

CHANNEL TUNNEL PROJECT OVERVIEW

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Over a century of history

From Napoleon's time to the mid 19th century, many ideas or proposals for a fixed link appeared. Geotechnical investigations evidenced the presence of Chalk strata adequate for tunnelling. French engineer Thomé de Gamond spent most of his life attempting to find practical solutions.

In the 1880's, undersea tunnelling actually started at Shakespeare Cliff and Sangatte, but was stopped for political reasons. The nearly 1.8 km dug on each side were found intact in UK (1987) and France (1958). In 1974, a tunnel scheme was stopped for political reasons on British side.

In 1979 the European Channel Tunnel Group initiated studies for various private railway tunnel schemes. A competition was organized by the French and British governments in 1985. Four main projects were submitted: Euroroute, a hybrid solution of a bridge-tunnel-bridge, Europort, a suspended bridge, Transmanche Express, four bored tunnels allowing both railway and road traffics, and Eurotunnel, a rail shuttle service for road vehicles with provision for through trains, using 3 tunnels, two for rail and one for maintenance.

The concession to build and operate the Fixed Link across the Channel was awarded on 20th January 1986 to France-Manche and Channel Tunnel Group subsequently to become Eurotunnel (ET) and Transmanche Link (TML) in March 1986.

The Fixed Link

Transportation system

The Fixed Link connects road/rail networks of UK and France and allows mixed traffic at short headway (3 minutes between trains) and high speed (100 to 160 km/h) of national trains and special "Shuttles".

"Shuttles" allow rail transportation of road vehicles (cars, lorries, coaches...), road to road, from one country to another.

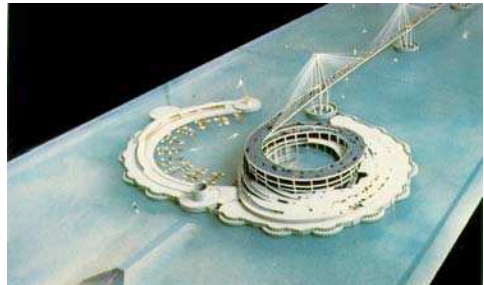
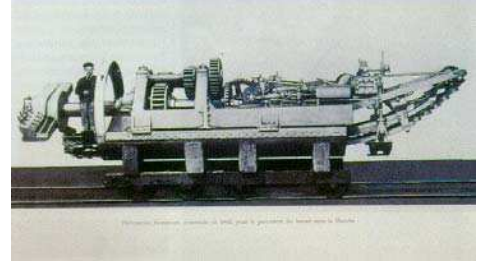
Two terminals connect road and rail networks. They are linked by three 50.5 km long tunnels - 9.3 underland in UK, 38 undersea and 3.2 underland in France - one service tunnel between both running tunnels, fitted with safety and electronical equipments to the highest standards.

Services to users

Road users drive their vehicles from motorways to aboard shuttles through the terminals, stay aboard their vehicle, and exit freely on the other side after a 35 minutes journey from platform to platform (27 in tunnels). Tolls, customs and allocation,



Above, Left: French Engineer Thomé de Gamond (1807-1876) has been promoting many technical solutions for a Fixed Link between 1834 and 1868; He even collected samples by over 30 m deep without diving equipment. Above, Right: The Beaumont boring machine, built in the 1880's by the Société de Construction des Batignolles (now Spie Batignolles), dug 1.8 km on each side of the Channel. Below: Two of the proposals presented in 1985, Europort (Left, a suspended bridge), and Euroroute (Right, which included bridges and tunnels connected by artificial islands).



directing of road vehicles is carried out prior to loading. No booking: shuttles are available at least every 30 minutes.

Freight or passengers direct rail journey between Paris, London, and Brussels is also possible. Eurostar trains reach London from Paris in 3 hours.

Project organisation

Eurotunnel

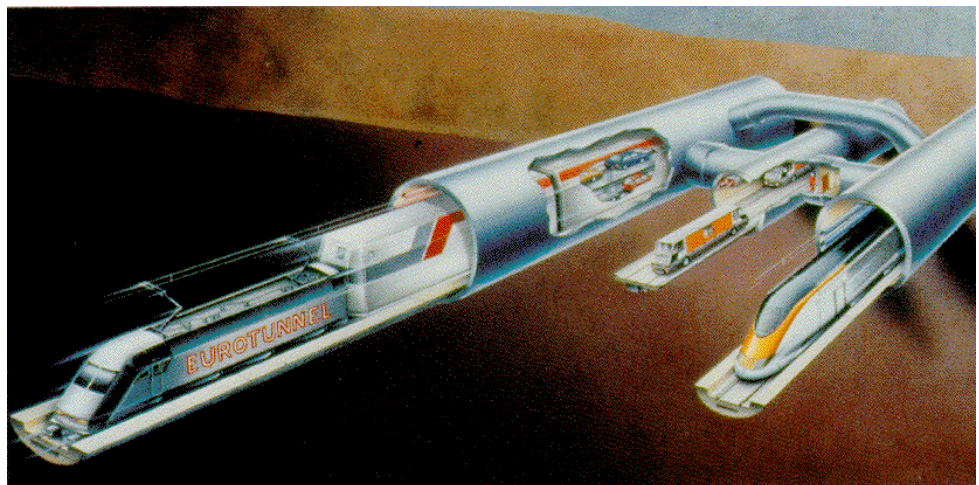
Eurotunnel (ET) is a bi-national company formed by Channel Tunnel Group (UK) and France Manche S.A. (FR). It is owner and operator of the project, and client of the contractor TML. During tender period

(1985-86), ET was owned by banks (50%) and by the 10 companies which will become TML (50%). Later, ET became independent, transferred to shareholders and banks.

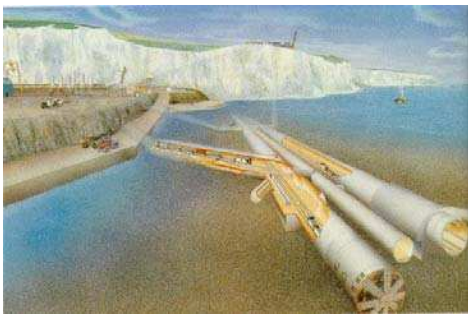
Contracts

The Concession Agreement (March 1986) is awarded for 65 years by the governments of UK and France to Eurotunnel. It is based on the proposal submitted in 1985 and includes the key requirements of the Governments.

