

Controlling the Normal, not the Exception

Ashby's Law of Requisite Variety in Traffic Management

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RailZurich2009

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ProRail

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Delft University of Technology

Time is central in service offer

- Quality of service:
 - make attractive offer
 - produce what has been advertised

2009

|  | Tijd | Station / Halte | Spoor | Richting | Reisdetails |
|---|-------|---------------------|-------|------------------|----------------|
| | 06:22 | Amsterdam Centraal | 4b | Utrecht Centraal | Intercity (NS) |
| | 06:29 | Amsterdam Amstel | | | |
| | 06:49 | Utrecht Centraal | | | |
| | 07:14 | Veenendaal-De Klomp | | | |
| | 07:21 | Ede-Wageningen | | | |
| | 07:32 | Arnhem | | | |
| | 07:51 | Nijmegen | | | |

61 (Amsterdam Centraal-Nijmegen)

| | | |
|--------------------|---|-------|
| Amsterdam Centraal | V | 06:15 |
| Amersfoort | A | 06:54 |
| | V | 06:56 |
| Kesteren | A | 07:22 |
| | V | 07:23 |
| Nijmegen | A | 07:46 |

1911

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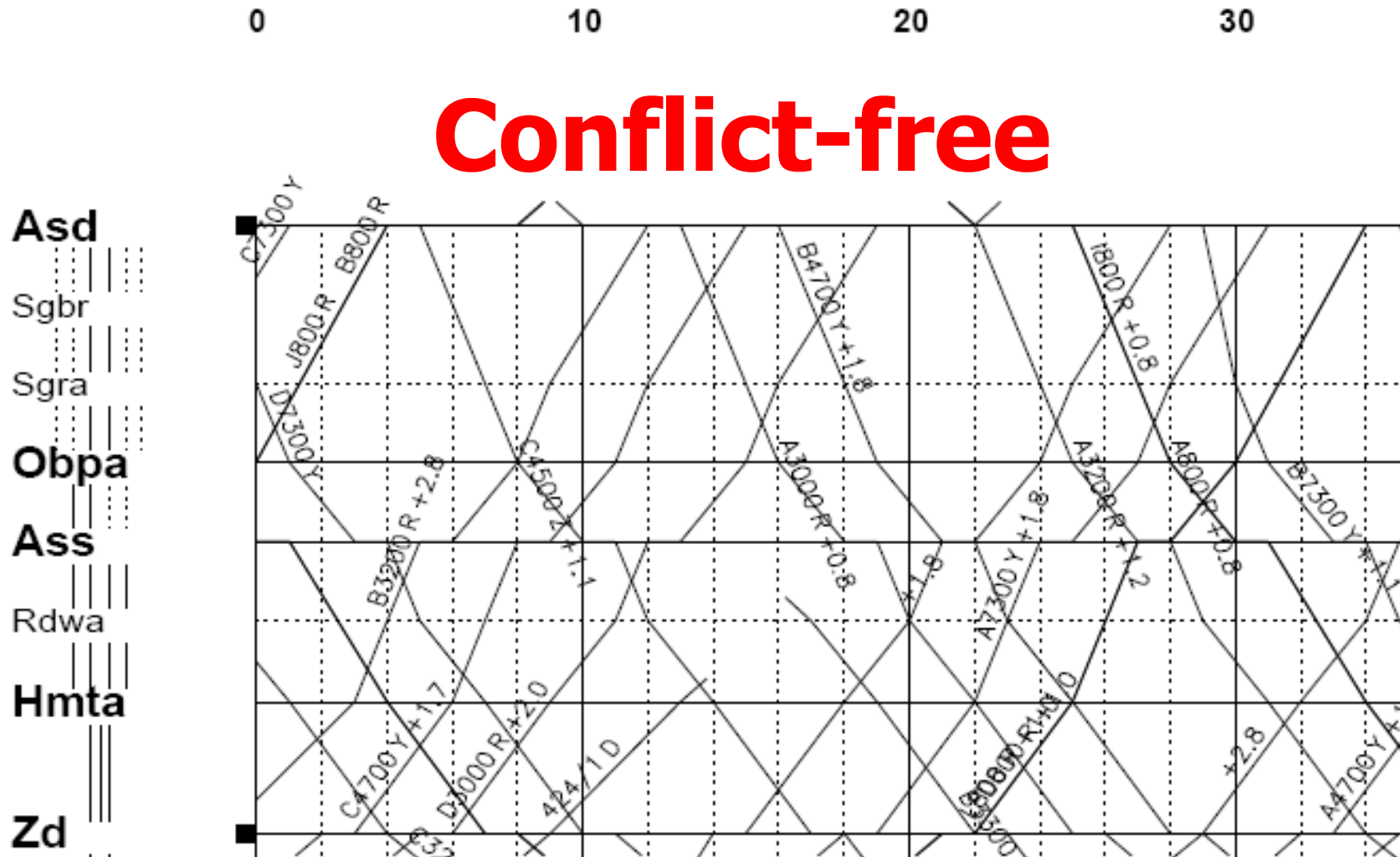
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Time is central in planning services



