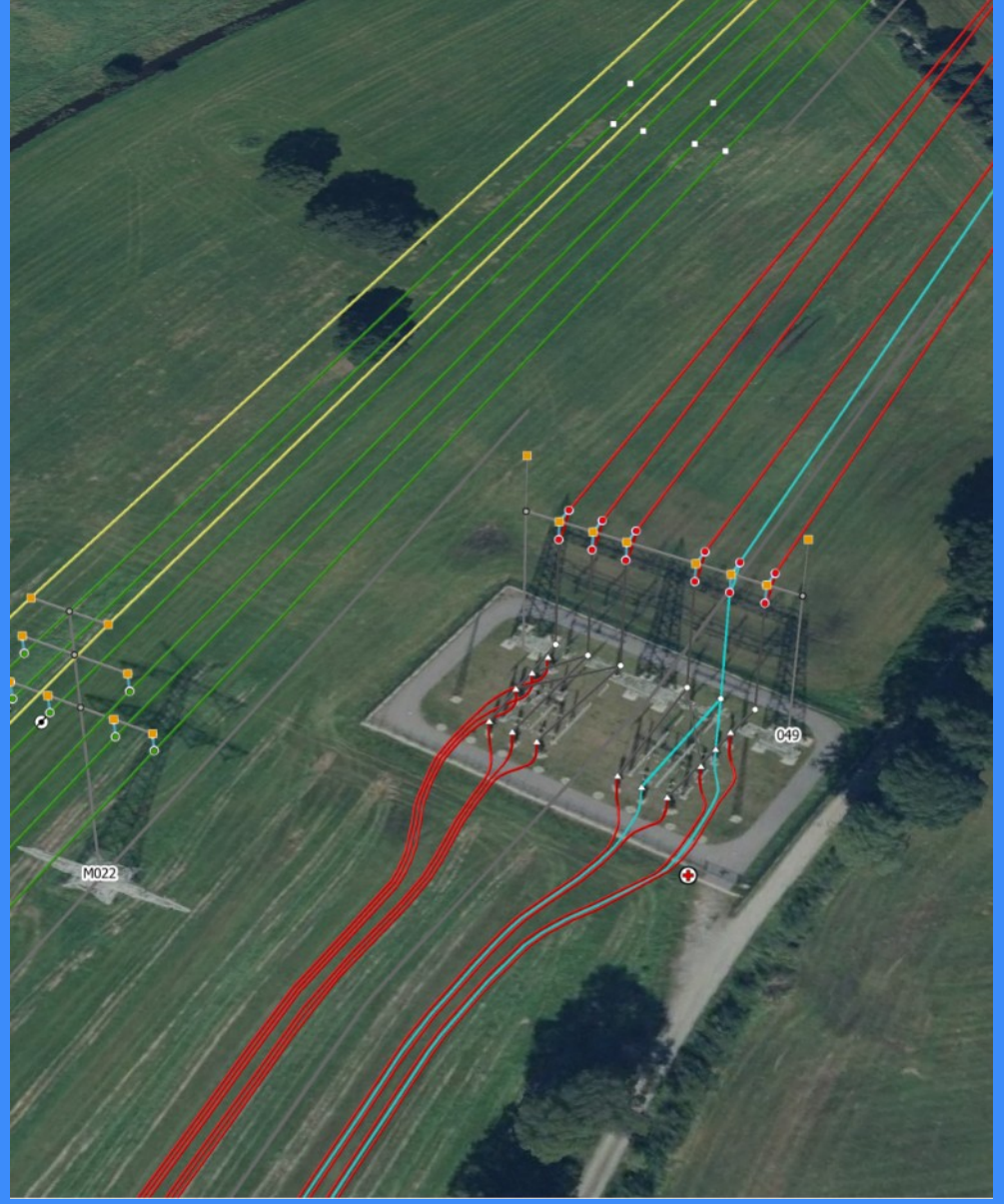
Combining Topology and the Digital Twin in a 3D Utility Network



Johannes Weigel, Harry van Zeijts

TenneT Asset Data Management

30.04.2026

A moment for safety

Together, we provide a safe working environment. We learn from mistakes. Sharing ideas and concerns as well as asking questions are a matter of course.

We would also like to draw your attention to the following safety measures in case we need to evacuate the premises.

