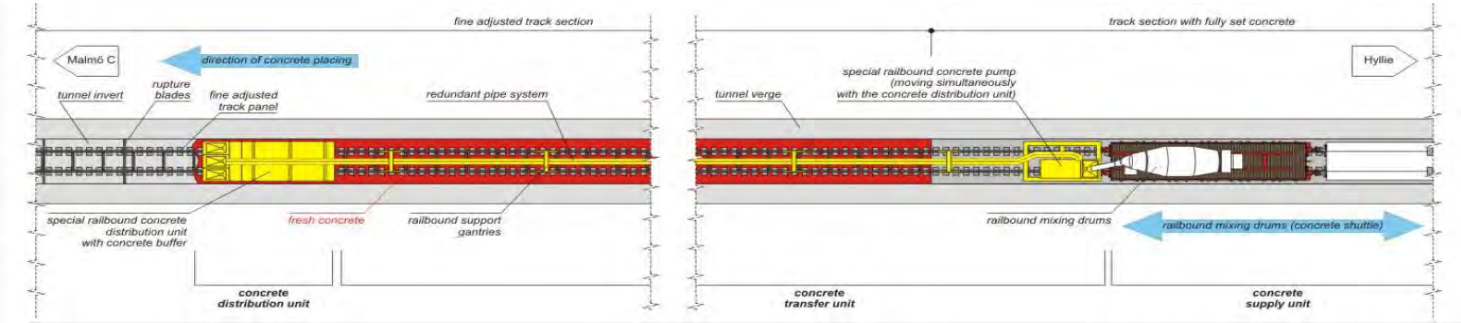
REPA
Residents' Environmental Protection Association

Sean Ring BSc Eng, FPWI

Founder Beazley Sharpe (Railwise) Ltd, Railway Engineering Consultants, 1998 to date

Extensive UK and overseas experience

- CTRL/HS1
- CrossRail
- London Underground; DLR; Track renewal programs; WCRM.
- Expert advisor to four clients on HS2



Rail systems fit out

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- **Timing**: Why does the Chiltern tunnel take so long (2.75yrs)?
- **Method of working:** Parallel versus sequential working
- **Realistic Chiltern tunnel fit out schedule:** Is 1.75 yrs realistic?
- **REPA 4.1km extension:** Can it be done in 3 months?
- **Ruislip?:** Should fit out be based at Ruislip?




……efficient fit out frees up lots of time

A1238 (33)

Tunnel boring

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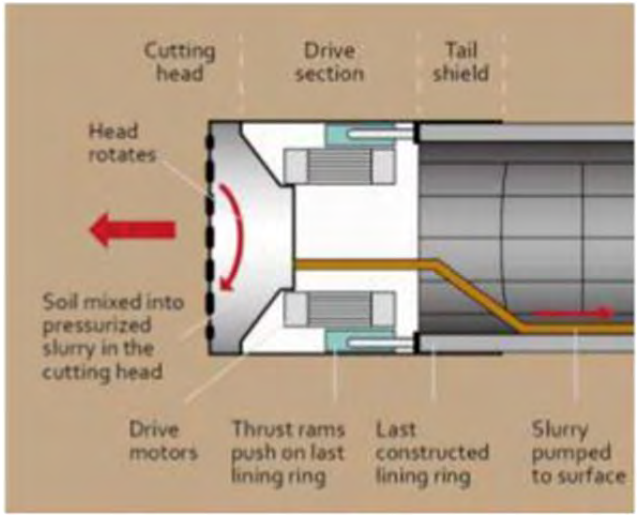
Rodney Craig BSc C Eng. MICE

- Halcrow Group (a CH2M Hill subsidiary). Director, 11yrs (to 1998).
- Head of Tunnels & Railways 1987-1994.
- British Tunneling Society - James Clark Medal winner 2004
- International Tunneling Association - Chair of U/ground Group
- 100+ publications

Extensive UK & international experience.

