B3 Substations and High Voltage Installations

Summer Webinar

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The development of mobile substation technology for flexible power system services

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Contents

Mobile Substations

- Background & drivers for increased mobility in substation plant
- Summary of CIGRE Working Group B3.41 ‘Mobile Substations Incorporating HV GIS’
- Example of a 400kV Mobile Substation Bay Design for application in the UK

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Background

Customer Expectations

- Utilities must speed up the transition to facilitate the integration of distributed and renewable resources
  - need to connect customers more quickly
- Reduced system accessibility
  - outage shortages require faster deployment techniques
- Lifetime of solutions
  - The concept of a 40 year asset lifetime may not be suitable in the future

Changing Network priorities

- Resource & skills constraints
  - find ways to reduce need for on site specialised skills
- Competition

Drivers for mobile solutions

Opportunities for Mobile Solutions

- Bridging capacity
  - provide a service to customers while reinforcement is on-going, reducing constraint costs and risk of stranded assets.
- Short-term additional capacity
  - where permanent capacity cannot be economically justified
- Failure Recovery
  - rapid supply restoration capability in the event of extreme events
- Managing Reliability & Resilience
  - safely bypass sections of the substation to carry out in-situ replacement.
  - support delivery of asset interventions

What is a Mobile Substation?

Definition

- Pre-assembled electrical substation comprising one or more bays
- easily transported, quickly installed and may be designed for relocation to an alternative site.

220kV GIS Bypass module & cable in Spain
Courtesy of R.E.E

B3 WG B3.41 *Mobile substations incorporating HV GIS*

Captured operational experience and different applications

- User case studies

Identified three categories of mobile technology

- Emergency, Intermediate and Semi-stationary types

Provide guidance on the use of mobile applications

- Need to balance the risks across the ‘end to end’ project
- Considerations on the asset life-cycle
    - Deployment - Design, Testing, Installation & Commissioning
    - Asset management – Transport, Relocation, Maintenance & Storage

Assess suitability of existing standards

- Existing standards have sufficient flexibility to accommodate the requirements for mobile applications –
- Customers need to understand & specify their requirements

Type A: Emergency Applications

Typical characteristics & use

- Rapid response time essential – matter of hours
- Remains mounted on vehicle during operation – generally short deployment time
- Regular relocation
- Unplanned deployment – emergency situations
- Typically kept in storage for Major emergencies
- Limited on-site testing

Image courtesy of Meidensha Corp

66/6.9kV Mobile Substation in Japan

A number of mobile substations were deployed to reinstate the power supply after the Great East Japan Earthquake in 2011

Type B: Intermediate Mobile Applications

Typical characteristics & use

- Rapid response time important
- Un-loaded from the transporation vehicle during operation
- A few relocations foreseen at time of purchase
- Planned deployment eg. to support infrastructure works/provide temporary additional capacity
- Deployed for longer periods typically months to a few years

Image courtesy of 50Hertz

110kV Mobile Substation in Germany

Used to support planned replacement works: installed for over 2 years at 2 separate locations

Type C: Semi-Stationary Applications

Typical characteristics & use

- Pre-assembled transportable solution
- Designed as a permanent solution
- Relocation may be possible
- Planned deployment eg. Applications where reduced installation time and/or reduced site works are required
- E.g. Offshore installations and Prefabricated modules

Image courtesy of CG Power

Image courtesy of Siemens

63kV Mobile Substation in France

Used for substation extension in an urban environment where limited space and time were available

National Grid's 400kV Mobile Substation Bay

A new concept to improve the operational flexibility in transmission substations

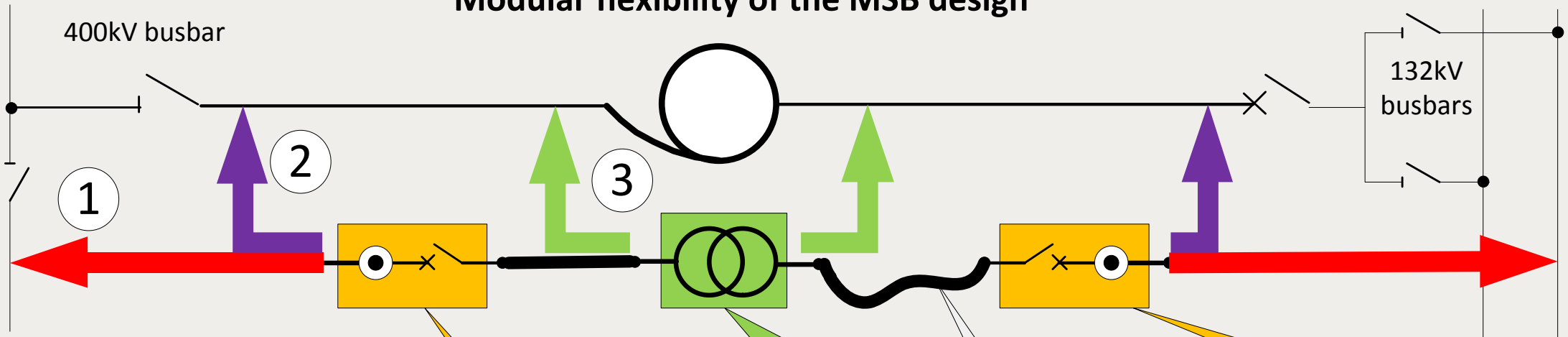
- Deployable in 10 days
- Re-deployable in 30 days

