



Optimal strategies to manage major disturbances

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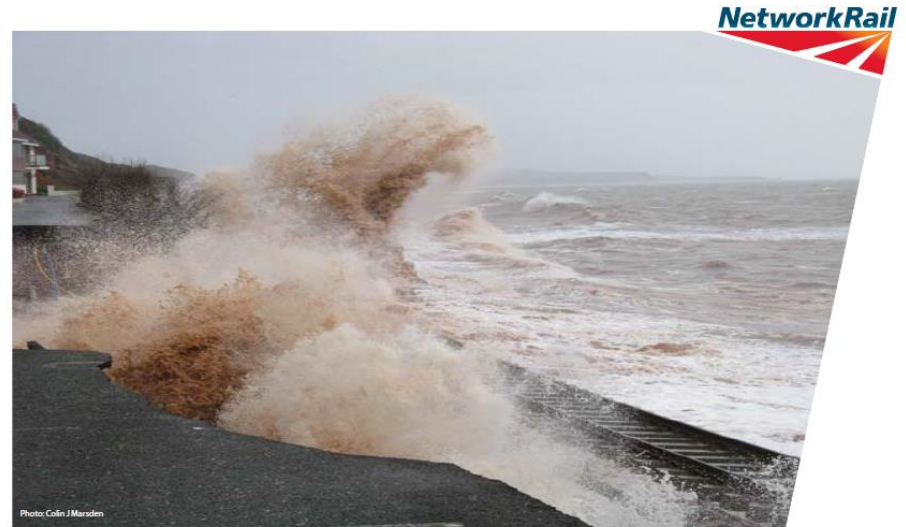
Our objectives