The Construction Contrat between Eurotunnel and Transmanche-Link sets out the



EUROTUNNEL won the competition in 1985: 3 tunnels, two for rail and one for maintenance, allow mixed traffic of special "shuttles" carrying cars and national trains (a EUROSTAR train is shown on the picture). They are connected every 375m by cross passages or technical rooms housing electromechanical equipments, and every 250m by piston relief ducts. Service Tunnel Transport System, used for maintenance, comprises 24 twin-cab rubber-tyred vehicles, top speed 80 km/h (incl. 12 ambulances and fire vehicles), electronically guided by an embedded cable in concrete.



Above: Shakespeare Cliff, main tunnelling site on UK side, from where started all British boring machines. Below: Shakespeare Cliff in 1988. Tunnelling spoil is being used to build a platform at the bottom of the cliff.



terms for design, construction and commissioning of the Fixed Link.

ET is also linked to the banks by a loan agreement, and to national railways by a usage agreement.

Safety Authority and Maître d'Oeuvre

The project is supervised on behalf of both governments by the bi-national Intergovernmental Commission (IGC) including a Safety Authority. Design, procedures, specifications, construction (particularly environmental, operational and safety issues), have been reviewed by experts appointed by the Safety Authority.

The Maître d'Oeuvre is a technical auditor reporting to ET, the IGC, and the Banks.

TML, Channel Tunnel Contractor

Transmanche Link (TML) is the Contractor responsible for the design, construction, and commissioning of the project.

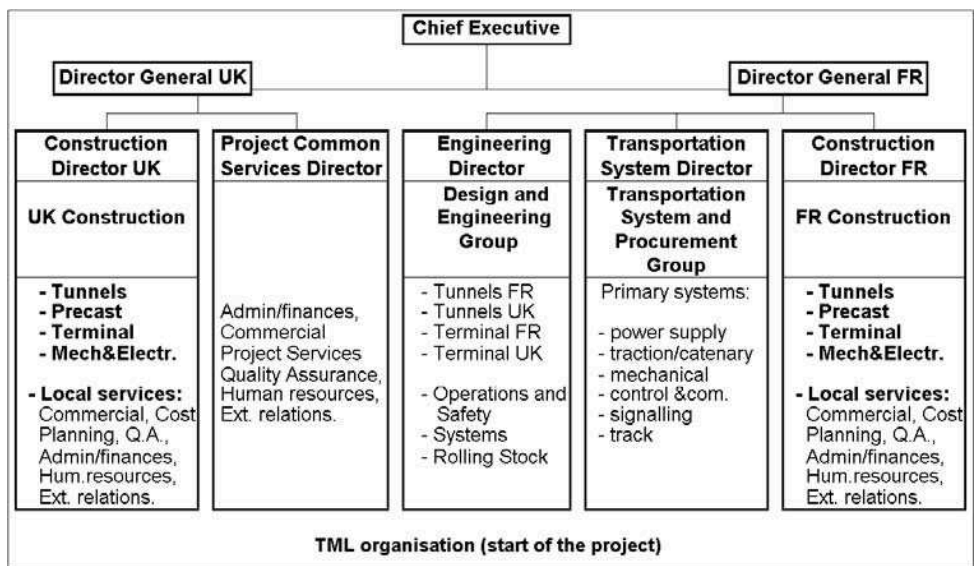
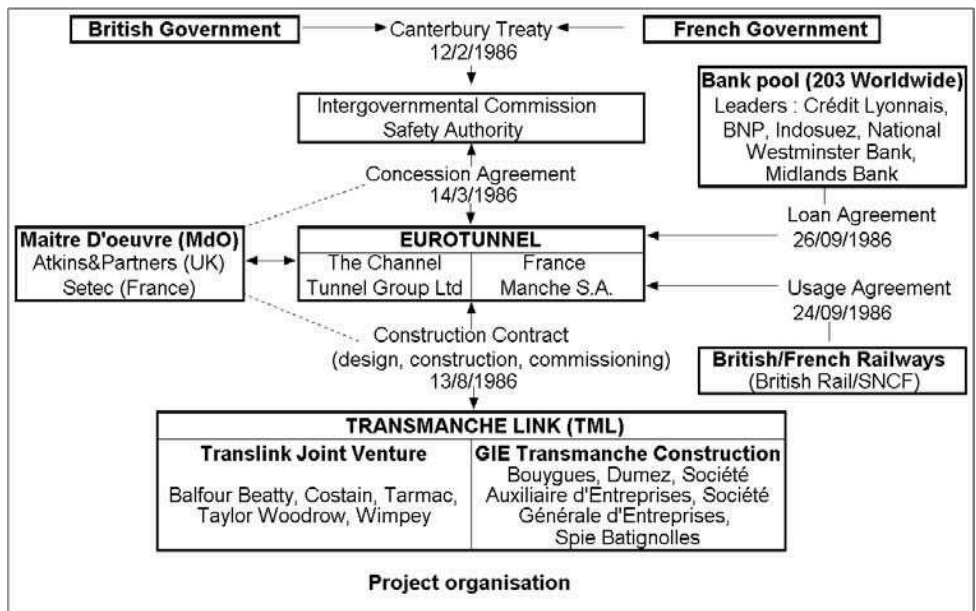
TML is a bi-national Joint Venture of two operating companies, each of them being itself a joint venture: "GIE Transmanche Construction" links 5 French companies (Bouygues, Lyonnaise des Eaux-Dumez, Société Auxiliaire d'Entreprises, Société Générale d'Entreprises, Spie Batignolles), and "Translink JV" links 5 British companies (Balfour Beatty, Costain, Tarmac, Taylor Woodrow, Wimpey).

These 10 contractors have together an international experience of tunnelling and mechanical/electrical engineering works representing thousands of kilometers.

