



ERTMS & HL3 & ATO

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ProRail

Agenda: ERTMS & ATO

- Kennismaking met ATO
- ATO projecten
- ATO specificaties
- ATO capaciteitsstudie

De metro rijdt al 50 jaar automatisch

GoA 2: accelereren en remmen door een automaat

- Eerste metrolijn : London Victorialijn (1967!)



GoA 3: zonder machinist

- London Docklands Light Railway (1987)



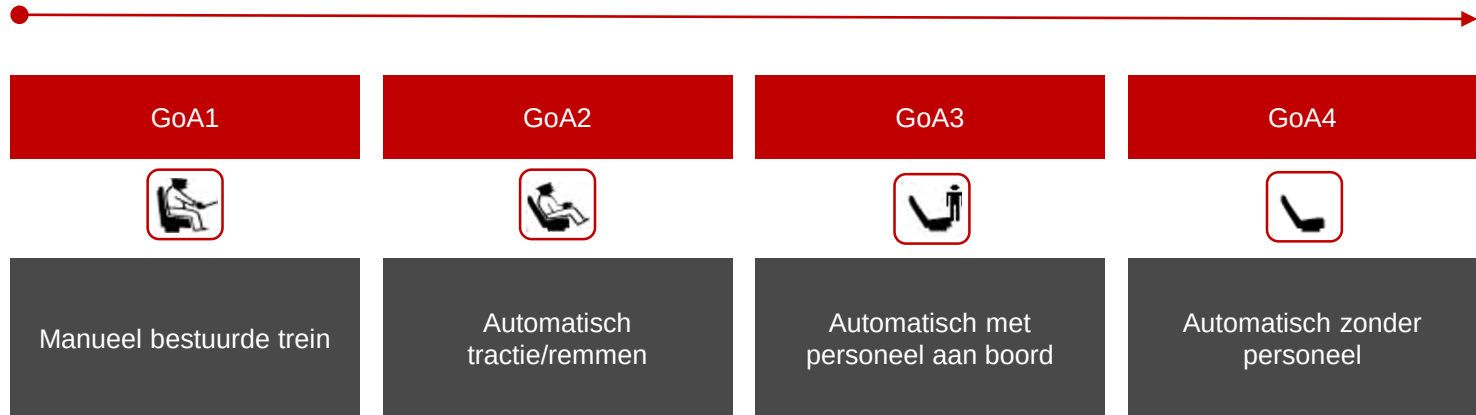
GoA 4: ook halteerproces geautomatiseerd,
geen supervisie aan boord

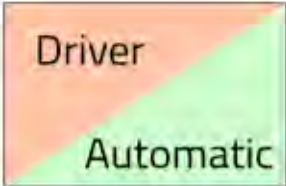
- VAL Lille (1983)

Grades of Automation

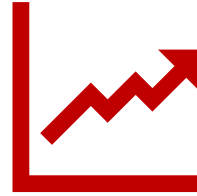
Trein met autonome functies

Autonome trein



Grade of Automation	Train Operation	Setting train in motion	Driving and stopping train	Door closure	Operation in event of disruption
GoA 1	ATP with Driver	Driver	Driver	Driver	Driver
GoA 2	ATP and ATO with Driver		Automatic	Driver	Driver
GoA 3	Driverless (DTO)	Automatic	Automatic		Attendant
GoA 4	Unattended (UTO)	Automatic	Automatic	Automatic	Automatic

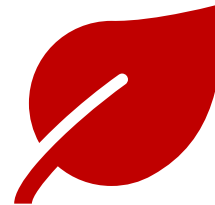
Doelen ATO



Capaciteit



Punctualiteit



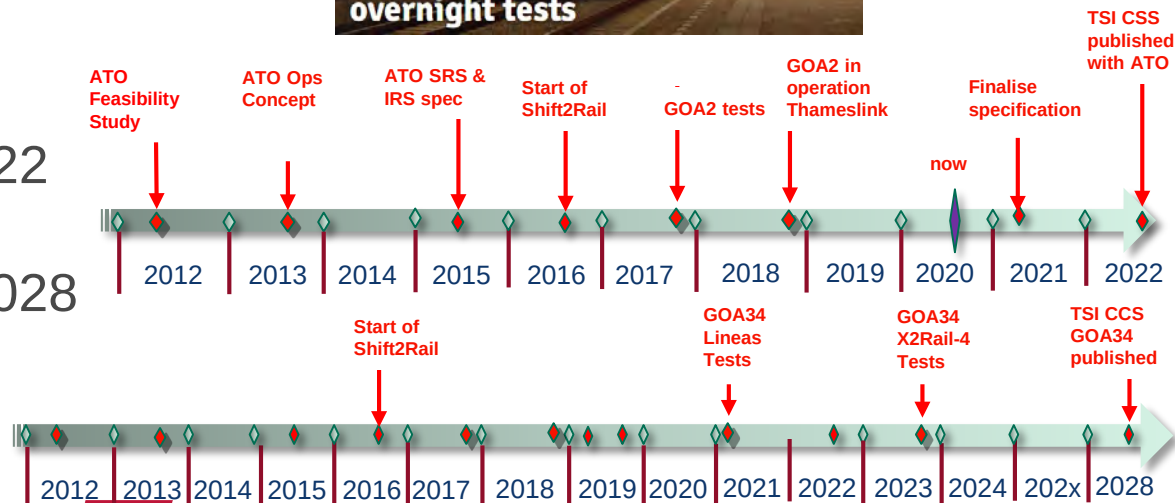
Duurzaamheid



Kosten

Een paar ERTMS ATO-projecten

- Thameslink
- Betuwe Route Test
- NS ATO SNG Test
- ERTMS GOA2, TSI 2022
- ERTMS GOA34, TSI 2028



