HS2

Phase 2b (Crewe – Manchester) – Tunnelling

Tim Smart - Managing Director, HS2 Phase 2

Expert Engineering Witness for the Promoter

P6(1)

Outline of Presentation

Introduction

Construction

(1) Tunnelling techniques

(2) Settlement

(3) Construction aspects

Operational aspects of tunnelling

(1) Safety arrangements

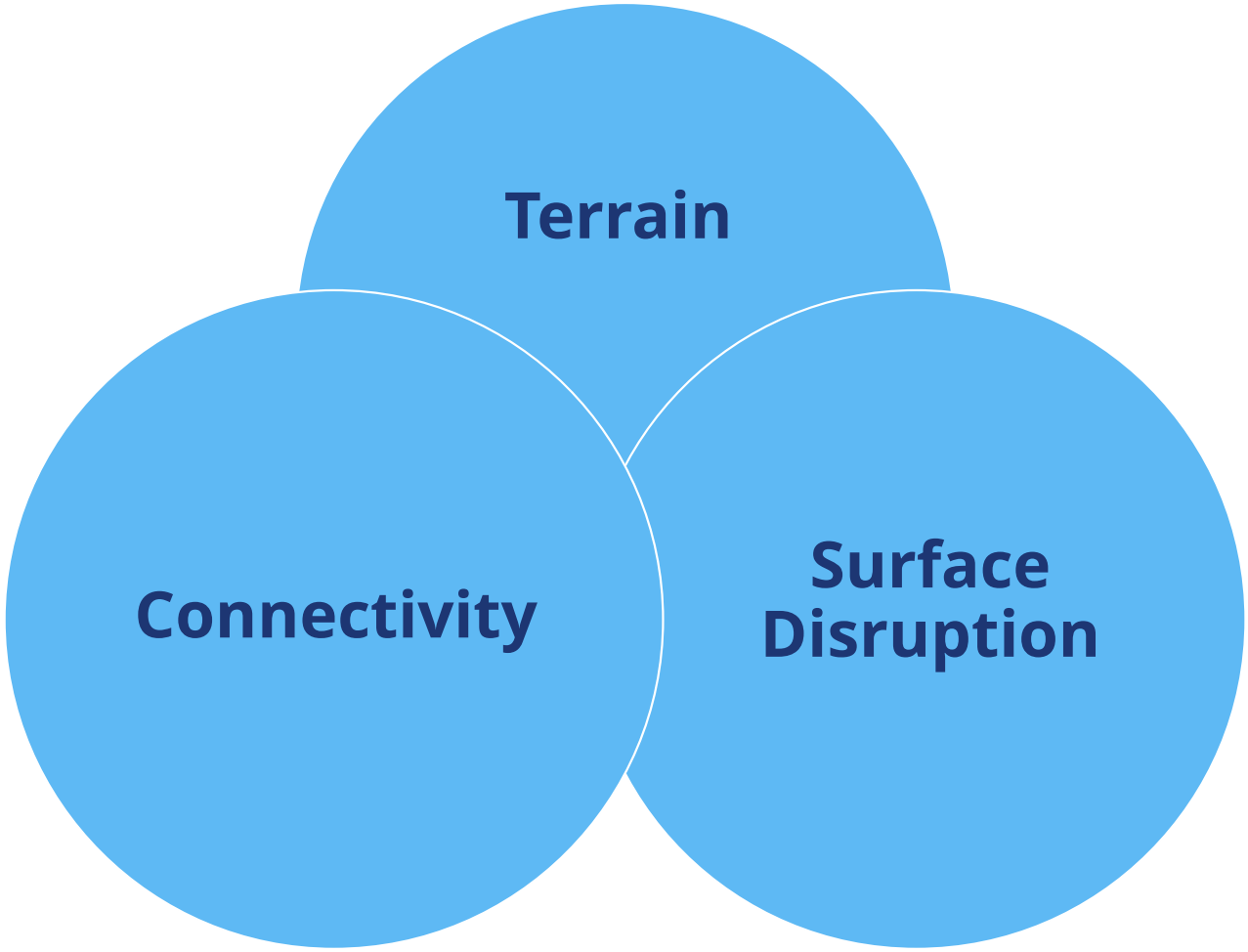
(2) Vibration

Cost implications

(1) Costs of tunnelling

P6(2)

Why Tunnel?



