

Swarm Robotics in Underground Construction

DCA-Europe 26th Annual Congress

Patrick Lane-Nott - Director of Engineering at hyperTunnel

Stratford-upon-Avon, UK
Thursday 6th October 2022

“Apple is going to reinvent the phone.”



Steve Jobs,
Co-founder, chairman and CEO of Apple Inc.
January, 2007

“A computer on every desk, and in every home”

Bill Gates,
Co-founder, and CEO of Microsoft Corp.
July, 1975



“[Tesla will] liberate the world, at last from the internal combustion engine”

Elon Musk,
Co-Founder & CEO of Tesla Motors.
May, 2007

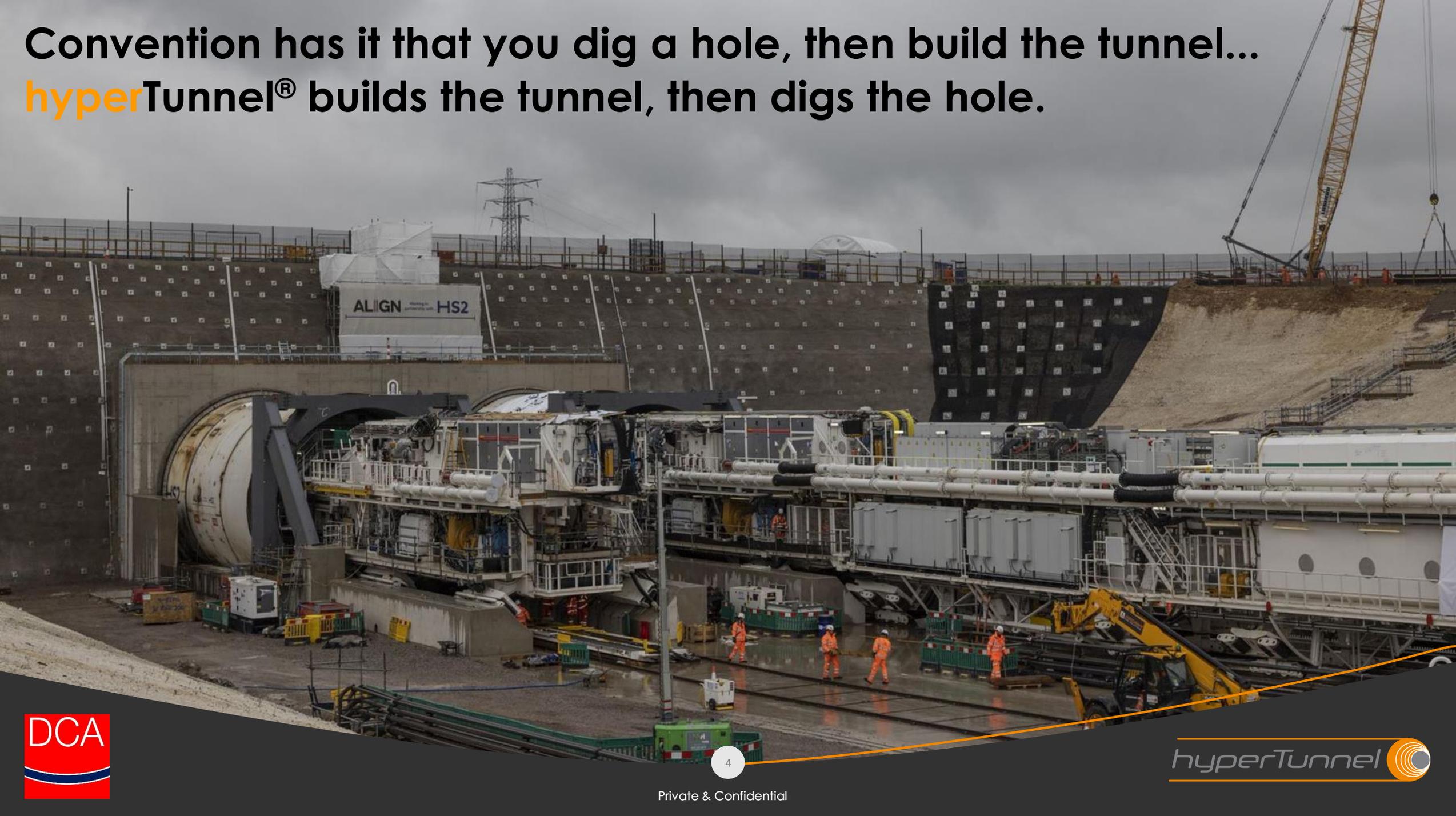


“By the end of this decade, all underground structures will be built by swarming robots”



Steve Jordan,
Co-founder of hyperTunnel
October, 2021

Convention has it that you dig a hole, then build the tunnel...
hyperTunnel[®] builds the tunnel, then digs the hole.



hyperTunnel[®] is revolutionising underground construction for a sustainable solution that is up to ten times faster but only half the cost.

hyperTunnel[®] has created a tunnelling method which combines proven technologies from other industries with **robotics, AI, digital surveying** and **swarm** control systems ... disrupting a \$120bn industry.



Greater
Speed



Enhanced
Safety



Lower Cost



Less
Environmental
Impact

Having emerged from a renewable energy technology, viz. Tidal Range Tunnels, hyperTunnel was

- **born green** and remains so driven, with dramatic reductions in environmental impact one of the company's four strategic offerings ... **green tech** growing **green jobs**.
- **born international** ...

The leadership team ...



Mark Carne CBE
Chairman
Recent CEO Network Rail



Nick Cremin
Deputy Chairman



Jeremy Hammond
Co-CEO



Steve Jordan
Co-CEO



John Moreland-Lynn
Director of Corporate Development



Patrick Lane-Nott
Director of Engineering

... supported by a

- Team of forty, mostly engineers who come from tech industries as diverse as Formula 1 and aerospace,
- Dedicated test site,
- Onsite geotechnical lab, and a
- Bot prototype manufacturing facility.