ATO gerelateerde specificatie groepen



Proposals
& Requirements

Communication &
Support



SBB CFF FFS



OCORA

Open CCS On-board
Reference Architecture



EUROPEAN
UNION
AGENCY
FOR RAILWAYS

Interfaces

Demonstrator & Requirements



IRCA

Reference CCS
Architecture



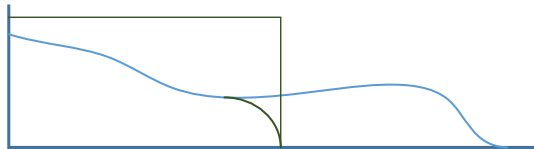
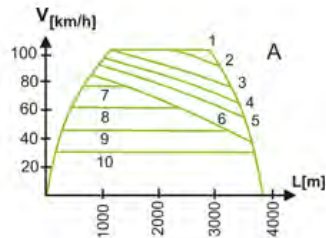
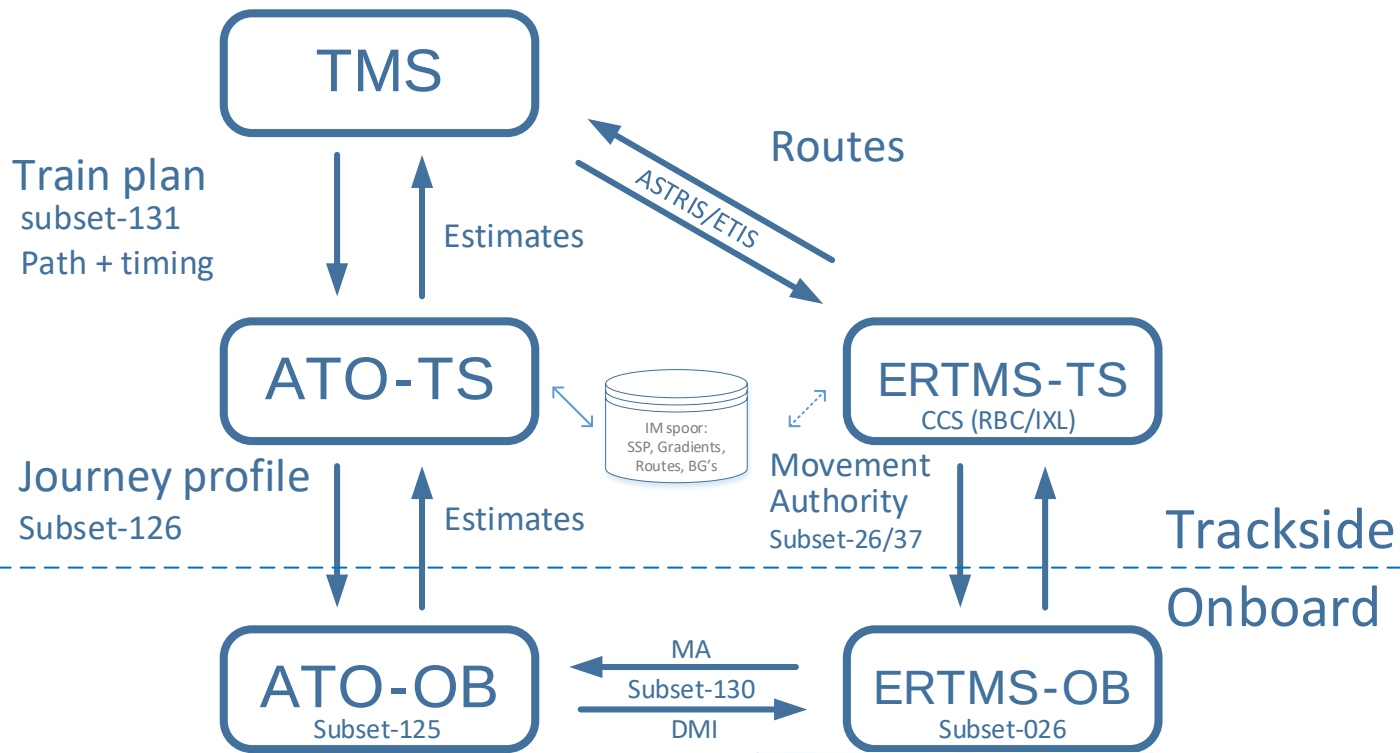
LinX4Rail

X2Rail-1,2,3,4
IP, WP,
Linx4Rail



TOBA

Telecom On-Board Architecture
Working Group



GOA2 (Automatic operation)





ERTMS, Hybrid Level 3 & ATO

TU Delft: Ruben Vergroesen, Rob Goverde, Egidio Quaglietta

ProRail: Alwin Pot, Henri Olink, Maarten Bartholomeus

ProRail

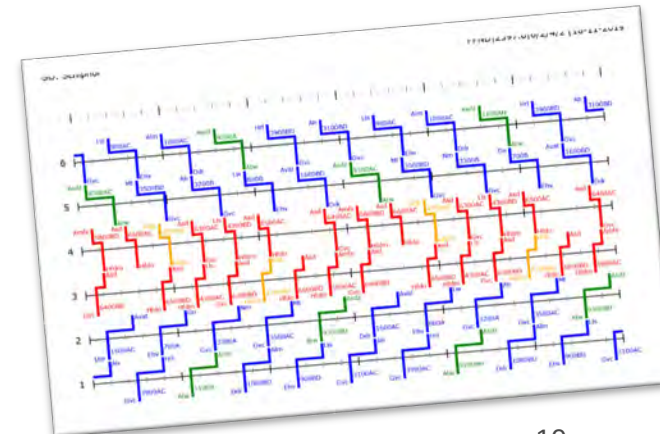
OV Saal studie ERTMS & ATO

Case OV SAAL

- Baanvak: **S**chiphol **A**msterdam **A**lmere **L**elystad corridor
- Dienstregeling 2030
- Infrastructuur 2030: ontwerp door TB, RVT en CM
- ERTMS (Baseline 3, L2 en HL3) & ATO (GOA2)

