Delivering Successful Tunnelling Projects
A Personal (Client's) View

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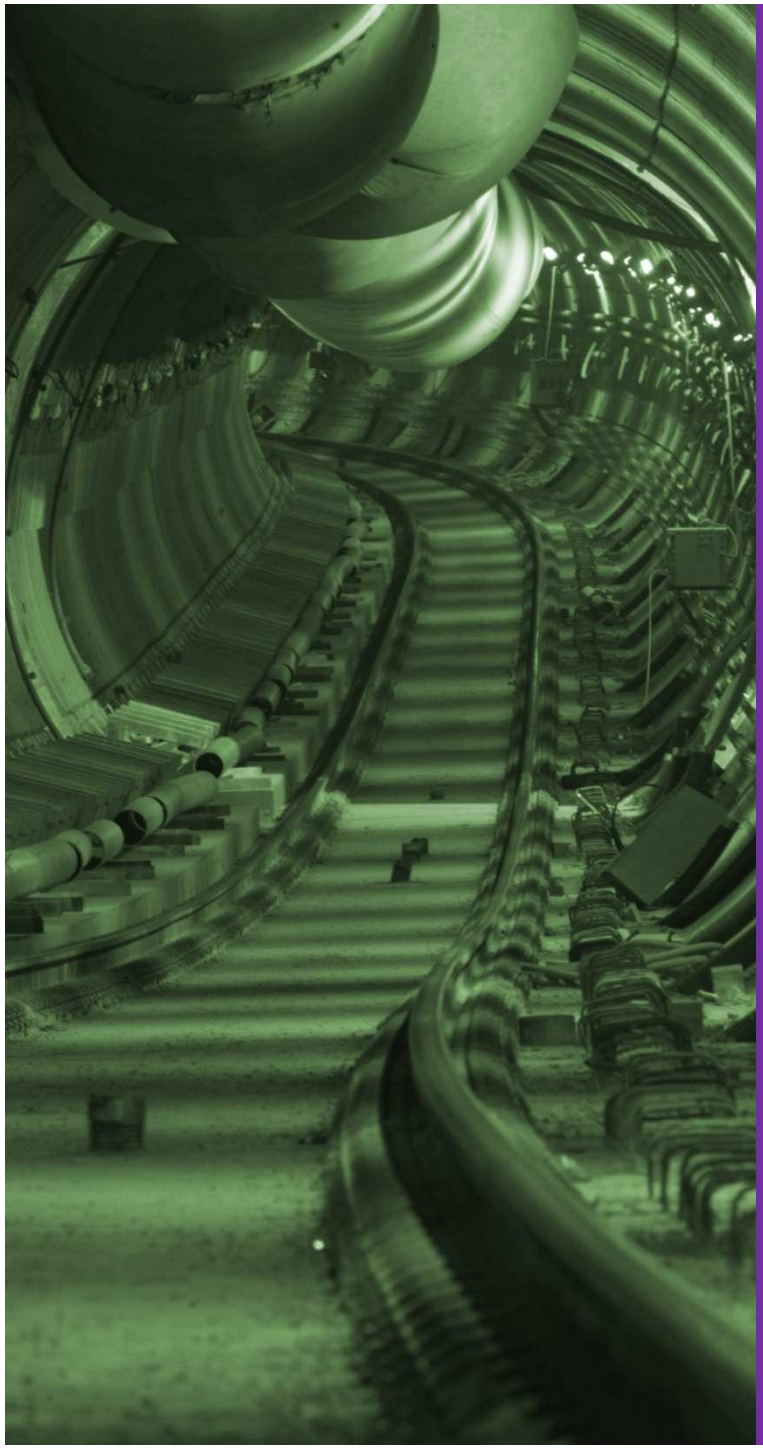
29th September 2010

Introduction

- The 1980s & 1990s
- Factors Influencing Change
- Heathrow Terminal 5 Tunnels – A Successful Project
- Framework For Successful Project Outcomes
- Summary



1980s & 1990s

building

LU blamed for two-year Jubilee Line Extension delay

15 September 2000

NCE+

British Library fails to meet the challenges of the internet age

Architects Journal – 30/05/2000

aj+

Dome lurches from crisis to crisis as bankers brought in

Architects Journal – 21/09/2000

Never mind a West Coast upgrade- the route is off track

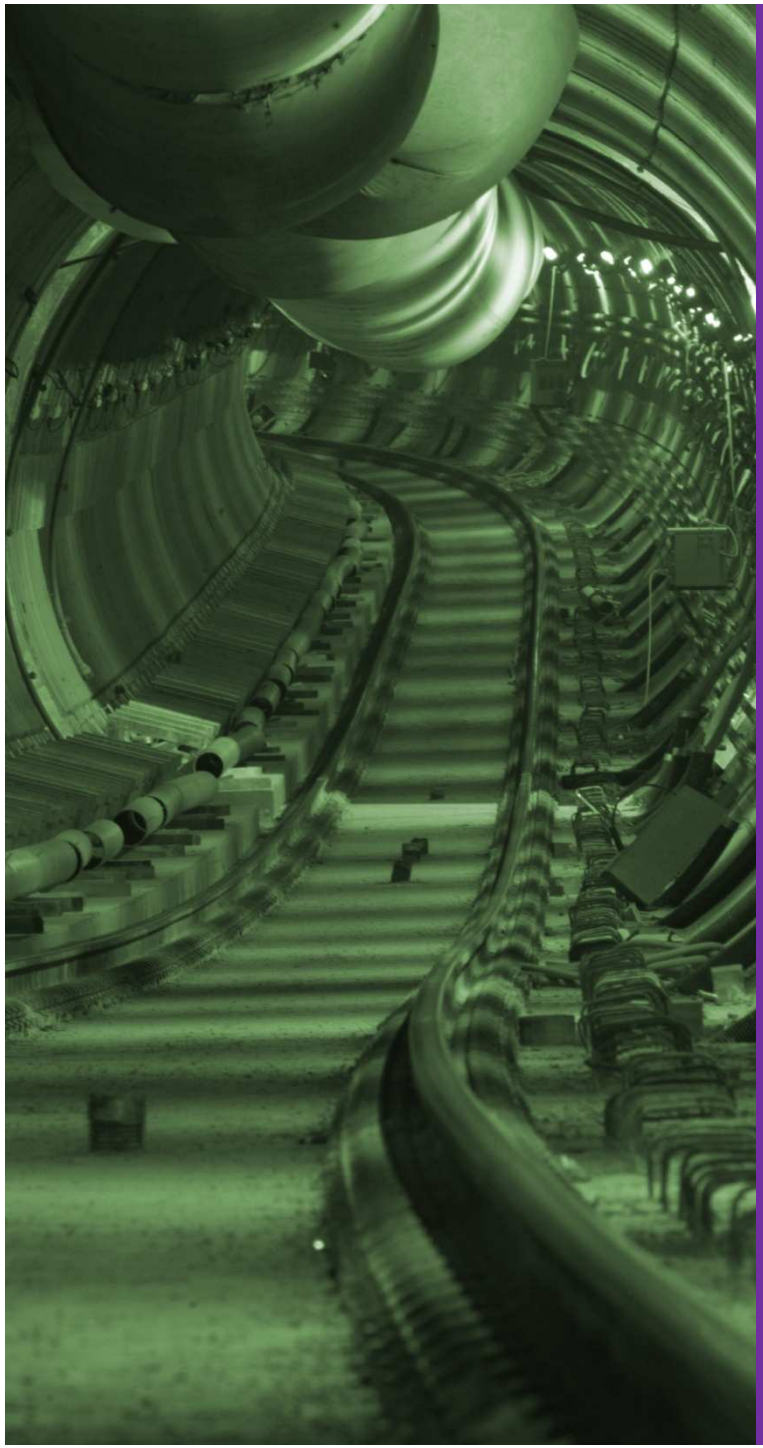
IT IS difficult to tell which project, the new Scottish parliament building or the upgrading of the West Coast Main Line, is the more tragic in terms of delay, cost-overruns and bungled management.
Scotsman July 03

Inquiry pledged into £400m bill for Scots parliament

Guardian April 2003

Railtrack calls in Americans on coast line

RAILTRACK plc yesterday brought in the US project management group Bechtel to take charge of the West Coast Main Line upgrade where budgeted costs have rocketed from £2.1 billion to more than £7 billion.