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Time is central to control process

Procesleiding Rijwegen A

| Pplg | Syst | WBI | VKL | PLM | Vtg/NB | Muteer | Selecteer | Klaar | Bijz.heden | Materieel | Info | Rijweg | ABT | ARI/ABT | CS | Spoor | 12:21 |
|------|--------|-----|-------------|------|--------|--------|-----------|-------|------------|-----------|------|--------|-----|---------|----|-------|-------|
| AH | 2040 | V 3 | 12:16 | | 12:16 | 24A | AK | m | | | | | | | | | |
| AH | 3040 | A 1 | 12:21 + 0 | Ahwa | 12:16 | AE | 21 | | | | | | | | | | |
| AH | 303037 | V 1 | 12:10 V+ 10 | Ah | 12:16 | 7A | 25B | m | | | | | | | | | |
| AH | 303037 | V 2 | 12:10 V+ 10 | Ah | 12:17 | 25B | 25A | m | | | | | | | | | |
| AH | 3743 | A 2 | 12:20 + 0 | Ahpr | 12:18 | 957 | 6A | | | | | | | | | | |
| AH | 3743 | V 1 | 12:21 + 0 | Ahpr | 12:19 | 6A | 22B | | | | | | | | | | |

VA

| | | | | | | | | | | | | | | | | | |
|-------|---|------------|------|-------|----|----|--|--|--|--|--|--|--|--|--|--|--|
| 124 | D | 12:19 + 8 | Zvg | 12:16 | WY | EV | | | | | | | | | | | |
| 30940 | D | 12:23 + 13 | Did | 12:20 | WY | EV | | | | | | | | | | | |
| 7539 | D | 12:26 + 0 | Ahwa | 12:23 | FV | NE | | | | | | | | | | | |
| 7542 | D | 12:32 + 0 | Zp | 12:29 | RU | EV | | | | | | | | | | | |
| 30939 | D | 12:38 | | 12:35 | FV | VY | | | | | | | | | | | |
| 3738 | D | 12:44 | | 12:41 | FV | NE | | | | | | | | | | | |
| 30942 | D | 12:49 | | 12:46 | WY | EV | | | | | | | | | | | |

