

BURO HAPPOLD

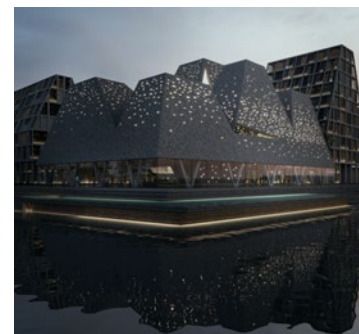
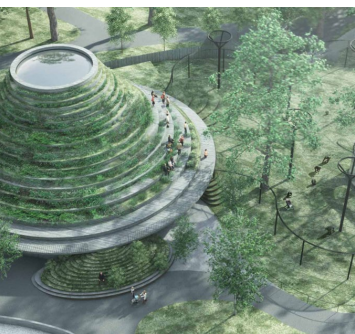
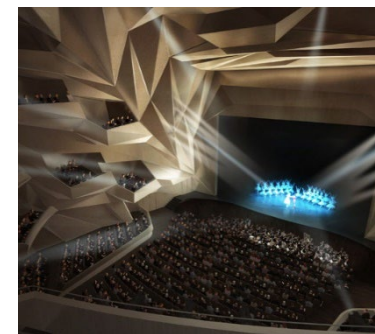
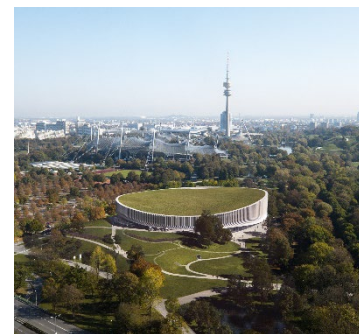
European Spallation Source (ESS)

Engineering the future of
scientific discovery

10 November 2022

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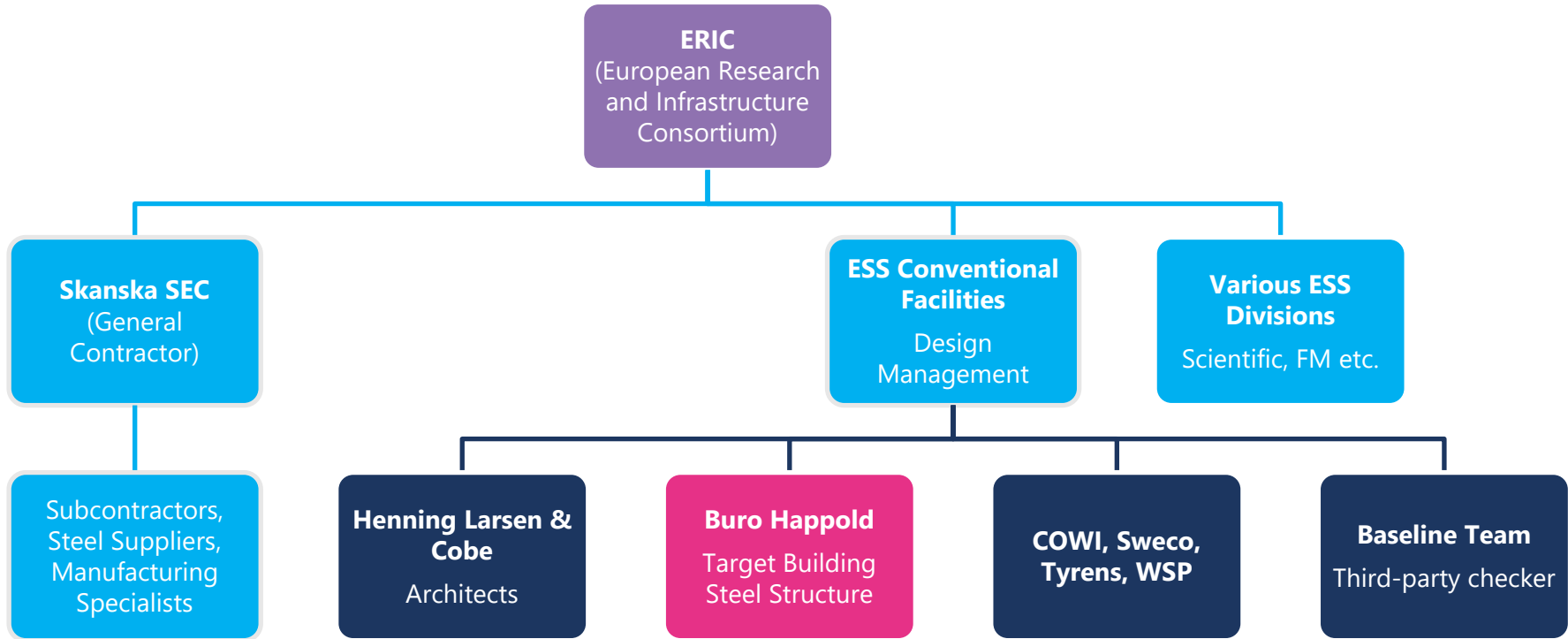


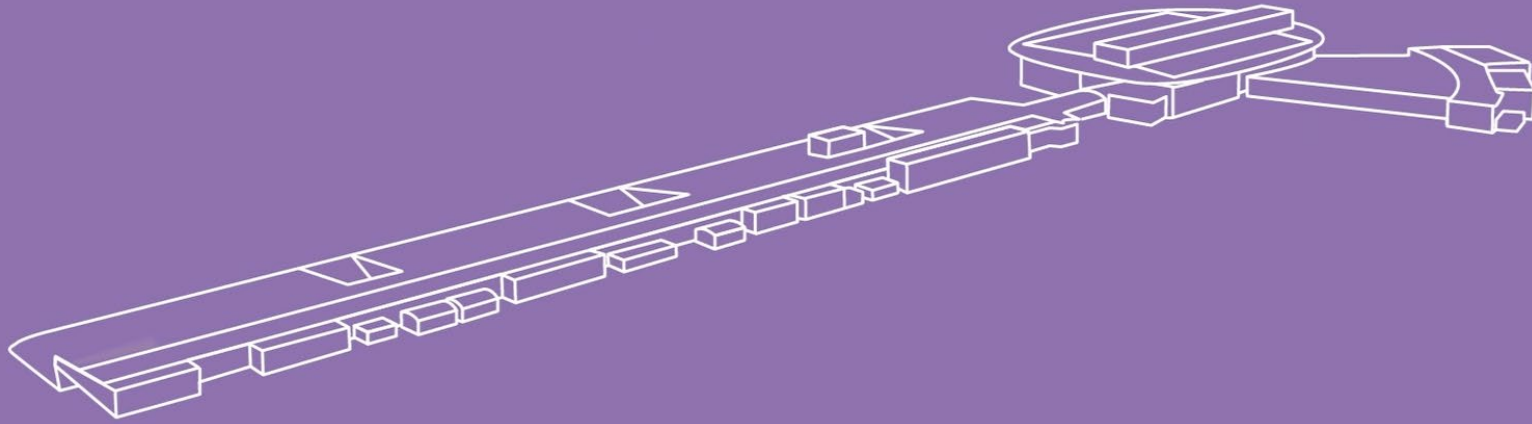
The World's Most Powerful Linear Accelerator