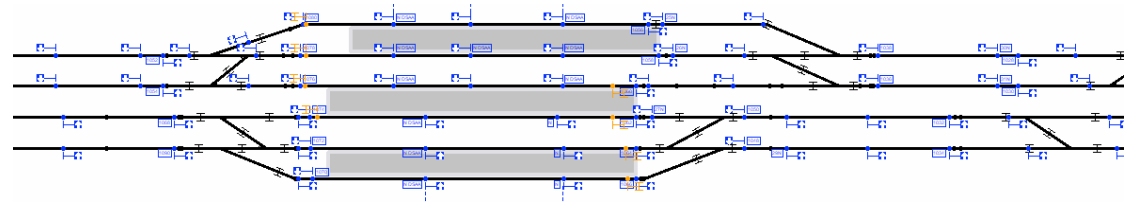
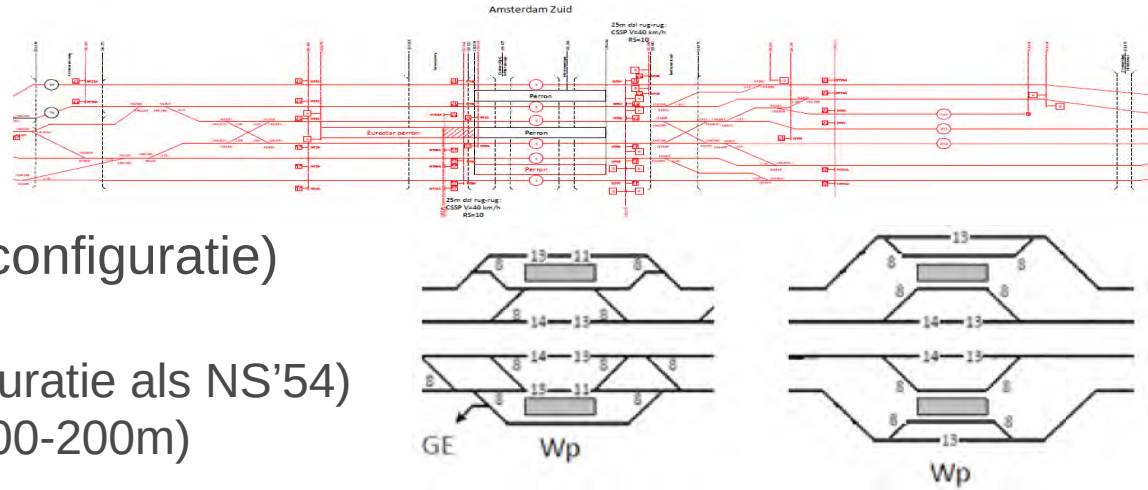
Studie

- Onderzoek capaciteit met simulatietool RailSys
- Impact ERTMS remcurves mcn, blok indeling en ATO
- Ondersteuning, toetsing en beoordeling door ProRail (TB, CM) en TU Delft



Modelleren infrastructuur

- 2030 infrastructuur
- NS'54 (huidige blok configuratie)
- ERTMS
 - L2 (zelfde blok configuratie als NS'54)
 - HL3 (korte blokken 100-200m)



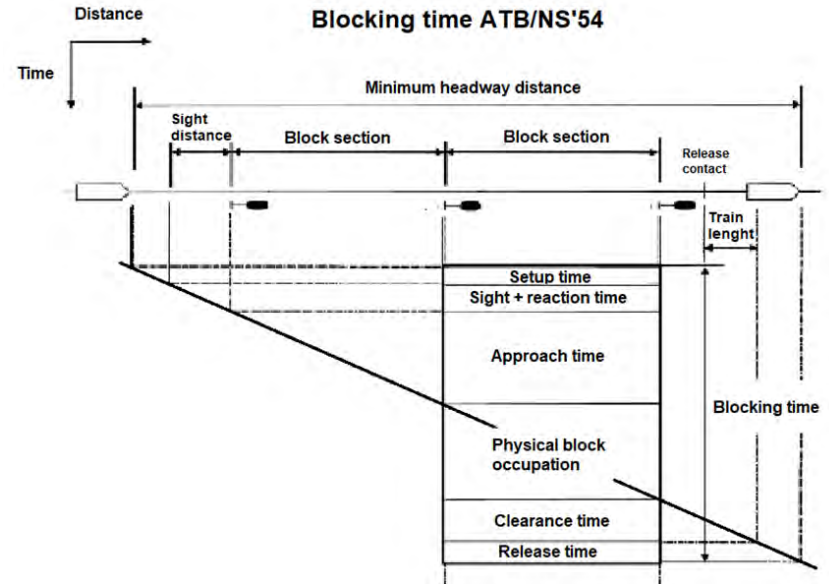
UIC406: Beoordelen dienstregeling

Bloktraptheorie

- Insteltijd (vaste waarde)
- Zicht + reactie tijd
- Toenadering
- Rijtijd (blok bezetting)
- Uitrijtijd
- Vrijgave (vaste waarde)

Afhankelijk van:

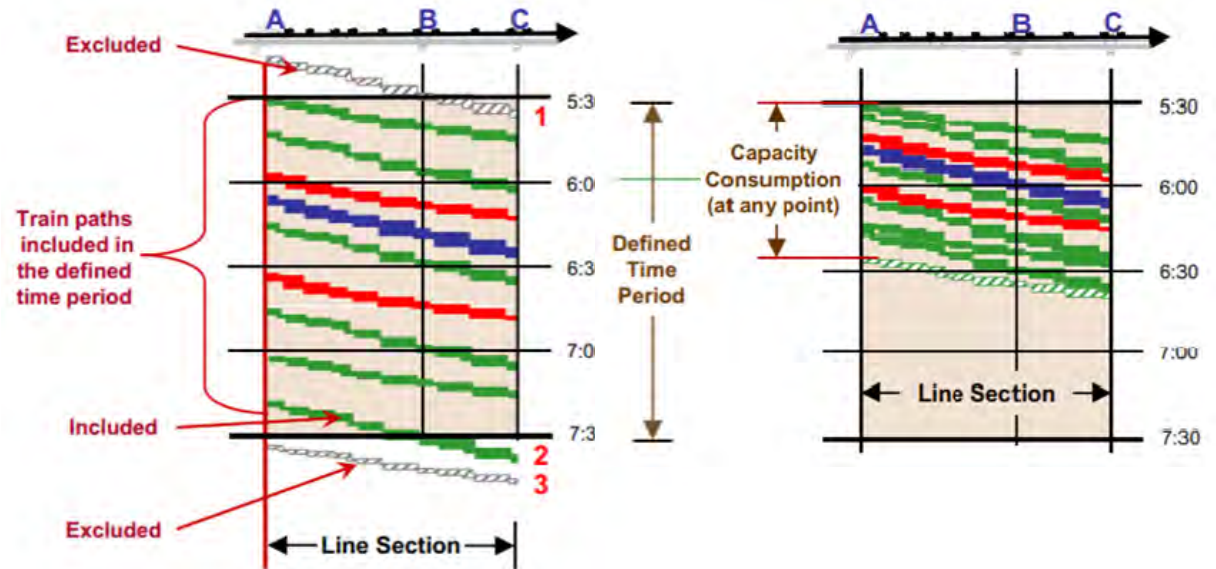
- Snelheid/remweg
- Treinlengte
- Blok lengte