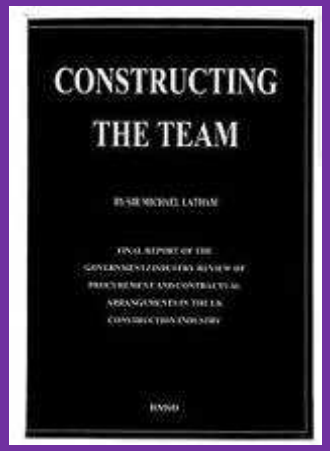


Factors Influencing Change

UK Society & Economic Pressures

Latham Report (1994)

- Condemned existing industry practices as *'ineffective', 'adversarial', 'fragmented', 'incapable of delivering for its customers',* & *'lacking respect for its employees'.*
- 53 recommendations – collaborative working etc



Egan Report (1998)

- Looking from Clients viewpoint
- 5 drivers identified; :*committed leadership, focus on the customer, integrated processes & teams, quality driven agenda & commitment to people.*

Contract /Procurement Changes

‘Green Book’ (ICHEME)

- End of 1980s water companies adopted Green Book, cost reimbursable payment process
- Less adversarial form of contract than ICE

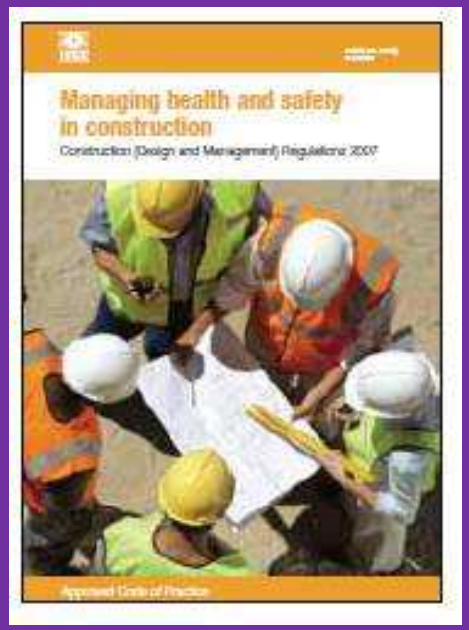
New Engineering Contract (NEC3) , 1993

- Sponsored by ICE, endorsed by Latham Report
- Simple language, non adversarial form of contract, project manager acts as Client
- Range of options; fixed price, target, reimbursed
- Changes called ‘Compensation events’ & ‘Early warning’ procedure. Cost & time implications assessed
- ICE has withdrawn its long standing Form of Contract

Legislative Changes – Health & Safety

- 1995 original regulations came into force

- 1st time duties of Clients & designers indentified



- Shift from complex regulations to strategy for H&S, focus on risk & influencing attitudes & behaviour of duty holders

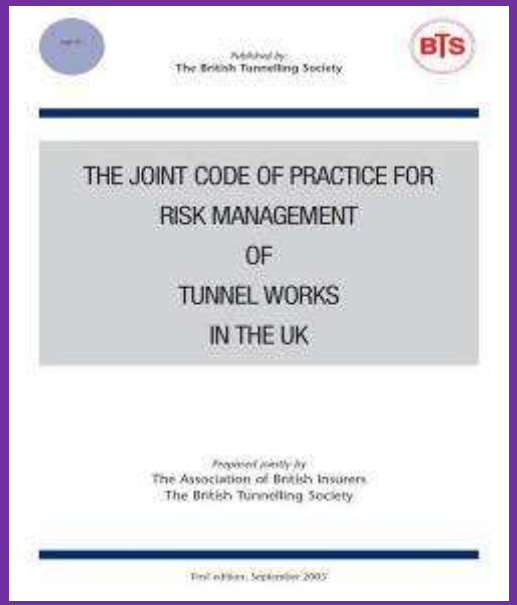
Catastrophic Events

- Heathrow Express Project – 20th October 1994 major collapse associated with NATM works
- The cost of recovery to BAA and the Insurers estimated to be Euros 500 millions
- No deaths but prosecutions on failings against the. Balfour Beatty and Geoconsult prosecuted against UK Health & Safety legislation
- Balfour Beatty's managing Director said after the court hearing....*'The collapse is a landmark in the industry and a reminder to all those operating in the industry'*
- Catalyst for change in behaviours, attitude and approach within the UK tunnelling industry.

Insurance Industry Pressure

- Published in 2003 in response to recent losses in the UK & overseas. Developed with the industry

- Objective – promote & secure best practice for minimising & managing risks in design & construction


Published by
The British Tunnelling Society

BTS

THE JOINT CODE OF PRACTICE FOR
RISK MANAGEMENT
OF
TUNNEL WORKS
IN THE UK

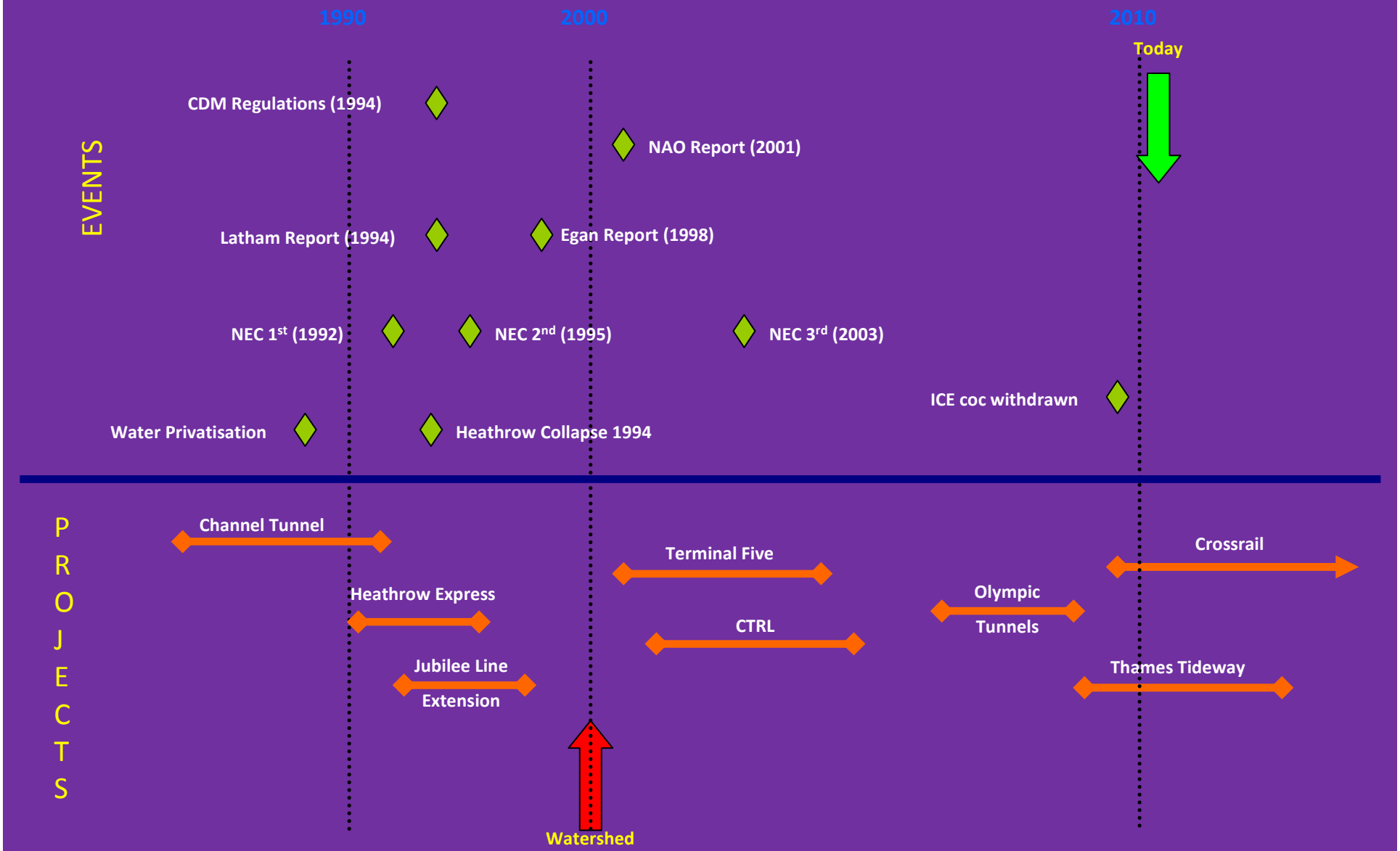
Prepared jointly by
The Association of British Insurers
The British Tunnelling Society