Unprecedented challenge

100 Billions Francs financial challenge

The client, owner, and operator of the system, Eurotunnel, had to be created and financed through a pool of 203 different



banks worldwide, using only private funds without any government money. Insurances for works and completion, and multiple methods of payments to manage technical risks added to financial complexity.

Bi-national and human challenge

French and British Engineering methods and expertise had to be brought together, integrating executives from 10 companies, incorporating and training 13,000 people (5300 in France, 90% local, trained from basic to highly qualified level in 3 years), into a single project team.

Fast-track programme

Design, construction and commissioning was completed within 8 years. 150 km of tunnelling had to be completed in 4 years, fixed equipment installation within 2 years after breakthrough, and commissioning including rolling stock, within 1 year. This meant, in less than 3 years, to :

- create and organize TML, a company employing 13,000 persons, with 10 billions francs yearly turnover.
- launch 11 TBMs with their logistics.

Each task (design, civil works, installation of fixed equipments, track, rolling stock tests,

commissioning) has widely (over one year) overlapped on the next one.

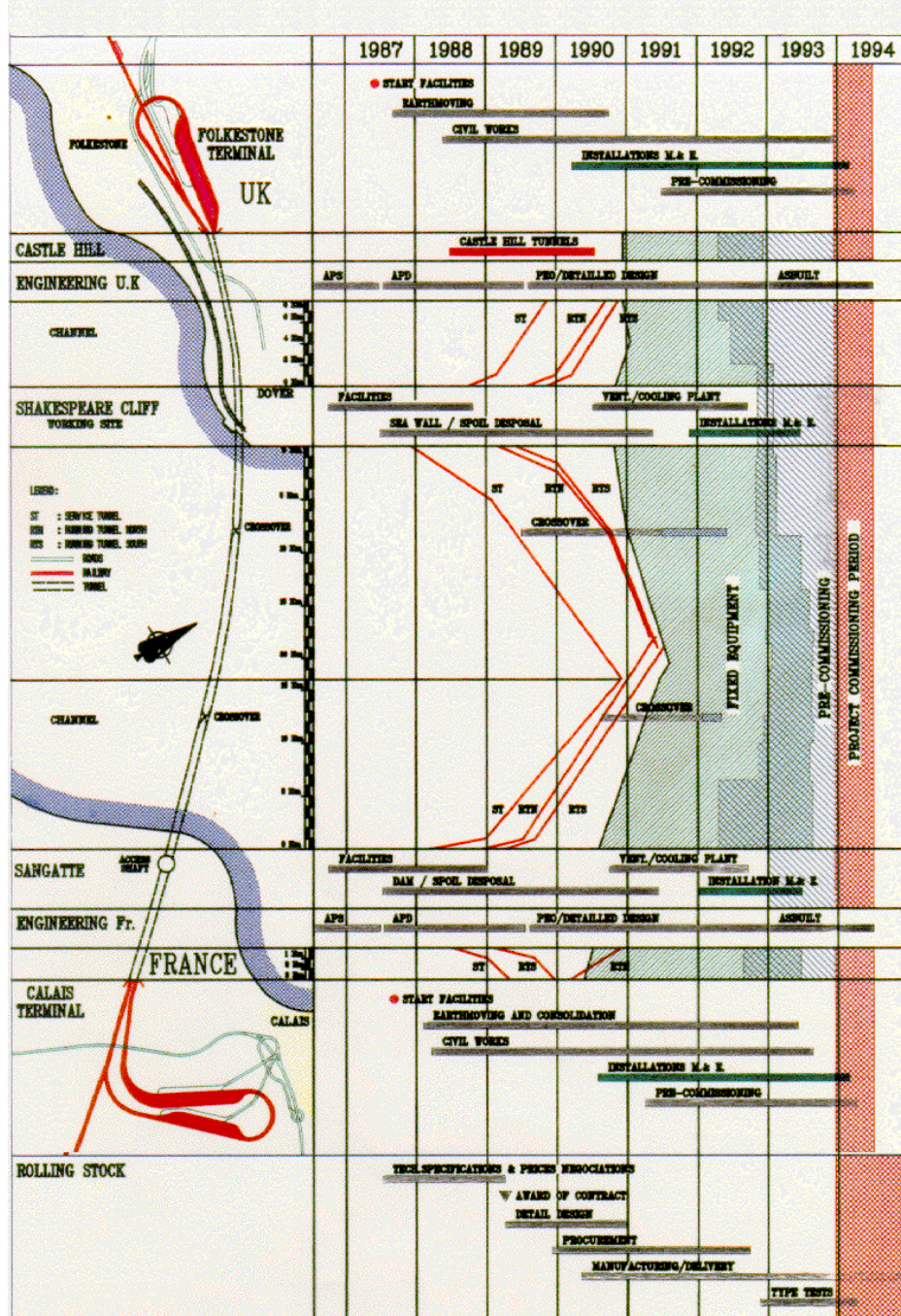
Meanwhile, tunnel environment was sustained by temporary ventilation, drainage, water, power, communication and monitoring systems, modified or removed, as permanent ones, of comparable capacity but totally different concept, were commissioned at the same time.

Despite many unforeseen problems, tunnelling works achieved the original 1986 programme.

High-tech research and developpement

Transfer a motorway traffic through hybrid airport-sized terminals (partly motorways partly train stations, airport-type security principles) onto an entirely new rail system with minimum transit time, with shuttles travelling on high capacity, high speed, mixed traffic rail network, in a confined tunnel environment, with strict operational and safety criteria, meant to develop, in half the usual time for such tasks :

- a very high integration between works and specific transport equipment,
- an unprecedented rolling stock: the heaviest trains (2300 T), the more powerful locomotives ever (5.5 MW), the



Overall project design, procurement, construction, and commissioning programme.

more complex safety embarked systems (50 km cables per wagon), heaviest traffic on rails (twice the most trafficked railway ever), the largest wagons on standard gauge 1.435 m track (section 4x5.5 m), travelling at 140 km/h a few centimeters from the walkways.