AH

| | | | | | | | | | | | | | | | | | |
|--------|-----|-------------|------|-------|-----|-----|---|--|--|--|--|--|--|--|--|--|--|
| 2039 | A 1 | 12:15 + 12 | Ed | 12:12 | AX | 23B | m | | | | | | | | | | |
| 2039 | A 2 | 12:15 + 12 | Ed | 12:13 | 23B | 4 | m | | | | | | | | | | |
| 303037 | V 3 | 12:10 V+ 10 | Ah | 12:19 | 25A | BE | m | | | | | | | | | | |
| 7539 | A 2 | 12:21 + 0 | Ahwa | 12:19 | 23B | 8 | | | | | | | | | | | |
| 3040 | A 2 | 12:21 + 0 | Ahwa | 12:19 | 21 | 6B | | | | | | | | | | | |
| 3743 | V 2 | 12:21 + 0 | Ahpr | 12:20 | 22B | BE | | | | | | | | | | | |
| 124 | A | 12:23 + 8 | Zvg | 12:20 | EV | 9 | | | | | | | | | | | |
| 7539 | V | 12:22 + 0 | Ahwa | 12:21 | 8 | FV | | | | | | | | | | | |
| 402039 | R | 12:23 | | 12:23 | 4 | 30 | m | | | | | | | | | | |
| 124 | V | 12:25 + 8 | Zvg | 12:24 | 9 | AK | | | | | | | | | | | |

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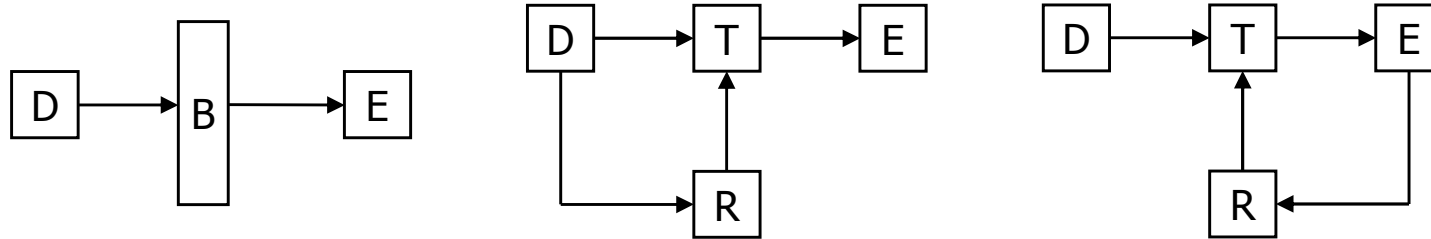


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Control in times of chaos: Ashby's Law of Requisite Variety

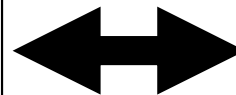
- Timing of services is influenced by disturbances
- Buffers and regulation can reduce effect of disturbances



- *"only variety in R can force down the variety due to D. Variety can destroy variety"*
- Without regulation, buffers must be as large as the deviations.
- Regulator needs information about disturbance and/or result; this information must have sufficient detail

Driver information today

| | | | |
|-------|---|--|-------|
| ----- | | | |
| | | | 3449 |
| 100 | | | |
| Hn | V | | 11:51 |
| Hna | - | | 11:52 |
| Obd | A | | 11:59 |
| Obd | V | | 12:00 |
| 130 | | | |
| Hwd | + | | 12:06 |
| Amrn | + | | 12:11 |



