MOTT MACDONALD

Bergen: A Case Study

Jim Sherry & John McInerney

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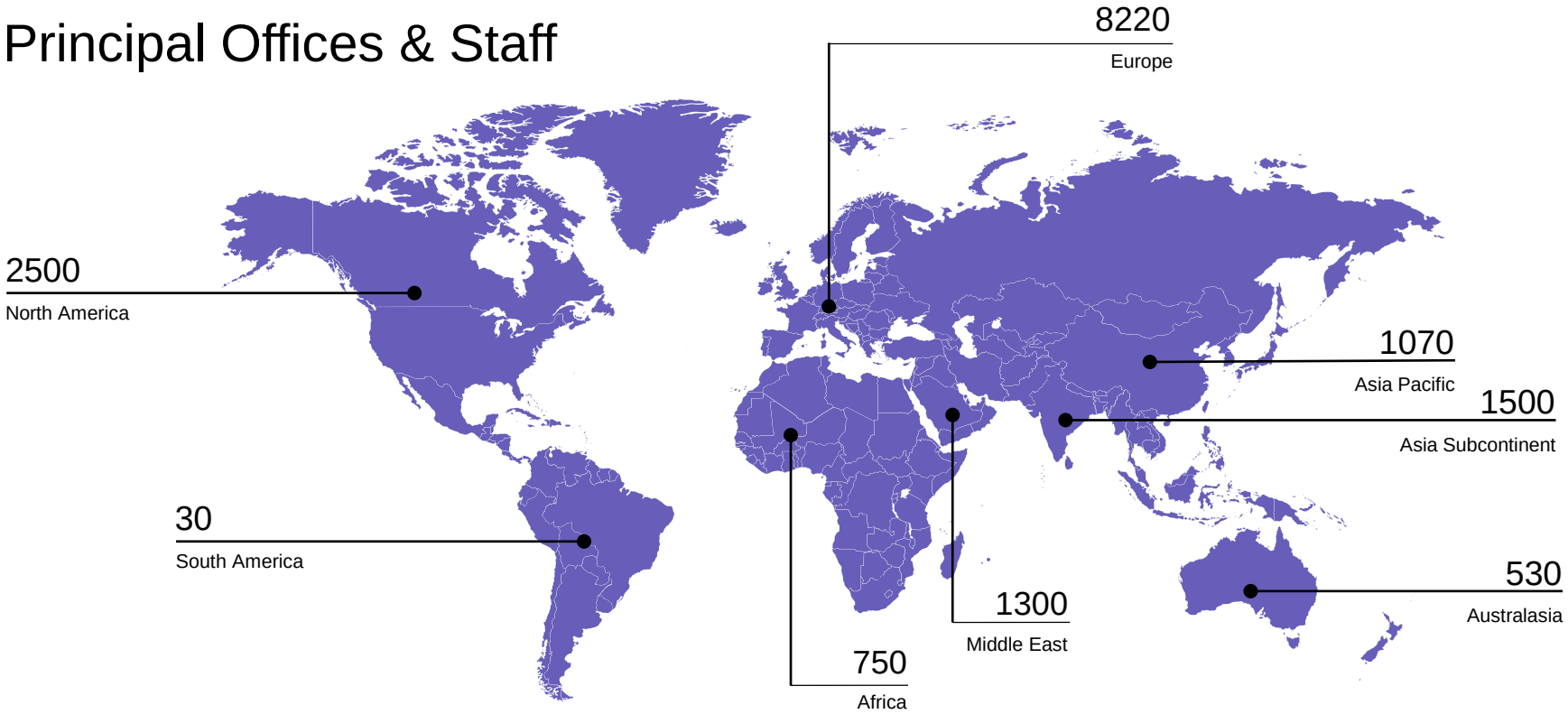
Introducing Mott MacDonald

We’re a global engineering, management and development consultancy focused on guiding our clients through many of the planet’s most intricate challenges.

Mott MacDonald Group – Key Statistics

Global Management, Engineering and Development Consultancy

Principal Offices & Staff



North and South America Brazil Rio de Janeiro Canada Calgary AB Montreal QC Toronto ON Vancouver BC USA Akron OH Arlington VA Atlanta GA Austin TX Baltimore MD Birmingham AL Buffalo NY Canonsburg PA Cape May NJ Charleston WV Charlotte NC Chicago IL Chipley FL Cleveland OH Corpus Christi TX Dallas TX Daphne AL Delray Beach FL Edmonds WA Freehold NJ Fuquay-Varina NC Gilroy CA Hattiesburg MS Houston TX Iselin NJ Jacksonville FL Lakewood CO Lexington KY Los Angeles CA Mobile AL Morgantown WV Morristown NJ Murray UT New Iberia NJ New Orleans LA New York NY Orange CA Panama City FL Pearland TX Pensacola FL Philadelphia PA Pittsburgh PA Pleasanton CA Portland OR Raleigh NC Sacramento CA Salt Lake City UT San Diego CA San Francisco CA San Jose CA Scottsdale AZ Seattle WA Shreveport LA Tallahassee FL The Woodlands TX Tulsa OK Washington DC Waynesburg PA West Houston TX West Monroe LA West Springfield MA Westwood MA **Europe** Albania Tirana Bulgaria Sofia Czech Republic Prague France Paris Hungary Budapest Ireland Cork Dublin Italy Genoa Kazakhstan Astana Netherlands Arnhem Norway Bergen Poland Gdansk Warsaw Romania Bucharest Russian Federation Moscow Slovakia Bratislava Turkey Istanbul Ukraine Kiev UK Aberdeen Altrincham Belfast Birmingham Brighton Bristol Cambridge Cardiff Colwyn Bay Croydon Derby Edinburgh Exeter Glasgow Guildford Hinckley Inverness Leeds Lerwick Liverpool London Manchester Newcastle Norwich Reading Sheffield Southampton York Western Balkans Belgrade **Africa** Botswana Gaborone Democratic Republic of Congo Kinshasa Ghana Accra Kenya Nairobi Malawi Blantyre Mauritius Vacoas-Phoenix Mozambique Maputo Nigeria Abuja Lagos Rwanda Kigali Sierra Leone Freetown **South Africa** Cape Town Durban East London Johannesburg Mafikeng Nelspruit Polokwane Port Elizabeth Pretoria Richards Bay Tanzania Dar es Salaam Uganda Kampala Middle East Bahrain Manama Kuwait Kuwait City Oman Muscat Qatar Doha UAE Abu Dhabi Dubai South Asia Bangladesh Dhaka India Ahmedabad Bangalore Chennai Delhi Hyderabad Mumbai Pakistan Islamabad Lahore Asia Pacific China Beijing Hong Kong Shanghai Shenzhen Indonesia Jakarta Japan Tokyo Malaysia Kuala Lumpur Mongolia Ulaanbaatar Philippines Manila Singapore Taiwan Taipei Thailand Bangkok **Australasia** Australia Adelaide Brisbane Melbourne Perth Sydney New Zealand Auckland

Our Sectors

Advisory

Built environment

Energy

International development

Transport

Water

Mott MacDonald in Ireland

- Offices:

  Dublin, Cork and Belfast: > 150 staff

- Operational in Ireland:

  Over 40 years

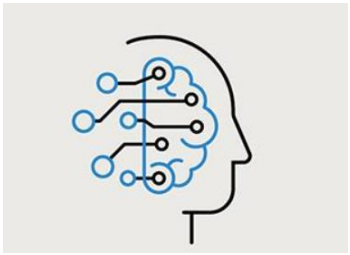
- Multidisciplinary Consultants:

  Design, project management and commercial services

- Sectors:

  Transport, Water Power, Environment, Built Environment

Building Information Modelling (BIM)



Go Digital: Innovating through technology and data to shape better insights, solutions and outcomes; simplifying and connecting what we do, delivering excellence to our clients today and opening opportunities for tomorrow.

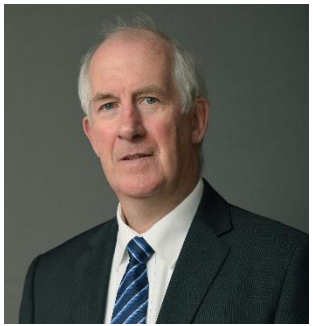
Digital Transformation:

The Staff – Bergen airport

Bergen Light Rail

Introduction

- Jim Sherry
  - Overview
  - BIM from a project managers viewpoint.