.... advised by a Technical Board of experts at the forefront of tunnelling



Peter O'Riordan
Chairman
Previously of Arup,
Crossrail, HS2



Bruno Combe
Tunnel Technical Director
Bouygues TP



Donal Coughlan
Technical Director at
Jacobs



Mike Devriendt
Associate Director at Arup



Gustav Jahnert
Innovations Manager at
Bauer Technologies



Dr Benoit Jones
Previously of Warwick University, HS2



Mike King
Previously Head of Underground Construction on
Crossrail



François Pogu
Managing Director VINCI Construction Grands Projects
UK



Greg Raines
Vice President Stantec



Götz Tintelnot
MBCC Group - CEO TPH
Bausysteme GmbH



Dr Kurt Zeidler
Owner of Gall Zeidler Consultants

... who are contracted but unpaid, critical and challenging but supportive.



Positive industry response



Business Age

INTERVIEW
Q&A with hyperTunnel, rival to Elon Musk's Boring Company

TBM TUNNEL BUSINESS MAGAZINE

hyperTunnel Develops New Way to Build, Repair, Enlarge and Monitor Tunnels

GROUND ENGINEERING

Tunnelling tech start-up reveals 'revolutionary' tunnel-building robots

WORLD CEMENT

Winners of Construction Startup Competition 2021 are announced

September 2021

The International Journal for the Tunnelling Industry

Tunnelling Journal

www.tunnellingjournal.com

Inside-Out Tunnelling

hyperTunnel says that it can build tunnels faster, safer and cheaper. Though secretive about their technology to date, co-CEO Jeremy Hammond and director of engineering Patrick Lane-Nott agreed to share some details with Kristina Smith.

There are other projects on the cards too, which will see hyperTunnel working as a subcontractor to tier 1 contractors. When Hammond and Lane-Nott spoke to TJ in August, contract announcements were imminent.

Disruptor: tunnel
The reason that Jordan and Hammond created hyperTunnel is just as exciting as the prospect of hyperTunnel's approach proving possible. Their initial goal was to make tunnel building more viable so that they can build a plethora of tunnels which would provide renewable energy through tidal range.
"We wanted to build an awful lot of tunnels to power the UK and Western Europe, all from the West coast of the UK," explains Hammond. "It was going to be hugely expensive, we were talking over £270bn at the time."
What do you do if tunnel building is too expensive? Invent a new way to do it, of course. So, Jordan did precisely that and then he and Hammond sought early-stage funding to assemble a team of people from a variety of industries and disciplines. Inexpensively, none of them were tunnellers, although there are civil engineers on the books now.

co-CEO and co-founder Jeremy Hammond says leads a diverse team including director of engineering Patrick Lane-Nott, who came to the company from Formula 1.

This is the hyperTunnel process in a nutshell: bore a series of small-diameter holes around the perimeter of a proposed new tunnel using horizontal directional drilling (HDD); survey the ground from those holes; send in a swarm of robots to create a tunnel lining from those holes; and then excavate out the middle as great speed. Simple, right?
Well, apparently it is. Director

difference between hyperTunnel and conventional tunnelling companies is attitude.
"They have a rather refreshing 'no respect' approach to things; we are normally concerned about," says Kurt Zeidler, of Gall Zeidler, who is one of several experts who have been drafted onto an advisory panel for hyperTunnel (see box p16). "When they come across a problem, they just say

New Civil Engineer

OCTOBER 2021

FUTURE OF TUNNELLING

BIM TODAY

SEPTEMBER 2021 • ISSN 2632-9336

How a Formula 1 mindset can revolutionise digital twins in construction

September 1, 2021

Complementing BIM with digital twinning is an F1-inspired approach that can significantly improve the potential of construction projects. It requires a certain discipline, explains Patrick Lane-Nott, director of engineering at hyperTunnel

SUPPORTED BY

FARO NEMETSCHKE GROUP SCIA revizto BLUEBEAM

Tunnelling leader during a recent hyperTunnel site visit: "I've seen the future of tunnelling"



Why now?

The global population is expected to increase to 9.2 billion in 2040⁽¹⁾, with urgent need for underground infrastructure.

Governments are pledging €billions toward infrastructure and require cost effective, sustainable solutions.

The €130 billion industry is slow to adopt innovations such as digital twins, 3D geotechnical layering, AI and robotics, which creates a **disruption opportunity**.

