Appendix 2.10 - FRANCE – Nanterre / La Défense – A14 / A86 Complex

1. AN UNDERGROUND URBAN HIGHWAY WITH SEVERAL INTERCHANGES

The A14-A86 complex, also called Nanterre-La Défense Tunnel, is located west of Paris under La Défense business district and its surroundings (**Figures 1 & 2**). It comprises two main sections, which are part of the A14 and A86 motorways respectively, and a number of connecting ramps. The A14 section is about 4 km long, and the A86 section about 1 km long. They each comprise two unidirectional tubes. With the connecting ramps, the total tube length of the complex is about 15 km.

Figure 1 - A14 Tunnel entrance, Paris's side (Wikimedia Commons/CC)

The tunnels have evolved alongside the surrounding urban environment over six decades, hence their complex architecture. Major Tunnel sections were opened between 1988 and 2004 and major retrofit works were carried out between 2009 and 2012 in order to comply with the regulations enacted after the Mont Blanc tunnel fire of 1999. The ventilation system, emergency exits, power supply and SCADA system were upgraded, and sensitive structures were protected to improve their resistance to fire.

The complex A14 / A86 has interfaces with a variety of neighbouring structures, e.g. other roads and road tunnels, public spaces, high-rise buildings, shopping malls, car parks, metro, railway and bus tunnels and stations. A new 32,000-seat rugby stadium is also under construction, and there are numerous other projects in the area, especially new high-rise buildings and malls. Some of these will be built over existing roads and modify the layout and operation of the complex.

Physical interactions such as shared walls, a ventilation duct for one structure crossing that of another, etc. are inevitable. Therefore, a large number of stakeholders have to intervene near or even within the perimeter of the A14-A86 complex for day-to-day operations, maintenance and new construction works. The regional road authority DIRIF, owner and operator of the complex, has interactions with a huge number of "neighbours".

The main dates in the history of the complex are summarised below:

- 1960s – 1970s: construction of La Défense business district, including the structures which are now the A14 tunnel;
- 1988 and 1993: opening of the first tunnel sections (westbound, then eastbound A14 Défense);
- February 1996: opening of the A86 tunnel;
- November 1996: opening of the remainder of the A14 tunnel;
- 1998 – 2004: opening of the A14-A86 underground interchange.

At the same time, urban projects for the area also evolved. The configuration of the tunnels is therefore quite different from the original project, which did not include a full underground interchange.