- John McInerney
  - Design features of interest
  - Systems Engineering
  - BIM

Bergen Light Rail

Rationale for Bergen Light Rail

Bybanen = light rail

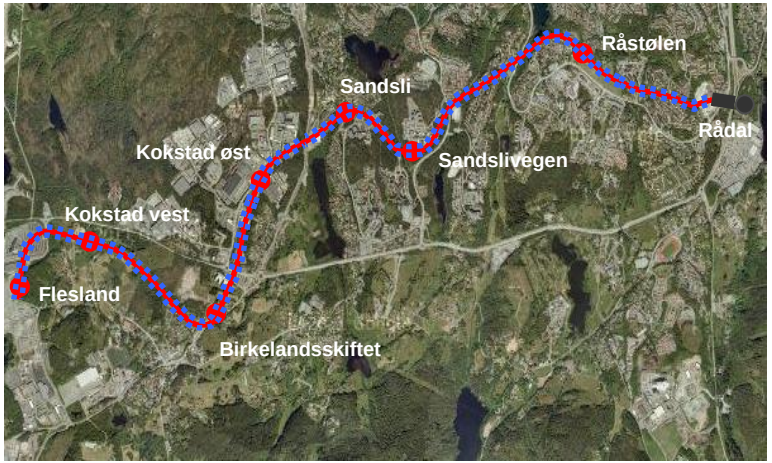
Overall Bybanen Layout

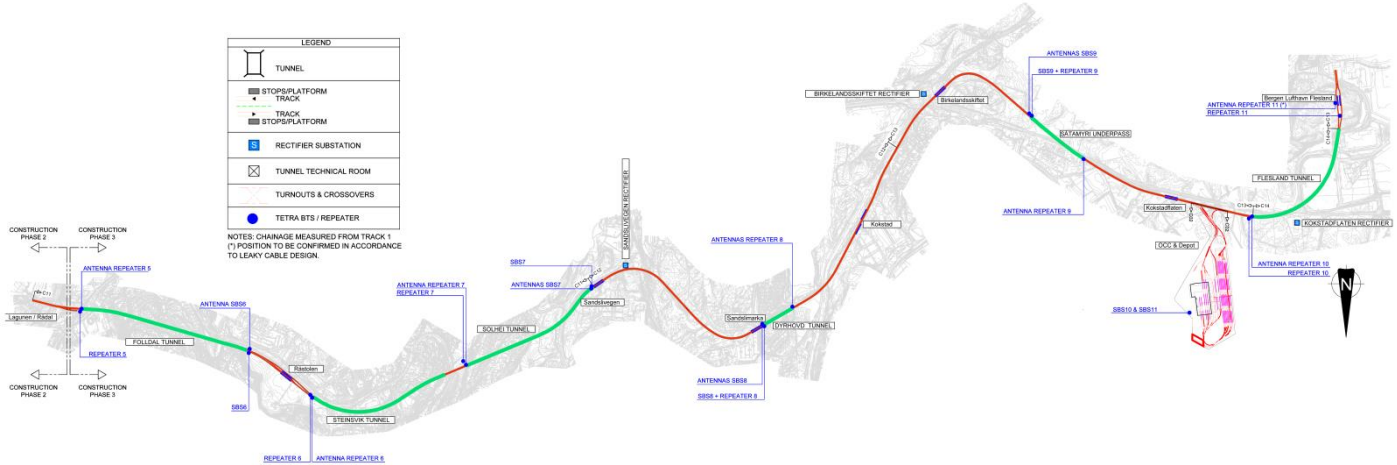
- 5 stages
- 1 & 2 operational
- 3 Mott MacDonald
- 4 & 5 future
- Mountainous terrain means linear urban development
- Vision: 80% of workplaces and 50 % of homes within 600m of a stop.

Bergen Light Rail

Stage 3 – Overall layout

- 6 tunnels
- 4 bridges
- New workshop & depot





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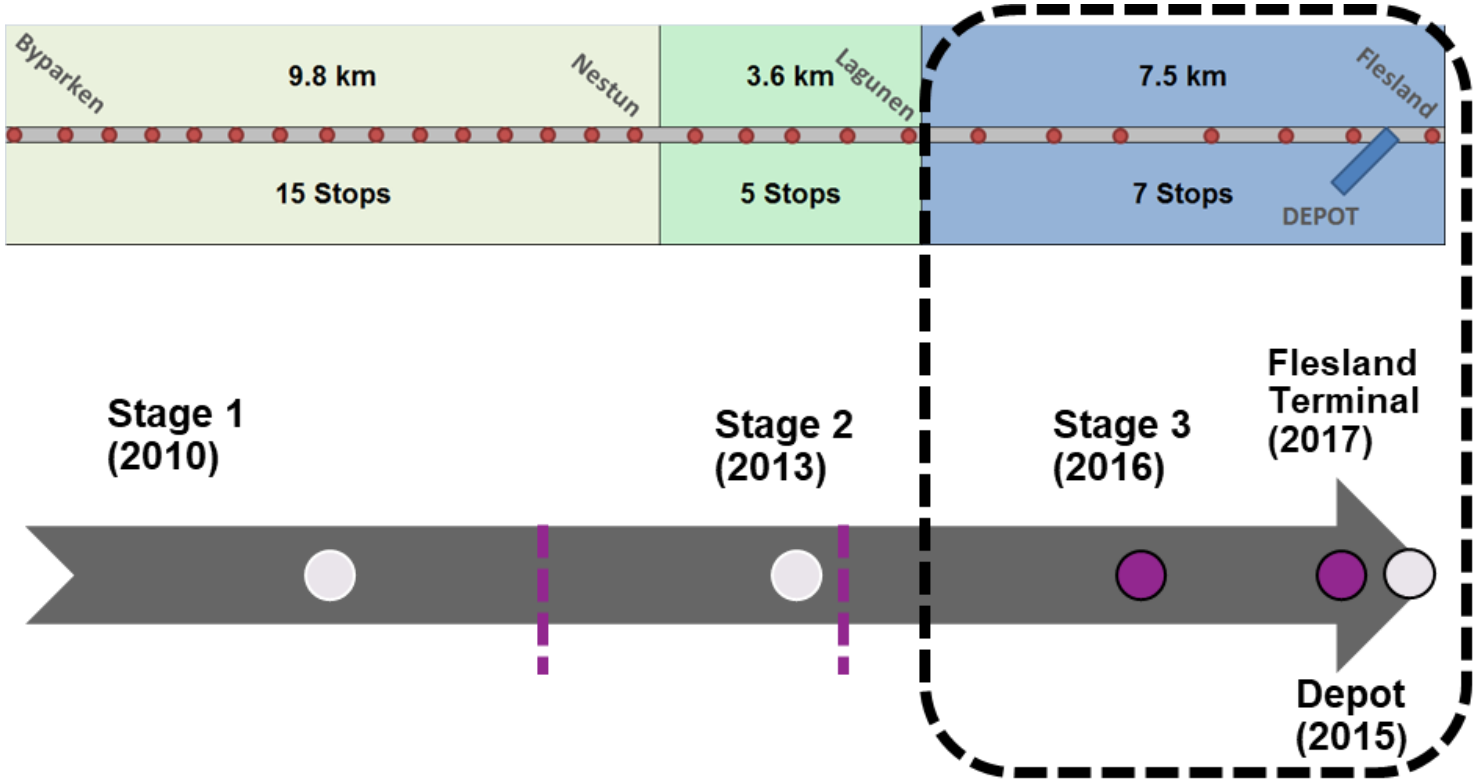
Bergen Tram Key Dates



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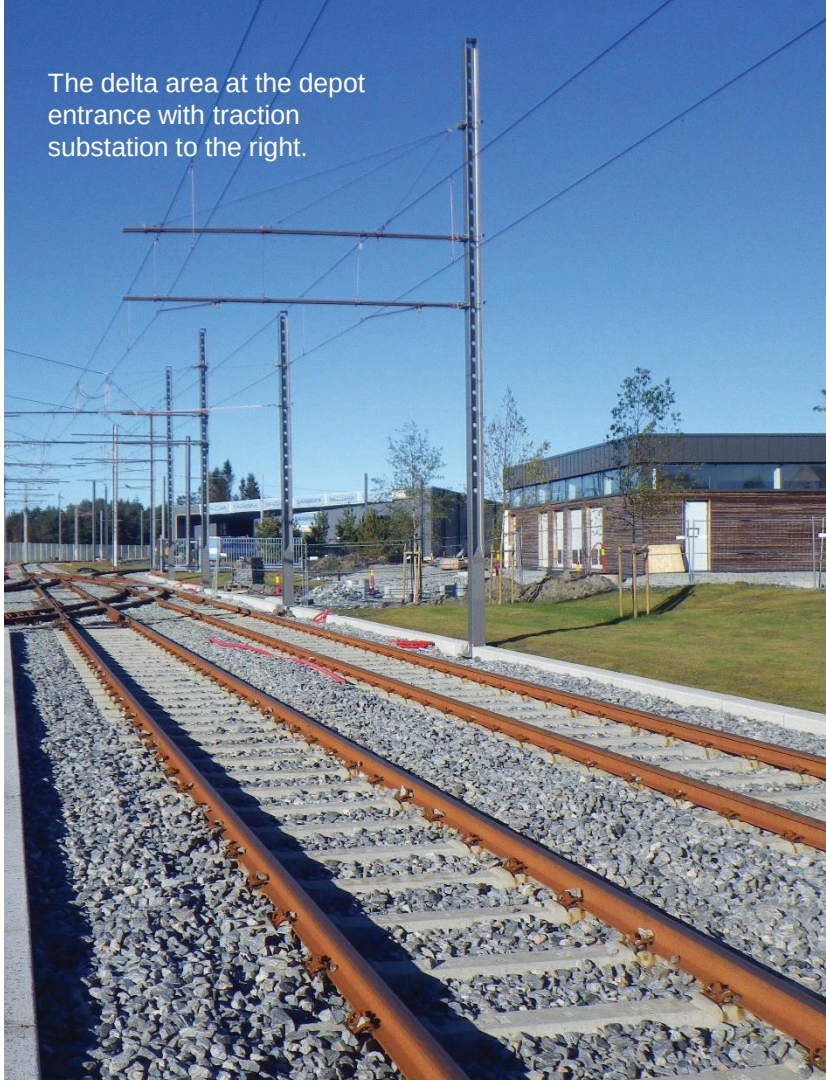
Stage 3 Project Scope