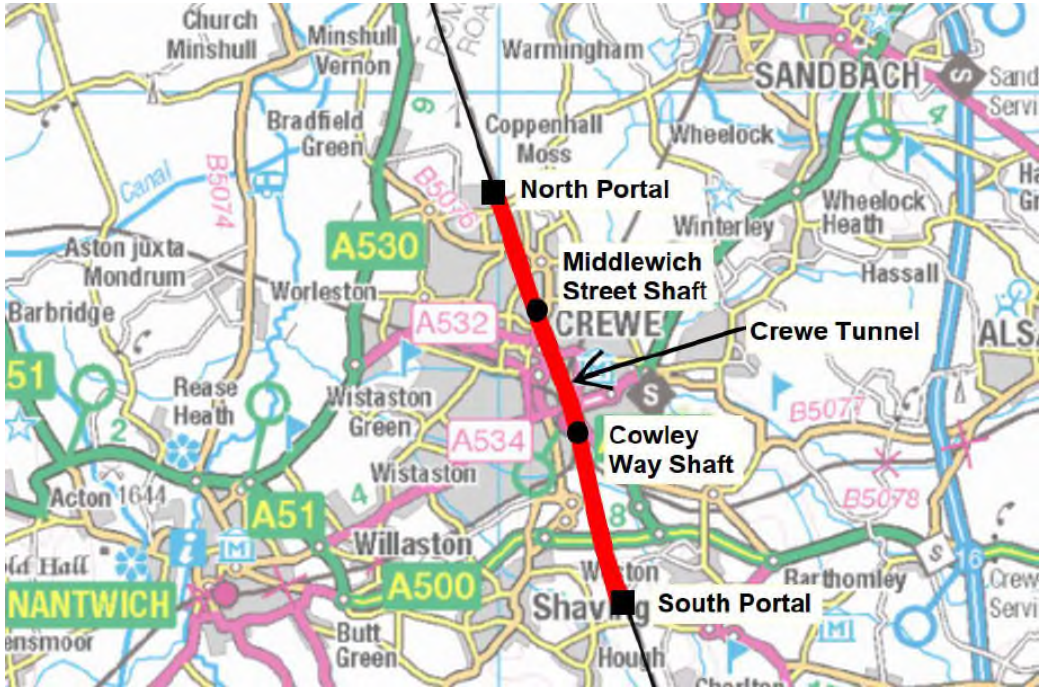
P6(3)

Crewe Tunnel

6.8km (4.2 miles) twin bored tunnel:

- South Portal by Hough, south of Crewe
- 2 vent shaft locations:
  - Cowley Way
  - Middlewich Street
- North Portal by Leighton, north of Crewe

Ground Investigation (GI) indicates glacial till (mixed ground) and mudstone



P6(4)

Manchester Tunnel

12.8km (8 miles) twin bored tunnel:

- South Portal adjacent Airport Station
- 4 vent shaft locations:
  - Altrincham Road
  - Palatine Road
  - Wilmslow Road
  - Birchfields Road
- North Portal 1.5km (0.9 miles) from Manchester Piccadilly Station

GI indicates mudstone, siltstone, sandstone and marls (hard clay, similar to mudstone)

P6(5)

Tunnelling Techniques

Bored Tunnels

- Shield type machines with precast segmental tunnel lining
- Used when surface access is very limited at depths typically below one tunnel diameter
- Longer tunnel lengths where economical to use machine