Analysis of European best-practices for **disruption management**

Identification of **lessons learned** and **recommendations**



Source: DB Mediathek

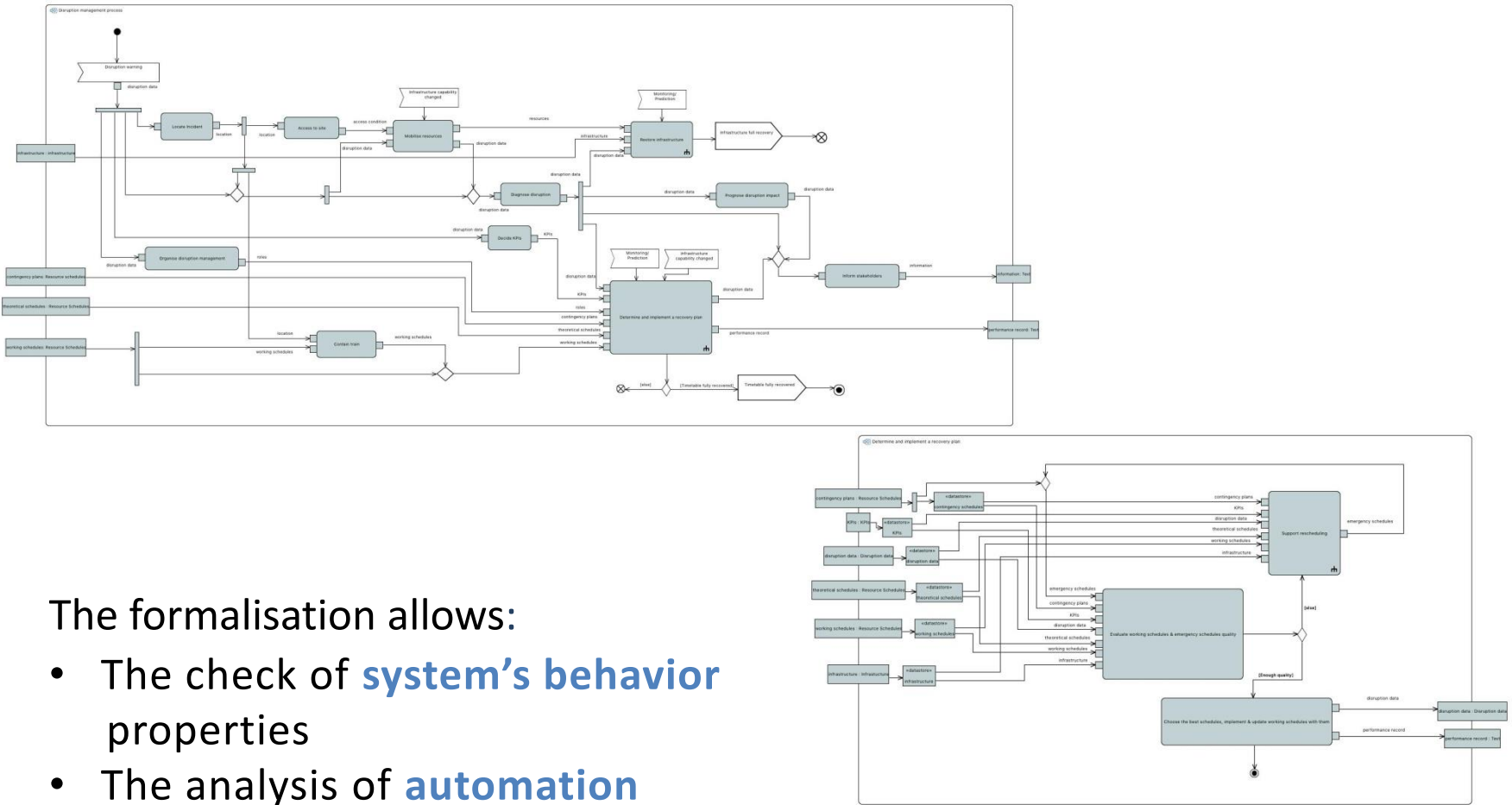


Development of a **roadmap** for increasing levels of automation in European railways

Study of an instance of **automation increase**

Disruption management process

The process has been formalised through **SysML activity diagrams**



The formalisation allows:

- The check of **system's behavior** properties
- The analysis of **automation**
- The validation at the **European level**

Analysis of incident records

E.G. SPITTAL (TWEEDMOUTH) FLOODING ON FRIDAY 10TH DECEMBER 2010 - London North Eastern route G

The management of this disruption follows the process formalized in the SysML diagrams



Some lessons learned:

- Generic contingency plans are not appropriate: **specific** responses must be provided for each incident
- **Coordination** of disruption management and emergency management is necessary
- Oral **coordination and communication** are highly important

The level of human-automation interaction is generally quite low in case of disruption

Some recommendations for possible improvements:

- Automatic **integration** of weather forecast models in the preparation for extreme weather events
- Automatic **information** sharing: communication across organizations
- Automatic **decision support tools**: quick and optimized
- Automatic state **monitoring**