- Expert witness for promoter to Select Committee: Heathrow X (three times) and DLR to Lewisham (twice)
- Chalk projects: Cuilfail road tunnel, Malmo City Link.
- Underground storage caverns and sewers.
- Channel Tunnel Rail Link/HS1
- Victoria line; Piccadilly Line and Jubilee Line Extensions
- Stanstead Airport Rail Link



Overseen 3 REPA technical reports

On REPA and CRAG Tunnel Teams

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HOC/01809/0036

Tunnel boring rates

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- **HS2 Ltd assume 80m/wk (average)**
- **REPA Engineering Report assumes**
  - Pessimistic case: – 90m/wk
  - **Central case: – 120m/wk**
  - Optimistic case: – 140m/wk

- **Common historical dataset**
  - Channel Tunnel: Chalk, long, no shafts, 25yrs ago
  - CTRL/HS1: Some chalk, short, shafts,10yrs + ago
  - Crossrail: Some chalk, short, recent (with stations)
  - Thames Water Beckton Tunnel: Chalk, current

……important to use realistic rates

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Why adopting realistic rates matters

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- **Cost:** tunnel costs are cheaper if go quicker
- **Design criteria:**
  - must design for both 'peak' and 'average' rates
- **Slack:** building in excessive slack increases cost
  - it should be risk related



…… need "realistic" not overly "conservative" rates

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HOC/01809/0038

Four areas of evidence

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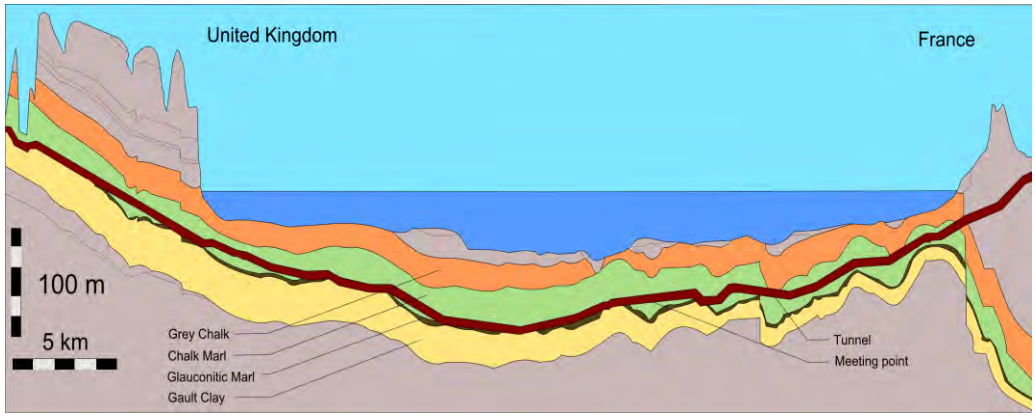
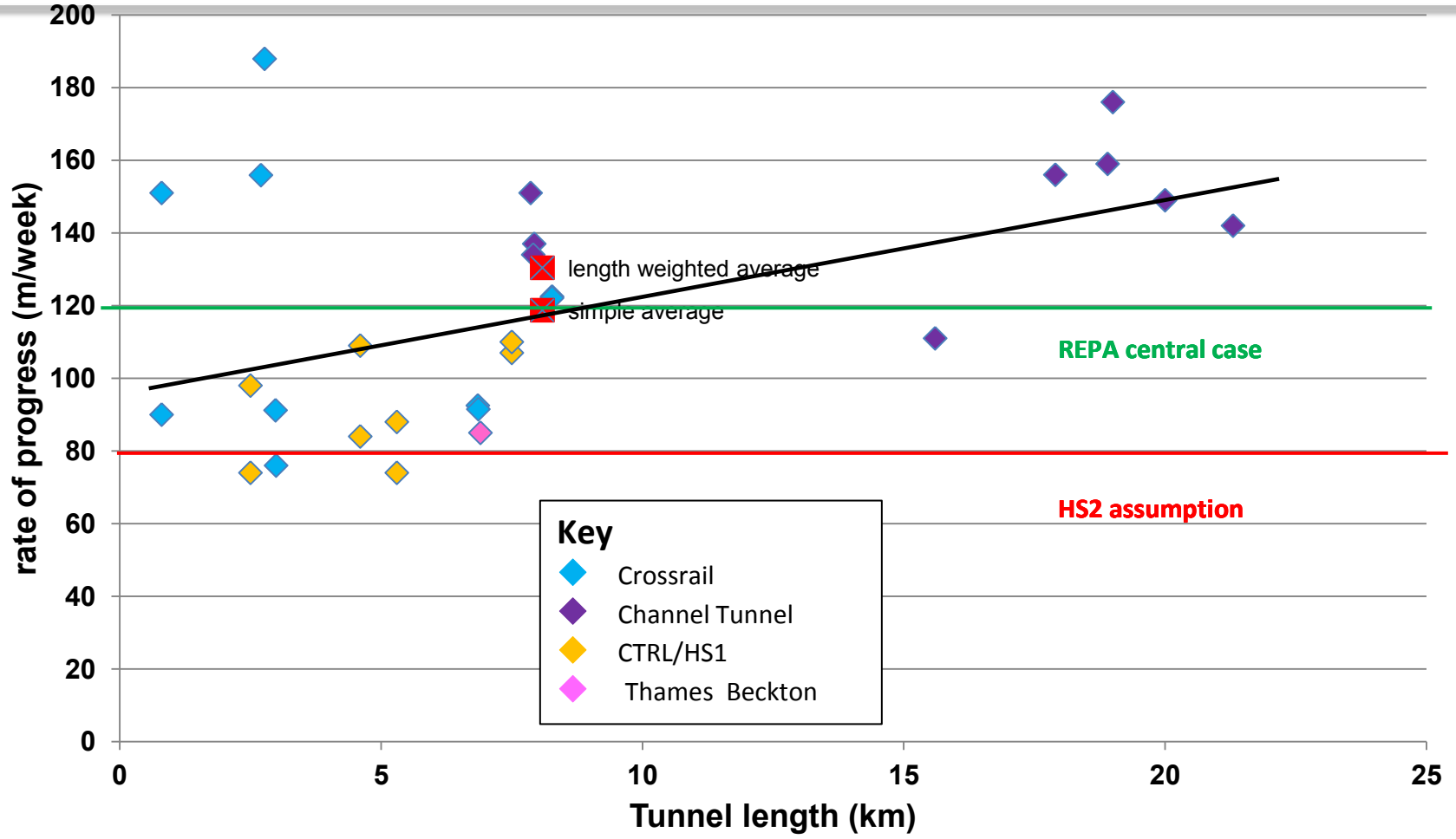
1. **Average boring rates of progress by length**
2. **Within drivage:**
   - ➢Learning curves
   - ➢Sustained rates of progress
3. **Shafts**
4. **Staggered starts**