Cut and Cover Tunnels

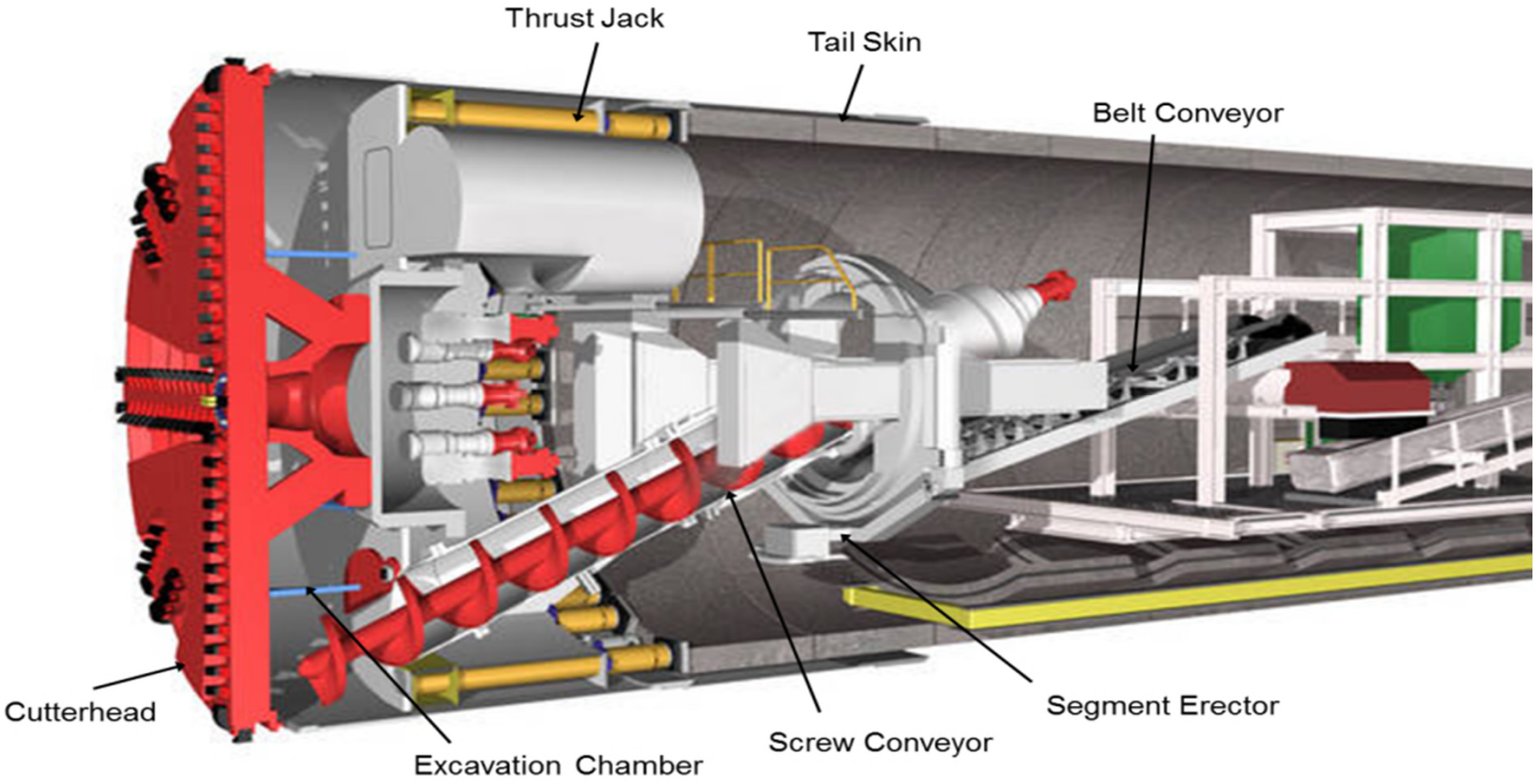
- Typically, concrete box structures constructed in excavated ground
- Used at shallower depths where there is good surface access

Mined/Sprayed Concrete Lining Tunnels

- Mechanically excavated with sprayed concrete lining in suitable ground conditions
- Used in shorter drives and cross passages

