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Visualising railway service quality

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Research Fellow

RSEI Comes of Age

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Outline

- Motivation
- Quality of Service (QoS) framework
- QoS quantitative evaluation
- Example of application – ON-TIME project
- Conclusions and future work

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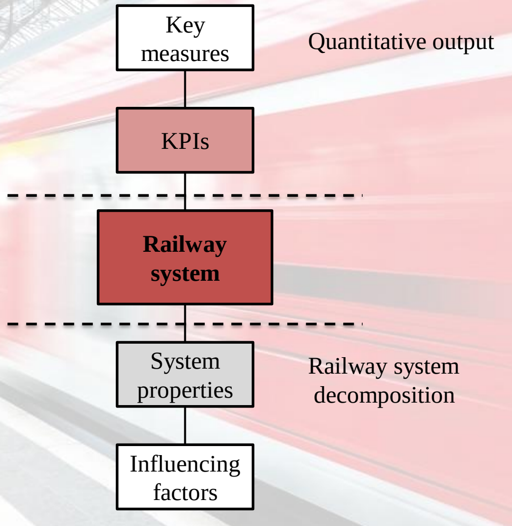
Motivation

- Differing perspective depending on the stakeholder
- Evaluation of quantity and quality of operational behaviour
- Whole system approach
  - Decomposition of system into properties
  - Measure the effect of changing system properties, i.e., quantitative evaluation

Quality of Service framework



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QoS framework applications

The QoS framework broadly has 4 applications:

- benchmarking of simulation tools
- comparison of timetables or operational control systems
- visualisation of delay propagation
- linking of real operational data and microscopic simulation

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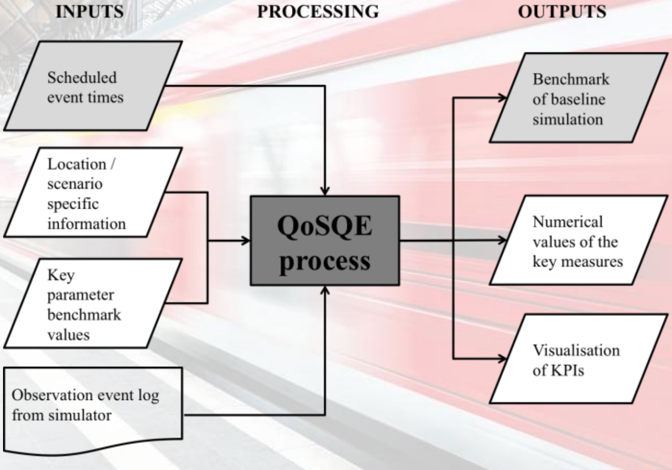
QoSQE methodology



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The full Quality of Service framework…

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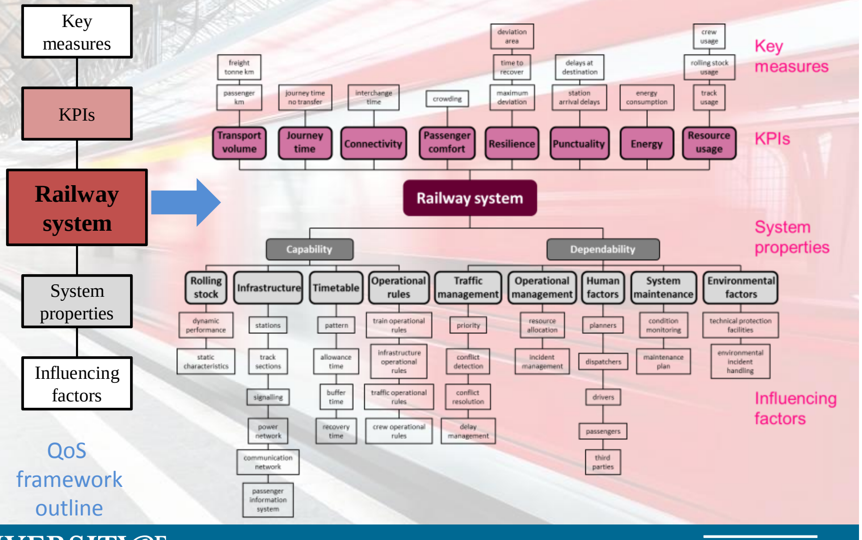
QoS framework