NOK 3.6bn (€ 450m)

- 8km of double track
- 6 tunnels, total length approximately 2800m
- 4 track bridges, total length approximately 340m, with the longest 110m
- 3 pedestrian bridges over track and roads
- 4 culverts for track, total length 680m
- 8 portals attached to tunnels
- 7 tram-stops
- Workshop Building for 50 Trams
- Parking Hall for 40 trams
- Office building for system control, drivers, maintenance staff, and administration
- Two storey park & ride car park – with bus stop on & tram line on the roof



The delta area at the depot entrance with traction substation to the right.

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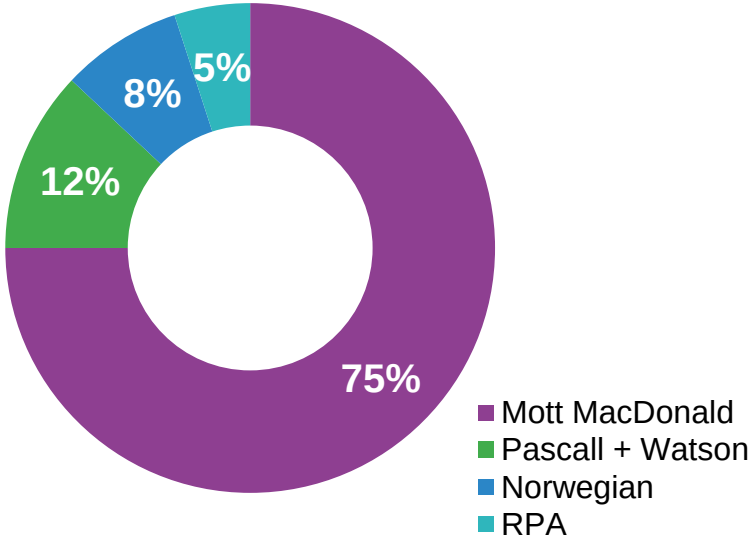
Multi office approach required for complex project

- 10 Mott MacDonald offices in 6 countries
  - Pascall + Watson - architecture
  - RPA (Railway Procurement Agency)
  - Ramboll Norway: g-prog
  - ACK arkitekter - *ansvarlig soker*



- 354,000 hours = 137 man years
- 34 people for 4 years. 67% Ireland based

- Mott MacDonald collaborative working processes
  - (BIM / CDE / Skype/ PiMS / Projectwise)

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PM Challenges for this major Infrastructure Project

- New country – no initial MMD presence
- BIM was a client requirement
- Set up local office, complete with suitable IT infrastructure.
- Assemble multi-disciplinary team across various offices and countries – based on most suitable skilled resource
- Optimisation stage with Client while setting up BIM process
- Tight fixed programme (cultural norm in Norway)
- Fixed budget
- International tender because quality technical solution required
- Client commercial driver resulted in 16 separate construction projects.

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BIM as a solution to challenges

- BIM is one of a range of complementary tools
- BIM was a client requirement, with clear definition
- Early decision not to base large team in Norway
- Skilled resources undertook their design in their home base as far as practicable.
- Detailed use of BIM was inevitable.
- Media reported project out-turn
- Construction Cost 3.6 to 3.75 billion NOK (4%) despite increased scope.
- Official Opening 15th August 2016 (target end June)

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BIM benefits on this project

- Safety:
  - - Line of sight visualisation in Depot optimised operations
  - - Line of sight visualisation in public areas informed urban realm
  - - Dyrhov tunnel lighting: model enables solution to unique technical challenge
- Advanced visibility of final scheme: client, stakeholders, users.
- Improved aesthetics
- Integration with adjacent developments:
- Predictable construction programme and sequence = cost savings
- Value for money
- Quality
- Smooth handover from designer to contractor
- Integration of BIM information into cable management system
- Re-use of waste material
- Reduced service diversions
- Model use beyond construction

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Lessons Learned for Project Manager

- Early detailed planning is essential including BIM execution plan and interfacing design development plan
- Suitable hardware capacity, internet connectivity and telephony infrastructure is essential
- Buy in by whole team is essential: 2D only or non-compliant processes are problematic
- Training and upskilling should be considered at an early stage

Future Direction

e.g. Sydney Metro

- Scope: JV RIBA2 stage station design. Significant co-ordination required at this complex design stage:
- Early deployment of Virtual Reality was of great benefit.
- Recommendations for further work:
- -	Model applications for requirements management
- -	Improved model based con-ordination tools
- -	Automated model validation.

BIM Positives

- Visualisation and interaction for client and stakeholders – they are starting to expect this
- Non-technical people understand models much more easily than 2D drawings
- Clashes, more especially interfaces with existing infrastructure and utilities, can be resolved prior to construction, thus saving cost
- Good models allow better contractor understanding and visualisation of the project, so they can tender more effectively, saving cost.
- Clear communication of design requirements to contractor
- Design and construction information brought to operation and maintenance life of the project.

BIM ‘negatives’ or Challenges

- We are developing skilled modelers – we need to maintain engineering and construction skills
- We need full change management discipline.
- We must understand the provenance and status of the model(s)
- We need suitable hardware capacity, internet connectivity, and telephony infrastructure.
- We need a suitable CDE, and a clear understanding of ownership
- We need to allow for cultural and language challenges
- Application of BIM is a cost to engineering consultants, not always recognised by clients. Application of BIM means consultants costs are front ended.

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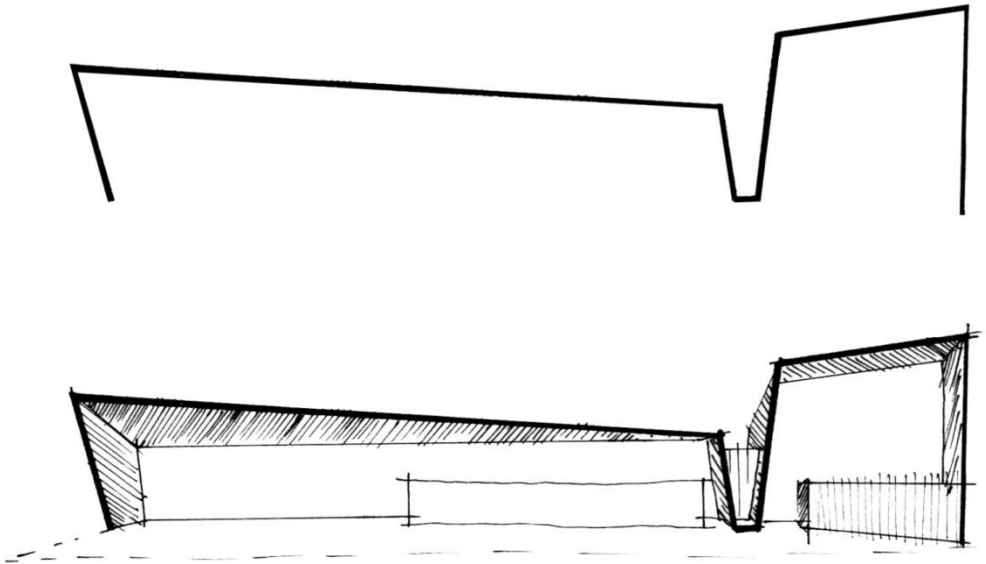
Architecture – South Facade