OV Saal capaciteitsanalyse

Compressie

- UIC 406
- Kielzogbuffer



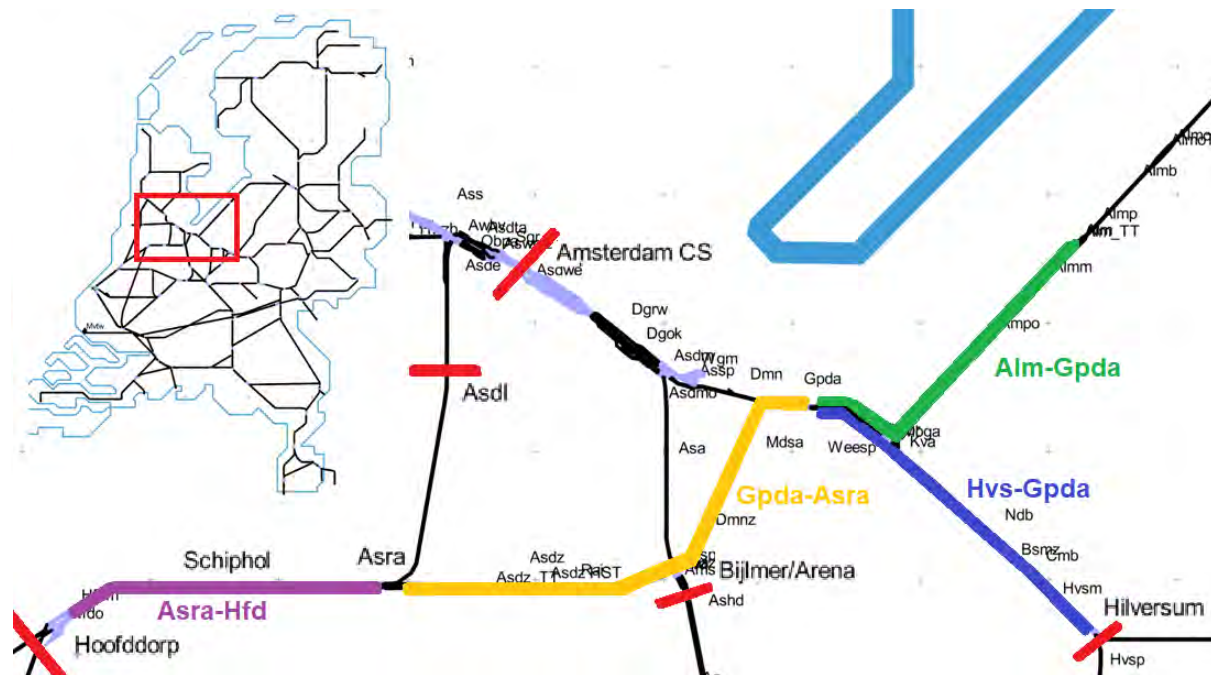
OV Saal capaciteitsanalyse

Compressie

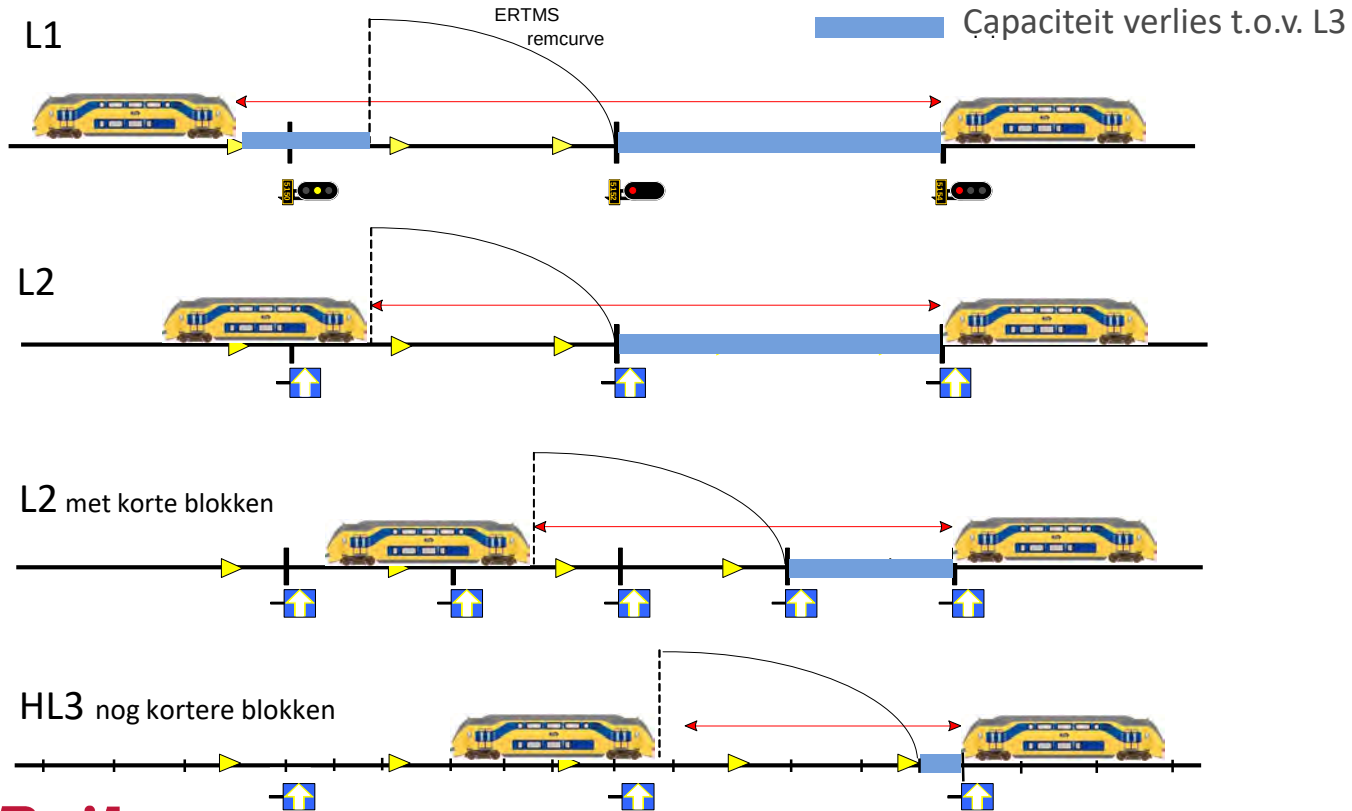
- UIC 406
- Kielzogbuffer

Infra

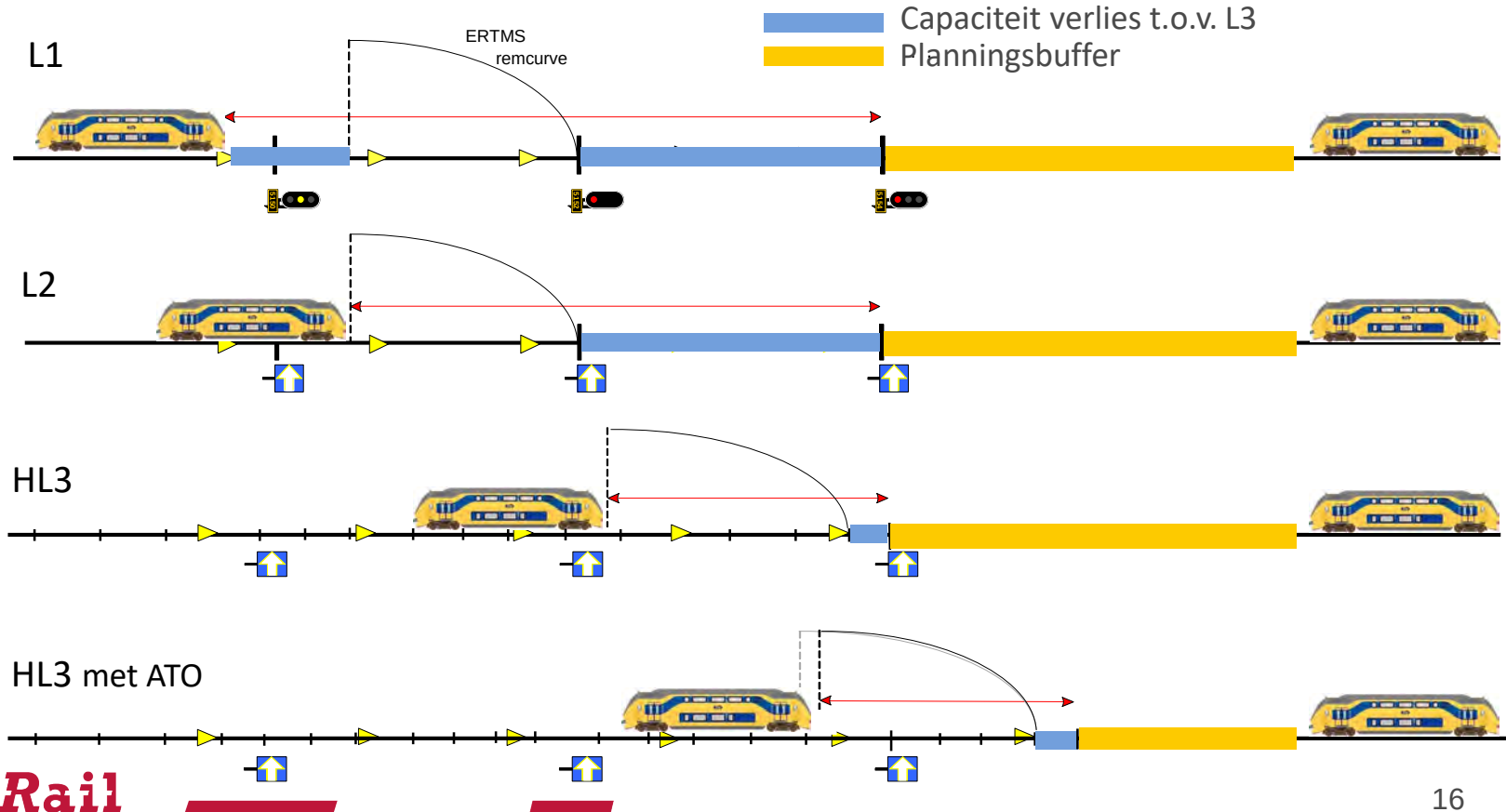
- 4 secties
- Kritieke sectie: Asra-Gpda