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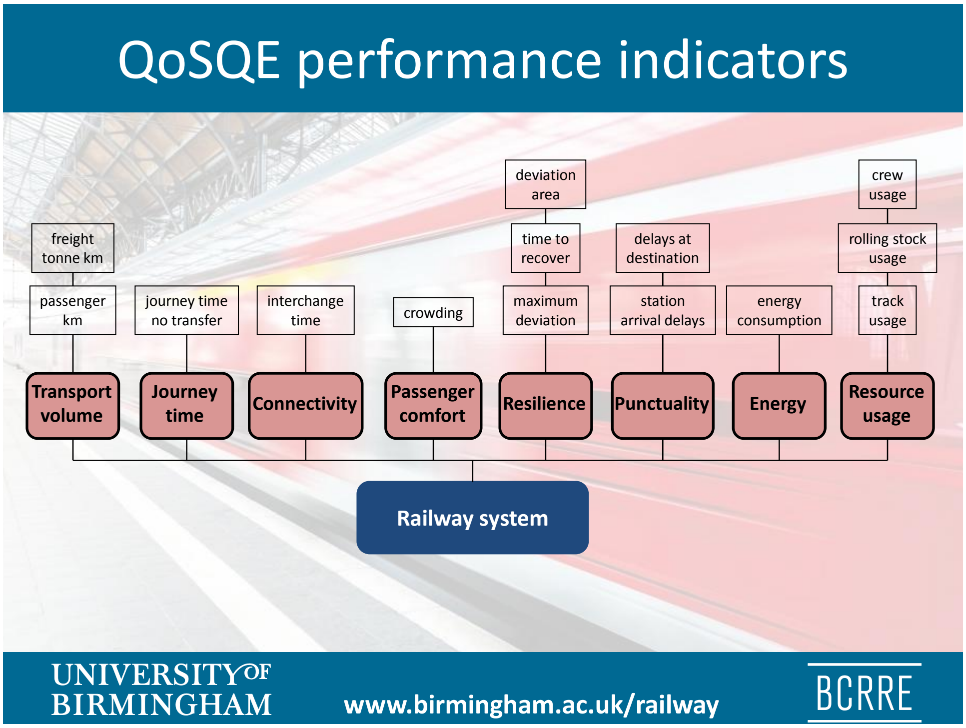
QoSQE performance indicators
deviation area
crew usage
freight tonne km
time to recover
delays at destination
rolling stock usage
passenger km
journey time no transfer
interchange time
crowding
maximum deviation
station arrival delays
energy consumption
track usage
Transport volume
Journey time
Connectivity
Passenger comfort
Resilience
Punctuality
Energy
Resource usage
Railway system
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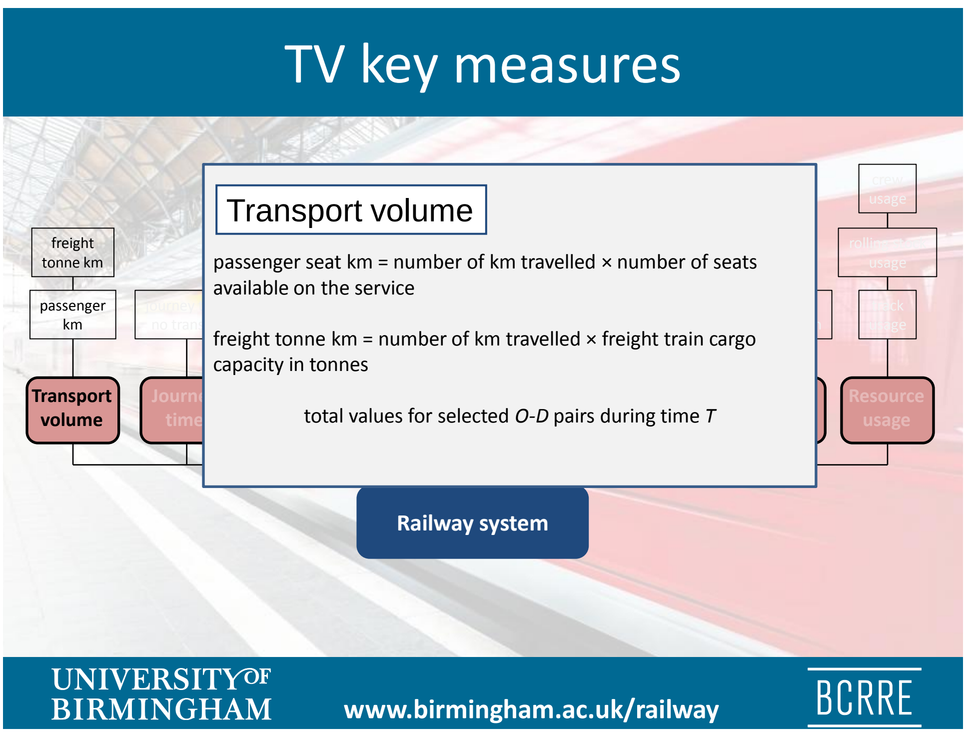
TV key measures
freight tonne km
passenger km
Transport volume
Transport volume
passenger seat km = number of km travelled × number of seats available on the service
freight tonne km = number of km travelled × freight train cargo capacity in tonnes
total values for selected O-D pairs during time T
Resource usage
Railway system
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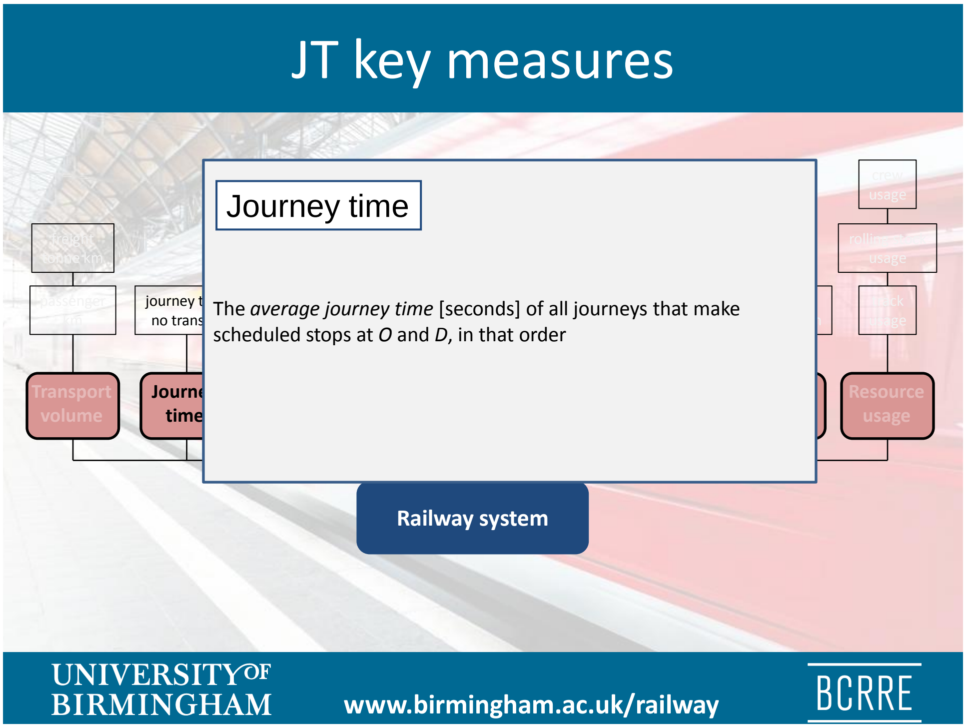
JT key measures
Journey time
The *average journey time* [seconds] of all journeys that make scheduled stops at *O* and *D*, in that order
Transport volume
Resource usage
Railway system