Follow the escape route as indicated

Use the stairs instead of the lift

Go to the assembly point

Follow the instructions of the in-company emergency responder

TenneT in figures 2024

9,700
colleagues

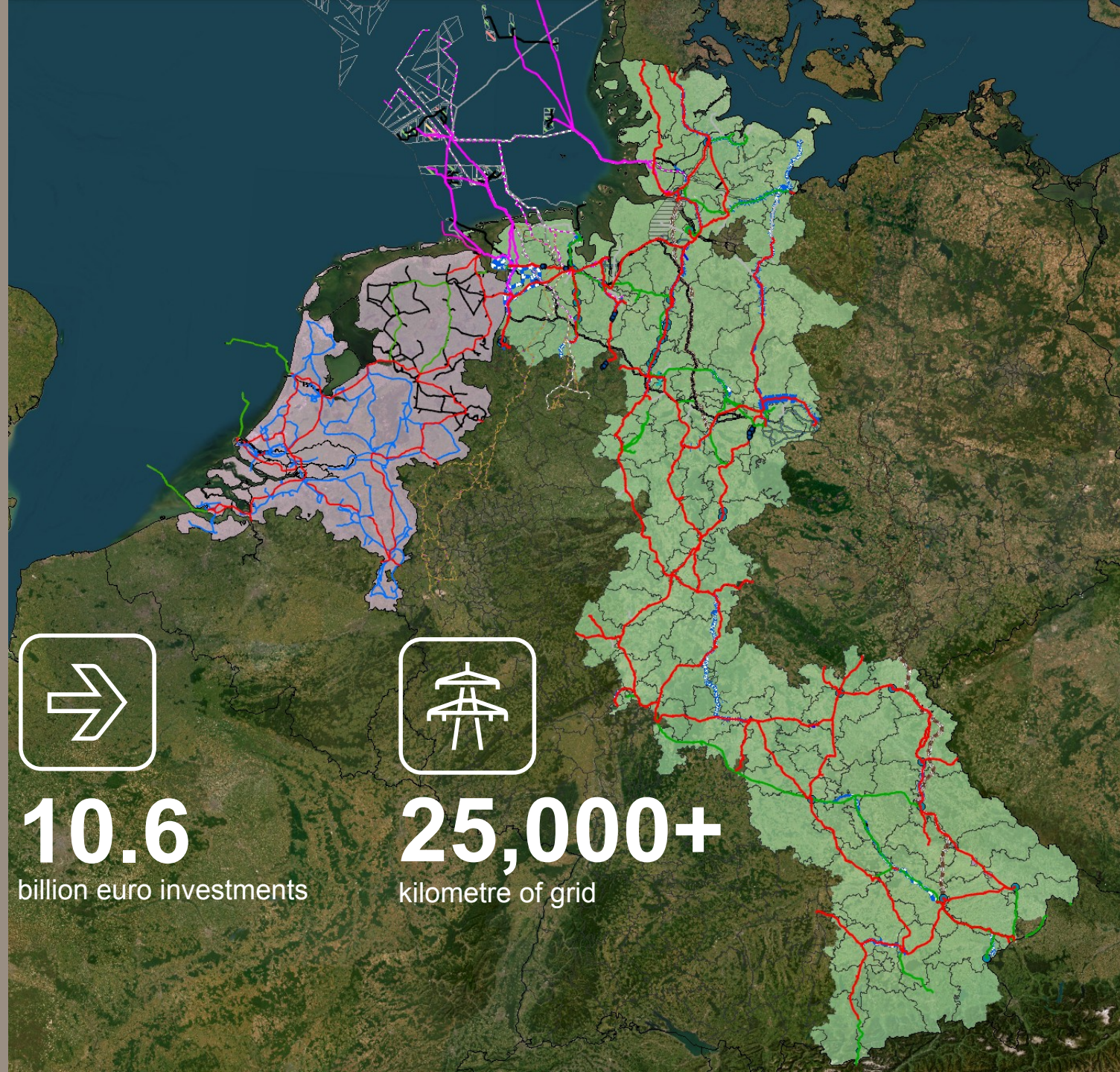
99.99988%
grid availability

1,745
million euro EBIT

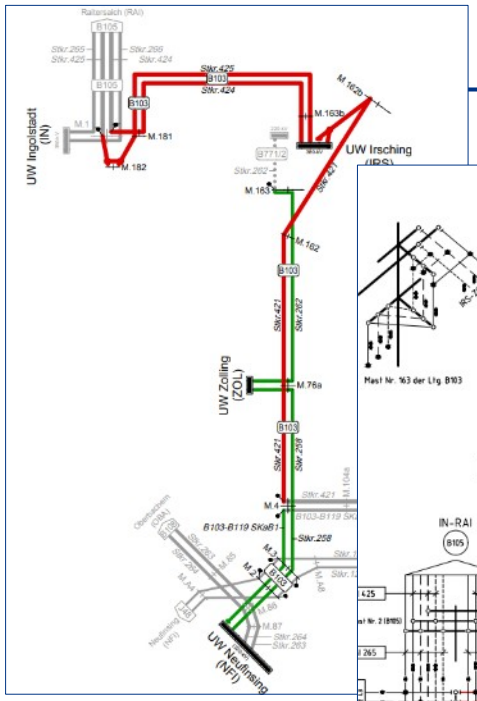
55
billion euro assets

10.6
billion euro investments

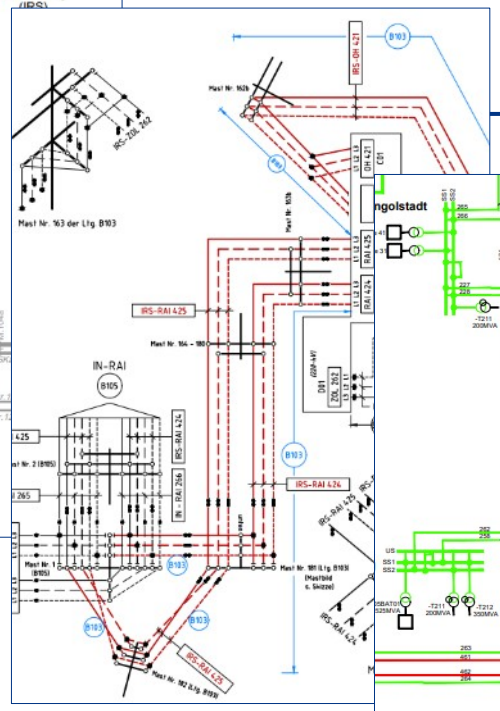
25,000+
kilometre of grid



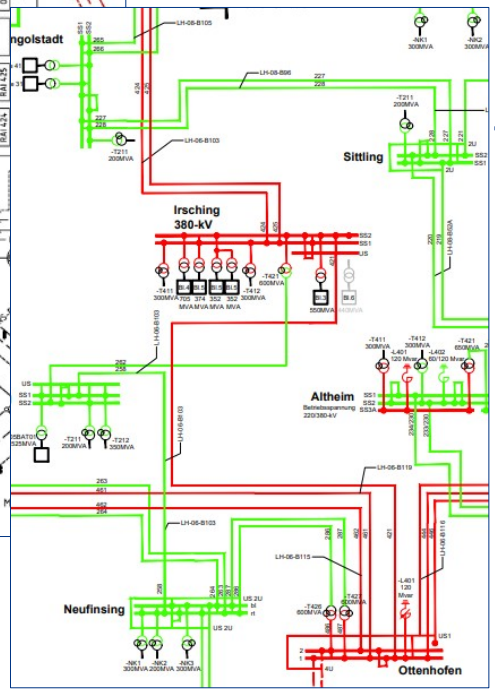
A single source of truth is so important that we built several!