The MSB is a wholly self-contained 3-phase solution, designed to be easily relocated to another substation and recommissioned in under a month

- 400/132/22 kV 240MVA transformer
- Composite bushings reduce weight, speed up installation and robust to repeated installation.
- Mixed technology switchgear (MTS) modules mounted on self-deploying structures
- Single core surface laid cables with and 'plug-in' cable sealing ends.
- Digital fully reconfigurable protection and control architecture.

The MSB Modular Design philosophy

Modular flexibility of the MSB design



Configurations

1 Add a new bay or Bypass whole bay – connect to busbars

2 Bypass busbar protection

3 Bypass transformer only

Mobile Transformer module
Transformers, CTs, metering
Auxiliary supplies

LV CB Module
LV CB, Busbars, cable, duct, cable sealing ends etc.
P&C module

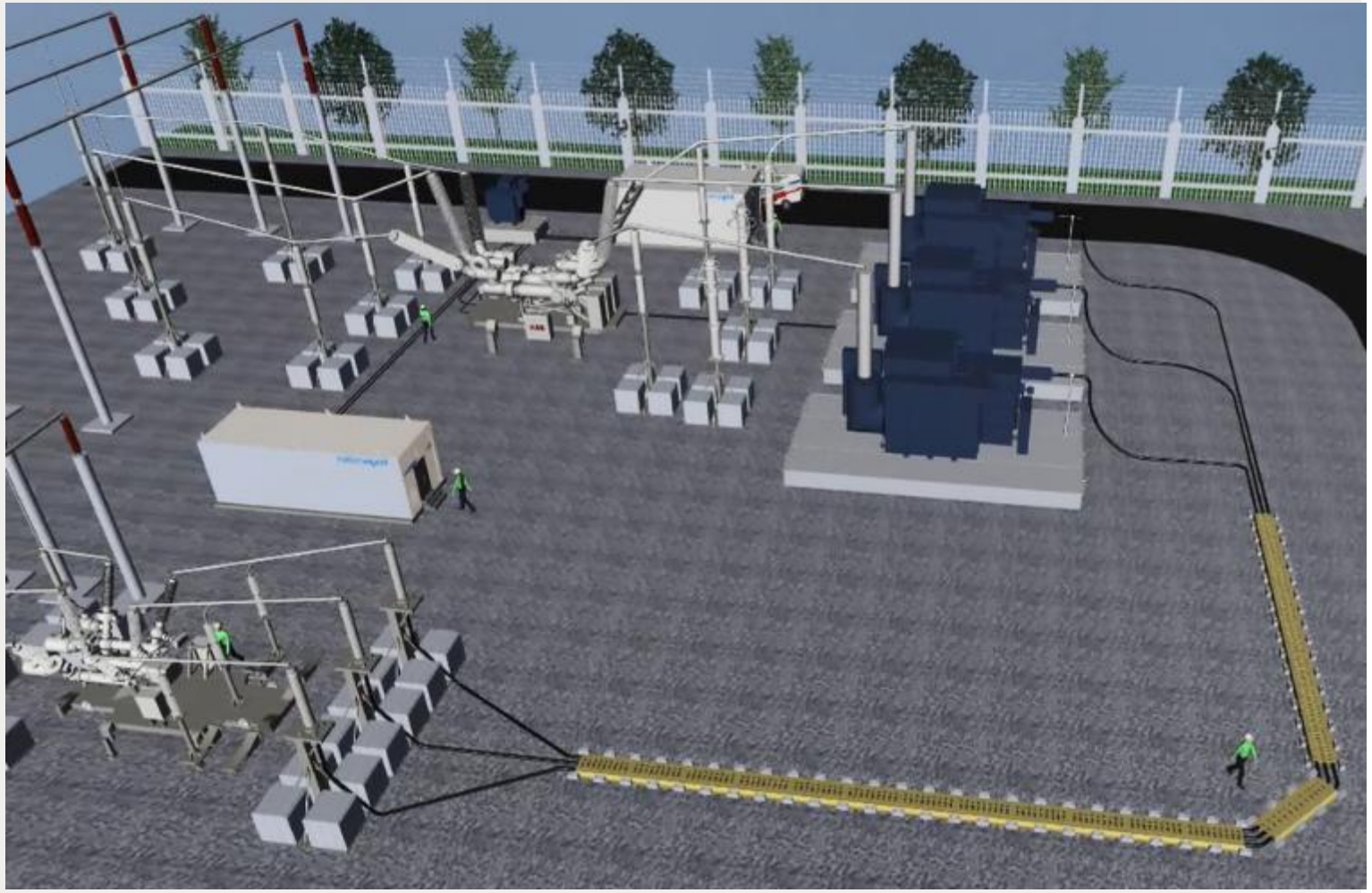
HV CB module
CB, CTs, connections, P&C - located close to busbars