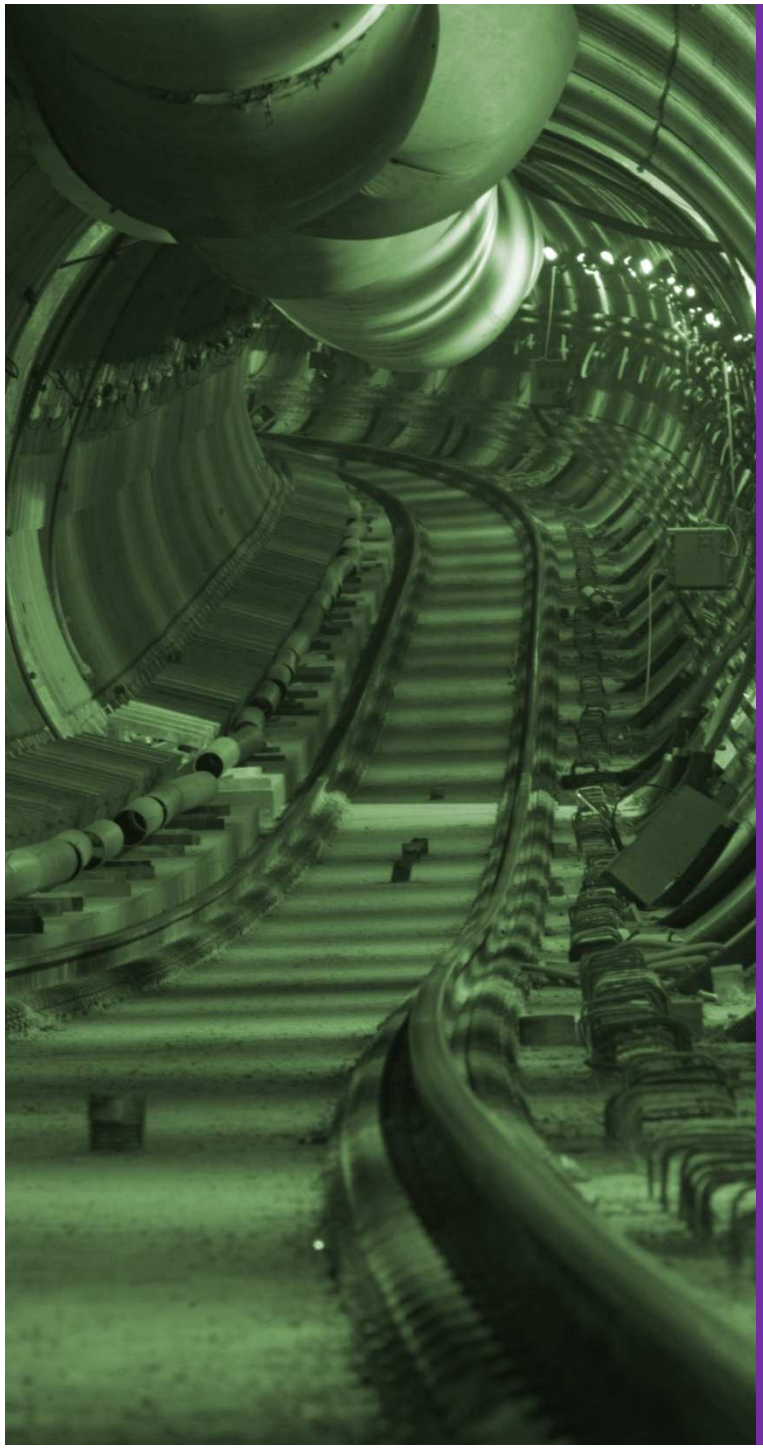
First edition, September 2003

Client Insistence On Achieving Planned Outcomes

- 1990s saw shift from public to private sector procurement led by water industries following privatisation
- Accountability to shareholders – need for certainties
- The Egan Report championed the needs of Clients