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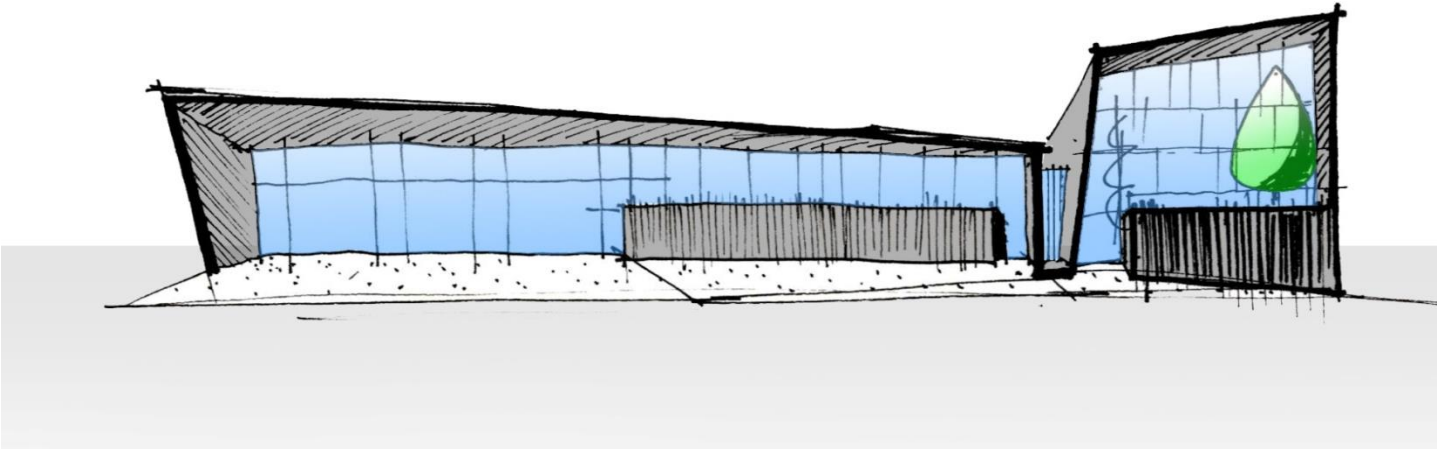
Architecture – South Facade



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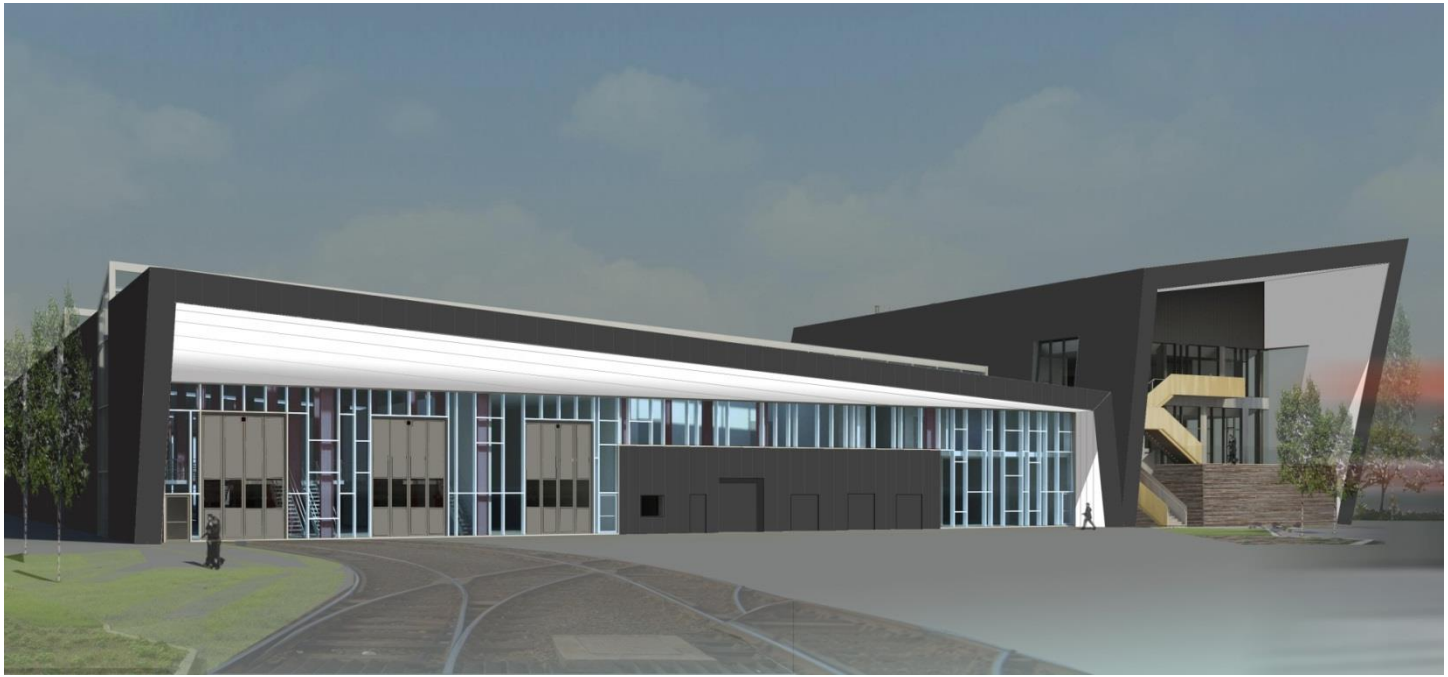
Architecture



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Architecture

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Thank you

Bergen Light Rail – BIM Case Study

Introduction

- John McInerney
  - Global Trends
  - BIM on Bergen Light Rail
  - BIM Market in Ireland now

Global Mega-trends

1 BIM in design and construction becoming business-as-usual

2 Focus on automation to deliver optimum solutions.

3 Emergence of Data Science in the world of buildings and infrastructure

4 Smart Infrastructure and Smart Cities enabled by Digital Twin

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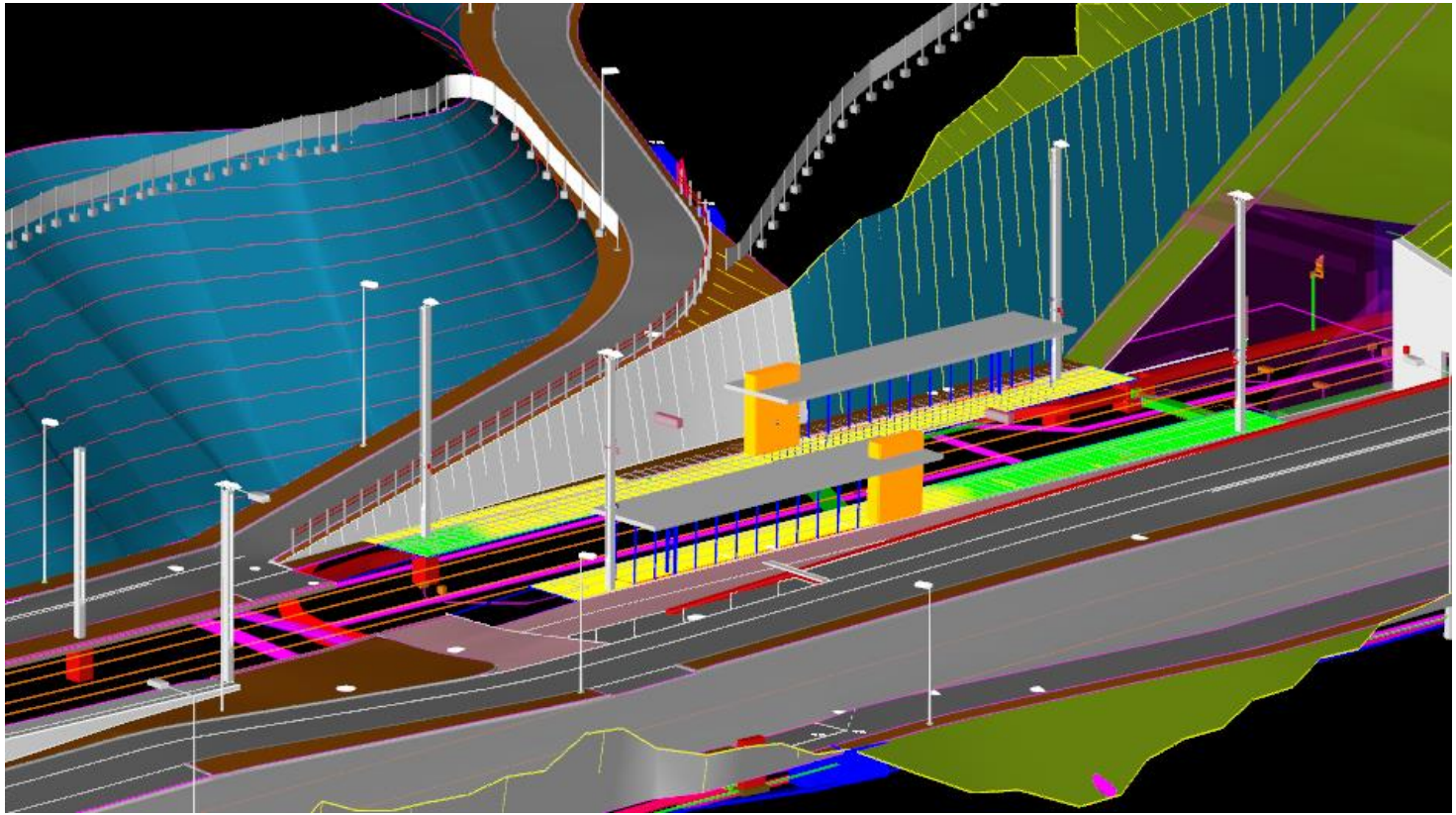
Building Information Modelling - BIM



