



Beyond gut feeling: optimising train repair networks

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Introduction: Jan Jaap

- Jan Jaap Vermeire
- MSc Econometrics, University of Amsterdam
- Simulation expert at NS (Dutch Railways) since 2016:
 - timetable design;
 - contingency planning for disruptions;
 - corrective maintenance.
- Other members of the SimTeam:



Ank van Paassen
Simulation-expert



Cor van 't Woudt
Simulation-expert



Camiel Simons
Simulation-expert



Rudy Verheul
Infrastructure in Railsys



The big question

Where should **maintenance facilities** be located, what **equipment** should they have, and how much **capacity** is needed to support current and future **timetables** and **train types**?

Finding the perfect balance given:

- Upfront investments in maintenance locations
- Operational pressure and additional non-revenue train kilometers
- Number of trains required
- Track capacity and space
- The need to accommodate future train types and timetable changes



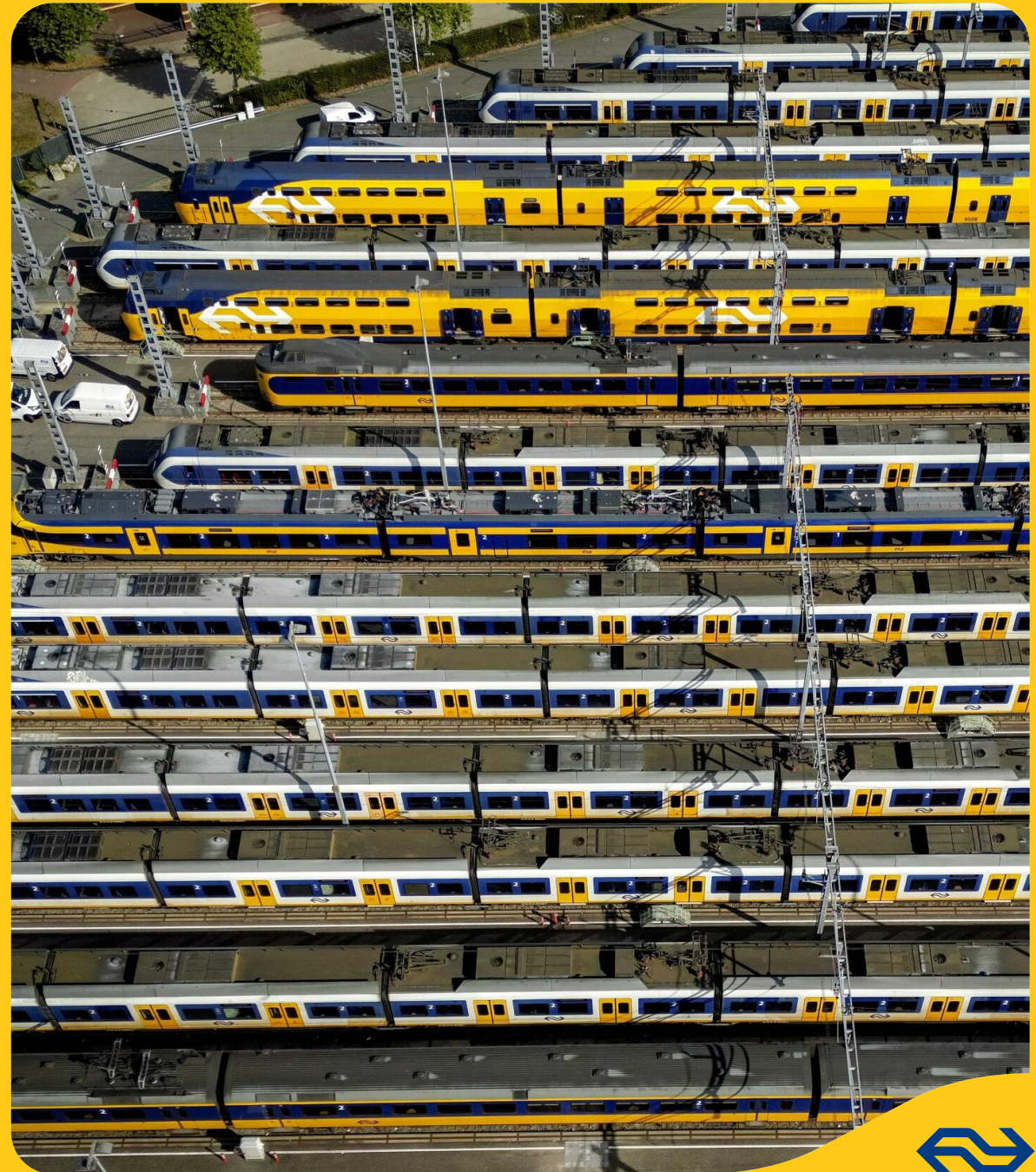
