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**

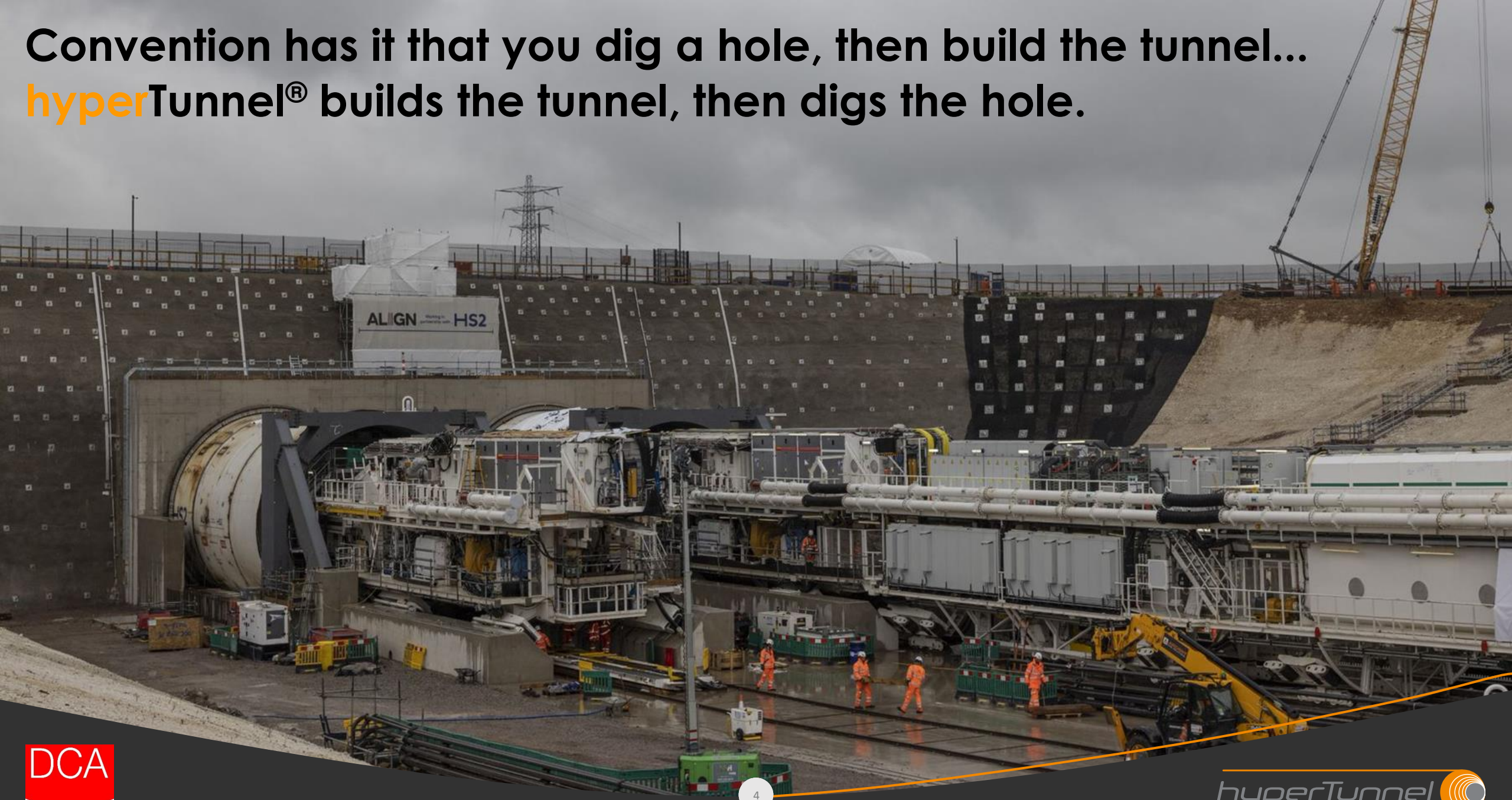
“[Tesla will] liberate the world, at last from the internal combustion engine”

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.