Line plan

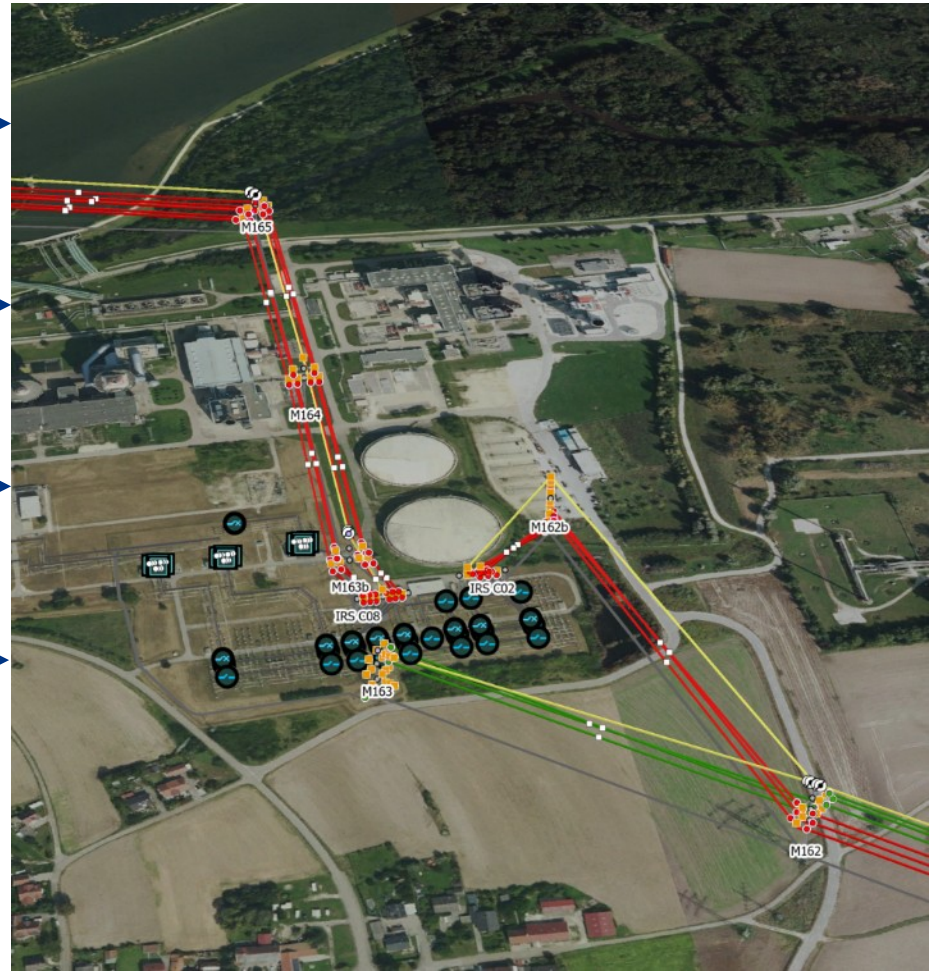


Phasing plan



Grid plan

Other Plans, Maps and data silos



One Single Source of Truth

Project leads come and go. The project stays!