Agenda

- A bit of context
- Why now?
- Why simulation?
- Approach
- The many possibilities
- Happily ever after...
- Questions



A bit of context

- NS is by far the **largest carrier** in the Netherlands, transporting **one million passengers a day** across **one of the busiest railway networks** in the world.
- NS has about **750 trainsets** distributed across **eight train types**.
- **30+ stabling yards**: train parking lots.
- **Defects occur constantly** — and each requires **different tools, knowledge and locations**.
- **25 maintenance locations**, ranging from very small to large.



Why now?

- Many locations are at **the end of their lifespan**.
- NS wants to move towards fewer, but better-equipped maintenance locations
- The **way trains are built is changing** (level boarding)
 - changing form of maintenance
 - different need for equipment (fewer pits, more aerial work platforms and balconies).



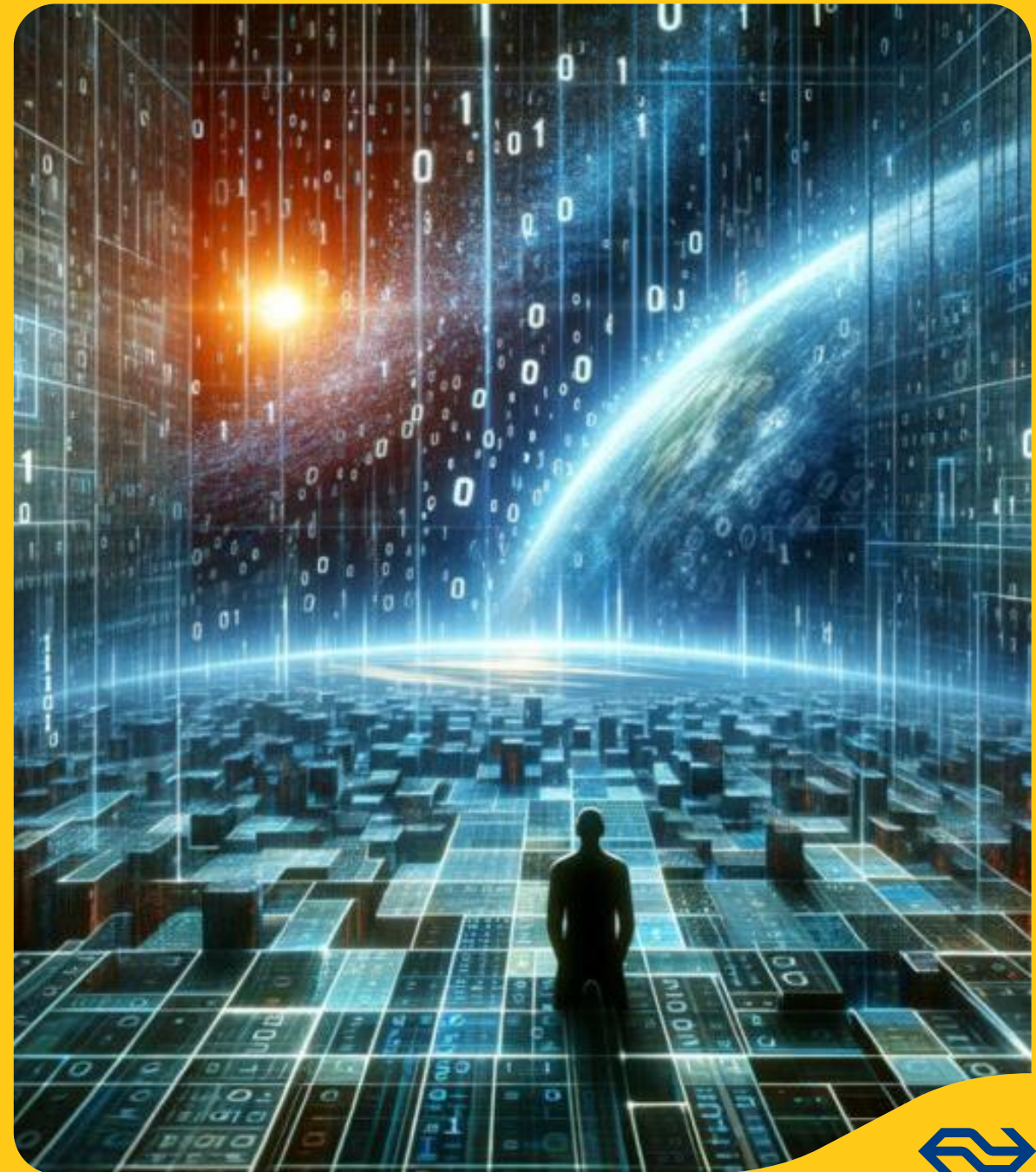
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Why simulation?