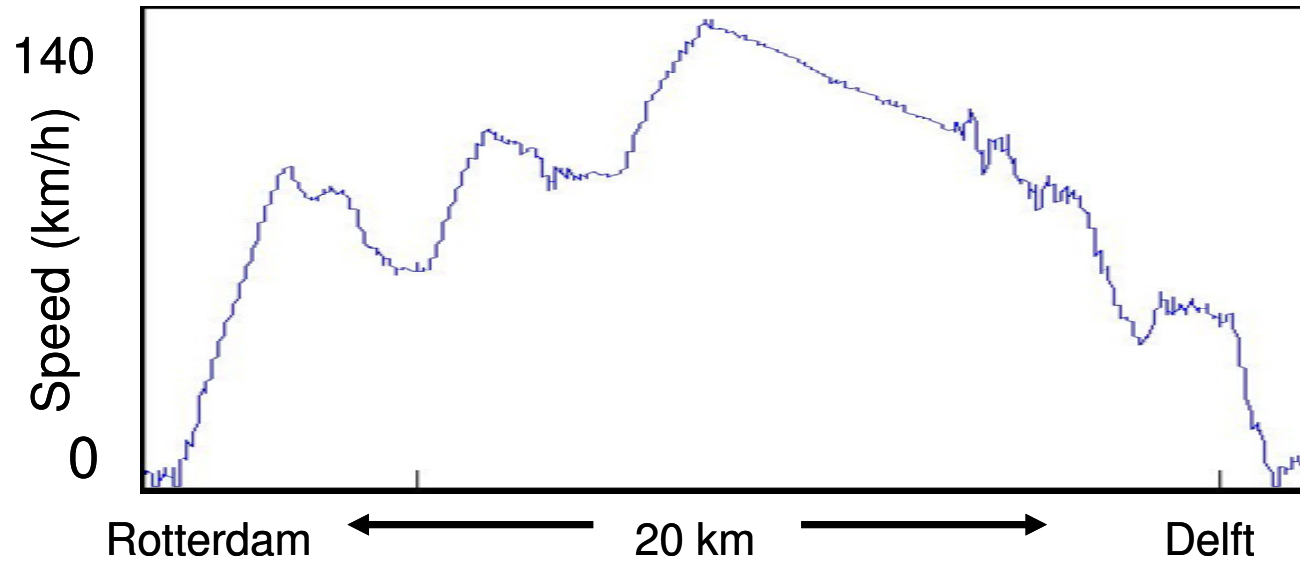
Time; not up to date

Up to date; no time
Indicates timing error

Poor control: Time and event are in conflict

- Driver has no information about path adherence
- Relying on signalling results in feedback control, and only on position. Leads to bouncing, stop signal approaches
- Requires buffers between train paths; but driver does not know these
- Signalling systems are a safety backup system, not a control system (*currently* this is also the case for ETCS)