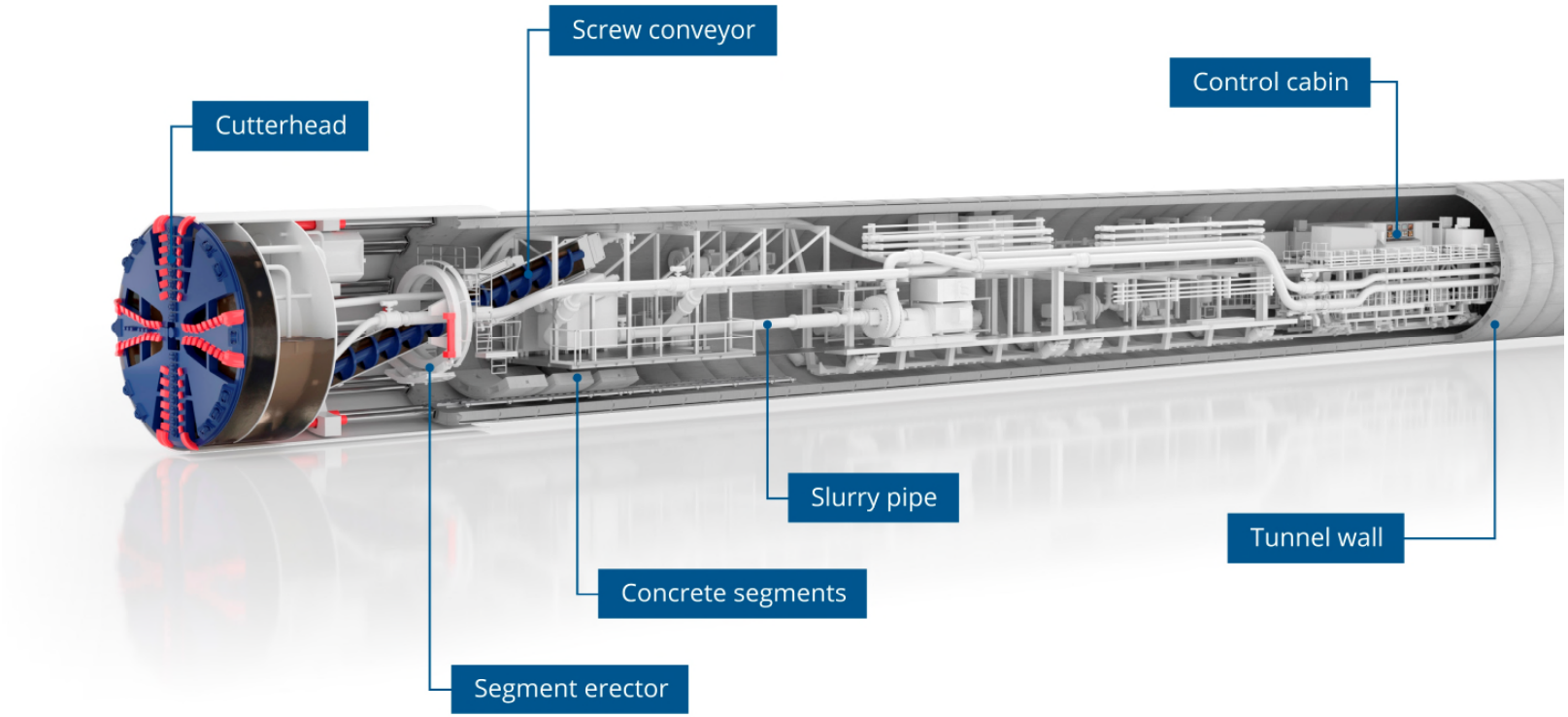
Tunnelling Techniques

Bored Tunnel - Earth Pressure Balance Tunnel Boring Machine (EPBM)



Tunnelling Techniques

Bored Tunnel - Slurry Tunnel Boring Machine



Tunnelling Techniques

Bored Tunnel – HS2 TBM on site at Long Itchington Wood showing back up arrangements