Note(s): (1) UN Population Forecast



hyperTunnel 

The hyperTunnel Method

The hyperTunnel Method

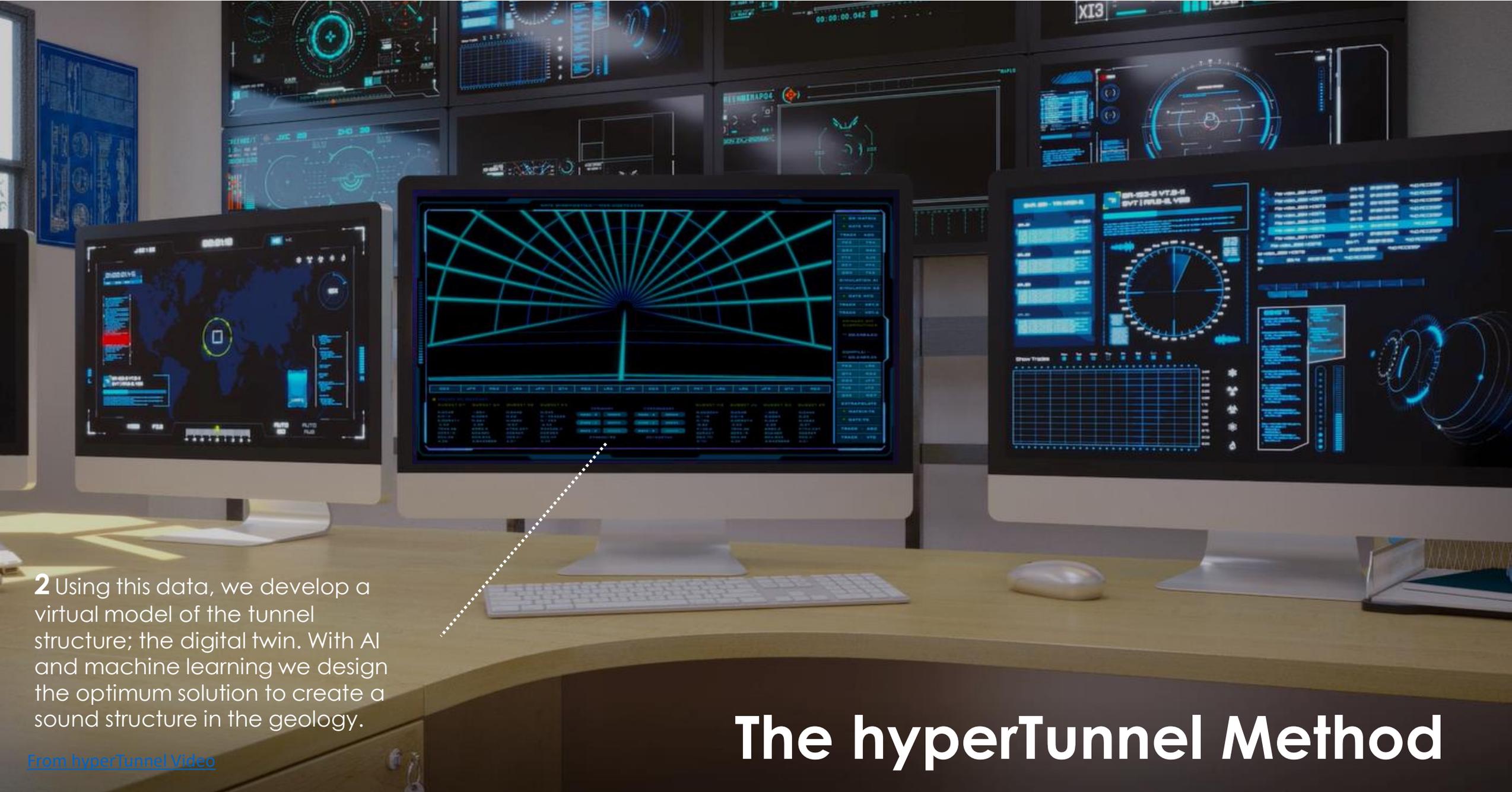
1 We drill and line pilot bores and send robots inside to inspect the geology taking core samples and scanning using ground penetrating radar.

Result: A near perfect understanding of the entire tunnel length's geology.



[From hyperTunnel Video](#)





2 Using this data, we develop a virtual model of the tunnel structure; the digital twin. With AI and machine learning we design the optimum solution to create a sound structure in the geology.

[From hyperTunnel Video](#)

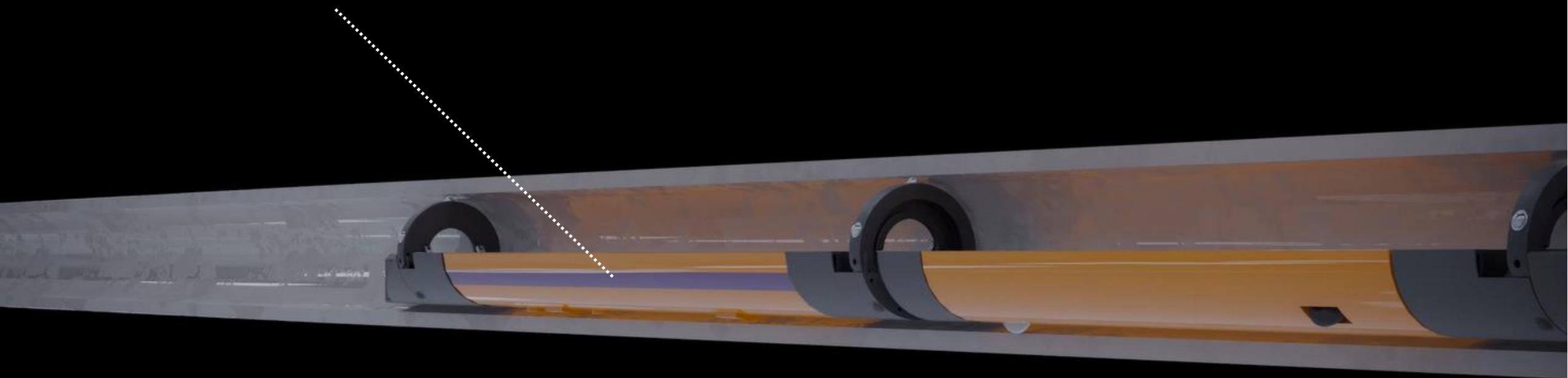
The hyperTunnel Method

The hyperTunnel Method

3 Once the tunnel profile is defined, we send a swarm of bots into these lined bores to visit planned locations in order to drill and deploy chemistry according to the AI generated design

[From hyperTunnel Video](#)

4 Thousands of robots will be used, all controlled using swarm technology to 3D print the tunnel in the same way that bees build a hive or termites build a mound.



The hyperTunnel Method

[From hyperTunnel Video](#)