2018 … 2019 … 2020 … 2021 … 2022 … 2023 … 2024 … 2025

BMR

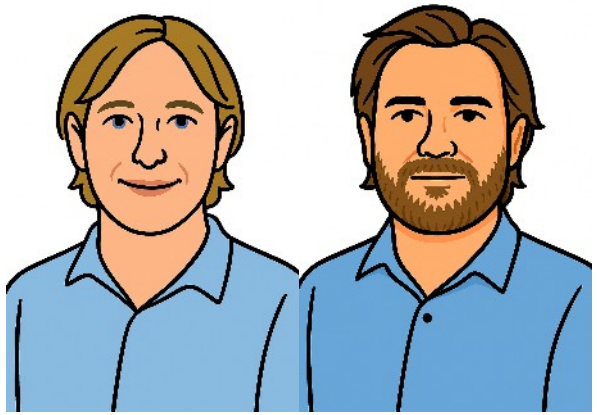
BMR2

OneBMR

OneIP

ArcGIS

BMRGIS



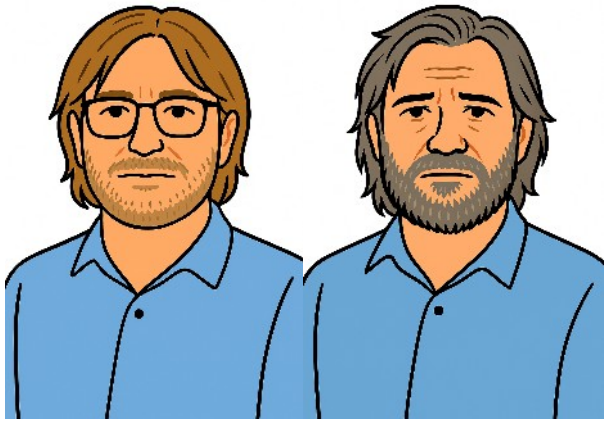
Names come and go

Suppliers come and go

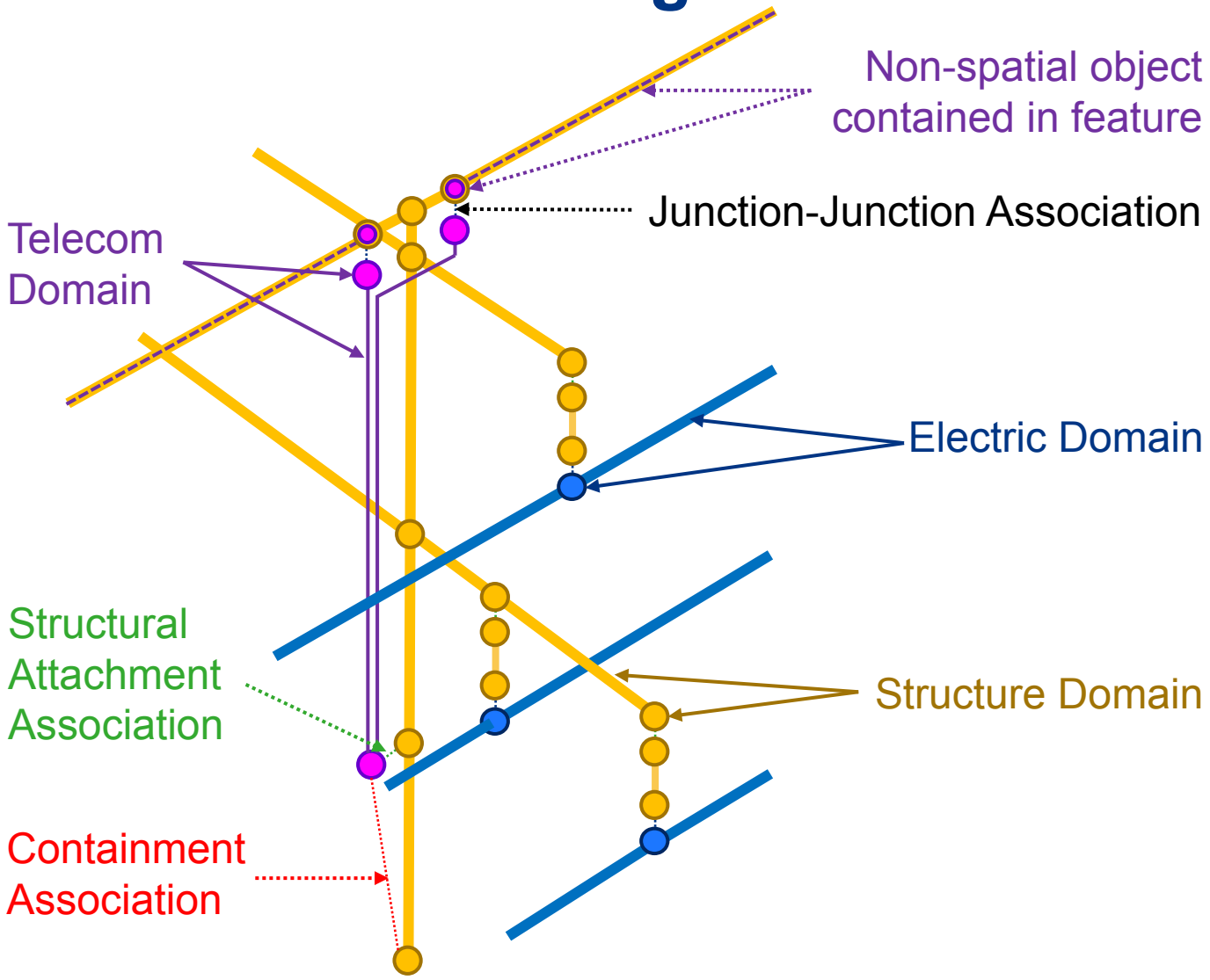
Deadlines come and go

…

Harry and Johannes stay …



All models are wrong. Some are useful.*



TenneT's TSO Utility Network

- Topological network of lines and junctions
- 1:1 match between objects in reality and objects in GIS
- Separate domains for structure, electric and telecom data
- Containment and structural attachment associations between different domain networks
- Junction-junction associations between features of the same domain
- Non-spatial objects to avoid congruent features

*) *George Box (Statistician)*

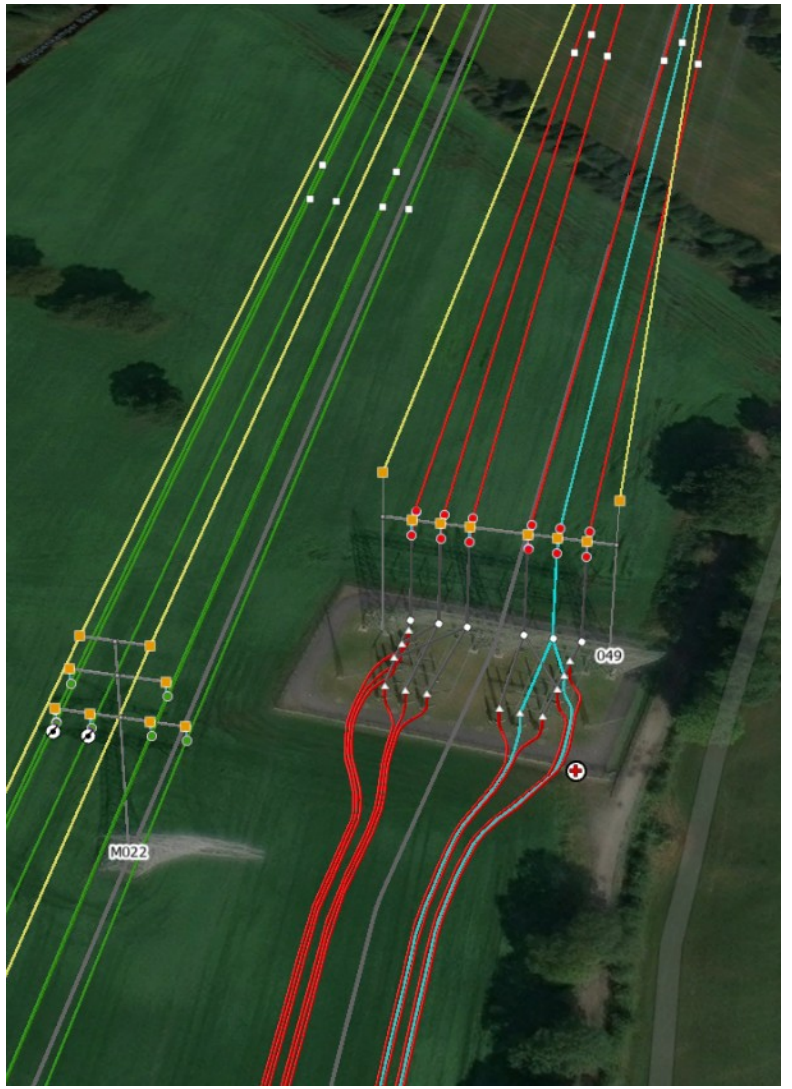
2D or not 2D? That is the question!