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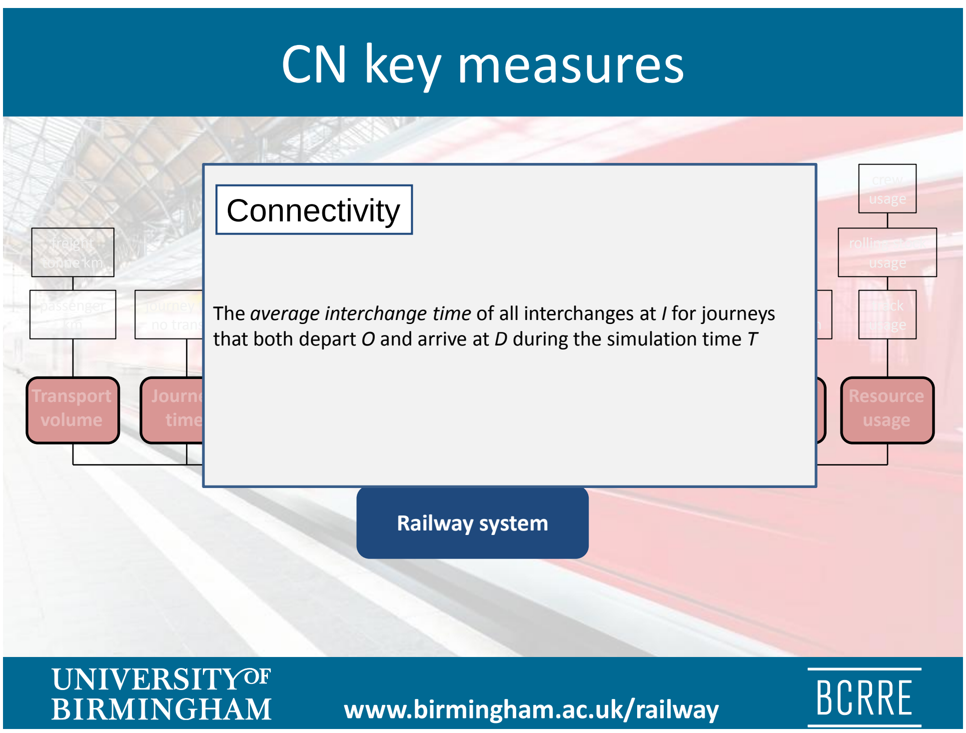
CN key measures
Connectivity
The *average interchange time* of all interchanges at *I* for journeys that both depart *O* and arrive at *D* during the simulation time *T*
Transport volume
Resource usage
Railway system
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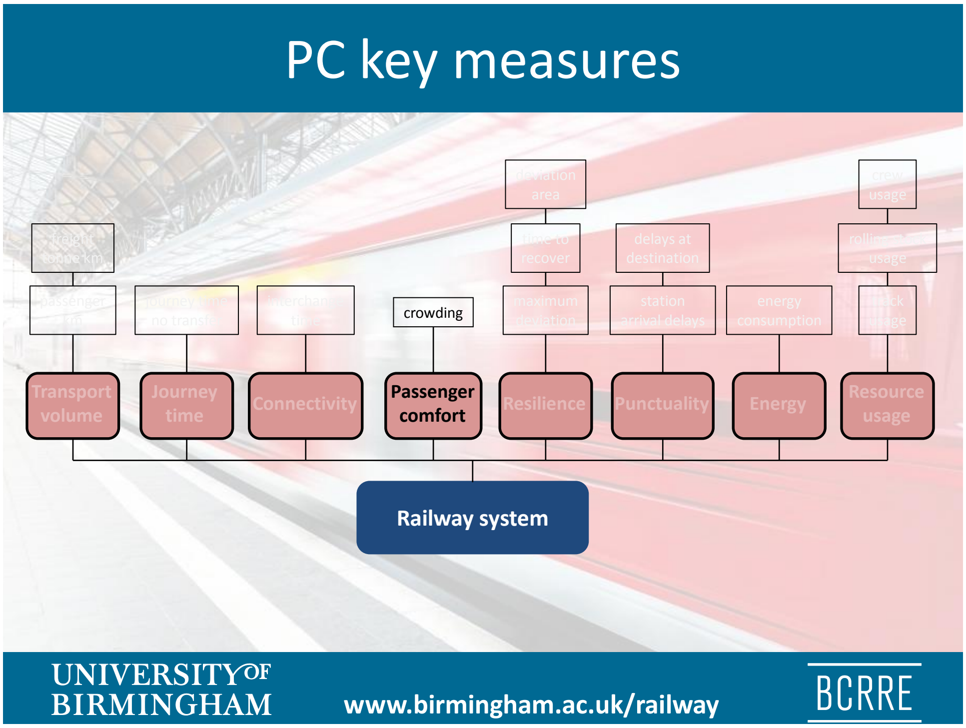
PC key measures
deviation area
crew usage
time to recover
delays at destination
crowding
maximum deviation
station arrival delays
energy consumption
Transport volume
Journey time
Connectivity
Passenger comfort
Resilience
Punctuality
Energy
Resource usage
Railway system
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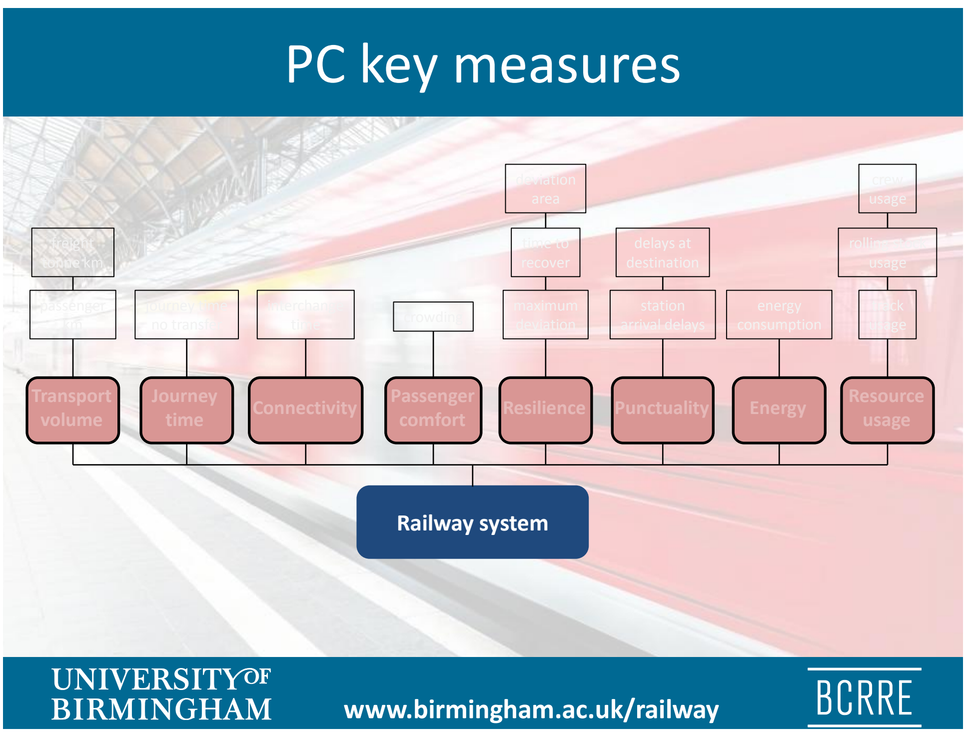
PC key measures
deviation area
crew usage
time to recover
delays at destination
maximum deviation
station arrival delays
energy consumption
Transport volume
Journey time
Connectivity
Passenger comfort
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Railway system
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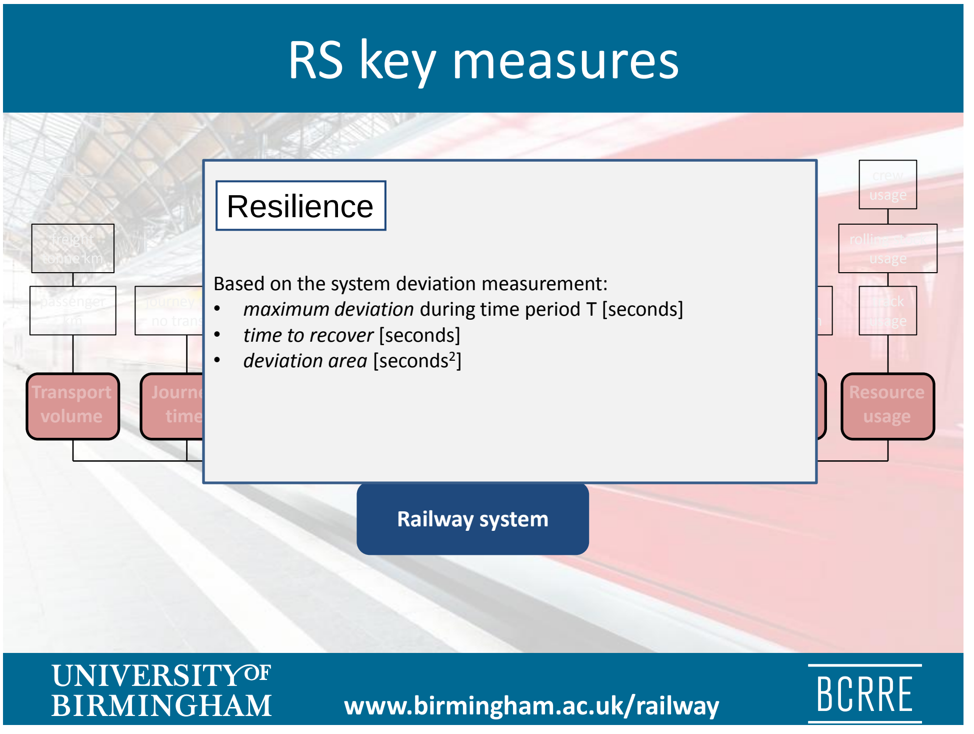
RS key measures
Resilience
Based on the system deviation measurement:
• *maximum deviation* during time period T [seconds]
