

GEOTECHNICAL SENSOR MONITORING TOWARDS DIGITAL TWIN APPLICATION

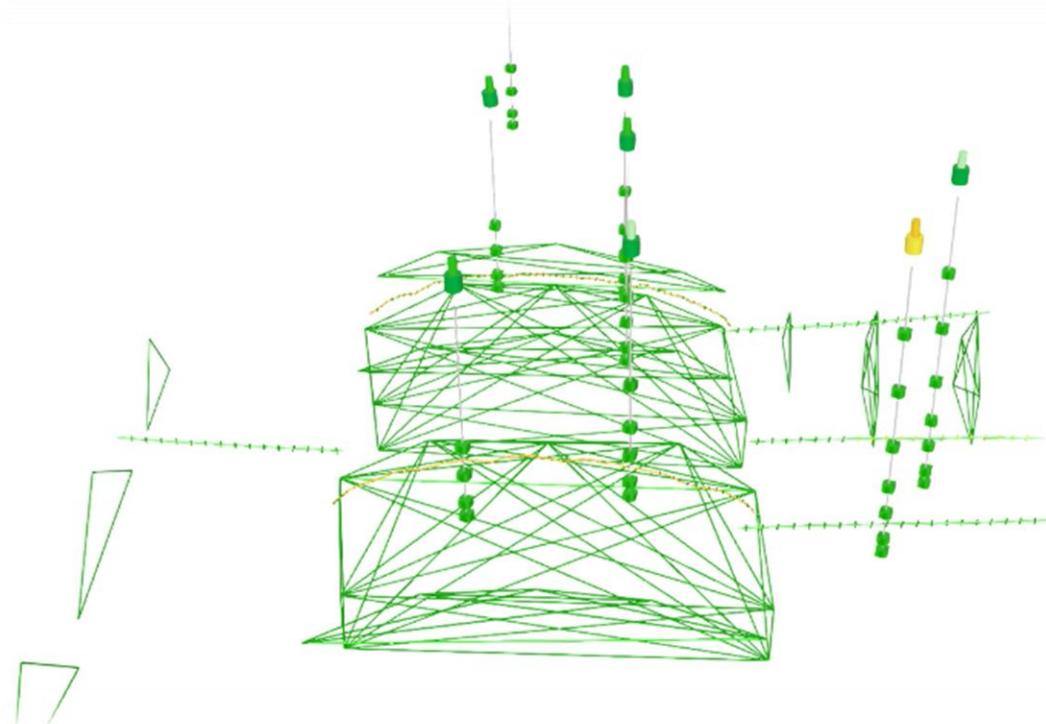


ISSMGE TC 222

Webinar 13 November 2025

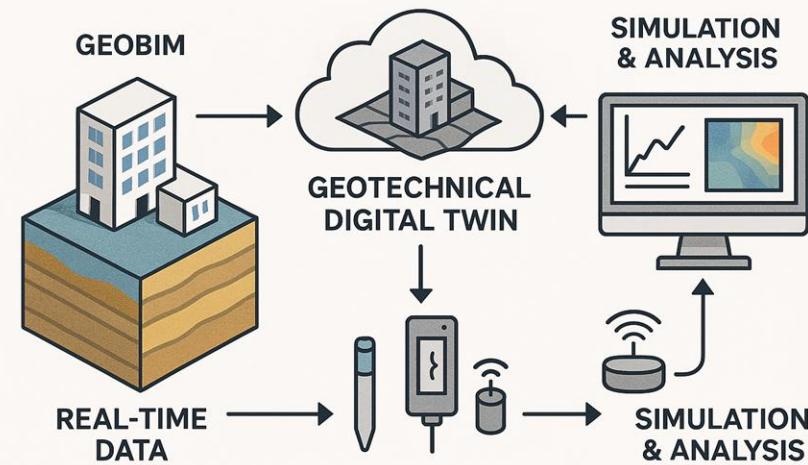
Mats Svensson, PhD

Tyréns Sweden AB



OUTLINE

- The drivers
- GeoBIM data management
- A few examples
- Sensor monitoring
- Do we have a digital twin?
- Future work



ARCHITECTURE OF A GEOTECHNICAL DIGITAL TWIN

Figure by Copilot

TYRÉNS SWEDEN

- 2 000 employees
- 140 geotechnicians
- Subsurface disciplines – 350 employees
 - Geotechnics
 - Environment
 - Rock engineering
 - Groundwater
- Exploring digitizing towards geotechnical digital twin applications

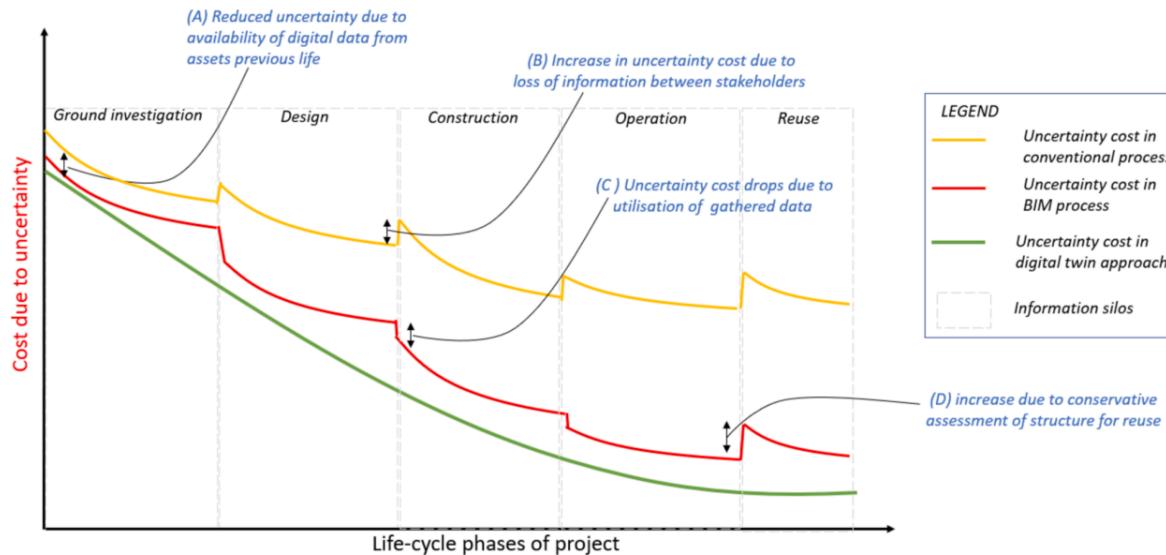


WHY GEOTECHNICAL DIGITAL TWIN?

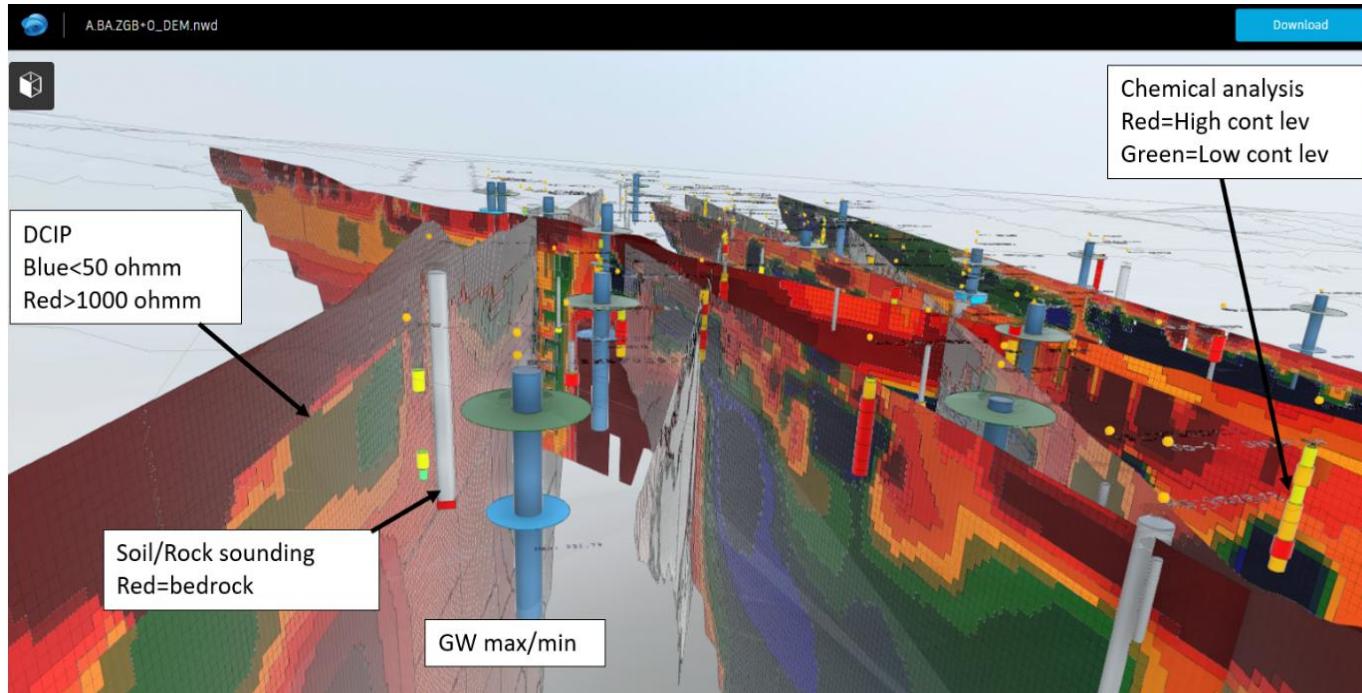
Geotechnics is very much about uncertainties