Advantages of 2D

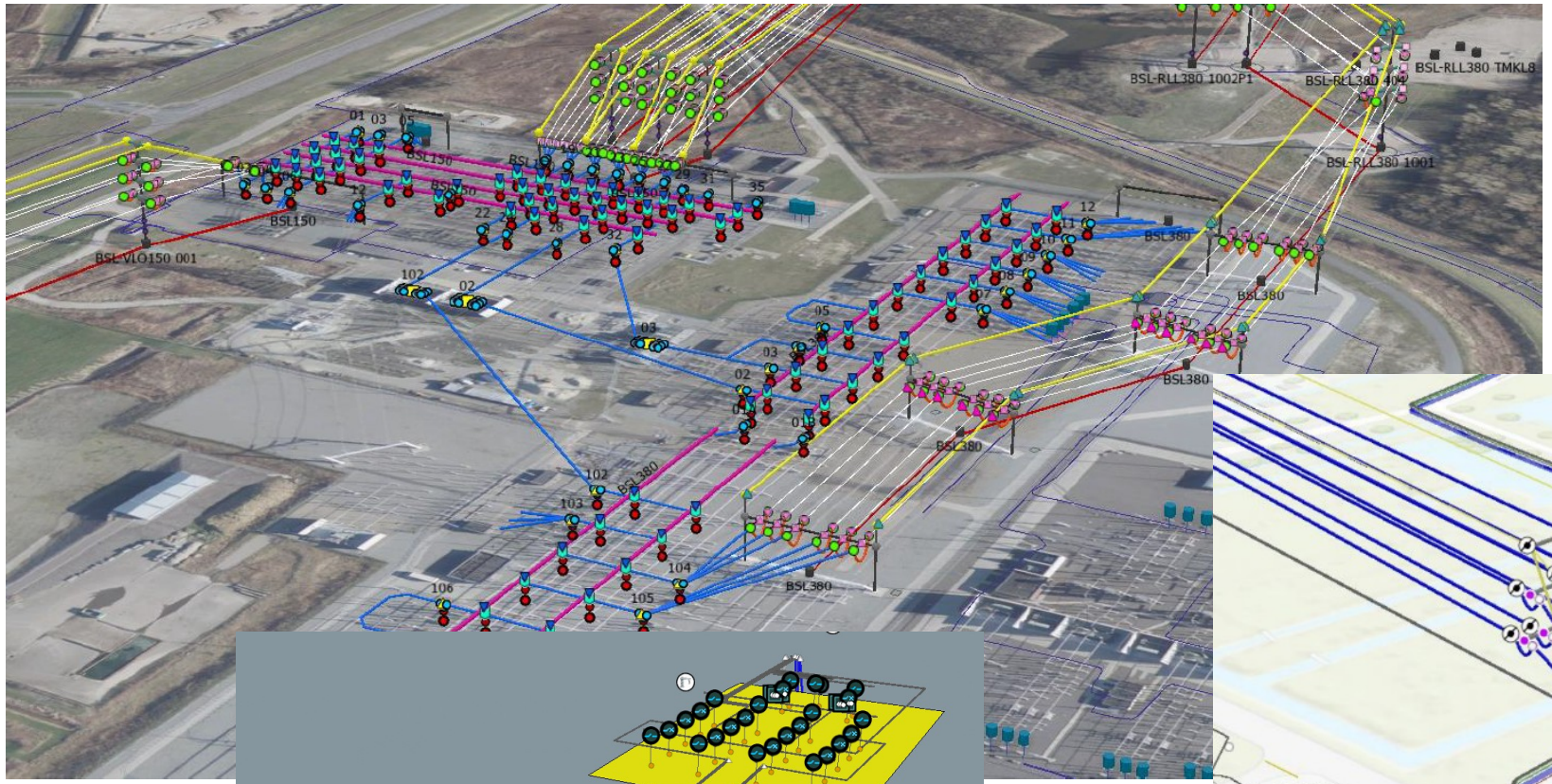
- Additional use cases (e.g. planning, 3rd party data)
- Better to print
- Overview maps
- Easier workflows (e.g. editing)