Tunnel boring rates - 1



.....supports REPAs central case

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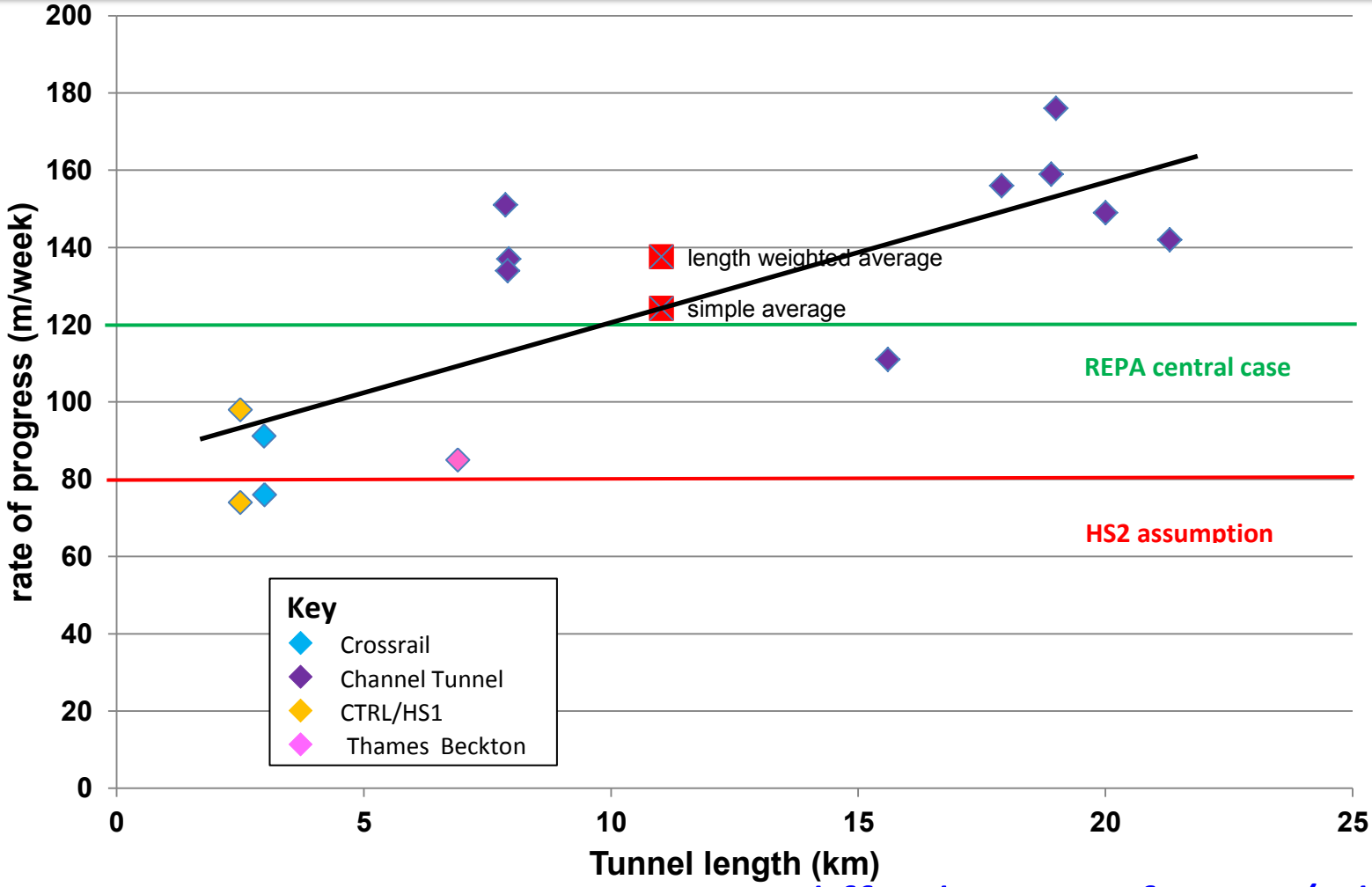
HOC/01809/0040