- The process modeled is highly **stochastic** and **complex**
- **Sensitive** to input parameters
- Small changes can have **big impacts**
- Capable of exploring wide range of **scenario's**



Approach

Desire for a quantitative way to investigate.

Not only averages, but statistical analysis and confidence levels.

AnyRepair - *Modelling corrective maintenance*

Input

- Timetables
- Fleet composition
- Defect profiles (chances & deadlines)
- Locations with workshop equipment
- Location capacity
- Distances between locations

Output

- Workload per location
- Which equipment is lacking (country-wide)
- # relocation km – to move train units from stabling yard to repair facilities

Out of scope

- Personnel and expertise
- Stock of spare parts
- Logistics within stabling & repair locations



Approach

- Main agent: **train-unit**
 - Timetable for the current and the following day
- Defects per traintype:
 - Probabilities based on historical data
 - Distribution across defect categories, such as wheels, motors, interiors, etc.
 - Required maintenance equipment;
 - Repair deadline



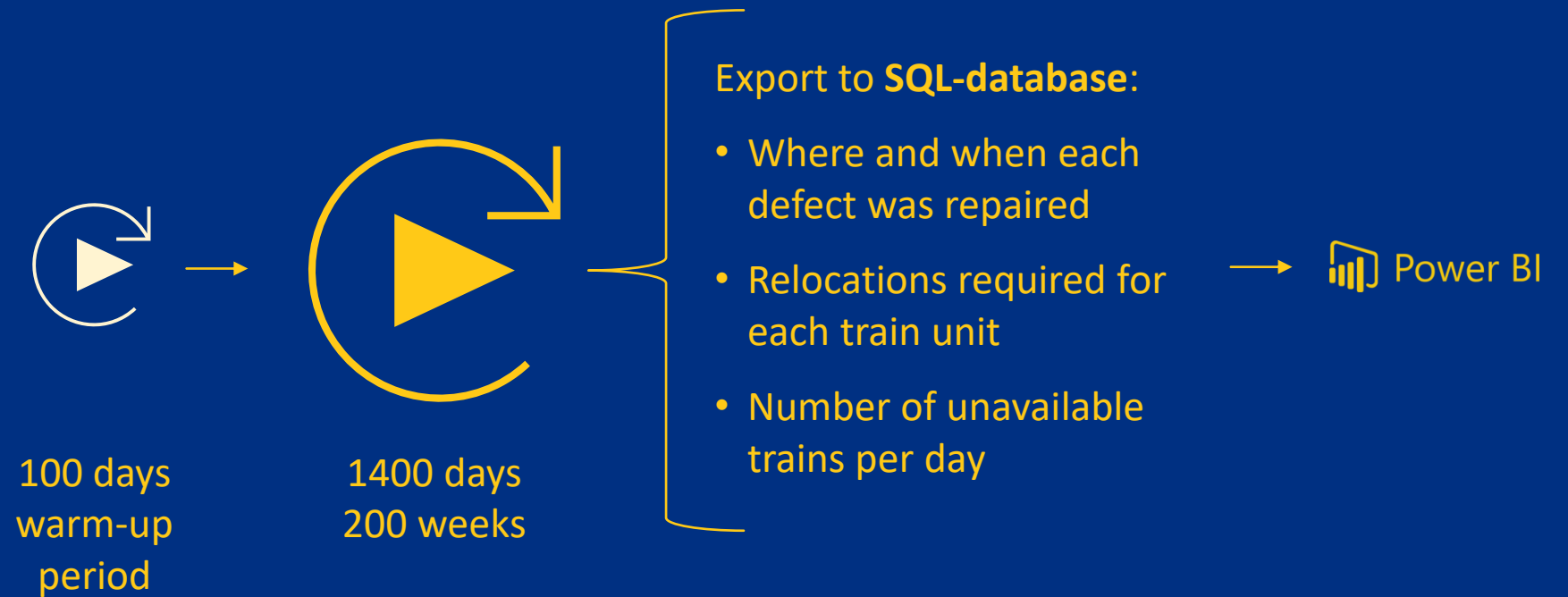
Approach

Daily maintenance planning:

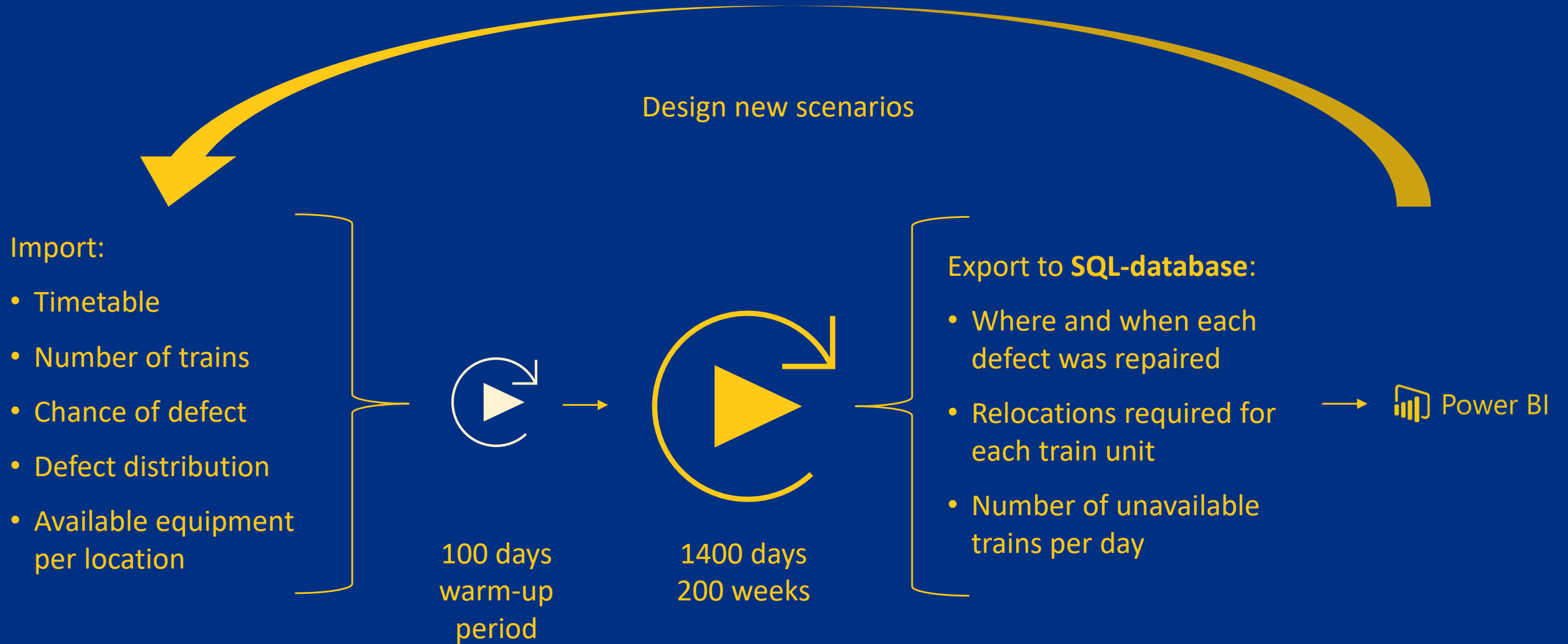
1. Plan the train units whose repair deadline falls on the next day
 - Schedule units that **can be repaired at their overnight locations** taking into account the available equipment and capacity at each maintenance location.
 - **Relocate** units to nearest available maintenance location when necessary
2. Check which other units can still be repaired at their overnight locations
3. To maximise the number of available units on Tuesdays and Thursdays (the busiest days), plan further ahead on the preceding days