DCA

hyperTunnel

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

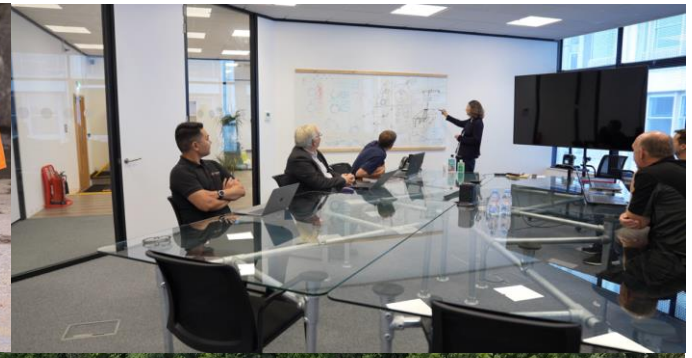
Steve Jordan
Co-CEO

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.



NetworkRail · Shell · SAB Miller · Williams · Boeing · Rolls-Royce · GE Aviation · ch2m · Arcadis · WSP · Jacobs · Arup · amec foster wheeler · Warner Bros. · Lotus F1 Team · McLaren Applied · Renault F1 Team · G4S · Smith & Williamson · Allen & Overy · Slaughter and May · Deloitte. · Cleary Gottlieb · Trafalgar Capital · Clearbrook Capital

…. 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

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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

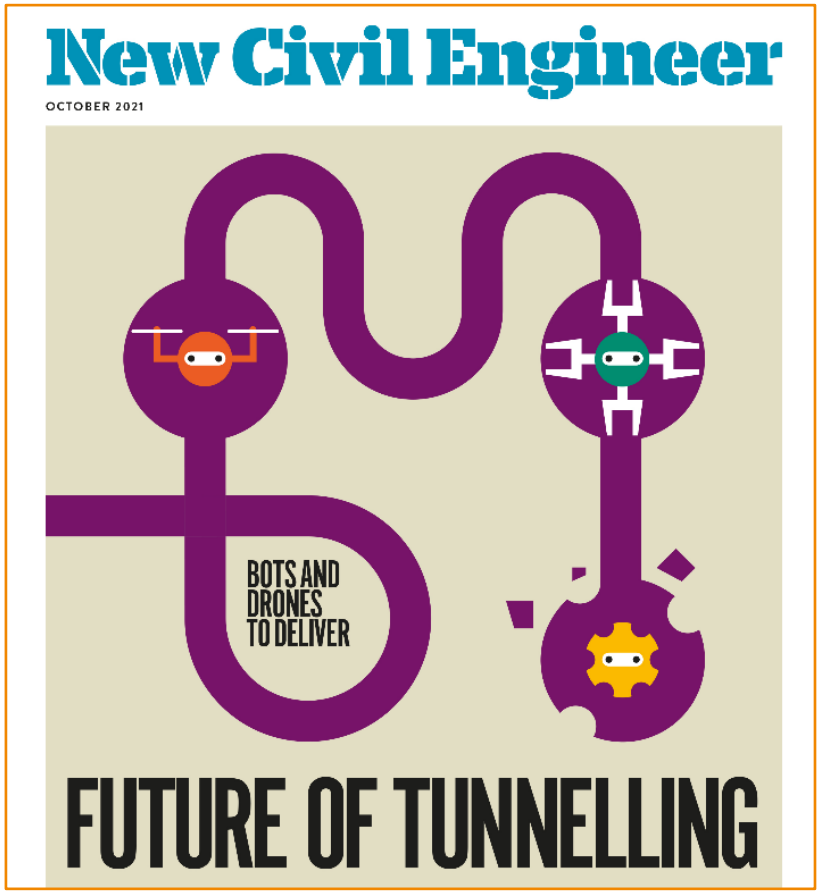
Götz Tintelnot
MBCC Group - CEO TPH Bausysteme GmbH

