

# IFC4.4 – Innhold og planlagt framdrift

Jan Erik Hoel



# Agenda

- Prosjektdeltakere og prosessen
- Kravinnsamling
- Konseptuell modell
- Viktigste aspekter med skjema utvidelsen
- Geometriske tillegg
- Uttestingsprosjektet



# ifcTunnel – Bidragsytere 2020-2023

## Infrastruktureiere:

- ANDRA (F)
- CFF-SBB (CH)
- TVK (S) / FTIA (FIN)

## Ingeniørfirma:

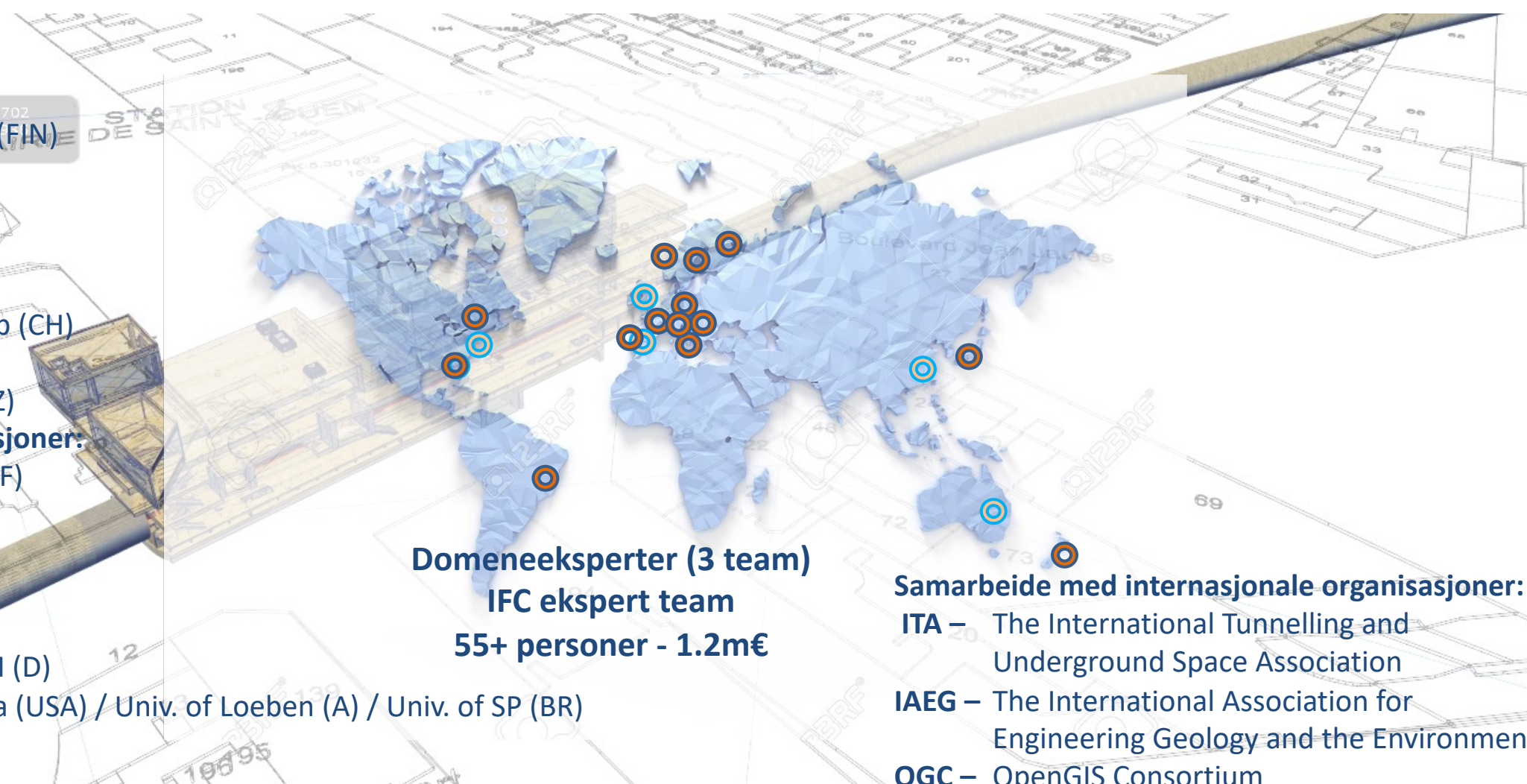
- IC-ELEA (SLO)
- GEODATA (I)
- ILF (CH)
- LOMBARDI Grp (CH)
- OYO (JPN)
- SEEQUENT (NZ)

## Nasjonale organisasjoner:

- DGTIM-CETU (F)
- NFF (N)**
- PTC (P)

## Forskning:

- MINnD (F)
- RUB (D) / TUM (D)
- Univ. of Florida (USA) / Univ. of Loeben (A) / Univ. of SP (BR)

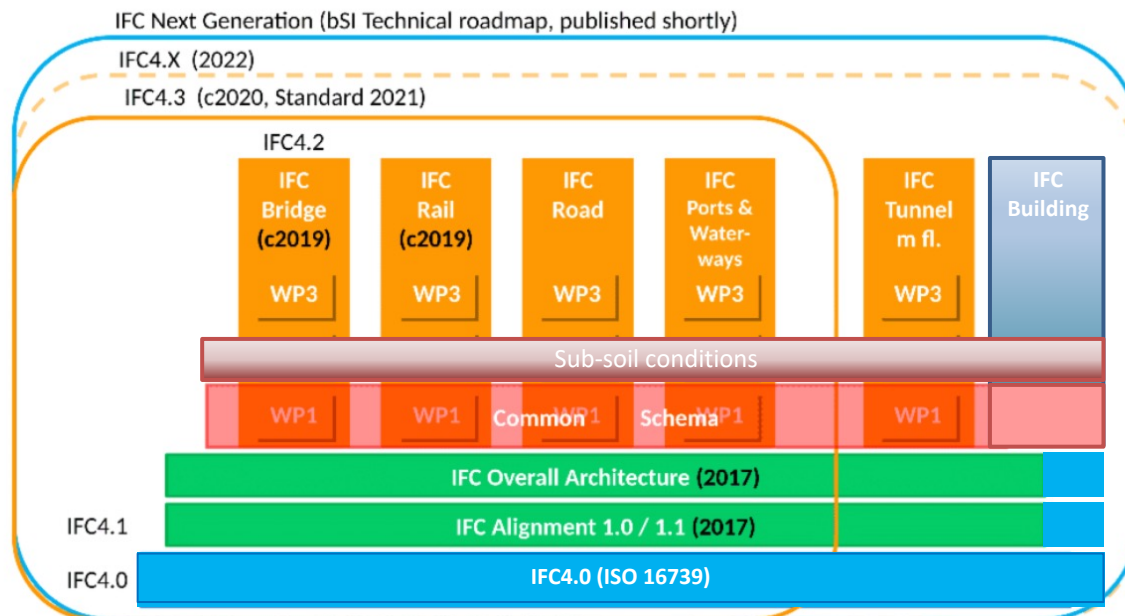


**Domeneekspertter (3 team)**  
**IFC ekspert team**  
**55+ personer - 1.2m€**

## Samarbeide med internasjonale organisasjoner:

- ITA** – The International Tunnelling and Underground Space Association
- IAEG** – The International Association for Engineering Geology and the Environment
- OGC** – OpenGIS Consortium

