The OpenTrack Speed-Instruction API
I. The objective of the OT speed-instruction API

II. Scenario Killwangen: Potential benefit of speed instructions (students essay)

III. RTSE I: time based OT speed-instruction API (implemented)

RTSE II: location based OT speed-instruction API (planned)
I. Adaptive Control (ADL ADaptive Lenkung)

Objective*:

- Train driver receives recommended speed instructions in cabine
- Improves prospective driving strategy, reduces unnecessary signal stops and braking maneuvers...
- ...and saves a huge amount of energy.

*Homepage SBB: *Energieeffizienz*

I. Influence of speed control on energy consumption

Casestudy with Interregio trains between Rotkreuz and Lucerne*


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Relative Energy Consumption

- Early rescheduling: 100%
- Late rescheduling: 120-130%
- No rescheduling: 150%
- Early rescheduling with coasting strategy: 88%
I. Influence of speed control on running time delay

Synchronous event:
last time interval with no influence

Figure 7.14: Detailed topology of the Rotsee single-line section

Casestudy with Interregio trains between Rotkreuz and Lucerne*

*M.Lüthi (2009): Improving the Efficiency of Heavily Used Railway Networks through Integrated Real-Time Rescheduling, Diss. IVT ETH Zürich
I. Influence of speed control on running time delay

Casestudy with Interregio trains between Rotkreuz and Lucerne*

* M. Lüthi (2009): Improving the Efficiency of Heavily Used Railway Networks through Integrated Real-Time Rescheduling, Diss. IVT ETHZ

Figure 7.14: Detailed topology of the Rotsee single-line section
I. Influence of speed control on running time delay

Figure 7.15: Running time of Interregio trains towards the single line section at Rotsee in dependence of the relative passing time with opposite train (green: major likelihood of no influence, blue: potential likelihood of an influence, magenta: possible likelihood of an influence; red: major likelihood of an influence)

Casestudy with Interregio trains between Rotkreuz and Lucerne*

I. SBB: Produktion systems

ADL functions as connecting link between dispatching and train driver

Völcker, Marcus (2012): *Adaptive Lenkung bei den SBB.*
http://www.it13rail.ch/downloads/presentations/7_Voelcker_ADL_IT13rail.pdf [download 22.11.2013]
II. Case Study Killwangen

**Killwangen-Spreitenbach: join of 2 main lines**

- Heitersberg line (Killwangen-Aarau), part of east-west transversal between Zurich and Berne
- Bözberg line, from Basel via Rheinfelden and Brugg to Zurich
II. Topology

Topology of station K LW: colorcode for train type based track utilisation

Legend:
- intercity / interregio train
- commuter train
- cargo train
- all train categories

Killwangen - Spreitenbach
II. Line frequencies extracted from time table

*line Brugg - Zürich Altstetten – Zürich HB* (from Fahrplanfelder 2012)

IR 1955 Basel-Zürich:
- train 3
- train 7

*line Lenzburg - Zürich Altstetten – Zürich HB*
- train 3
- train 4
- train 5
- train 6
- train 7
Example

door failure at train 3
(IR 1955 Basel-Zürich, 2 min departure delay in Baden)

• train 3 passes KLW at 07:14 instead of 07:12, (which corresponds to the planned passing time of train 4).

• Strong influence on the complete train set of scenario, three trains from the Lenzburg line (train 4, 5 and 6) cannot pass KLW as a „cluster of three“ between 07:14 and 07:19 any more.
III. Speed instructions

- The mask ‘Analyzer’ is used in order to execute speed controlled simulations.
- The ‘Analyzer’ mask opens by selecting the respective train (siehe figure).
- In the field „Req. Speed“ you can enter the intended speed.
- This speed is respected only if it is below the technical speed of the respective edge (Otherwise the train drives with the technical track speed on the respective edge).
II. Operation state planned
07:10:30
II. Operation state: 07:15:30 MAEG-KILW

**without speed control**

- **Train 5**
  - **Simulation time:** 07:15:30
  - **View:** MEAG-MELH

<table>
<thead>
<tr>
<th>Track</th>
<th>Time</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>2109</td>
<td>140 km/h</td>
</tr>
<tr>
<td>5</td>
<td>709</td>
<td>60 km/h</td>
</tr>
<tr>
<td>4</td>
<td>559</td>
<td>60 km/h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>+32 s</td>
<td>140 km/h</td>
</tr>
<tr>
<td>+2 s</td>
<td>60 km/h</td>
</tr>
<tr>
<td>+7 s</td>
<td>60 km/h</td>
</tr>
</tbody>
</table>

**with speed control**

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</tr>
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</table>
## II. Connection matrix reference case

### Ankünfte

<table>
<thead>
<tr>
<th>Zug</th>
<th>SOLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC 560</td>
<td>07:23</td>
</tr>
<tr>
<td>IC 710</td>
<td>07:22</td>
</tr>
</tbody>
</table>