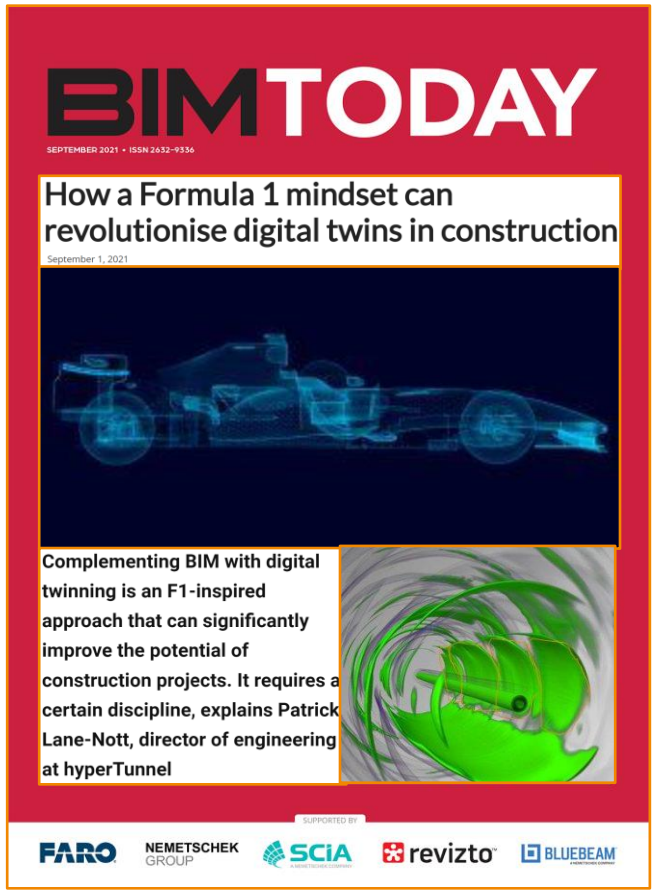
Dr Kurt Zeidler
Owner of Gall Zeidler Consultants

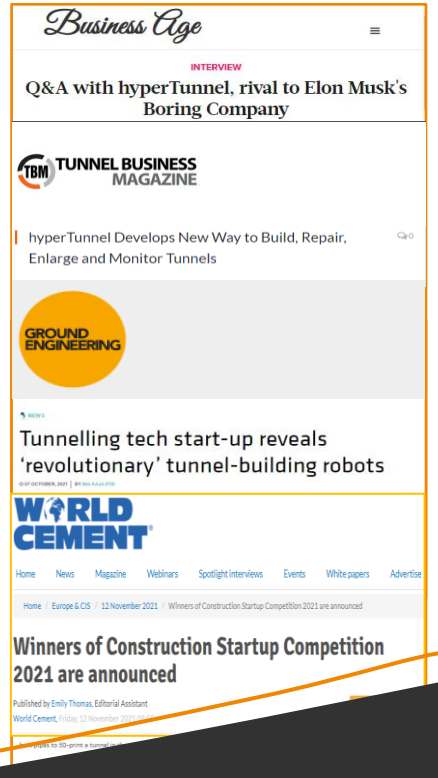
… who are contracted but unpaid, critical and challenging but supportive.

ARUP · Jacobs · HS2 · MORGAN SINDALL · MBCC GROUP · BOUYGUES · VINCI CONSTRUCTION · ch2m · Crossrail · GZ Gall Zeidler Consultants · BAUER · Stantec · MOTT MACDONALD

Positive industry response







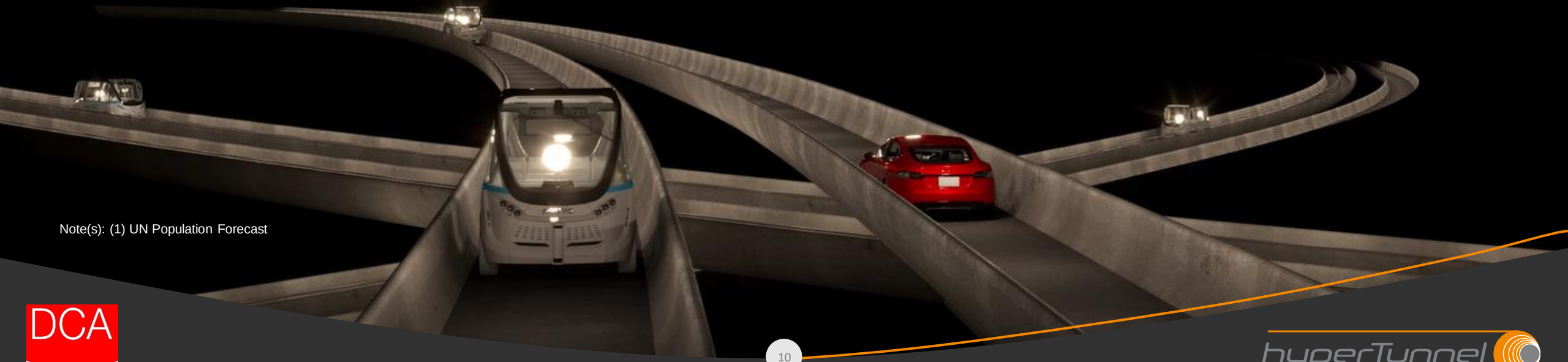
Tunnelling leader during a recent hyperTunnel site visit: **"I've seen the future of tunnelling"**