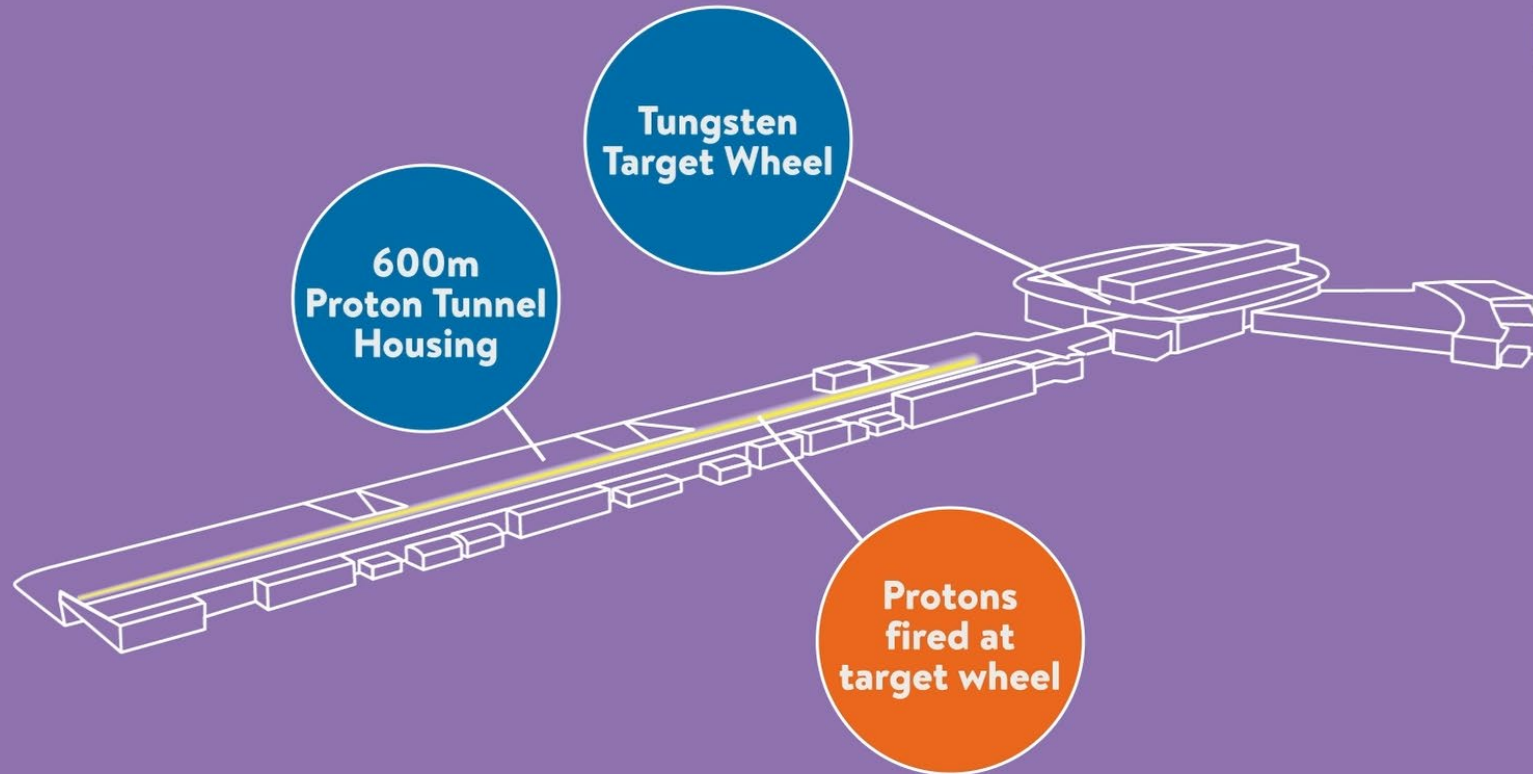


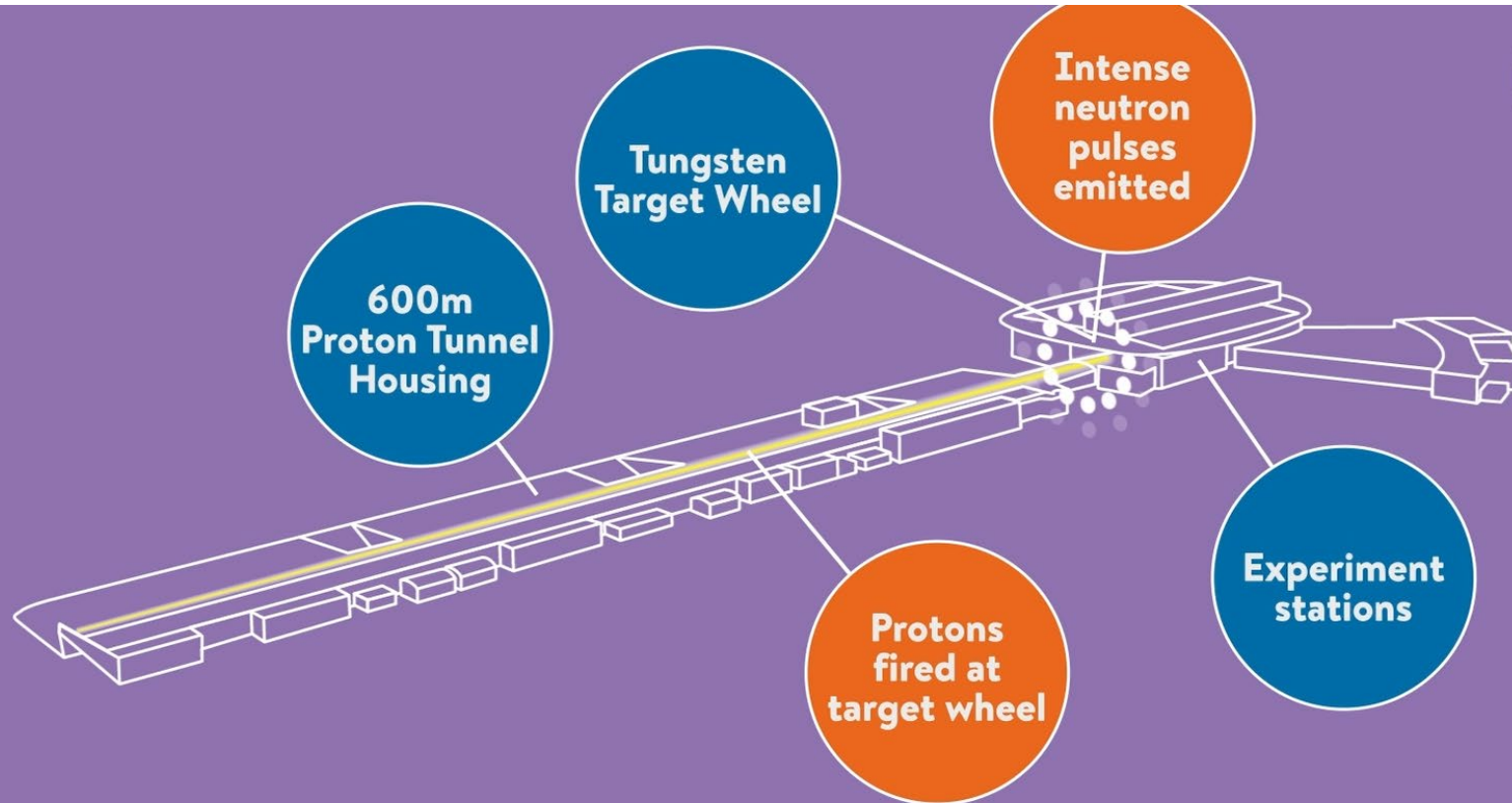
European Spallation Source

Project Set-Up













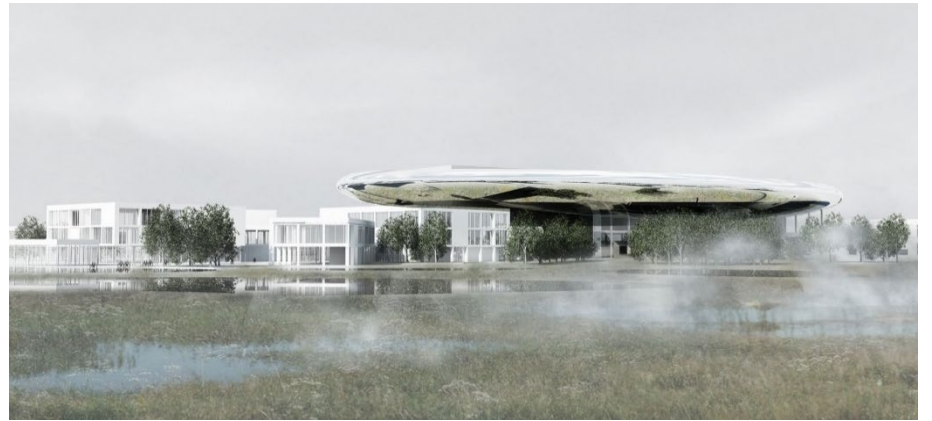
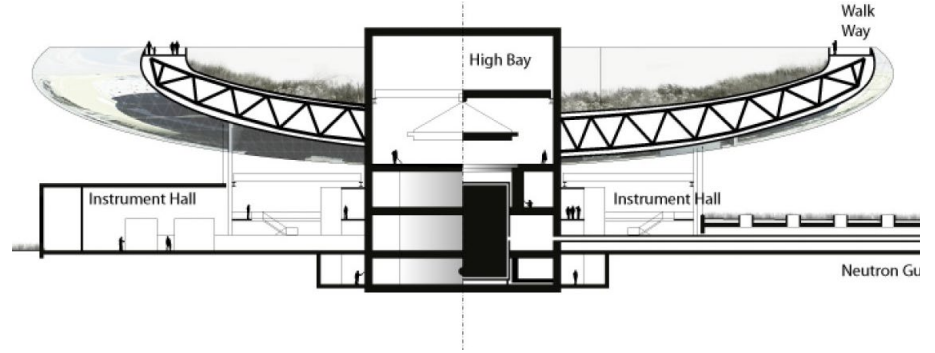
Key Challenges

How can we make the visual identity for ESS economically viable?

2012



Initial Competition Proposal



Do you think it would work if it was designed for an earthquake?