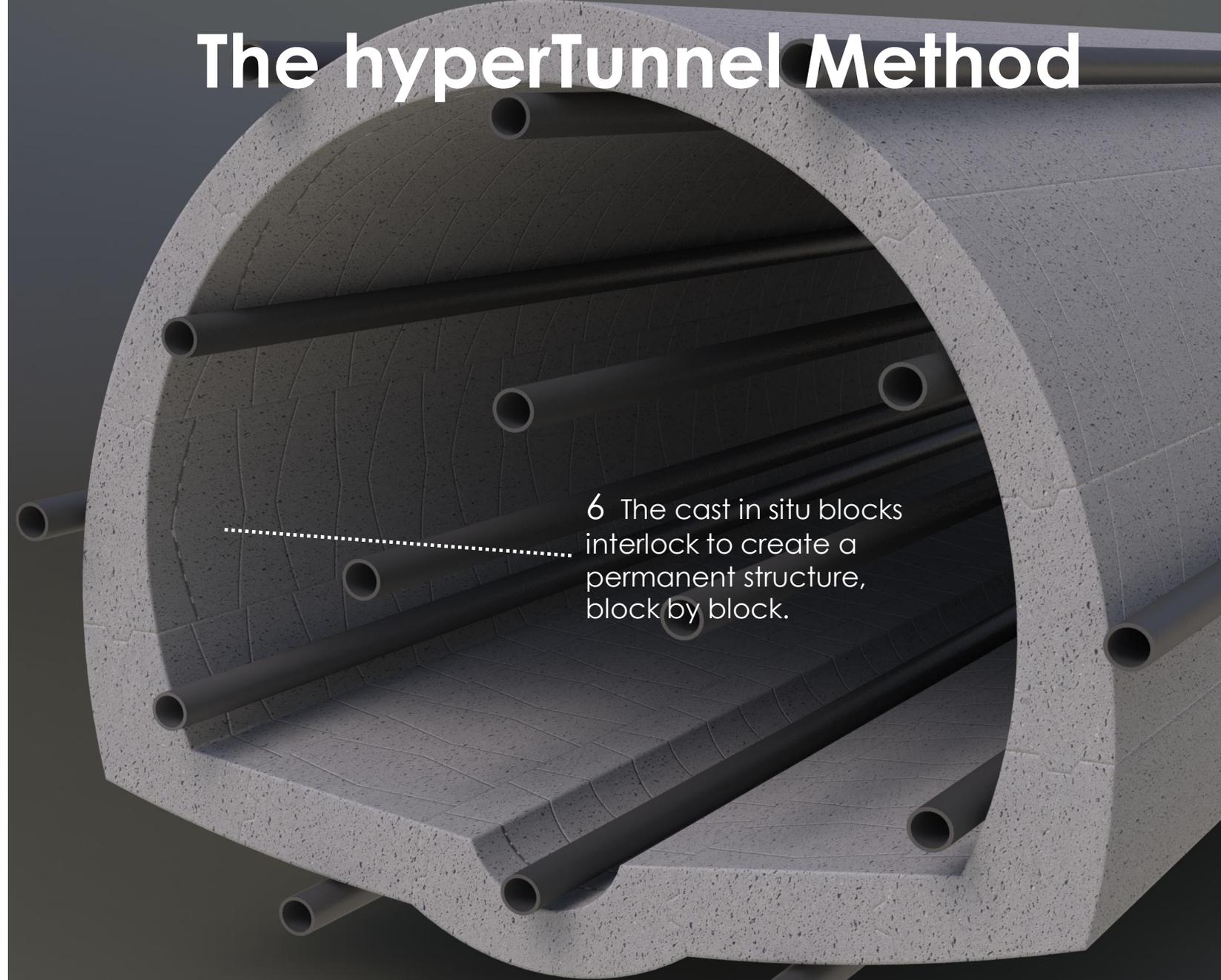
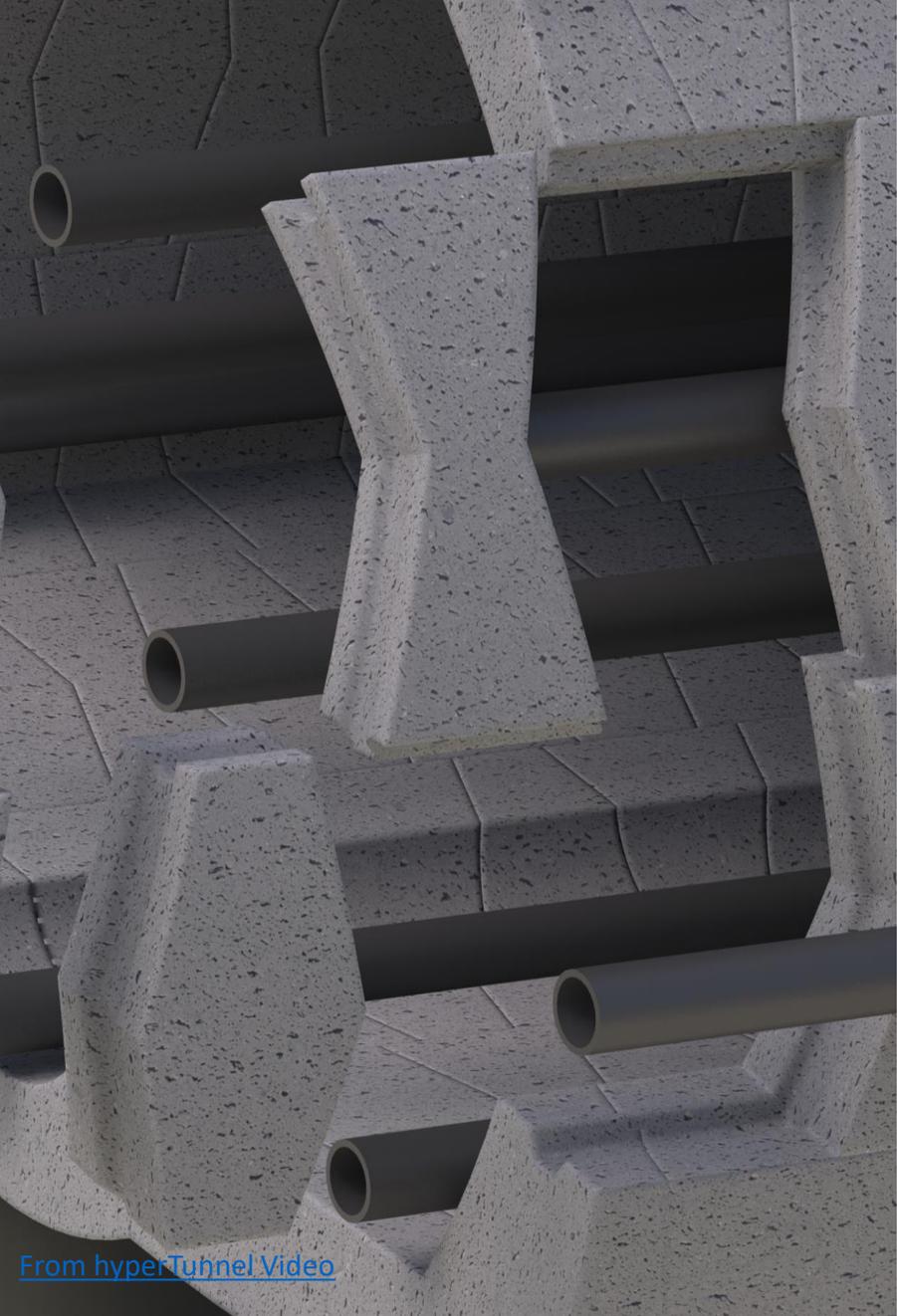