N. Babanagar et al.

Tunnelling and Underground Space Technology incorporating Trenchless Technology Research 155 (2025) 106140

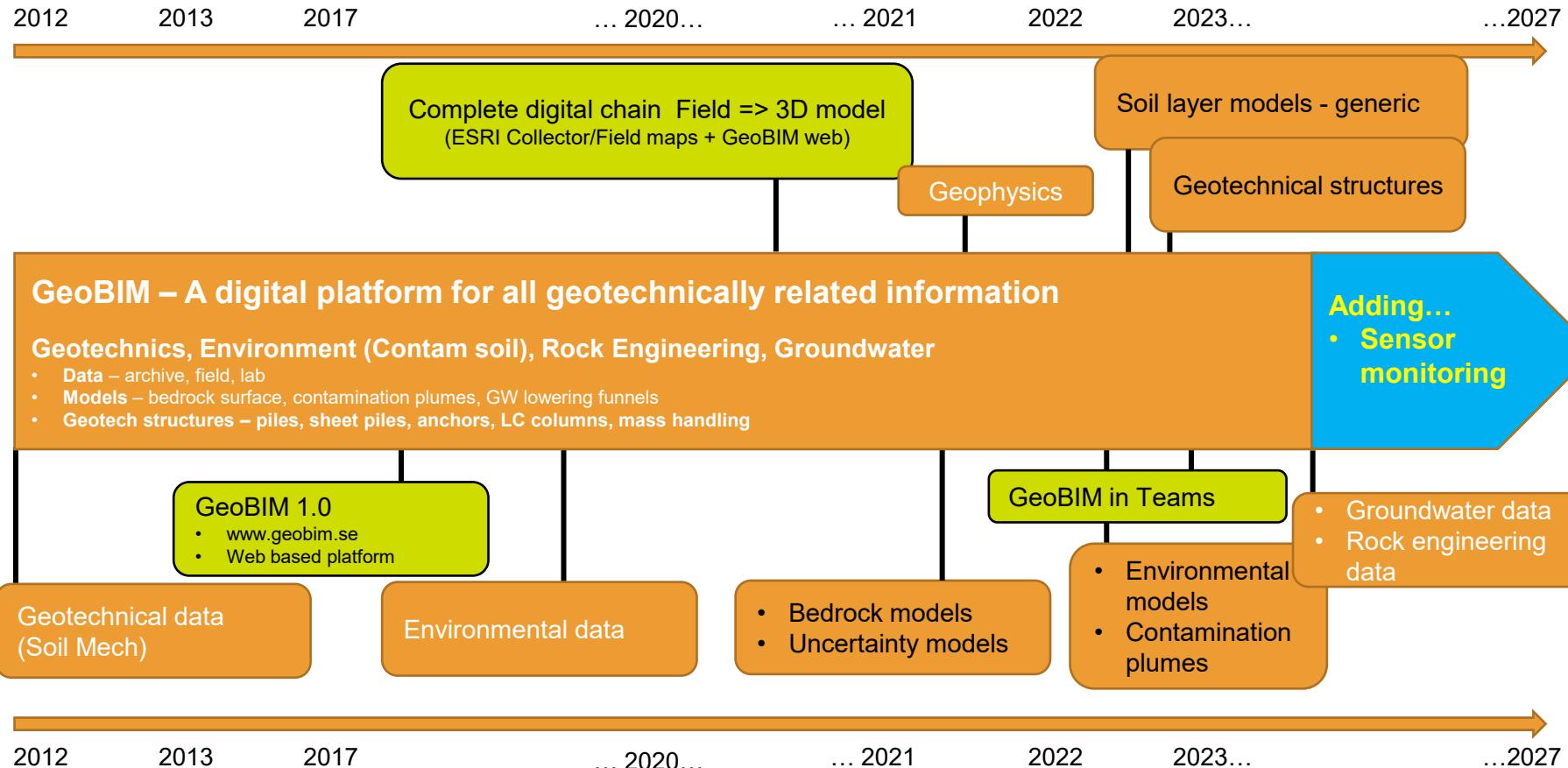


THE DRIVER

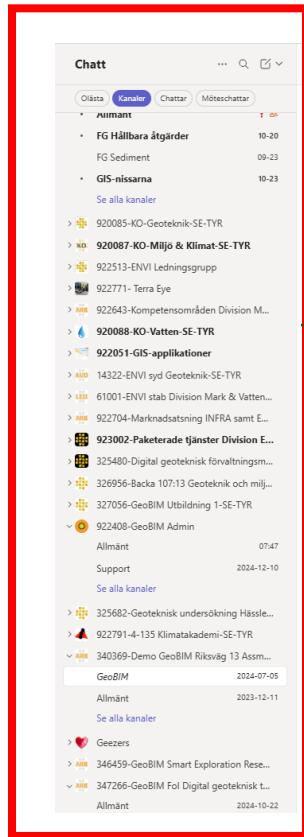


Project Bräcke railway yard, Sweden, 2019.

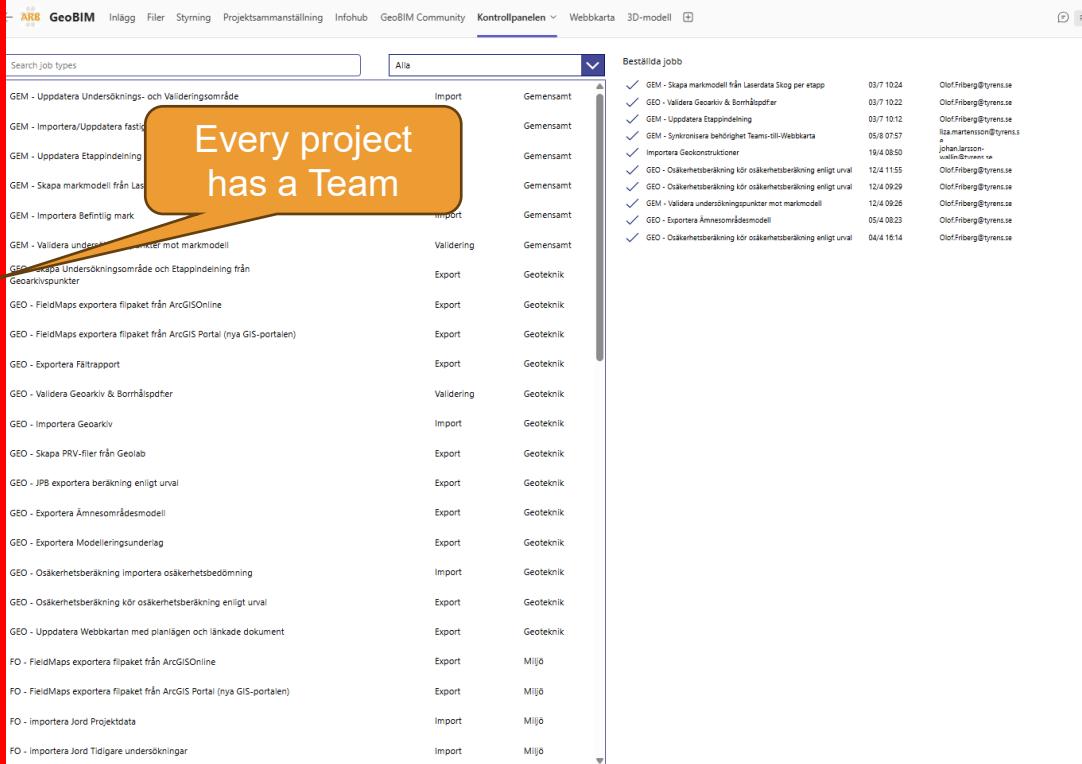
GEOBIM DATA MANAGEMENT



WHY MICROSOFT TEAMS?!