Bouncing train



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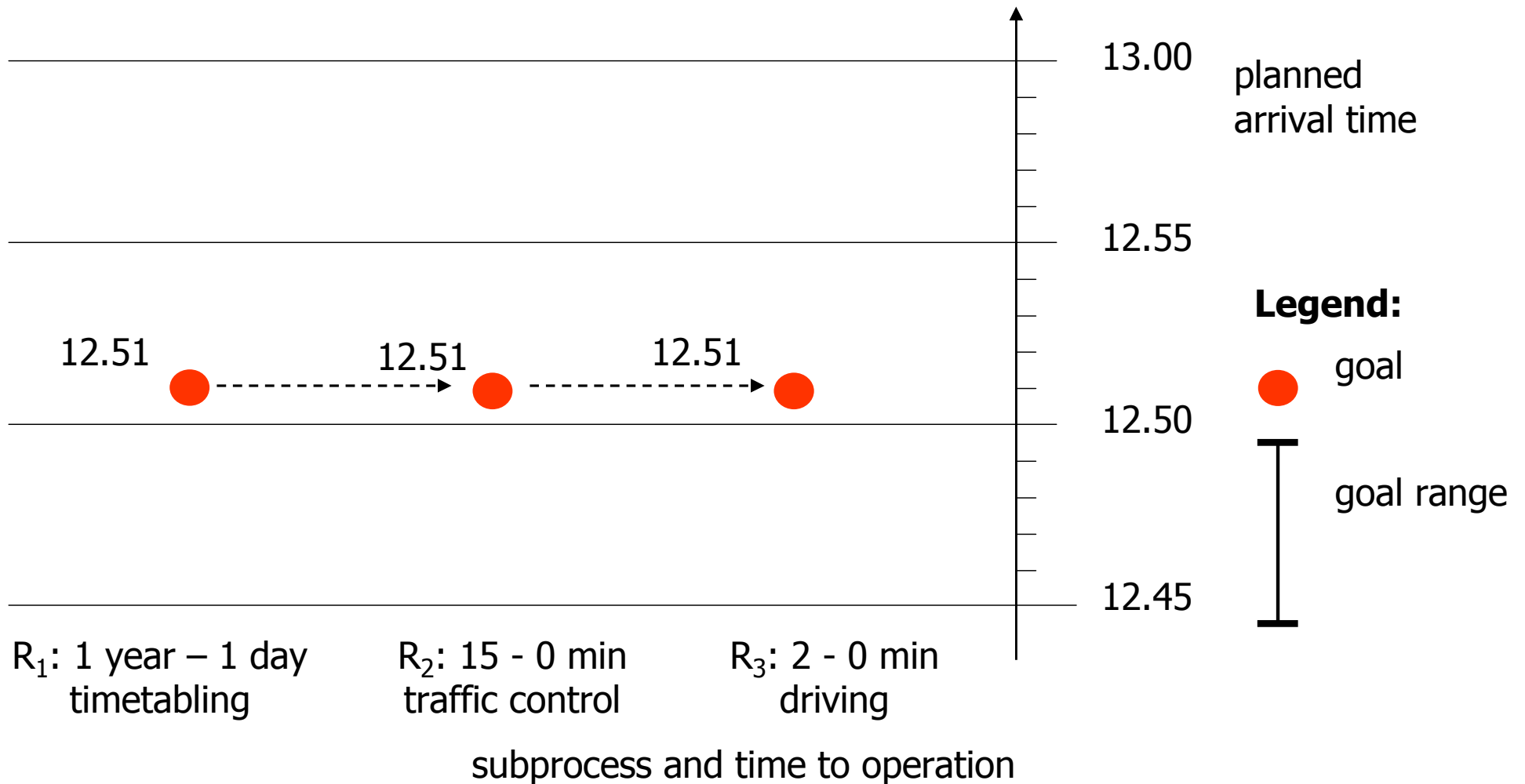
ProRail