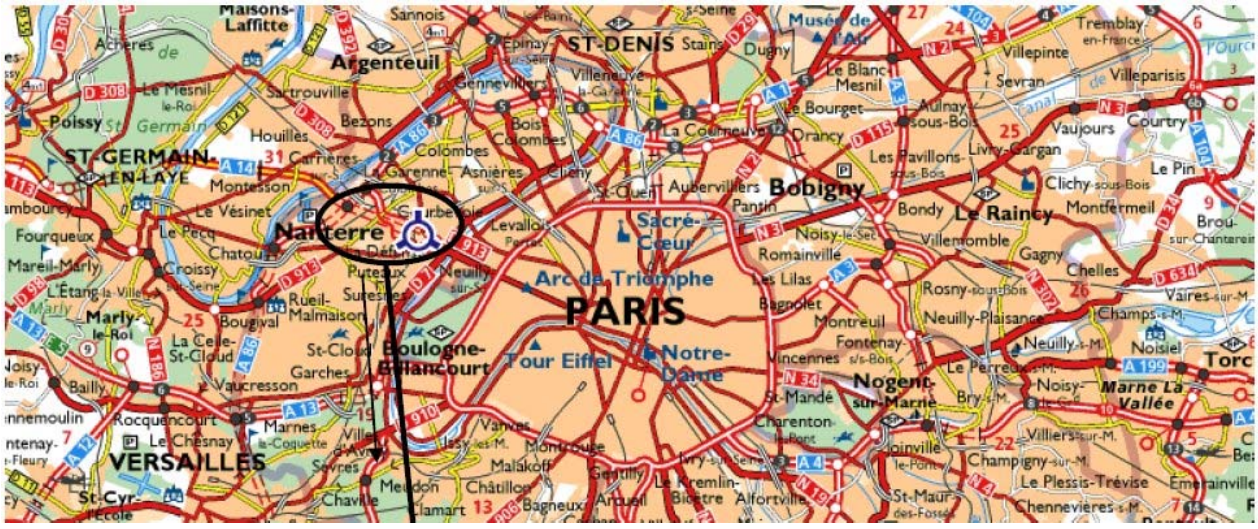

Figure 2 - location in the Ile-de-France urban area

2. MAIN CHARACTERISTICS

2.1 GEOMETRY

Due to the dense urban environment and numerous modifications of the project over the years, various geometries are present in the A14-A86 complex. All sections of the tunnel were built using cut-and-cover techniques, so the cross-section is always rectangular, but the number of lanes varies between one and four, and hence the width of the tubes varies up to 20 m. The vertical clearance is 4.50 m, but some sections have ceiling heights up to about 9 m.

The complex comprises the following sections (see **Figure 3 below**):

- A14 Défense (underneath the "pear" drawn by the Défense Ring Road or "Circulaire"): the highway itself has 2 to 4 lanes per tube and there are several exits/accesses (see below);
- A14 Nanterre (West of the "pear"): 3 lanes in each direction, no intermediate exchanges;
- A86 South: 2 to 4 lanes in each direction;
- A86 North: 2 to 4 lanes in each direction;
- Interchange: ramps are numbered B1 to B8 (not all of them are currently underground but they should be eventually) and generally have a single lane. Some ramps share common sections.
- Access and exit ramps in the Défense section: exchanges with roads RN 192, RD 914, RN 1013 and RD 7: 1 or 2 lanes.

The longitudinal profile is adapted to the pre-existing neighbouring structures, and is therefore wavy; slopes are up to 3.3% in the main tunnels (A14 under the interchange, pictured on **Figure 4**) and 4.8% in some ramps.

Interchange A 14 / A 86 motorways

Figure 3 - general layout or the A 14 / A 86 complex

2.2 INTERCHANGES AND SIGNALLING

The complex A 14 / A 86 includes a main motorway interchanges (with 8 ramps) and connections with the main roads of La-Défense District (with 8 ramps).

A 14 / A 86 complex was built with the "cut and cover" construction method, enabling simpler accommodation of signalling systems.

The **Figure 4** below shows a view of the westbound A14 tunnel in the interchange zone, showing the main tunnel and the B1 ramp (length: 715 m) connecting it to the southbound A86 tunnel (right).

The signs combine dynamic and directional signing and their layout differs from the national standards because of geometric constraints.

Figure 4 - motorways interchange A 14 / A 86 (AM/CETU)

2.3 ESCAPE FACILITIES

There are 74 emergency exits, around 200 m apart in "regular" tunnel sections. All of them provide direct access to the surface or a neighbouring building. There are no cross-passages between tubes, "dead end" shelters or escape routes through ventilation ducts.

2.4 TRAFFIC CONDITIONS, ACCIDENTS

2.4.1 Traffic conditions

The complex is classified as a motorway. Access is prohibited for vehicles transporting dangerous goods, cyclists, pedestrians and light motorcycles (under 50 cc). Larger motorcycles, passenger cars, buses and heavy goods vehicles are authorised.

The traffic volume is large, with an average annual daily traffic of about 100,000 vehicles per day (both ways) in all sections, with some variations. Excluding the years during which refurbishment works took place (2009-2012), the A14 Défense section has the heaviest traffic. Rush hours are not well distinguished in some sections, while others exhibit significant peaks in the morning or evening. Night traffic is low but the tunnels are generally busy throughout the day.

Heavy goods vehicles represent only 3 to 5% of the total traffic.