LV cable
LV cable to connect remote LV CB module to SGT module.

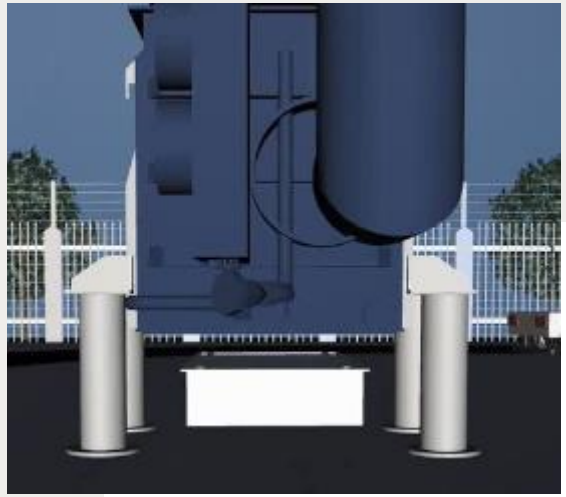
The 400kV/132kV MSB Layout

Key features

- 3x Single phase 80MVA 420/132kV transformers
- 420kV MTS Switchgear
- 132kV MTS Switchgear
- 132kV surface laid single core XLPE cable
- Portable Relay Room
- Temporary 400kV busbar systems

