EVs	Liu et al. (2017) [15];	Moderate 50% and Optimistic 100%

- Moderate and optimistic Automated vehicles (AVs) scenarios
- Moderate and optimistic Electric vehicles (EVs) scenarios
- Assumptions on market share and changes in value of time and travel cost from literature review
- Only minor changes in assumptions between high-speed, regional and metro

AV and EV scenario results – High-speed

- Shift2Rail innovations are also present, results for Swedish value of time set
- Moderate AV and EV innovation do not affect rail demand but lower ticket prices
- Optimistic EV innovation wipe out the rail demand increase of S2R

Scenario name	Rail mode share (%)	Ticket price (€)	Frequency	Load factor	Producer surplus (€)	Consumer surplus (€)
Baseline	24%	47	12	0.80	176760	0
Shift2Rail	35%	63	16	0.80	393771	31438
	(48%)	(34%)	(33%)	(0%)	(123%)	/
Moderate AV	35%	59	16	0.80	365955	111147
	(48%)	(26%)	(33%)	(0%)	(107%)	/
Moderate EV	35%	43	16	0.80	251006	440542
	(48%)	(-8%)	(33%)	(0%)	(42%)	/
Optimistic AV	29%	27	16	0.66	97432	881578
	(23%)	(-43%)	(33%)	(-17%)	(-45%)	/
Optimistic EV	17%	23	11	0.58	37906	1099185
	(-27%)	(-52%)	(-8%)	(-28%)	(-79%)	/

SPD Regional

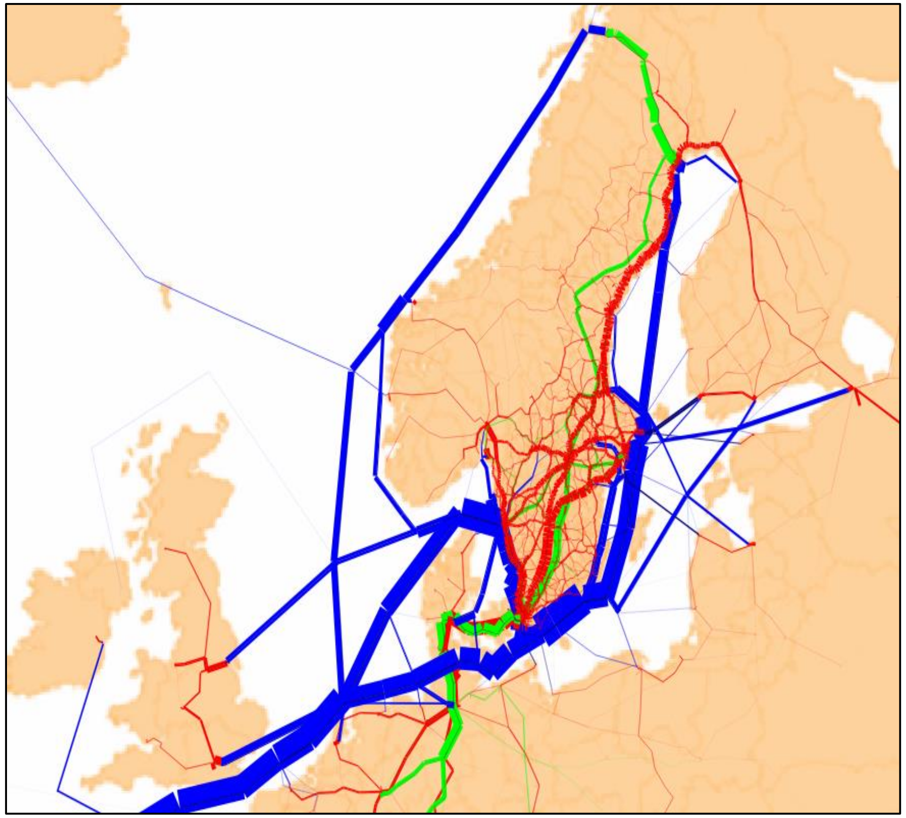
- Similar model type as for high-speed SPD, even though the alternative modes differ
- Frequency much lower than maximum usable track capacity (capacity constrained only at some nodes)
- Average delay minutes decreases substantially (-52%)
- Significant effect of S2R innovations (rail modal share increases from 18% to 29-40% depending on the value of time (VOT) assumptions)
- Already Moderate EV innovation reduce S2R rail demand increases substantially
- Optimistic AV and EV innovation wipe out the S2R rail demand increases

SPD Metro

- Similar model type as for high-speed SPD, even though the alternative modes differ
- Frequency at maximum usable track capacity and is not increased by S2R innovations
- Only minor effects of S2R innovations (rail modal share increases from 30% to 31%)
- Inelastic SPD – Small demand changes also in Optimistic AV and EV scenarios

SPD Freight - Modelling

- KPI computations based on a generic corridor
- Modal share computations are done over an entire network (Sweden).
- Network model: Samgods (cost-minimizing model)
- We represent improvements in terms of percentages.
- Evaluation: Tonnes-km on Swedish territory only (and territorial waters). Reason for this is that flows over the Baltic Sea may cause untypical results for European conditions.



SPD Freight – Results

- Very strong impact on modal shift by S2R innovations (rail modal share increases from 21% to 32-47% depending on capacity constraints on rail or not)
- However, large variations for different commodity types.
- Most important drivers are (probably): reduced operational costs, driving time and max load capacity.
- Assumptions that S2R improvements are done on the whole rail network may be too optimistic (?)
- No improvements on sea have been considered.

Thanks for your attention!

The authors express their acknowledgement to the Shift2Rail Joint Undertaking for financing the projects IMPACT-2 (GA 777513) related to the work presented here. This contribution reflects the views of the authors and does not necessarily reflect the views or policy of the Shift2Rail Joint Undertaking or the European Commission.

The results leading to this publication have received funding from the Shift2Rail Joint Undertaking under the European Union's Horizon 2020 research and innovation programme, grant agreement No 777513 for the project "Indicator Monitoring for a new railway PAradigm in seamlessly integrated Cross modal Transport chains – Phase 2", IMPACT-2.

Contact

Filiz Kurt
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR) | Institut für Verkehrssystemtechnik
Lilienthalplatz 7, 38108 Braunschweig
Phone +49 531-295-1092
E-Mail filiz.kurt@dlr.de
www.DLR.de

Michael Meyer zu Hörste
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR) | Institut für Verkehrssystemtechnik
Lilienthalplatz 7, 38108 Braunschweig
Phone +49 531-295-3440 |
E-Mail Michael.MeyerzuHoerste@dlr.de
www.DLR.de

Ida Kristoffersson
The Swedish National Road and Transport Research Institute
Box 55685, 102 15 Stockholm
Phone +46 8 518 388 11
E-Mail ida.kristoffersson@vti.se
www.vti.se