The traffic volume is growing on A86 and decreasing on A14, due to the general saturation of the road network in the area, especially Paris where traffic volumes are also decreasing.

Congestion occurs on a regular basis in the Paris-bound tube of A14, especially during the morning rush hour. Traffic is generally not stopped; the average speed is about 20 km/h. In other parts of the tunnel, congestion is much less frequent (1 to 2% of the time). However, provisions ensuring safety even in the case of congestion, such as dedicated ventilation scenarios, exist in all parts of the tunnels.

2.4.2 Accidents

Between 2005 and 2011, there were 38 accidents with casualties (5 fatalities and 4 serious injuries), 8 accidents without casualties but with major consequences on the operation, and 10 fires including 3 HGV fires. These fires caused little or no damage to the tunnel, and no casualties.

The number of accidents (relative to the traffic and length) is far less than the national average for one-directional urban tunnels. This can be explained by the dense traffic and moderate speeds.

2.5 VENTILATION

Transverse ventilation is used in all tubes, except the A14 Nanterre section which has longitudinal ventilation. This is because this part was built before the construction of an underground interchange was decided, and was once a standalone tunnel.

Since the 2009–2012 retrofit, smoke extraction rates are generally compliant with the French regulation which requires a minimum flow rate given by the formula 80 [m3/s]+1.5 [m/s] x A, in which A is the cross-sectional area.

Ventilation ducts are mostly located in the side walls. 18 ventilation plants house 62 extraction fans with a wide range of sizes, flow rates and power ratings (30 to 90 m3/s, 55 to 355 kW). There are also 61 fresh air supply fans with flow rates ranging from 15 to 77 m3/s.

The large number of ventilation plants (**Figure 5 below**) reflects the constraints associated with building the tunnels in successive stages in a dense urban environment.

Congestion happens in the tunnels, but only at peak times and at certain locations (mainly on the Paris side). Therefore, it is possible to operate the smoke control system with a longitudinal strategy in most cases, which is regarded as a more robust strategy. This is achieved by blowing outside air upstream of the fire, creating an overpressure, and extracting air downstream. Smoke is extracted at the same time, but this is not the primary goal in that situation. The possibility of "longitudinal operation" is determined automatically by analysing the

speed of the traffic in the tunnel sections downstream of the fire. If traffic is blocked, or the result is uncertain, the system reverts to "transverse operation". No closed-loop control exists, meaning that for each possible fire position, one "longitudinal" and one "transverse" scenario can be applied. Studies have shown that the influence of the wind on the ventilation of the complex is relatively weak, which allows this approach to be applied generally.