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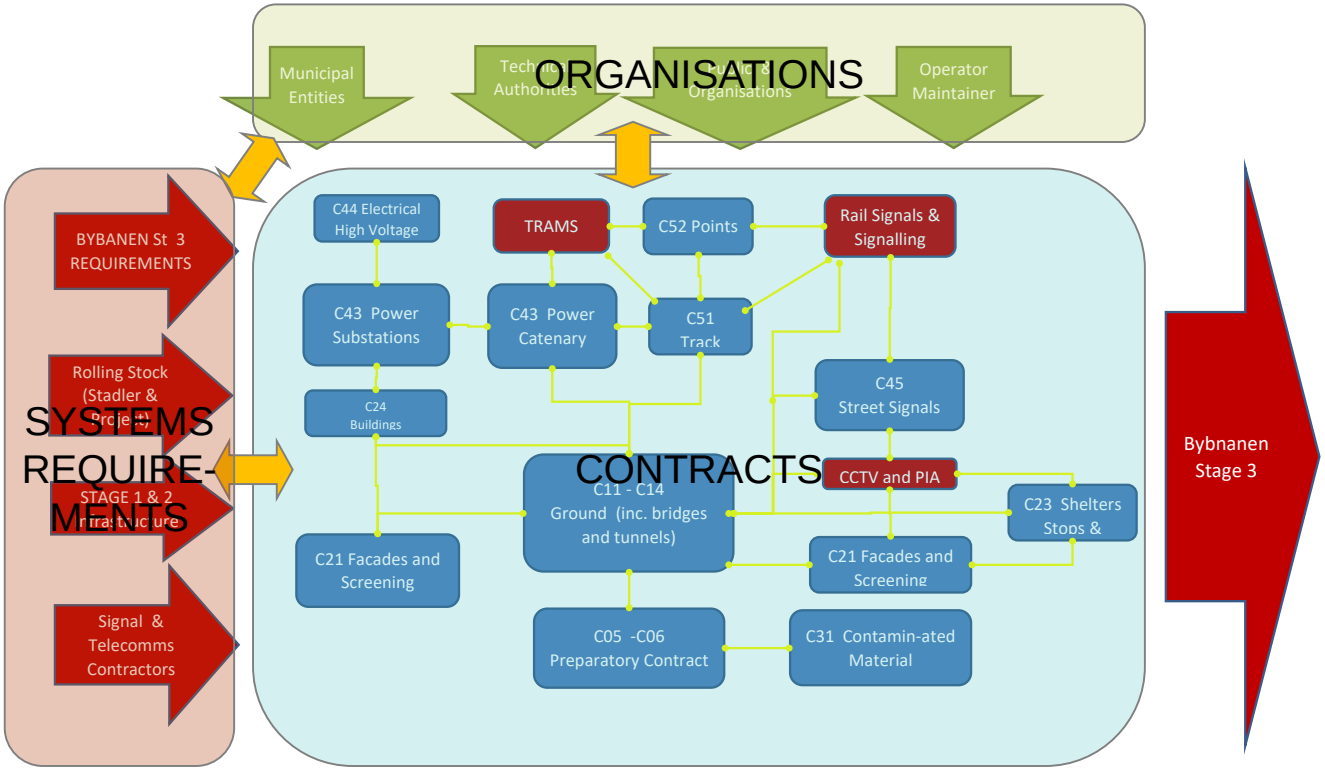
Systems Engineering



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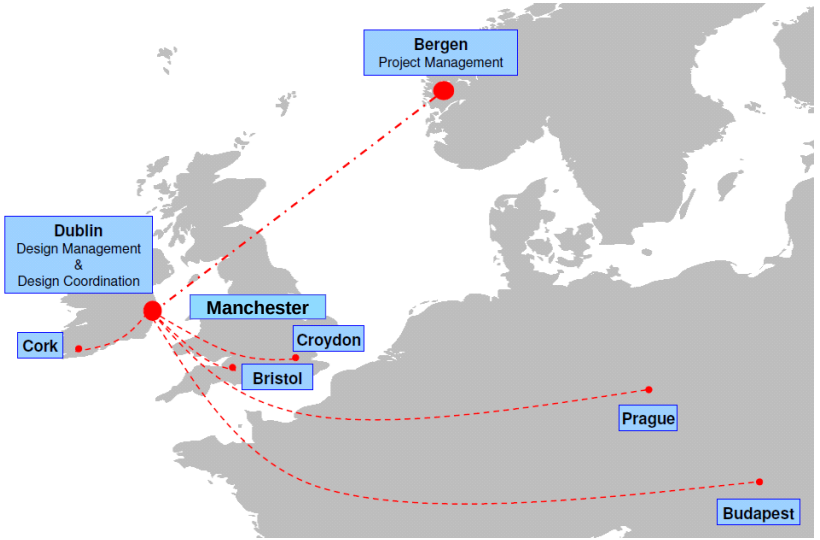
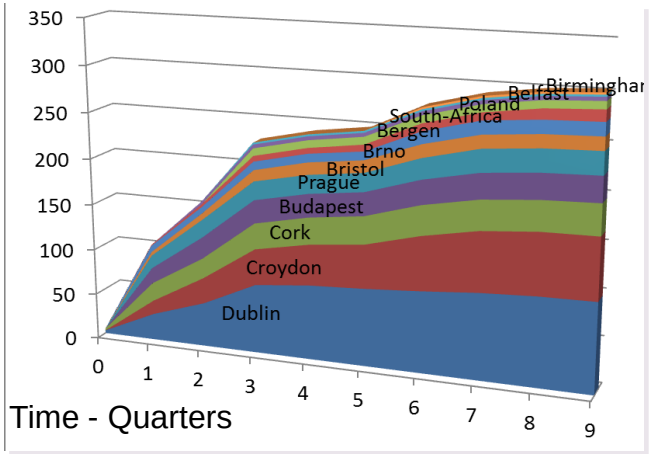
Project team collaboration

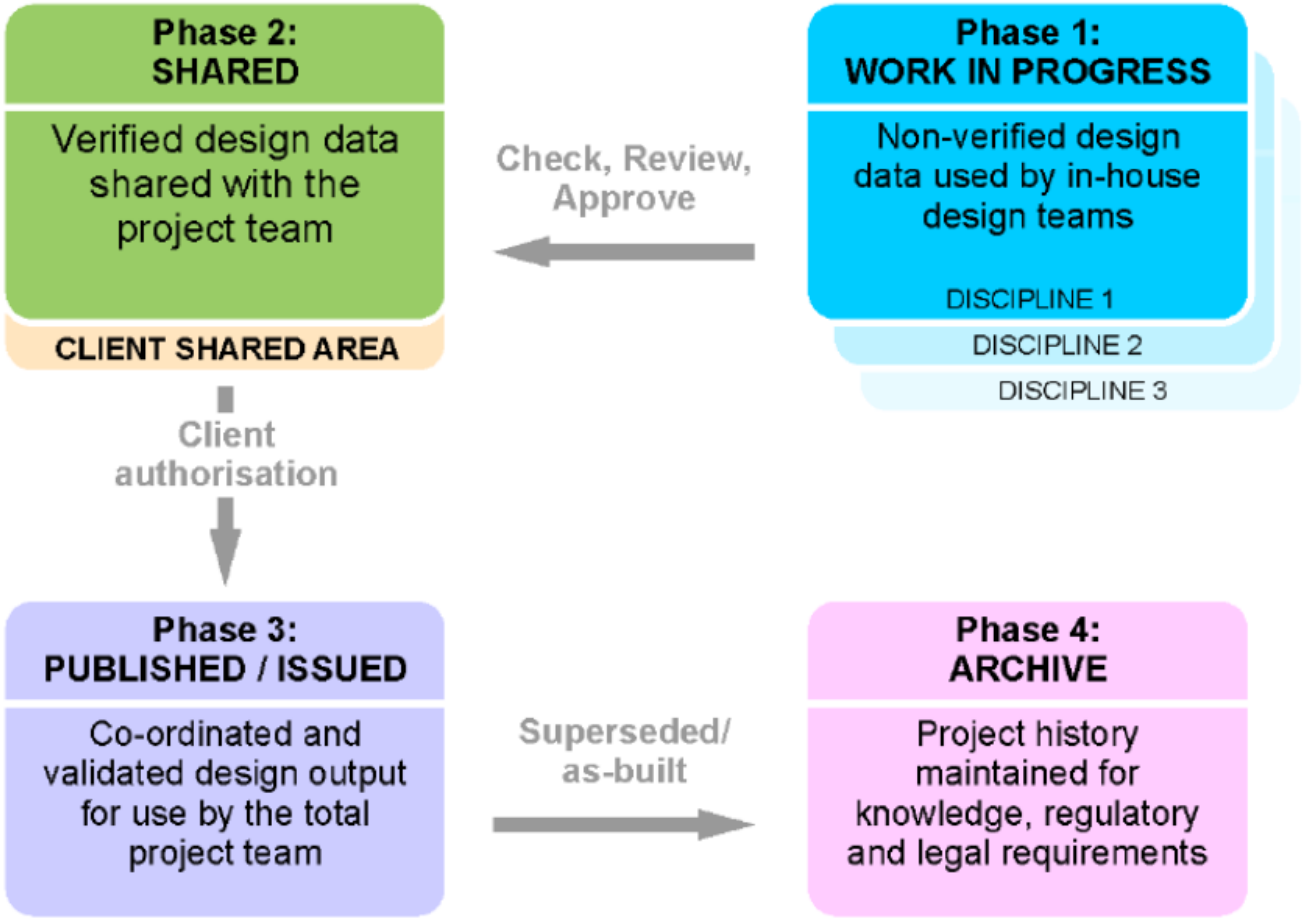
- Project Team Collaboration
- Dublin : Civil, Elec,Rail Systems
- Cork : Roads, Bridges, Retaining Structures
- London: Tunnels
- Budapest : Tunnels
- Bristol : Geotechnical
- Prague & Brno : Bridges
- Bergen : Client Interface



