Velsertunnel

Retrofitting Tunnel: Design Build and Maintain-contract of the Velsertunnel

Dr. Ir. Jan Van Steirteghem
Director Besix Engineering Department
À COEUR, VALENT IN D’IMPOSSIBLES
I’m not stubborn...
My way is just better.
Agenda

1) Few words about BESIX
2) The project scope – renovating while keeping stakeholders satisfied
3) Main technical challenge – durability of the existing concrete
4) Building Information Management – A game changer
5) Discussion
Video presenting BESIX
(excluded from PDF)
Our commitment to excellence

Excel in creating sustainable solutions for a better world.

As BESIX Group we develop multiple services to create value for our clients, whilst incorporating the evolving expectations of the end users and building on strong partnership with all stakeholders.

1. Leveraging on our customer centricity
2. Promoting a great place to work
3. Developing a “one-stop-shop” solution
4. Being a leader in open innovation
5. Synergizing our ways of working
6. Promoting openness towards new ventures & activities for business

Our values

> Excellence  > Co-creation  > Respect  > Passion  > Unity
A strategy of diversification
Geographical spread & activity scope reinforce our service offerings and mitigate risk

- **CONCESSIONS & ASSETS**
- **REAL ESTATE**
- **CONTRACTING**

**N°1 in Belgium**
**N°75 TOP 250 International Contractors**

- 65% activities abroad
- 20 countries
- +95 years international activity
- +55 years experience in the Middle East

Privately Owned
50% MIC
50% OC

United Kingdom: The Netherlands, Belgium, Luxembourg, France
Italy, Denmark, Switzerland, Montenegro, Azerbaijan, Bahrain, Qatar, VAE, Oman
Morocco: Egypt, Saudi Arabia, Cameroon
Equatorial Guinea
Cameroon
Poland
Switzerland
Montenegro
Azerbaijan
Egypt
Saudi Arabia
Sri Lanka
Oman
VAE
Bahrain
Qatar
Australia

**Tuesday, February 20, 2018**
From Foundations to Finishing: in-house capacity

- Quarries
- Asphalt plants & Concrete production
- Steel production
- Steel reinforcement cut & bend plants
- Foundations
- Cables, Pipes and Utilities
- Roads
- Water Works
- Isolation materials
- Interior fit-out
In Belgium: a dense regional network
Retrofitting of Velsertunnel

Client

Rijkswaterstaat
Ministry of Infrastructure and the Environment

Consortium

Hyacint

Lead Contractors

Besix
DuraVermeer
Spie

BIM Consultants

Infranea

Croon
TBI techniek
The project scope – renovating while keeping stakeholders satisfied
# Tender procedure

Best Value for Money based on risk mitigation

<table>
<thead>
<tr>
<th>Criterium</th>
<th>Subcriterion</th>
<th>Maximaal kwaliteitswaarde (€)</th>
<th>Beoordelingscijfer/ Behaalde Kwaliteitswaarde (€)</th>
<th>Totale (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Projectbeheersing</td>
<td>1.2 PMP Convergentiefase</td>
<td>€10.000.000,00</td>
<td>0.5</td>
<td>€5.250.000,00</td>
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<tr>
<td></td>
<td></td>
<td>€10.000.000,00</td>
<td>9</td>
<td>€7.500.000,00</td>
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<tr>
<td>2. Publicaties</td>
<td>2.1 Visie en aanpak KMO</td>
<td>€5.000.000,00</td>
<td>5.5</td>
<td>€625.000,00</td>
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<tr>
<td></td>
<td>2.2 WUU</td>
<td>€10.000.000,00</td>
<td>3.000.826</td>
<td>€3.994.494,09</td>
</tr>
</tbody>
</table>

Subtotaal kwaliteitswaarde criteria 1 t/m 2 | €24.369.494,09

<table>
<thead>
<tr>
<th>3. CO2 Ambitie</th>
<th>Praratiecentraal Kwaliteitswaarde</th>
<th>5% van de inschrijvingsprijs</th>
<th>€3.350.000,00</th>
</tr>
</thead>
</table>

Totale kwaliteitswaarde (1 t/m 3) | €27.719.494,09

<table>
<thead>
<tr>
<th>Inschrijvingsprijs Renovatie (deel Werk)</th>
<th>€50.313.000,00</th>
<th>€55.313.000,00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inschrijvingsprijs MIO (deel RO)</td>
<td>€7.687.000,00</td>
<td>€7.687.000,00</td>
</tr>
</tbody>
</table>