5 The 'bot carves precise chambers in the geology and these are then filled with suitable construction material.

The hyperTunnel Method

[From hyperTunnel Video](#)

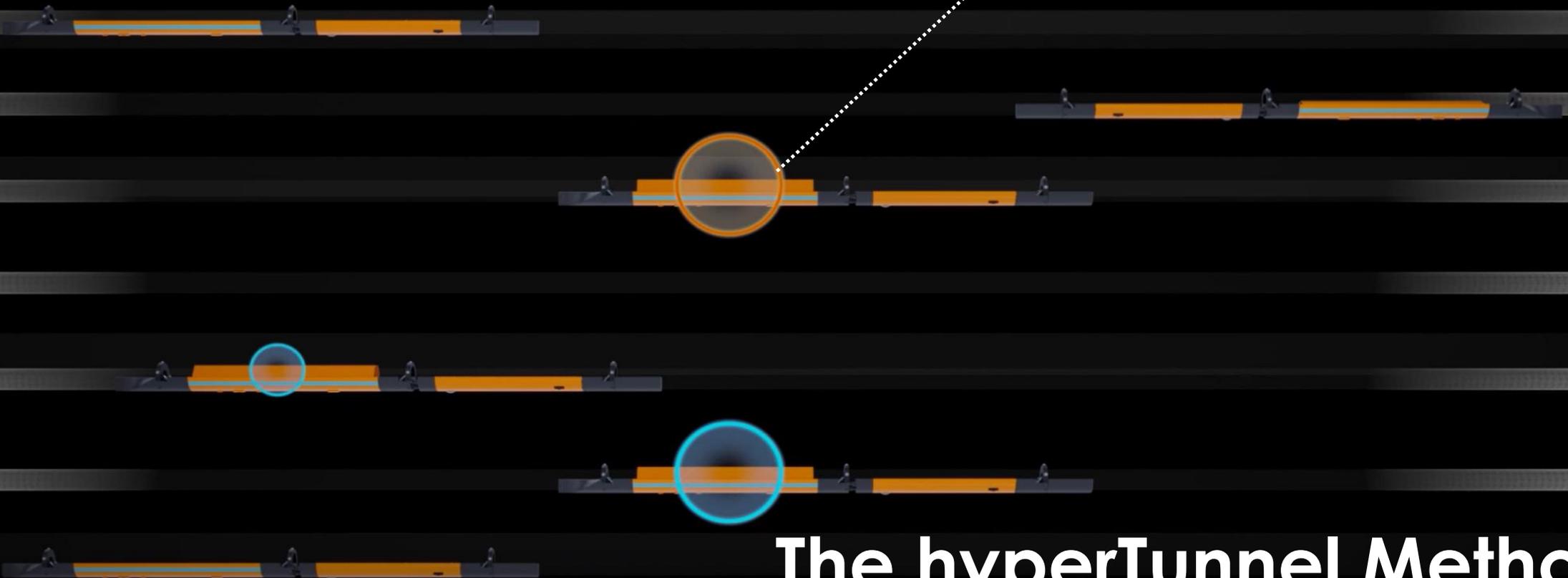
The hyperTunnel Method



6 The cast in situ blocks interlock to create a permanent structure, block by block.

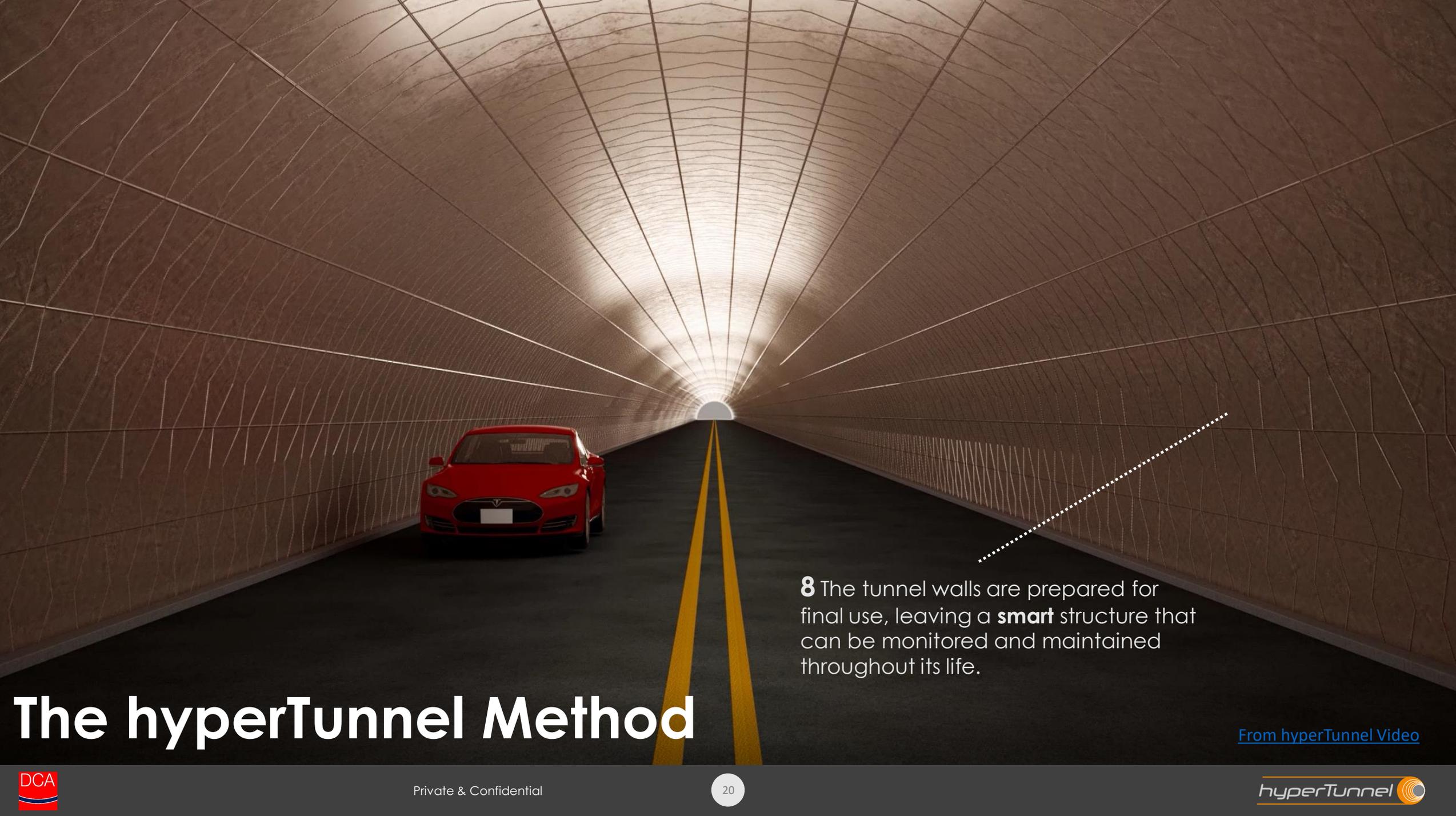
[From hyperTunnel Video](#)

