Operative Traffic Management for Energy-Efficient Train Operation

Michael Ummels

DLR — German Aerospace Center
michael.ummels@dlr.de

(Joint Work with Tilo Schumann)
Motivation

Starting point: Many train operators have installed driver advisory systems (DAS) into their rolling stock → energy savings.

Drawback: DAS do not take conflicts with other trains into account.

Next generation: Connected DAS. Examples:

- CATO (Iron ore line from Kiruna to Narvik)
- ADL (Switzerland)

These are monolithic solutions where DAS and central unit have been designed together.

Our Contribution: Open system that can work with DAS from different vendors.
Blocking Time Windows

Assumption: Fixed-length block system with trackside signals.

Blocking time window describes the period of time a block is exclusively allocated by a train.
Blocking Time Window Approximation

Problem: Exact trajectory not known in advance due to differences in driving style, variances in dwell time, … \(\Rightarrow\) Approximation.
Conflicts

A conflict occurs if the blocking windows of two trains overlap in at least one block section (e.g. due to a primary delay).
Conflict Resolution

Signalling system resolves conflicts “by force”.

Problem: High energy consumption and larger blocking windows.
Conflict Resolution (Cont.)

Better: Identify and resolve conflicts ahead of time.

Requirement: Protocol for communication with trains.
The EETROP Protocol

EETROP: Simple XML protocol for exchanging train data (RailEnergy).

<positionReportMessage>
  <systemTime>2013-03-14T09:13:51.0</systemTime>
  <trainIdentity>1234</trainIdentity>
  <position>
    <trainPosition>
      <trackRef>tr1a</trackRef>
      <positionOnTrack>200.0</positionOnTrack>
    </trainPosition>
    <trainSpeed>29.7</trainSpeed>
  </position>
</positionReportMessage>
The EETROP Protocol (Cont.)

EETROP: Simple XML protocol for exchanging train data (RailEnergy).

```
<partialTarget>
  <trainPosition>
    <trackRef>tr2b</trackRef>
    <positionOnTrack>1200.0</positionOnTrack>
  </trainPosition>
  <time>10:52:06.597</time>
  <speed>10.0</speed>
  <earliestLatest>EARLIEST</earliestLatest>
  <slowerFaster>FASTER</slowerFaster>
</partialTarget>
```

Target points specify earliest or latest arrival at a given waypoint.
System architecture

Note: (Energy-optimal) Trajectory optimization performed by DAS.

Note: Any DAS may be used as long as it supports EETROP.
Implementation (Closed Loop)

1. Initialization
2. Read train positions
3. Blocking time window approximations
4. Conflict?
   - Yes: Resolve first conflict
   - No: Emit target points

RailsML®
Demonstration

**Demonstration:** In DLR’s simulation environment RailSiTe®.

**Scenario:** Slow regional train (automatically controlled) followed by InterCity train (manually driven).

**Line:** Electrified main line from Paderborn to Warburg in Germany.

**DAS:** provided by TU Dresden and Interautomation.
Results

![Graph showing speed and energy consumption for different train types and conditions, with Mileage [km] on the x-axis and Speed [km/h] or Energy consumption [kWh] on the y-axis.]
Conclusions

Results:

▶ Open system for network-wide optimization.
▶ Potential for massive energy savings.

Challenges:

▶ Study influence on line capacity.
▶ Incorporate dispatching decisions.
▶ Separation of infrastructure and train operation.