



Tunnels & Tunnelling
Experience Record
Specialist Mechanical &
Electrical Services
Safety Strategies

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INTRODUCTION

Tunnel Engineering Consultants (TEC) is a Joint Venture of Royal HaskoningDHV (RHDHV) and Witteveen+Bos (WB). TEC combines knowledge, expertise and experience of the mother companies (9000 professionals) within the field of large underground projects.

TEC guarantees continuity and specialized knowledge of tunnel design and construction to solve complicated underground mobility challenges through an integral, innovative and sustainable project approach.

In addition, TEC is able to draw on the considerable expertise of two Dutch engineering consultancy firms and covering the entire range of civil, structural and architectural engineering required for small and large building projects, environmental impact assessment, legal aspects and project management.

This TEC experience record intends to give an impression of the capabilities of Tunnel Engineering Consultants in the field of tunnel related design and tunnel construction related consultancy. It will provide an overview of services that TEC can offer within the preparation and realization of tunnel project.

This document provides a selection of appealing projects in which TEC was and is involved including the position TEC had in the project.



TEC PROFILE

Tunnel Engineering Consultants v.o.f. (TEC) is specialised in consultancy works for underground infrastructure and tunnel projects. TEC is established in 1988 as a Joint Venture between two major engineering consultancy firms:

- Royal HaskoningDHV
- Witteveen+Bos Consulting Engineers b.v.

Profile

TEC's key expertise is tunnels; in-situ land tunnels, bored as well as Cut&Cover and immersed tube tunnels. The Scope of work comprises tunnel design with construction supervision including the mechanical and electrical tunnel installations. Together with the Dutch Ministry of Transport and Public Works – Tunnel engineering Department (Rijkswaterstaat), TEC developed advanced knowledge in tunnel engineering.

The participating firms employ more than 9000 engineers and specialists and have a total annual turnover of about 950 million EURO (2013). They have subsidiaries and branch offices in countries worldwide.

Royal HaskoningDHV

www.royalhaskoningdhv.com



Royal HaskoningDHV is a leading independent, international project management and engineering consultancy service provider. Specialising in planning and transport, infrastructure, water, maritime, aviation, industry, energy, mining and buildings, each year we contribute to the delivery of some 30,000 projects around the world on behalf of our public and private sector clients.

Our 8,000 staff adds value to our client's projects by providing a local professional service in more than 35 countries, via our fully integrated international office network. As leaders in sustainability and innovation, we are deeply committed to continuous improvement, business integrity and sustainable development, and work with our clients, stakeholders and communities to enhance society together.

Prior to the merger on 1 July 2012, Royal Haskoning and DHV have successfully delivered millions of world class projects during the past two centuries. With roots established in The Netherlands, the UK and South Africa, our combined experience and longevity spans more than 225 years. Now, as one company, we have the power to make a bigger difference in the world as we rise to the challenges of our 21st century planet, towards a better, brighter future.

Today Royal HaskoningDHV ranks in the top 10 of global, independently owned, non-listed companies and top 40 overall. This makes us the first choice consultancy provider for involvement in major world themes, such as 'pit-to-port', food and water scarcity, the development of mega-cities, and sustainable infrastructure and energy resources & supply, such as wave and hydro power. We are also well positioned to contribute to the latest business models, such as Public-Private Partnership.



Witteveen+Bos Consulting Engineers b.v.

www.witteveenbos.com



Witteveen+Bos is a private limited company whose shares are owned entirely by its employees, who are either participants, partners or senior partners. This unique ownership structure ensures above-average commitment, good financial performance and a high profile. It is a structure that appeals to our clients, because it gives them confidence in our commitment. Our net result is paid out entirely as a dividend to our shareholders, so they share in large measure in the company's result.

The Witteveen+Bos organisation is built around the cells concept that we have shaped in the form of PMCs (product market combinations). Organisationally, the PMCs are clustered into five sectors. The five sectors are: Ports and hydraulic engineering, Spatial development and the environment, Urban development and traffic, Water, and Infrastructure and Construction,

Next to the offices in The Netherlands, Witteveen+Bos also has offices in Belgium, Kazakhstan, Indonesia, Russia and Latvia.

Witteveen+Bos is committed to being a first-rate consultancy and engineering firm. Performing at the very highest level is a precondition for achieving this goal. We think striving for the top is a healthy ambition. A national and international orientation towards products, markets and the labour market is essential to operating being the best in our field of work.