The screenshot shows the Microsoft Teams interface with a red border around the left sidebar and the main chat area. The sidebar lists various channels such as 'FG Hållbara åtgärder', 'GIS-nissarna', and 'Se alla kanaler'. The main area shows a list of messages and attachments.

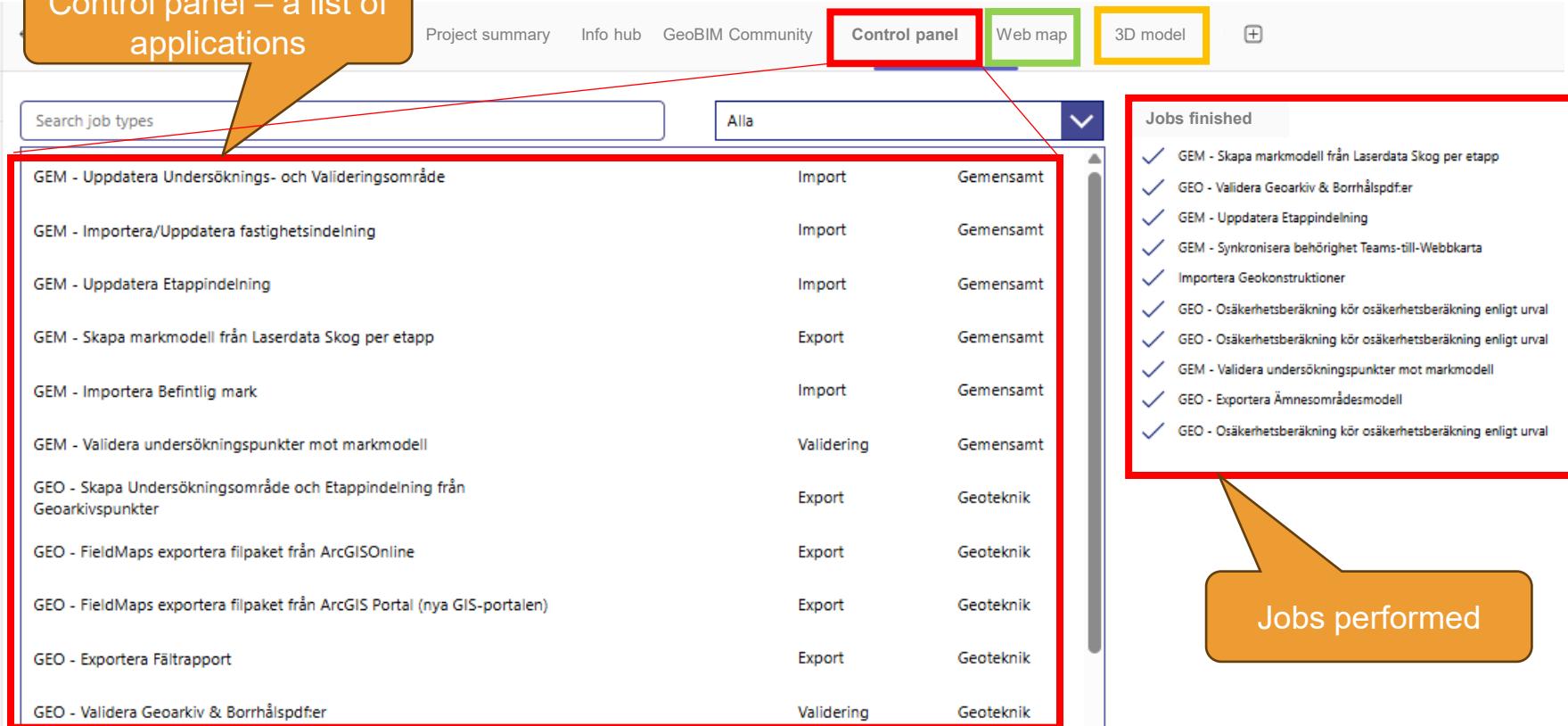


The screenshot shows the Microsoft Teams Control Panel (Kontrollpanelen) with a search bar for 'Search job types' and a list of tasks under 'Beställda jobb'. A large orange callout bubble with the text 'Every project has a Team' is overlaid on the center of the screen.

Job Description	Type	Category	Date	Assignee
GEM - Uppdatera Undersöknings- och Validatoringsområde	Import	Gemensamt	03/7 10:24	Olof.Friberg@tyrens.se
GEM - Importera/Uppdatera fastighetsinventering	Import	Gemensamt	03/7 10:22	Olof.Friberg@tyrens.se
GEM - Uppdatera Etappindelning	Import	Gemensamt	03/7 10:12	Olof.Friberg@tyrens.se
GEM - Symfonisera behörighet Teams till Webbkarta	Import	Gemensamt	05/6 07:57	Iza.martensson@tyrens.se
GEO - Importera Geokonstruktioner	Import	Gemensamt	19/4 08:50	johan.larsson- wells@tyrens.se
GEO - Osäkerhetsberäkning för osäkerhetsberäkning enligt unval	Import	Gemensamt	12/4 11:55	Olof.Friberg@tyrens.se
GEO - Osäkerhetsberäkning för osäkerhetsberäkning enligt unval	Import	Gemensamt	12/4 09:29	Olof.Friberg@tyrens.se
GEM - Validera undersökningspunkter mot markmodell	Import	Gemensamt	12/4 09:26	Olof.Friberg@tyrens.se
GEO - Exportera Åmnedområdesmodell	Export	Geoteknik	05/4 08:23	Olof.Friberg@tyrens.se
GEO - Osäkerhetsberäkning för osäkerhetsberäkning enligt unval	Import	Gemensamt	04/4 16:14	Olof.Friberg@tyrens.se

WHY MICROSOFT TEAMS?!

Control panel – a list of applications



The screenshot shows the Microsoft Teams Control Panel interface. At the top, there are tabs: Project summary, Info hub, GeoBIM Community, Control panel (which is highlighted with a red border), Web map (highlighted with a green border), 3D model (highlighted with a yellow border), and a plus icon.

A large orange speech bubble points to the 'Control panel' tab. A red line connects it to a search bar labeled 'Search job types' and the word 'Alla' (All) in a dropdown menu.

The main area displays a table of applications:

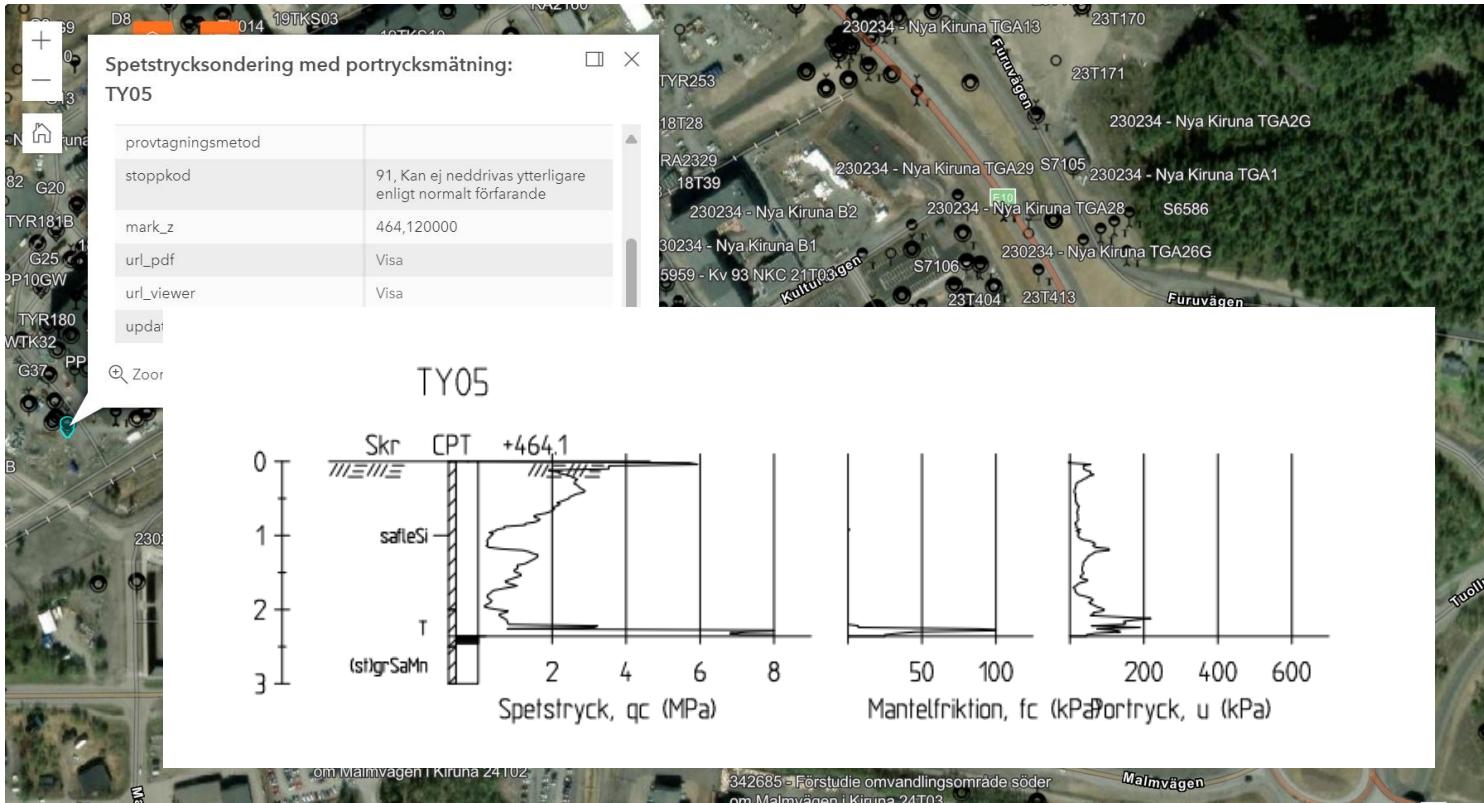
GEM - Uppdatera Undersöknings- och Valideringsområde	Import	Gemensamt	
GEM - Importera/Uppdatera fastighetsindelning	Import	Gemensamt	
GEM - Uppdatera Etappindelning	Import	Gemensamt	
GEM - Skapa markmodell från Laserdata Skog per etapp	Export	Gemensamt	
GEM - Importera Befintlig mark	Import	Gemensamt	
GEM - Validera undersökningspunkter mot markmodell	Validering	Gemensamt	
GEO - Skapa Undersökningsområde och Etappindelning från Geokärvspunkter	Export	Geoteknik	
GEO - FieldMaps exportera filpaket från ArcGISOnline	Export	Geoteknik	
GEO - FieldMaps exportera filpaket från ArcGIS Portal (nya GIS-portalen)	Export	Geoteknik	
GEO - Exportera Fältrapport	Export	Geoteknik	
GEO - Validera Geoarkiv & Borrhålpdfier	Validering	Geoteknik	