- the largest real-time data system ever (excepting in space exploration) able to manage shuttles travelling at train speeds (140 km/h) with the kind of headway (3 minutes between trains) only found on much slower, lighter, and smaller urban subways trains.

Design challenge

The scale of the design is massive. The project is contractually defined by the following categories of performances :

- system throughput
- performance of shuttle trains
- environment
- safety and passengers evacuation
- scenarios and operational procedures

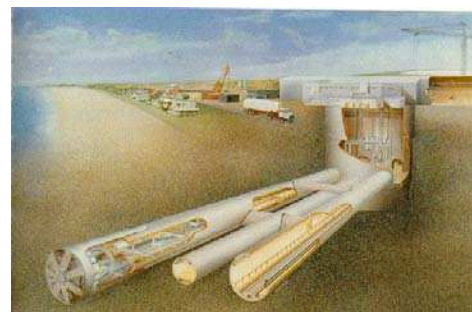
For fixed equipment and rolling stock, the emphasis on engineering activities shifted to design monitoring and interfaces management across all engineering disciplines. The challenge, in the early stages, was to provide sufficient information to allow civil works to proceed.

External influences

Organisations involved (Banks, Safety Authority, environmental issues, local authorities, public opinion...) interfered strongly and permanently on a project constantly under media spotlight.

Both unprecedentedly huge and accurate

The projects combines the largest size and complexity ever in civil works (longest undersea tunnels, strongest concrete, works to last 120 years...), with unprecedent reliability and accuracy (a few cms or mm tolerances to meet undersea at 18 km distance, to align track and walkways...). A high speed train, carrying cars, at urban subway headway, with a nuclear concept for safety, using 150 km of tunnels driven within 150 mm tolerances!



Above: Sangatte Shaft (55 m diam, 65 m deep), concentrating all tunneling activities on French side. Below : View inside the shaft. 6 precast segments are being transferred into tunnels.



Sangatte worksite: Precast plant, shaft with facilities, and Fond Pignon dam where tunnel spoil is stored.

TML organisation

Management principles

The whole project was beakdown into groups: French Construction, UK Construction, Transport System/Engineering.

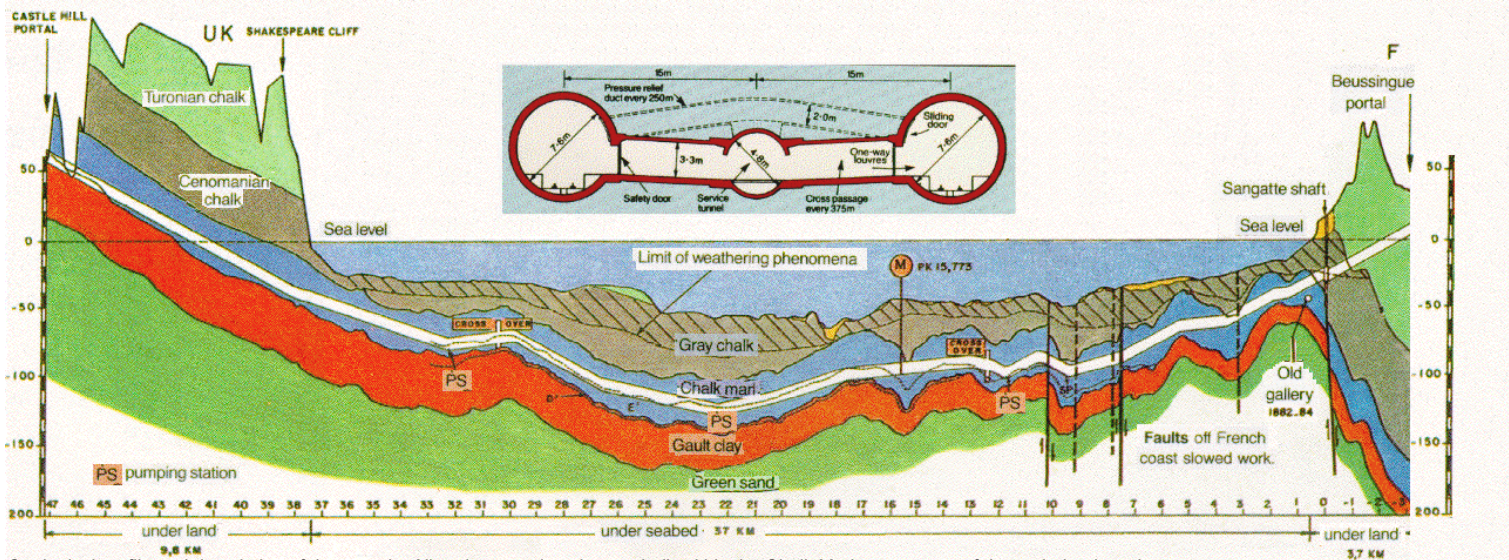
Each group was divided into human-scaled, manageable, sub-projects: tunnel construction, terminal construction, precast factory, M&E installation for Construction Groups. Transport System/Engineering Group was splited into primary systems (power supply, catenary, ventilation, etc...).

Quality system

The need for a global, planned, approach for the achievement of quality led to a classification allowing flexibility, with requirements depending on the criticality of tasks: quality requirements are identical for all tasks, but the methodology for management of this quality is graded from level 1 to level 3, according to complexity, "maturity" of the technology used, and impact of a disorder on the overall works.

Design studies

Design included four phases: Development Study, Outline Design (APS), Definitive



Geological profile and description of the tunnels. All underground works are built within the Chalk Marl, except part of the underland sections.

Design (APD) and Detailed Design (PEO). Functional studies, civil/electro-mechanical design, and construction overlapped widely (over 1 year) one on each other.

Engineering management concentrated on running a centralised TML organisation, to actually co-ordinate all aspects of design. Close cooperation between engineering and construction departments in TML, through site engineering teams, helped to meet the tunnelling target dates.

The huge volume and diversity of the development and design workload and the range of specialities involved, has led to subcontract part of specialized expertise to external design organisations. Extensive use of major independent consultants was done in UK. French member companies of TML created fully integrated design teams, such as BETU ("Tunnel design office"), and BETER ("Terminal design office").