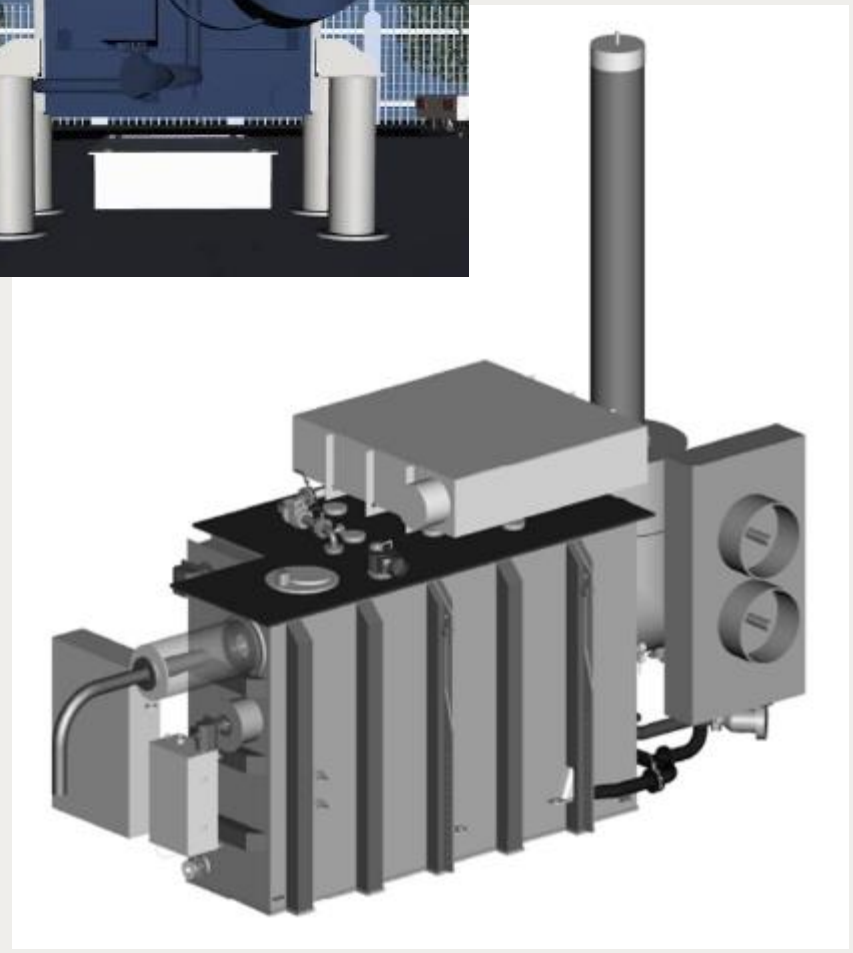


Mobile Transformer module



Single phase modules

- 400/132/22kV 80MVA Autotransformer
- Self deploying with ‘elephant feet’
- Category STGO 3 – 93 tonnes
- Impedance to match existing site 240MVA SGTs
- Vacuum tap-changer



Features of the mobile transformer:

- Plug in dry type polymeric bushings
- Low fire hazard synthetic insulating fluid
- Compact KDAF cooling

Compact switchgear modules

Mixed Technology Switchgear (MTS)

- Plug and Switch System (PASS) modules
- 420kV & 132kV modules
- Self deploying module
- Dry-type lightweight polymeric bushings
- Rotating bushings which fold down for transportation
- no on site gas handling required

Features of mobile switchgear:

- Pre-tested & commissioned

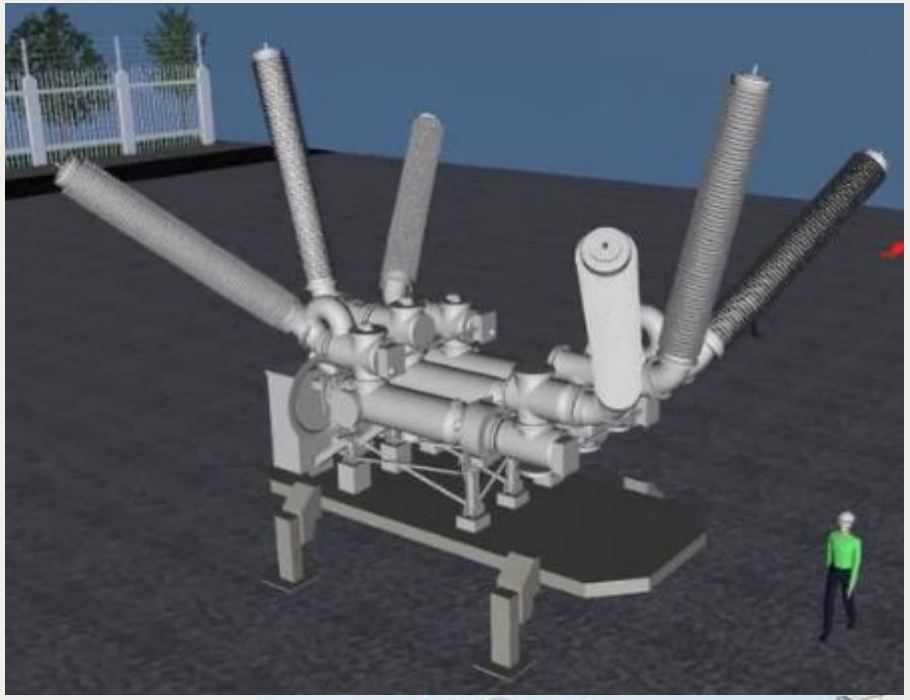


Image courtesy of ABB

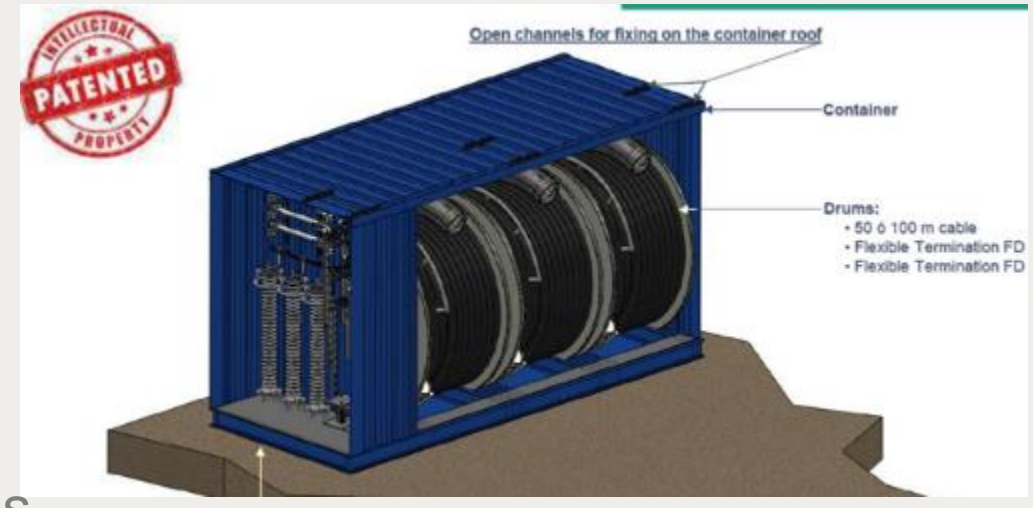
132kV Cable system

Robust Cable design

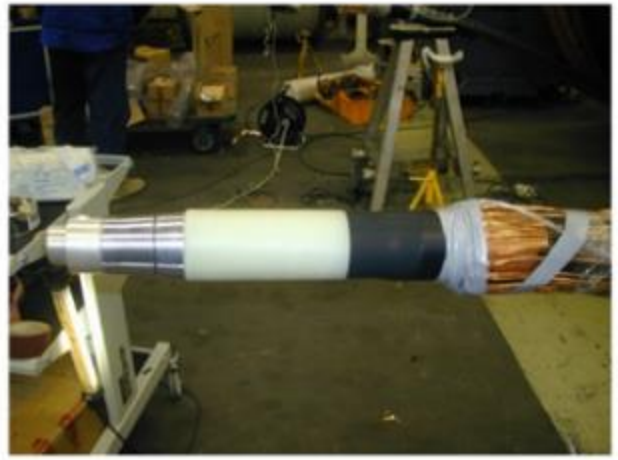
- 3x single phase cores/ Laminated sheath
- XLPE insulation with UV resistant robust outer sheath
- Dry-type polymeric terminations

Flexibility for re-deployment

- Surface laid cable restrained with ratchet straps
- Cable drum deployment method (motorised option)
- Different lengths required to cover range of deployment scenarios (30m, 150m, 250m
- Additional tests specified (reverse bend test and foil peel strength test) to mitigate risk of frequent re-rolling.



Factory prepared Click-Fit cable end



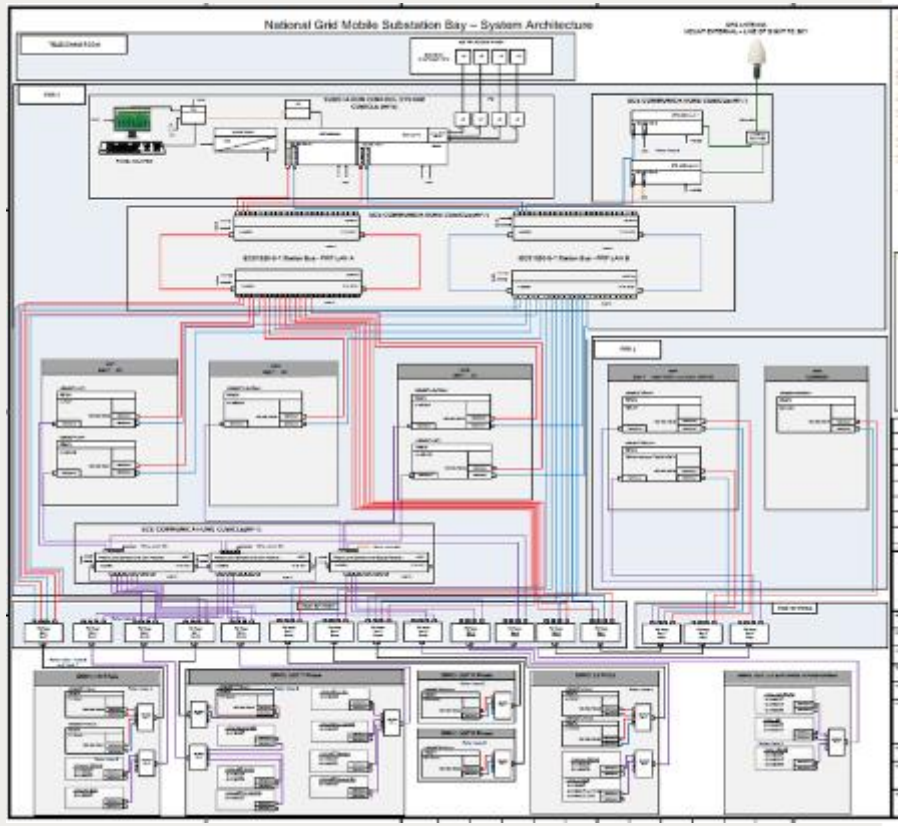
Protection & Control

Fully digital solution

- Transformer Bay functionality
- IEC 61850 & Merging units with Parallel Redundancy Protocol
- Process Bus & GOOSE communication between modules
- Self diagnostics