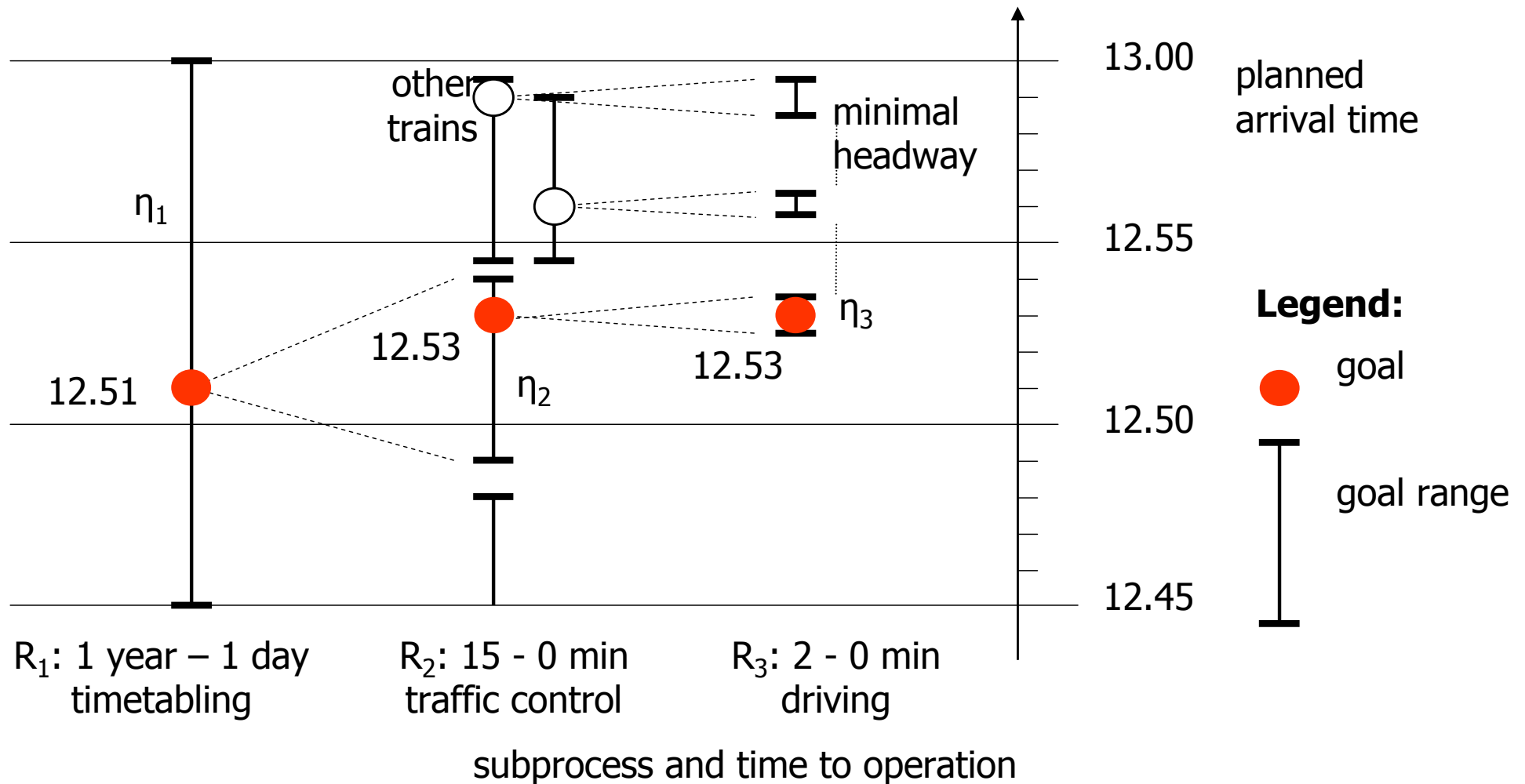
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Current information flow



Coherent information flows



RouteLint

- Decentral logic
- Informs about disturbance (feed forward control)
- Relative and implicit timing