Tunnel boring rates: tunnels in chalk - 2



.....difficult to justify 80m/wk

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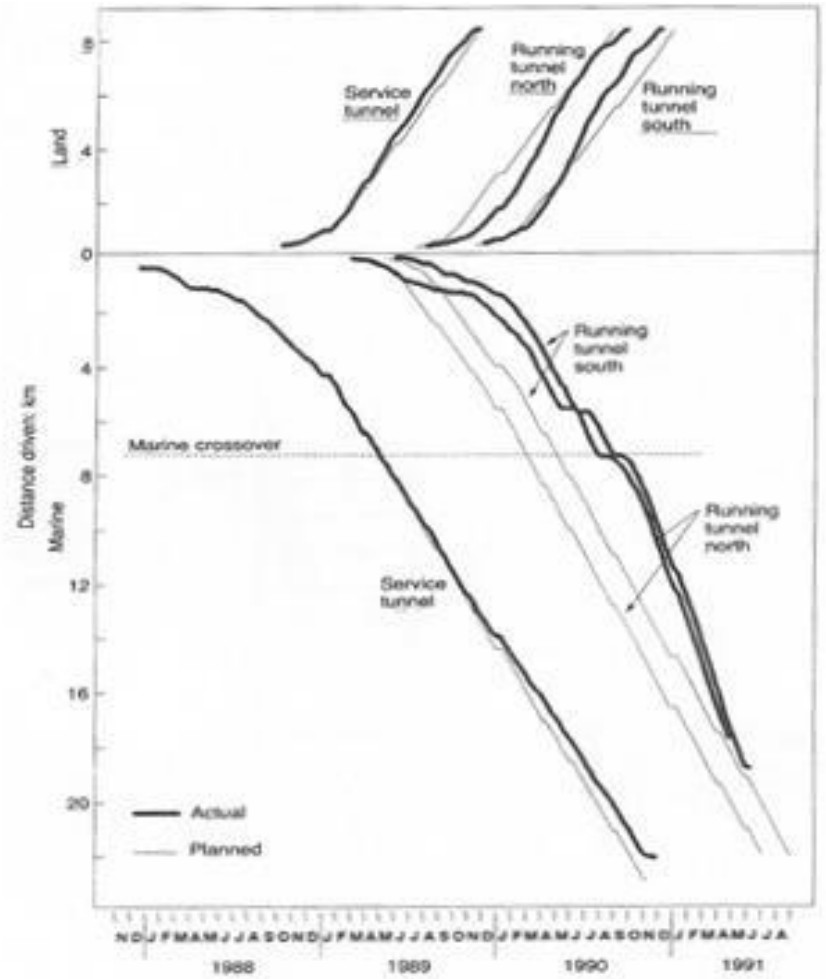
HOC/01809/0041