2016



Challenging Design Criteria

**Four
simultaneously
operational
cranes**

**1: 100,000
year wind
and snow
effects**

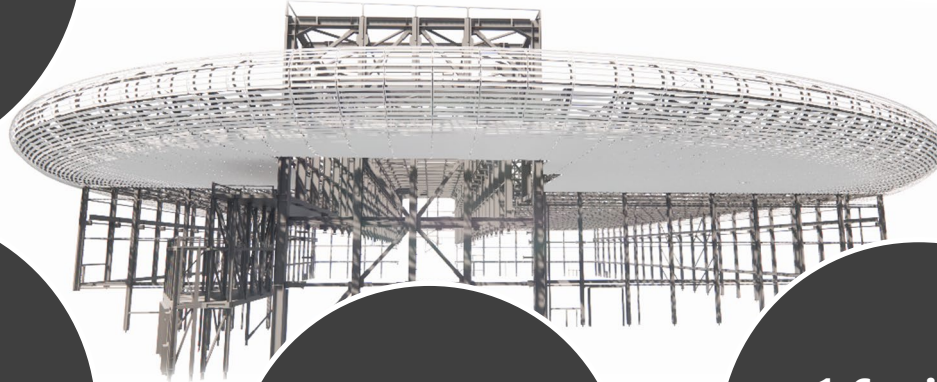
**Snow drift
up to 7m
deep**

**Accidental
column
removal**

**Strict
movement
limitations for
airtightness**

**1: 1 million
year seismic
event**

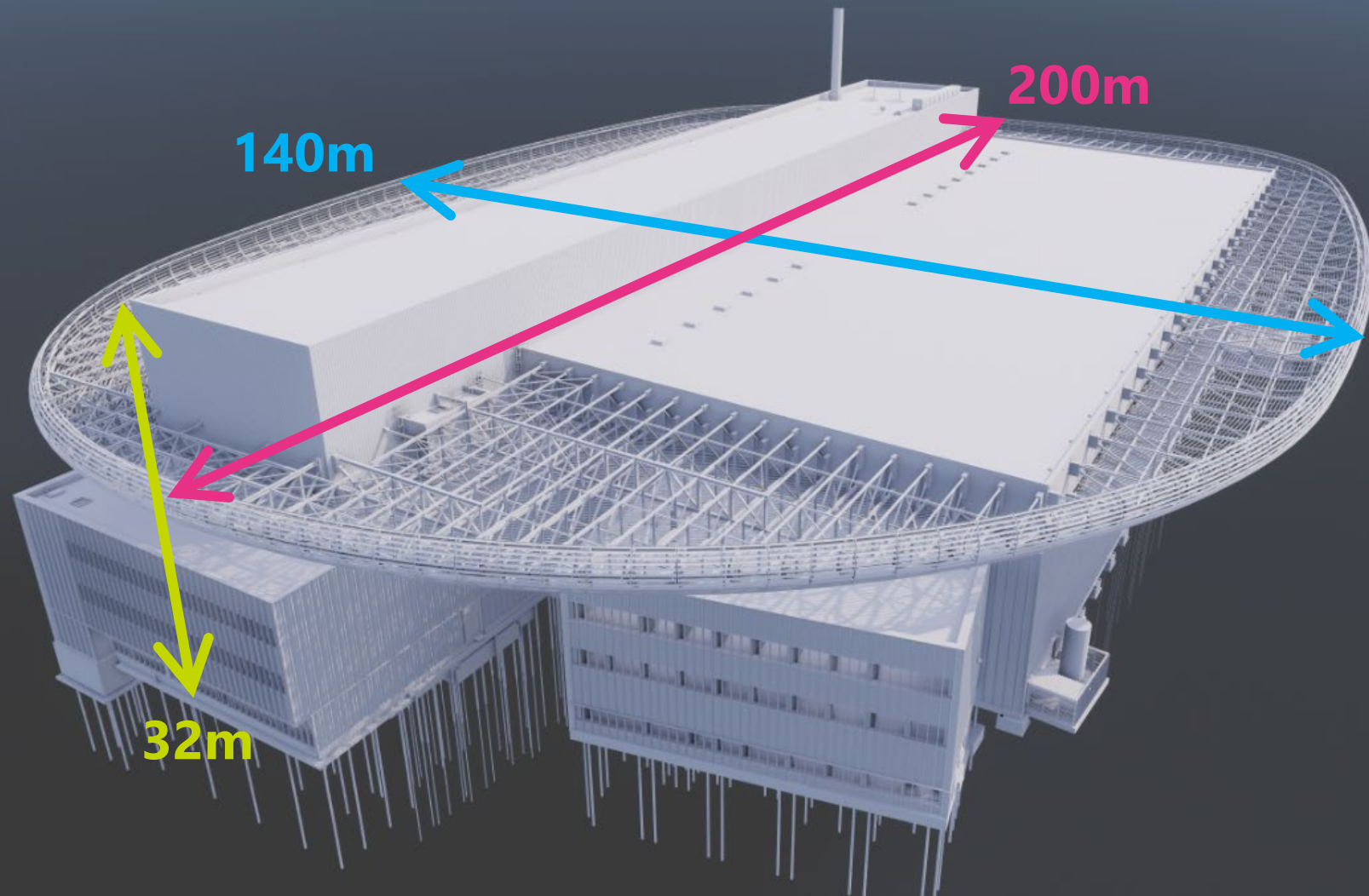
**1,6 million
design
combinations**



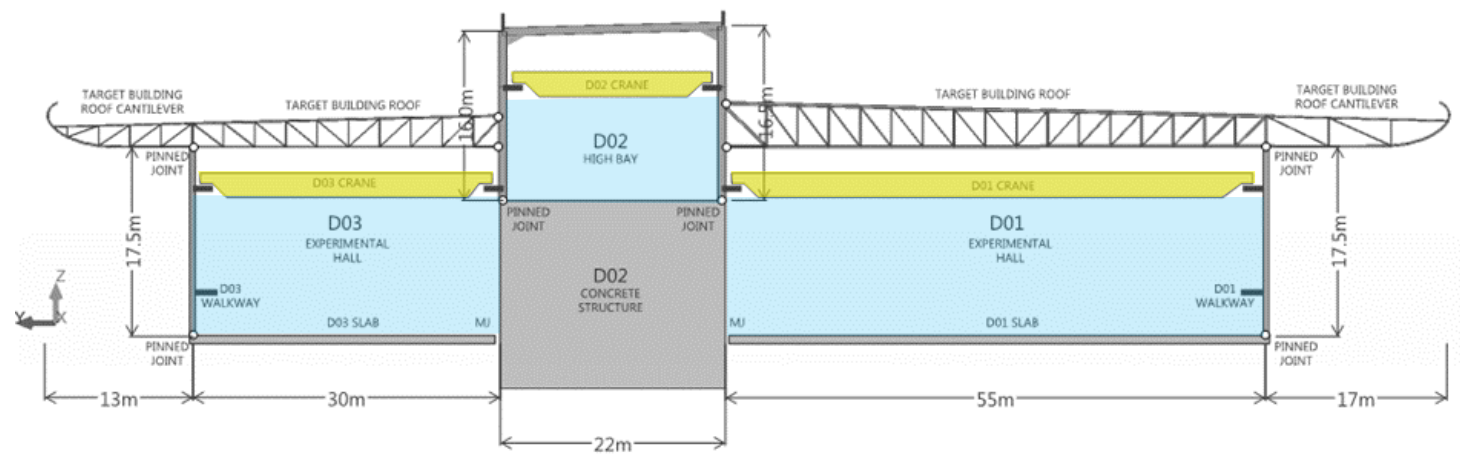


The Target Building

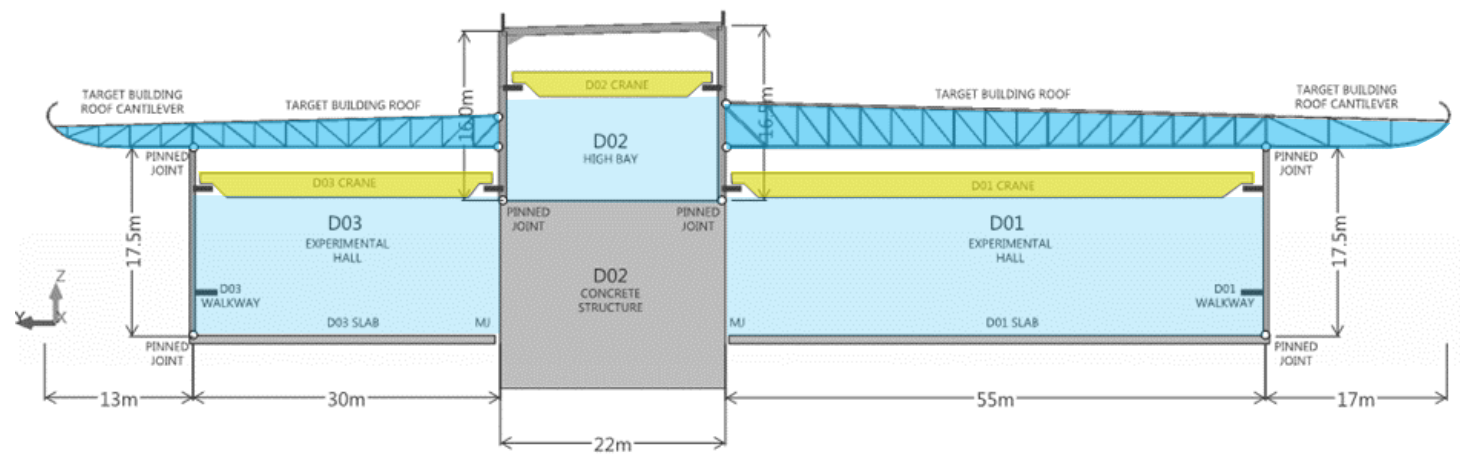
Structural Overview



Cross Section

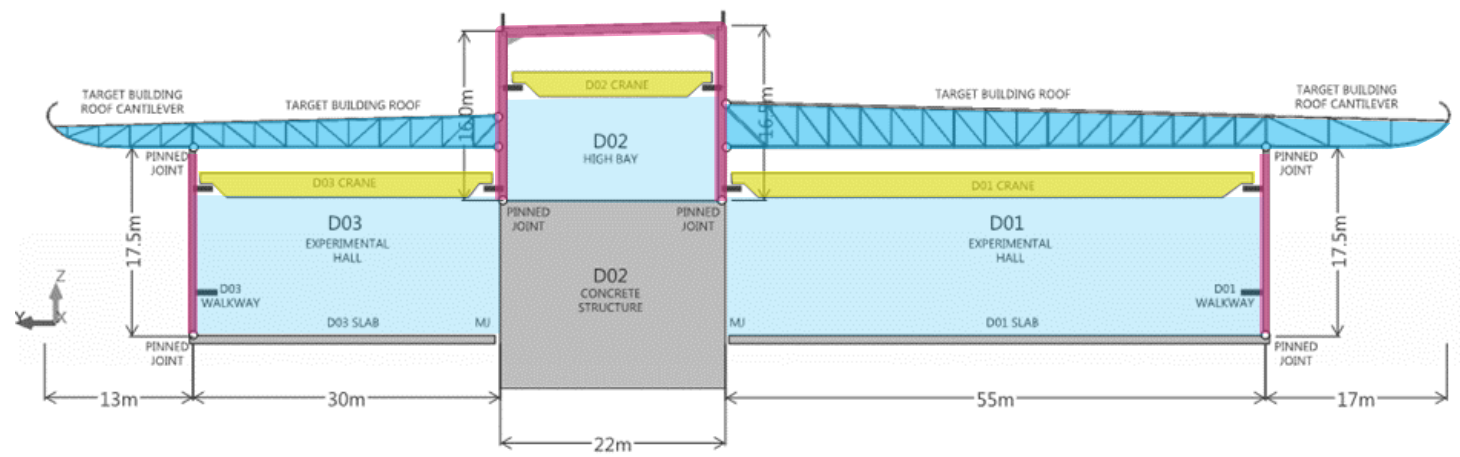


Cross Section





Cross Section





DEMATEK

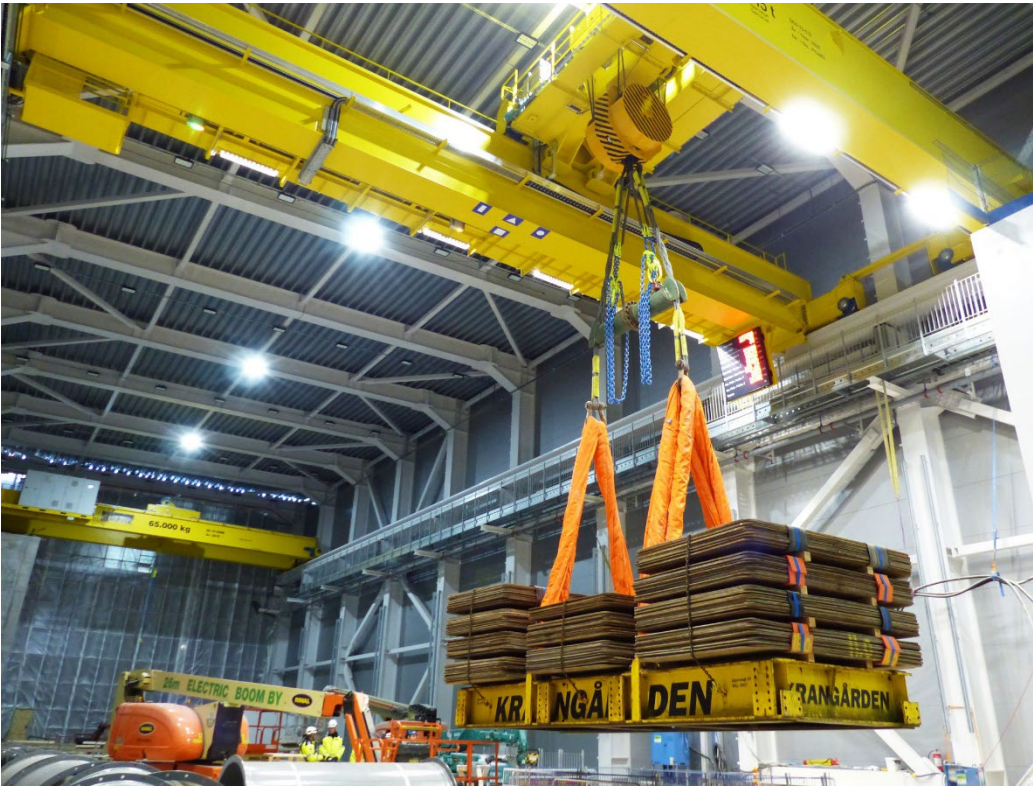
65.000 kg

Nr: P12506

År: 2019 CE

D02-74:C15

Crane Testing

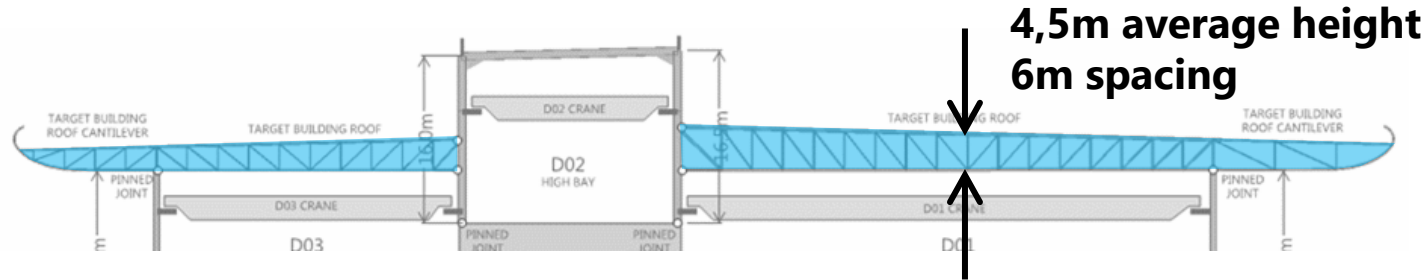




Achieving Cost Efficiency

Truss Height and Spacing Optimisation

Material cost and Transportation



Height	Spacing	Weight / Carbon Content	Surface Protection Area
3,5m	3m	75%	100%
4,5m	6m	60%	65%
4,5m	12m	100%	60%
5,5m	12m	80%	50%