# bSI – IFC/ISO for infrastruktur prosjekter



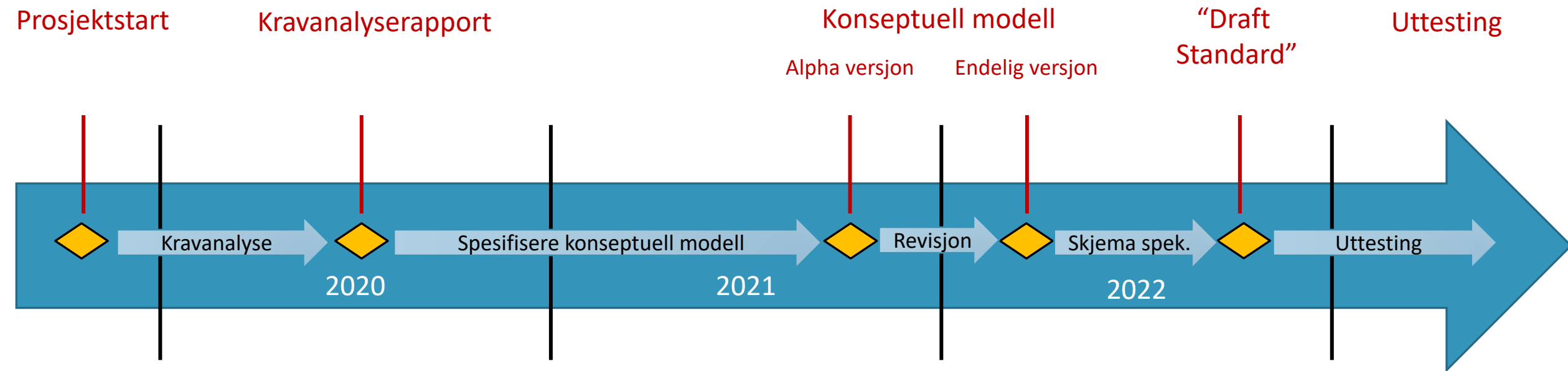
ETT samlet skjema for bygget miljø



ISO 16739 IFC inkl. IFC4.3



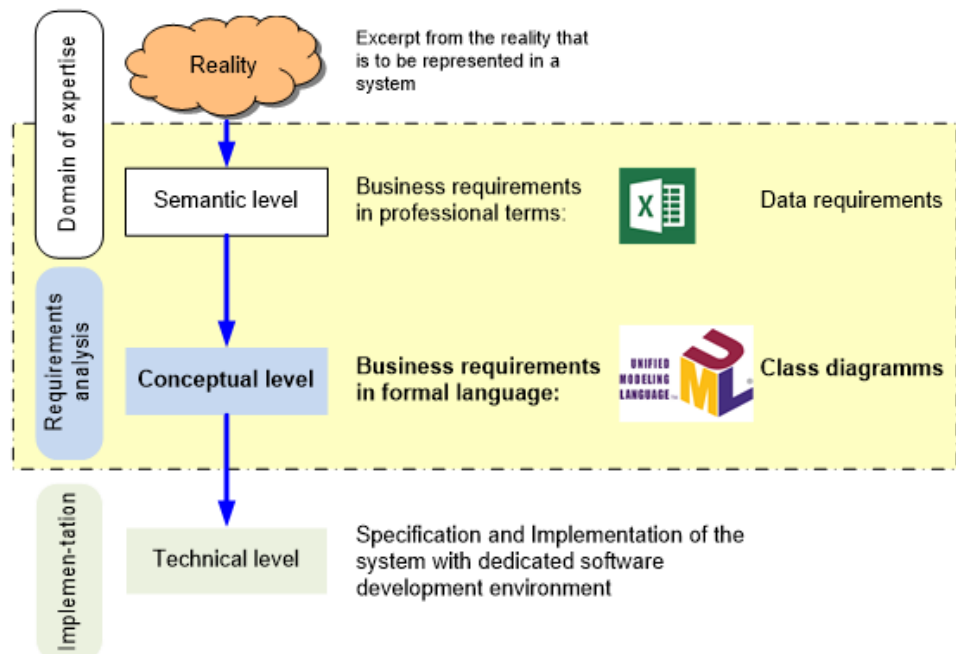
# Framdrift





# IfcTunnel – Brukerhistorier

Geologi/geoteknikk



Simuleringer og byggefaser

Domain conceptual model

Anbud

Bygging og statusoppfølging

Overlevering

- Initial state modelling	High Priority
- Geologic modelling	High Priority
- Geotechnical modelling for design	High Priority
- Geotechnical modelling for construction	High Priority
- Exchange of alignment and major road/railway parameters	High Priority
- Technical visualization	High Priority
- Realistic Visualization	Low Priority
- Safety visualization	Low Priority
- Design coordination	High Priority
- Design to design w. reference models	High Priority
- Design to design w. full model logic	Out of Scope
- Structural & geomechanical analysis	Low Priority
- Air flow simulation	Low Priority
- Standards compliance	Low Priority
- Quantity take-off	High Priority
- Construction sequencing	High Priority
a - Design to tender: Construction Model	High Priority
b - Design to tender: Geotechnical Model	High Priority
- Design to construction - DONE	High Priority
- Prefabrication	Low Priority
a - Progress monitoring	High Priority
b - Geological monitoring - DONE	High Priority
c - Scanning during construction	Low Priority
d - Quantity determination for billing / payment	High Priority
- Machine guidance & control	Low Priority
- Damages recording	Low Priority
- Settlement monitoring	Low Priority
- Handover to GIS	High Priority
- Handover to AM	High Priority



# IfcTunnel – Krav konsensus

## Revisjonsprosessen for krav

3 måneder/ 10 land

200+ kommentarer/forslag

⇒ Justerte krav

### Feedback:

ITA I AEG DACH F I JPN N NZ S US

### Subjects:

- Geometry & geopositioning
- Spatial structure & project structure
- Geology & geotechnics
- Excavation
- Excavation support
- Lining & water proofing
- Tunnel subsystems

	ITA	AEG	DACH	F	I	JPN	N	NZ	S	US
Geology & geotechnics	X	X	X	X	X	X	X	X	-	X
Excavation	X	-	X	X	X	X	X	-	X	-
Excavation support	X	-	X	X	X	X	X	-	X	-
Lining & water proofing	X	-	X	X	X	X	X	-	X	-
Tunnel subsystems	X	-	X	X	X	X	-	-	-	-

Chapter	Subject	Page	Date	Comm. nbr	Comments
9	Excavation requirements	135			
9.1	Overview				
9.1.1	Abbreviations				
9.1.2	Conventional tunnelling				
9.1.3	Mechanised tunnelling				
9.1.4	Cut-and-cover tunnelling				
9.2	Semantics				
9.2.1	Conventional tunnelling				
9.2.2	Mechanised tunnelling				
9.2.3	Cut-and-cover tunnelling				
9.3	Geometry				
9.3.1	Conventional tunnelling				
9.3.2	Mechanised tunnelling				
9.3.3	Cut-and-cover tunnelling				
10	Excavation support, ground improvement, water				
10.1	Excavation support				
10.1.1	Conventional tunnelling				
10.2	Ground improvement and water control				
10.2.1	Conventional tunnelling				
10.2.2	Mechanised tunnelling				

Chapter	Subject	Page	Date	Comm. nbr	Comments
11	Tunnel systems requirements	135			
11.1	Systems, sub-systems, components & characteristics	135			
11.1.1	Systems, sub-systems, components & characteristics	135			
11.1.2	Systems required during construction	136			
11.1.3	Existing Ifc4.3 objects vs specific IfcTunnel objects	137			
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11.6.2	Energized equipments during tunnel construction	155			
11.6.3	Main components and characteristics	155			
11.7	Drainage	158			

Chapter	Subject	Page	Date	Comm. nbr	Comments
3	Use cases	10	22/02/2021		For UC 1 - Initial State Modelling - Required semantic information for existing structures should include: loads brought to the ground + sensitiveness to displacement
		10&11	22/02/2021		UC 2x - ISO standards for Geotechnics should be mentioned similarly as for UC 15b
		12	22/02/2021		UC 4c - Safety visualization - Would consider Priority medium or high (often requested by customers)

International Association for Engineering Geology and the Environment

IAEG C25 – ENGINEERING GEOLOGICAL MODELS

Comments on IFC Tunnel Project Report WP2: Requirements analysis report (RAR)

At the suggestion of Pat McLarin of Sequent, Steve Parry (past Chair) and Fred Baynes (current Chair) of IAEG Commission 25 prepared these comments.