• *time to recover* [seconds]
• *deviation area* [seconds^2]
Transport volume
Resource usage
Railway system
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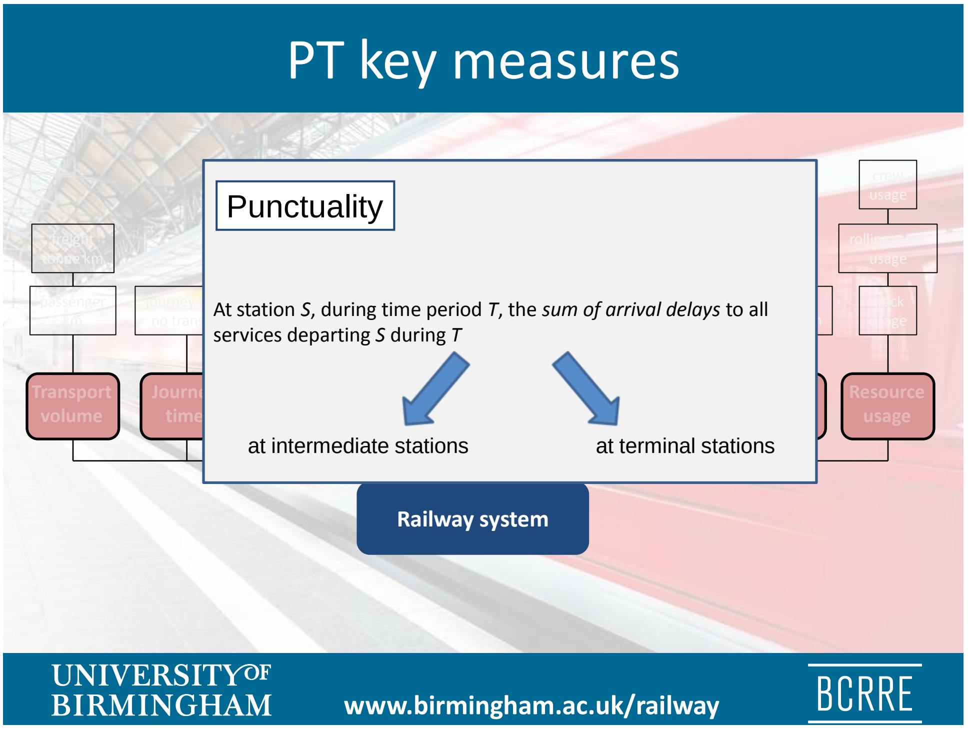
PT key measures
Punctuality
At station *S*, during time period *T*, the *sum of arrival delays* to all services departing *S* during *T*
at intermediate stations
at terminal stations
Transport volume
Resource usage
Railway system
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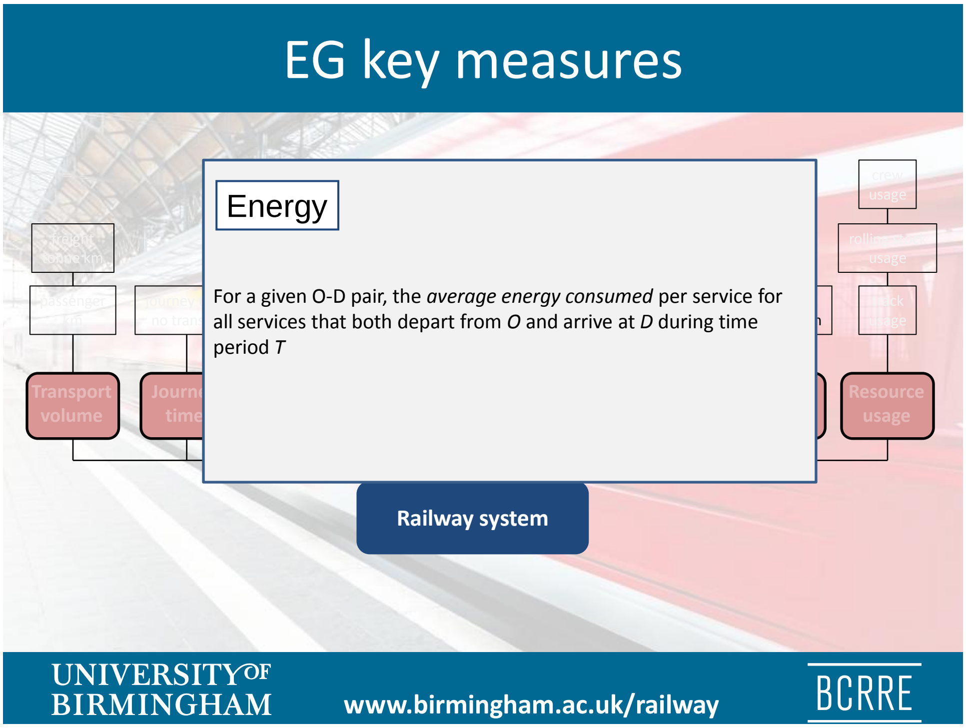
EG key measures
Energy
For a given O-D pair, the *average energy consumed* per service for all services that both depart from *O* and arrive at *D* during time period *T*
Transport volume
Resource usage
Railway system
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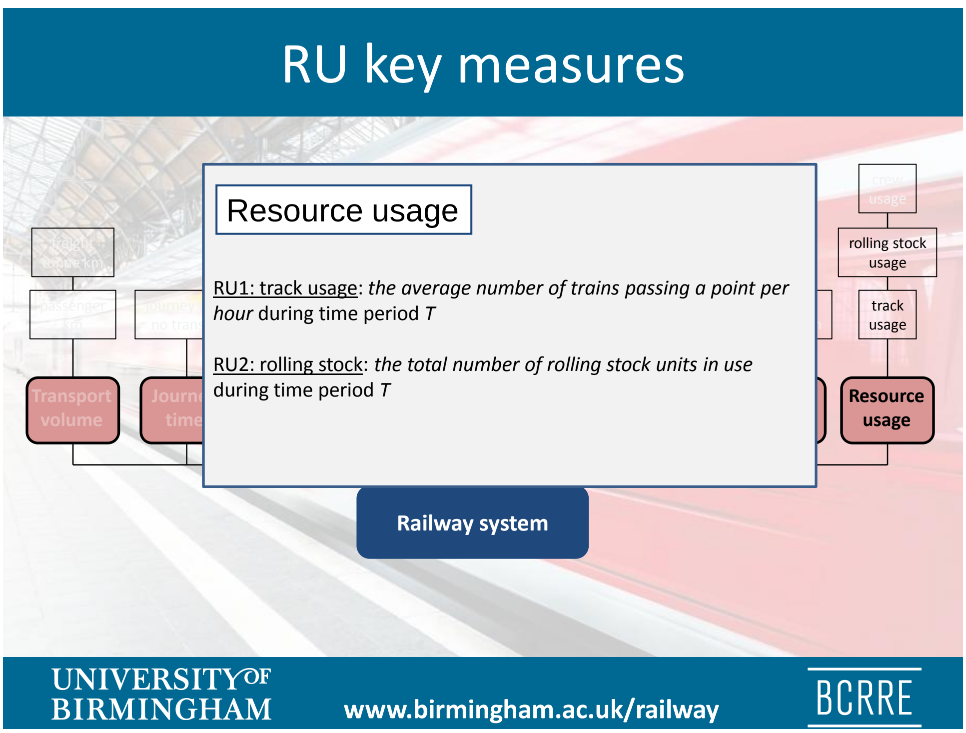
RU key measures
Resource usage
RU1: track usage: *the average number of trains passing a point per hour* during time period *T*
RU2: rolling stock: *the total number of rolling stock units in use* during time period *T*
rolling stock usage
track usage
Transport volume
Resource usage
Railway system
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Example: ON-TIME project