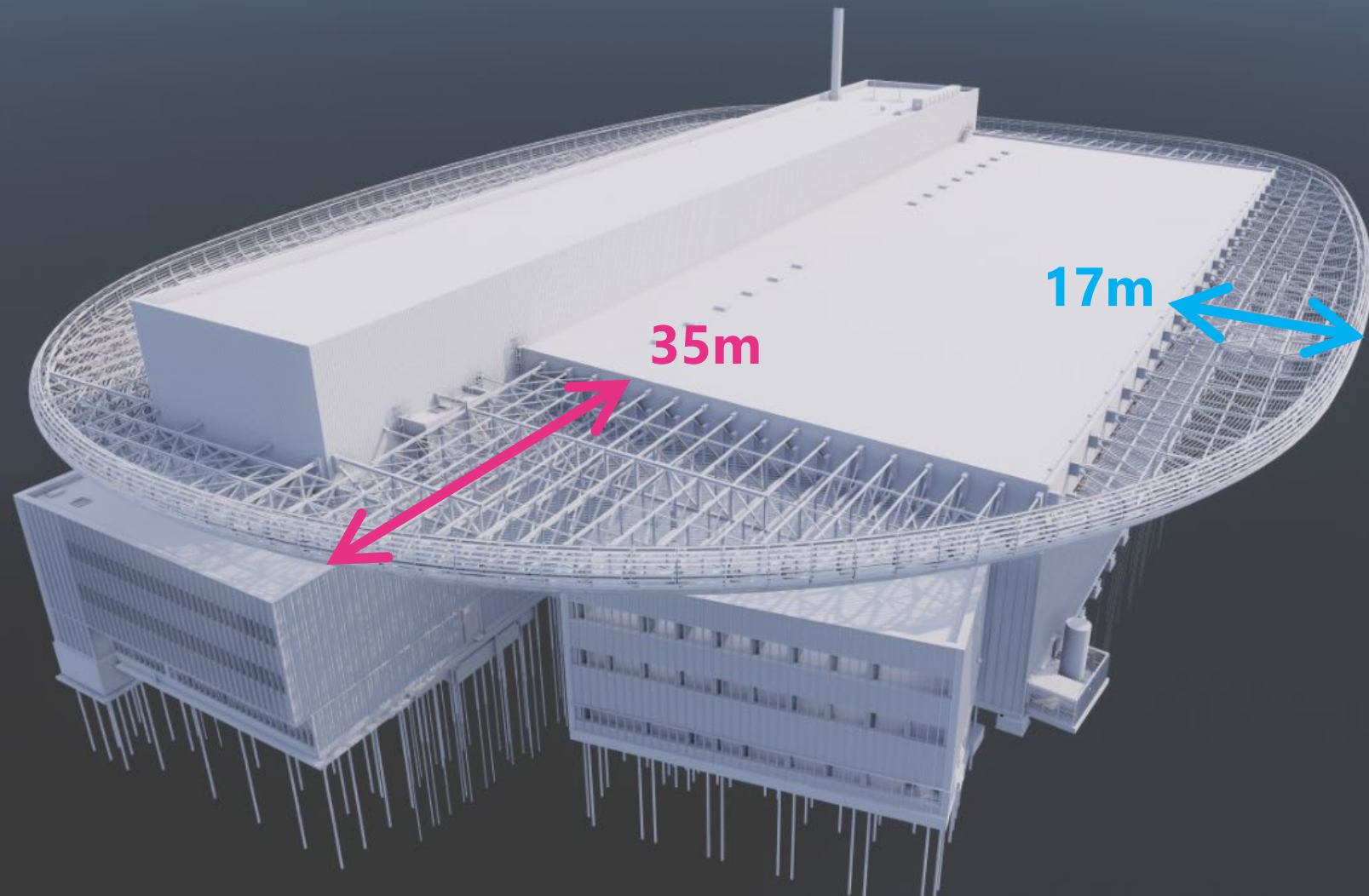


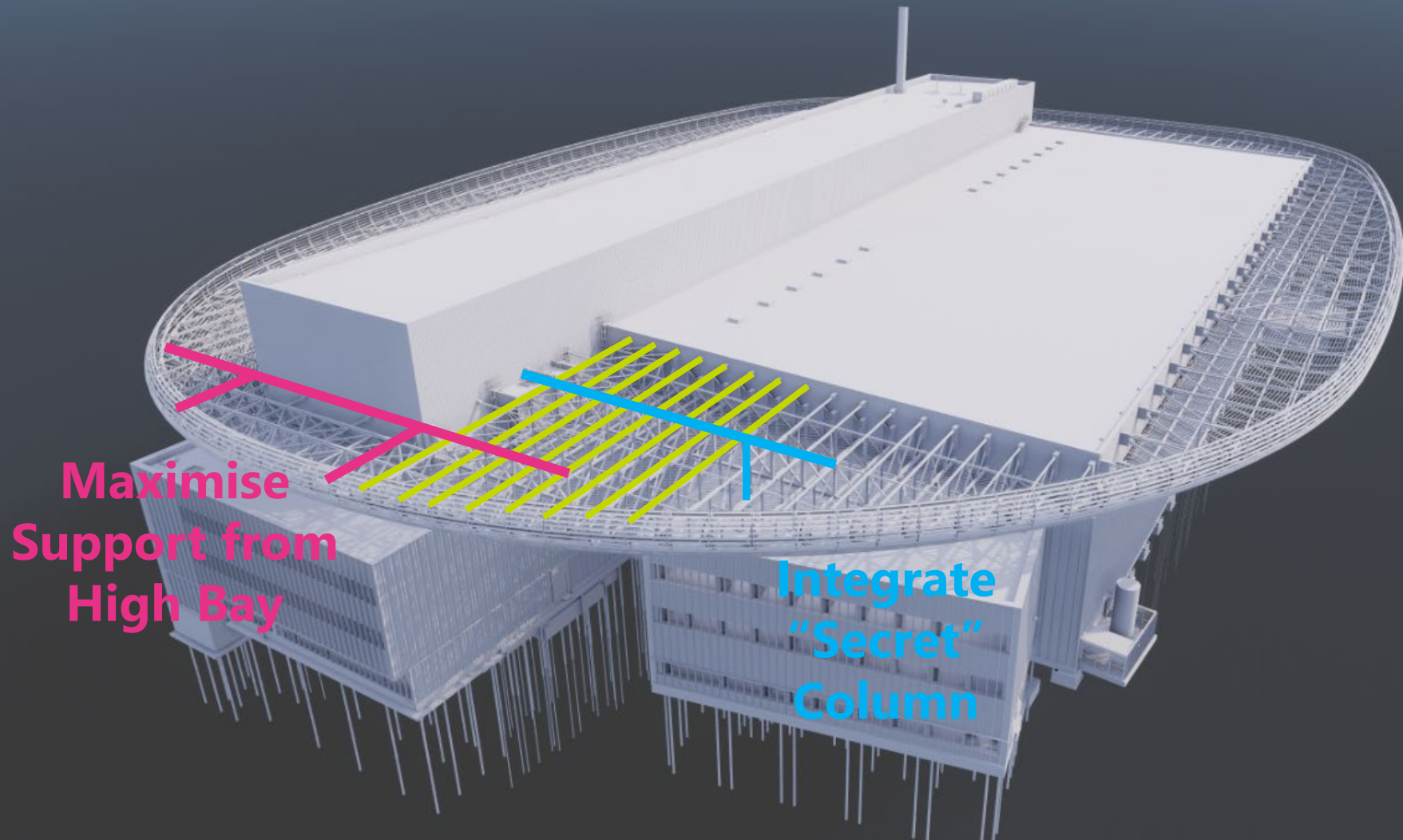






The Corners...