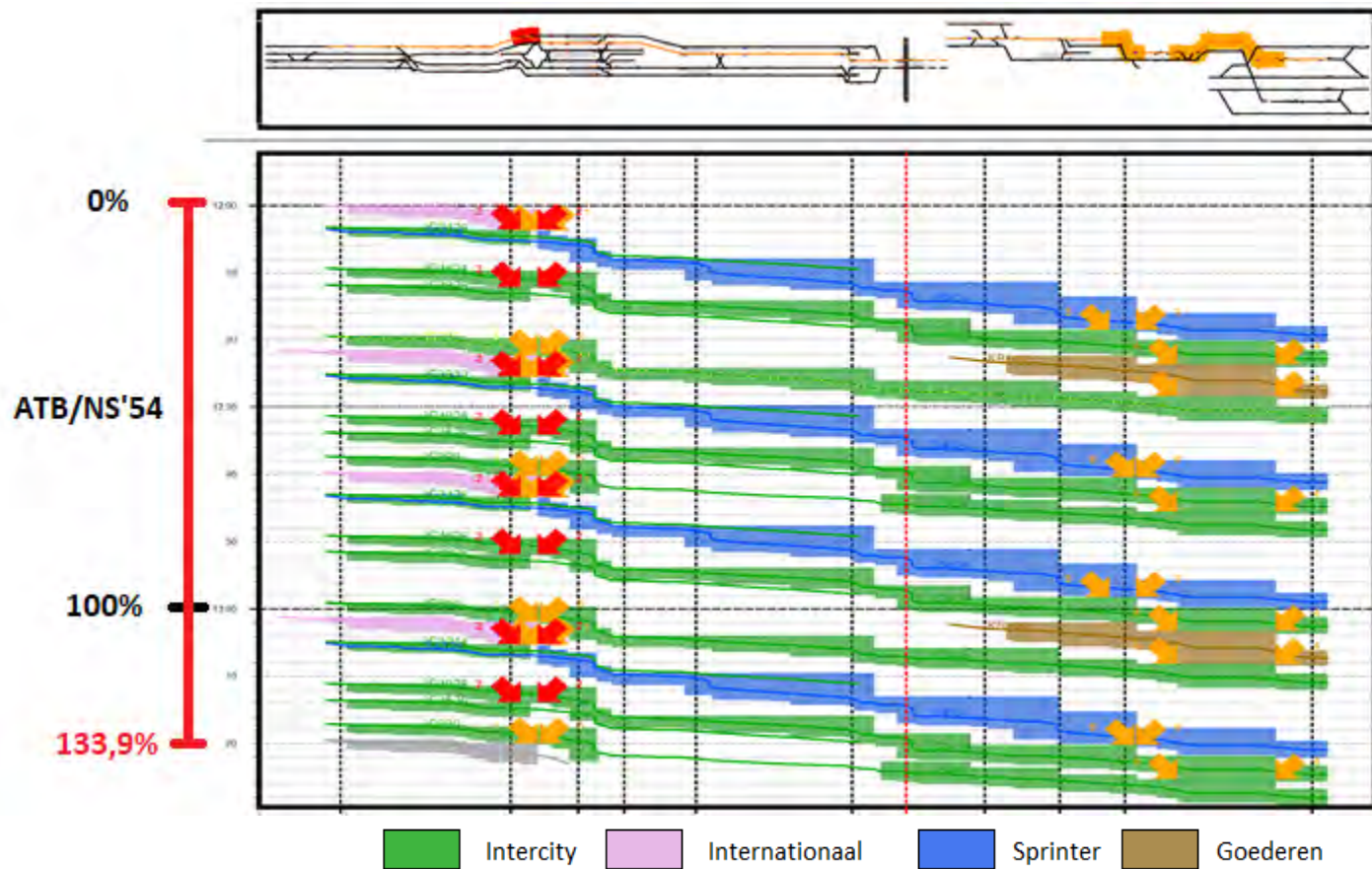


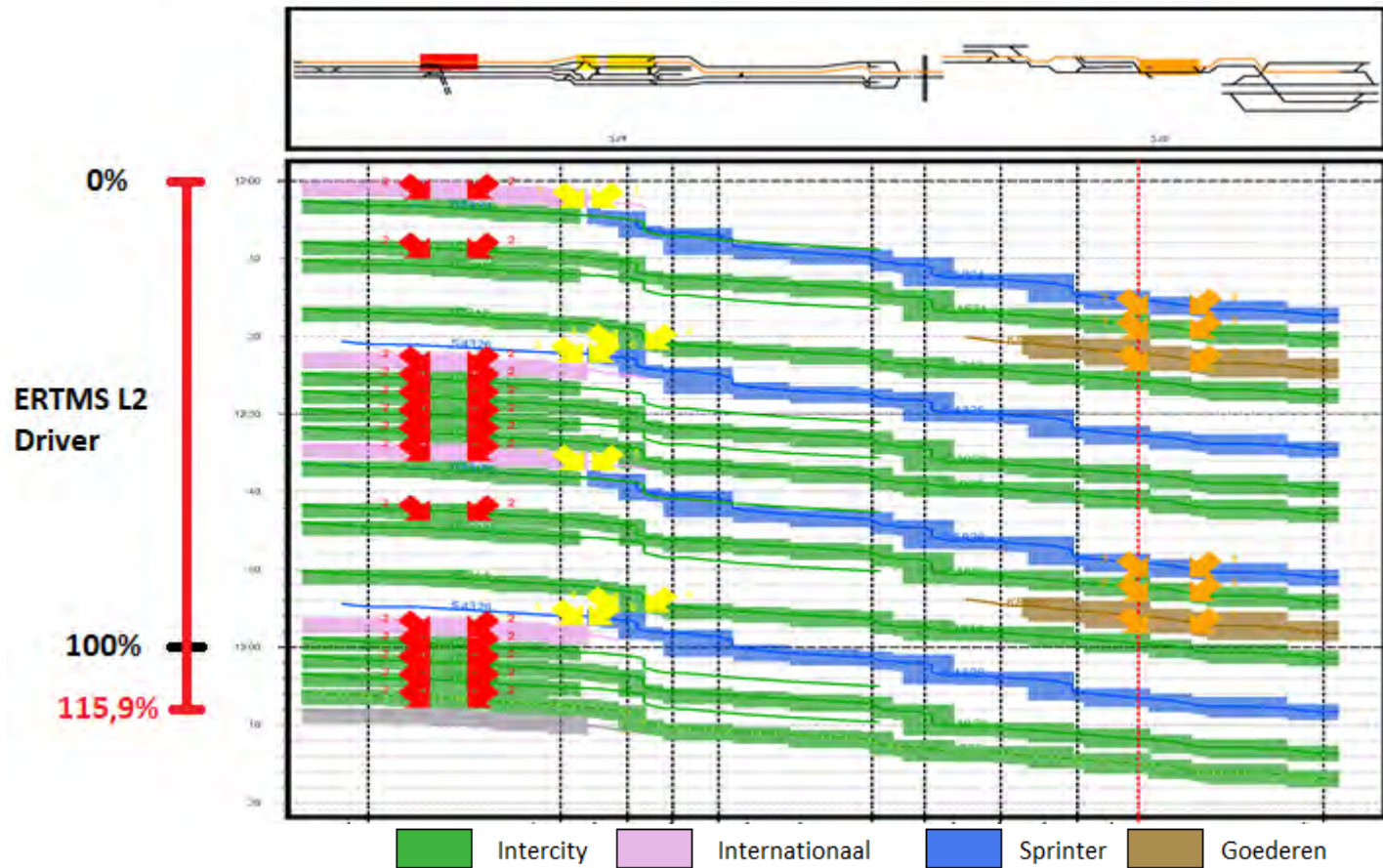
ERTMS Levels



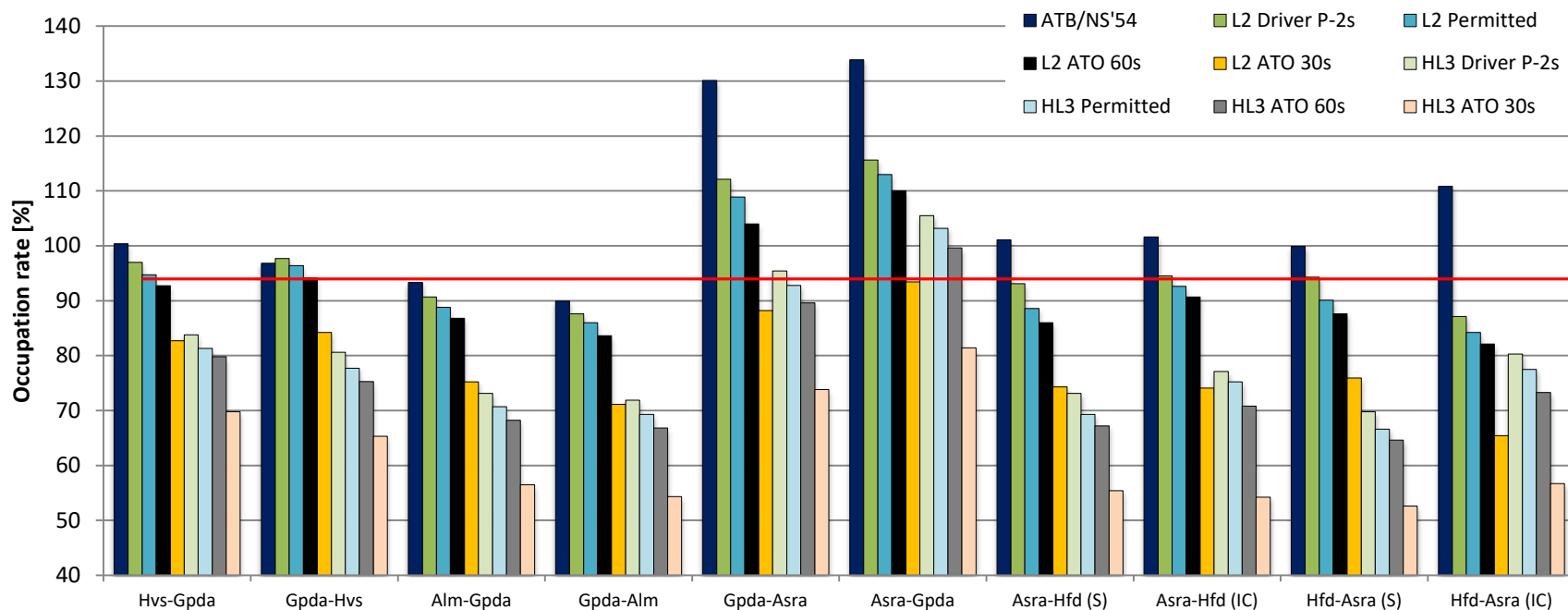
ERTMS Levels en ATO







UIC compressie resultaten per sectie en systemen



UIC compressie resultaten

Use of ERTMS/ETCS
braking curves

Shorter (virtual)
blocks (HL3)