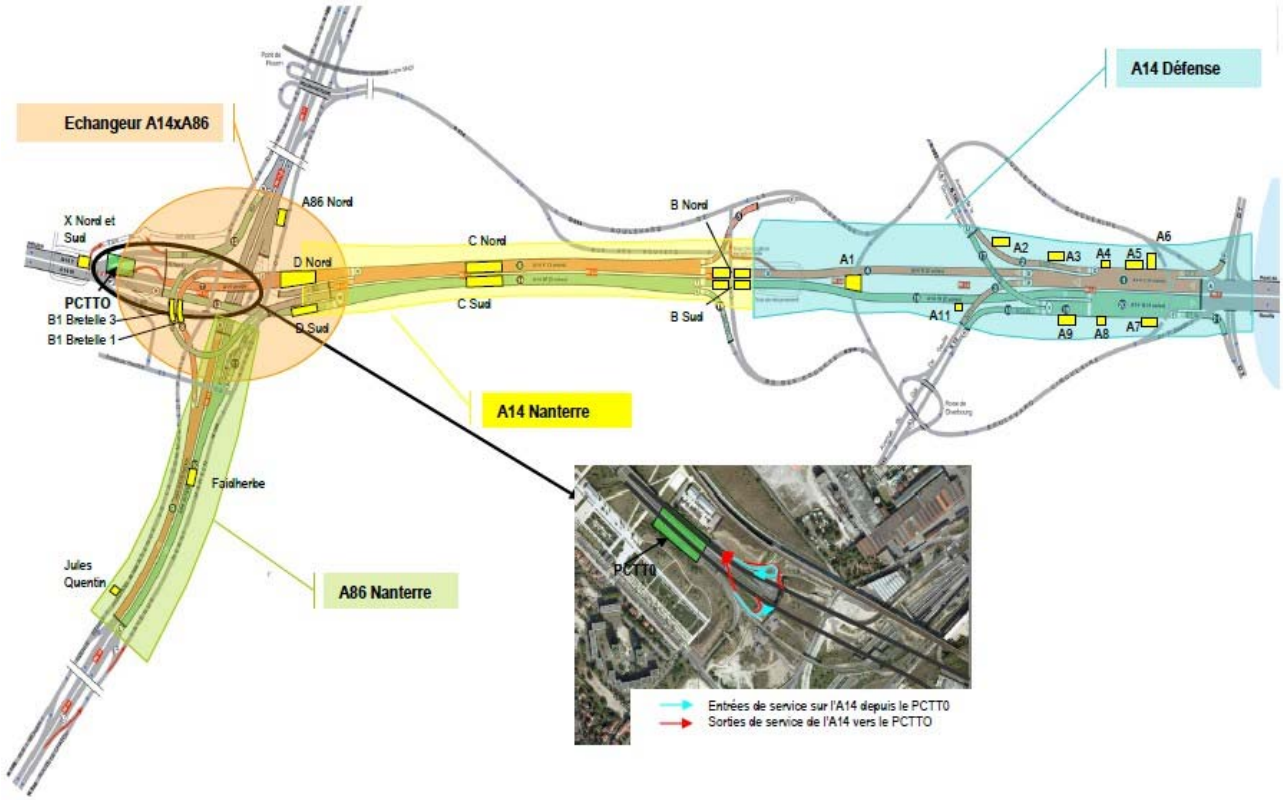

Figure 5 - location of the ventilation plants

2.6 ENVIRONMENTAL ISSUES

2.6.1 Air quality

Traffic is dense and pollution levels are high in the whole Paris metropolitan area. The district of La Défense is no exception. The A14-A86 complex and other underground infrastructure represent a large part of the local traffic. High concentrations can therefore be expected near the portals, but the tunnels also protect most of the densely populated business district from pollution. Pollution levels are monitored by AIRPARIF as in the rest of the metropolitan area. CO, NO2 and opacity sensors exist in the tunnel and are used to control the ventilation system in accordance with the French regulations, the most critical pollutant being NO2 with a maximum concentration of 0.4 ppm.

2.6.2 Noise

Standard noise reduction measures are applied in the ventilation plants.

2.7 FACILITIES AND OPERATIONAL EQUIPMENT

The A14-A86 complex is equipped with the usual operational equipment for urban tunnels, especially CCTV with automatic incident detection and equipment for emergency closing (barriers, variable message signs).

3. OPERATION AND SAFETY

The A14-A86 complex is monitored from the Nanterre control room (PCTT) of the regional road authority (DIRIF). The PCTT is located just outside the A14 tunnel on the western end, but it is in charge of many urban highways in the Western part of the Paris metropolitan area, also including other tunnels such as "Amboise

Paré", "Saint-Cloud" (length: about 800 m each) and "Belle Rive" (1080 m). The PCTT is in charge of both traffic management and emergency procedures, which represents a heavy load for the operators.

In the case of a major event, especially fire, priority is given to its management. As in many emergency situations, the management of rescue operations is given to the fire brigade upon their arrival.

The area is served by the Paris Fire Brigade (BSPP), which has two stations very close to the complex: one in La Défense and one in Nanterre. Both are located within 100 m of the tunnels, although they are not dedicated to them.