Fictieve inschrijvingsprijs (totale inschrijvingsprijs (Werk + MIO) minus totale kwaliteitswaarde) | €39.280.305,91

Alle bedragen exclusief RTW
Tender procedure

Best Value for Money based on risk mitigation
Tender procedure
Best Value for Money based on risk mitigation
**Tender procedure**
Best Value for Money based on risk mitigation

<table>
<thead>
<tr>
<th>Naam inschrijvers</th>
<th>Inschrijvingssom</th>
<th>Fictieve inschrijvingssom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Combinatie Dura-Besix-Spie</td>
<td>€ 67.000.000</td>
<td>€ 39.280.506</td>
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<tr>
<td>2 Combinatie Imtech-Mourik</td>
<td>€ 57.067.917</td>
<td>€ 41.174.864</td>
</tr>
<tr>
<td>3 Combinatie Cofely-Ooms</td>
<td>€ 82.927.532</td>
<td>€ 60.044.351</td>
</tr>
</tbody>
</table>
As-built information consists only of 60-year old drawings
  > UNCERTAINTY
EU Directive 2004/54/EC on safety requirements for tunnels in TEN-T network
  > QUALITY
High density of Traffic & Safety equipment and installations
  > COMPLEXITY
Tunnel closure contractually limited to 3+3+3 months
  > DEADLINES
Public and Private stakeholders very skeptical and critical
  > IMAGE
1. First think Risk
identify and analyse key risks to project goals, for each phase

2. It’s all about the process!
define mitigating measures + implement control processes
focused on managing the key project risks

3. Risk-driven strategy
Good and Fast won’t be cheap
Characteristics:
2 (technical) ventilation buildings – protected heritage
2 (technical) service buildings

Opportunities of the Velsertunnel

4 instead of 2 service buildings
Opportunities of the Velsertunnel

Characteristics:
1 longitudinal service corridor in middle of the cross section
1 longitudinal service corridor at each side of the circulation tubes (2 in total)

3 instead of 1 service corridors
Video showing phasing of project using BIM model (excluded from PDF)
Main scope of renovation

Increase Headroom by 12cm (from 417 cm → 429 cm)
1) About 7 cm on the ceiling
2) About 5 cm on the floor
Main scope of renovation

Tunnel protection system – Hard ware
1) Avoid the entrance of too high trucks
2) Have them stopped at tunnel entrance
3) Avoid damage to tunnel (structural) and equipment
Main scope of renovation

Build new escape routes
1) 5 in total
2) Reduce evacuation distance
3) From vertical evacuation to horizontal evacuation
Main scope of renovation

New ventilation system
1) Dismantle the existing transversal ventilation
2) Install a new longitudinal ventilation
3) 21 new ventilators installed in total
## Facts & figures

**GUNNING**
- Juli 2014
- Tunnel dicht: april 2016
- Tunnel open: januari 2017

**AANNEEMOMSOM**
- €95 miljoen
- Inclusief bereikbaarheidsmaatregelen: €110 miljoen

**OPDRACHTGEVER**
- Rijkswaterstaat

**OPDRACHTNEMER**
- Combinatie Hyacint (Dura Verno, Besix en Spie)

**CONTRACT**
- Design & construct met meerjarig onderhoud (zeven jaar)

---

**40 Dixies**

**5 Nieuwe veilige ruimtes**

**12 km**
- Tijdelijk aangelegde omleidingsroutes, inclusief Wijker tunnel en A9.

**Hoeveelheid beton tijdens de bouw**
- 220.000 m³

**Hoeveelheid beton tijdens de renovatie**
- 600 m³

**Hoogte gebruikt asfalt tunnel**
- 14.051,76 ton

**MHI**
- 3.147,46 ton

**12 km GLASVEELKABEL**
- 45 km

**LENGETE KABELS**
- Koererkabel: 375 km

**COATING**
- 22.470 liters verf

**21 nieuwe ventilatoren**
- Type: Ventilatie

**EXTRA DOORRIJHOOGTE**
- 12 centimeter

**77 Camera's**

**2200 LED-lampen**

**OPPERVLAKTE LICHTROOSTER**
- 54.000 m²

**Reparatiemortel**
- 22.616 zakken (565.418 kg)

**Mortel**

---

**Omlading**
- 12 km
Renovatie Velsertunnel 2016: hoe blijft de IJmond bereikbaar?

Verkeershinder beperken

In 2016 gaat de Velsertunnel negen maanden dicht voor renovatie. Rijkswaterstaat en de omgevingsploegen IJmond houden de regio bereikbaar met onder meer omleidingsroutes, een extra pont en tijdelijke extra rijstroken in de Wijkertunnel.