To the right, a red box highlights a section titled 'Jobs finished' containing a list of completed tasks:

- GEM - Skapa markmodell från Laserdata Skog per etapp
- GEO - Validera Geoarkiv & Borrhålpdfier
- GEM - Uppdatera Etappindelning
- GEM - Synkronisera behörighet Teams-till-Webbkarta
- Importera Geokonstruktioner
- GEO - Osäkerhetsberäkning kör osäkerhetsberäkning enligt urval
- GEO - Osäkerhetsberäkning kör osäkerhetsberäkning enligt urval
- GEM - Validera undersökningspunkter mot markmodell
- GEO - Exportera Ämnesområdesmodell
- GEO - Osäkerhetsberäkning kör osäkerhetsberäkning enligt urval

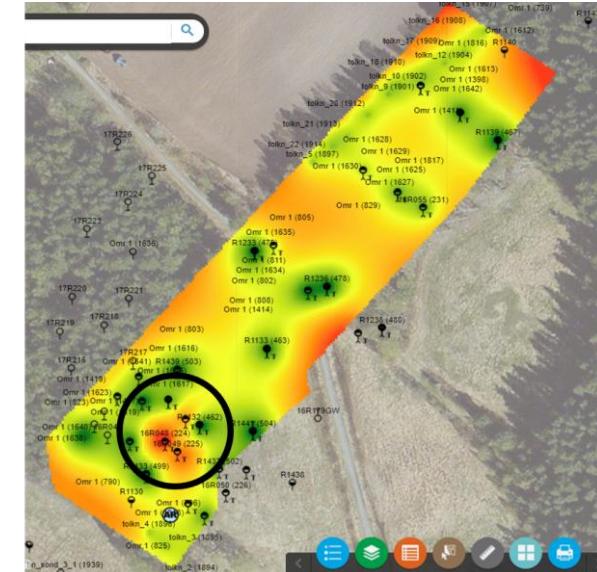
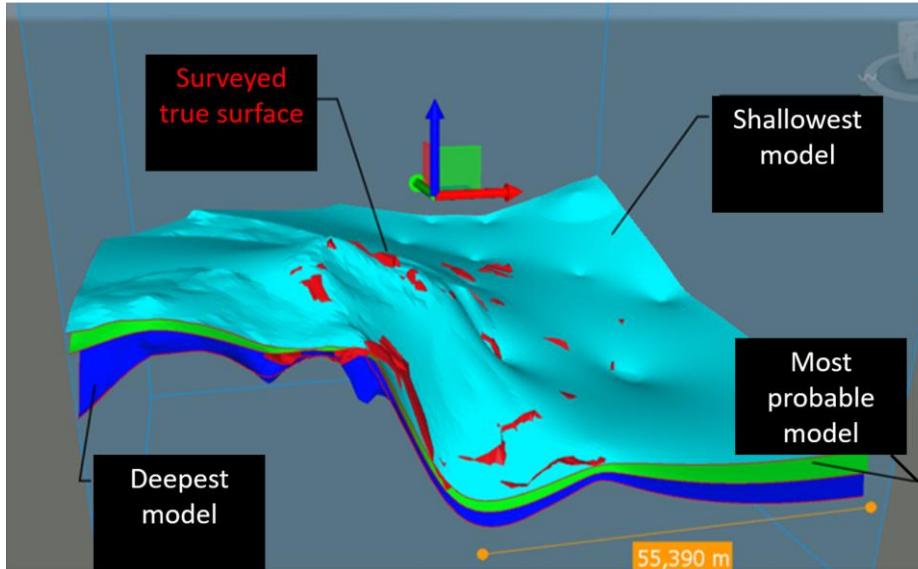
An orange speech bubble at the bottom right points to this list and contains the text 'Jobs performed'.