The aim of the project is stated as "to create and provide the engineering and construction industry with an open BIM data exchange standard capable to exchange and archive tunnel models in a neutral ISO format that is vendor-independent and persistent for the long run" (p7). I.e. its primary focus is on digital data exchange. However, the report is considerably broader and includes, for example geological and geotechnical attributes to be captured as well as discussing visualization.

The report uses the term model and modelling but these are not defined.

This classification can be based on geological categories like e.g., age, stratigraphy and structural-tectonic position of lithology ("geological model") or the mechanical material properties and aspects relevant for design and construction ("geotechnical design models") (p50). Although it is noted that Figure 8-3 uses the term "engineering geological models".

Whilst such definitions of models have been adopted by others, problems with the use of "geological models for engineering purposes" have been documented (Knoll 2003, Sullivan 2010) and consequently IAEG C25 (Parry 2014) use the term Engineering Geological Model (EGM).

In addition, and more importantly with respect to IFC WP2, C25 divided EGMs into two types, those based on conceptual ideas and those based on observational data. Whilst the term "conceptual model" is used in WP2 a definition is not provided but it does not align with that used in C25.

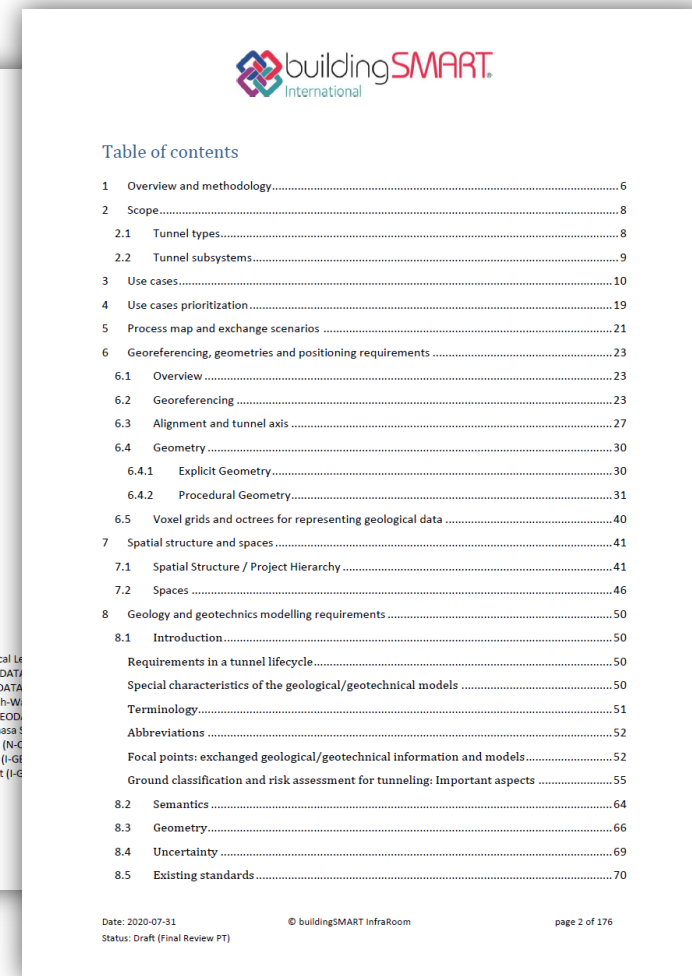
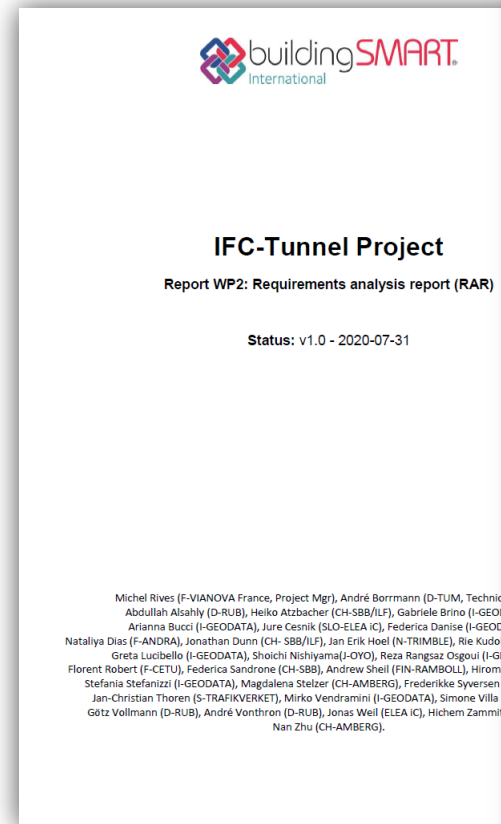
IAEG C25 (Parry et al., 2014) note that conceptual models are "based on understanding the relationships between engineering geological logs, their likely geometry, and anticipated distribution and are developed from pre-existing information based on geological concepts within a general context of civil engineering. They potentially involve a relatively high degree of uncertainty which is directly related to the type and amount of existing data and the knowledge and experience of those involved. However, when such models are proficiently developed, they provide an extremely powerful tool for appreciating and communicating what is known about a site, what is conjectured and where

1 of 4



# IfcTunnel – Kravanalyse rapport

- **Kravanalyserapporten** baserte seg på input fra domeneekspertene.
- Dokumenterte:
  - Prioriterte brukerhistorier
  - Prosesser
  - Dataoverføringsscenarier
  - Generelle konsepter
    - Georefering, Geometri, Linjeberegning, ...
  - Detaljert beskrivelse av spesifikke temaer:
    - Geologi/geoteknikk
    - Tunneldriving, sikring, innerkledning
    - Systemer



[https://publications.cms.bgu.tum.de/reports/IR-TUN\\_Requirement-Analysis-Report\\_v1.0.pdf](https://publications.cms.bgu.tum.de/reports/IR-TUN_Requirement-Analysis-Report_v1.0.pdf)

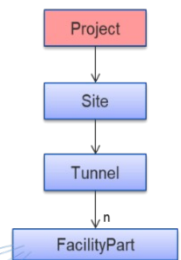
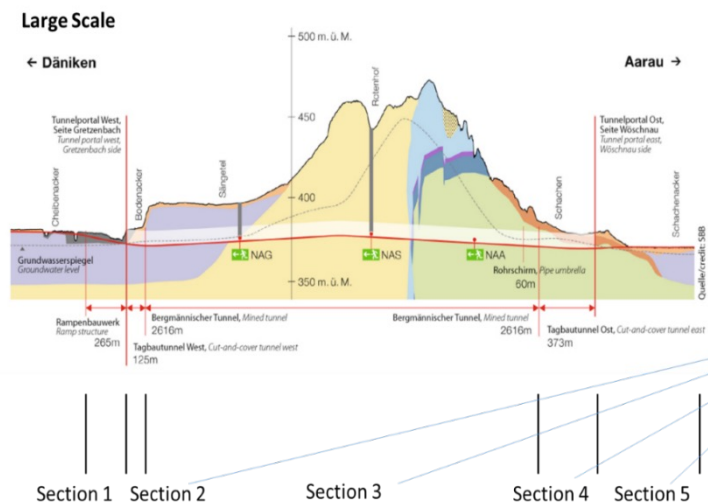