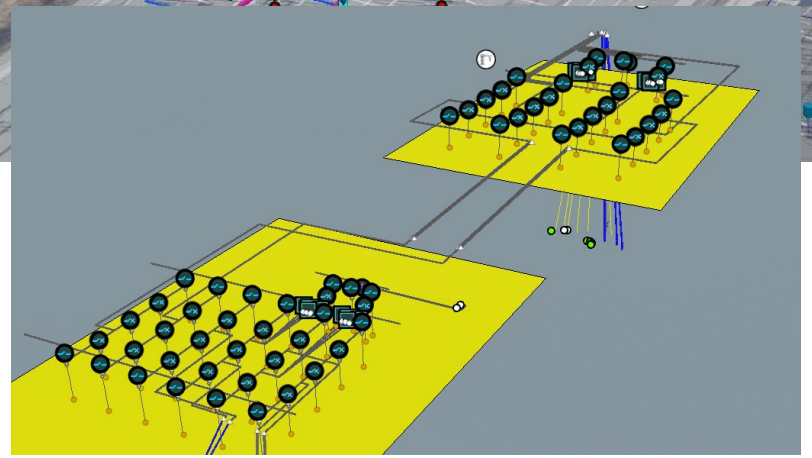
Advantages of 3D

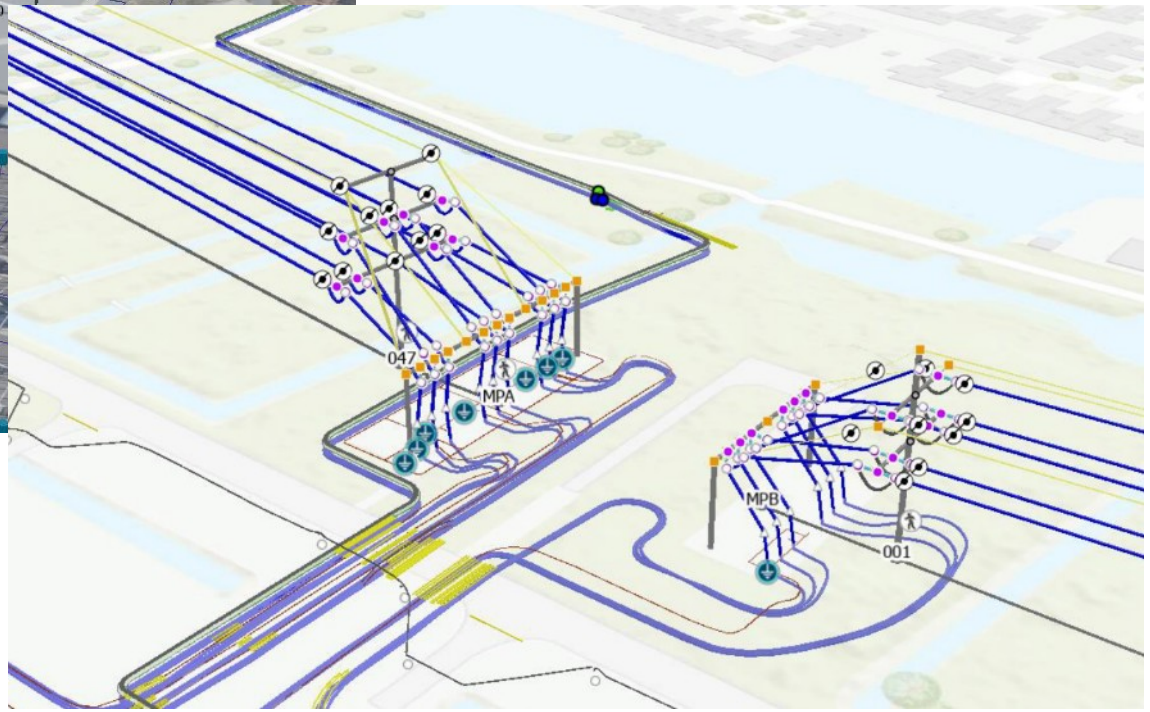
- Additional use cases (e.g. stations, system operation)
- Legal requirement in NL for 3rd party documentation
- Depth of burial needed for underground cables
- Complicated situations can be easier to show in 3D
- Vertical lines (e.g. risers)



With the right movie, 3D can enhance the experience*







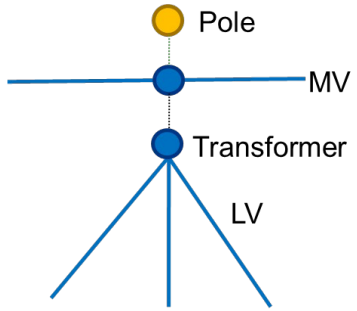
Some more scenes from inside BMRGIS to show the value and necessity of 3D modelling and asset data representation

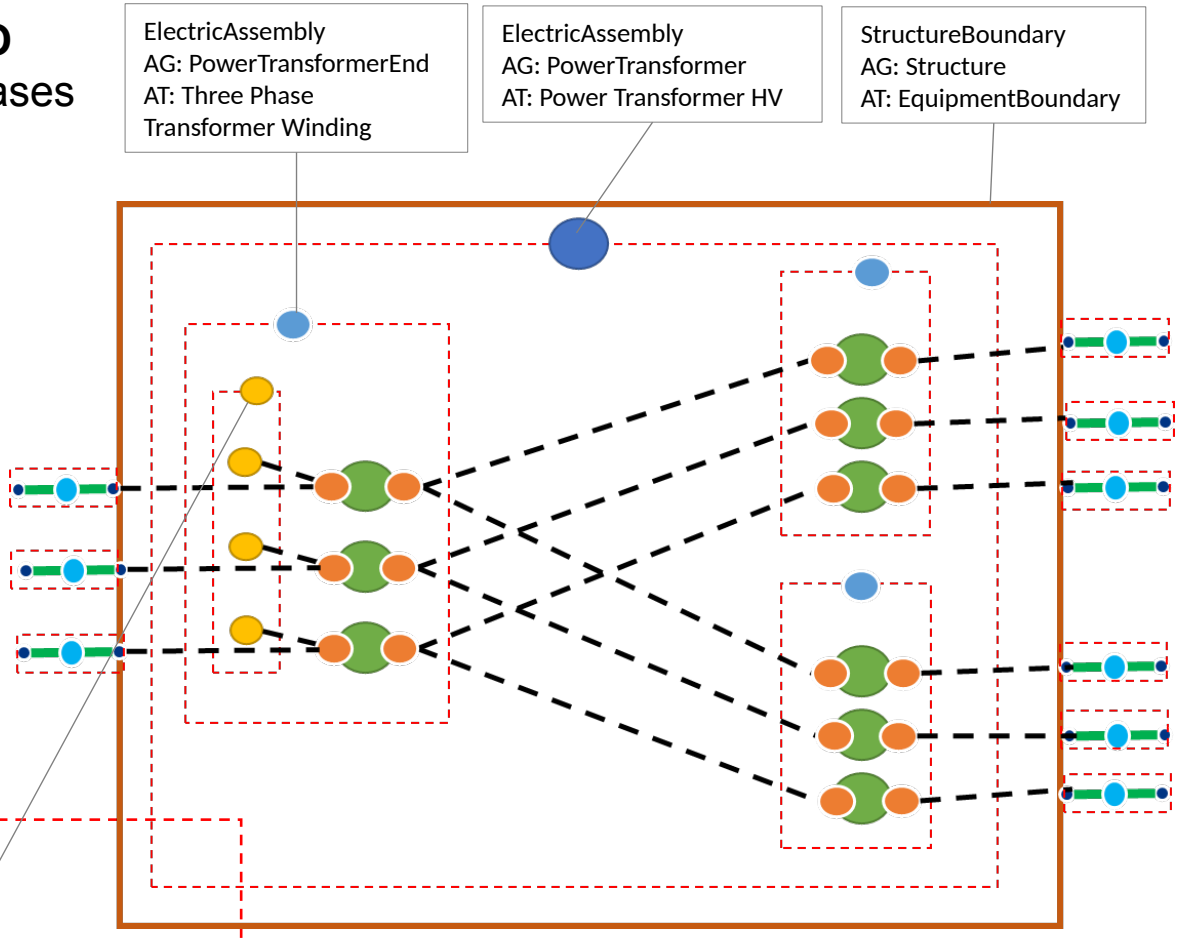
*) *Peter Jackson (Filmmaker)*

Everything's bigger ~~in Texas~~ at a TSO

Transformer bank at a DSO
- Small distance between phases
- Simple associations
- 2D modelling sufficient