- Project aim: an improvement in capacity by reducing delays and improving traffic fluidity

- Evaluation and comparison of traffic management approaches
  - For minor perturbations
  - For major perturbations

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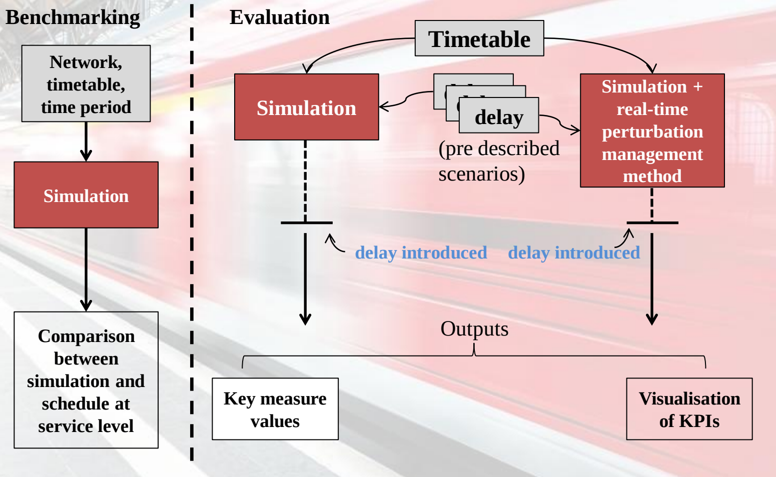
QoSQE applied in ON-TIME



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ON-TIME case studies

- Iron Ore line, Sweden and Norway
- East Coast main line, UK
- Section of Dutch network, The Netherlands

- Minor perturbations
  - e.g. temporary speed restriction, signal failure
- Major perturbations
  - e.g. complete line blockage

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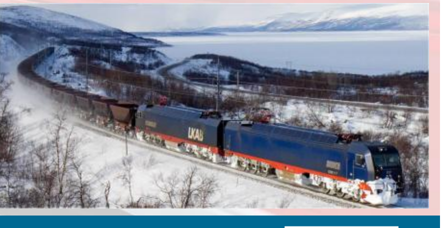
ONTIME case studies

- Iron Ore line, Sweden and Norway

- Minor perturbations
  - e.g. temporary speed restriction



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IOL simulator benchmarking

Comparison between timetabled and simulated event times for IOL simulation…

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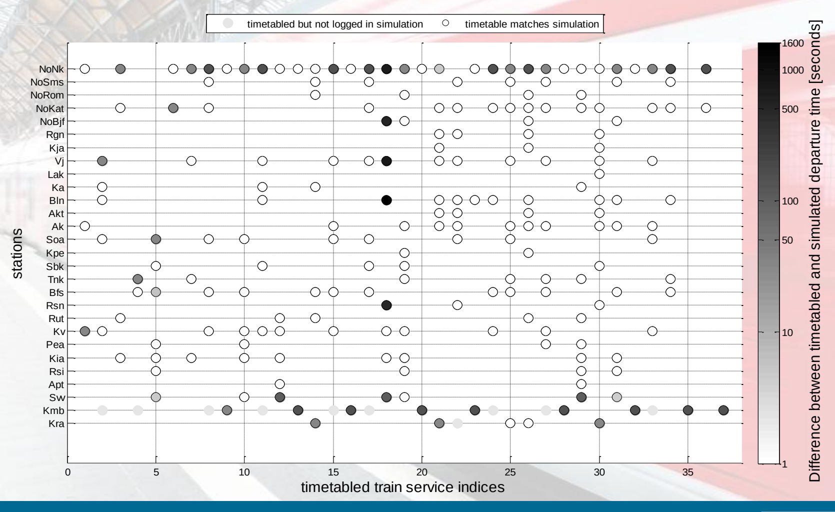
IOL simulator benchmarking



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IOL quantitative evaluation

Quantification of key measures…

1. Demonstration of resilience KPI
   - using in-built simulator logic only
2. Key measure results
   - using perturbation management algorithms

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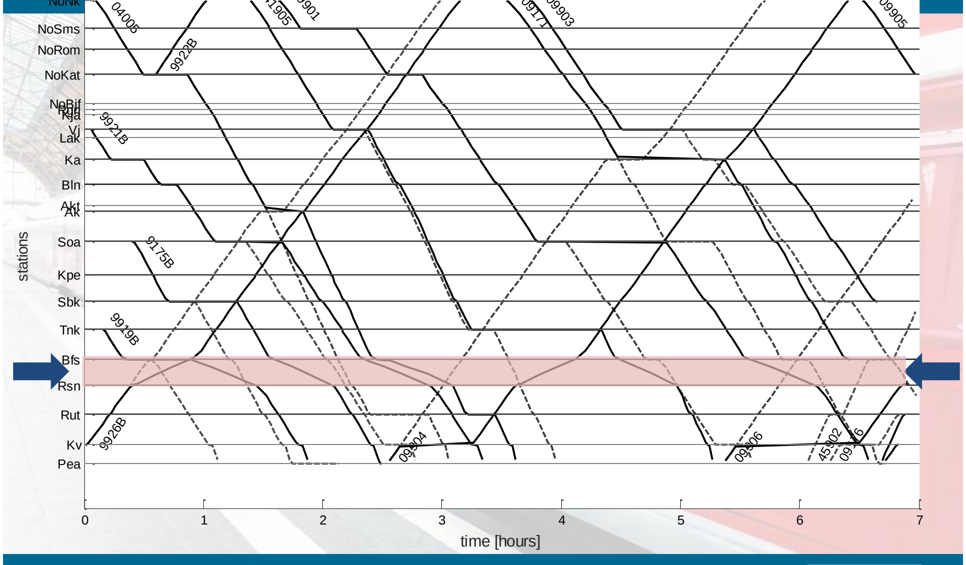