Omlaidingsroutes

Locanten regio IJmond dat voor de IJmond tunnel, gaat tijdens de renovatie van de Wijkertunnel die. Langer afstand kunnen via extra voltooid extra kansen voor de Reizigersch.

Reistijd

Een niet in de renovatie bij de verkeershinderen in diep roekeloos. Sluit oplossing bij de leiden begonnen tot onverwacht. Fatwacht grootroost en verdacht waarschuwingen kunnen waarschuwingen altijd laten met het toezicht.

Hulpdiensten

Door de toegang tot het tunnelnetwerk extra ingrijpen gezien bij deze omlaidingsroutes omrn opstelling van gemakief, en PBM, en PBM, kunnen tijdens de verkeersdiensten altijd door de hulpdiensten worden hulpdiensten.

Fietsen aanrekkelijk

Wonen met de IJmond fietsen voor, tijdens en na de renovatie van de Velsertunnel, ook in de omgeving voor de fietsers van het Fietsen en Reizen. Ook wordt het fietsnetwerk verder ontwikkeld. Meer informatie

Calamiteitenbogen

De calamiteitenbogen op de beide knooppunten Velsen en Beverwijk blijven tijdens de renovatie van de Velsertunnel de twee rijstroken. Zij zijn aangelegd zodat het verkeer via Beverwijk en Velsen naar de soden naar de wijc en Knooppunt Velsen, Rijkswaterstaat gebruikt voor de fietsen en Reizen.

Shuttlebus

In de kustlijn- en verderderpunts van het verkeer tussen stations en bedrijven van de IJmond. De optimale scheepvaart en wel worden voor de door af. VIA wordt met reis naar Rijk op www.pmverktakt.nl.

Keerlussen

Rijkswaterstaat legt vier keerlussen aan de tweede knooppunten Velsen en Beverwijk erwaar een omlading van de Wijkertunnel. Het zorgen ervoor dat verkeer tussen smid en Drontenburg en van de weer de rijrichting van de Reizigersch.

Extra pont

Tijdens de spits wordt de extra pont van de Wijkertunnel op werkdagen voor en twee poot. De vaart van het minimaal te minuten.

Meer informatie

Over de renovatie Velsertunnel en verkeersinformatie: www.rijkswaterstaat.nl/Velsertunnel
Algemene op plattegrondverlichting: www.rijkswaterstaat.nl/omgeving

www.rijkswaterstaat.nl/omgeving

Maart 2018
Over 200 meetings with stakeholders in the course of the project to mitigate their worries and create enthusiasm.
10,000 people visited the tunnel just before its opening
(50,000 applied)
6,000 runners participated to the Velsertunnel run (20,000 applied)
Main technical challenge – durability of the existing concrete
Introduction

Velsertunnel

Coentunnel

Other structures
Introduction

- **1ST COENTUNNEL**
  - Build in 1966
  - Immersed tunnel – segments of 90 m
  - Total length 1187 m – length of immersed part 587 m
  - 2 tubes of 2 traffic lanes + tube for evacuation purposes

- **Other structures**
  - Build between 1964 and 1989
  - 36 bridges and fly overs

- **Velsertunnel**
  - Build in 1957 (started in 1941 but stopped due to WWII)
  - Cut & cover
  - Total length 1664 m – covered section 768 m – typical diagonal props
  - 2 tubes of 2 traffic + 3 service corridors
1\textsuperscript{st} Coentunnel

Tunnel

- **Research approach**
  - Grouping of the tunnel in nine parts: entrance of tunnel (open) up to exit tunnel
  - Measurement of concrete cover
  - Core drilling for laboratory research
    - Chloride profile
    - Carbonation depth
    - Chemical stability – petrographic analyses
  - Analyses of the current condition of the structure comparing the chloride profile and carbonation depth with the concrete cover
  - Extrapolation of the current condition while predicting its future behavior (2066)
1\textsuperscript{st} Coentunnel