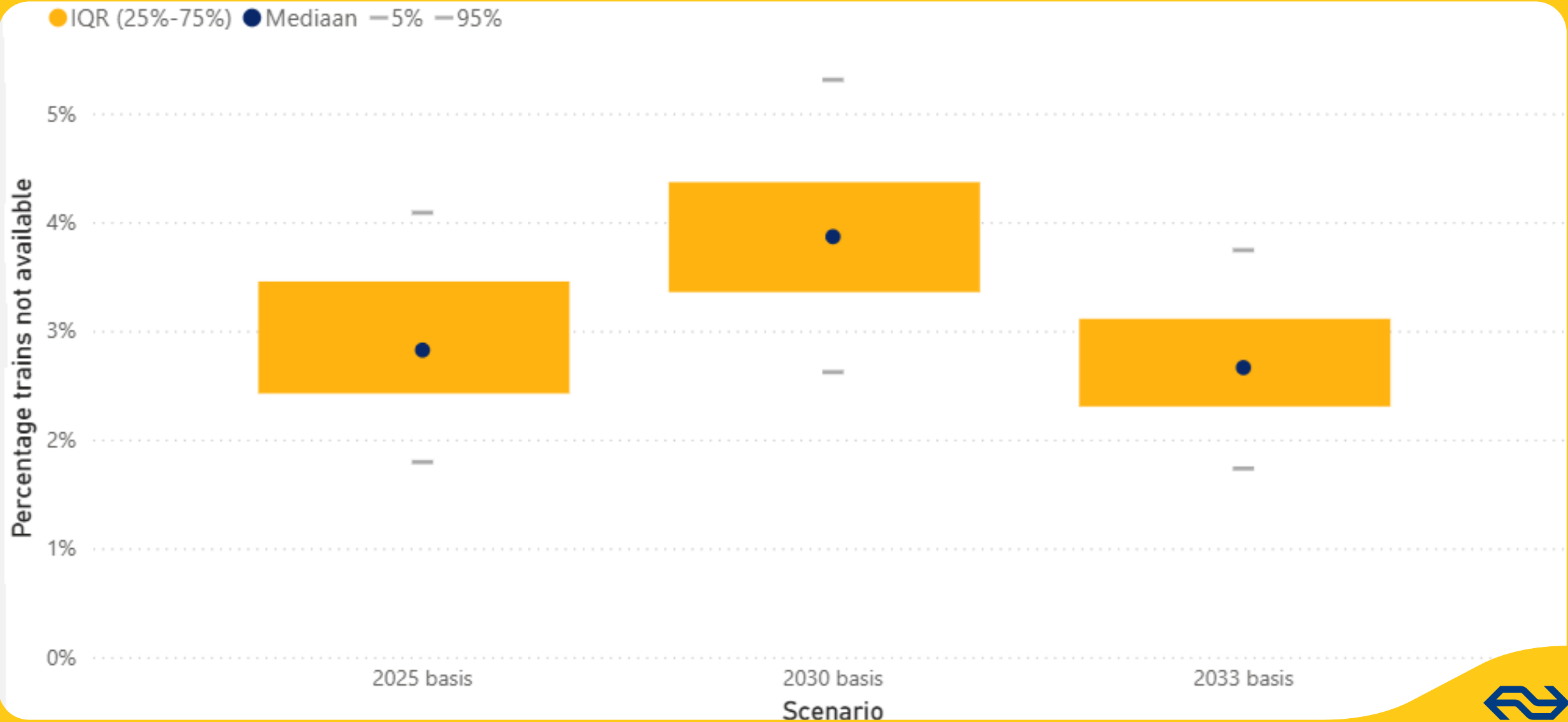
Approach



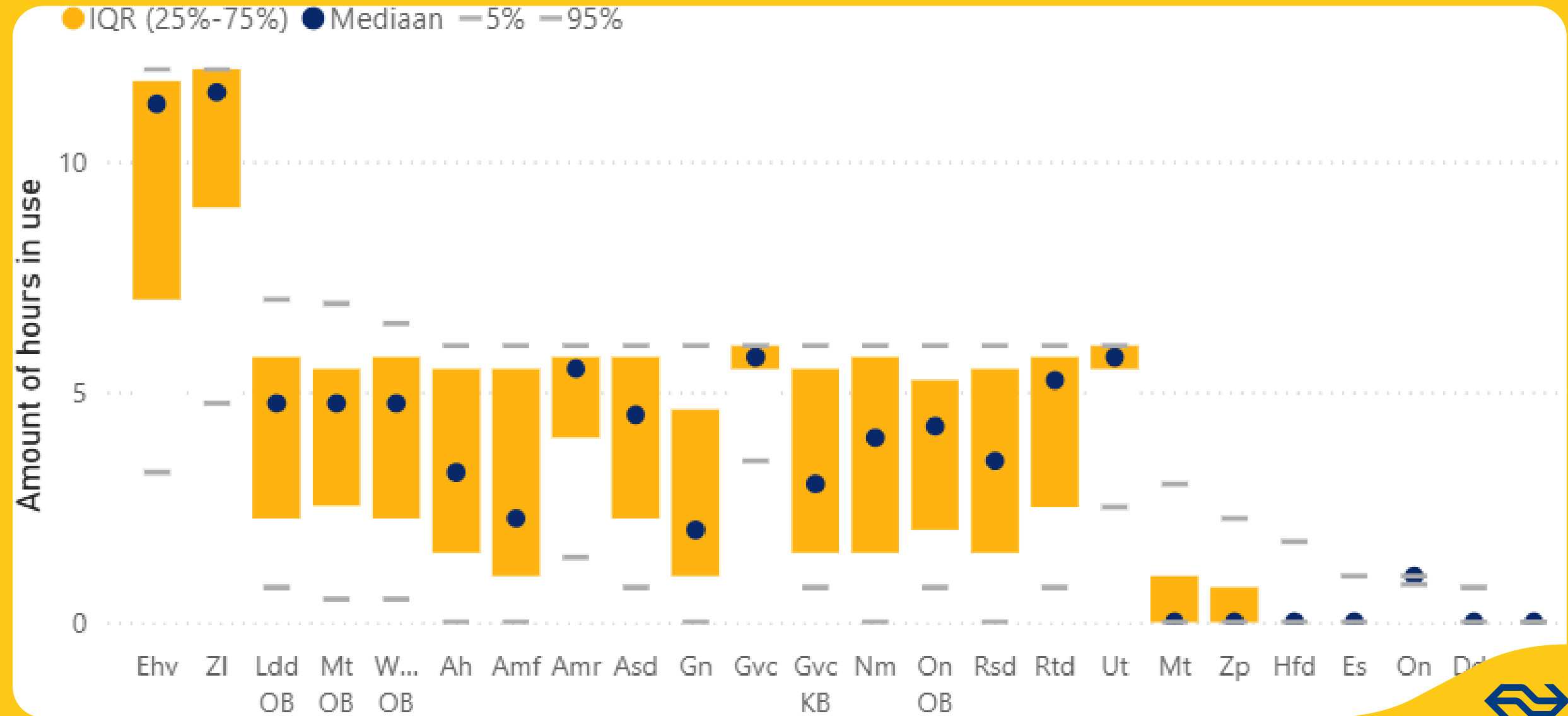
Approach



The many possibilities

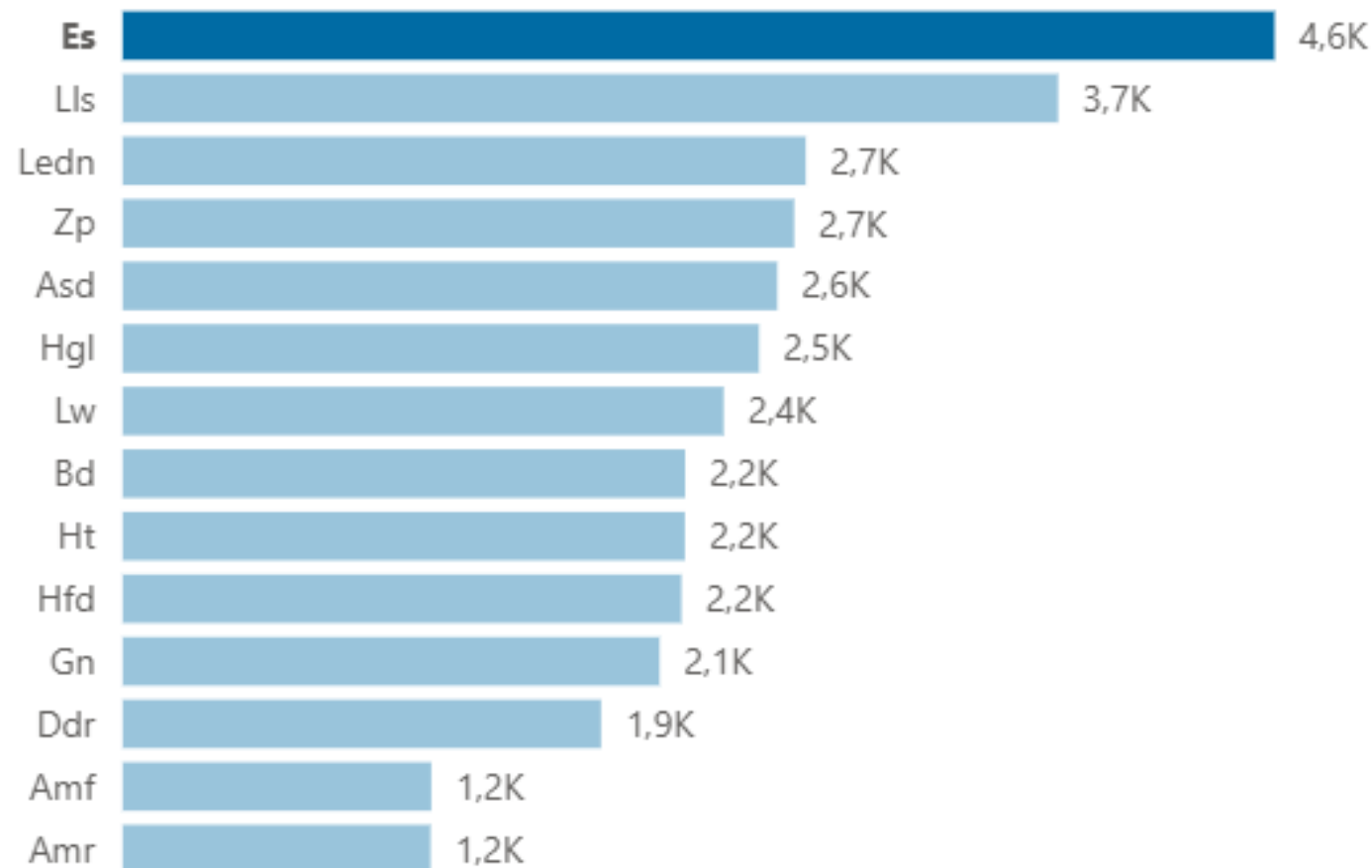


The many possibilities