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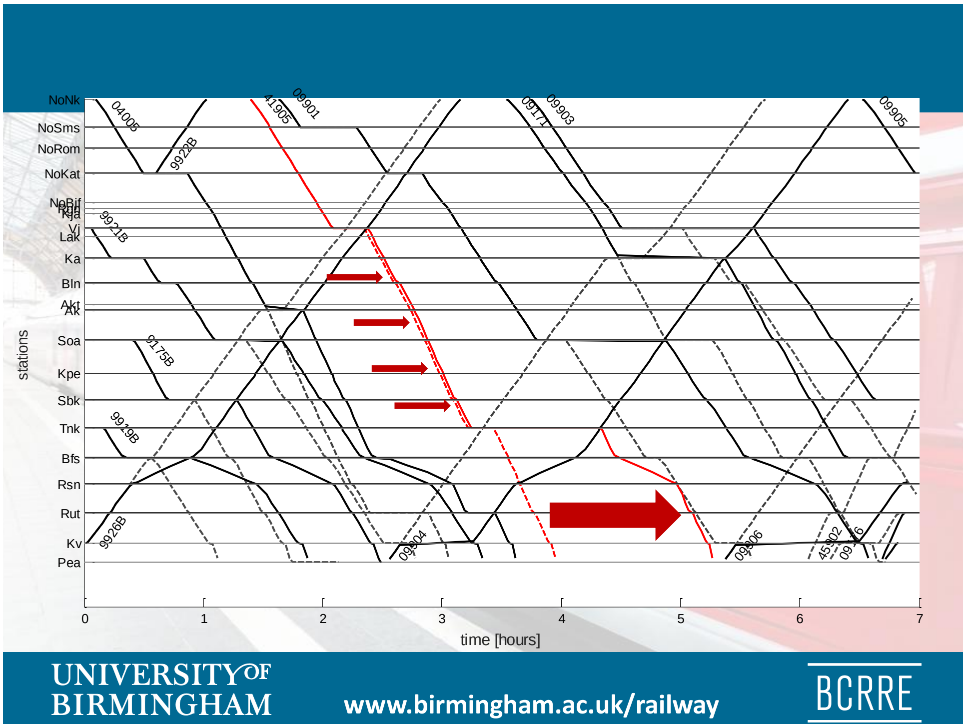
NoNk
NoSms
NoRom
NoKat
Ka
Bln
Soa
Kpe
Sbk
Tnk
Bfs
Rsn
Rut
Kv
Pea
stations
time [hours]
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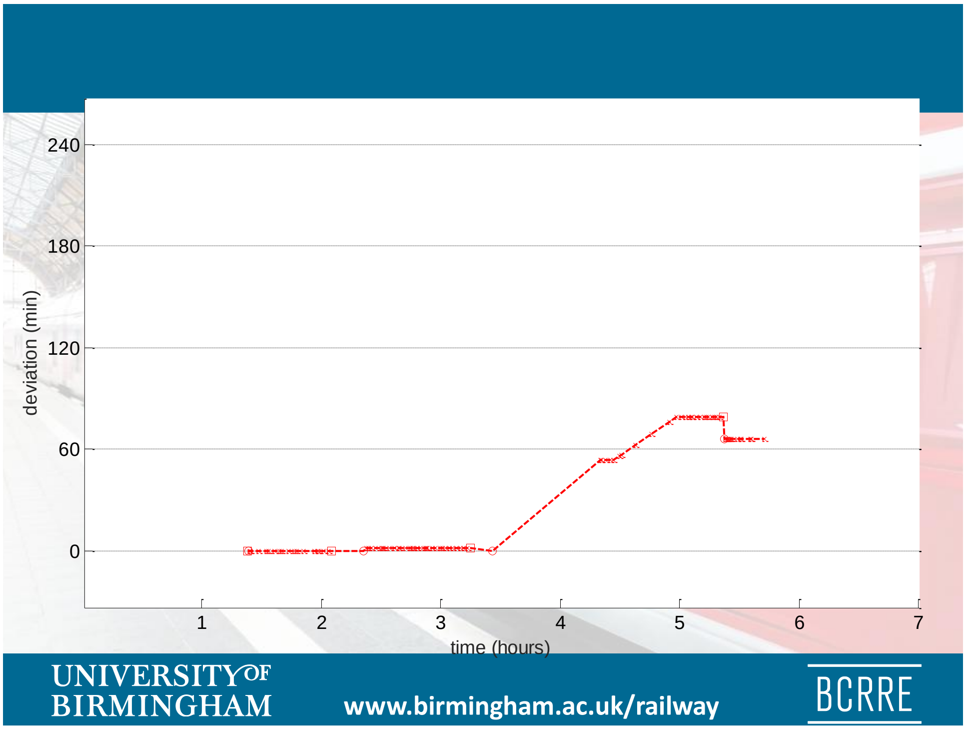
240
180
120
60
0
deviation (min)
time (hours)
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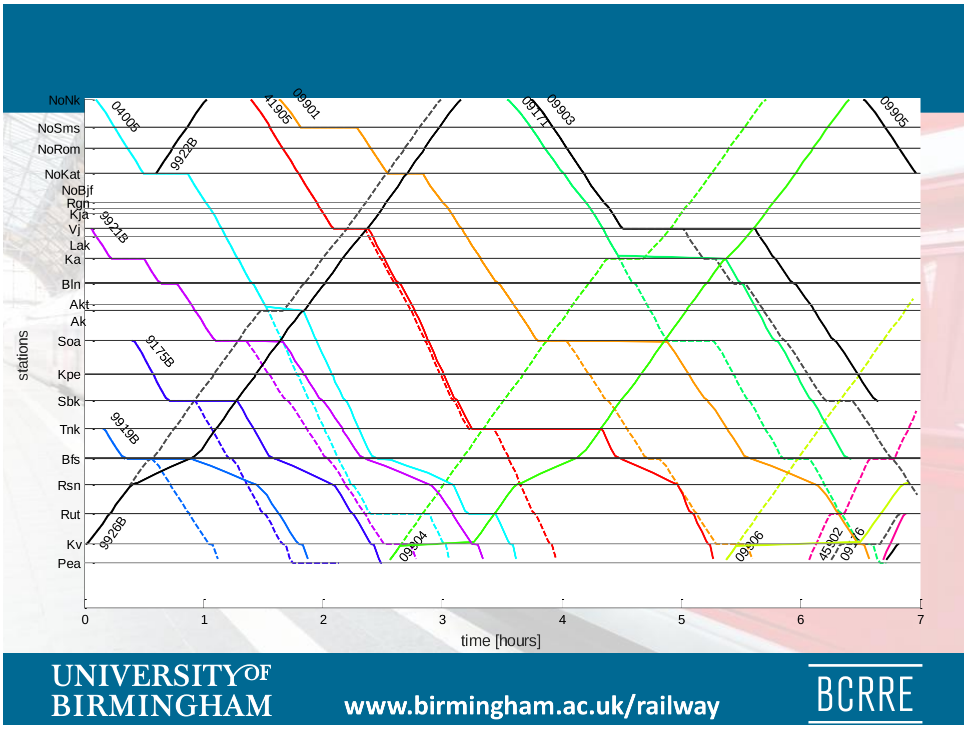
stations
time [hours]
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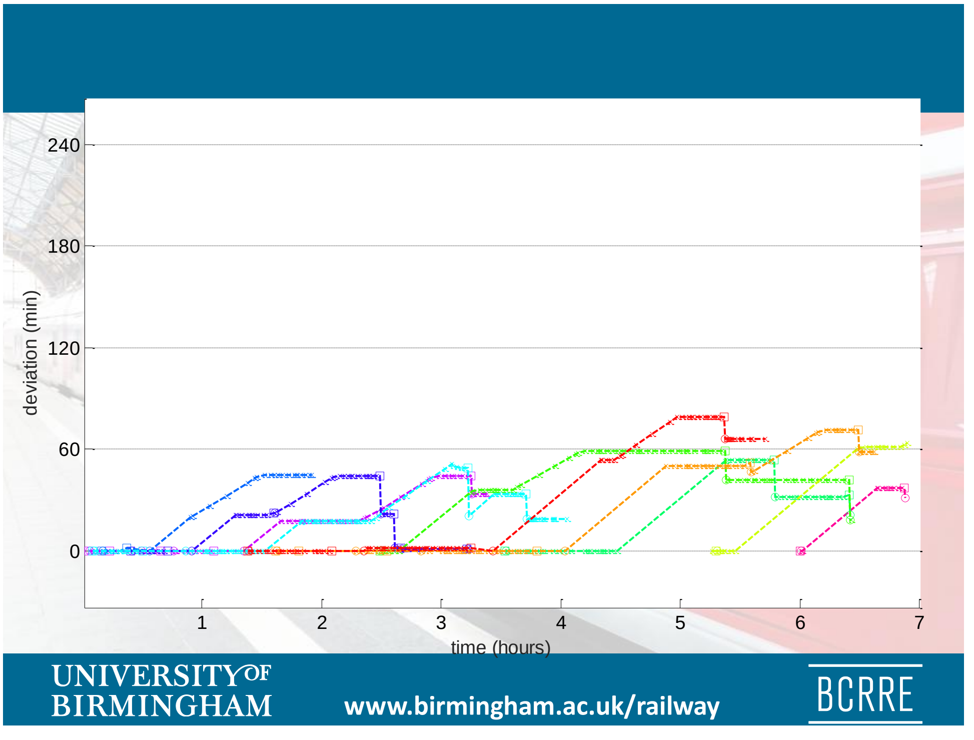
deviation (min)
time (hours)
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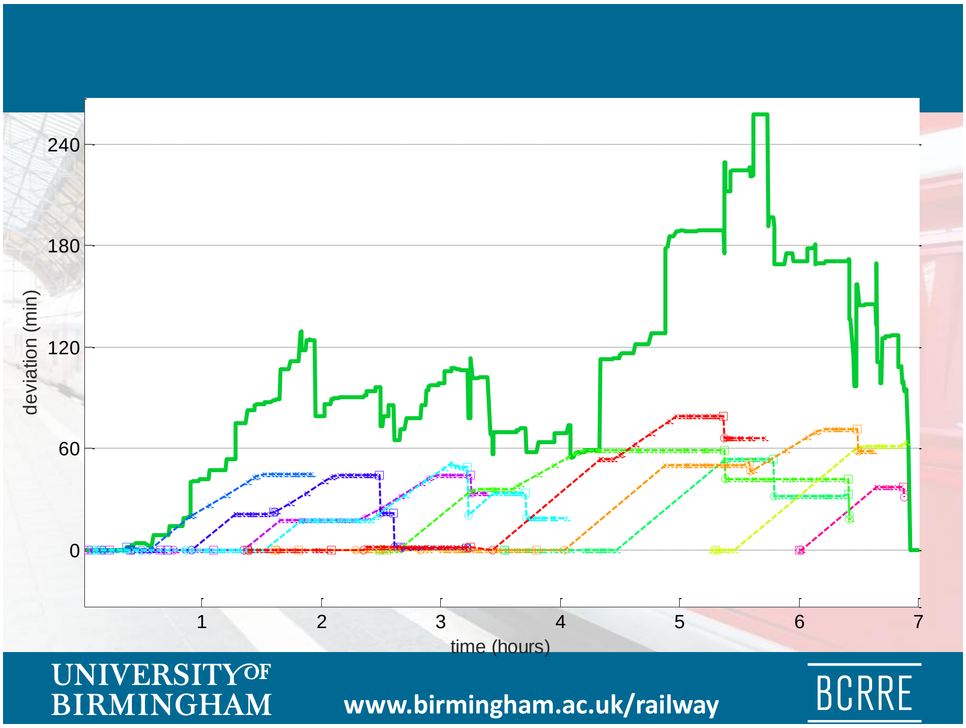
deviation (min)
240
180
120
60
0
1
2
3
4
5
6
7
time (hours)