# IfcTunnel – Romlig nedbrytning

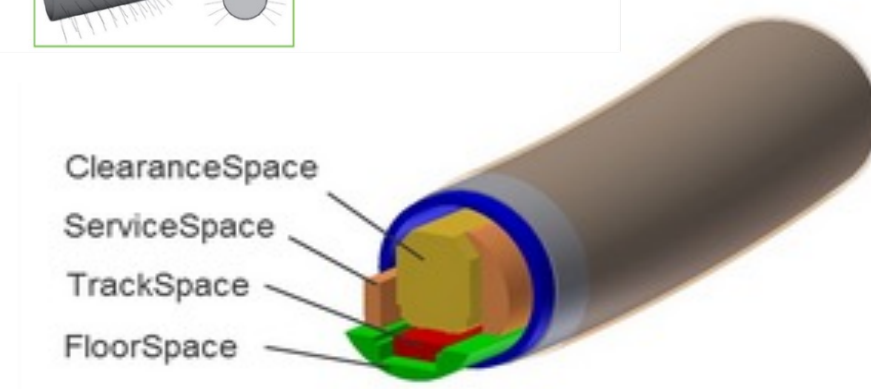
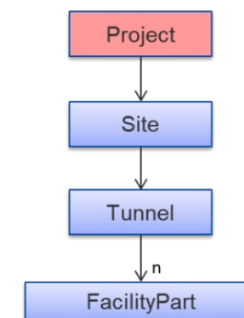
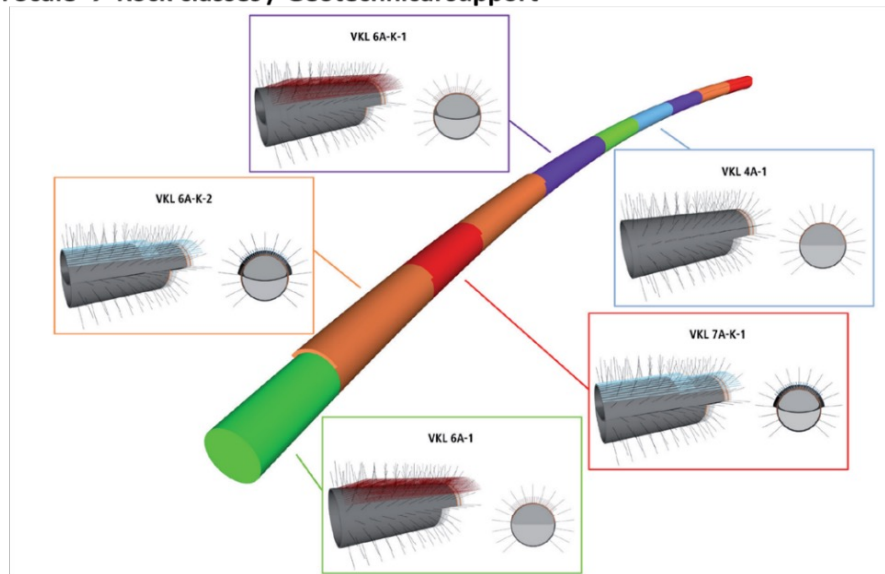
## ■ Fleksibel nedbrytningsstruktur krever:

- Ulike skalaer:
  - Stor / medium / liten
- Ulike retninger:
  - Langsgående / på tvers / vertikalt



Credit/Source: SBB

## Medium Scale → Rock classes / Geotechnical support



# IfcTunnel – Romlige definisjoner



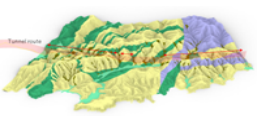
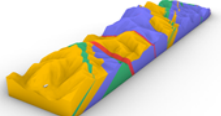
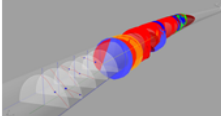
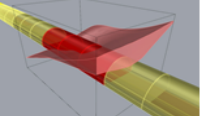
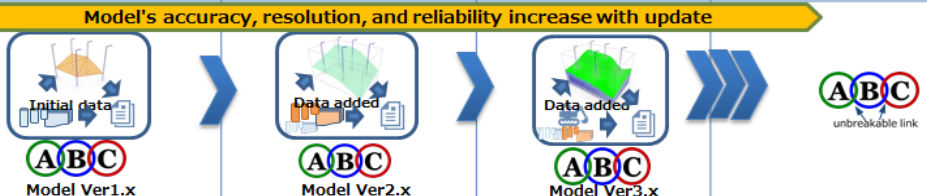
Romlige definisjoner som kan benyttes for beskrive **Tunneldriving-, sikring- og innerkledningsprosesser**

Romlige definisjoner som kan inneholde **systemer og utstyr**



# IfcTunnel – Geologi og geoteknikk

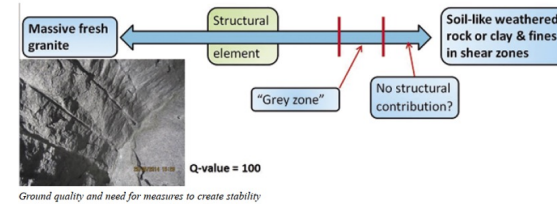
- Geologi/getoteknikk er ikke godt nok definert i IFC4.3 eller av OGC
- Beskrivelse av lag og diskontinuiteter (slepper, sprekker osv)
- Sentrale utfordringer: **Usikkerhet** som fører til **risiko**
- Skiller klart på:
  - Registrerte data: “Bok A”
  - Tolkede data: “Bok B”
  - Prosjekterte tiltak: “Bok C”
- Kobler og harmoniserer mot eksisterende standarder:
  - OGC GeoSciML, DIGGS, AGS

Lifecycle stage	Plan & Investigation	Investigation & Design	Construction	Maintenance
Primary objective of modeling	Tunnel routes / alignment studies (UC 2a)	Tunnel Design (UC 2b, 12b)	Construction management (UC 15b, 2c, 12b)	Measures to deformation and damage (2C)
Model example	 Regional-scale engineering-geological model	 Tunnel-scale engineering-geological model	 Geol. Tunnel Docu./as-built model	 As-built model for specific area
Modeling area	Relatively wide area including potential tunnel routes	Around the tunnel corridor	Around the tunnel excavation	Selection of previous models around zones of interest
Approx. resolution required to the model	>10m mesh	<10m mesh	Down to 0.1m mesh	Down to 0.1m mesh
Input data for modeling <b>Book A: Factual Data</b>	<ul style="list-style-type: none"> <li>• Previously existing data and first project-specific site investigation results</li> </ul>	<ul style="list-style-type: none"> <li>• Pre-existing data</li> <li>• Mainly project-specific site investigation results (including field mapping)</li> </ul>	<ul style="list-style-type: none"> <li>• Pre-existing data</li> <li>• Site investigation results</li> <li>• Geol. tunnel (and other) documentation, additional investigation</li> </ul>	<ul style="list-style-type: none"> <li>• Pre-existing data</li> <li>• Site investigation results</li> <li>• Data obtained during construction</li> <li>• maintenance data</li> </ul>
Model content <b>Book B: Interpreted models</b>	<ul style="list-style-type: none"> <li>• Regional topography, geology, hydro-geology, etc.</li> <li>• Engineering-geological aspects to be considered for tunnel route selection (potential hazards)</li> </ul>	<ul style="list-style-type: none"> <li>• Geological conditions and geotechnical design parameters (like rock mass strength, permeability, discontinuity pattern etc.)</li> <li>• Engineering-geological aspects to be considered for tunnel design and construction (potential hazards)</li> </ul>	<ul style="list-style-type: none"> <li>• Encountered geological and geotechnical conditions</li> <li>• Potential hazards during construction</li> </ul>	<ul style="list-style-type: none"> <li>• Relationship among damage area, geotechnical condition and tunnel</li> </ul>
Implications <b>Book C: Design solutions and applications based on the interpreted models</b>	<ul style="list-style-type: none"> <li>• Decisions on alignment, land acquisition, etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Ground behaviour, construction method, support measures, ground improvement, system behaviour, excavation classes etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Observation and interpretation of displacements</li> <li>• Adjusted prediction of expected geotechnical conditions</li> <li>• Safety management</li> <li>• Comparison to predicted conditions</li> </ul>	<ul style="list-style-type: none"> <li>• Safety monitoring, routine maintenance works, counter measures for damages etc.</li> </ul>
Remarks	<ul style="list-style-type: none"> <li>• The model (B) should be accompanied by the base data (A) to enable an update with new data and to evaluate the model's uncertainty</li> <li>• The implications (C) depend on the model and should be linked to it</li> <li>• Consequently, ABC should be linked as one package and be delivered next phase.</li> </ul>			
Schematic drawing of the inheritance of the geological/Geotechnical models through the life cycle of a tunnel.	<p style="text-align: center;"><b>Model's accuracy, resolution, and reliability increase with update</b></p> 			