Tunnel

- Research approach
  - Extrapolation of Chlorid migration (RWS directive based on Duracrete)
1\textsuperscript{st} Coentunnel

Tunnel – results of the research

- Blue line is measured value
- Red line is best fit
  - $\Rightarrow$ Cs, Ci and Da are variables that can be used for extrapolation in the future
1\textsuperscript{st} Coentunnel

Tunnel – results of the research

Chloride Profile at entrance of tunnel

Chloride Profile at exit of tunnel
1\textsuperscript{st} Coentunnel

Tunnel

- Conclusions of the research
  - Chloride profile at the walls of the ramp is too high \(\Rightarrow\) potential current measurement and destructive research done \(\Rightarrow\) no current active corrosion
  - Remaining life time guaranteed if concrete cover is 45 mm
  - 45 mm concrete cover in the walls is minimal required in relation to fire resistance
  - Concrete cover is measured and extra mortar is applied to reach for 45 mm concrete cover on all wall surfaces. No extra mortar is added on roof plate.
  - Roof & props are protected by fire proofing mortar
  - Inspection of complete tunnel every 5 years
1\textsuperscript{st} Coentunnel

- Fire proofing
- Mortar for durability reasons and fire protection
- Coating for light reflexion
1st Coentunnel
Tunnel link structures - research approach

Grouping of the different structures

- 36 structures are grouped into 9 groups

Core drilling and inspection
- Cores drilled in abutments, columns, decks + concrete cover measurements + visual inspection

Laboratory analyses
- Carbonation
- Chloride profile
- ASR/DEF

Technical analyses
- Current condition
- Future condition (80 years after completion)

Monday 19 February 2018
CERES Presentation
1\textsuperscript{th} Coentunnel

Tunnel link structures

- Conclusions of the research
  - Chloride profile at some of the columns and abutments is too high $\Rightarrow$ potential current measurement and destructive research done $\Rightarrow$ local current active corrosion
  - Local replacement of the concrete cover (up to 15 mm after reinforcement) and application of repair mortar
  - Local application of water sealing coating – repair of rain water drains and joints
  - Inspection and local potential measurements every 5 years
Velsen tunnel

Tunnel

- Research approach
  - Ventilation and emergency tube was analysed before tender stage
  - Traffic tunnel is analysed by contractor
  - Grouping of the tunnel in 2 x 3 parts: entrance of tunnel (open) and middle part – for every tube
  - Measurement of concrete cover
  - Core drilling for laboratory research
    - Chloride profile
    - Carbonation depth
    - Chemical stability – petrographic analyses
  - Analyses of the current condition of the structure comparing the chloride profile and carbonation depth with the concrete cover
  - Extrapolation of the current condition while predicting its future behavior (2058)
Velsen tunnel

Tunnel

- Research approach
  - Extrapolation of carbonation

\[ t_{ld} = \left( \frac{d_c}{x_c t_{insp}} \right)^2 \cdot t_{insp} \]

- Extrapolation of Chlorid migration (RWS guideline)

\[ C(x,t) = C_s - (C_s - C_i) \cdot \text{erf} \frac{d_c}{2 \sqrt{D_a \cdot \left( \frac{t_{insp}}{t} \right) \cdot t}} \]
Velsen tunnel

Tunnel

- Conclusion of the research
  - No extra measurements are needed to guaranty global durability of the tunnel (up to 2058)
  - Local concrete repair needs to be done: mainly at joints and at early age cracking.
  - High concrete cover (average > 50 mm  ➔ no need for fire proofing of the walls)
  - Old ribbles (7 cm) are removed to increase tunnel head room
Velsen tunnel

Tunnel

- Conclusion of the research
  - Coating applied on walls (request client)
  - Fire proofing (hard boards) on deck

Inspections, core-drilling, concrete lab research, analyses done by:

Bernd Van den Bossche
Building Information Management – A game changer
Aim for zero failure project
  > First-time-right!

  > Create a single common data environment
  > Integrate all engineering processes
  > Focus on requirements & interface management
bim as in *Building Information Modelling*

1. to improve the conceptual / architectural / engineering process
2. to integrate and coordinate all design disciplines, to avoid clashes
3. to automate the production of drawings, quantities, planning, ...