Progress within drives -1



Proceedings of the ICE on Channel Tunnel 1993

Channel Tunnel

- **Initial low rates** – learning curve
- **Thereafter sustained rate of progress** – no slowing down with length
- **Faster than programme**

……other projects confirm this same profile

Progress within drives - 2

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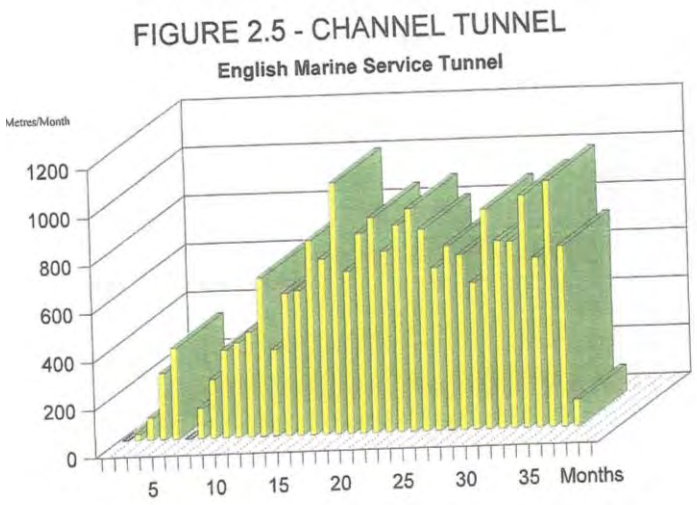
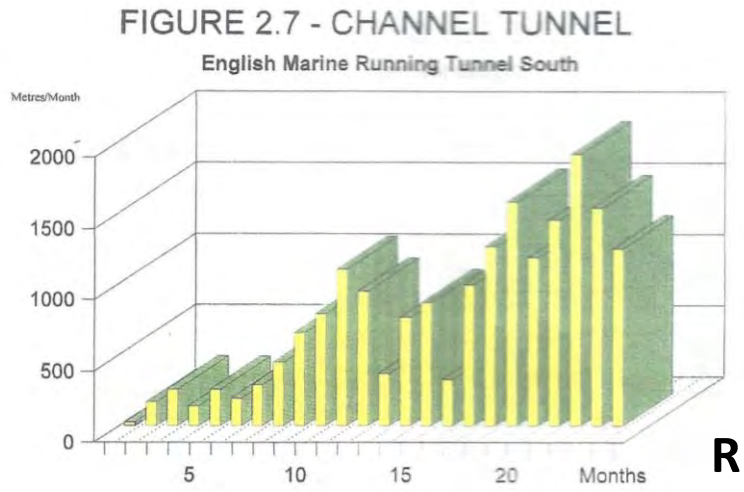
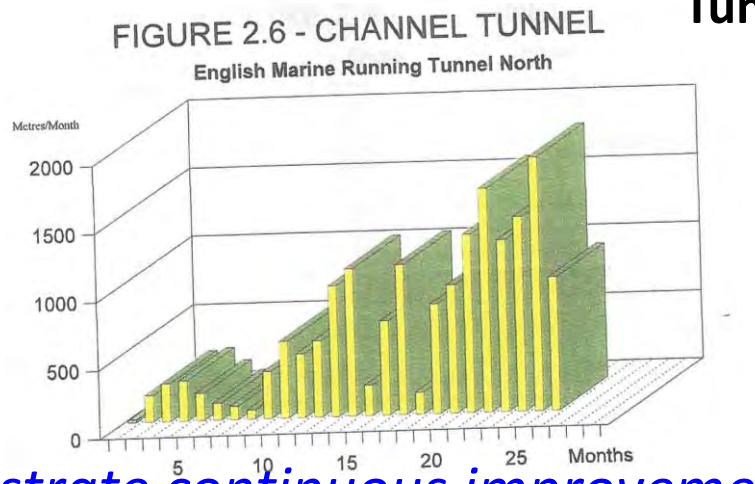
Channel Tunnel



Service Tunnel





Running Tunnels

Extract from Conference on Gibraltar straight fixed link, by UN and ITA. Paper by Rodney Craig, April 1999

……running tunnels demonstrate continuous improvement

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HOC/01809/0043

Do vent shafts add delay?