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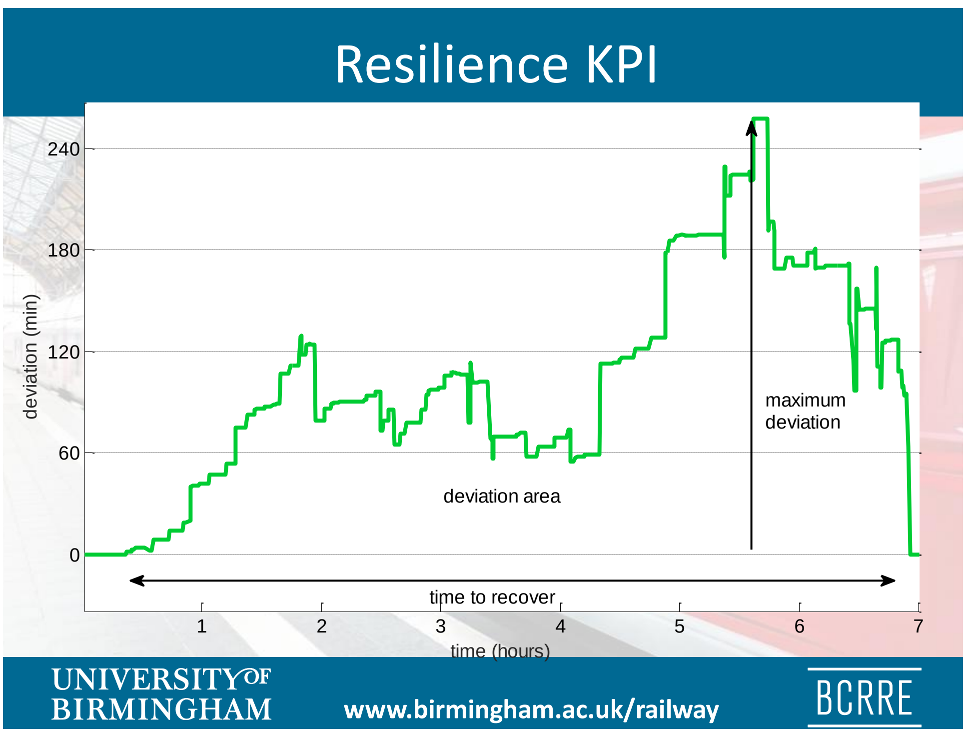
Resilience KPI
deviation (min)
240
180
120
60
0
maximum deviation
deviation area
time to recover
1
2
3
4
5
6
7
time (hours)
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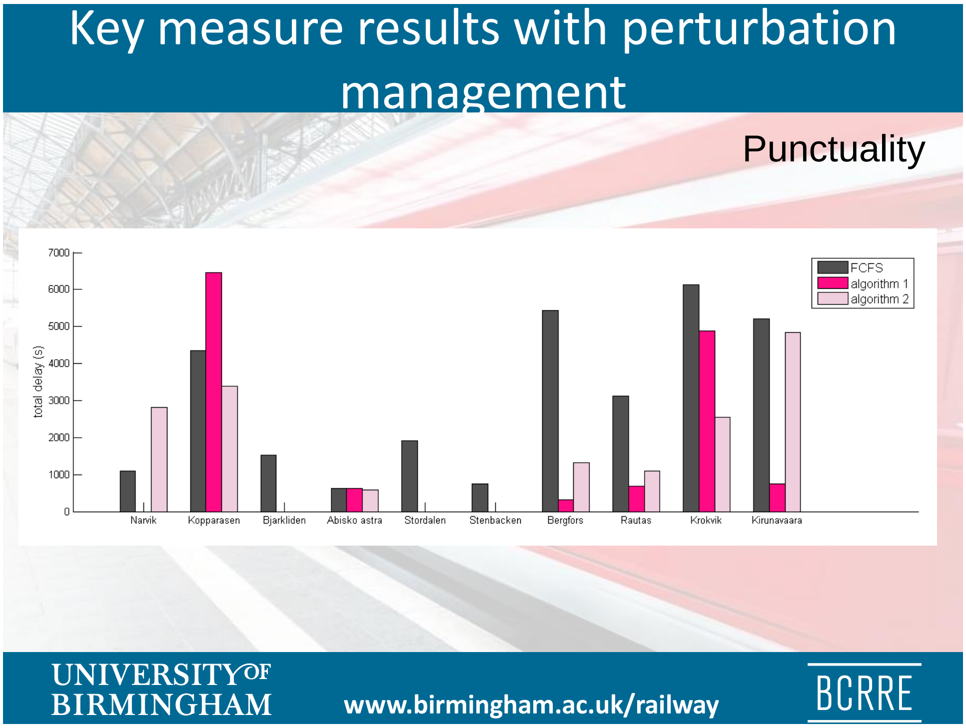
Key measure results with perturbation management
Punctuality
total delay (s)
FCFS
algorithm 1
algorithm 2
Narvik
Kopparasen
Bjarkliden
Abisko astra
Stordalen
Stenbacken
Bergfors
Rautas
Krokvik
Kirunavaara
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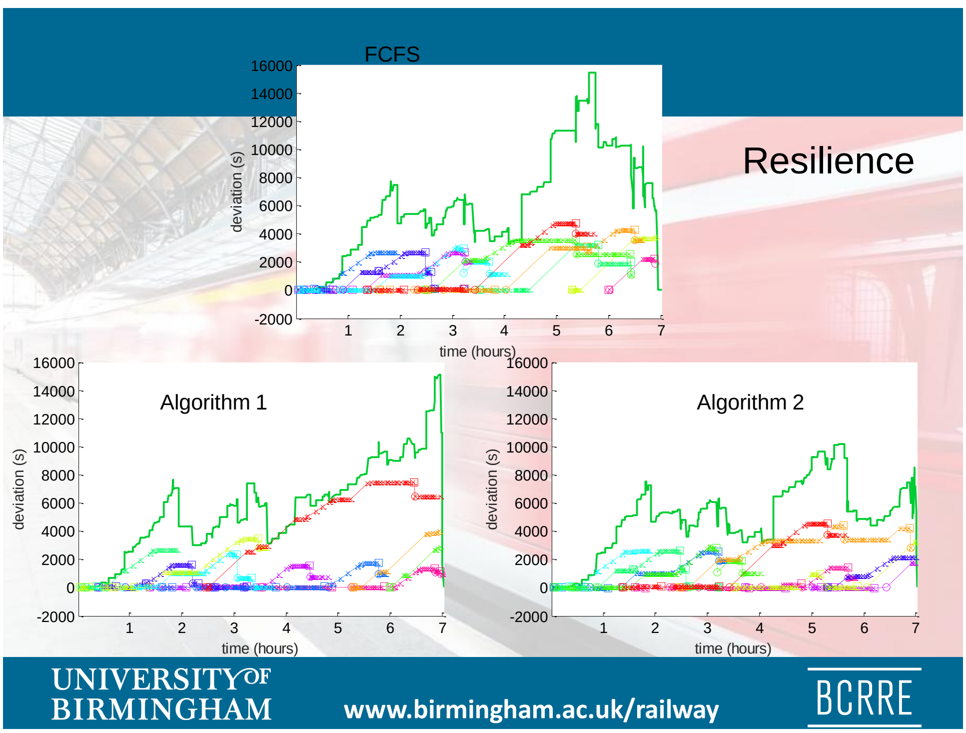
Resilience
FCFS
Algorithm 1
Algorithm 2
deviation (s)
time (hours)
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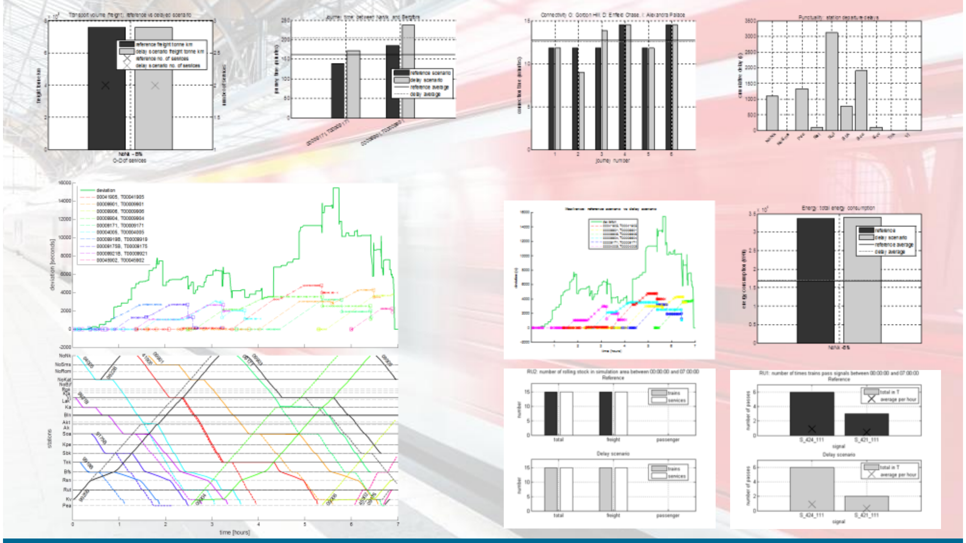
Visual summary