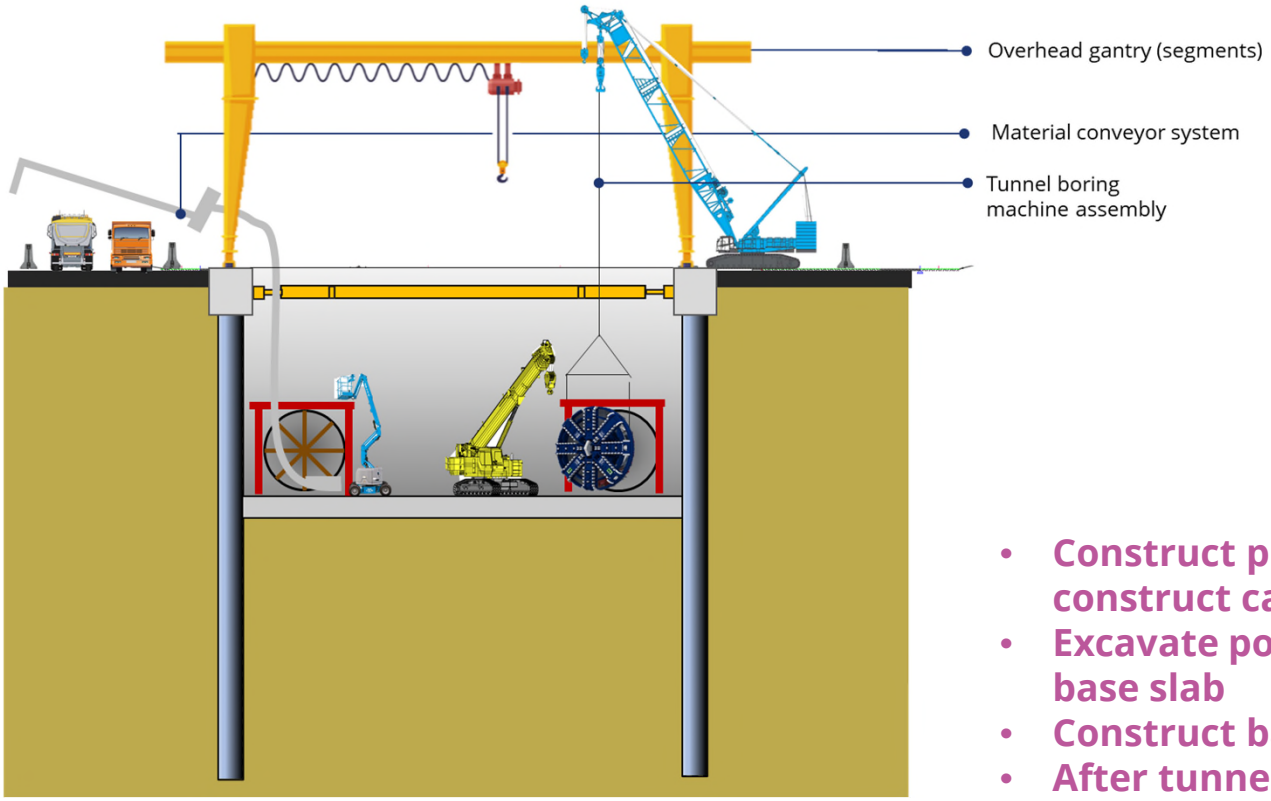
Tunnelling Techniques

Bored Tunnel – Chiltern Tunnel South Portal

Tunnelling Techniques

Bored Tunnel – Precast tunnel segments for tunnel ring construction at the South Portal site Chiltern Tunnel, Phase One

Portal Construction Methodology – Space Constrained Site



- Construct piled retaining walls, cut down piles and construct capping beams
- Excavate portal and install temporary props down to base slab
- Construct base slab, tunnel "eyes" and assemble TBM
- After tunnelling, complete portal and headhouse

Tunnel Portal

Left – tunnel portal visualisation

Right – existing tunnel portal on HS1

Settlement & Rate of Tunnelling

- The rate of tunnelling is dependent on ground conditions. It is also important in minimising settlement, which is achieved by continuous (24hr) and controlled operation of the tunnel boring machines.