Internationally, Witteveen+Bos has achieved a good position in the following areas:

- preparation, transport and distribution of drinking water
- effluent treatment
- water management
- environmental technology and policy
- ports, dredging, coastal water engineering, river water engineering
- tunnels



SERVICES

TEC provides a full range of consultancy services from feasibility studies, design, tender documents, tender evaluation, design reviews, value engineering, cost analysis, detailed design, and construction supervision to project management for underground engineering, related electrical and mechanical works and traffic engineering. In addition, we are able to draw on the considerable expertise of three Dutch engineering consultancy firms covering the entire range of civil, structural and architectural engineering required for small and large building projects, environmental impact assessment, legal aspects and project management.

Moreover, TEC has at their disposal specific expertise of the Dutch Ministry of Transport and Public works – Tunnel Engineering Department (Rijkswaterstaat), a governmental organisation involved as designer and owner / operator in about 26 road and railway tunnels and their installations in the Netherlands.

Expertise

- Civil
 - immersed tunnels
 - shield tunnels in soft soil
 - cut & cover tunnels
 - pneumatic caissons
- Electro mechanical installations
 - ventilation
 - pumps
 - lighting
 - power supply
 - traffic control
 - operation
- Safety aspects
 - Safety analysis
 - Operational procedures
 - QRA and Scenario Analysis
- Risk assessment & Value Engineering



SPECIALIST MECHANICAL & ELECTRICAL SERVICES/SAFETY STRATEGIES

General

In addition to the design and consultancy services related to tunnel technical installations that make part of the various civil works assignments by TEC and its partners, also specialist (stand-alone) M&E Services have been provided. The following projects are described hereafter.

- Traffic Control Centre for the southern part of The Netherlands
- Traffic Control Centre for the eastern part of The Netherlands
- Dordrecht region tunnel and bridge installation renovation
- Botlek tunnel renovation
- 2nd Coentunnel, Amsterdam, The Netherlands
- Safety concept and Systems North South Metro Line Amsterdam, The Netherlands

Projects of which M&E Services was a significant part but that were described earlier in this Experience Record are:

- Noordtunnel, the Netherlands
- Wijkertunnel, the Netherlands
- Daugava tunnel, Riga, Latvia
- Thomassentunnel, the Netherlands
- New Tyne Crossing, United Kingdom
- Busan – Geoje Link, South Korea
- Oosterweel tunnel, Belgium
- Fehmarnbelt tunnel, Germany-Denmark
- Shenzhong Crossing, China
- Santos Crossing, Brazil
- Sharq Crossing, Doha, Qatar
- Sluiskil tunnel, the Netherlands
- South taxiway tunnel, The Netherlands
- Amsterdam Schiphol Airport Freight traffic tunnel, the Netherlands
- Aqueduct Gaag, the Netherlands



Traffic Control Centre for southern part of The Netherlands

Project

The Traffic Control Centre for the southern part of The Netherlands is located in Geldrop. This centre processes data received from the roadside installations in the provinces of Noord-Brabant and Limburg. These installations are linked to the traffic control centre by telemetry systems. The traffic control centre is used by the Ministry of Traffic and Public Works to inform, guide and direct road users.

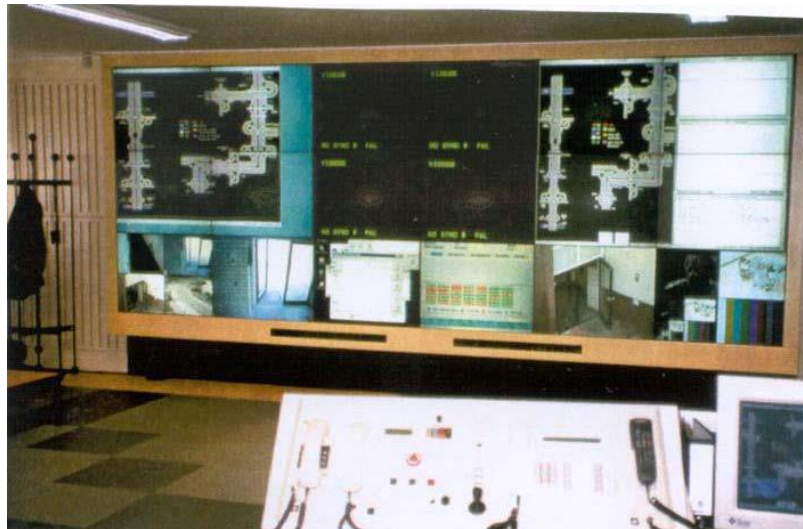


Figure: Plan of the Traffic Control Centre

TEC's scope of work

The work consisted of:

- Basic design
- Final design
- Development of tender documents
- Supervision, and
- Project management



Traffic Control Centre for eastern part of The Netherlands

Project

The Traffic Control Centre for the eastern part of The Netherlands is located in Wolfheze. This centre processes data received from the roadside installations in the provinces of Gelderland, Drenthe, Groningen and Friesland. These installations are linked to the traffic control centre by telemetry systems. The traffic control centre is used by the Ministry of Traffic and Public Works to inform, guide and direct road users.