GeoBIM – THE DIGITAL ARCHIVE



ADVANCED ANALYSIS TOOL

BEDROCK SURFACE INCL UNCERTAINTY MAP

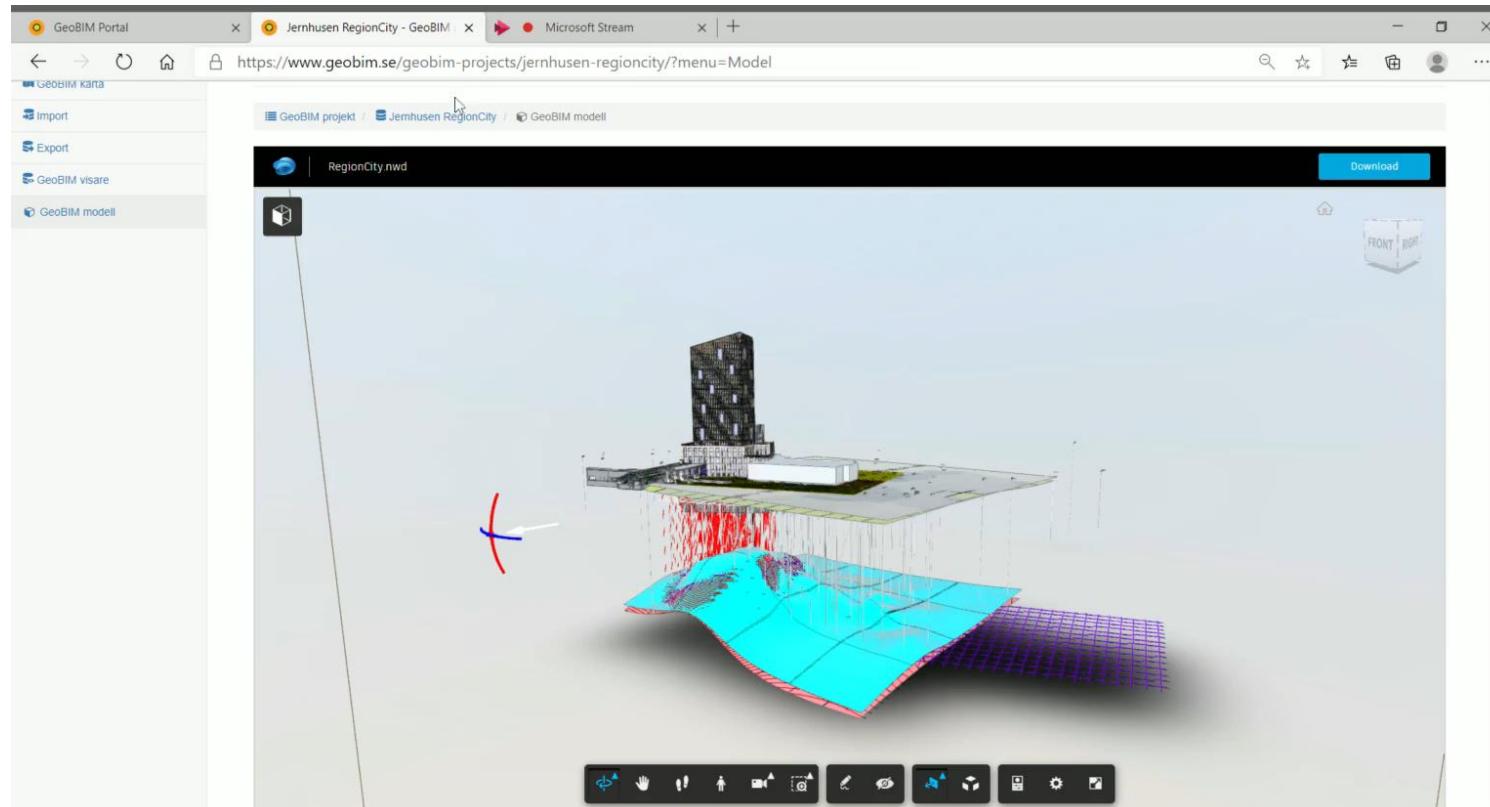


Control panel

Web map

3D model

VISUALIZATION



CUSTOMER APPLICATION

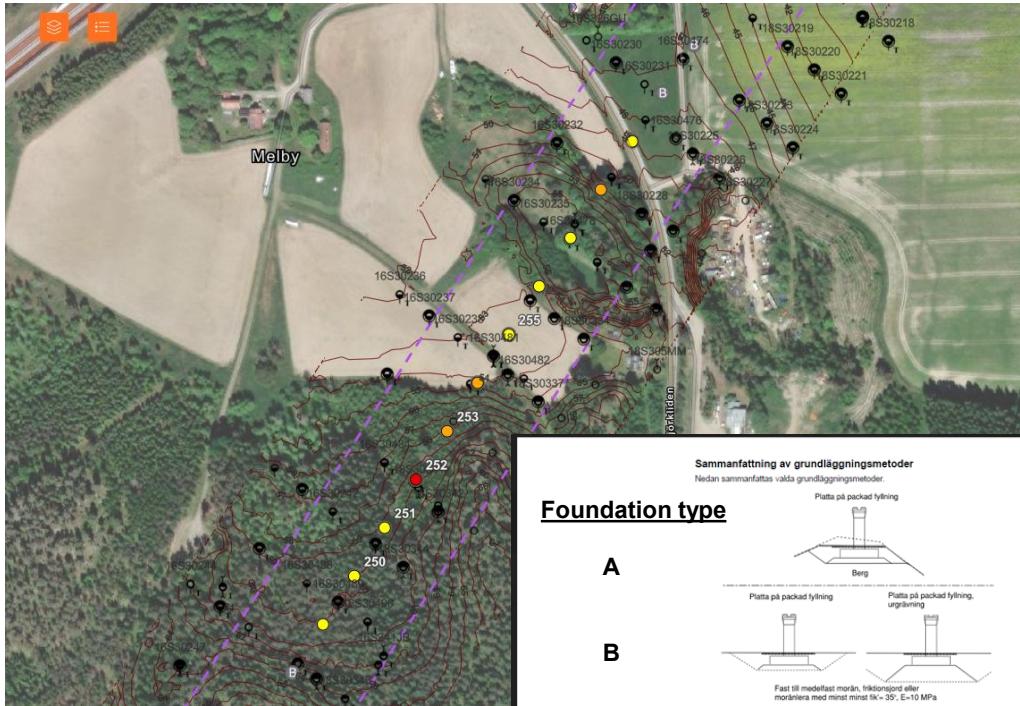
SKANSKA – HIGH SPEED TRAIN FOUNDATION

TYRÉNS

SKANSKA



ANALYSIS FOUNDATION TYPE



Foundation type

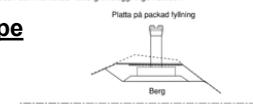
1

1

1

Sammanfattning av grundläggningssmetoder

Printed on recycled fibres



Platta på packad fyllning

engraving

Figure 1. A schematic diagram of the experimental setup for the two-photon absorption measurement.

For more information about the study, please contact Dr. Michael J. Hwang at (319) 356-4000 or email at mhwang@uiowa.edu.

.....
.....

Fast till medeltast morän, friktionsjord eller moränlera med minst minst fik= 35°. E=10 MPa

Slagna betongpålar
a) Snötebärspr.
Borrade betongpålar
a) Snötebärspr.

b) Manteibärande

33 B

1990-1991
1991-1992

For more information about the study, please contact Dr. Michael J. Hwang at (310) 794-3000 or via email at mhwang@ucla.edu.

Figure 10. Schematic diagram of the two types of bridge structures used in the study.

G

Jordprofil 5-6
SAMILAT urvalskriterium i GeoBIM-databasen
 $\phi > 35$ gr inom $z < 20$ m umy ELLER $c_u = 50-100$

Jordprofil 2- 4, 7 (M)

SAMLAT urvalskriterium i GeoBIM-databaser

OVERCOMING HINDERS

HINDERS

- Lack of **data formats**
- Lack of **transfer formats**

SOLUTION

- Best practise
 - Experts agreement
- Delivery specifications
 - Project
 - Company
 - Nation
 - ...