Optimised driving
behaviour (ATO)

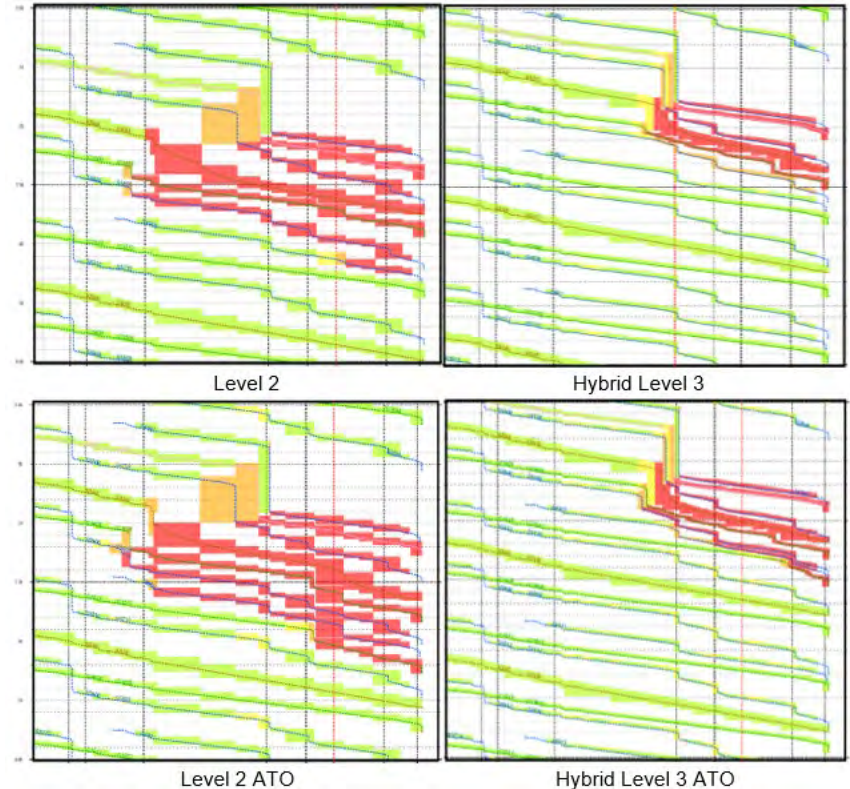
Reducing buffer
times (ATO)

System	Av. Occupation rate [%]	vs ATB/NS'54	vs HL3
ATB/NS'54	106 %		
ERTMS Level 2	97 %	9%	
ERTMS HL3	81 %	25%	
ERTMS HL3 & ATO 60sec buffer	76 %	30 %	5 %
ERTMS HL3 & ATO 30sec buffer	62 %	44 %	19 %

Stabiliteit ERTMS, HL3, ATO

- Gevolgen kortere opvolging/bandbreedte
- HL3 + ATO: vergelijkbare stabiliteit met 50% meer treinen

System	Frequency trains/h	Affected trains	Solved after
ATB/NS'54	12	7	00:37:07
L2 driver	12	7	00:35:44
L2 + ATO	15	8	00:37:29
HL3 driver	16	6	00:27:11
HL3 + ATO	18	8	00:28:47



Conclusies

- ERTMS & ATO heeft veel potentieel
- Grootste capaciteitswinst ERTMS in blokverdichting (HL3)
- Korte blokken geven ook verbetering dienstregeling stabiliteit
- ATO voor een baanvak als SAAL vergt ontwikkelingen in TMS (VPT)



Pier Eringa: doorpakken met zelfrijdende treinen

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More info:

- ERTMS specification, ERA, TSI CCS, annex A, set #3. <https://www.era.europa.eu>
- Hybrid Level 3 Principles, EEIG User group. <https://ertms.be/workgroups/level3>
- ATO Shift2Rail project IP2: <https://shift2rail.org/research-development/ip2/>
- ATO GOA34 X2RAIL: https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-4

- OKE Operationeel kenniscentrum ERTMS: <https://ertms-nl.nl/oke/default.aspx>
OKE Talkshow Hybrid Level 3 Maarten: <https://www.youtube.com/watch?v=WkCDwb4bFIM>

- Study Ut-Ht HL3 2018: <http://resolver.tudelft.nl/uuid:639015a7-d633-4b73-b782-9b9a153eae11>
- Study OV Saal HL3 & ATO 2020: <http://resolver.tudelft.nl/uuid:971cdcde-1a9a-490a-b72c-8490f2f668ed>

- ATO Test Betuwe Route: https://www.prorail.nl/sites/default/files/eindrapport_ato_verkenning_betuweroute.pdf
- ATO TNO ProRail study: <https://www.tno.nl/nl/over-tno/nieuws/2018/10/zelfrijdende-treinen-drijvende-kracht-in-de-toekomst-van-spoortransport/>

- Movies:
 - HL3 ATO ENIF UK: <https://youtu.be/kqYq4WJq1FI>
 - HL3 Living lab DB: <https://youtu.be/K6mS6akRmvA>
 - ATO Thameslink: <https://www.thameslinkprogramme.co.uk/learning-legacy/new-trains-technology/ato/>
 - ATO ProRail: <https://www.youtube.com/watch?v=ggHvfixk2SU>
 - ATO Test BetuweRoute: <https://www.youtube.com/watch?v=dJLc1Q8CdPk>