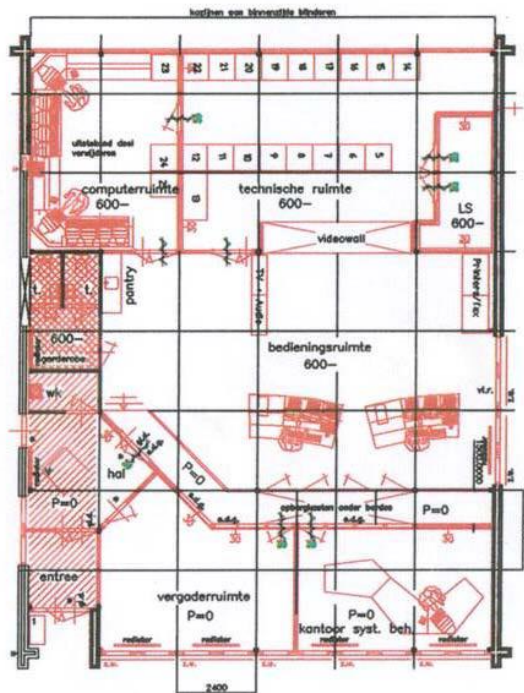


Figure: Plan of the Traffic Control Centre

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Dordrecht region tunnel & bridge installations renovation

Project

The technical installations of the traffic control systems in the Dordrecht region were outdated and needed to be replaced. Due to the fact that new and improved technology became available as well as new legislations for tunnel installations, the Tunnel Engineering Department of the Ministry of Transport and Public Works commissioned TEC to provide their services to renovate the control systems for the “Drecht” and “Noord” tunnel, as well as the bridge over the river “Noord”, the “Wantij” bridge and the “Papendrechtse” bridge.

The renovation of the installation systems and control units for the three motorway bridges included the energy supply (opening and closing), traffic lights for ships, traffic lights for cars, traffic barriers, hydraulic drive, emergency motor (in case the main motor breaks down), CCTV-installations (cameras), noise barrier installations, video screens and building installations (heating, ventilation, sanitary installations).

The renovation of the installation systems and control units for the two motorway tunnels included energy supply, ventilation, lighting, emergency buttons (to close off the tunnel), UPS (uninterruptible power supply), drainage, traffic installations (cameras, traffic sensory systems), communication (phones, speakers) and fire fighting installations.

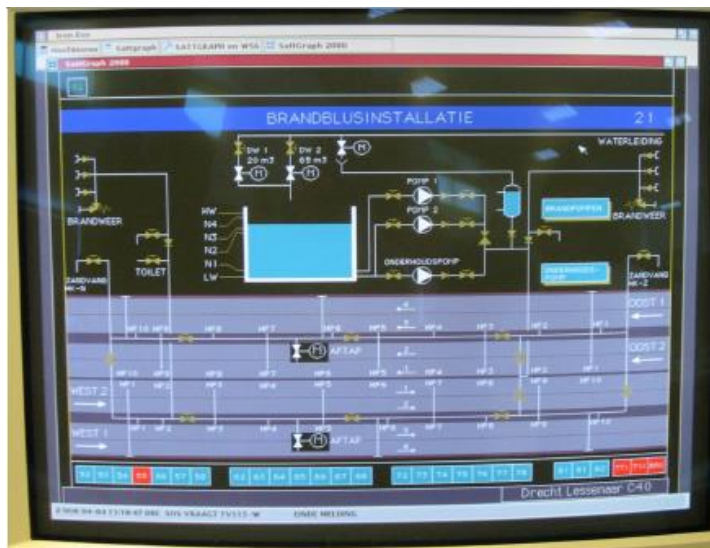


Figure: Installations

TEC's scope of work

- To prepare a conceptual design, a final design and tender documents.
- Control of detailed engineering and construction of the installations.
- Responsible for construction supervision management on site.



Botlek tunnel renovation

Project

The project relates to the renovation of the emergency power installations and Speed Discrimination System of the Botlek tunnel.