Roadmap for automation increase

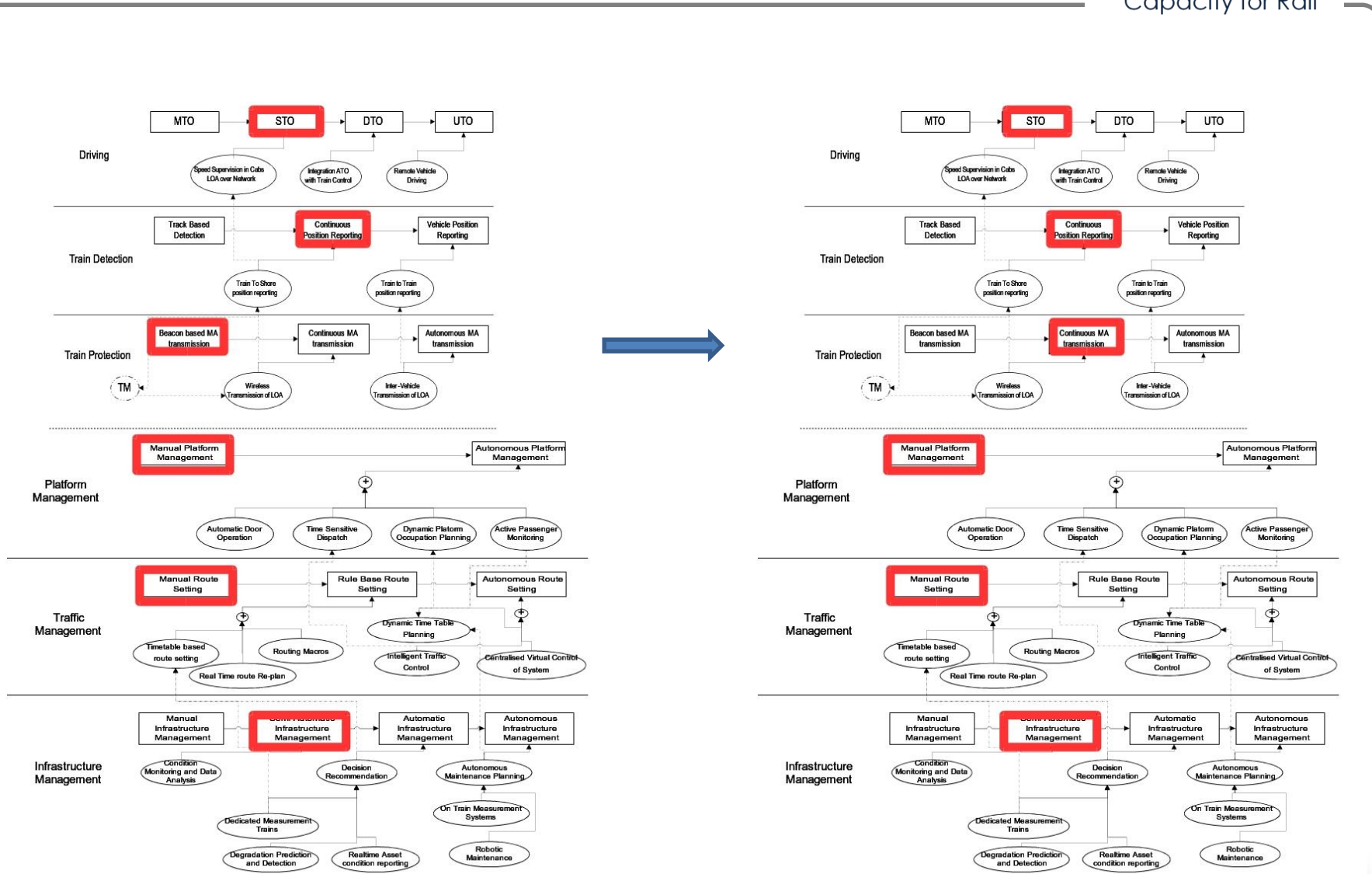
First focus: different **individual aspects** of the railway system