Time Line of Change



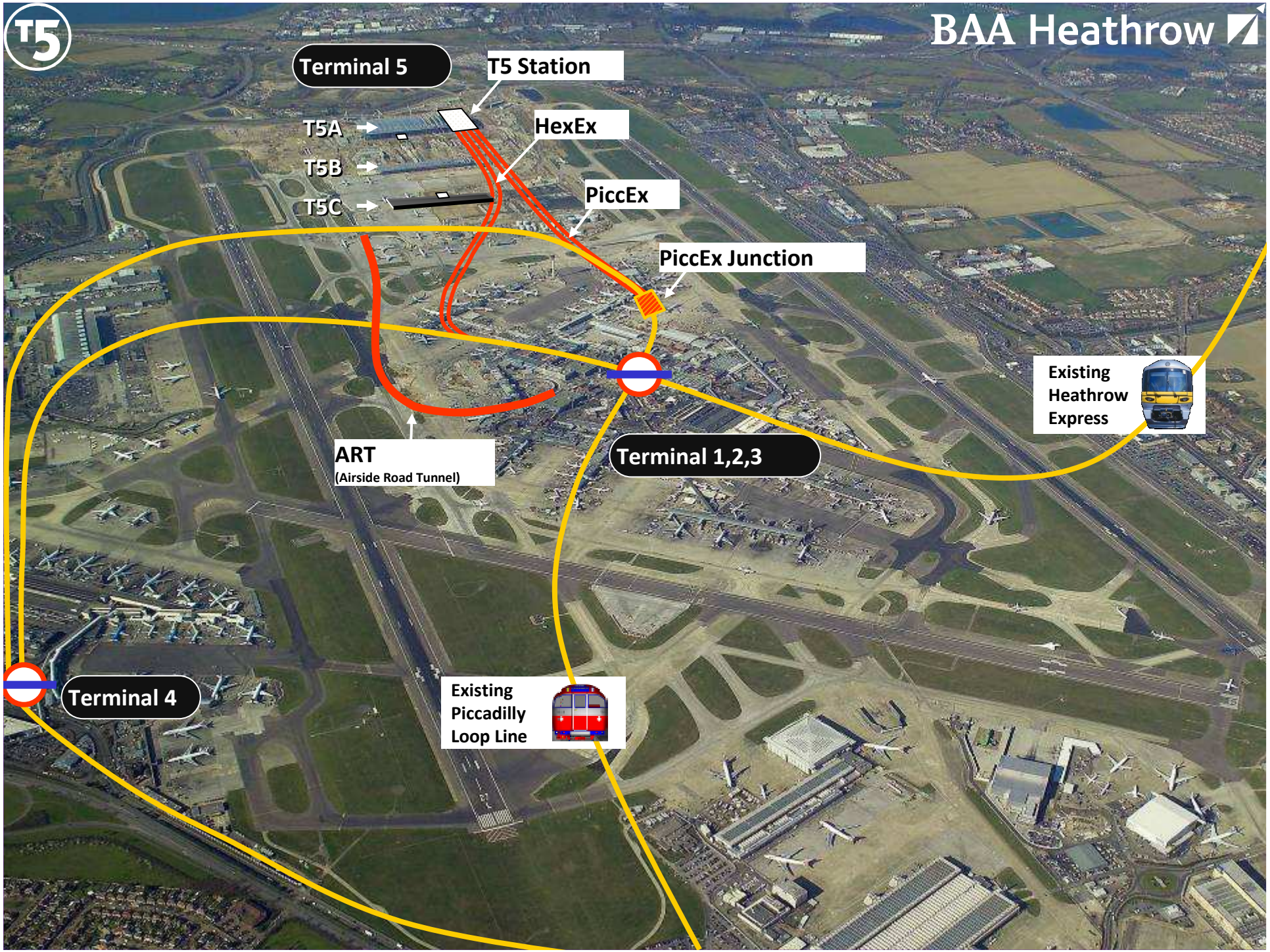


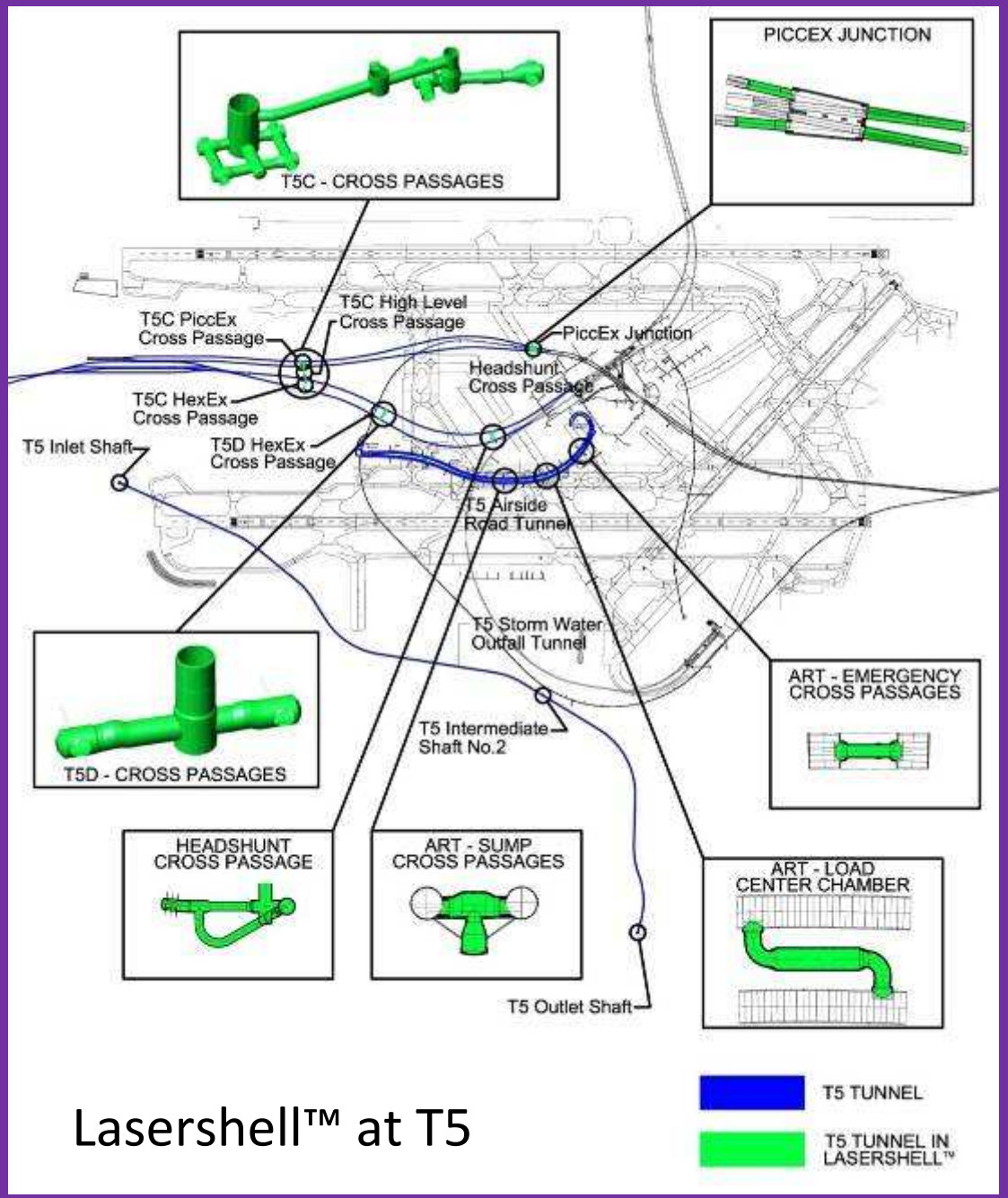
T5 Tunnels

A Successful Project

Why T5

- Meet increase in air travel demand - 30-35 million passengers per annum
- Increase Heathrow's capacity
- £4.3 billion investment which opened on 30 March 2008


T5
BAA Heathrow
Terminal 5
T5 Station
T5A
T5B
T5C
HexEx
PiccEx
PiccEx Junction
Existing
Heathrow
Express
ART
(Airside Road Tunnel)
Terminal 1,2,3
Terminal 4
Existing
Piccadilly
Loop Line



Lasershell™ at T5

The Team

BAA	Client & Overall Project Management
morgan VINCI	Tunnel Construction
Mott MacDonald	Overall Civil Design
BM	Sprayed Concrete Lining (SCL) Design

What Approach was needed ?

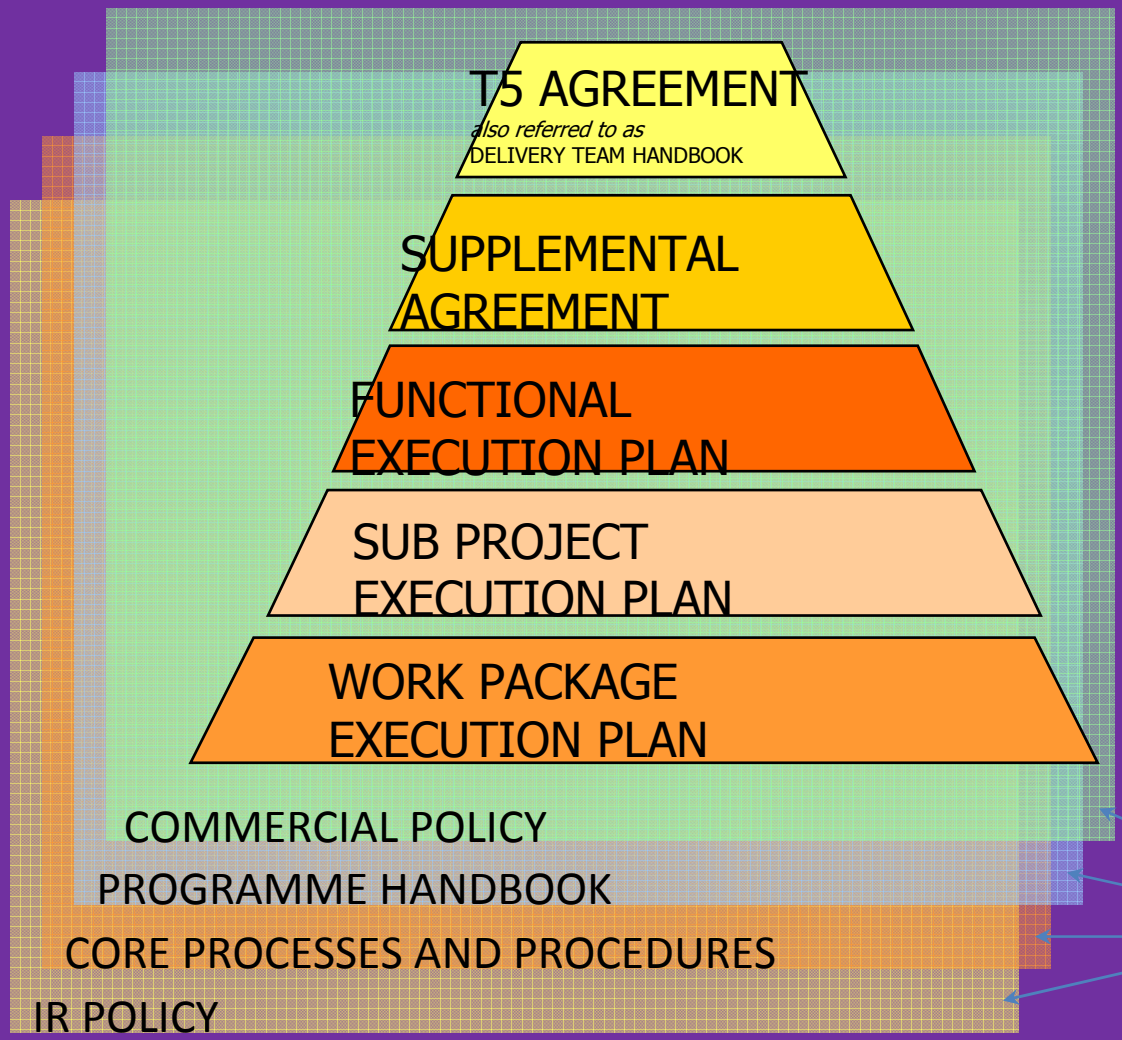
- Needed partners not suppliers
- Needed a culture where opportunity was actively pursued
- Needed to be realistic about risks and ensure they were properly managed
- Needed to create an environment where people could perform and where they were motivated to deliver exceptional performance
- Recognised that being successful meant doing something different – Procurement strategy = T5 Agreement

The T5 Agreement – The Contract

- It focused on performance not failure
- This approach was based on relationships & behaviours rather than transactions
- Cost reimbursed work, guaranteed profit and incentive target
- It focused on people and behaviours and not companies in integrated teams all striving for common goal
- Management of risk fundamental element

How the Various Documents fit together

The document:



What it is:

The terms and conditions everybody working on T5 is bound by.

The detail of the agreement which is signed by the suppliers. It defines the work they're doing on T5.