The mechanical and electrical installations that required renovation consisted of:

- Energy power systems
- Distribution systems
- UPS-system
- Speed Discrimination System
- Plant control and control systems



Figure:

TEC's scope of work

- To prepare a conceptual design, final design and tender documents.
- Control of detailed engineering and construction of the installations.
- Responsible for construction supervision management on site.



2nd Coentunnel, Amsterdam, the Netherlands

Project

Every day, over one hundred thousand cars are using the Coen tunnel, much more than this motorway section can handle. In order to regenerate the traffic flow, the Dutch Public Works decided to expand this motor way section by the realization of the second Coen tunnel and the renovation of the existing tunnel.



Figure Existing Coen tunnel



Figure: Areal view Coen tunnel

In order to connect the tunnels to the A8 and A10 motorways, various connecting roads had to be realized. Rather than the technique the complexity of the project is based on the requirement that the link must be fully operational during construction of the new tunnel, the rehabilitation of the old tunnel and the integration into the new expanded road network.

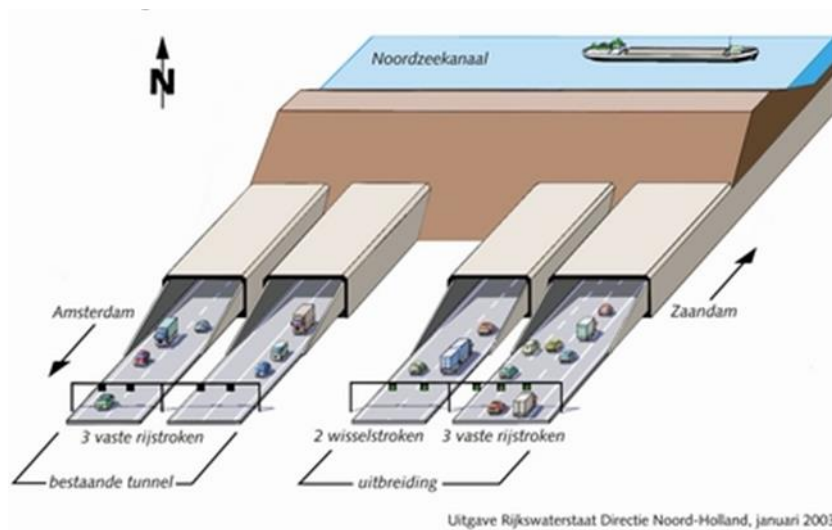


Figure New Road Lay-out



TEC's scope of work



Through Mother Company Royal Haskoning TEC provided various design services:

1. Final Design for the traffic and tunnel systems (TTS) to realize an increased capacity for the Coen Tunnel route based on the System Design:
 - Design subsystems for TTS system, such as communication systems, control systems, power supplies, lighting and ventilation systems, building services, fire extinguishing, traffic and drainage systems, etc.
 - Technical design in text and/or single-core wiring diagrams and/or I/O lists, light calculations, cable calculations, power balance/energy matrix, capacity of pumping systems, water hammer analysis, etc.
 - Specification of procedures for verifying the requirements associated with the system.
 - Coordination interfaces and defining interface requirements.
 - Coordination space aspects and recesses for the traffic and tunnel systems.
 - Reliability Availability, Maintainability, Safety, Health and Environmental analyses associated with the system.
2. System Design for the traffic and tunnel technical systems (TTS) to realize an increased capacity for the Coen Tunnel route based on requirements specified by the Ministry of Public Works:
 - Preparation of integrated design at level 0 (highest level of the System Engineering methodology) for the TTS system, applying the methodology of system engineering.
 - Preparation safety and tunnel scenarios (flow of events in time), including what-if analyses (analysing and evaluation of the effects of a failure of