Maximise
Support from
High Bay

Integrate
"Secret"
Column





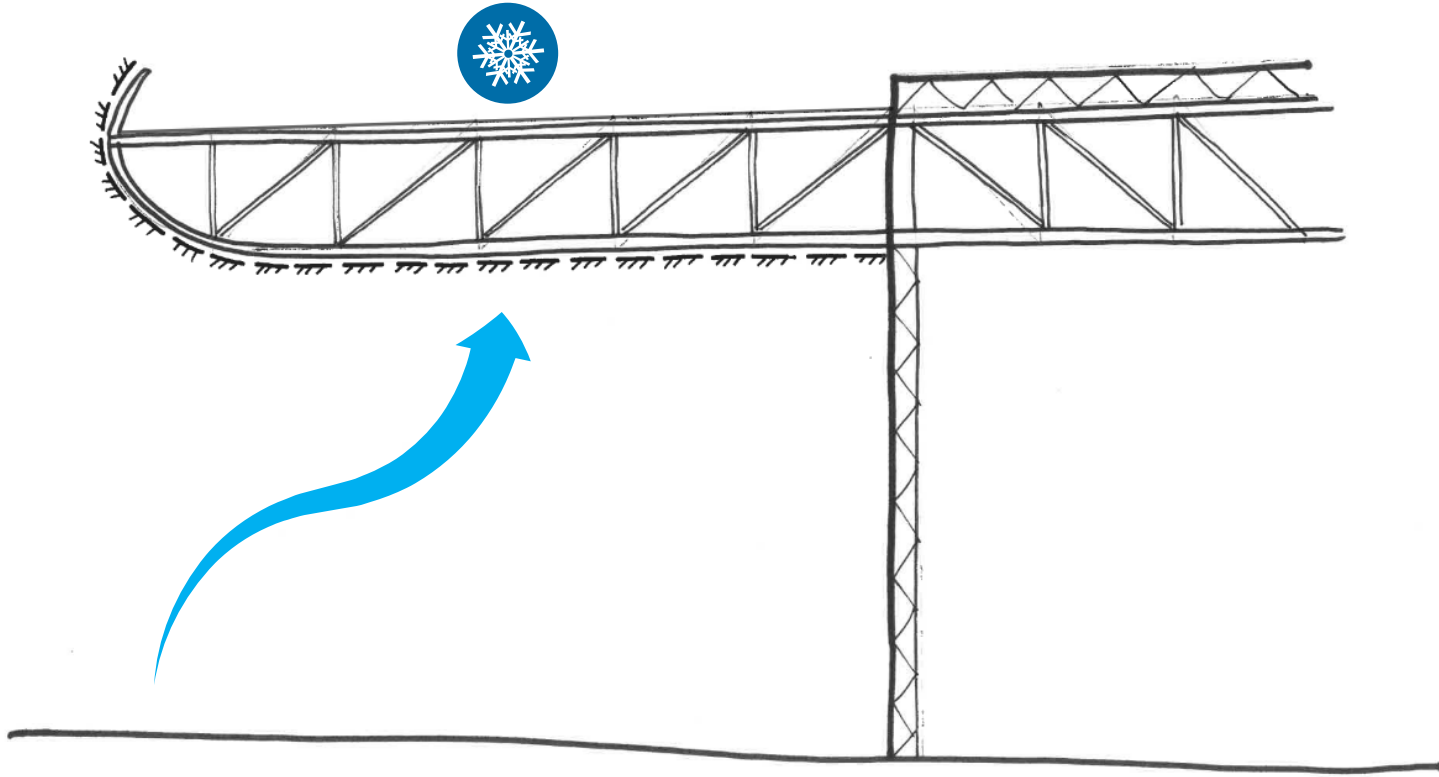


Façade Optimisation

Structural and Buildability

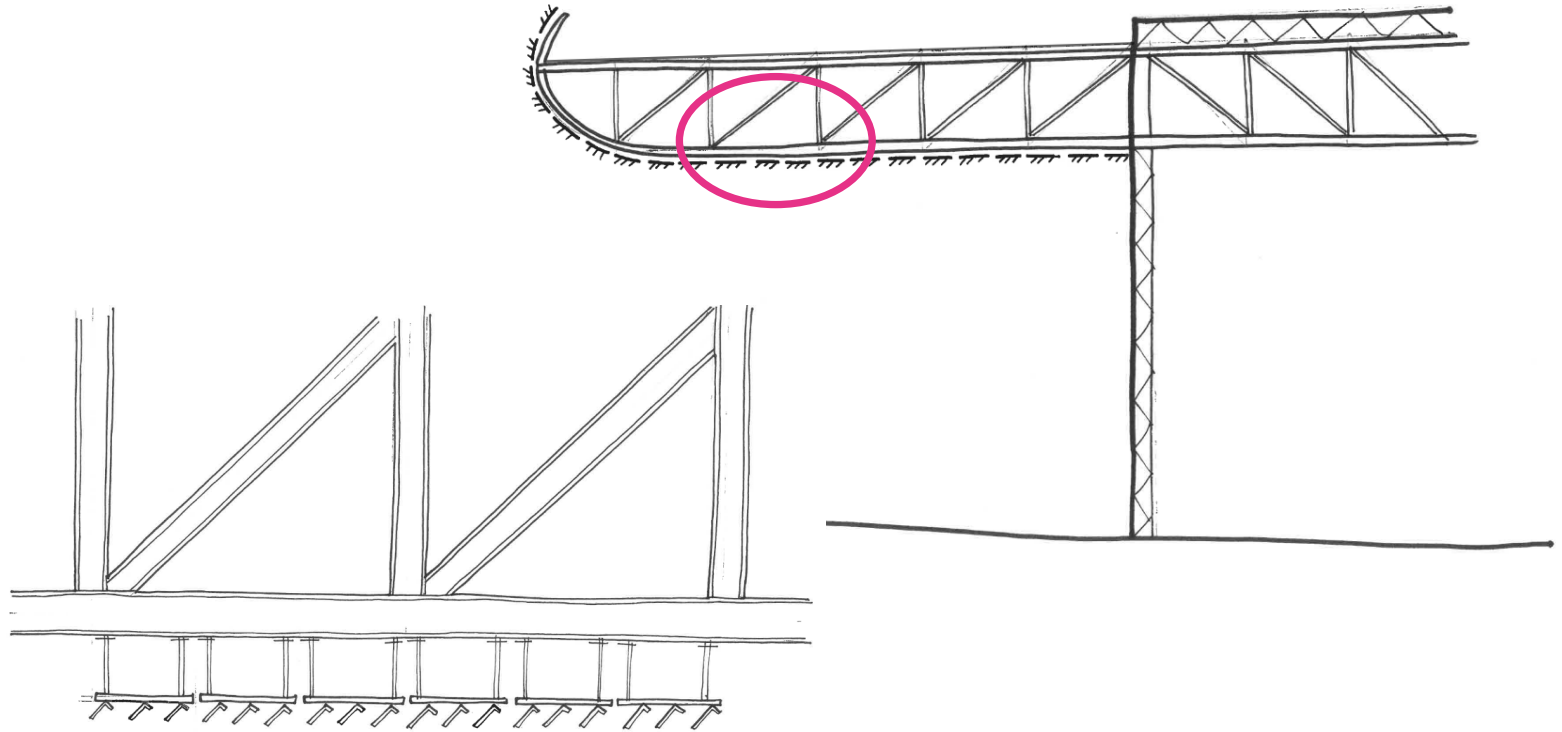
Façade: Structural Optimisation

Reducing the load on the Cantilever



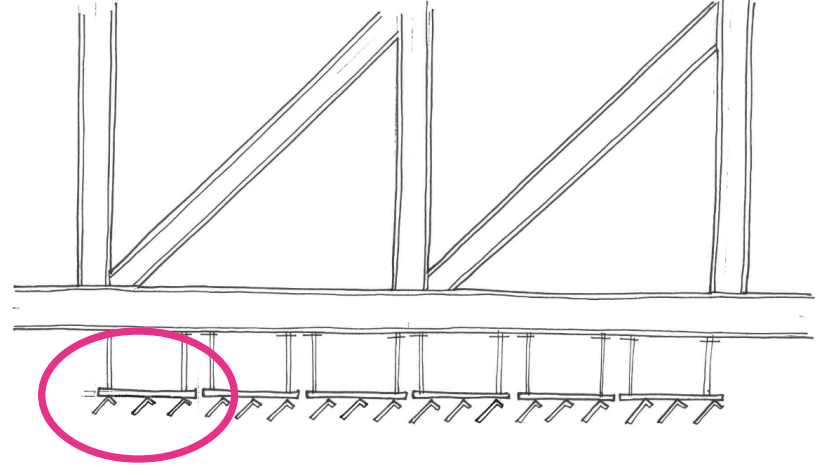
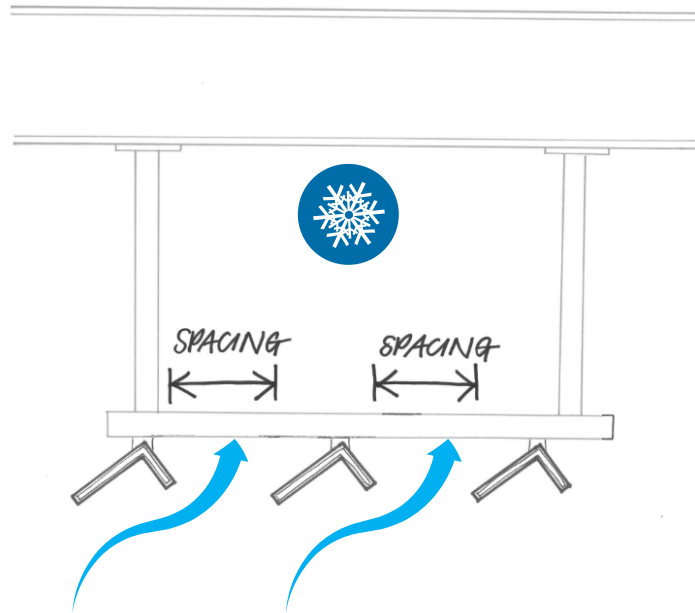