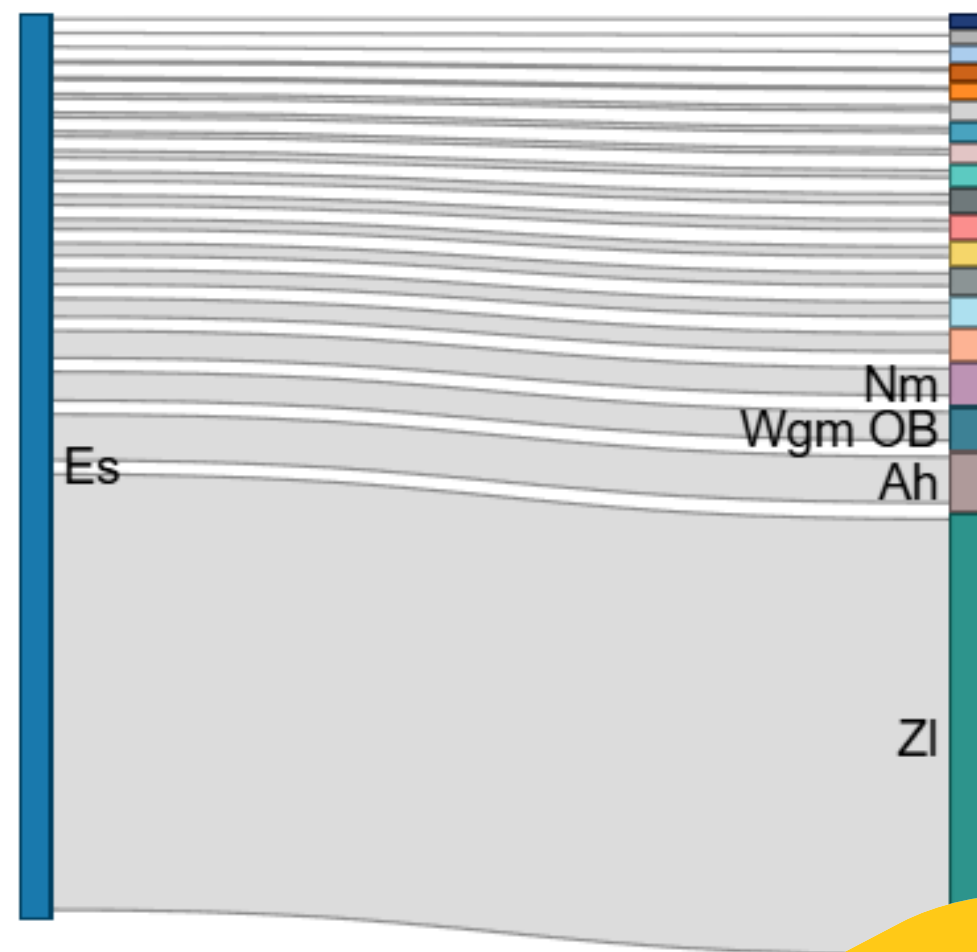


The many possibilities

Amount of trains moved from location



Moved from location to location



Happily ever after...

- Forms the basis for the new vision on maintenance-facility strategy, including decisions on locations, capacity and equipment.
 - Identified significant potential cost savings.
- From a one-time decision-support tool for developing a new vision to an annually updated tool for validating the long-term strategy.
- New insight: challenging year 2030 can be managed with temporary measures.





AnyQuestions?