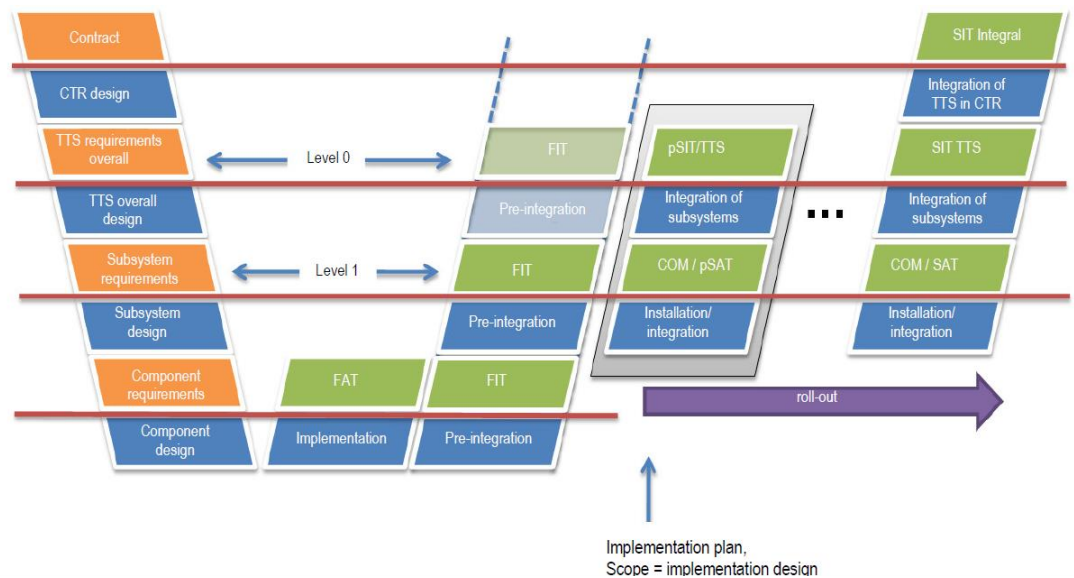
one or more of the related systems during each scenario step), in order to discriminate the critical events.

- Preparation system scenarios on the basis of these safety and tunnel scenarios (response of the technical system) in which the integrated operation of the subsystems of the TTS system is shown.
- Allocation of the requirements to the subsystems for the TTS system, such as communication systems, control systems, power supplies, lighting and ventilation systems, etc.
- Identification of system interfaces.
- Specification of the procedures for verifying the requirements associated with the system.

3. Master test plan traffic and tunnel systems

To full fill the operational requirements and secure the safety aspects, the traffic and tunnel systems (TTS) will undergo a strict verification and validation process. This set of procedures will assure the quality and cohesion of the delivered (sub)systems and the integrated operation of the system.

The Master Test Plan' (MTP) describes these processes at a strategic and tactical level, documents the verifications to be performed, at what level and who is responsible. In respect to the System Engineering methodology, the MTP is the leading document in the verification and validation.





Safety concept and Systems North South Metro Line Amsterdam, the Netherlands



Safety Concept

An integrated safety approach has been developed by TEC for the new underground North/South metro line based on the “**Safe Haven**” concept. As legislation in the Netherlands did not provide a safety framework for underground structures, a project specific concept has been developed.

Evacuation and fire-safety design of the underground mass transit system (with bored and immersed tunnels, underground stations, rolling stock) are the main safety topics. A functional fire safety approach (FSE) has been followed. The leading principle of the safety concept is that all the measures will be taken to ensure that in case of emergency the trains will reach the stations. The tunnels are situated at such depth that emergency crews cannot be on hand immediately in case of an incident. The passengers should therefore in all situations be transported to the stations. These stations are the Safe Havens. A rapid and safe evacuation from the stations is of utmost importance for the total safety concept.

The depth of the (multi level) platforms and spatial constraints required a solution in which safe evacuation will be supported by escalators and an emergency ventilation system. The stations are furthermore equipped with emergency power supplies, detection systems, smoke and heat extraction systems, fire proofing etc. to prevent or control incidents.

For the main Central Station Transport hub, special attention was given to the multiple and complex safety interfaces with other public transit areas, not only for the final result but also during the ten year construction period.

TEC was responsible for the design of the Integral Safety Concept and all the safety assessments like: Fire safety analyses (FSE), Quantitative risk analyses, HAZOP, Hazard Logs, Safety Cases, evacuation simulations (3D), Smoke extraction and CFD modelling, program of safety requirements. The fire load assessment and structural integrity requirements were also part of the works performed. This concept has been developed in dialogue with both the legislation authorities and rescue services.



Systems

Functional and technical specifications for all the mechanical and electrical systems (MEP-systems) of the metro system are developed by TEC, taking into account the specific (safety) requirements and constraints of the underground structures.

Parts of the design-services are the following subsystems:

- Escalators and elevators
- Smoke exhaust systems (emergency ventilation)
- Ventilation (HVAC)
- Electrical Power supply (trains and systems)
- Lighting systems
- CCTV- and communication systems
- Emergency stations
- Pumping and drainage systems
- Detection systems

All these systems are designed in compliance with the reliability and safety requirements as part of the integral RAMS and Life Cycle Cost (LCC) assessments.