Power transformer at a TSO
- Big distance between phases
- Multi-level containments
- 3D modelling appropriate





Containment:

Equipment Boundary contains:
- Power Transformer

Power Transformer contains:
- Three Phase Transformer Winding (3)

Three Phase Transformer Winding
- Three Phase Tap Changer (1 – Left)
- Single Phase Transformer Winding

Three Phase Tap Changer contains:
- Single Phase Tap Changer

Equipment Line (outside Transformer) contains:
- Bushing
- Equipment ends

Junction-Junction:

Equipment End <-> Winding terminals
Windings <-> Single Phase Tap changers
Windings terminals <-> Windings terminals

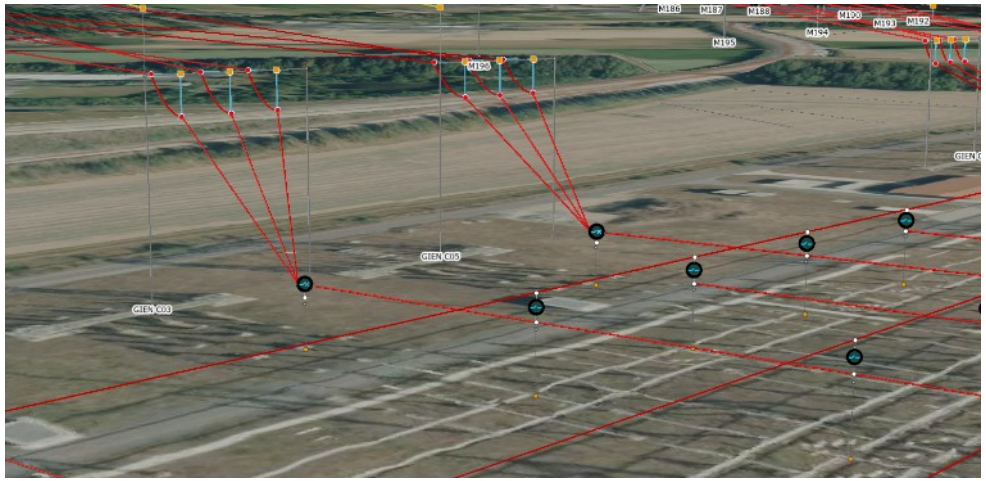
Digital twin of TenneT's assets with 6 letters*

Bedrijfs **B**etriebs
Middelen **M**ittel
Register **R**egister
GIS **GIS**

Resilient because …

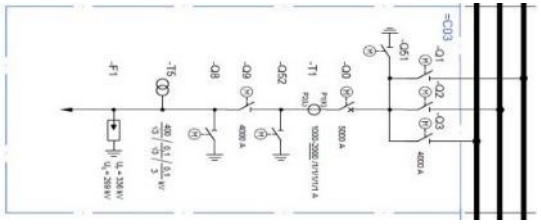
- Uses national languages
- Data model based on international standard (CIM)
- Spatial registration
- Scalable (in a map sense)
- 1:1 representation of assets

➔ **Where do you want your digital twin to be if not in the GIS?**

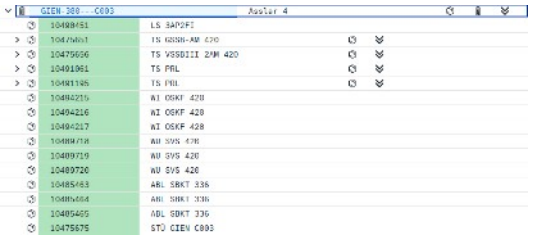


+ Location + Topology + Integration =

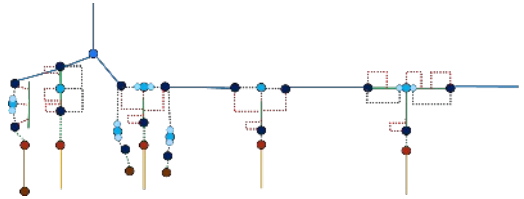
Information



+ Data



+ Modelling



***) BMRGIS**

To fight the bug, we must understand the bug*

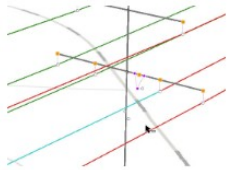
3D - Attaching electric line to another electric clamp fails (ESRI: BUG-000170222 for ArcGIS Pro) Esri Case #03855266(Closed)

Beschreibung

Bug combined into one ticket with all other 3D editing issues https://tennet-nl.atlassian.net/browse/ONEERP-172435

It is not possible to attach an electric line to another electric clamp (tool used: Edit Vertices). The electric line always snaps back to where it was.

Tested with AT AC Overhead Conductor HV, AC Overhead Clamp HV



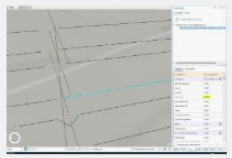
3D - Edit vertices not possible - 3D (ESRI: BUG-000170222 for ArcGIS Pro) - Esri Case #03855266

Beschreibung

Bug combined into one ticket with all other 3D editing issues https://tennet-nl.atlassian.net/browse/ONEERP-172435

Hi,

I created the feature AClinesegment wrong and I want to move the vertix in to the right position. But with accepting the changes (F2) the vertix jumps in to the old position.



Workaround is to delete and recreate the featue.

Weekly touchpoint with ESRI to report bugs related to Utility Network and 3D editing

3D - Moving tower 3D - not all parts move with - Esri Case #03855266(Closed) for 3D - 2D has no ESRI case #

Beschreibung

Bug combined into one ticket with all other 3D editing issues https://tennet-nl.atlassian.net/browse/ONEERP-172435

2D & 3D issues reported together in this bug - this bug now only refers to the 3D issue

For 3D part of the issue (status= open and known ESRI issue): BUG-000170222 for ArcGIS Pro

For 2D part of the issue (reported in this bug https://tennet-nl.atlassian.net/browse/ONEERP-170011): *Guus: this was *not* resolved by me, please see the comments I made below on 13 feb 2025. At first it *seemed* to work, but I later found it doesn't

We found a tower that is movable in 2D (3D was not possible at all). When we tried to move the tower, the whole tower with all its components did not move.