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- **Channel Tunnel evidence:** contained no shafts
- **Shaft allowance:** HS2 Ltd say allow one month
- **CTRL evidence:***
  - Average of 18.5 days
- **Shafts a maintenance opportunity**: retool and do major maintenance – can speed up next stage

* *From paper published by Rodney Craig 2004 in BTS*

…… evidence shows shafts cannot add much

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HOC/01809/0044

Do staggered starts cause delay?

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TBMs will have staggered starts in twin bored tunnels

Drive	Start lag	End lag
Channel tunnel		
Marine (north/south)	13 weeks	4 weeks
Land (north/south)	17 weeks	10 weeks
CTRL		
220 up/down	8 weeks	6 weeks
240 up/down	10 weeks	2 weeks
250 up/down	13 weeks	1 day

- Stagger diminishes over drivage.
- Makes sense as 1st bore proves the ground

… staggers don't impede the next stage (clear out & base concrete)

Tunnel boring summary

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✓ **80m wk unrealistic:** progress rates in long tunnels have been much higher than 80m/week

✓ **Learning curve:** progress rates initially low, but increase to a steady rate

✓ **Sustained rates:** no tendency for rates to drop with increasing length of drivage

✓ **Shafts add little delay**: Ventilation shafts have little impact on overall rates; an opportunity for re-tooling

✓ **Staggered starts:** stagger in starts reduces over drive

……. 80m/week simply too low

Programme Summary

- **HS2 Ltd: programme suggests the REPA tunnel with fit out from one end, cannot be done.**
- **REPA contend:**
  - **Fit out can be done and from one end (as Chiltern Tunnel can be completed within 1.75 years)**
  - **Tunnel boring can be done within the 3.2 years**
- **Fit-out from both ends: HS2 Ltd agrees this avoids extending the programme but REPA say bakes-in cost and has an environmental impact.**

…HS2 Ltd have a solution but it costs

Cost – the dispute

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Item	Net Costs in £m	HS2 Ltd July 15	HS2 Ltd* published rates	REPA 11 June 2015 Report	REPA 19 July Amended	Difference
Land & Property (£m)		-32.7		-11.4	-11.4	21.3
Tunnels (£m)		**134.5**		**71.5**	**55.5**	**-79.0**
	Bored Tunnels	181.8	170.2	139.4	102.7	-79.1
	Green Tunnel	-57.1		-67.9	-57.1	0.0
	Portals	-10.4			-10.4	0.0
	Shafts	14.2		0.0	14.2	0.0
	Disposal costs	6.1		0.0	6.1	0.0
Civil Engineering (£m)		**-57.0**		**-68.6**	**-83.4**	**-26.4**
	Cuttings	-33.3	-79.4	-53.8	-53.8	-20.5
	Landscape/Planting/Noise	-7.3		0.0	-7.3	0.0
	Bridges	-10.5		-7.8	-7.9	2.6
	Highways	-7.2		-2.0	-7.2	0.0
	Utilities Culverts	-7.3		-5.0	-7.3	0.0
	Extended preliminaries	8.5		0.0	0.0	-8.5
Railway systems (£m)		**21.7**		**0.0**	**21.7**	**0.0**
Indirect costs (£m)		18.0		0.0	-1.1	-19.1
ECP/VE (£m)		-8.1		0.0	0.5	8.6
Net TOTAL £m		**76.4**		**-8.5**	**-18.1**	**-94.6**

* from Tunnel Guide (for tunnelling), and 2012 Appendix A (for cuttings)

...almost a £100m gap between us

Tunnel costs - evidence

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- **The issue: HS2 Ltd estimate tunnel boring costs for REPA that appear greater than in their Tunnel Guide, and are much greater than from 2012 Appendix A rates, that REPA used**

- **Evidence areas**
  - **Tunnel Guide costs and tunnel comparator evidence**
  - **Appendix A cost similar to comparator tunnels**
  - **How costs change with length**
  - **Marginal costs**
  - **Faster means cheaper**