Then, collection of relevant elements into a **unified framework**

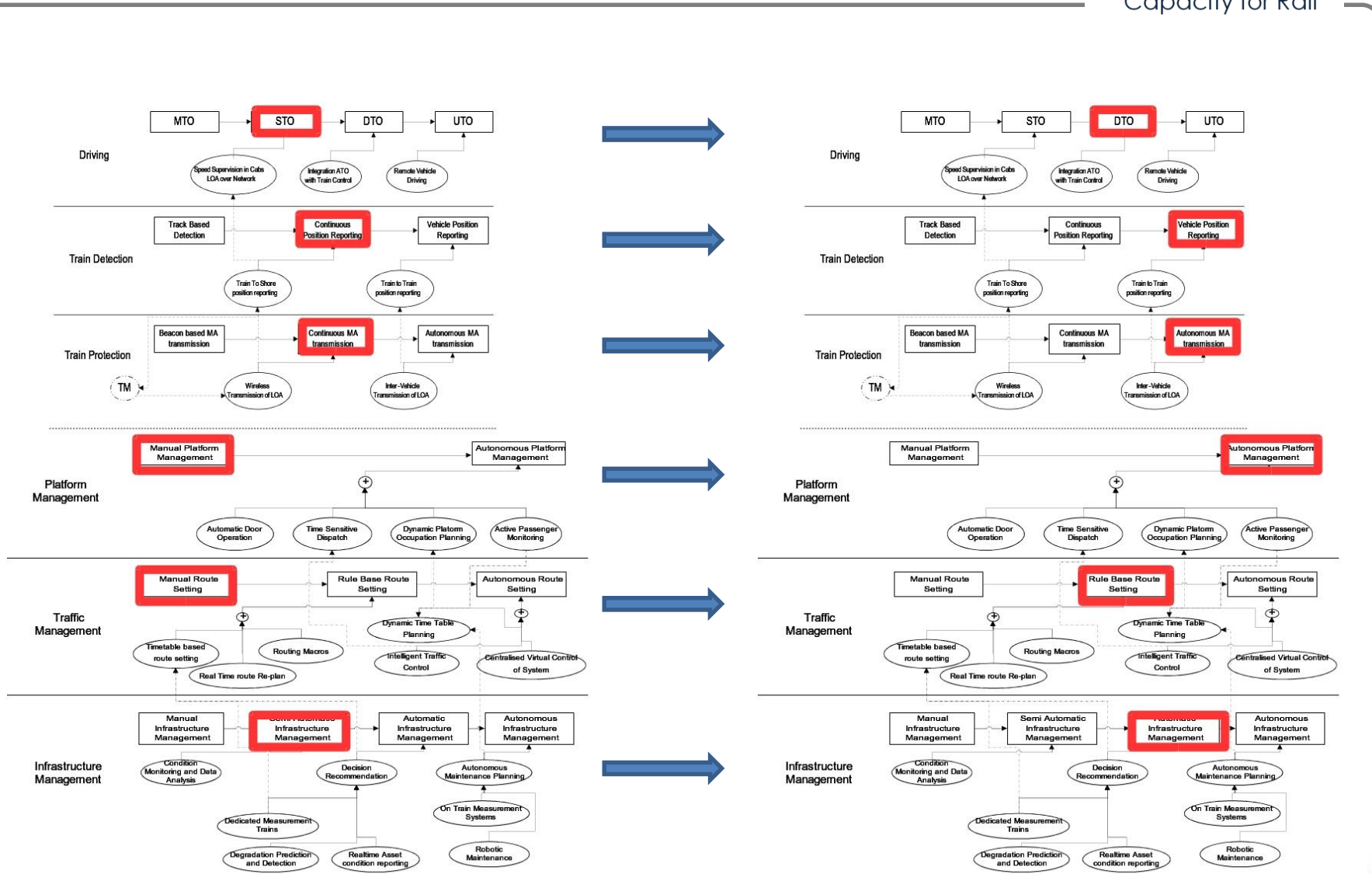
The overall improvement of capacity and reliability will be achieved only when the **whole system** will have reached a maturity level

Infrastructure	Manual	Semi-Automatic	Semi-Automatic	Automatic	Automatic	Autonomous
Platform Management	Manual	Manual	Manual	Automatic	Automatic	Automatic
Traffic Management	Manual TM	Manual TM	Manual TM	Rule Based TM	Rule Based TM	Autonomous TM
Train Protection	Induction Based	Induction Based	Radio Based	Autonomous	Autonomous	Autonomous
Train Detection	Track Circuits & Axle Counters	Augmented Train Detection	Augmented Train Detection	Autonomous	Autonomous	Autonomous
Driving	Manual	Semi-Automatic	Driverless	Driverless	Unattended	Unattended
Grade of Automation	GoA 0	GoA 1	GoA 2	GoA 3	GoA 4	GoA 5