BIM as in *Building Information Management*

1. to assure project quality (scope, time, budget)
2. to integrate the project management information and processes
3. to reduce failure costs > to manage project risks
As-is survey by static laser scanning:
- accuracy → 5 millimeters
- fast → 2 night closures
- complete → all details included
- flexible → single survey, multi measure
Modelling in Civil3D & Revit:
- object-oriented model
- direct from point-cloud
- model on a need-to-know basis
- point-cloud always in background
Capturing & Modelling Strategy
- consistently risk-driven
- on a need-to-know basis
# Paying for the As-is Reality...

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Scan cost [EUR/m²]</td>
<td>0.76</td>
<td><strong>24000 EUR</strong> (2 nights + 2 days) 2x1600mx10m = 32000 m²</td>
<td>-</td>
<td>185 (x243)</td>
<td>870 (x1144)</td>
<td>17.6 (x23)</td>
</tr>
<tr>
<td>Design cost [EUR/m²]</td>
<td>185 (x243)</td>
<td>80% of 10.5mio EUR 45500 m²</td>
<td>-</td>
<td>-</td>
<td>80% of 49.5mio EUR 45500 m²</td>
<td>80% of € 1 mio EUR/year 45500 m²</td>
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<tr>
<td>Renovation cost [EUR/m²]</td>
<td>870 (x1144)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Maintenance cost [EUR/m²/year]</td>
<td>17.6 (x23)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

...in general (for buildings)

- **2 à 4**
- **400 à 1000**
- **110**
Modelling strategy > Level of Development as specified in BIM Execution Plan

Modelling the Retrofit Reality

All engineering disciplines contribute to the integrated design
MODELLING THE RETROFIT REALITY

BIM coordination as a constant control process

60+ CAD aspect models!
Integration of highway design (Bentley MX, Civil 3D)
with structural design (Revit)
and technical installations (AutoCAD 3D, Plant 3D)

CERES – February 2018
MODELLING THE RETROFIT REALITY

BIM coordination as a constant control process

1 Coordination Model

67 CAD models federated in Navisworks, for (bi)weekly Baseline and Design Meeting

> to identify (interface) risks
> to explore design and build strategies
> to boost inter-disciplinary cooperation
**BIM GOALS – FROM LITTLE BIM TO BIG BIM**

bim as in *Building Information Modelling*

1. to improve the conceptual / architectural /engineering process
2. to integrate and coordinate all design disciplines, to avoid clashes
3. to automate the production of drawings, quantities, planning, ...

BIM as in *Building Information Management*

1. to assure project quality (scope, time, budget)
2. to integrate the project management information and processes
3. to reduce failure costs > to manage project risks
<table>
<thead>
<tr>
<th>Engineering Requirements of 160 Object Types</th>
<th>With &gt; 2,000+ Instances!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bestaande tunnelwand</td>
<td>To manage the engineering (requirements) of 160 object types, with &gt; 2,000+ instances!</td>
</tr>
<tr>
<td>Terreinen</td>
<td></td>
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<tr>
<td>TER-ASNAanlegsteiger Noord</td>
<td></td>
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<tr>
<td>TER-ATOoomkelder</td>
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<tr>
<td>TER-HEKzitkelder</td>
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<td>TER-POMpompachgrond</td>
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<td>TUN-Tunnelciviel</td>
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<td>TUN-BARBarmier</td>
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<tr>
<td>Halve betonnen stepbarrier, type hoog</td>
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<tr>
<td>Halve betonnen stepbarrier, hoog links aanziendbaar</td>
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</table>
MANAGING COMPLEXITY – HOW?

The bigger perspective ...

SE is a methodology to design, build, maintain and operate complex systems successfully.
Because information is:

*implicit, unstructured and unrelated*
METHOD: SYSTEM ENGINEERING

From document-based to data-based workflows

1 - make explicit
From document-based to data-based workflows

1 - make explicit

2 - structure

3 - relate
INTRODUCING A SYSTEM-BASED APPROACH

‘Data-based’ workflow

All processes based on
explicit, structured and related information
METHOD: SYSTEM ENGINEERING

All non-geometric project information is managed in a SE-database.

SE-database = Single Point of Truth

- 17 organisations have access
- 295 people are registered
- 7GB of textual data
- 70% reduction in e-mail usage!
INTEGRATION OF SE AND BIM

The best of two worlds ...

SE-objects connected to CAD/BIM-objects in a bi-directional way, with iBIM Connectors
INTEGRATION OF SE AND BIM

The best of two worlds ...