train ahead with
6 min delay →

own train →

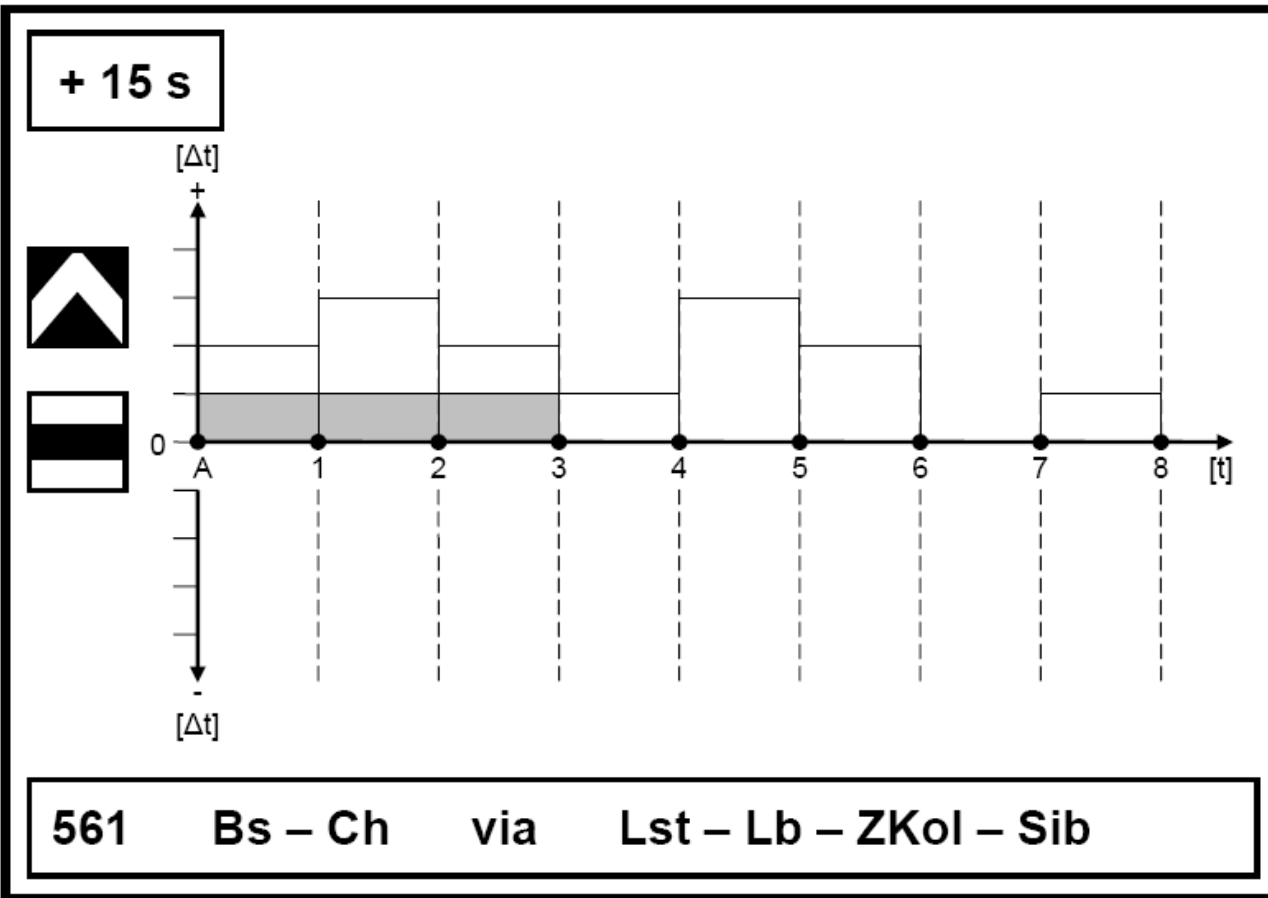
train behind →

| Treinnr | 10:42 | Vertr. |
|---------|----------|--------|
| | Kfhaz-LR | |
| 805134 | Zwd-1 | 0 |
| | Zwd-LT | |
| | LU | |
| 12346 | Ddr-1a | +6 |
| | Ddr-1b | |
| | Ddr-34 | |
| 1934 | RA | +1 |
| 2234 | RA | +1 |

Co-Production

- Central logic
- Information about desired path to be followed (feedback control)
- Absolute timing

Example for a slight delay



Legend

- $[t]$ Next 8 minutes trip time ahead
- $[\Delta t]$ running time deviation in seconds
- + 15 s** Total time deviation with regard to schedule
- Maximal recoverable delay in corresponding time window
- Recommended correction in corresponding time window
- 561 ... Indication field for train number, origin, destination and intermediate station
- Driving mode: example for intermediate fast running

Discussion

- Time windows are the key
 - Agreement of tolerance between IM and TOC
- ETCS (Level 2) and implementation?
 - Supplies technical components (DMI, GSM-R)
 - National traffic management systems threaten interoperability
 - European traffic management functions not yet developed
- Safety effects
 - Distraction or steering towards a conflict-free path?

Time control is possible: we should do it

- Uncontrolled trains mean unnecessary conflicts
- Railways currently overcome this by placing buffers
- A good communication structure is the basis for co-operation in railways
- Implementation of traffic management information systems is independent of progress with signalling
- Someone is implicitly paying for the lack of control

Time control: Yes we can!

- Routelint and Co-Production are ready for roll-out
- They provide multiple benefits
- Their successful introduction requires less money than leadership

Questions?

**Thank you for
your attention**

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