- **PiMS ProjectWise – Key Dates**
- 2012 Q1,2: Bergen Line Setup
- 2012 Q3: Bergen Depot Setup
- 2013 Q1: Add Project Stage Controls

- **External Collaboration**
- Client 3D Workshops
- Contractors / Local Authorities




Phase 2:
SHARED
Verified design data shared with the project team
CLIENT SHARED AREA
Check, Review, Approve
Phase 1:
WORK IN PROGRESS
Non-verified design data used by in-house design teams
DISCIPLINE 1
DISCIPLINE 2
DISCIPLINE 3
Client authorisation
Phase 3:
PUBLISHED / ISSUED
Co-ordinated and validated design output for use by the total project team
Superseded/ as-built
Phase 4:
ARCHIVE
Project history maintained for knowledge, regulatory and legal requirements

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BIM – Software Selection

- Features
- Interoperability
- Hardware & network requirements
- Client/contractor compatibility

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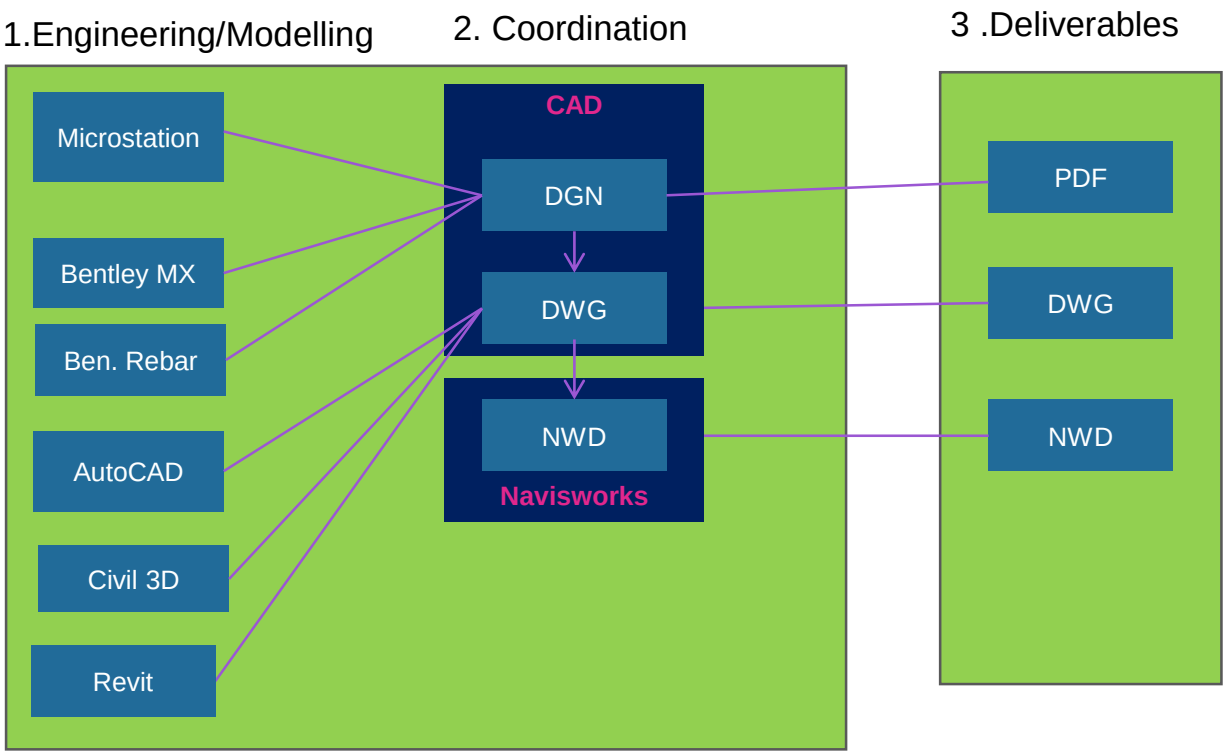
Software selection



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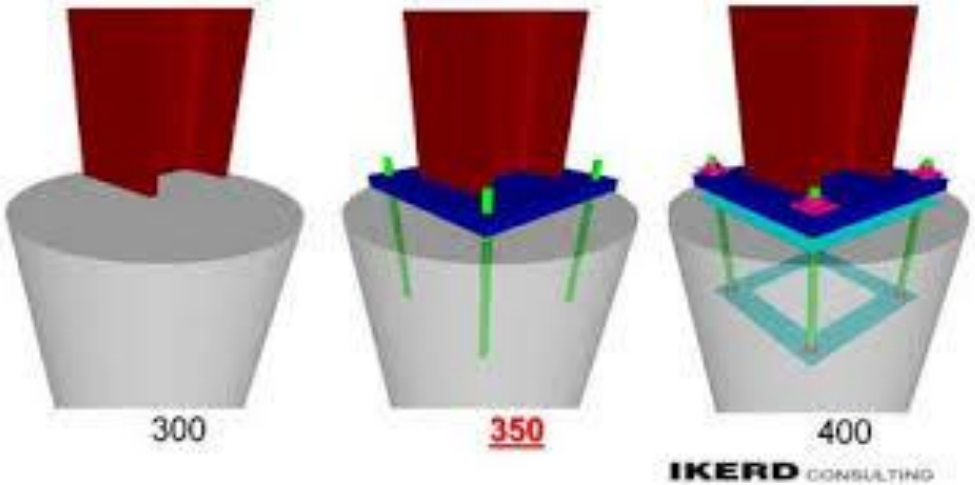
Level of development & detail



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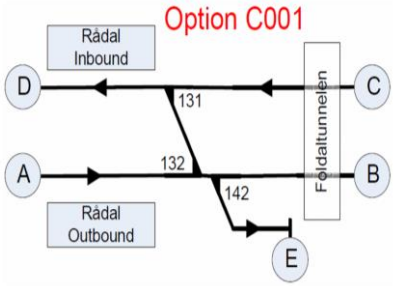
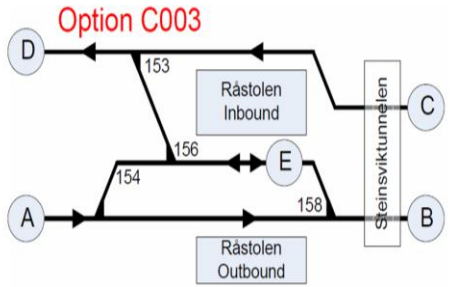
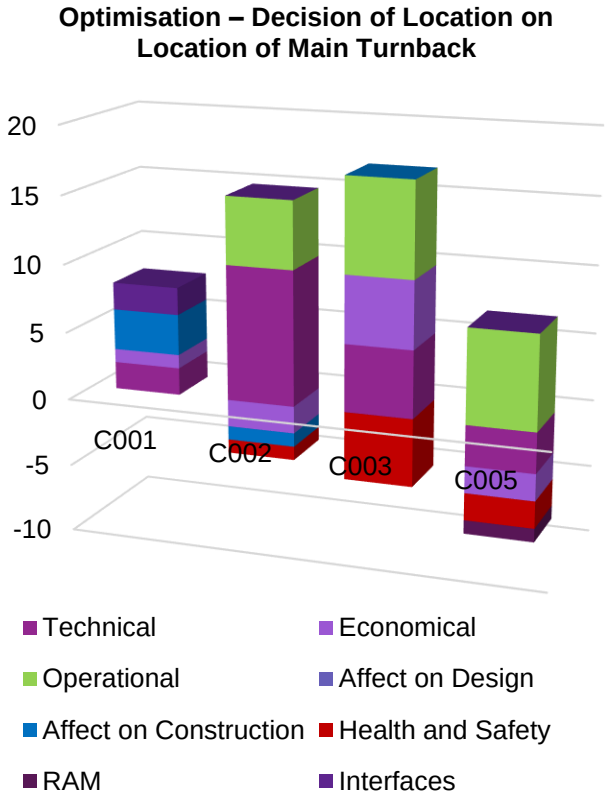
Options Assessment - Turnback Location