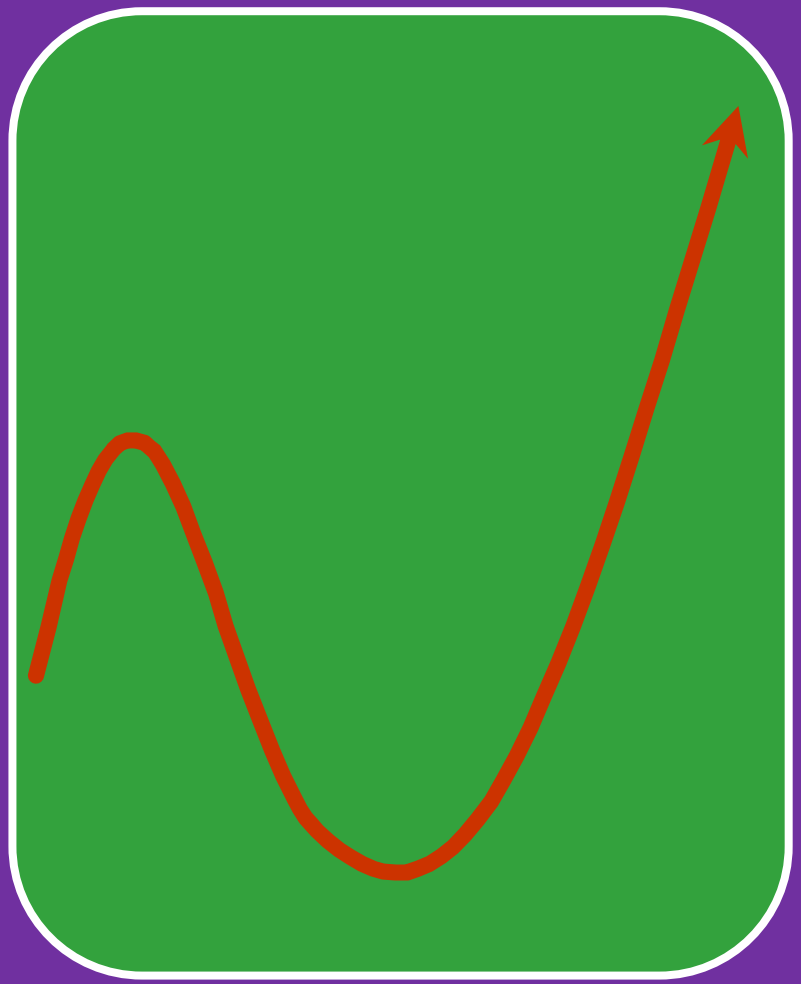
The support required to enable projects to deliver.

The team's plan of work.

This is the breakdown of work by supplier (combines preliminaries, specifications & drawings).

Supporting documents (evolve)

Implementing the T5 Agreement



- Delivering exceptional performance … manage change
  - appropriate support and leadership
  - planning and doing things differently
  - knowing where we are and doing the right things at the right time
  - staying flexible (agile) and changing where necessary
  - knowing it will get rough along the way
- Success depends on how well we weather the storms
- To implement the above needed the Right values & behaviours – Commitment, Trust & Teamwork

What the Approach Meant To Different Audiences

BAA PLC	Suppliers	Teams on T5	All T5 Team members must demonstrate:
Enabling exceptional performance **e.g. BAA holds all the risk all of the time / on time, in budget and to quality.**	**It gives them an opportunity to create competitive advantage for their business – Using T5 as showcase.** **Enabling a step change in performance.**	**Working in highly Effective integrated teams that are committed to achieving T5 Milestones.** **It's about trusting each other and relying on each other to work together.** **It's about supplier teams, and BAA staff working on one team.**	**Commitment** **Trust** **Team work**

Aligned in our focus on exceptional performance

The Three Values & Behaviours Which Underpinned The Agreement

Commitment

- Being seen to do what we say
- Challenging targets
- Value-focused
- Managing the supply-chain
- Enabling processes & solutions

Teamwork

- Fully inclusive teams
- Integrated
- Co-located
- Share responsibility
- Share success
- Outcome - not problem - focused
- Helping & supporting
- Enabling individuals
- Managers as enablers
- Fully empowered
- Trained
- Celebrate achievements
- Leading by example

Trust

- Partnering
- Co-operation
- Meaning what we say
- Respect
- Selected on merit
- Treating our workforce with respect

Management of Risks

- BAA owned the risks and the Teams managed them.
- Integrated Teams focused on solutions not contractual differences
- Project process of Project Execution Plans, review workshops & Risk Assessments
- All accidents are avoidable
- Significant Challenges – Workforce safety, controlling ground movements, Cost & Time

AFP

Safety, Technical Innovations & Managing Ground Movement

The Challenges. . . .

Workforce & third party Safety

Ground movement control

- Airport taxiway & stand infrastructure
- Fuel & fire mains
- Buildings, existing railway tunnels

Tunnel Method Performance Criteria

- Target tunnel horizon the London Clay.
- Theoretic calculations establish requirement to maintain 1.5~2 bars face pressure to contain surface settlements within 15~25mm.
- Re-use of tunnel spoil for T5 Earthworks. Airport taxiway and building infrastructures

Managing Safety Risk

- Behavioural safety initiatives (IIF)

- Adopting cause control measures & technical innovations – controlling ground movements

IIF Programme

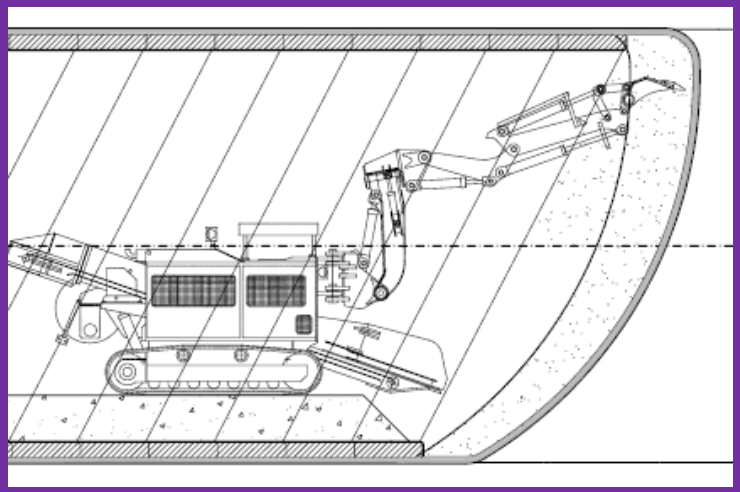
What is it ?

- Making safety personal – focusing on individuals
- Moving safety to a core value
- Creating a vision that all accidents are avoidable

How is it achieved ?

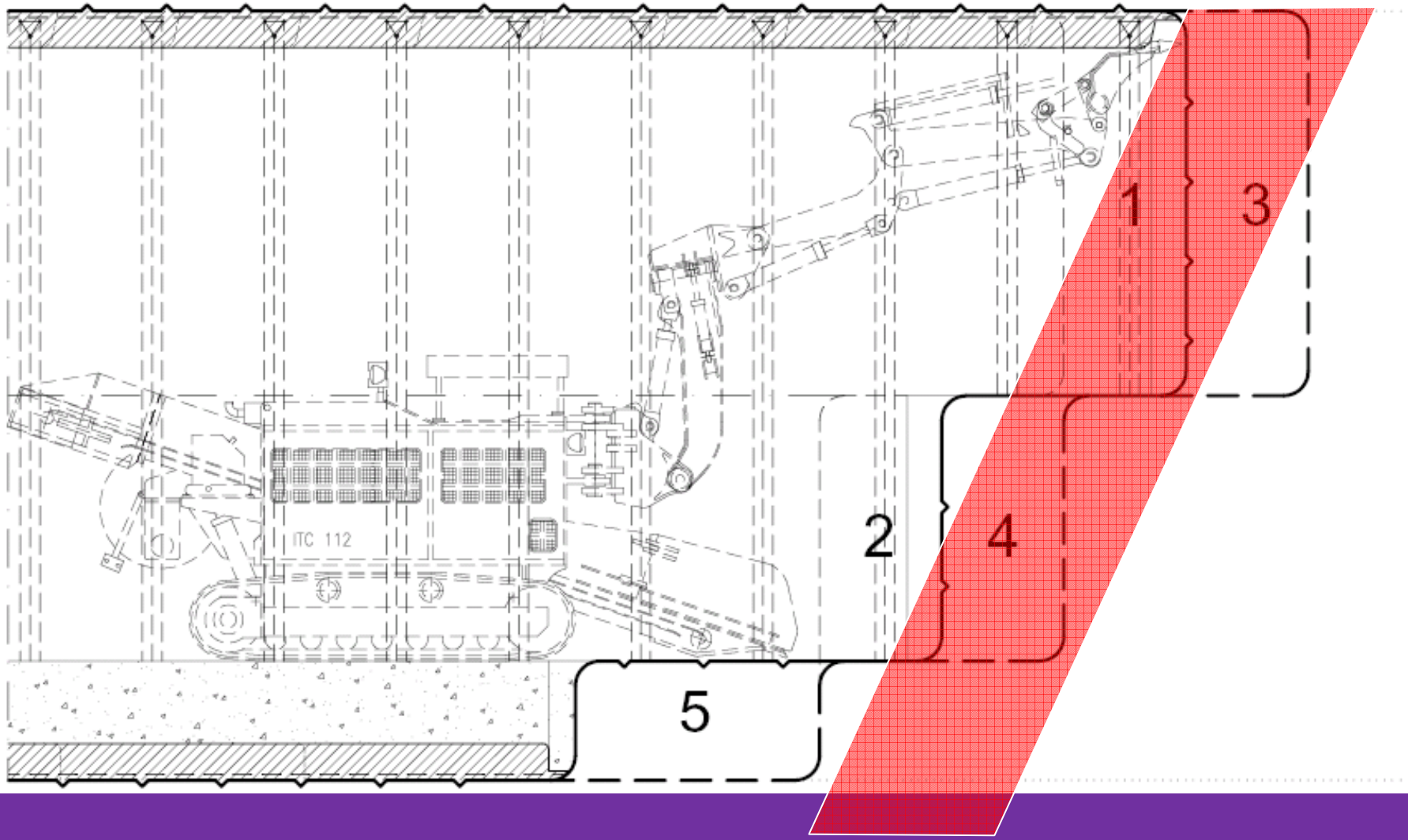
- Only happen if we do something different
- Engaging everyone in making safety central
- Gaining genuine commitment from everyone
- persuading people to take personal responsibility
- Conversations, highly visible Safety Leadership
- Honesty, openness and support