Programme management

A hierarchical planning/control system allowed overall strategic planning, detailed

day-to-day planning of long linear works, and proper reporting to management.

Programmes at manageable size were produced from level 1, overall project programme (covering tasks in both the UK and France), to level 4, detail programmes in various formats (4-week look-ahead programme, co-ordination programmes, ..)

A real-time computerized reporting system allowed to monitor remotely, day by day, progress on all aspects of the project. (tunnelling, earthworks, installation..)

Commissioning

Unprecedented procedures have been established to guarantee passengers safety and start up the system. Tests included several phases : 900 subsystems individual tests, primary systems empty test, primary systems full load test, overall transport system test.

1000 Eurotunnel staff have been trained by TML. 660 operating manuals in both languages (24 copies each) have been delivered. 140 spare parts lists including 18,000 items have been established.

Scope of civil engineering

Main Railway Tunnels (RTs)

The two parallel running tunnels are 50 km long, at 30 m distance, lined diameter is 7.6 m, excavated diameter is 8.8 m. There are lined with high strength precast concrete segments. Ground conditions, watery and faulted in France, led to rings formed by 6 waterproof segments bolted, instead of 9 segments in UK, unsealed and unbolted.

Each running tunnels houses a single line rail track, overhead catenary, power supply, drainage, cooling pipes, two walkways, and auxiliary services.

Service Tunnel (ST)

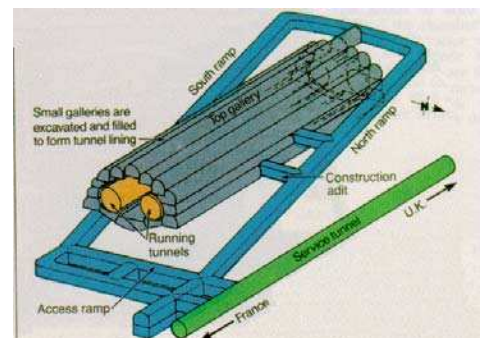
The service tunnel is 50 km long, lined diameter is 4.8 m, excavated diameter is 5.8 m. Located between running tunnels, it provides access to these in both normal and emergency conditions.

The Service Tunnel Transportation System includes 24 rubber-tyred vehicles rolling (top speed 80 kph) on cast-in-place concrete, electronically guided by an embedded cable. It allows maintenance of permanent equipments.

Special underground works

- 2 undersea huge crossover caverns (160 m long, 180 to 270 m² cross section), located at the third points of

Structures of the French crossover cavern



Above : Launching the "T2" Tunnel Boring Machine (TBM) from Sangatte Shaft (running tunnel north undersea). Below : Inside the control cab of a TBM.



Tunnel views during works, showing temporary equipments (trains, track, water pipes, power and communication cables..): Service Tunnel (above) before breakthrough with ventilation duct. Running Tunnel (below), near a piston relief duct, with still temporary catenary, track, and pipes, but also some of the permanent equipment already installed.





British Terminal at Folkestone (left), and French Terminal at Coquelles site (right).

running tunnels, enabling a train to cross from a tunnel to another, to close tunnel sections to traffic during maintenance.

- . 270 cross passages of 3.3 m internal diameter, every 375 m, between service tunnel and running tunnels.
- . 194 piston relief ducts (2.0 m internal diameter), linking running tunnels every 250 m.
- . 156 electrical rooms, and 58 signalling rooms (internal diam 3.3 to 4.8 m), housing fixed equipment for power supply and control and communications, lined with cast iron or concrete, accessible from service tunnel only.
- . 5 pumping stations excavated.

Terminals

The Terminals, connecting the Eurotunnel Transportation System to road and rail networks on both sides of the Channel, are designed to ensure all services to the users, and operation, management, maintenance and safety of the system.

Coquelles Terminal

The French terminal covers 700 hectares (size of Orly Airport) of land mostly unsuitable for building and agriculture, and included over 12,000,000 m³ of earthworks. Due to space availability, rolling stock maintenance is concentrated on the French side. Soils consolidation and extensive drainage works (250,000 m³ storage tanks) had to be carried out.

Folkestone Terminal

The site for the UK terminal, identified during previous, aborted, 1974 project, covers some 140 hectares including access roads. The main terminal area is 2.5 km long and 800 m wide at the west end tapering to 150 m at the east end.

Sangatte shaft/Fond Pignon dam

The huge shaft (diam. 55 m, 65 m deep) is the French tunnelling site. Located at Sangatte near the coast about 3.2 km from the Beussingue Portal, it used to house all, highly sophisticated, tunnelling logistics. It now connects major permanent services (ventilation, cooling etc..) to tunnels.

Fond Pignon, a large dam built over former 2nd World War works from the Atlantic Wall, 1.6 km away from Sangatte, stores 5,400,000 m³ of tunnelling spoil.

Shakespeare Cliff

It is the UK tunnelling site. The adit A1 and the short stretch of tunnel built in 1974 has been incorporated to new works excavated using the NATM technique.

The chalk spoil placed at the Shakespeare Cliff Lower Site, about 200 m from the cliff, in a 1700 m long seawall of mass concrete contained by a double row of sheet piles, is now a landscaped platform housing permanent services of the tunnel.

Portals aerea

Portals are tunnel entrance and exit. On French side, the 2,000,000 m³-trench at Beussingue allows access to the portal.

On British side, three parallel tunnels have been built through Castle Hill, 493 m long, built using NATM primary lining and an in-situ secondary concrete lining. There are connected to the main, TBM-excavated, tunnels through Holywell works, which are reinforced concrete box structures, 512 m long, built within an open cut.

Transportation system

Primary systems:

- power supply,
- traction and catenary,

- mechanical,
- control and communication,
- signalling,
- track.

Power supply

Main functions:

- receive power from both national grids, transform voltage for traction and auxiliary uses, deliver power for auxiliary services, and provide system earthing.
- automatic switch, in case of failure, from one grid to the other, or from north to south running tunnel, or from a technical room to the nearest one.
- provide lighting in tunnels/terminals.