Façade: Structural Optimisation

Reducing the load on the Cantilever



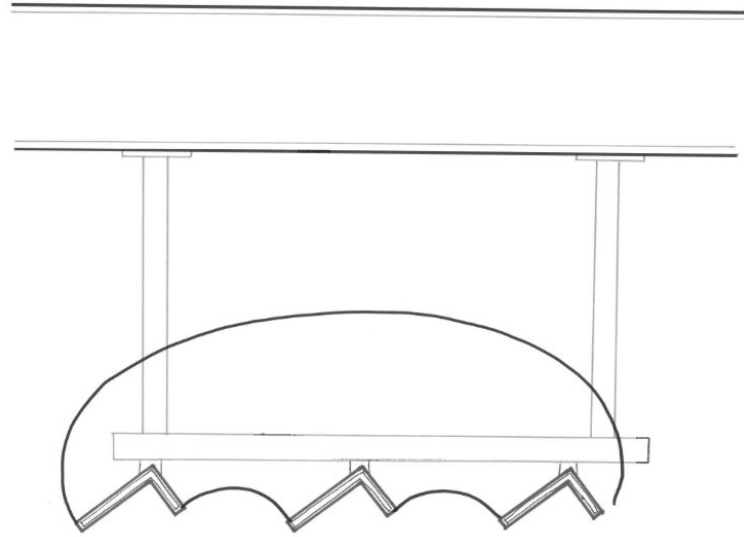
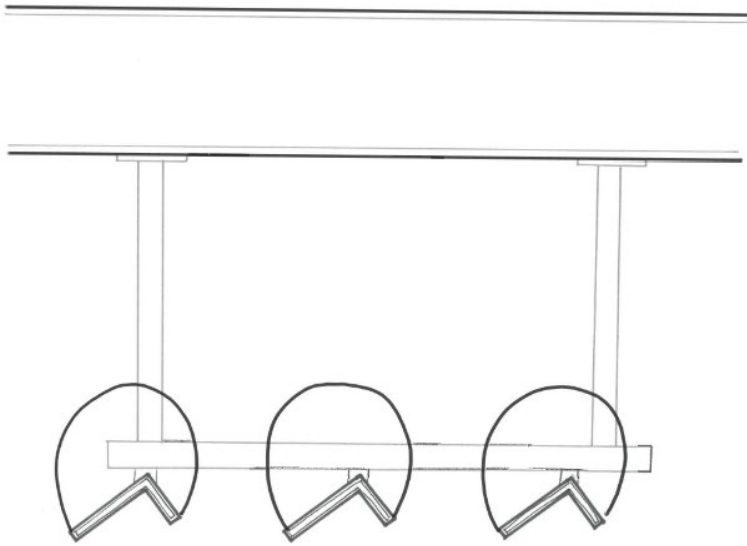
Façade: Structural Optimisation

Reducing the load on the Cantilever



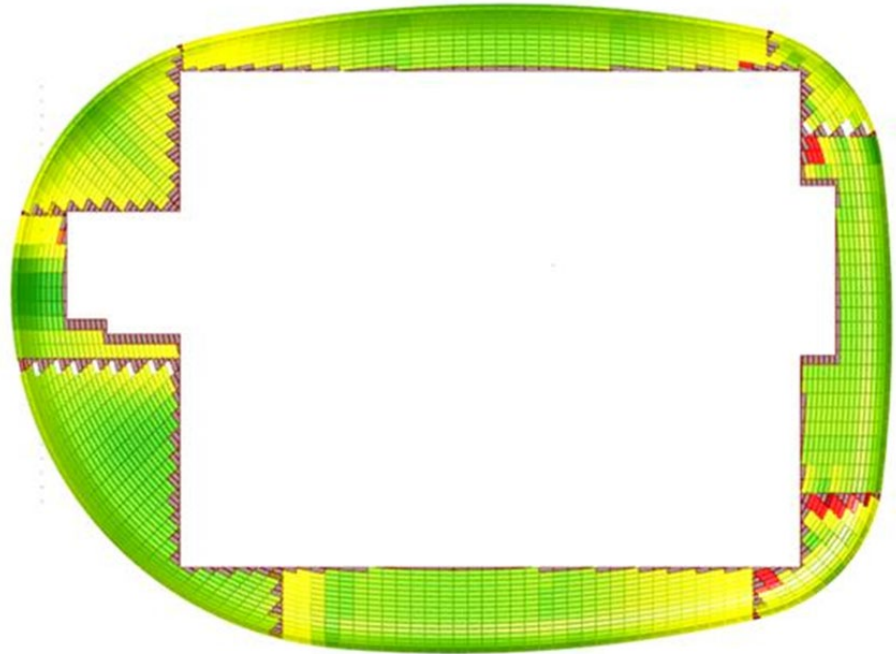
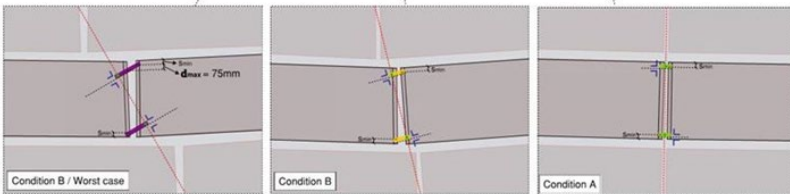
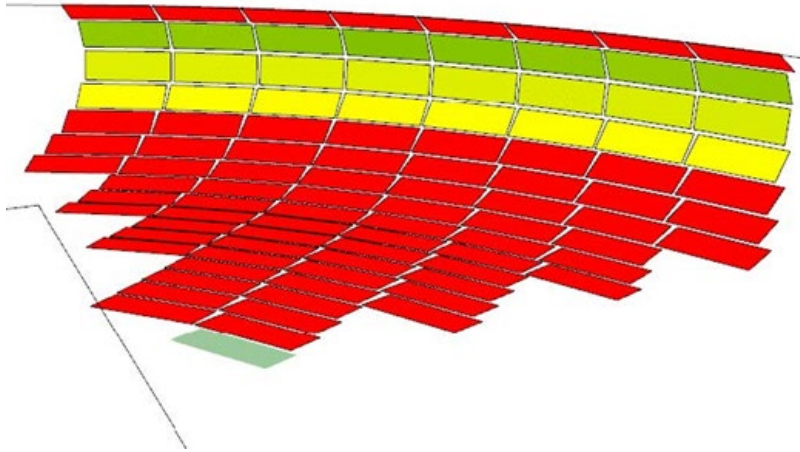
Façade: Structural Optimisation