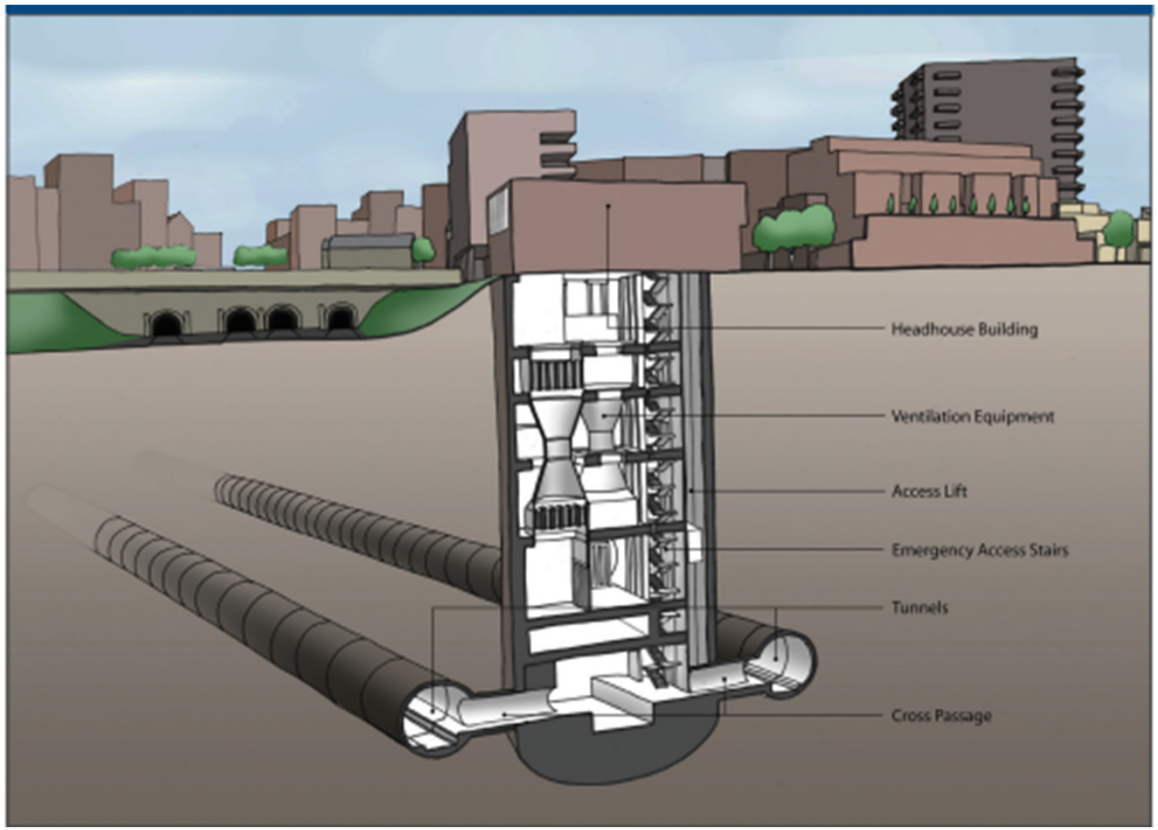
- In order to keep settlement to acceptable limits HS2 has specified maximum of 1% volume loss for bored tunnels. The Promoter's policy on ground settlement is set out in Information Paper C14.

- Volume loss is the amount of loss material in the region of tunnel, occurred through sub-surface construction process. During tunnelling, the amount of sub-surface excavated material tends to lead localized ground movement inward to the tunnel.