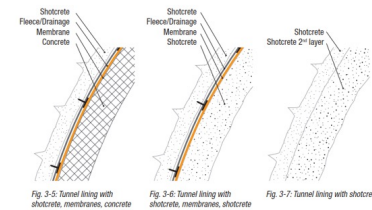
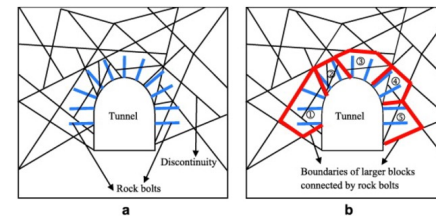
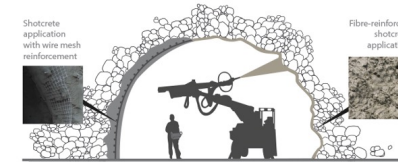


# IfcTunnel – Tunnel driving

- Tunnel drivingsmetoder
  - Tunnelboremaskin (TBM)
  - Boring og sprengning
  - “Cut and cover”

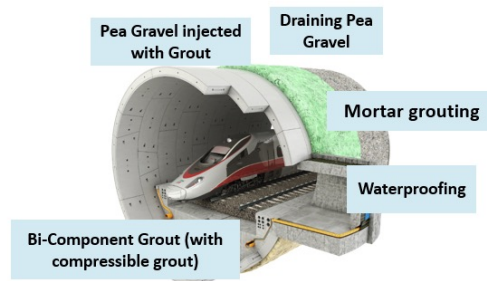
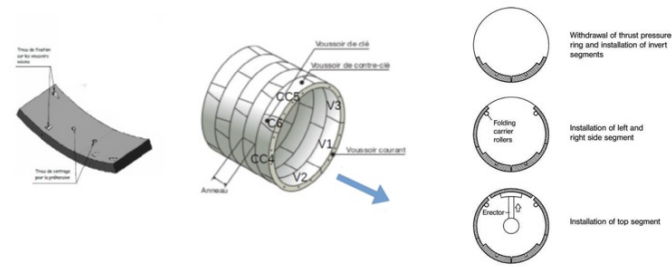


## Boring og sprengning

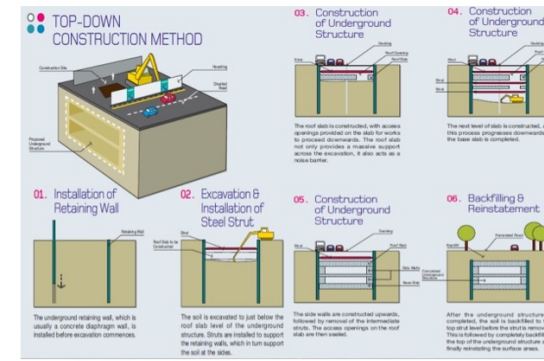


Lining types

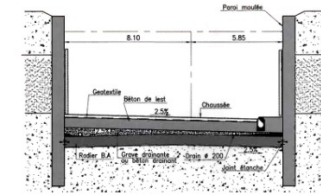
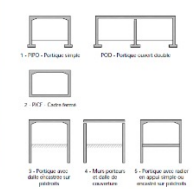
## TBM



## Cut & cover



Retaining walls  
 Covered structures



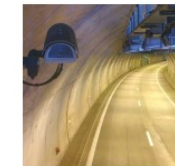
# IfcTunnel – Tekniske systemer

- Ventilasjon
- Brann
- Drenering
- Elektrisitet
  - Lav- og høyspenning
- Sikkerhet og evakuering
- Kommunikasjon



### Ventilation

- Civil engineering associated to ventilation
  - Air ducts Civil engineering : galleries, shafts, tunnel ducts, branches
  - Premises, units, factories, central ventilating
  - Arrangements in tunnel, bosses
- Electromechanical
  - Electro-fan (and its control accessories)
  - Accelerator (and its control accessories)
  - Disconnecting devices: registers, motorized hatches, valves, doors
- Sensors
  - Air quality: CO, NOx
  - Air quality: opacimeter
  - Anemometer
  - Tunnel air temperature sensor
  - Weather station
- Other
  - Organs of Acoustic attenuation

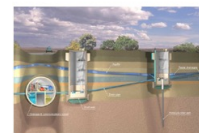


### LowVoltage / Energized Equipements

- Power supply
  - High tension
  - Transformation
  - Low tension
  - Wiring
- Lighting
  - Devices
  - Junction box
  - Sensors
  - Runway lights
- Networks
  - Optical Fibre junction box
  - Optical Fibre cable
  - Switch
  - Network Supervisor
- Centralised Technical Management system / Oversight
  - Programmable logic controllers
  - Remote output input module
  - Supervisory server
  - Archiving server
  - Supervision
  - Maintenance station
- Video surveillance
  - Shooting equipment
  - Automatic Incident Detection
  - CCTV system
  - Visualization system
- Emergency Call Network
  - Business Continuity Plan (BCP)
  - Emergency Call Station
  - Server of Emergency Call Station
  - radiating cable
  - Mast
  - Antenna
  - Transmitter / receiver
  - Radio station

### Drainage

- Network of Drainage - Sanitation
  - Identification data of drainage-sanitation network
  - Typology of drainage sanitation network
  - Information of network control
  - Information of network construction (activities)
  - Information of Network Maintenance (Activities)
  - Information of network dismantling (activities)
  - Transport of effluents
  - Absorption of effluents (terminals)
  - Access to the network (sewing)
  - Management of effluent
- Drained Space
  - Typology of drained space
  - Typology of effluents
  - Liaisons between objects
  - Topological data of collected surface
  - Hydraulic surface data collected
- Water point
  - Typology of water point
  - Data of water point identification
  - Liaisons between objects
  - Hydraulic data of water point



### HighVoltage / Traction

- Aerial High Voltage
  - Delivery point of Aerial High Voltage
  - Artery of Aerial High Voltage
- Low Voltage Distribution
  - Force Lighting Station / Force Station
  - Emergency power - Uninterrupted power supply and generator (room for battery and generator)
  - System protection and grounding system
- TRACTION
  - Traction Substation + Switching Station
  - Traction Distribution
  - Traction Control Feedback Circuit
  - Staking energy recovery system
- Autonomous systems
  - Autonomous production plant
  - Low Voltage Distribution