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Conclusions

- The QoSQE showed that the perturbation management approaches applied in ON-TIME resulted in improvements
  - in particular to the resilience and punctuality KPIs
  - less significant, but still positive outcome for the other KPIs
- Since the built-in simulator dispatching logic is used in the benchmark simulations, no quantitative conclusions can yet be drawn about the effects of perturbation management systems in real railway networks
- General implications
  - Extension to platform independence
  - Applicable to the assessment of operational data

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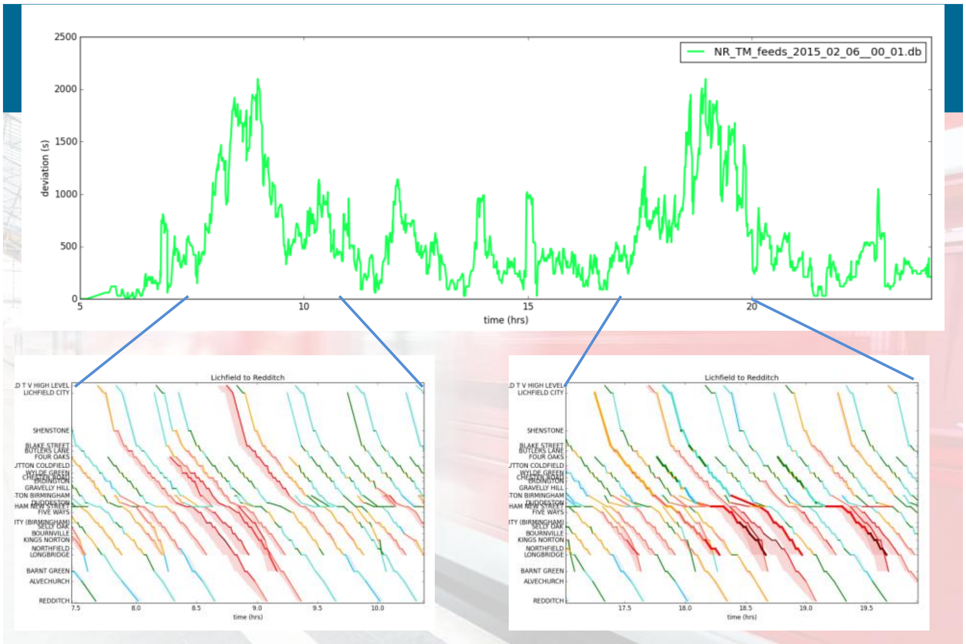

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Thank you

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G. L. Nicholson, D. Kirkwood, F. Schmid, C. Roberts. (in press). 'Benchmarking and evaluation of railway operations performance', *Journal of Rail Transport Planning and Management doi: 10.1016/j.jrtpm.2015.11.004*

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