Control

- Dedicated stand-alone SCADA connection
- Not connected to ARS
- Reconfigurable options identified for Mesh and DBB substations



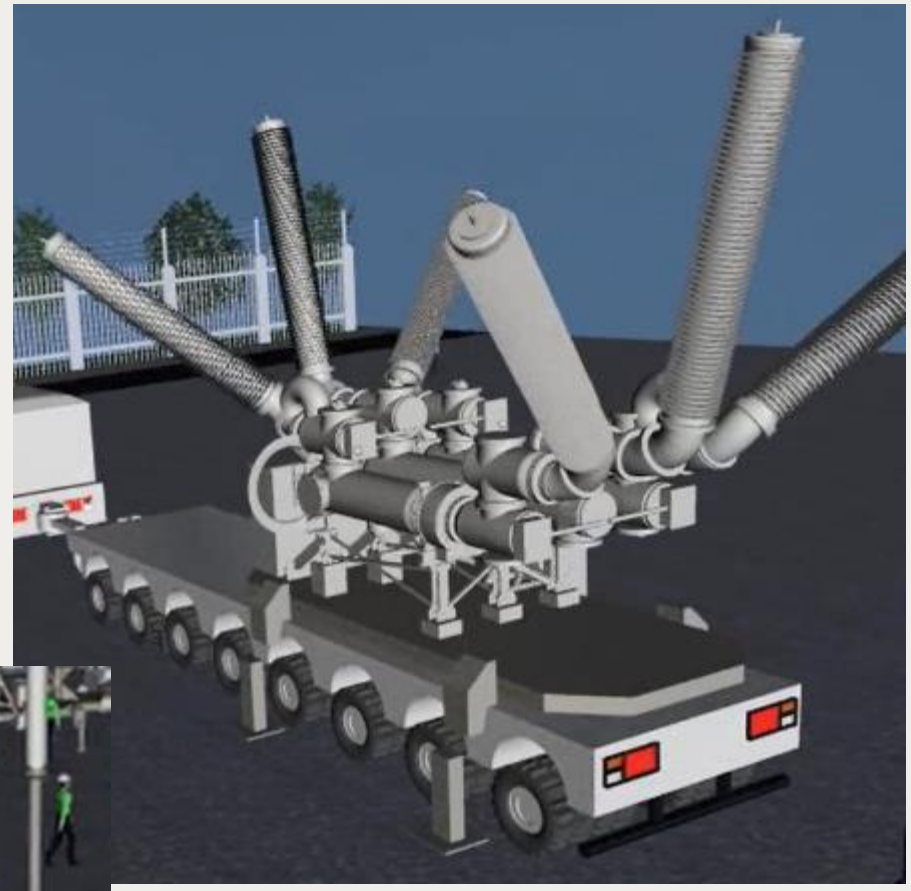
Transportation & Installation

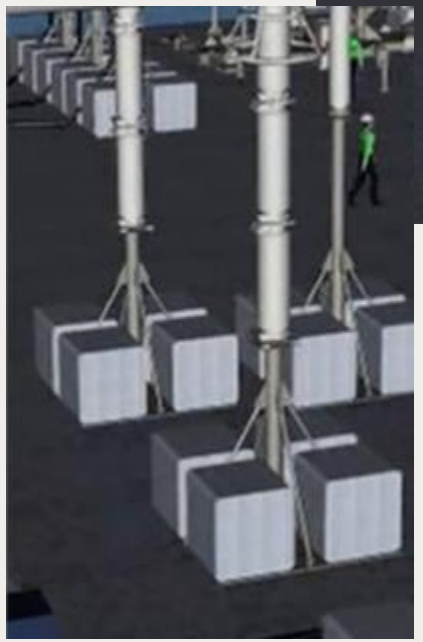
Deployment

- 10 days (will require site preparation)
- Re-deployable in 30 days
- Self installing modules

No permanent civils

- Weight spreader plates
- Surface laid cable
- Temporary Post insulators & concrete blocks
- Temporary Bunding
- No wet trades