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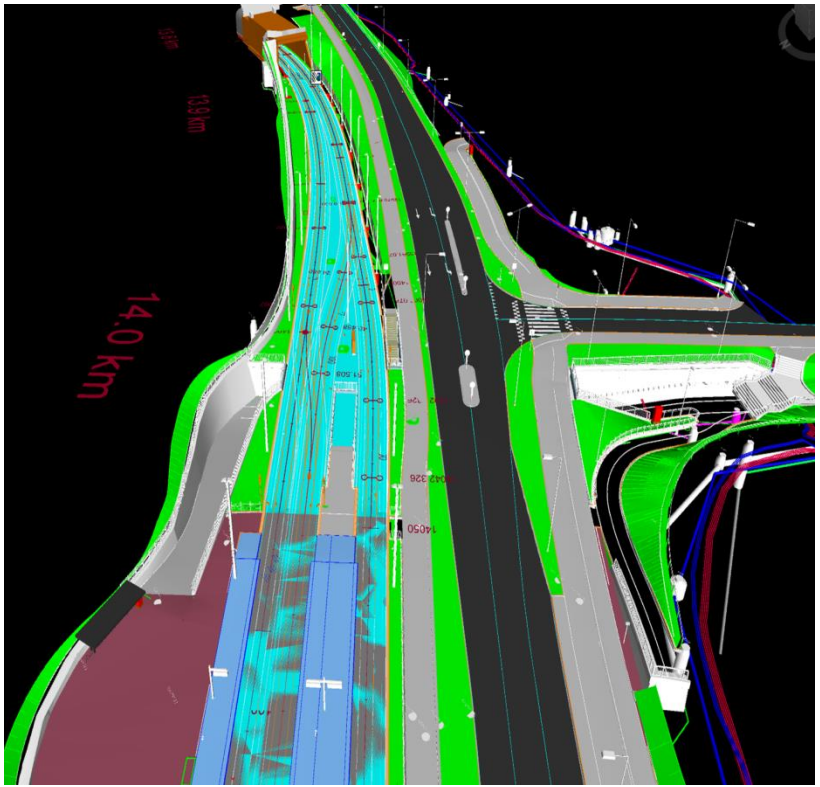
Rastolen Terminus



Rastolen Terminus

- Tram Partial Terminus
- Pedestrian facilities
- School
- Pedestrian underpass
- Road and cycleway
- Vertical gradients


Råstølen

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Airport - Platform

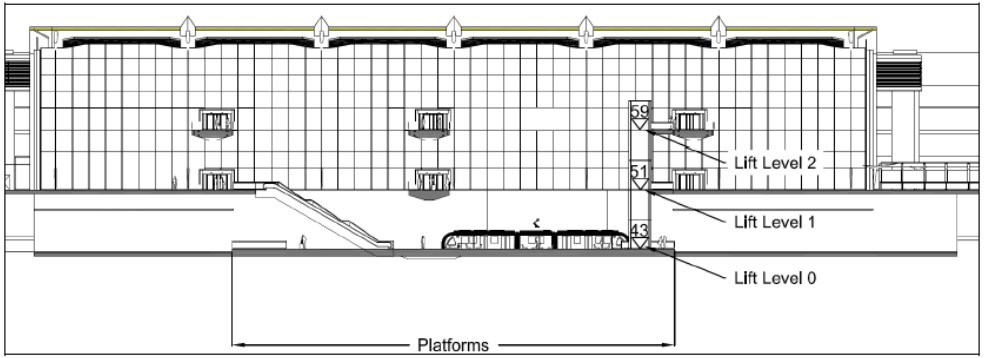

Figure 2. Schematic layout. Cross-section[2].

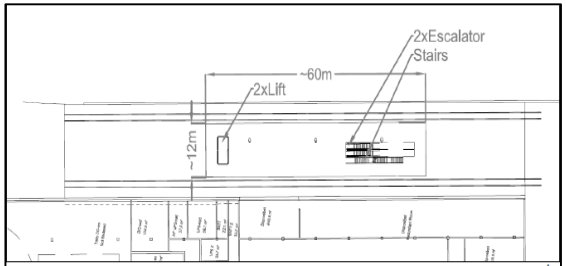

Figure 1. Schematic layout of the tram platforms. Plan View[1].

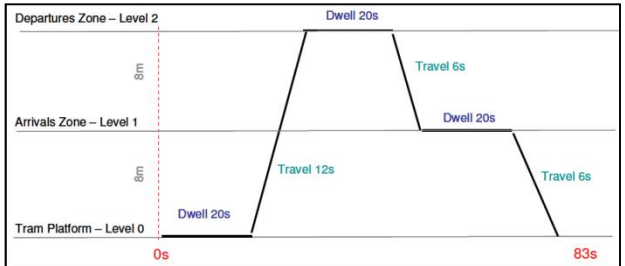

Figure 3. Assumed lift cycle.

Bergen Light Rail – Avinor Stop

Avinor Stop under construction

31/01/2019

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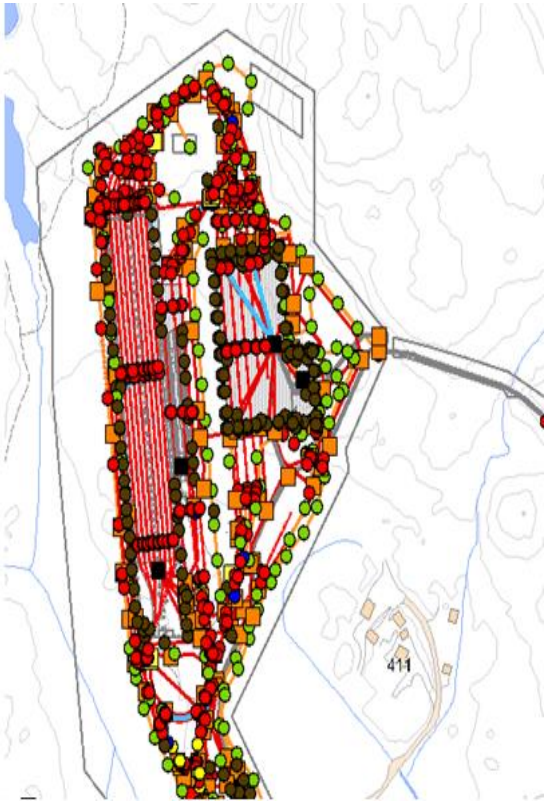
3D Ducting and Cable Management System

- 56,4 km ducting



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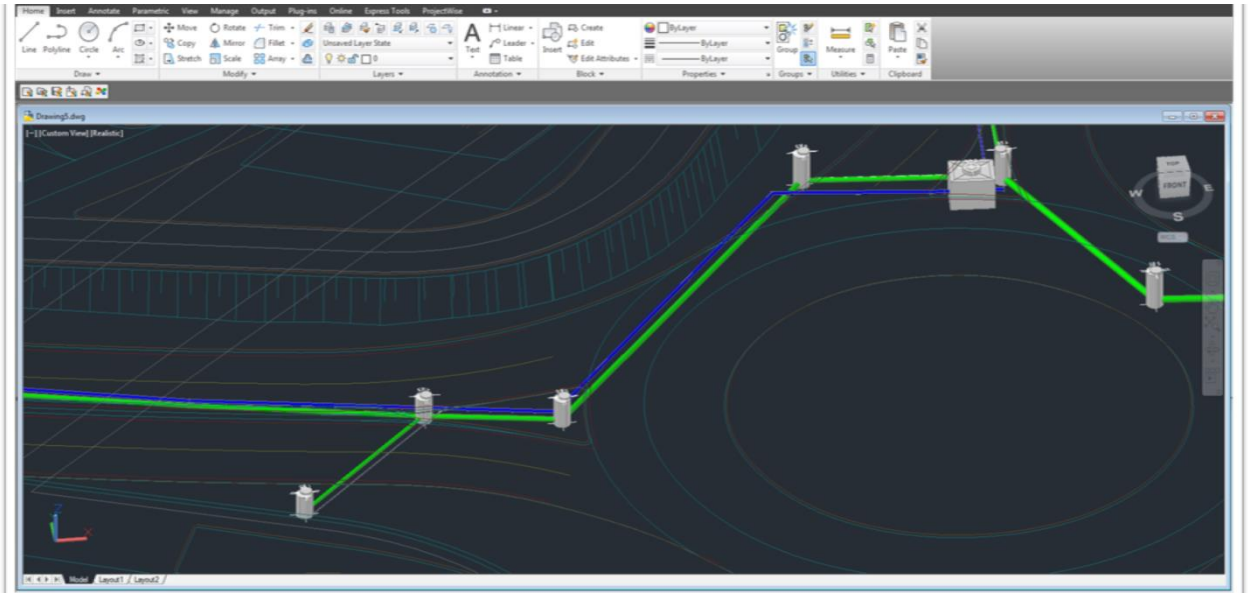
BIM Results – Construction information