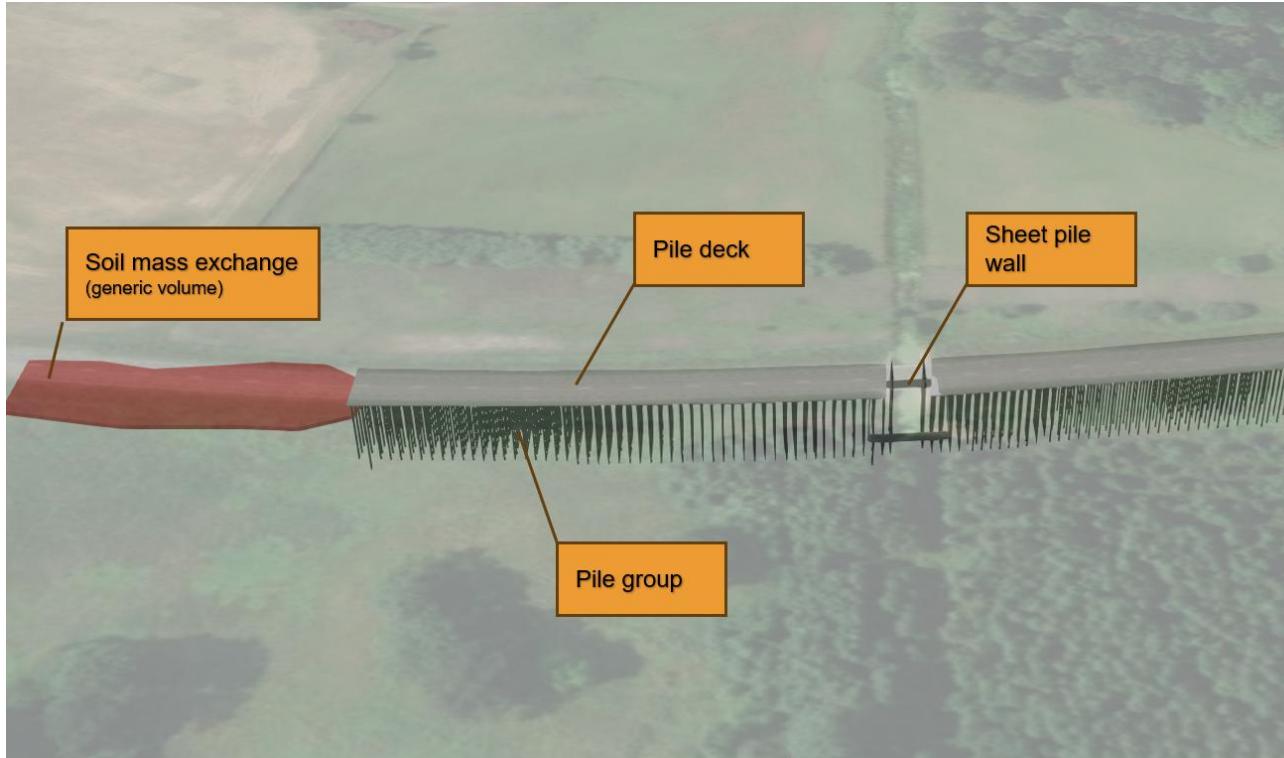
DELIVERY SPECIFICATION

IMPORT OF GEOTECHNICAL STRUCTURE DATA



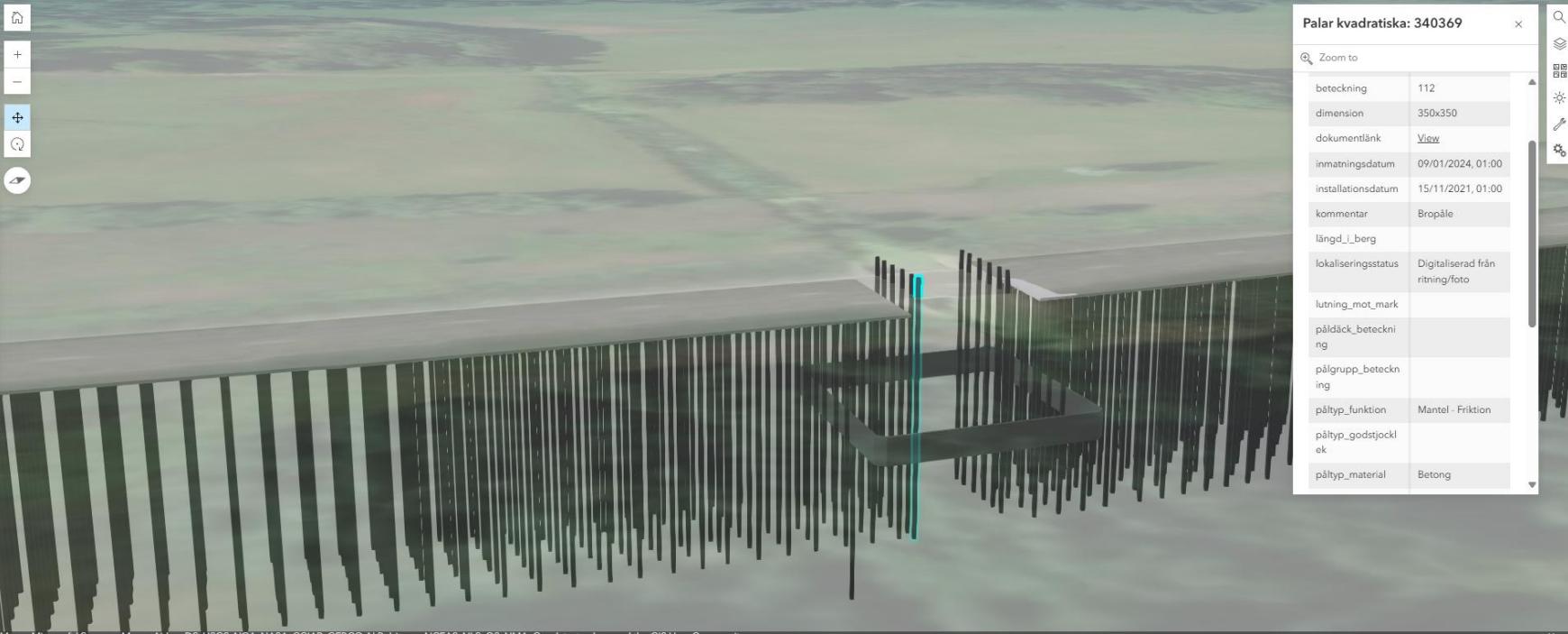
	Piles										
Position						Pile type					
Coordinate system	Elevation system	Northing (X)	Easting (Y)	Inclination (to ground surface), n:1	Pile head elevation + xx.xx	Material	Installation method	Type	Function	Thickness (Steel piles)	
SWEREF 99 13 30	RH2000	6159514,71	165612,3		36,48	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159514,77	165614,6		36,49	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159514,62	165616,8		36,48	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159514,57	165619,1		36,46	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159514,51	165621,4		36,48	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159514,43	165623,8		36,47	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159517,05	165612,4		36,49	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159516,94	165614,5		36,49	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159516,99	165616,7		36,49	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159516,77	165618,7		36,49	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159516,75	165621,6		36,49	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159516,67	165623,6		36,49	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159519,28	165612,3		36,5	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159519,24	165614,5		36,49	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159519,24	165616,9		36,49	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159519,07	165619,2		36,49	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159518,92	165621,5		36,49	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159519,1	165623,7		36,49	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159521,52	165612,4		36,51	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159521,36	165614,5		36,5	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159521,33	165616,7		36,5	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159521,34	165619,3		36,5	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159521,33	165621,6		36,5	Concrete	Hammer		Friction		
SWEREF 99 13 30	RH2000	6159521,27	165623,8		36,5	Concrete	Hammer		Friction		

ASSMÅSA, Malmö



ASSMÅSA, MÄLÖ

Scene Viewer
Tyréns Portal for ArcGIS 340369_GeoBIM_SCENE



Palar kvadratiska: 340369

Zoom to	
beteckning	112
dimension	350x350
dokumentlänk	View
inmatningsdatum	09/01/2024, 01:00
installationsdatum	15/11/2021, 01:00
kommentar	Bropåle
längd_berg	
lokaliseringstatus	Digitaliseras från ritning/foto
lutning_mot_mark	
påldäck_beteckning	
pålgrupp_beteckning	
påltyp_funktion	Mantel - Friktion
påltyp_godstjöcklek	
påltyp_material	Betong

MISSING... ON THE ROAD TO A DIGITAL TWIN

Sensor monitoring

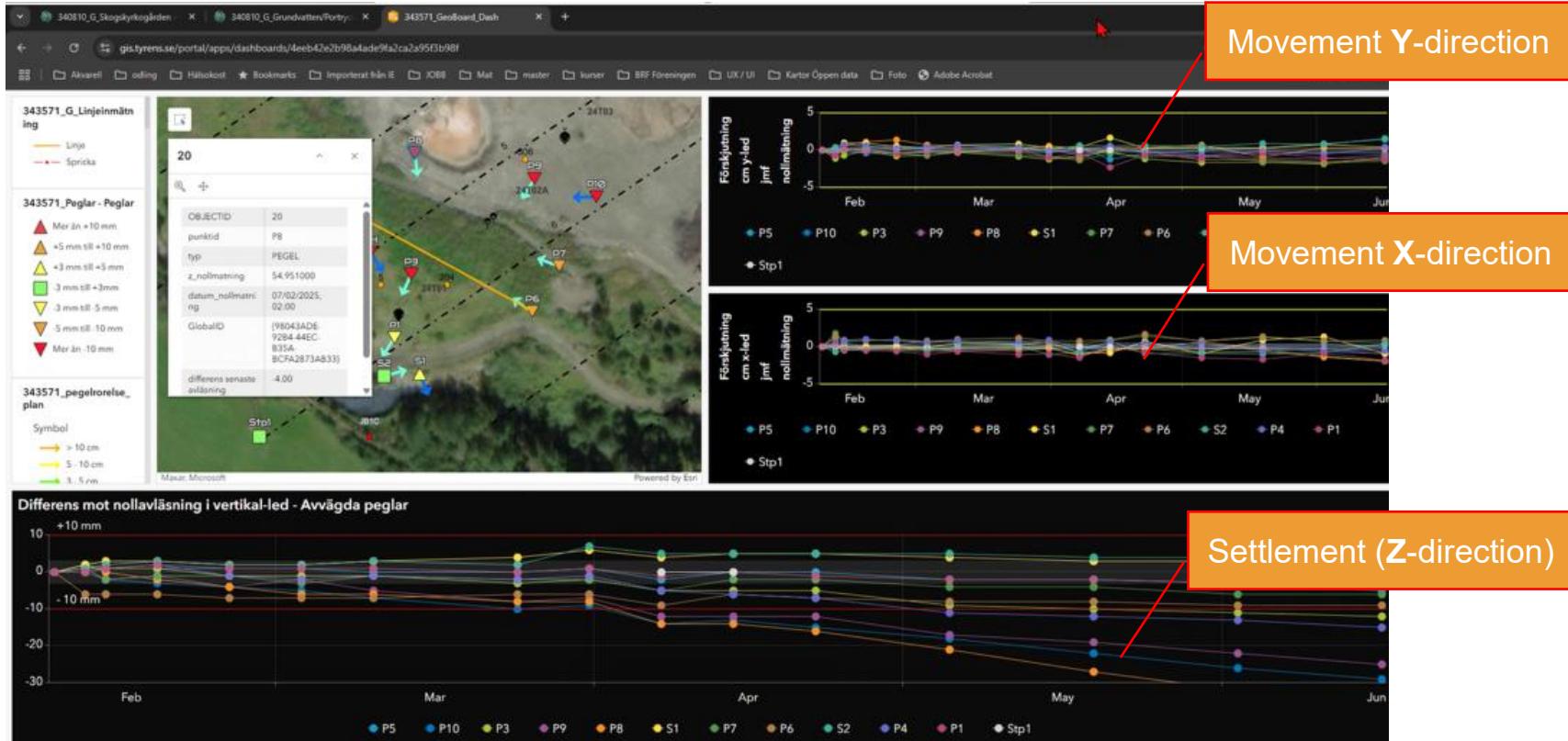
SENSORS

Delivery specifications for:

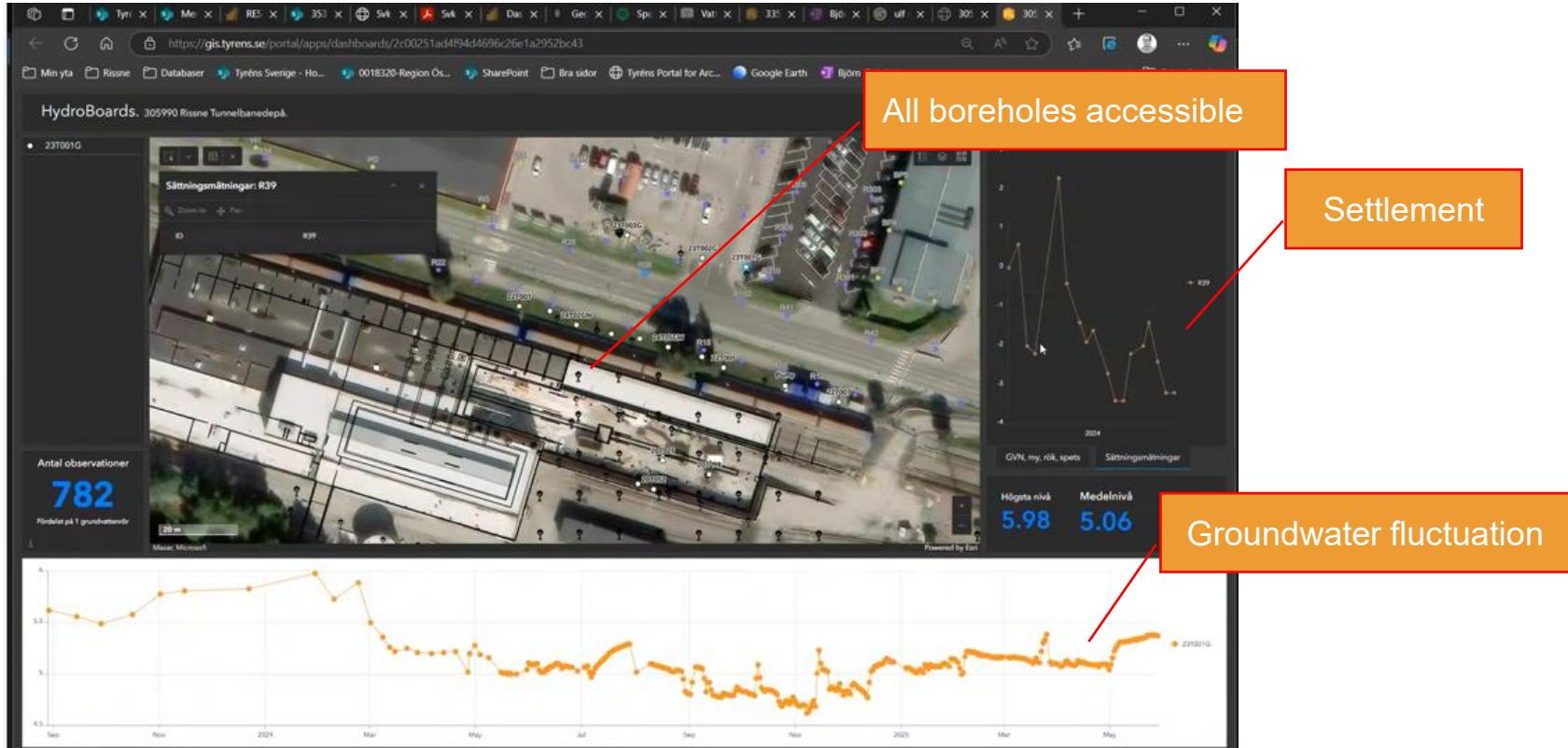
- Soil movement (surface) – X, Y, Z
- Inclinometers
- Groundwater – open pipes, piezometers
- Extensometers (tunnels)
- Fibre optics