Testing & Commissioning

Testing

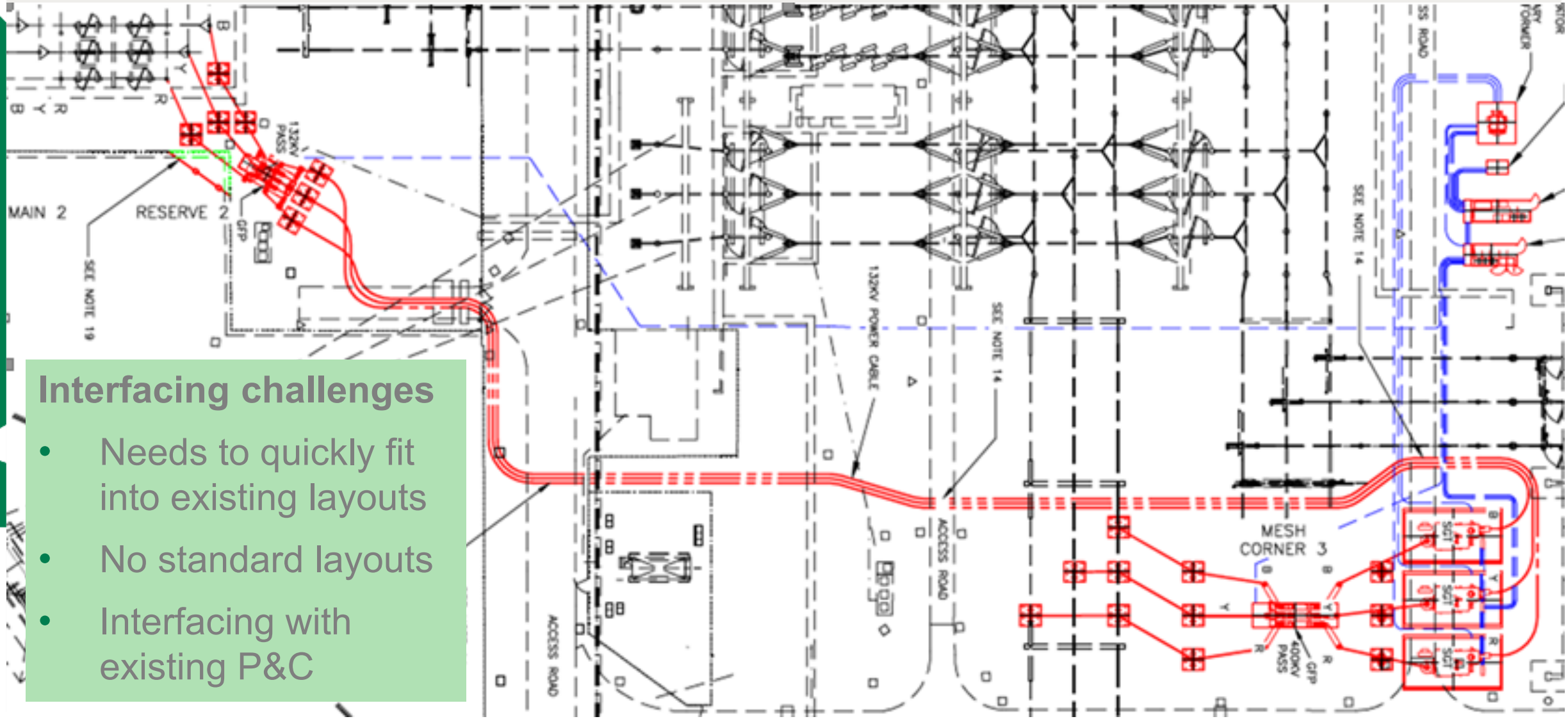
- Focus on Factory testing – extra where required
- Consideration around self configuring equipment - Less site testing
- Monitor transportation and installation – shock recorders etc.

Commissioning

- New faster procedure required
- Utilise isolated busbar sections to avoid interfering with existing busbar protection
- Connect to feeder side of a disconnector where possible
- P&C - Plug and play – pre-configured
- Stand-alone SCS

Compromise to existing site operations and commissioning practices will be necessary

Example of a 400kV MSB Application



Interfacing challenges

- Needs to quickly fit into existing layouts
- No standard layouts
- Interfacing with existing P&C

Asset Management Challenges

Interfacing

- Interaction with existing substation functions

Site

- Impact on site activities due to surface cables (access routes)
- Adequate laydown space

Asset Management

- Review equipment lifetime due to frequent movement & relocation
- Protection and reuse of cables
- Tracking assets
- Maintenance between deployments

MSB Summary

Benefits

- The MSB is a new design concept for use in transmission substations to provide operational flexibility and resilience in a less certain future.
- It has the potential to enable utilities to be more agile and replace their assets in a more flexible manner and move assets to where they are more effective.