Cause Control Measures - Lasershell™



Triggers for development:

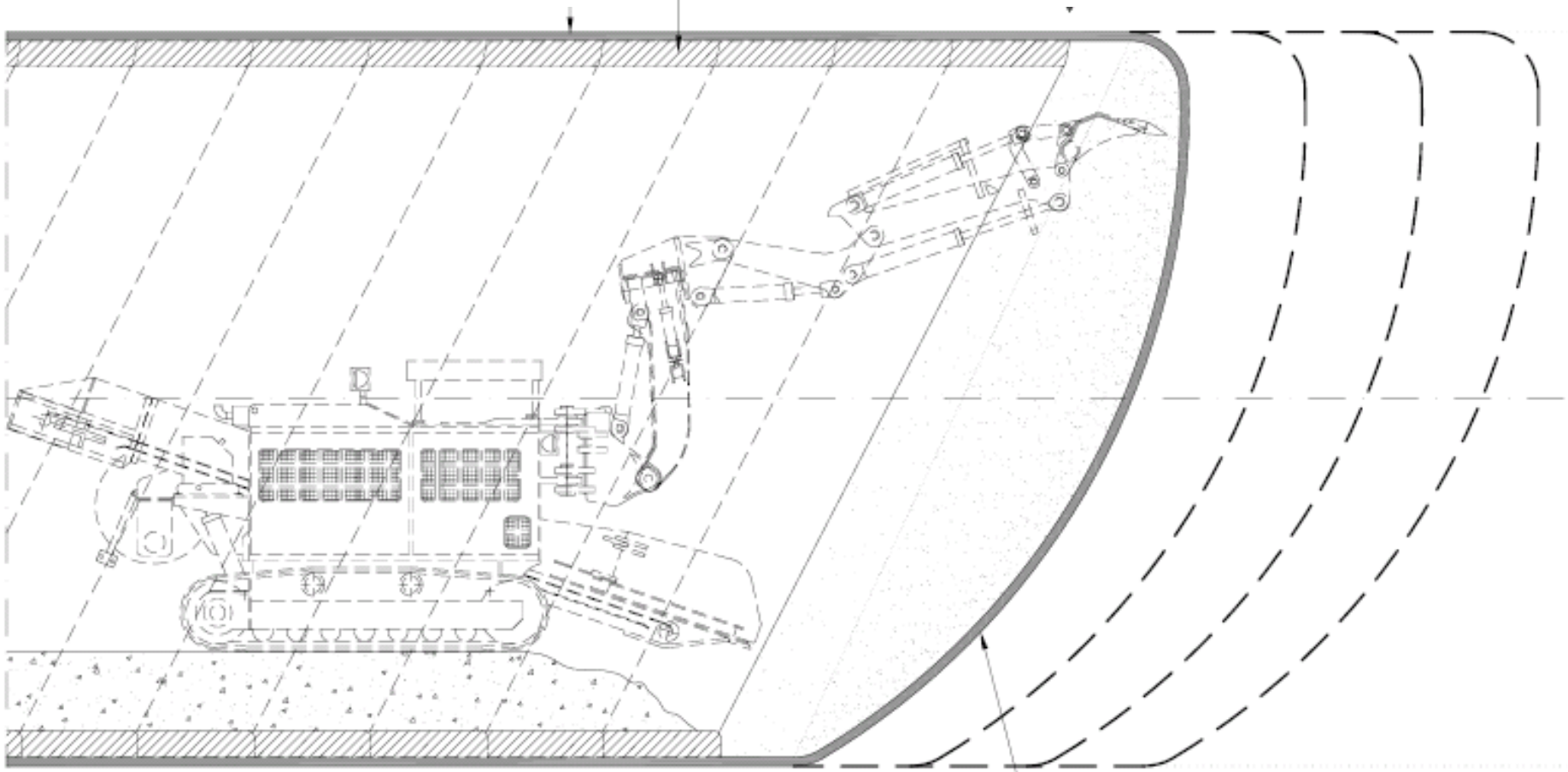
- Safety
- Mechanisation
- Fast ring closure & minimising joints
- Building a permanent lining during excavation and support
- Buildability of complex geometries



1 crown excavation, crown support, 2 bench excavation, bench support, 3 crow...5 invert

Steel fibre reinforced lining 1st layer

Steel fibre reinforced lining



Driving Direction

Face Support

TBMs - Key requirements

- Ability to maintain a controlled pressure of up to 2 bars at the face with cover less than 20m
- Ensure that the excavated materials (circa 170,000m3 in-situ) can be re-used as a fill material
- Able to tunnel through mixed faces (clay – water bearing gravels) at portals

TBM Development

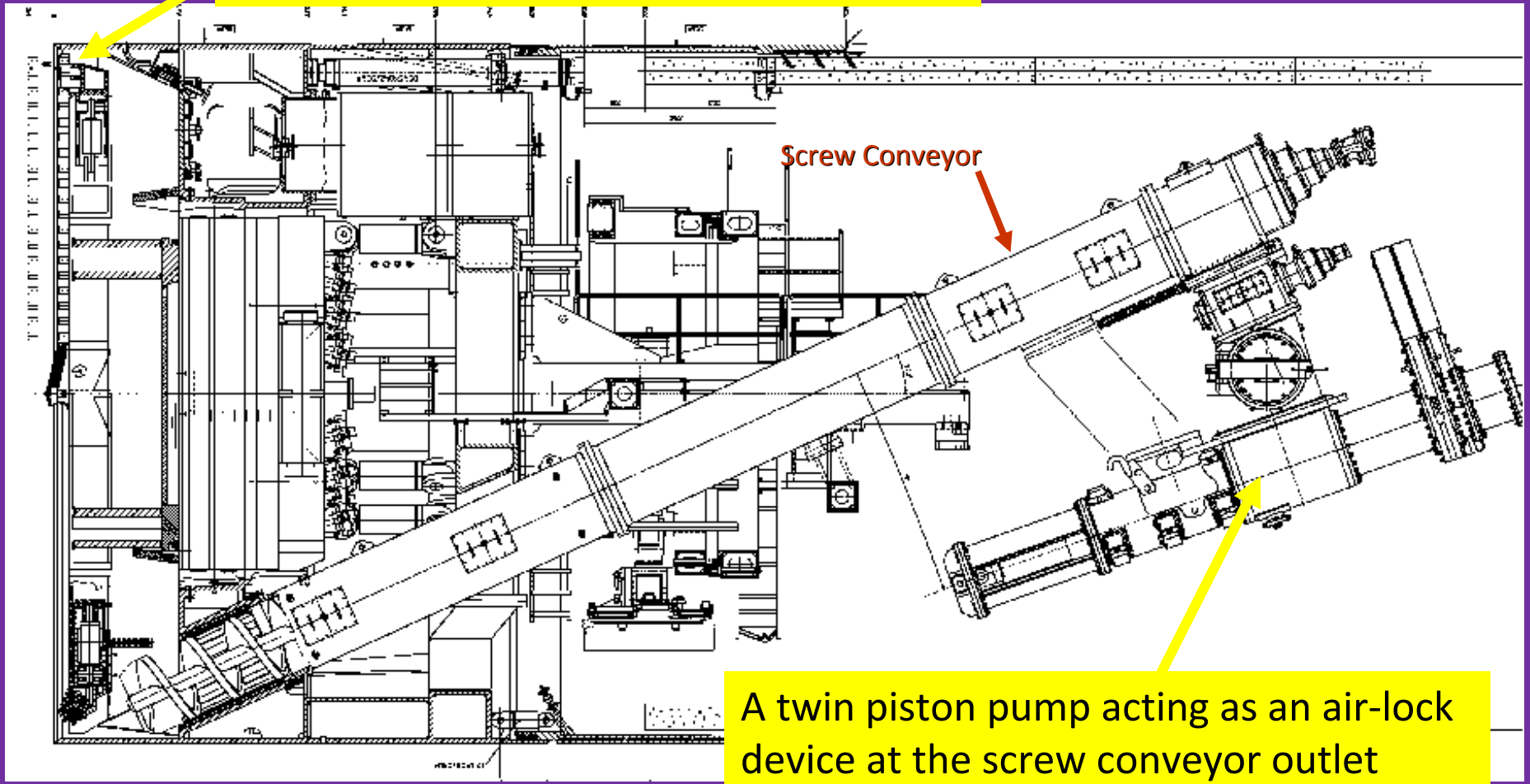
- Two concepts considered: EPB & mechanical support of the face.
- Team's approach: Make best use of the highly impermeable nature of London Clay and use of compressed air as a confinement mode. Maintain EPB capabilities for portals.
- Key issue: How to form a plug in the screw able to sustain a 2 bar air pressure.