The following objects got stuck at the old position and did not move with the tower. This can be seen when checking the tower in the scene.

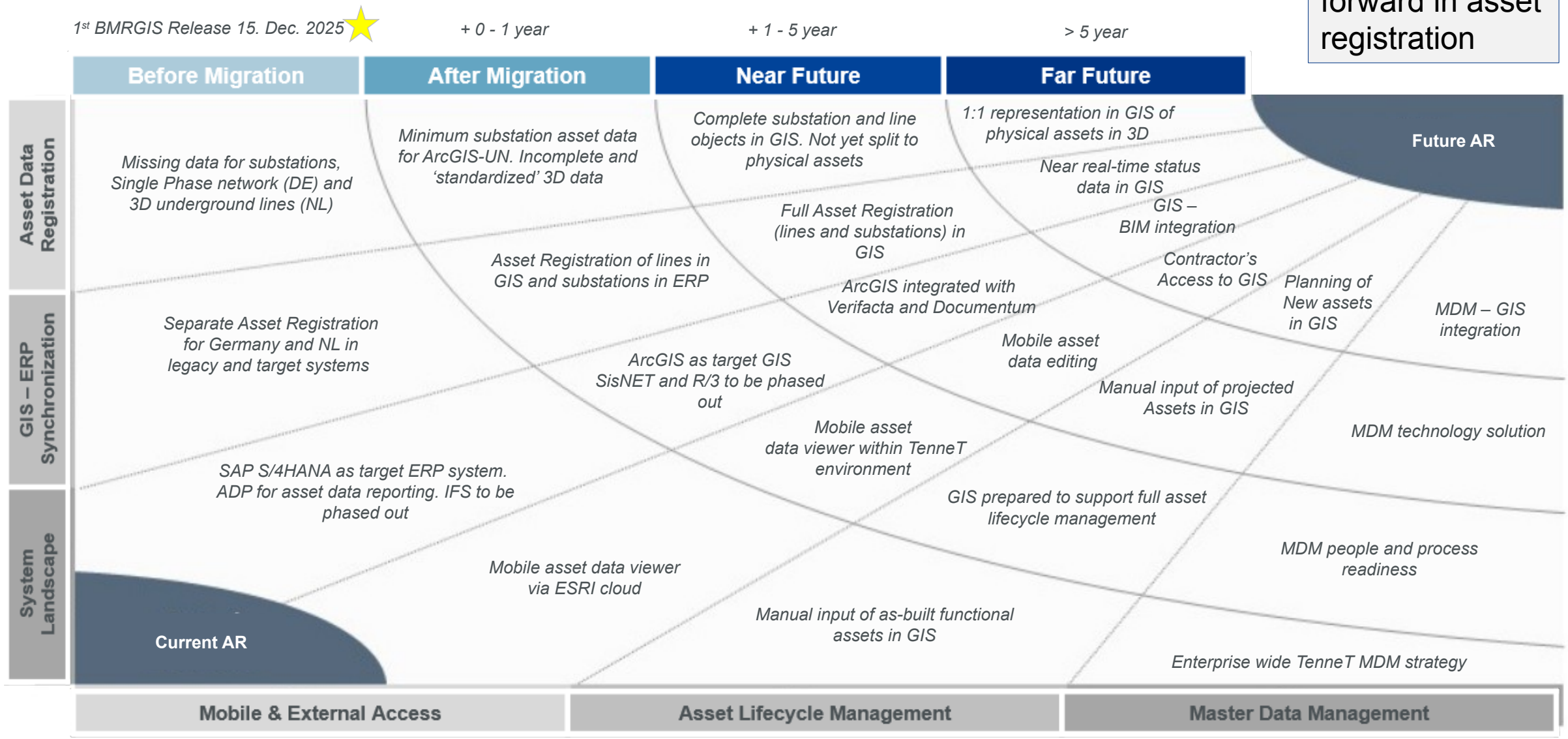
- Insulator Top
- Insulator bottom,
- AC Overhead Clamp HV
- Brackets
- Generic Structure Junction

**) Tehat Meru (Sky Marshal, Starship Troopers)*

***) Addition by Johannes Weigel: Meaning, we should be able to reproduce it and show it to ESRI*

I never think of the future. It comes soon enough*

TenneT‘s way forward in asset registration



*) Albert Einstein (Physician)

Seldom remembered or soon forgotten? Lessons learned!

- What is already on the market, buy it!
- Make sure there is enough Business Support.
- Keep to the original scope.
- Don't put Master Data Management out of scope.
- If the answers of an offering supplier aren't believable, don't believe them!
- Don't change the software of the offered solution.
- If the new system cannot do what is promised, stop the project and restart with the second option.
- Within a GIS system, everything is connected. So, build things in the correct order:
  1. Building, and completing the Data Model (according to the business needs and international standards, not the legacy data structure**)
  2. Normalizing the Data Model
  3. Functionality and Attribute Rules
  4. Layout, Interfaces and Migration
- If the result is an unworkable system, go through the steps 1 untill 4 again.
- Documentation must be ready before go-live.

**) All quotes on this page from Harry van Zeijts (Data manager)*

***) Addition in brackets from Johannes Weigel (also Data Manager)*

Lighting the way ahead together

TenneT is a leading European grid operator. We are committed to providing a secure and reliable supply of electricity 24 hours a day, 365 days a year, while helping to drive the energy transition in our pursuit of a brighter energy future – more sustainable, reliable and affordable. In our role as cross-border Transmission System Operator (TSO) we design, build, maintain and operate over 25,000 kilometres of high-voltage electricity grid in the Netherlands and large parts of Germany, and facilitate the European energy market through our 17 interconnectors to neighbouring countries. We are one of the largest investors in national and international onshore and offshore electricity grids, with an underlying revenue of EUR 8.4 billion and a total underlying asset value of EUR 55 billion. Every day our 9,700 people are highly motivated to ensure that the supply and demand of electricity is balanced and always available for over 43 million people.

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