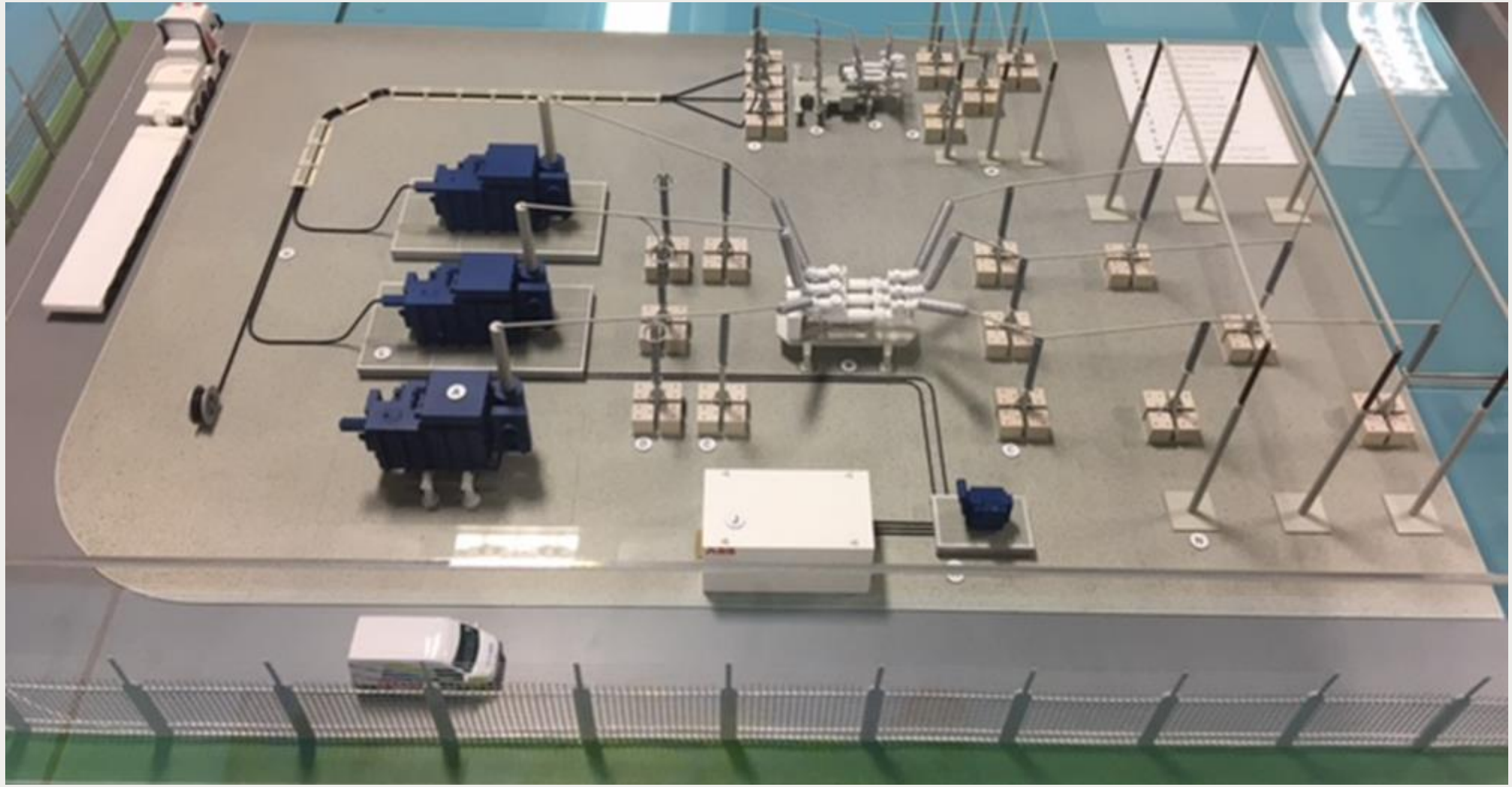
Challenges

- There remains a lot that needs to be understood, particularly around procedures and methodology to integrate the MSB into mainstream utility operation at the transmission level.
- This will challenge the ‘traditional’ transmission mind set, not only on a technical level but also commercially and operationally.

Further information

- Paper B3-109 CIGRE 2018 ‘The development of a 400kV mobile substation bay for flexible transmission services’

And finally…here's one we built earlier!



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Any Questions?

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