Large scale trials at Herrenknecht factory

- Turning London Clay into an EPB paste feasible but requires a lot of energy (confirm lab test with foam suppliers)
- Virgin London Clay cannot reliably form a plug within the screw able to withstand a 1.5~2 bars air pressure
- Design Challenge: design a mechanical airlock system

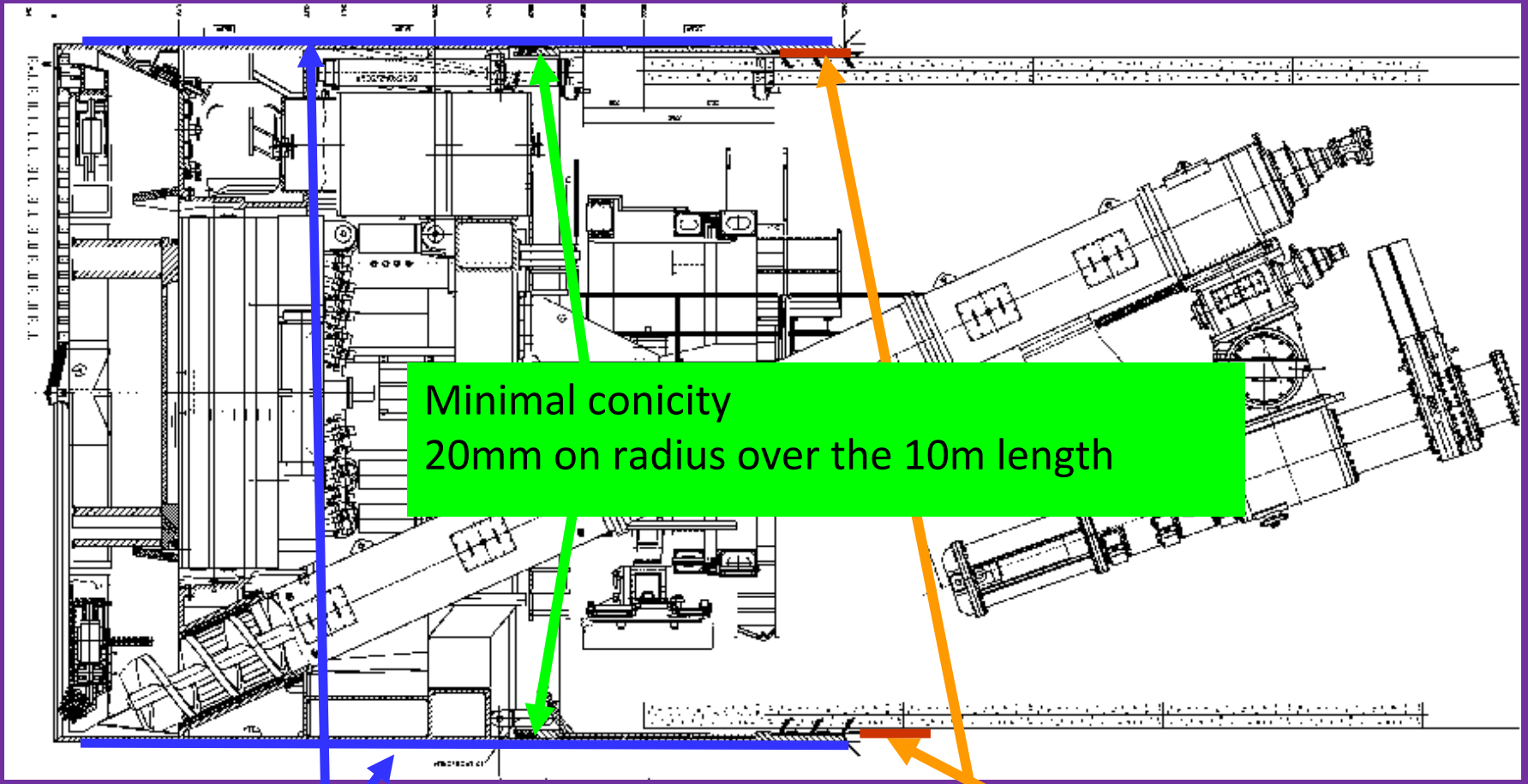
The Concept

A cutterhead in recess within the cutting edge to ensure airtightness



A twin piston pump acting as an air-lock device at the screw conveyor outlet

Other features contributing to settlement mitigation



Minimal conicity
20mm on radius over the 10m length

Pressure grouting through tailskin

Bentonite injection in the annulus

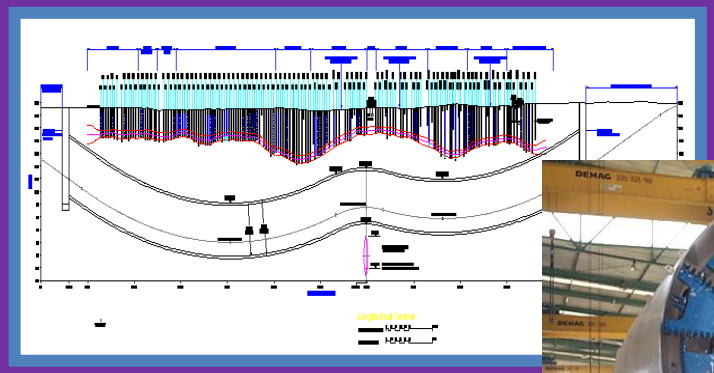
From Concept to Reality

- Dual-mode TBM
  - 9.18m excavated diameter
  - 10.4m long shield with 6 back-up gantries
  - Thrust: 69,300 kN
  - Torque: 17,200 kN.m

- Putzmeister Pump
  - 2 cylinders, 750mm diameter
  - Output: 400 tonnes/hr
  - Weight: 40 tonnes

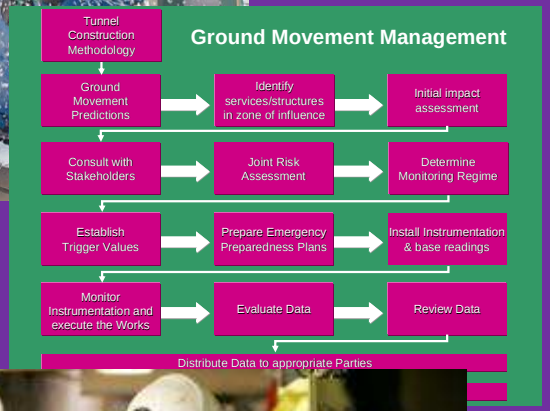
Managing Ground Movements Risks – Robust Processes