### Fire protection

- Fire Water supply
  - From the public network
  - Water connection point and counting
  - Storage / Cistern
  - Group of Pressurizing
  - Room for Pressurizing Group
- Delivery
  - Description of the network
  - Underground pipe
  - Culvert
  - Overhead line
  - Description of the freeze protection
  - Insulating
  - Electric tracing
  - Axis
  - Pressurizing Pressurizing
  - Device to prevent pressure checks
  - Pipe (object) / branch of network (for calculation)
  - Canteleins (leads)
  - Pipe (interface)
  - Pipeline (ducts) / (range)
- Restitution
  - Recess for a fire hydrant or surge
  - Fire hydrant
  - Surge
  - Connector
  - Taps (Product / Range)
  - Hydromaturation
  - Electrical tracing
  - Corrosion protection

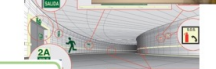


- Signage and Safety Equipment
  - Closing and signaling
  - Auto-rescue
  - Security niche
- Ventral local
  - Ventilation ducts
  - Technical premises
  - PAU and possibly sound device
  - Signage (after the tunnel gate to the assembly point)

- Shelters with tracking
  - SAs
  - Waiting area
  - Geometry related to pedestrian traffic (connection with the outside, for users and rescue)
  - Doors
  - Ventilation of the shelter (including overpressure)
  - Ventilation of the path (direct connection with the outside)
  - Lighting
  - Fire resistance
  - PAU
  - Sound system (speaker)
  - Signage (after the tunnel gate to the assembly point)

### Safety / Evacuation

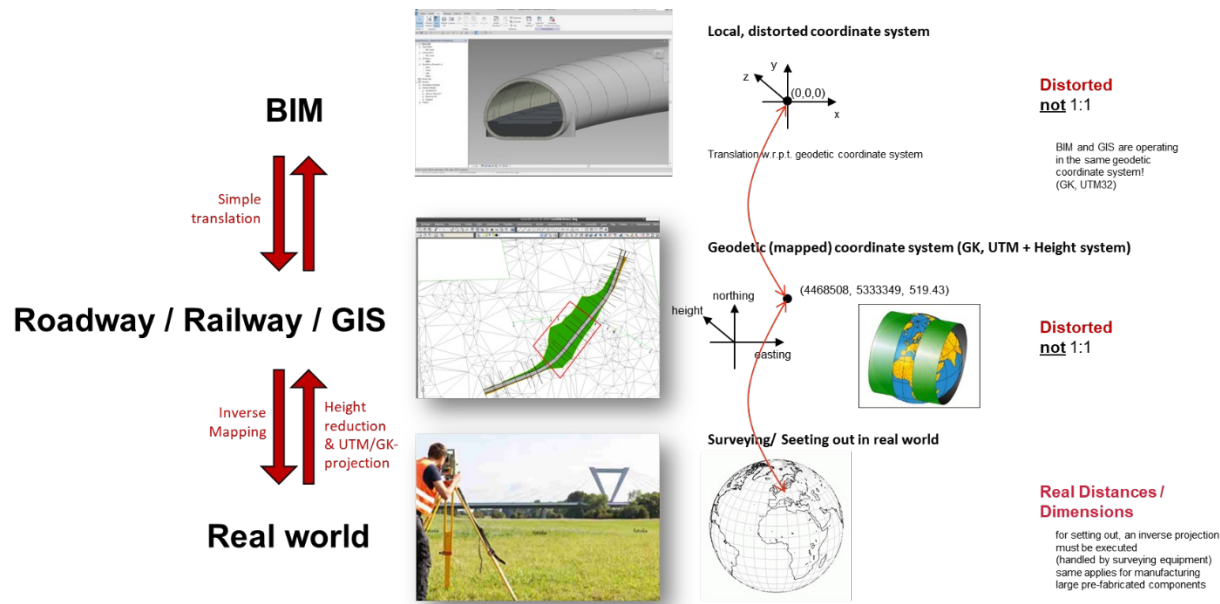
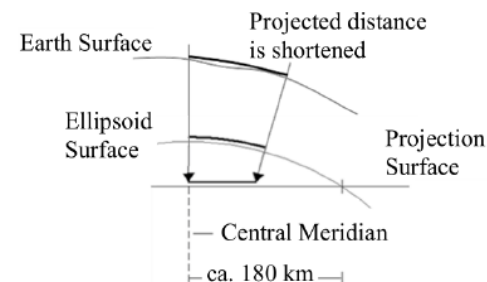
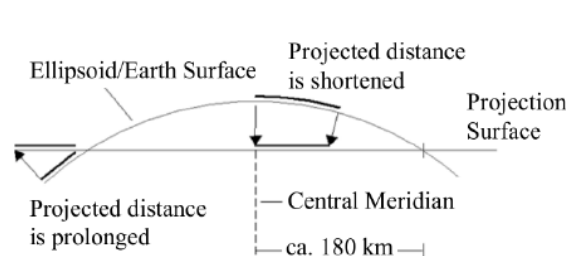
- Specific equipment in tunnel
  - Flash fire
  - Guide chevron
  - NETS
- Lighting in case of evacuation
  - Positioning of the flash lights
  - Positioning of the rafters
- Sound system
  - Positioning
  - Characteristics
  - Sirens
  - Sound beacon
- Airlock
  - Dimensions
  - Characteristics
  - Ventilation
  - Doors
- Waiting area
  - Dimensions
  - Characteristics