### Zugverbindung

<table>
<thead>
<tr>
<th>Zug</th>
<th>Ankunft</th>
<th>Abfahrt</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC 560</td>
<td>07:23</td>
<td>07:24</td>
</tr>
<tr>
<td>IC 710</td>
<td>07:22</td>
<td>07:26</td>
</tr>
<tr>
<td>IC 710</td>
<td>07:22</td>
<td>07:28</td>
</tr>
<tr>
<td>IC 710</td>
<td>07:22</td>
<td>07:28</td>
</tr>
<tr>
<td>IC 710</td>
<td>07:22</td>
<td>07:28</td>
</tr>
<tr>
<td>IC 710</td>
<td>07:22</td>
<td>07:40</td>
</tr>
</tbody>
</table>

### Legende

- **Weiter**: Der Zug verkehrt nach Ankunft im ZHB weiter nach.
- **Zugverspätung**: In unserer Betrachtung gilt: Grundsätzlich werden keine Anschlussverzögerungen in die Piktogramme aufgenommen, aus welcher der Zug kommt. Bei S-Bahnen und dem internationaler Verkehr (TGV/EC, EN) werden keine Anschlüsse hergestellt.

### Anmerkungen

- **Anschluss**: Der Zug verkehrt nach Ankunft im ZHB weiter nach.
- **Zugverspätung**: In unserer Betrachtung gilt: Grundsätzlich werden keine Anschlüsse in die Piktogramme aufgenommen, aus welcher der Zug kommt. Bei S-Bahnen und dem internationaler Verkehr (TGV/EC, EN) werden keine Anschlüsse hergestellt.
II. results scenario door failure train 3

aggregated delay and connections in Zurich

delay (min)

connections

reference state  without speed control  with speed control
II. Lead time $\Delta t$ for all speed adaptations (ADL-communication)

- Required time to distant signal: 5.0 min
- Remaining time until Signal A switches to ‘green’: 5.5 min

V=60 km/h

V=55 km/h

- Required time to distant signal: 5.5 min
- Remaining time until Signal A switches to ‘green’: 5.5 min

6 minutes

$\Delta t$

- train 5
- train 6 vs. AN
- train 6 vs. AD
- train 6 vs. AS
- train 7
- train 8
- train 9
- train 10
- train 11
III. RAIL TRANSPORT SERVICE ENVIRONMENT (RTSE) PROJECT PARTNERSHIP

ZHAW, School of Engineering
- Jürgen Spielberger (InIT)
- Claudio Gomez (IDP)
- Bernhard Seybold (IDP, TrafIT)
- Albert Steiner (IDP)
- Raimond Wüst (IDP)

Data analysis and Process-optimisation

Consulting traffic engineering BdK-Projekt

SBB CFF FFS Rail operations Practical requirements

industry partner
- Marco Laumanns (IBM Research GmbH)
- Daniel Hürlimann (OpenTrack Railway Technology)
- Ivan Levkov (Emch + Berger AG)
- Peter Grossenbacher (SBB Infrastruktur Betrieb)

ZHAW, Institute for Data Analysis and Process Design, Raimond Wüst
III. RTSE: focus on network-connectivity effect
Motivation: problems in service delivery

- Limited usability of public transport due to communication problems
- Decreasing service reliability due to operational volatility and technical disturbances
- Considerable total delay times due to local dispatching decisions


Another red signal!  
Now that I have just caught up 4 minutes of my 5-minute delay.

“The Interregio to Lucerne was unable to guarantee the connection. We are sorry for any inconvenience caused”

“I am sorry, I am unable to tell you if you are going to reach the train to Cham! Please listen to the loudspeaker announcement at the station!”
III. Layer Multi-Component Closed Loop Control Framework  

System overview

- (I0) common data
- (I1) service intention
- (I2) production plan and unfeasible train runs (if any)

Management Layer
- (I1) definition of service intention
- (I2) infeasible train runs
- (I3) timetable and actor instructions for real-time process configuration of the railway network.
- (I4) position and process state messages
- (I5) new scheduling constraints related to the available resources

Logical Layer
- (I2) SI based (re-)scheduling
- (I3) creation of actor instructions
- (I5) root cause analysis

Physical Layer
- (I4) mapping of event messages to Petri-net

Available resources

Real railway network

Simulation of railway network
III. RTSE Information flow

guard instructions: connections, departures, arrivals, platforms, etc.

driver instructions: trip times, departure times, speed recommendations

operator instructions: route changes, route reservations, route cancellations, train sequences etc.
III. OpenTrackDispatcher

timetable messages
trainArrival (trainID, stationID, time, [delay])
trainDeparture (trainID, stationID, time, [delay])
trainPass (trainID, stationID, time, [delay])

route messages
routeReserved (routeID, trainID, time)
routeReleased (routeID, trainID, time)
infraPartReserved (infraPartID, trainID, time)
infraPartEntry (infraPartID, trainID, time)
infraPartExit (infraPartID, trainID, time)
infraPartReleased (infraPartID, trainID, time)

train messages
setRequestedSpeed (trainID, speed, [time])
resetRequestedSpeed (trainID, [time])
setEngineSwitch (trainID, switchOnOffFlag, [time])
setPerformance (trainID,
  performanceFactorOnTime,
  performanceFactorDelayed, [time])
Model Calibration

test scenario
RTSE Overall Process Integration

Time Deviations of Process Events
III. Model Calibration: Time Deviation of Events

**Proposal:** implement location based speed instructions
QUESTIONS?