7 We then inspect again with our survey bots to ensure the chemical has spread evenly and matches the digital twin design.



The hyperTunnel Method

[From hyperTunnel Video](#)

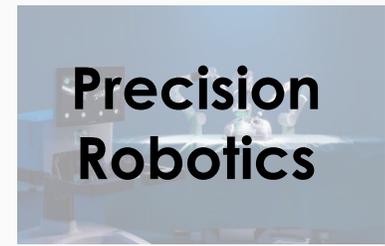
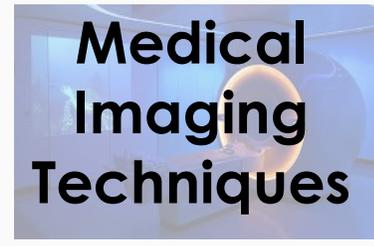
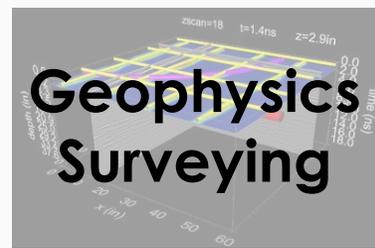
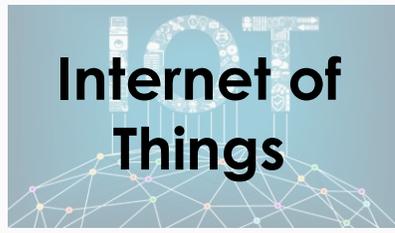


8 The tunnel walls are prepared for final use, leaving a **smart** structure that can be monitored and maintained throughout its life.

The hyperTunnel Method

[From hyperTunnel Video](#)

hyperTunnel[®] leverages existing technologies



Productivity & reliability: Swarms & bots



in nature...



in industry...

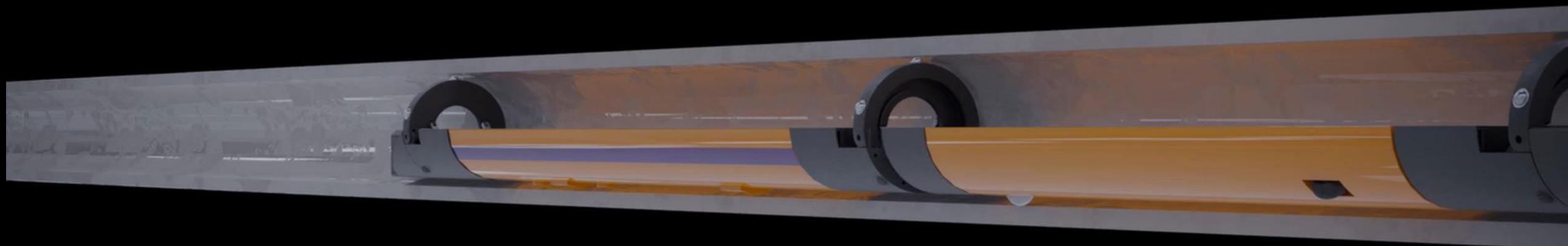


in recreation...



and in pipes

The hyperSwarm



[From hyperTunnel Video](#)



“What we do isn’t new...
but where we do it is.”

Captive bots operating on a physical grid system



Site Setup

- Build environment – install grid
- Introduce Robots to grid

Operation

- Robot is sent an address and task
- Robot navigates to the address
- Robots carry out the task
- Robots report task is complete
- Check power and location status
- Repeat cycle



<https://www.youtube.com/c/TechInsiderVideos>

Captive bots operating on a physical grid system

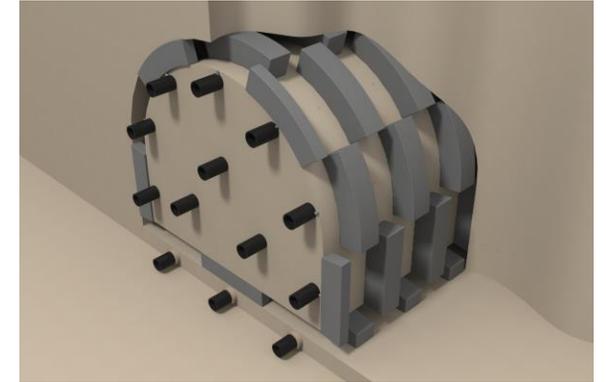
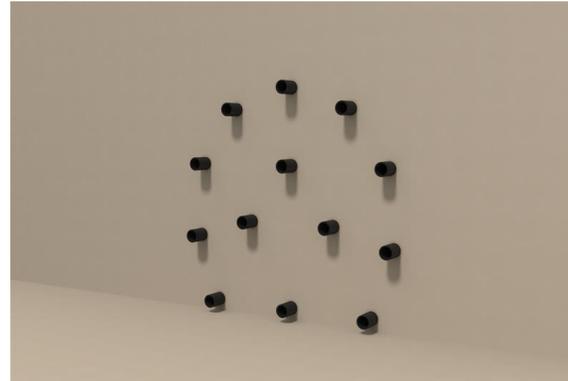