…….let's look at the evidence

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Benchmarking Study

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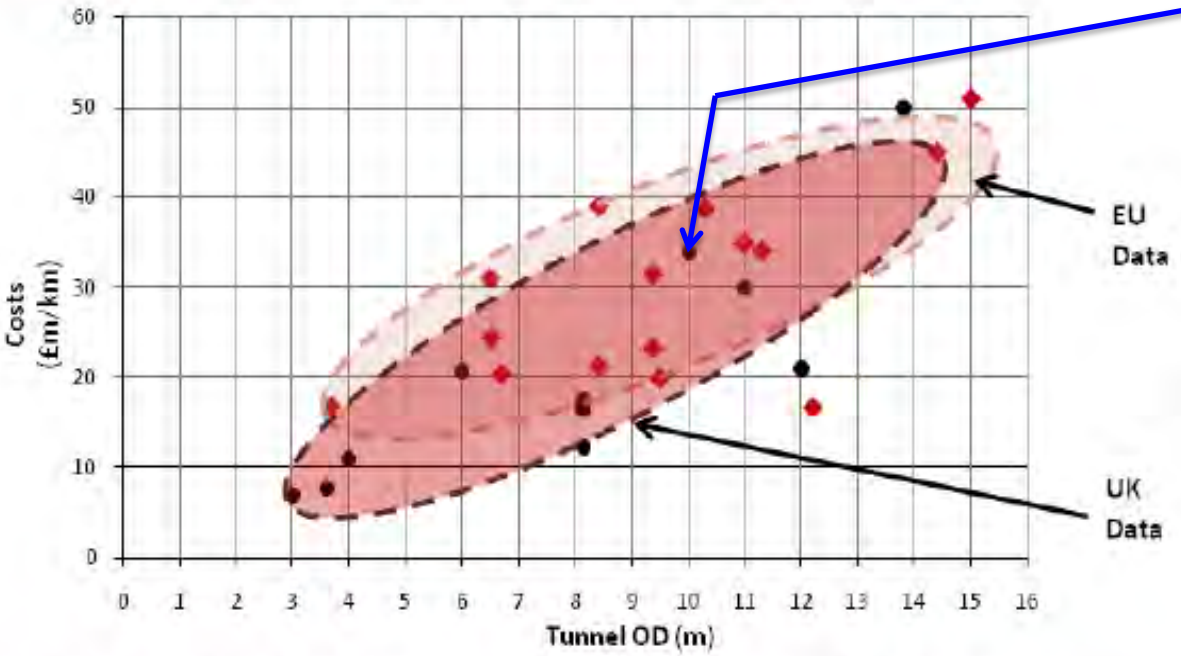
Chart G.1: The effects of tunnel outside diameter on unit costs



Source: Infrastructure UK Cost Questionnaires and British Tunnelling Society

HS2 Ltd Guide Example Tunnel

Study

Wide range techniques, OD's, and countries

.....so does benchmarking support the Tunnel Guide?

Comparator tunnels

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		Outside Diameter	Cost £k/m	Adjusted* Cost £k/m	Cost £k * route m
UK 1	CTRL	8.1m	£12.0	£15.0	
UK 3	CTRL	8.1m	£16.5	£20.7	£36.1
UK 4	CTRL	8.1m	£14.6	£18.4	
UK 8		6.5m	£15.2	£26.2	£52.4
average				**£20.1**	**£40.2**
HS2 Ltd Guide Example Tunnel		**9.6m**	**£33.1**	**£33.1**	**£66.2**
% increase				*+64%*	
HS2 Ltd Appendix A*		**7.25m ID**			**£42.5**