Reducing the load on the Cantilever



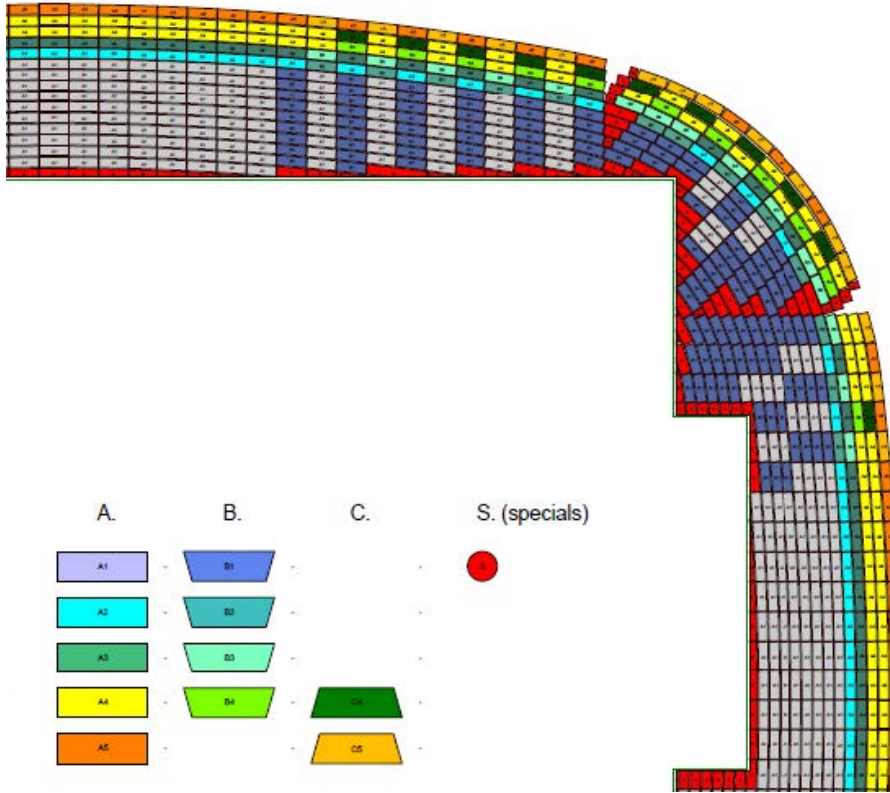
Façade Optimisation

Reducing number of panel types



Façade Optimisation

Reducing number of panel types



3114
Panels

87%

11
standard
panels

Special
panels
limited
to 13%







Conclusion

Conclusion

Key lessons learnt

- Consider buildability and structural performance together at an early stage
- Think out of the box when it comes to unique challenges
- Use computational tools to assist the optimisation process
- Final tonnage of roof alone:
 - 1700kg (18,000m²)
 - 95kg/m²
- **Challenging structures (even with incredibly challenging design criteria) can be economically viable!**