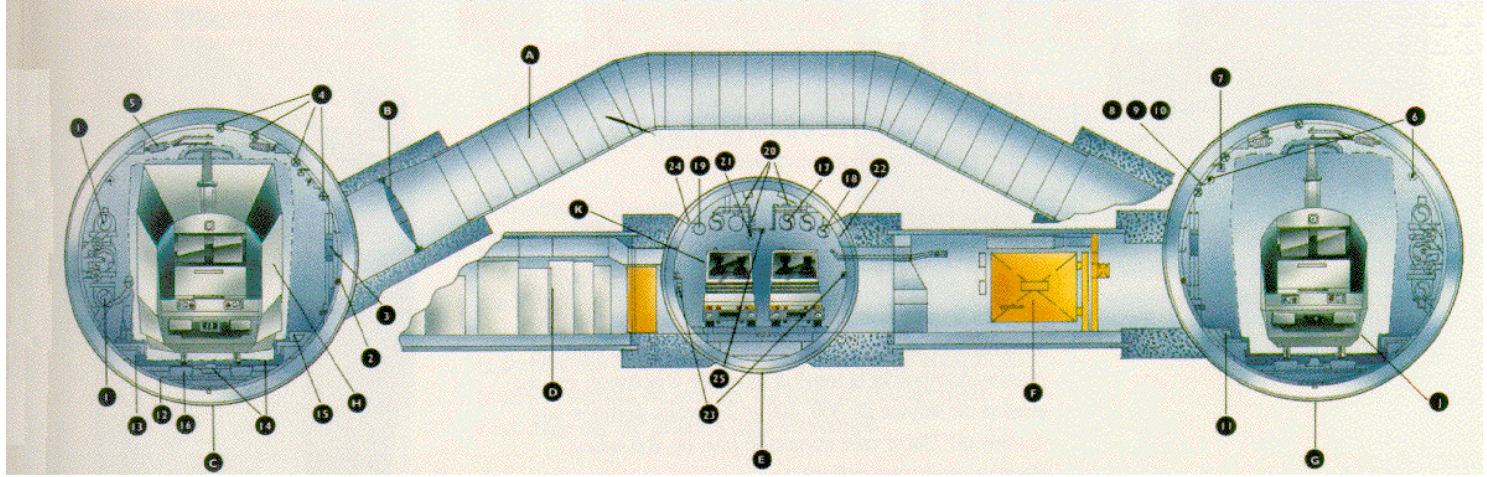
Main quantities:

- 2 main Terminal substations (1 in France and 1 in UK), 160 MW each (equivalent of a city of 250,000 inhabitants), transforming power received from the French grid (225 kV) and the UK grid (132 kV) into 25 kV for catenary to power the trains and 21 kV to feed auxiliary services such as ventilation, drainage and cooling systems.
- 28 secondary substations in tunnels transforming 21 kV into 3.3 kV.



Former tunneling sites on both sides of the Channel are now landscaped and house permanent facilities (ventilation, cooling, fire fighting, and diesel power plants, electrical equipments...). Shakespeare Cliff lower site has been built with tunneling spoil (right, above), and is now a 25-Ha platform (right, below). Sangatte Shaft, once the complex construction facilities removed, contains now large ventilation ducts (below, left).





A Piston relief duct at 250 m intervals
 B Piston relief damper
 C Running tunnel north marine
 D Typical technical room
 E Marine service tunnel
 F Typical cross-passage with bulkhead door
 G Running tunnel south marine
 H Euroshuttle
 J British Rail train
 K Service tunnel transport system

Running tunnels

1 Cooling water pipes flow and return
 2 Firemain 100NB (125 m each side of cross-passage)
 3 Catenary tensioning weight (2 No. every 1.2km)
 4 Tensioning weight pulleys every 1.2km
 5 Catenary equipment (every 27 m)
 6 Leaky feeder
 7 Main lighting
 8 2 x 20 kV cables
 9 1 x 3.3kV cable
 10 Low-voltage cables
 11 Signalling cables
 12 Phase 1 track concrete and drainage

13 Walkway concrete
 14 Phase 2 trackbase concrete + 1 (future)
 15 Precast walkway units
 16 Track blocks
Service tunnel
 17 Drainage pipes 400NB 3 off + 1 (future)
 18 Firemain
 19 Firemain 250NB (future)
 20 20kV/3.3kV and other supply cables
 21 Leaky feeders
 22 Control and communication cables
 23 Main lighting push buttons (both sides)
 24 Loudspeakers (both sides)
 25 Main lighting

Main fixed equipments of the Transport System.

- 200 electrical rooms (tunnels and terminals) bringing down the 3.3 kV to 400 V.

- 20,000 lighting features in the tunnels.

Power in tunnels included 350 km of brackets and 1300 km of cables.

Traction and catenary

The 195 km-overhead catenary system, isolated every 1200 m in tunnels, includes 950 km of cables (25 kV / 2,500 A), 3 neutral sections for each tunnel (1 per portal, 1 at mid-point), 15,000 brackets.

Mechanical sub systems

Four remote-controlled sub-systems:

- normal and supplementary ventilation,
- drainage,
- fire-fighting,
- cooling.

Normal Ventilation System (NVS),

designed to supply fresh air, and maintain service tunnel as a "safe haven" in case of emergency, includes:

- 2 plants, each housing 2 hydraulically adjustable semi reversible fans diam 2.8m, 70-90 m³/s, 3500 Pa.
- an air circuit through service tunnel including 270 cross passage doors (design pressure 3 T/m²), 38 air distribution units to running tunnels, and 2

airlocks at both ends of service tunnel.

Supplementary Ventilation System

(SVS), designed to control smoke in case of fire, provides 100 m³/s undersea, using:

- 2 plants, each housing 2 hydraulically adjustable fully reversible fans diam 4.8m, 260-300 m³/s, 1500 Pa .
- an air circuit through running tunnels including 194 piston relief ducts dampers diam 2 m (design pressure 3 T/m²), 2 crossover doors, each 70m long, 6.8 m high, weigh 184 T (design pressure 1 T/m², closing in 3 minutes).