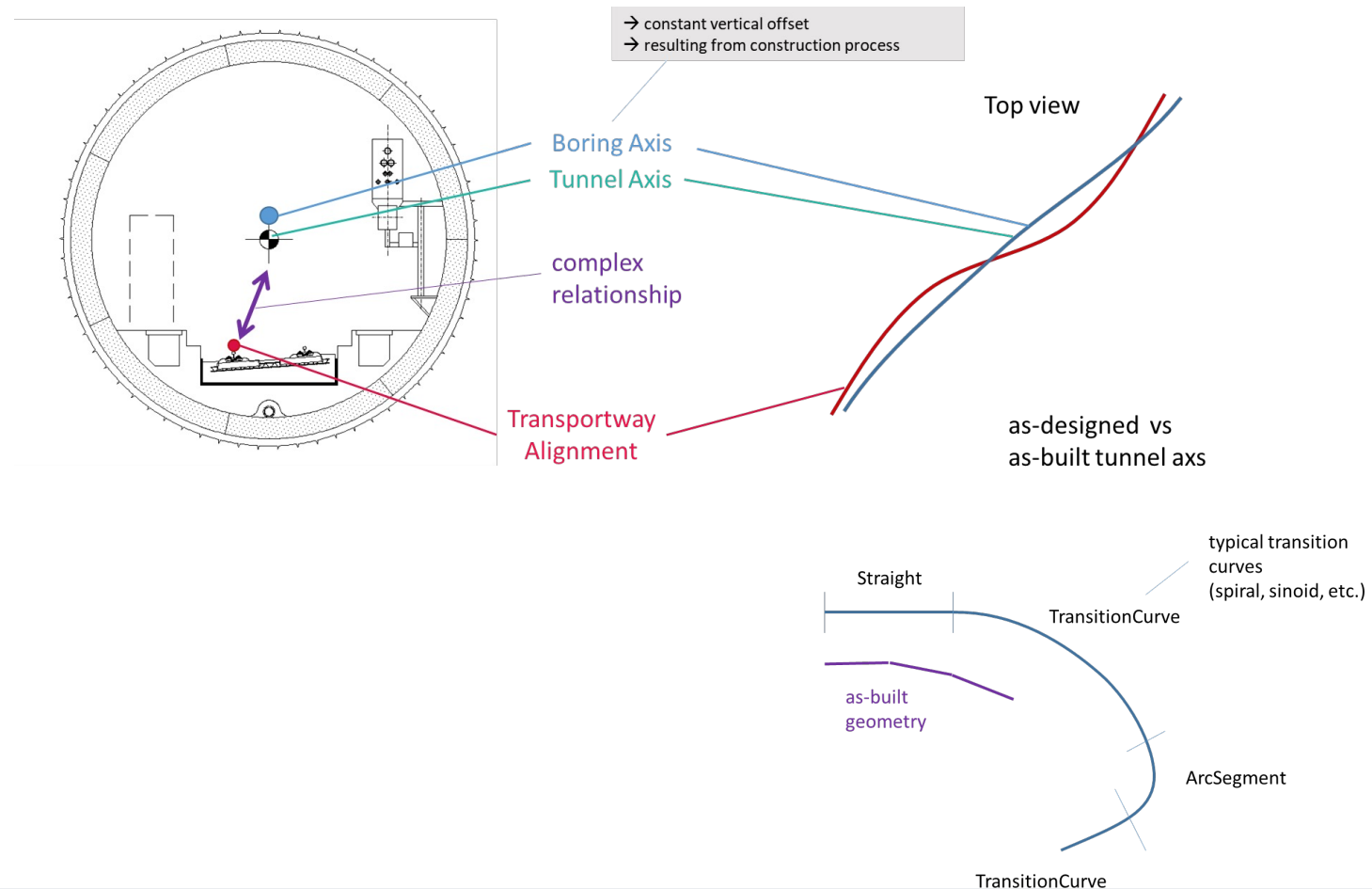
# IfcTunnel – Koordinatreferanser

- Lange tunneler er typisk prosjektert basert på et geodetisk koordinatreferansesystem.
- Geodetisk koordinatreferansesystem er basert på en projeksjon.  
→ De har en fordreining
- IFC må tilby en klar og utvetydig definisjon for å unngå feiltolkninger.



# IfcTunnel – Geometri: Referanselinjer

- Referanselinjer er viktige for:
  - Tunnel akse
  - Basis for “swept” geometri
  - Plassering av elementer lang aksen
- Skiller mellom:
  - Referanselinjen for vei/ jernbane
  - Bore aksen (som prosjektert)
  - Tunnel aksen (som bygget)
- IFC 4.3 oppfyller alle kravene:
  - Ikke nødvendig med utvidelser i IFC4.4