Site Setup

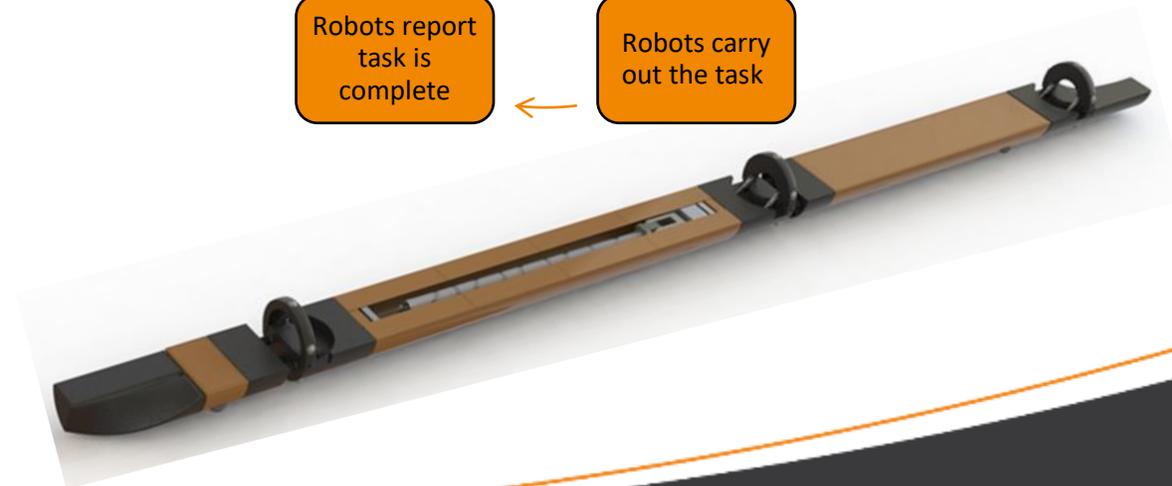
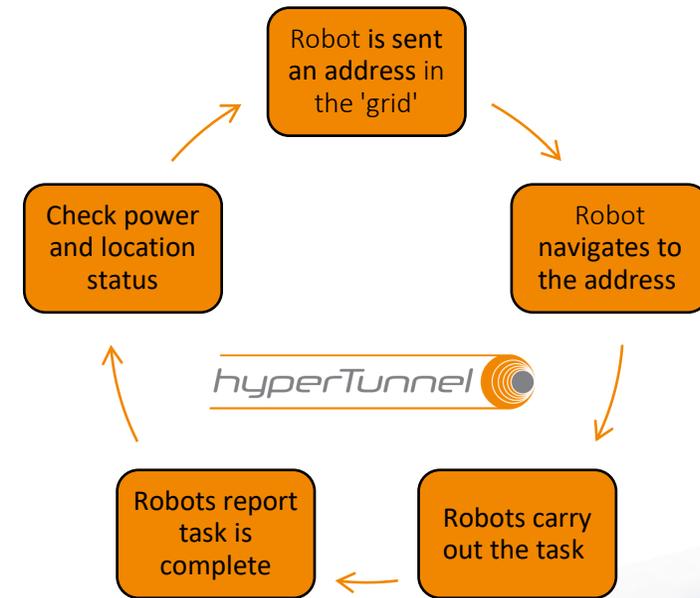
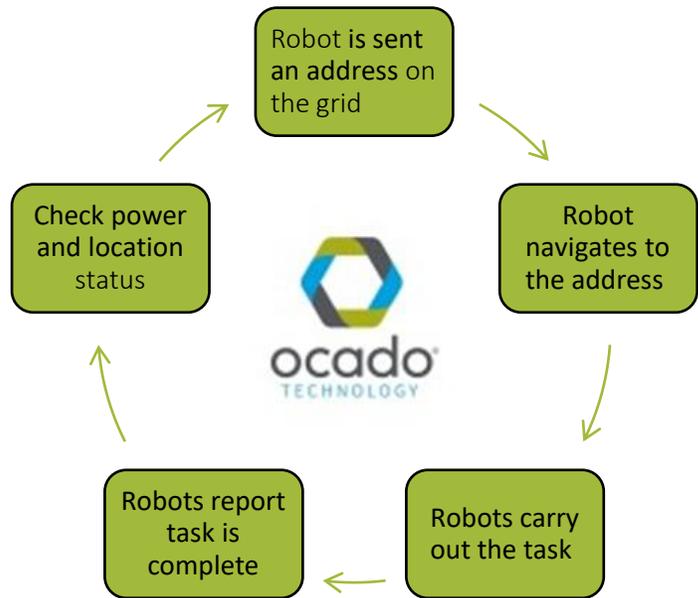
- Build environment – install grid (pipes) using HDD
- Introduce robots to grid

Operation

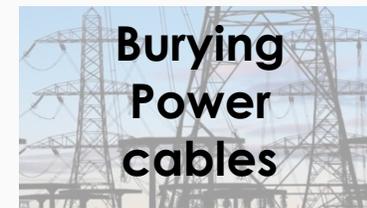
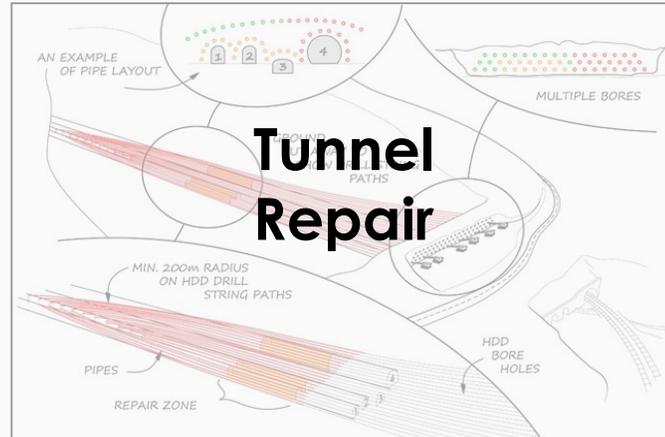
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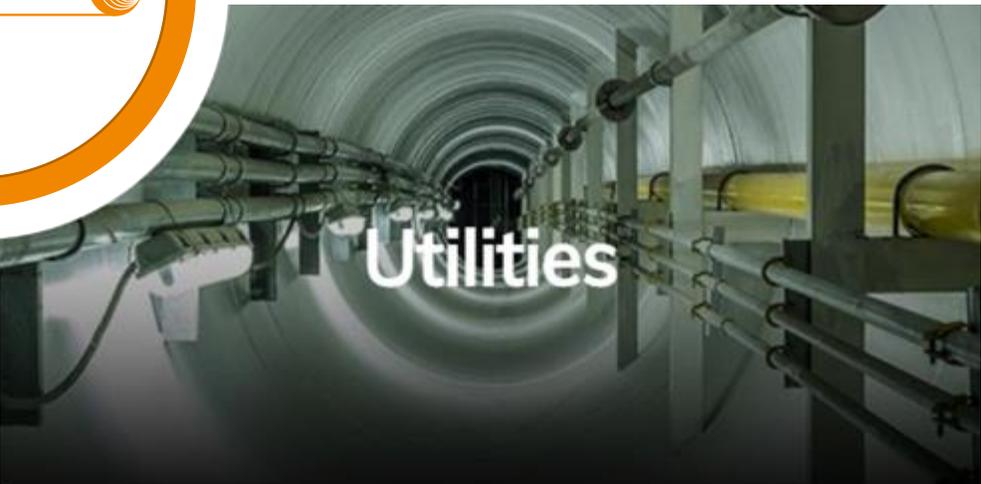
Process Comparison