- Design



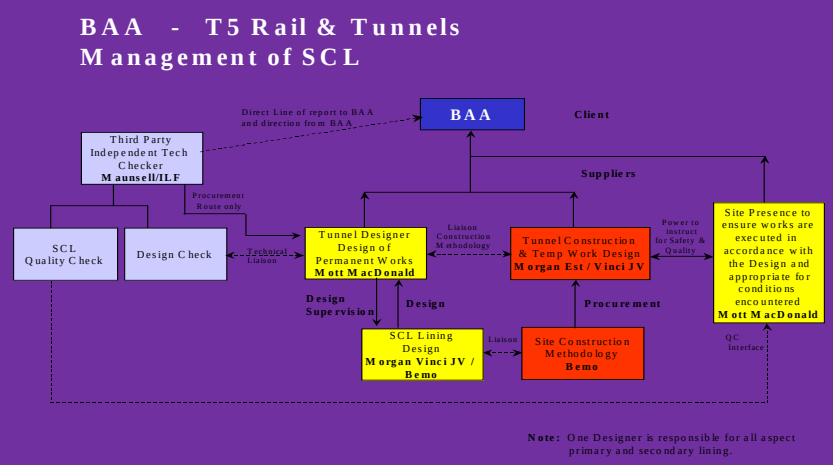
- Construction Methods

- Robust Ground Movement Management Process

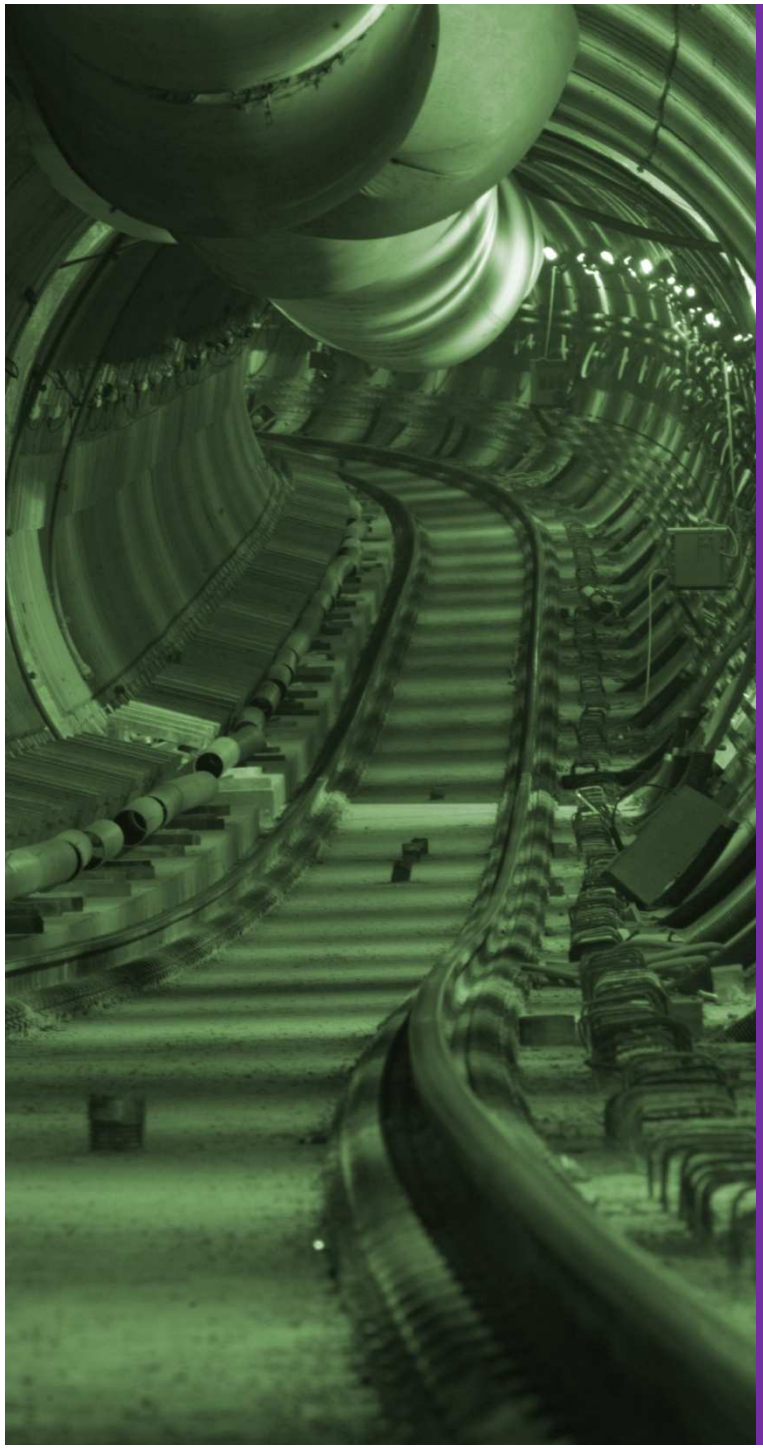


- Competent, skilled staff

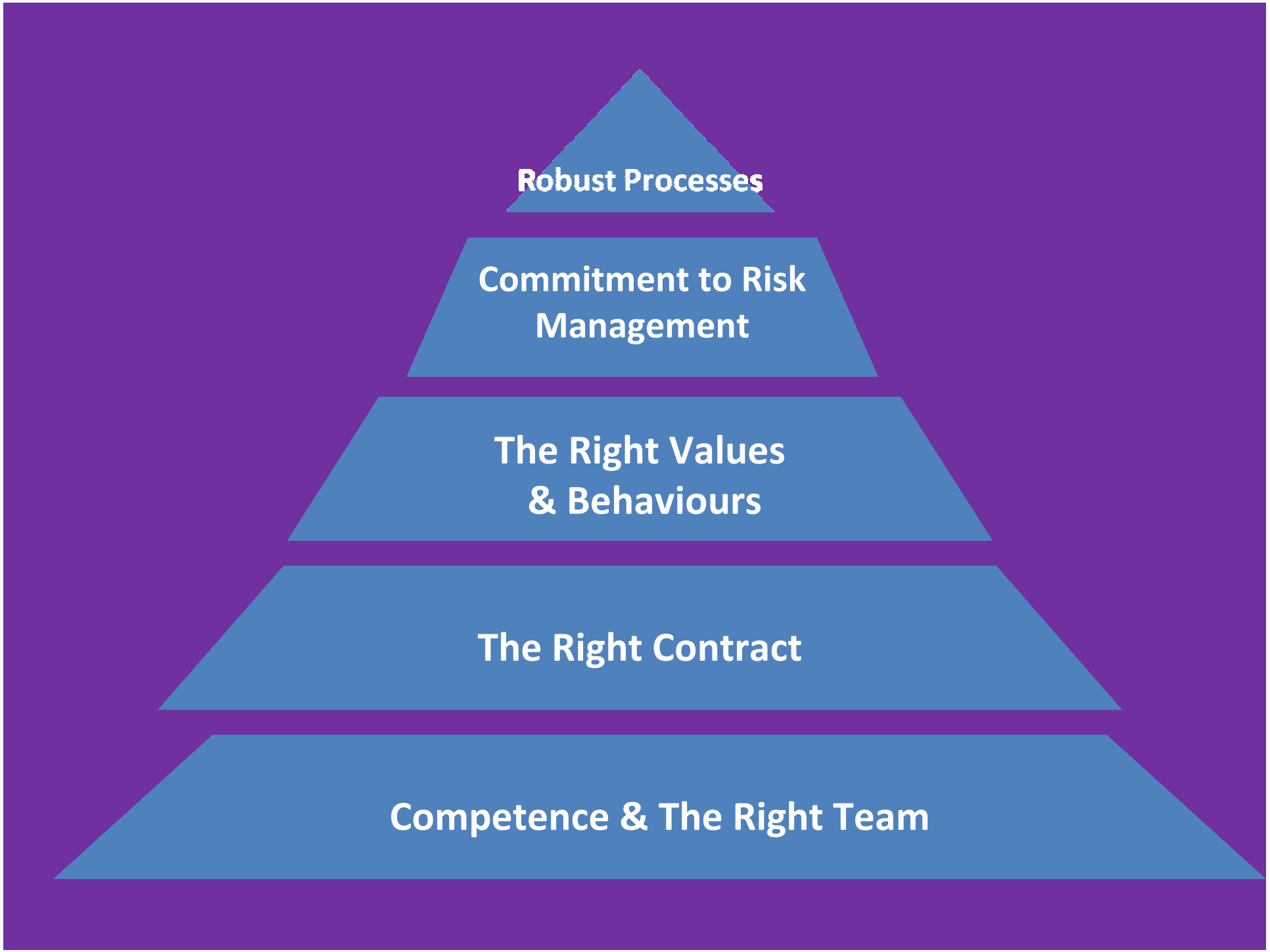
Integrated Assured Design & Tunnel Construction



- Against the backdrop of the 1994 collapse
- Assurance team sole responsibility was the safety of the works – eliminate risk of major ground movement & collapse
- Specific roles & responsibilities fully integrated but independent of the construction with the team accountable directly to the client
- This role was crucial to success of the project and was an example how all the elements of invaluable learning over the previous ten years came together



Framework For Successful Project Outcomes


Robust Processes
Commitment to Risk Management
The Right Values & Behaviours
The Right Contract
Competence & The Right Team

Summary

- UK Tunnelling industry has undergone a major step change since the early 1990s driven by several factors
- T5 Tunnels has been one of the UK flagship successful projects completing 14km of successful incident free tunnelling to time and cost targets
- Framework for success – competence, the right contract, the right behaviours, commitment to risk management and robust processes

Thank you
Ian Williams