Safety Arrangements

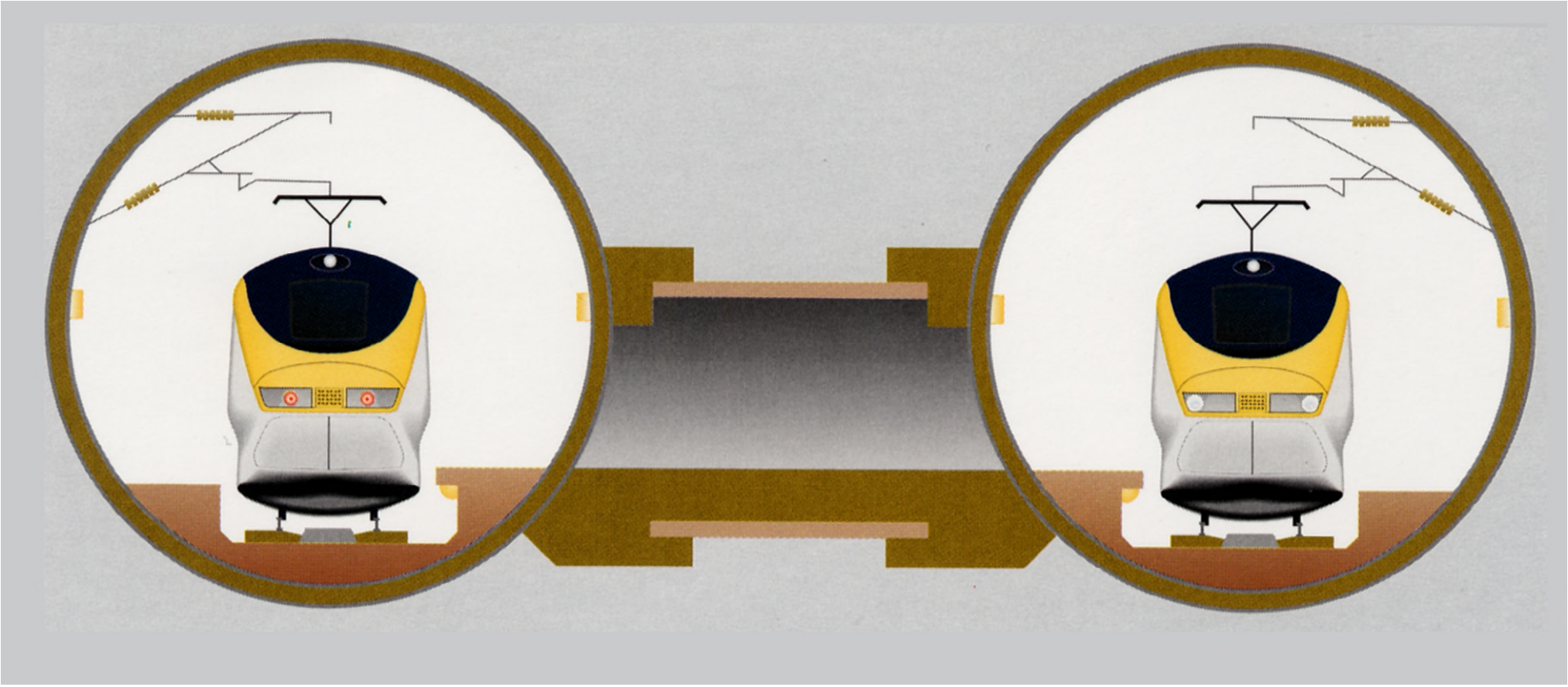
Vent shafts required for:

- Emergency intervention
- Tunnel ventilation
- Removal of smoke in case of fire
- Fans may be vertical (shown) or horizontal (positioned at ground level – more surface space but less volume to excavate)
- Power distribution for electrical and communication systems (greater shaft spacing lessens the effectiveness of Low voltage power)



Safety Arrangements

Tunnel cross passages



Safety Arrangements

Evacuation Walkway &
Tunnel Cross Passage
Opening HS1

Safety Arrangements

Shafts and Cross Passages

Fire Intervention

- UK custom, practice and Fire Rescue Service training is for intermediate shafts
- Typically shaft spacing for Fire and Rescue intervention is 3.3km (2.1 miles) max

Fire Fighting Point defined as:

- Location outside tunnel where Fire and Rescue Services can rendezvous and can have access to water and fire-fighting equipment. Can be used for passenger evacuation in extreme circumstances
- Water supply capacity is a minimum of 800 l/min for 2 hours

Place of Relative Safety

- Either shaft to surface every 1km (0.6 miles), or a cross passage every 500m to independent tunnel tube for evacuation (National Technical Specification for Safety in Rail Tunnels, BS 9992, Fire safety in the design, management and use of rail infrastructure)

Costs of Tunnelling

Fixed Costs

- Tunnel Boring Machines
- Back-up material handling
- Power supply plant
- Mechanical and Electrical systems

Linear Costs

- Labour
- Lining materials
- Excavated material disposal
- Ground monitoring
- Ground treatment
- Tunnel logistics

Incremental Cost increases

- Surface arrangements for drive sites, reception sites and tunnel logistics
- Introduction of shafts
- Increase in number of cross passages
- Increase in tunnel Mechanical and Electrical systems

Cost vs. Length (Indicative)