hyperTunnel[®] applications



Target industry sectors



Exclusive Distribution Agreements

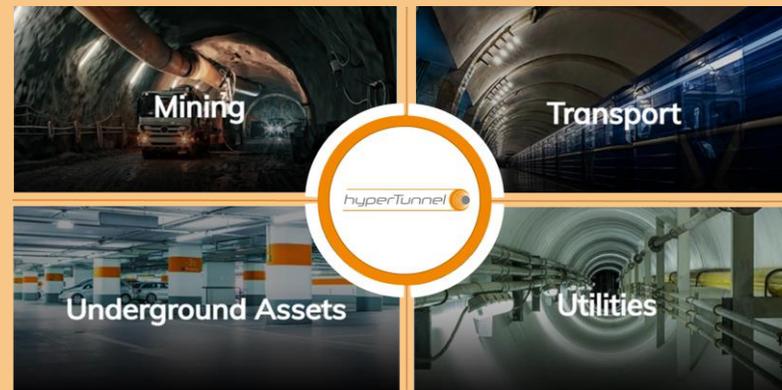
Key element of hT's GTM strategy

- Description
 - An **annual licence fee** payable monthly in advance, subject to
 - **Discounts** to reflect the level of hT Technology development and
 - Distributor spend on hT Technology and hT Consulting Service
 - **Scope exclusivity** within the relevant **sector** of each **territory**

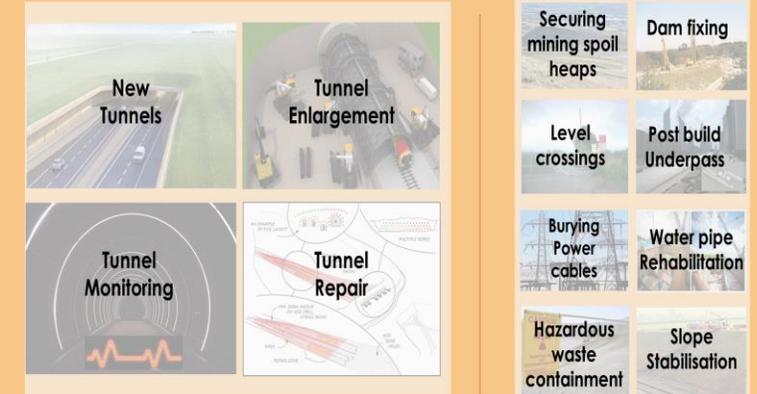
Territories



Sectors



Scope



- Distributor benefits
 - Early **low-cost bet** that secures future territories,
 - Access to the hT **distributor portal**
 - brings **cutting edge technology** to their markets
 - Creates **differentiation & competitive advantage**

- hT benefits
 - Contractor has **Skin in the game**,
 - **commitment** from contractors and forces the market to talk about hT
 - Early and consistent **revenue stream**
 - development with a customer focus

Relevance to United Nations SDG targets



By 2030 we aim for our method to have been used on >400 tunnel construction, repair and enlargement projects. This will drive our sustainable growth to become a respected, international Mid-Cap. Each project used will have had multiple impacts on UN SDGs:



- **Goal 6** 'Clean water and sanitation'; building underground provides clean water and wastewater infrastructure faster and less expensively. Manage existing underground assets, potentially including non-invasive repair contribute to targets 6.1 to 6.5. **Use on 40 water projects, each serving 5m people brings clean water and sewage to 200m**
- **Goal 7** 'Affordable and clean energy'; building tunnels faster and less expensively will allow new energy infrastructure to be built, contributing to targets 7.1 and 7.2 **Use on 40 energy projects, each serving 5m people brings clean and affordable energy to 200m people**
- **Goal 9** 'Industry, innovation and infrastructure'; Targets 9.1 and 9.4 and Goal 11 'Sustainable cities and communities'; Targets 11.2, 11.5 and 11.6. **Use on 360 transport tunnels, each serving 5m people delivers improvements to make transport faster and more sustainable to 1.8bn sooner than other tunnelling methods**
- **Goal 13** 'Climate change'; Target 13.1. **We expect to realise CO2 emissions reductions of up to 50% vs benchmark figures of 17,000t/km (8m diameter); 29,000t/km (Thames Tideway 7.2m). Use on 400 projects, 4,000km of tunnels represents a CO2e saving of 34-116mt, by reducing cement use and reducing energy expenditure by only excavating what is needed**
- **Goal 15** 'Life on land'; Target 15.5 **We expect to avoid 10Ha of above ground habitat destruction for each tunnel we build, preserving 4,000Ha of habitat, improving biodiversity**



Thank you for your time

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www.youtube.com/hyperTunnel

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hypertunnel.co.uk

With Deep Tech, the future of tunnelling is not boring...

Today

Tunnelling
fragmented

2030s

Dominated by scaled
autonomous tunnelling solutions
... Swarm Construction

...it's **hyperTunnel**[®]