Drainage system: collects and pumps out water in tunnels, using 3 pumping stations (4 excavated, 1 not equipped at Sangatte), capacity 1200 m³/h each. It is designed for

a seepage of 20 l/s/km, and a storage time of 2 hours in case of emergency.

Fire-fighting system: provides water supply as close as possible to any fire in the tunnels. It includes 4 tanks (800 m³ at each portals and shaft), each associated with a pump house. The network includes 60 km of pipes, diam. 100 to 250 mm, and is able to deliver 120 m³/h (under 7 bars).

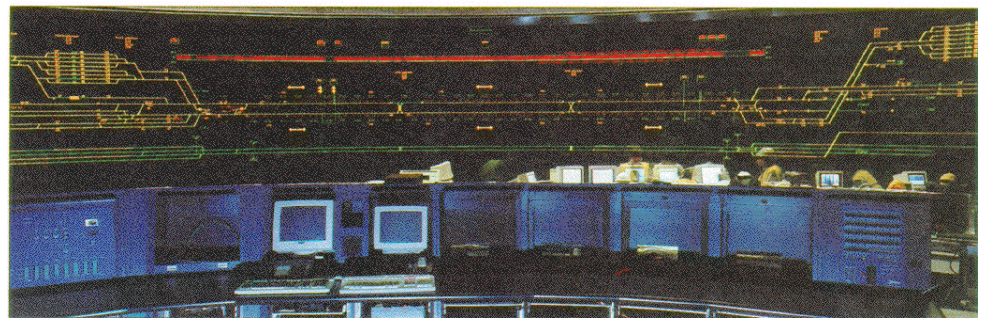
Cooling system: compensates heat from air friction generated by trains, and heat produced by engines or electrical equipments. It is based on a closed circuit chilled water, and includes 2 cooling plants, total 40 MW, located at Sangatte and Shakespeare Cliff, supplying cold water (4 °C, 220 l/s) through 200 km of pipes of diameters 400 and 320 mm.

Over 550 km of piping, and 120,000 brackets or supports have been installed.

Control and Communications

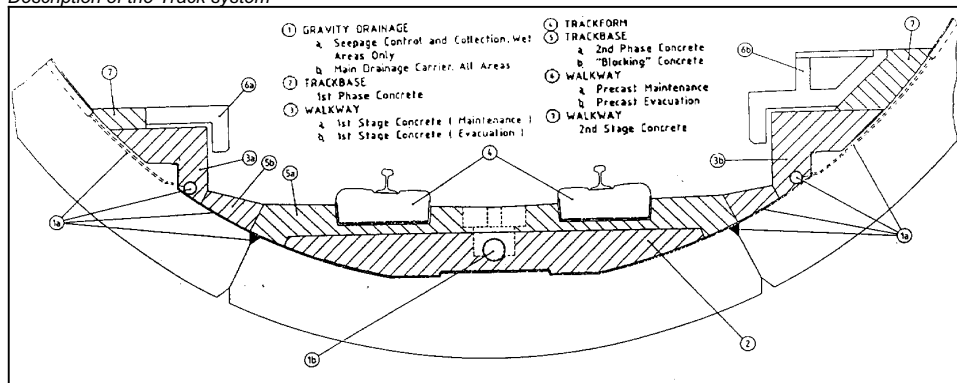
The C&C constantly monitors over 26,000 information It includes 3 optic fibre cables (238 km total length, capacity 700 million bits of information per second), 2,700 telephone sets, 4,400 loudspeakers and 1,200 fire detectors. Main sub systems are:

- 2 Control Centre (RCC) at Coquelles and Folkestone, each able to monitor and control all rail/road traffic and all fixed equipments. The main general mimic panel is located at Folkestone.