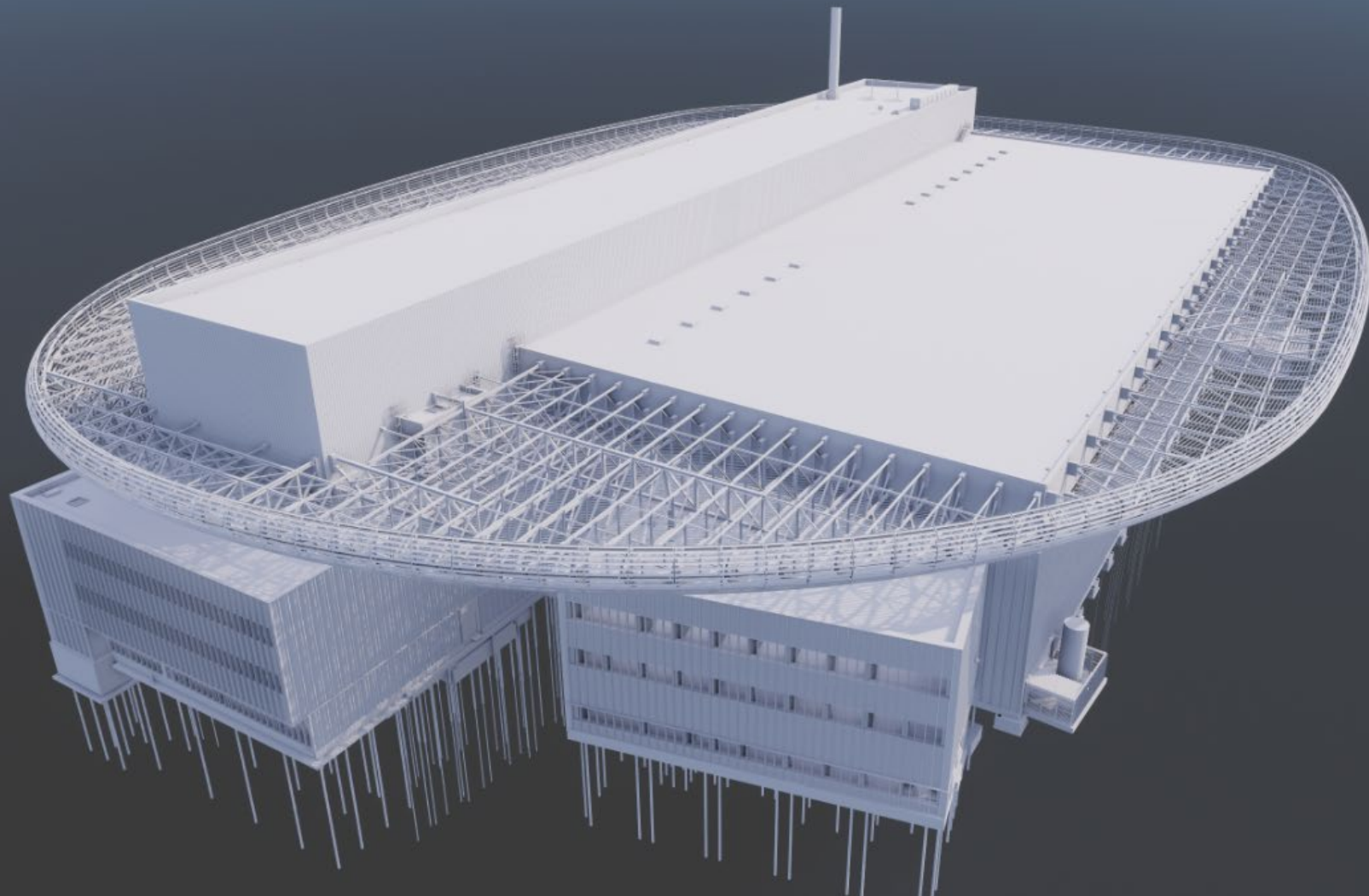
BURO HAPPOLD

Thank you for your time

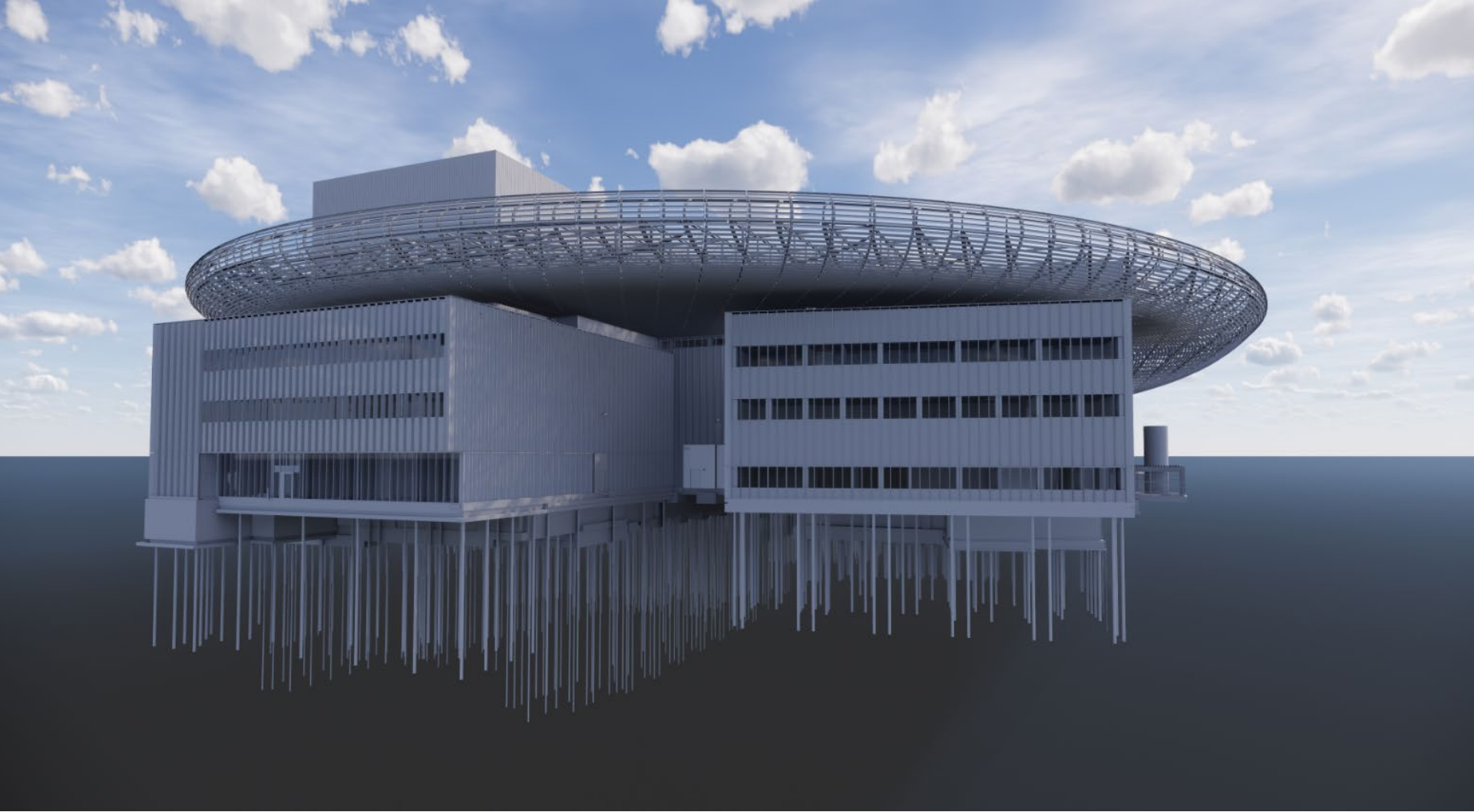
Questions welcome

Paul Roberts
Director, Copenhagen
Paul.Roberts@burohappold.com

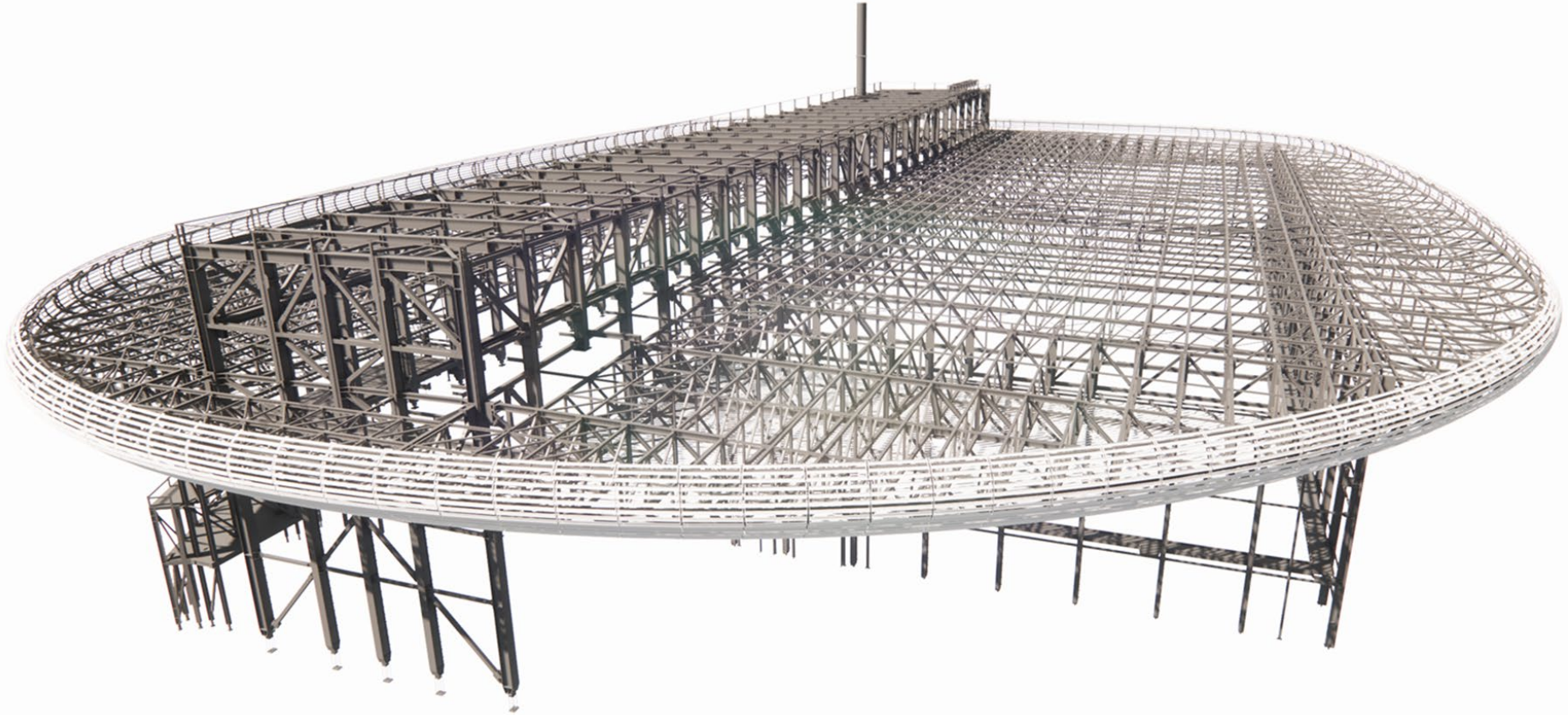
www.burohappold.com



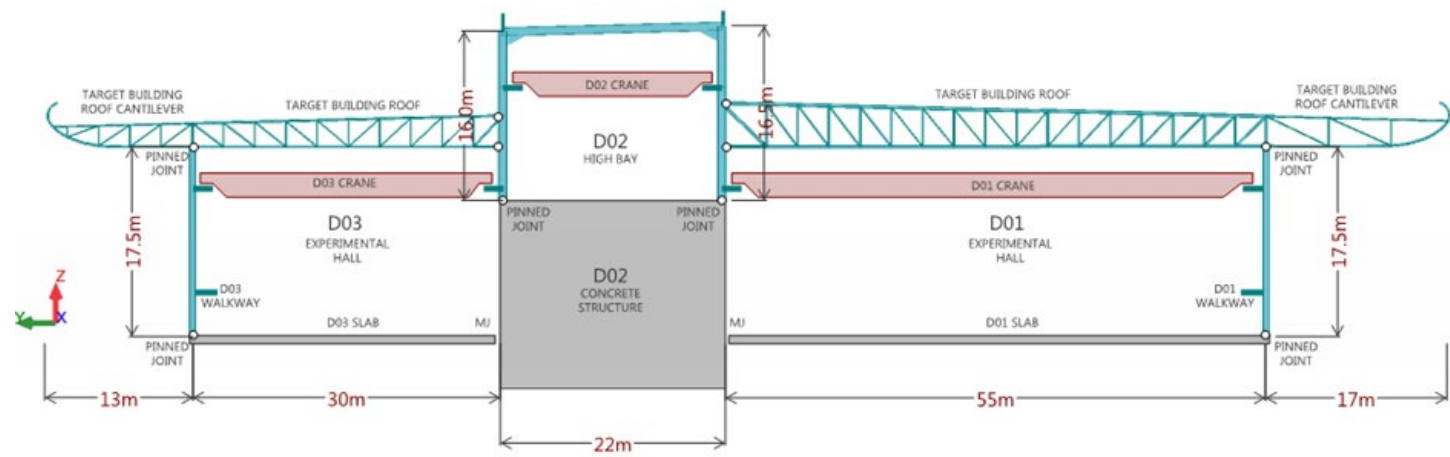
SPARE SLIDES



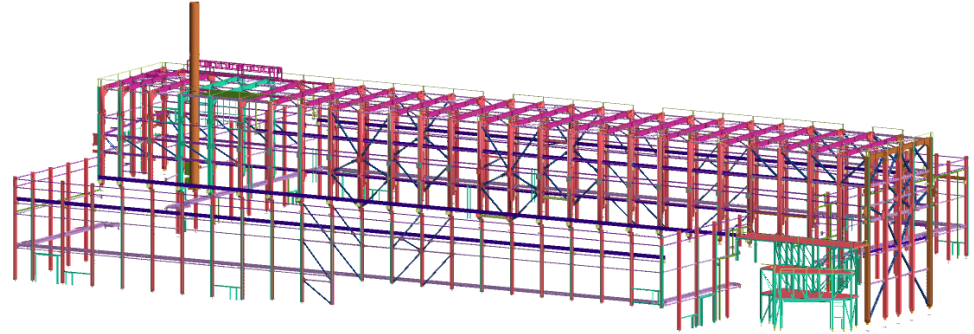
The Final Model



Cross Section



Software & Outsourcing (IDH)



Calculate yesterday's estimates