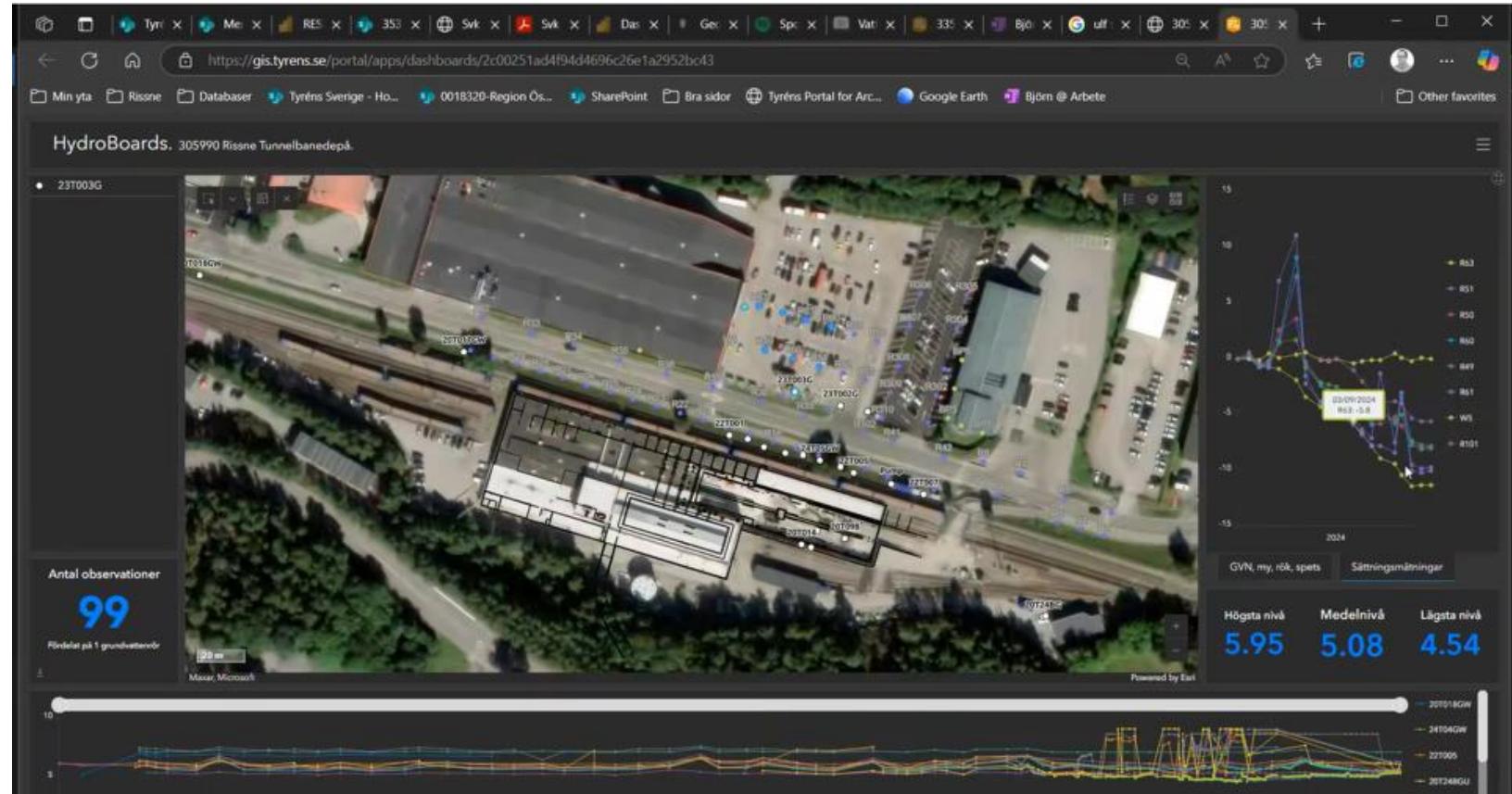
LANDFILL, NORRKÖPING



RISSNE TRAIN DEPOT, STOCKHOLM

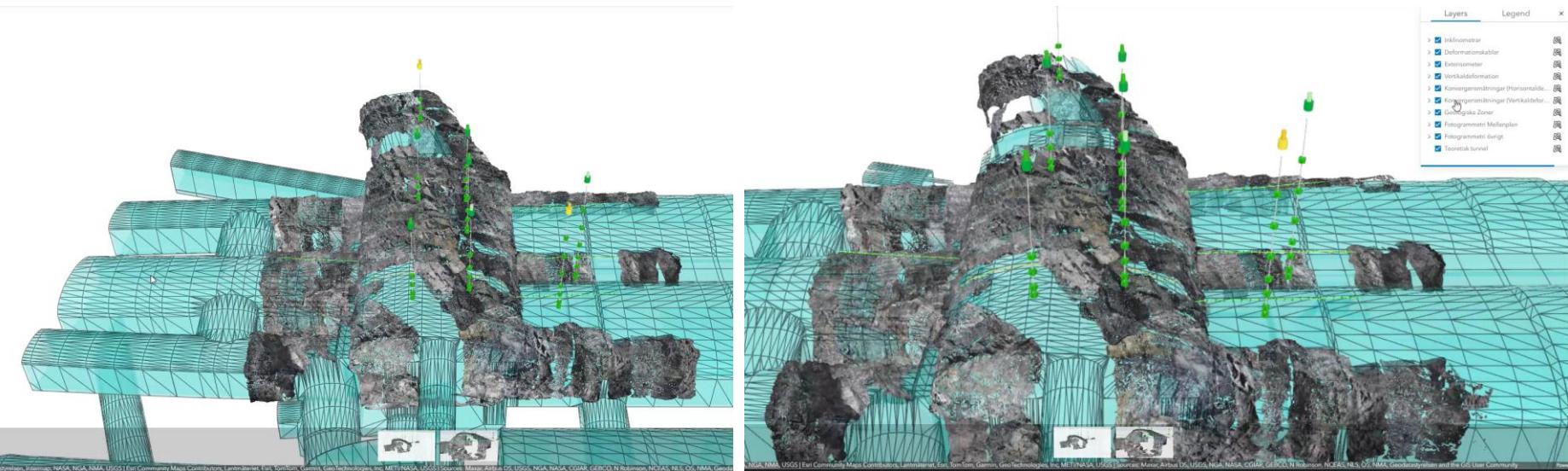


RISSNE TRAIN DEPOT, STOCKHOLM



KORSVÄGEN, GOTHENBURG

RAILWAY TUNNEL STATION, WEST LINK PROJECT



KORSVÄGEN, GOTHENBURG

RAILWAY TUNNEL STATION, WEST LINK PROJECT



Control Objects Basic data

Number E4-9	Type D: Dub: z	Alarm.Nr EXTIV9	Tag
Group EXT_W	Category E-IV	Contractor	Status

Alt.Jämförelse
Med(7-14):2m

Zero measurement
2023-01-18

Latest registration
2025-07-03 11:30:

Day
0

Supplement[m]
0

Notes
250602/ONY: slutningsfel(0.37mm)
250528/PKH: slutningsfel(1.3mm)
240910/USV: replacement on 2024-08-28 registered

Metadata (key=value)

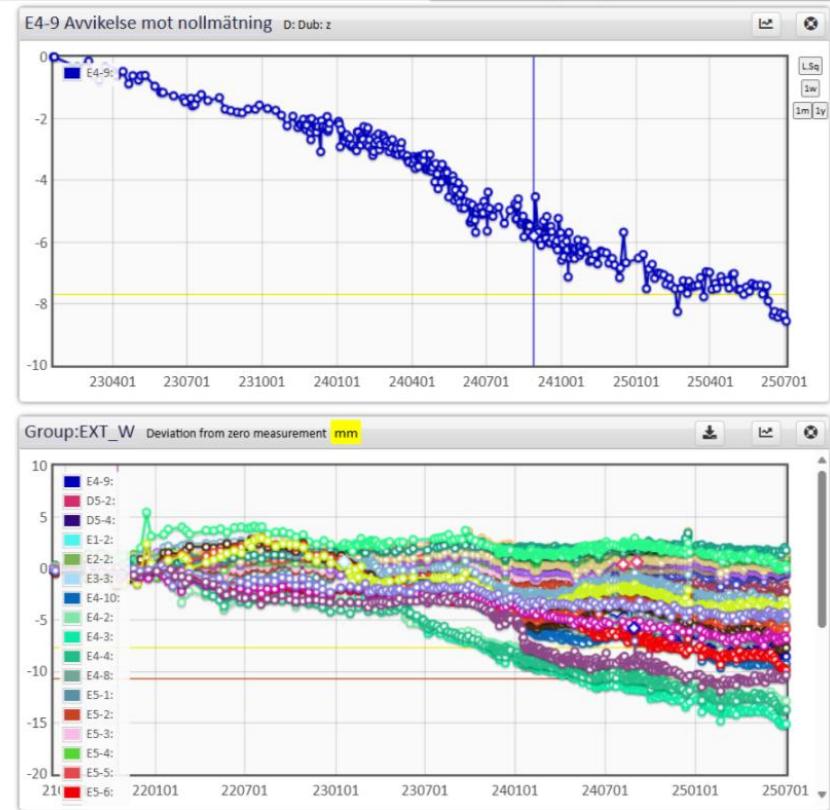
Koordinatsys. plan Koordinatsys. höjd

Links
Link to Projektnav map
E05: 57.69577707, 11.98421769

Link to external maps
Google Maps | Geo: URL

Larm/Rict/Green values Larm mot Measures 0

Alarm.Nr Naming

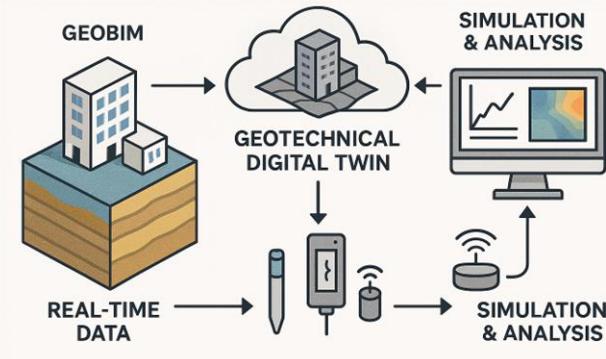


DO WE HAVE A DIGITAL TWIN?

A geotechnical digital twin is a dynamic, virtual representation of a geotechnical system (soil, rock, and associated structures) that is continuously updated with real-world data, including sensors, measurements, and models, to reflect its current and future state.

It combines 3D models of geology and structures with real-time data and computational models to enable simulation, analysis, and decision support throughout the entire lifecycle of a project.

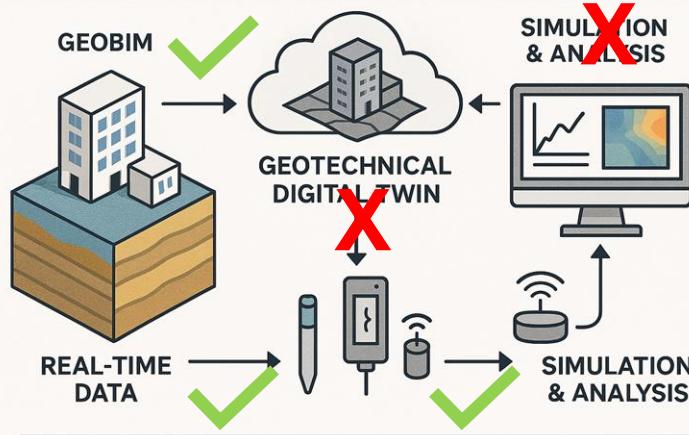
Source: Various....



ARCHITECTURE OF A GEOTECHNICAL DIGITAL TWIN

Figure by Copilot

DO WE HAVE A DIGITAL TWIN?



- Structured data flow
 - all subsurface disciplines
 - geotechnical structures (objects)
 - monitored data (time series)

- In the same database
 - Field and lab data
 - 3D models
 - Geotechnical structures
 - Monitored data

=> NO

Figure by Copilot

FUTURE WORK

- Develop a data pipeline to collect and store sensor data in real time
- Implement an analysis engine:
 - Signal processing (filtering, noise reduction)
 - Trend analysis and anomaly detection
- Connect to geotechnical calculation models
 - Plaxis, GeoStudio (SLOPE), inhouse applications
- Automated feed back loop
 - Define rules and triggers
- Predictive functionality
 - ML to predict future conditions (stability, settlements)
 - Simulate scenarios based on incoming data and historical trends
 - Integrate with decision-support systems for proactive risk management



Small pilot project

THANKS

Mats.svensson@tyrens.se

www.tyrens.se