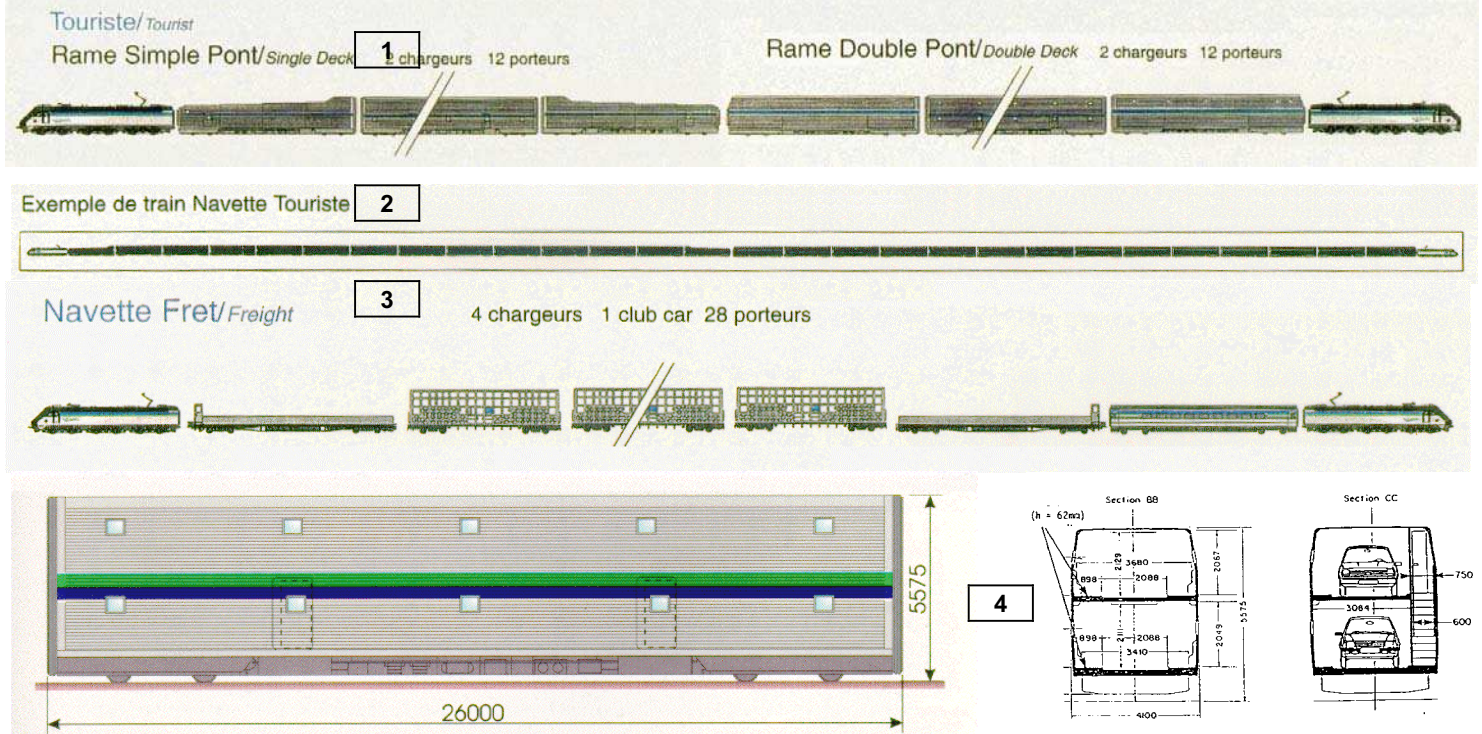


Main mimic panel at Folkestone, one of the two control centres.

Description of the Track system



① GRAVITY DRAINAGE
 a. Seepage Control and Collection, Wet Areas Only
 b. Main Drainage Carrier: All Areas
 ② TRACKBASE
 1st Phase Concrete
 ③ WALKWAY
 a. 1st Stage Concrete (Maintenance)
 b. 1st Stage Concrete (Evacuation)
 ④ TRACKFORM
 TRACKBASE
 a. 2nd Phase Concrete
 b. "Blocking" Concrete
 ⑤ WALKWAY
 a. Precast Maintenance
 b. Precast Evacuation
 ⑥ WALKWAY
 2nd Stage Concrete



Description of the rolling stock : (1) - layout of a Tourist Shuttle, composed of a single deck rake and a double deck rake, each including 12 wagons and 2 special loader/unloader wagons. (2) - elevation view of a complete Tourist Shuttle (775 m long). (3) - layout of a HGV Shuttle, 650 m long, using open wagons as carriers, and platform wagons as loaders, plus a club car for lorry drivers. (4) - View and cross-section of a double deck wagon part of Tourist Shuttles.

- Data Transmission (including PABX network, clock systems, etc...)
- Radio Transmission including trains to RCC, and tunnel to tunnel.
- Fire Detection and Protection
- Access Control, and Terminal Traffic Management.

Rail signalling system

Main functions:

- ensure safe train operations,
- give instructions to locomotive drivers,
- check locomotive drivers behaviour.

There is no lateral light. Informations are directly relayed and displayed inside the driver's cabin (TVM 430 operated through the track). The system, extrapolated from French TGV's systems, includes the latest Automatic Train Protection (fail-safe behaviour, automatic speed limitation) .

Track system

Design criterias

The performance specifications led to :

- concrete support system to last 50 years under a potential traffic of 240,000,000 tonnes per year (most heavily trafficked railway ever).
- tolerances on gauge widening and rail position: absolute value of +/- 4 mm and relative value of +/- 2 mm (much higher than TGV tracks). Tolerance on position with respect to the walkway: +/- 15 mm.
- a rail fastening allowing minor service adjustment of rail position, cheap maintenance, renewed components.
- low aerodynamic resistance to airflow under the trains.

Track design

Tunnels include a Sonnevile non-ballasted concrete track, consisting of UIC 60 kg/lm rails, mounted on pairs of independent

concrete support blocks, spaced at 60 cm centres along the track. Rails are isolated from blocks by nylon clips and rubber O-ring. Each block rests on a 12 mm thick micro-cellular pad inside a rubber boot and cast into the trackbase concrete. This system intends to maintain high geometric tolerances and to provide two levels of resilience between the rail and the invert of the tunnels. Design speeds are 200 km/h for TGVs through trains and 160 km/h for shuttles. In the Terminals, the track is ballasted.

The BETU played a key-role in the design of both trackform and walkways in tunnels.

Main quantities

- 195 km of standard gauge 1.435 m rail track (22,729 T of rails) , 176 sophisticated switches.
- 140,000 tonnes of temporary track to dismantle and 55,000 m3 of mud removed during tunnel cleaning.

90 km of railway tracks were laid in France, in 16 months, including, inside tunnels :

- 153,000 independent concrete blocks and 6,000 tonnes of rails, 350 lm/day of finished track installed.
- 170,000 m3 of concrete placed for walkways and invert and 42,000 tonnes of precast elements.

French Terminal includes 50 km of track, over 140,000 m3 of ballast, 86 switches.

Rolling Stock

Rolling stock includes 43 locomotives and 512 wagons, forming Tourist Shuttles or Heavy Goods Vehicles Shuttles (HGV).

Shuttles have a maximum weigh of 2,370 Tonnes, maximum speed is 160 km/h. Air suspension ensures a smooth ride. Noise is no higher than on current TGV's .

There are hauled by two locomotives (22 m long, 3 m wide and 4.1 m high, 4 to 6 MW), located at the front and the rear, each able to complete alone the journey in case of failure.

Tourist Shuttles, 775m long, average capacity 135 vehicles, consist of two rakes each of 14 wagons, a loading unloading wagon at each end and twelve identical 25 m long closed carrier wagons. All are fitted with automatic fire fighting systems, and are able to contain 30 minutes a vehicle fire without stopping nor contaminating the rest of the train. Double deck carrier wagons can carry 4 to 5 cars, on 2 m high and 3.7 m wide deck. Single deck wagons are for vehicles like coaches, minibuses.

HGV shuttles , are 650 m long, with single deck, open wagons (20 m long, 4 m wide, 5 m high, load capacity up to 44 T). Drivers are carried in a special amenity coach between the locomotive and HGV wagons.

Inside view of a double deck tourist wagon. After complete loading, a set of fire doors/curtains per deck (right of the picture) is automatically closed, in order to isolate any fire from the rest of the train.