SE-objects connected to CAD/BIM-objects in a bi-directional way, with iBIM Connectors
INTEGRATION OF SE AND BIM

CAD & BIM objects are just a representation!

160 ‘as required’ object types have 2,028 ‘as designed’ instances
EXAMPLE: PRO-ACTIVE INTERFACE MANAGEMENT

"Solving a clash in BIM is always cheaper than on site!"

€80 versus €1000

Source: Dr. Ir. Thomas Vandenberg, Besix – BIM Manager for Grand Egyptian Museum project
EXAMPLE: PRO-ACTIVE INTERFACE MANAGEMENT

The best clash is the one that never materializes!

Designer
[CAD]

BIM
[Navisworks]

SE-database
[Relatics]

CAD model with "as designed" object instances

BIM environment with all the active CAD models (and object instances)

Clash test or visual inspection

Clash report

Version management of designed models

SE tree with "as required" object types (+ requirements)

Interfaces between SE object types

Interfaces between sets of instances

Interface review + indication of "guilty" object instance and corresponding version of the CAD model which has to be adapted

Designer
[CAD]

BIM
[Navisworks]

SE-database
[Relatics]

[IBIM connector]
EXAMPLE: PRO-ACTIVE INTERFACE MANAGEMENT

The best clash is the one that never materializes!

127 Interface Types between couples of Object Types

92 Clash Tests in Navisworks

iBIM automatically generates the clash search sets

300 Clash Reports

Navisworks searches for clashes and iBIM reports back to SE-database

1,500 (groups of) clashes detected and fixed

+ many more prevented by good communication and exchange of geometric information
FROM DESIGN TO CONSTRUCTION

Virtual Design & Construction in the project reality

Precise setting-out data for new perforations generated from the BIM-process.

Thanks to the BIM-process only 2 new perforations for the ‘Fire Stations’ had to be made, instead of 42 new ones and 44 to be filled.
FROM DESIGN TO CONSTRUCTION

Virtual Design & Construction in the project reality

Non-geometric project mgt information
> in SE Database

Geometric project mgt information
> in BIM System

Non-geometric + geometric project mgt information
> on mobile devices

- Up-to-date information: anytime, anywhere
- Direct communication: office <> field
- Fully integrated & managed with/from SE Database
- SE consistent: explicit, structured, related

CERES – February 2018
FROM DESIGN TO CONSTRUCTION

Virtual Design & Construction in the project reality

10 differences?

10 differences?
Virtual Design & Construction...
FROM BIM TO VIRTUAL REALITY

Extending the value of the BIM model to Simulation Applications
FROM BIM TO VIRTUAL REALITY
Extending the value of the BIM model to Simulation Applications
FROM DESIGN TO CONSTRUCTION

Virtual Design & Construction in the project reality

10 differences?

10 differences?
BENEFITS OF RISK-DRIVEN BIM-STRATEGY

Achieving the ROI ...

€ 500,000
BENEFITS OF RISK-DRIVEN BIM-STRATEGY

Achieving the ROI ...

€ 500,000
- € ???K hand-over to client

versus SATISFIED CLIENT !!!
versus publicity
versus lessons learned
versus prevented failure costs
versus time gain

versus € 250K penalty/day
versus € 90M total project cost
versus € 10.5M design cost
EXTENDING THE VALUE OF THE BIM-MODEL

During Engineering
- > central model for design & interface meetings
  > simulation of camera installations

During Construction
- > 4D-planning
  > central source for all setting-out activities
  > validation of as-built survey <> as-designed data (first-time-right!)

During Operations
- > 4D-planning of inspections & preventive maintenance
  > briefing of maintenance crews & training of safety personnel
  > asset management
CONCLUSIONS & RECOMMENDATIONS

BIM ... Beyond the image

1. Information Management should be part of overall Project Strategy
2. Integrating all information (geometrical and non-geometrical) pays off!
3. Information you develop during the subsequent project stages is an asset with a tangible value
4. Discussing risks and opportunities with your client with respect to information can help to build a strong relationship based on trust which will lead to a win/win situation
Video with footage from the renovation made by RWS (excluded from pdf)
Questions & Discussion
1) Contract management vs. collaboration / co-creation in our industry
2) Added value of universities in renovation challenge in Western Europe
3) Digitization in construction: game changer or overrated?