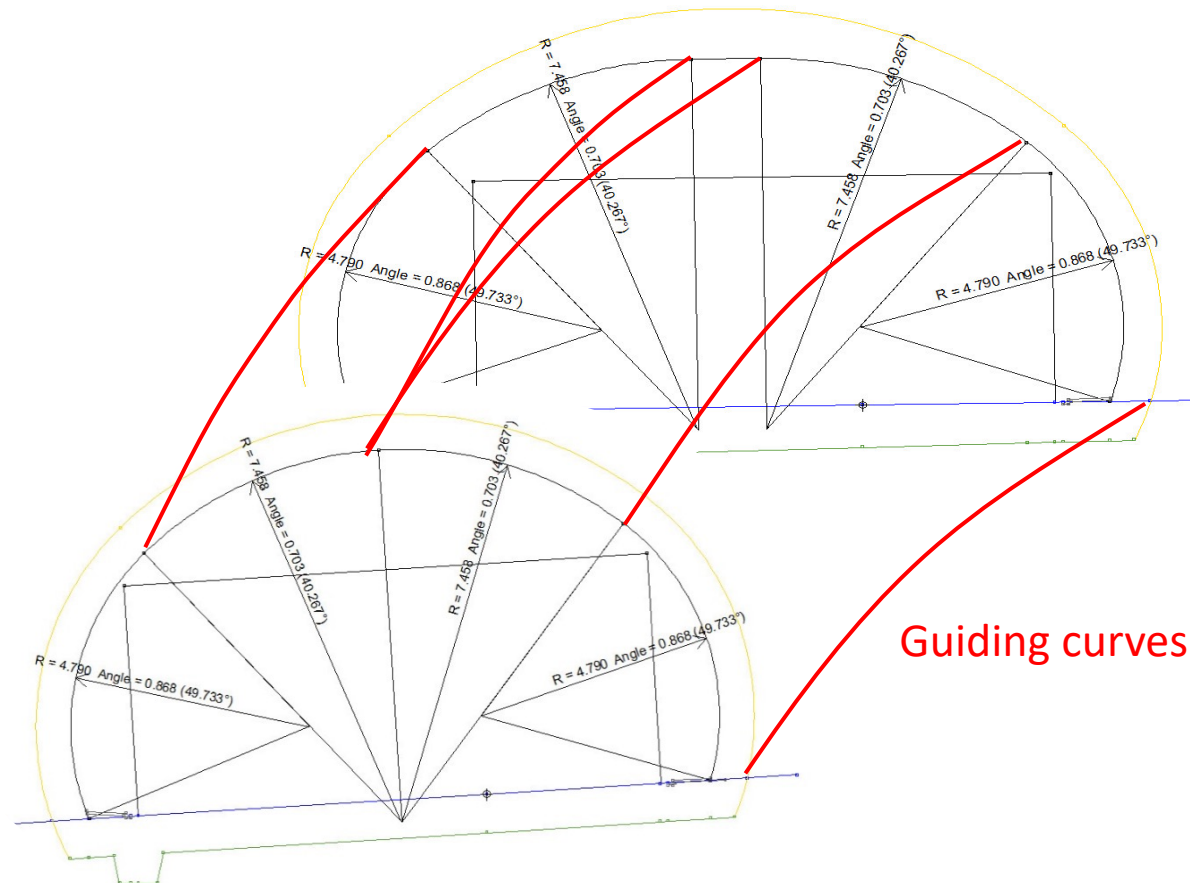




# IfcTunnel – Geometri: “Guided Sweep”

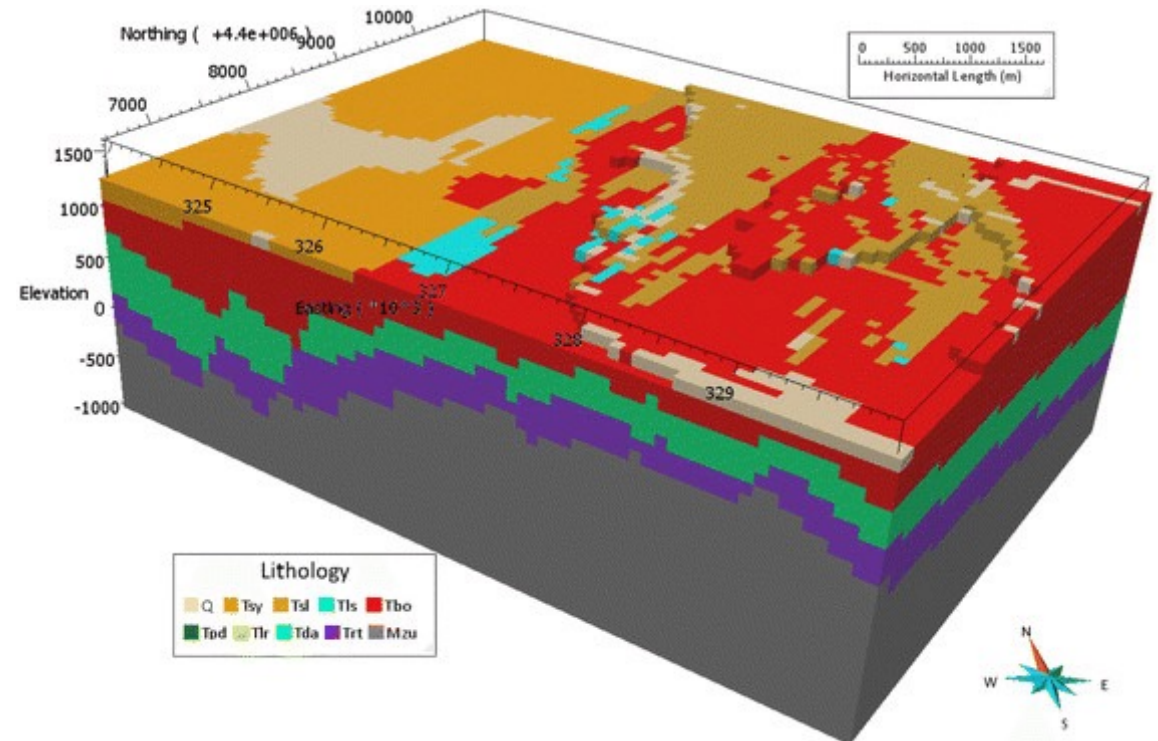
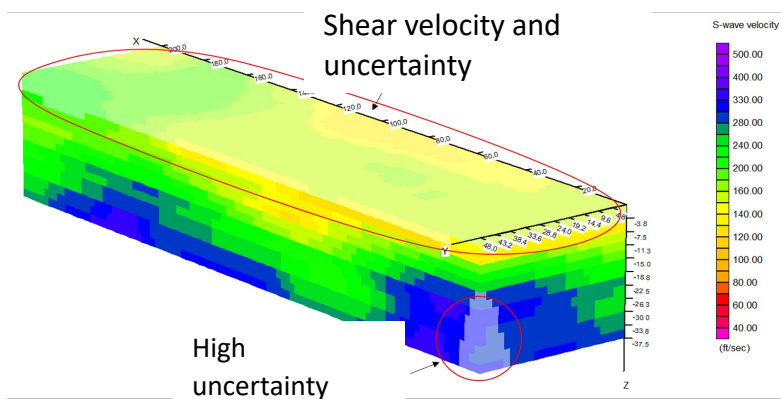
## “Guided Sweep”

- Varierende tverrsnitt langs referanselinja.
- Definerer interpolasjonen mellom tverrsnitt med “Guiding Curves”.
- “Guiding Curves” kobler tilhørende punkter i to etterfølgende tverrsnitt.



# IfcTunnel – Geometri: Voxel representasjon

- Voxel representasjon støtter romlig variasjon av vareierende grunnforhold **uten å måtte definere spesifikke avgrensninger**.
- Kan benyttes for å modellere usikkerhet og risiko bl.a..



Source: Witter et al. 2016

# IfcTunnel (IFC4.4) – Uttesting

**Målsetning: Teste ut dataoverføring og dokumentasjon, skjemavalidering**

Deltakere:

- Leverandører av kommersiell prosjekteringsprogramvare
- Leverandører av kommersielle databaseløsninger
- Leverandører av kommersielle bibliotek:
  - GeometryGym / ODA / RDF / Rhino / SafeSoftware / THC / Unity3D
- Konsulentfirma som utfører løsningsintegrasjoner
- Skreddersømløsninger
- Maskinstyringsprogramvare
- Valideringsløsninger for IFC-filer:
  - ACCA / IfcOpenShell / THC
- BIM Innsynsverktøy
- BIM samordningsplattformer

Pr. i dag er det 9 firma som deltar aktivt.

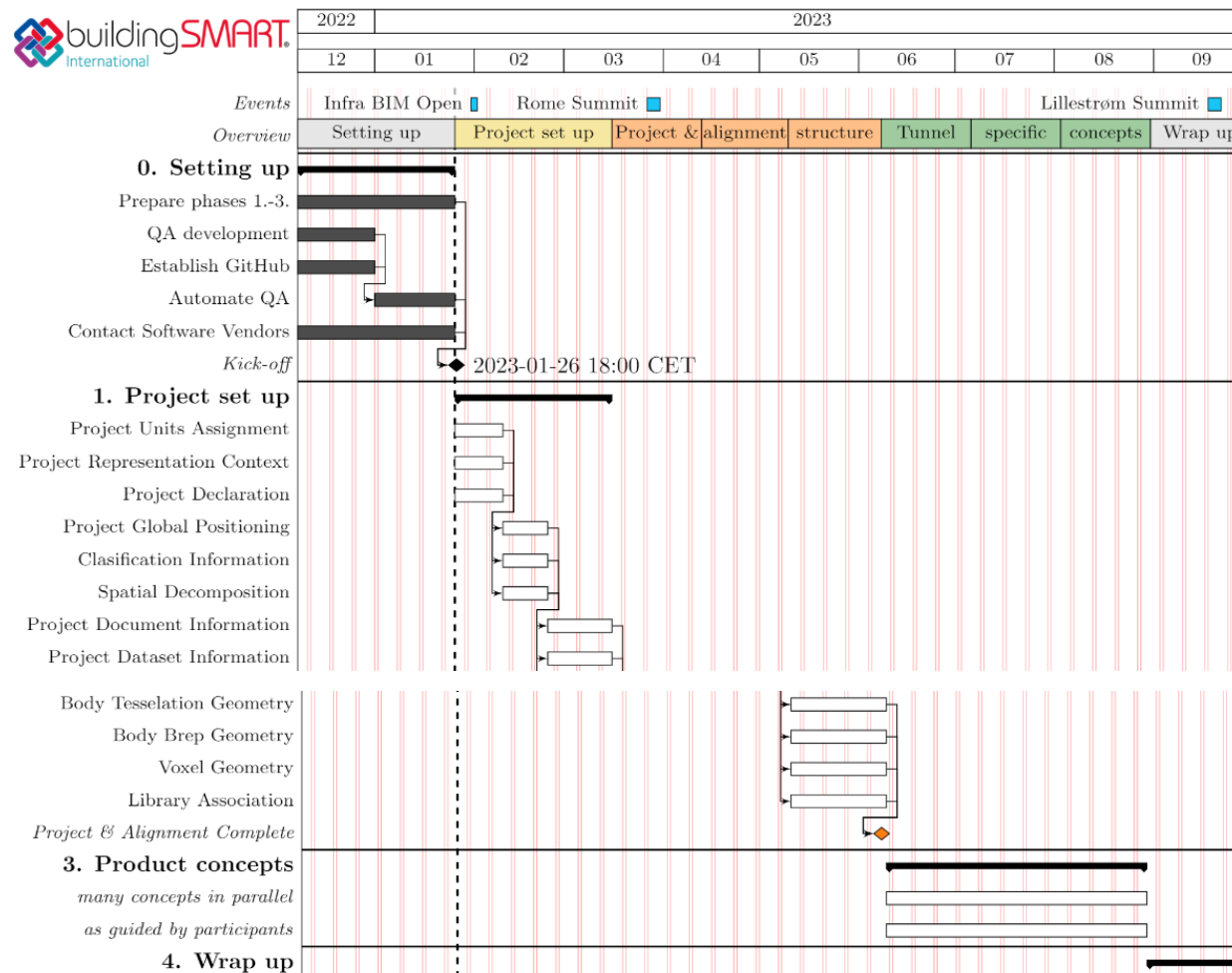
<https://github.com/bSI-InfraRoom/IFC-Tunnel-Deployment>





# IfcTunnel (IFC4.4) – Uttesting

## Tidsplan



- Uttesting gjennomføres i sprinter
- Produserte filer valideres automatisk ved innsjekk i GitHub
- Ukentlige møter