Roadmap: GOA 1 and GOA 2



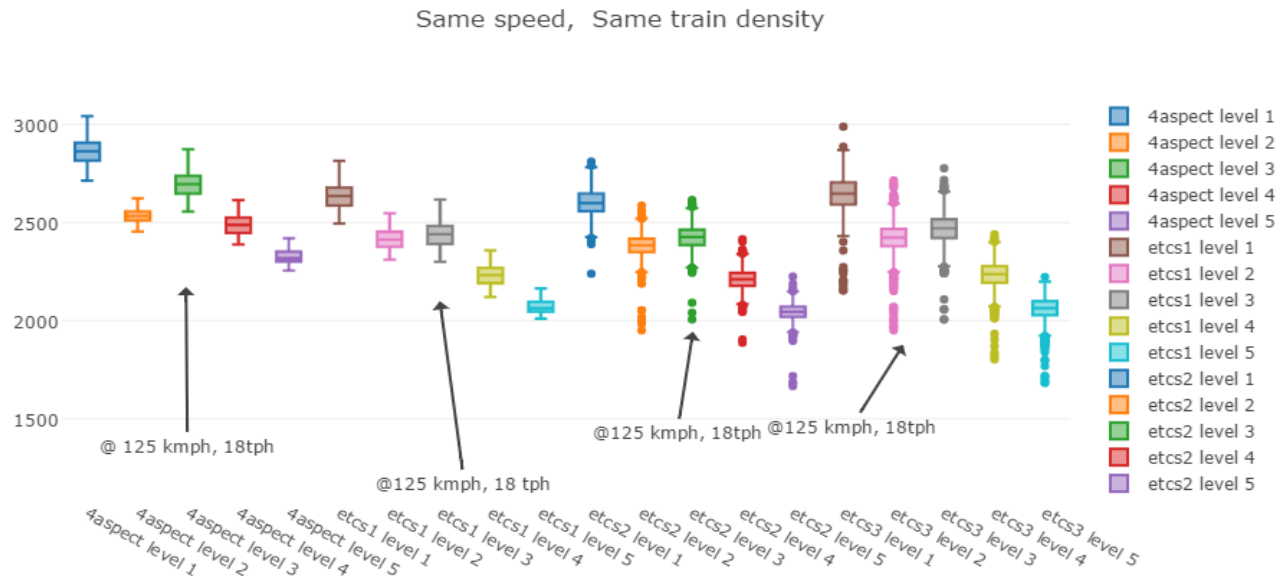
Roadmap: GOA 2 and GOA 3



Validation through simulation

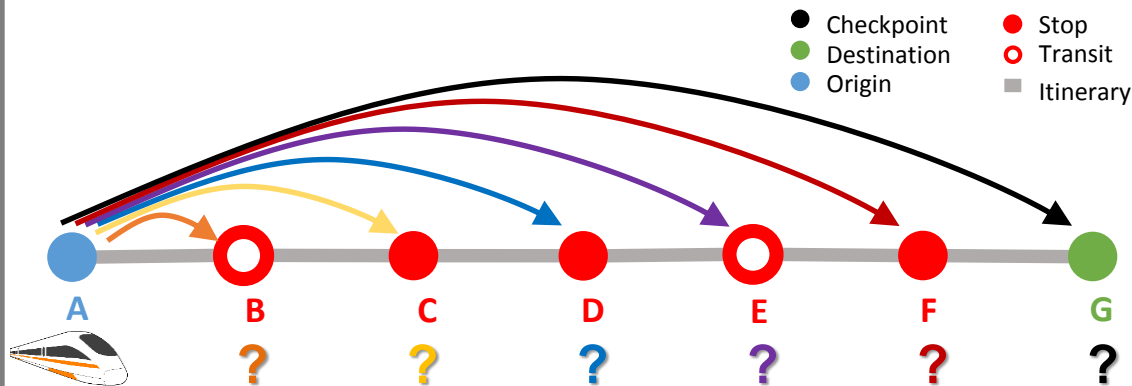
The results show that **incremental improvements** of automation **do not** necessarily show capacity improvements

Coherent automation, as in the roadmap, yields improvements



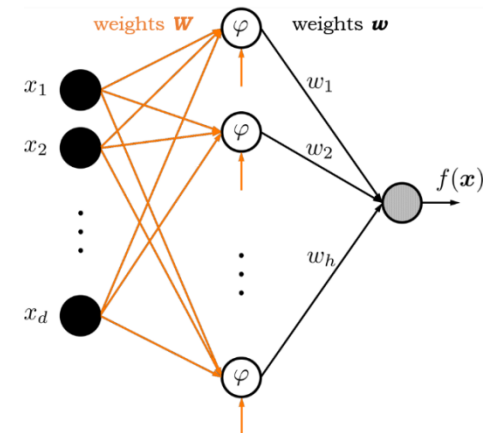
An instance of automation increase: delay prediction

Data-driven multivariate regression models **predict delays** at checkpoints



Extreme learning machines

(artificial neural networks) solve the regression problems



In tests on real Italian data, **the models outperform the current technique** by a factor of $\approx 2x$ (on total average)

The team



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Thank you for your kind attention

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