**Adjusted to 9.6OD of HS2 Ltd example tunnel*

.....so £42.5k/route metre looks reasonable

Cost versus length

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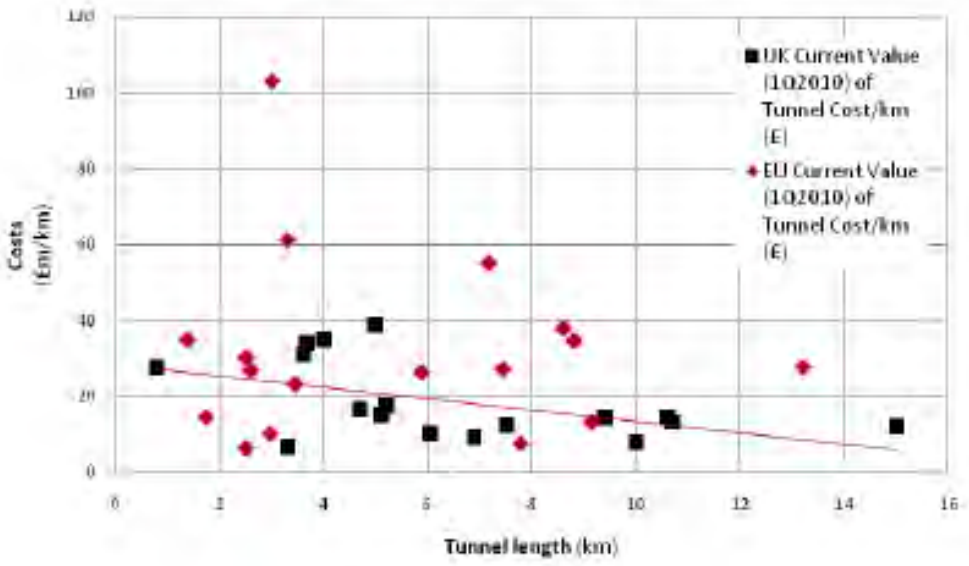
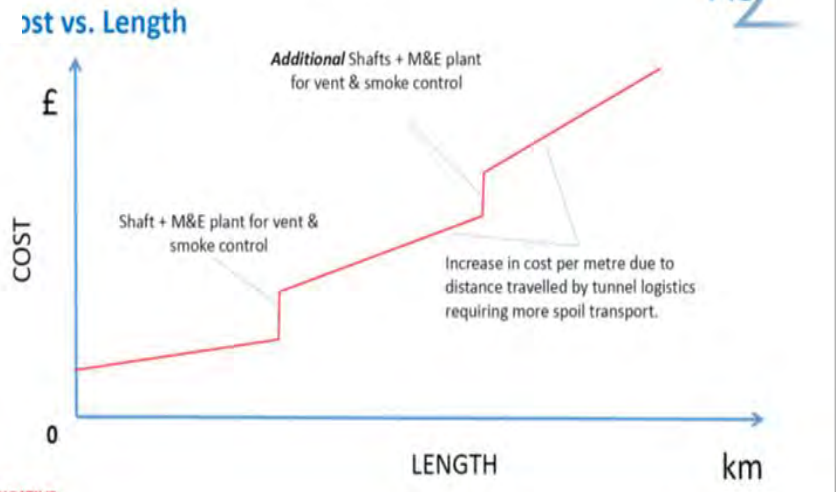


HS2 Ltd suggest unit costs increase with length

nfrastructure UK Cost Questionnaires and British Tunnelling Society.

British Tunnelling Society show unit costs reducing with length



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INDICATIVE

.....so unit costs go down not up with length

HOC/01809/0052

Marginal costs

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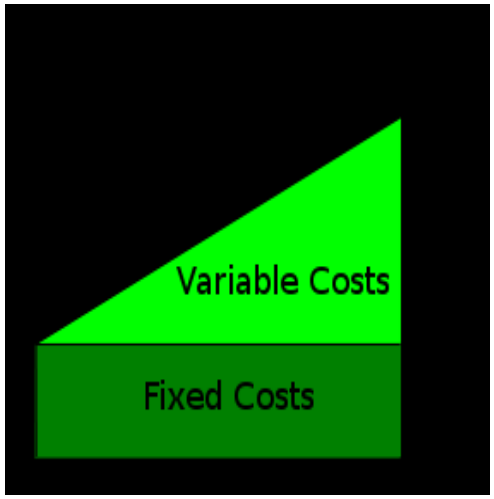
Marginal cost rate is the appropriate rate for the 4.1km REPA extension

- REPA assumed 80% variable costs, 20% fixed.

- **REPA Evidence**
  - Longer tunnels have lower unit costs – BTS evidence
  - FOI 13-621R : gave 80%:20% split



REPA assumed a marginal rate of 80% of £42.5k per metre

Time-based costs

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Time costs money

- **How much?:** A 20% reduction in tunnelling time delivers 5% less cost (*REPA Report, para 4.24*)
- **Tunnel Guide confirmation**: 20% less time boring a 13.3km tunnel saves 5.3% in direct costs.
- **REPA central case (120m/week):**

➢ Reduces time by 33%

➢ Boring speed benefits not counted

….. realistic timescales will make tunnelling cheaper

Tunnel costs summary

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✓ **Guide costs are not representative:** they are well above relevant comparators (Guide 64% higher than the benchmark)

✓ **Comparator tunnels, eg HS1, confirm original values:** the tunnel evidence aligns with the original 2012 Appendix A values, which is what REPA used

✓ **Marginal costs are appropriate for REPA:** evidence to support the 80% REPA used.

✓ **Cost by length:** Costs go down not up with length

✓ **Time is money:** realistic time scales are also important for costs

…HS2 Ltd's tunnel costs appear too high