3D model – setting out

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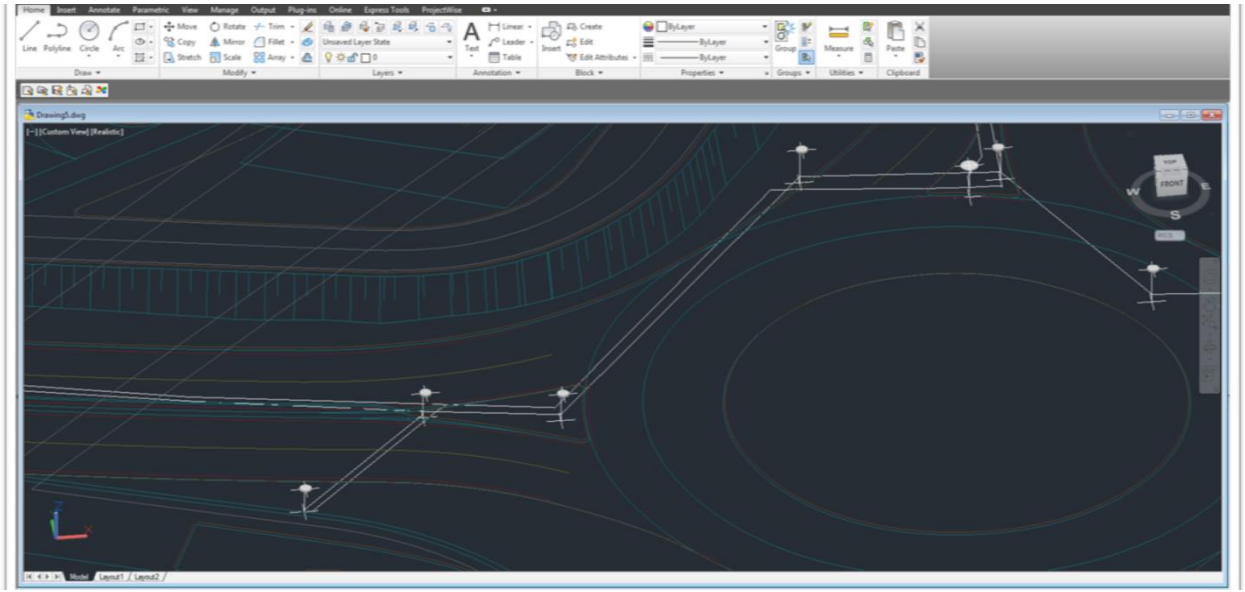
BIM Results – Construction information

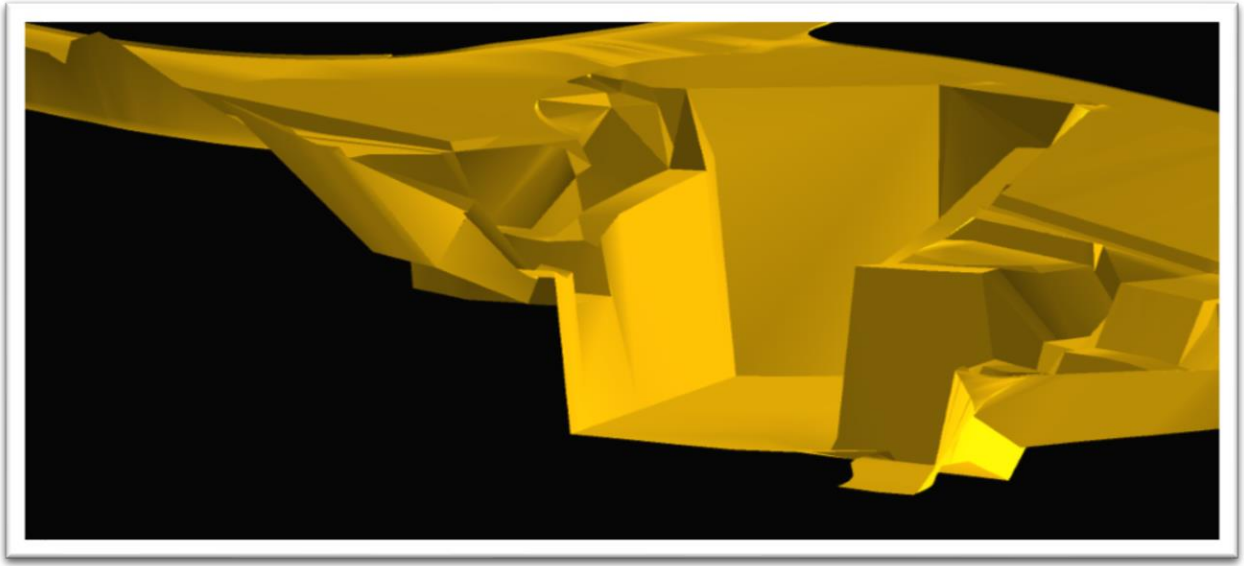


3D model – setting out

Bergen Light Rail

3D Model – setting out

- Information Directly from 3D Model
- Appreciation of Construction Interfaces
- Maintain Project Controls



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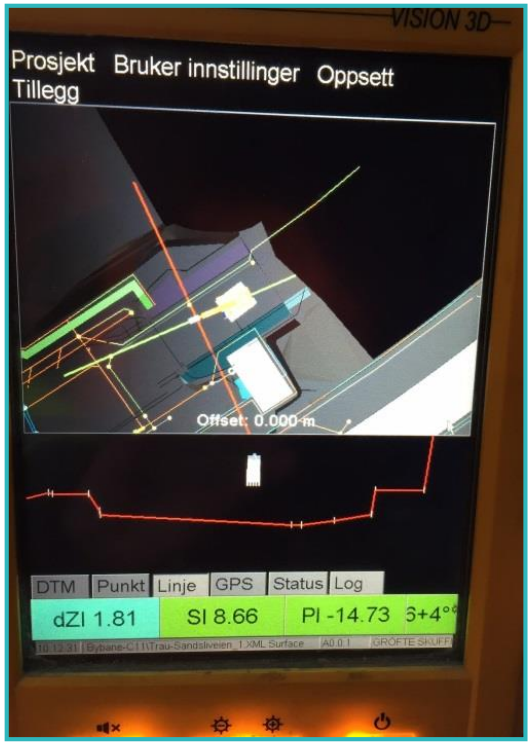
3D Model – setting out



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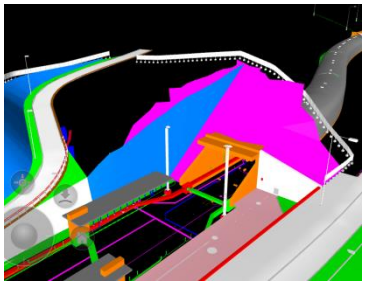
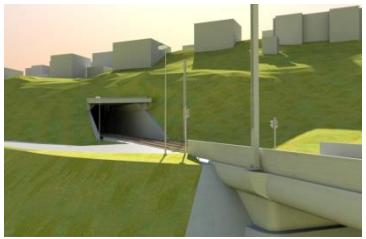
BIM Results: Client benefits of BIM

Shared understanding



Stakeholder

Visualisation Model for Stakeholder



Construction Progress

Reputation

.....MMD has produced a fantastic 3d model which runs through a very complex terrain. From what i have seen on other projects, this is maybe the most complete and advanced infrastructure model you can find today.....

.....A lot of the things MMD has done in this project with 3d models will probably set a benchmark for how things, are presented in 3d in future infrastructure projects in Norway.

Stian Veseth VESETH AS

BIM Market in Ireland

- CITA Roadmap to Digital Transition:

  Q2 2019 - Govt Mandate for Level 5 Projects

- Designers/Contractors:

  Need standards to justify investments

- Contract types:

  D&B vs Design Only / Build Only

  Collaboration vs Competition

  PAS1192 +/- Other Stds?

- Client Requirements:

  Goal : Construction Savings / FM Savings ?

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Thank you