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

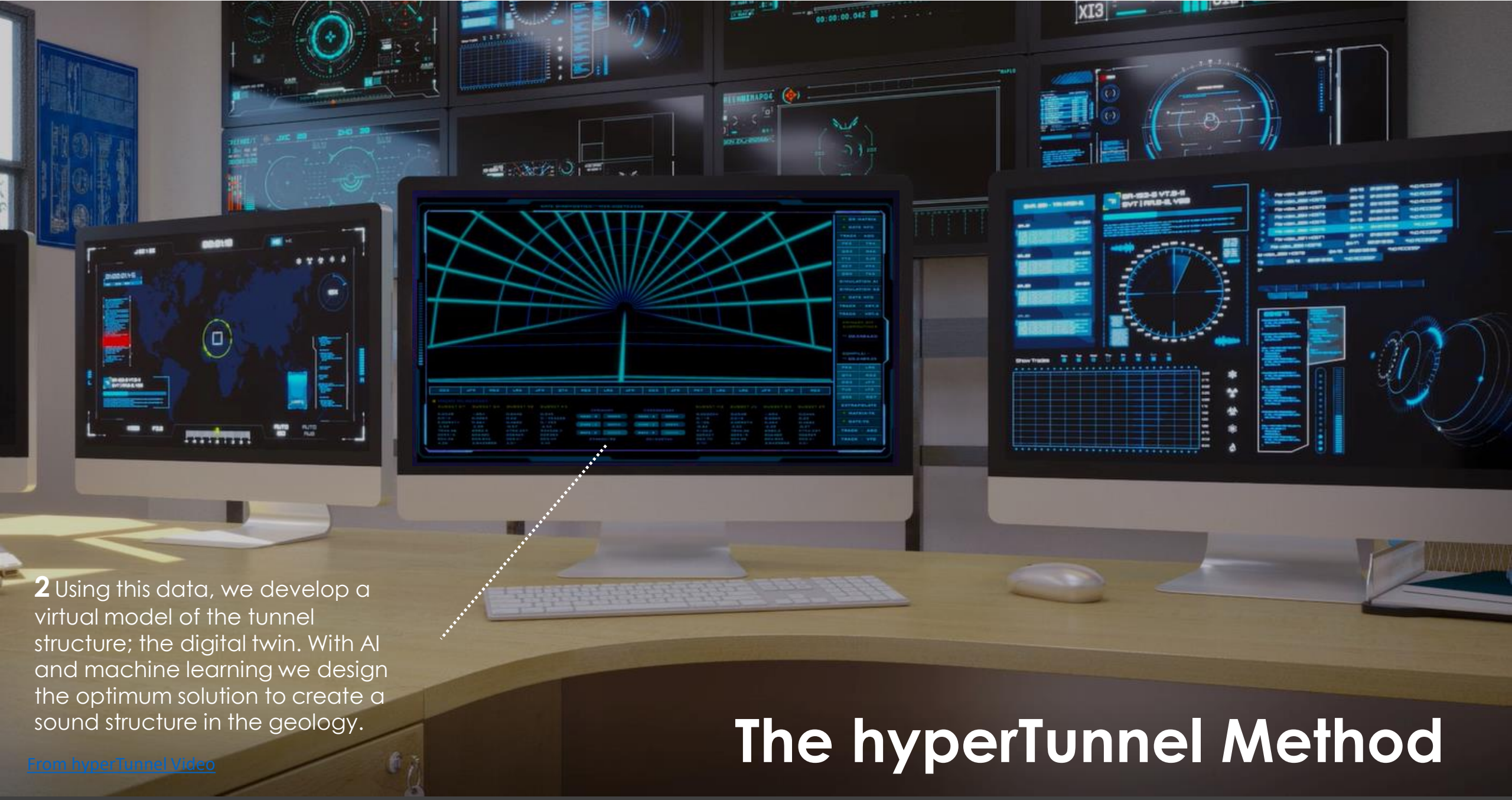
The hyperTunnel Method

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

DCA

hyperTunnel

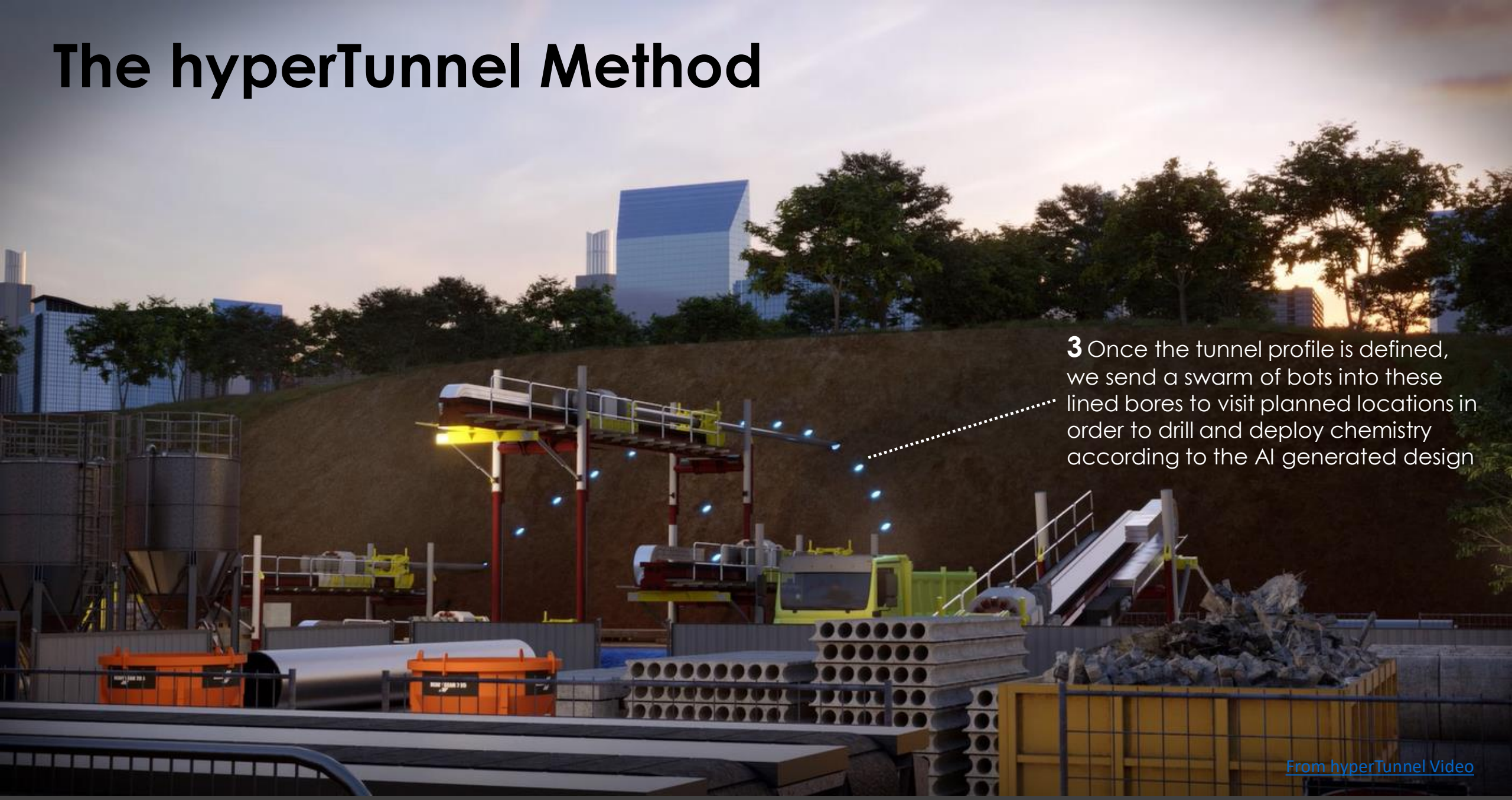


2 Using this data, we develop a virtual model of the tunnel structure; the digital twin. With AI and machine learning we design the optimum solution to create a sound structure in the geology.

From hyperTunnel Video

The hyperTunnel Method

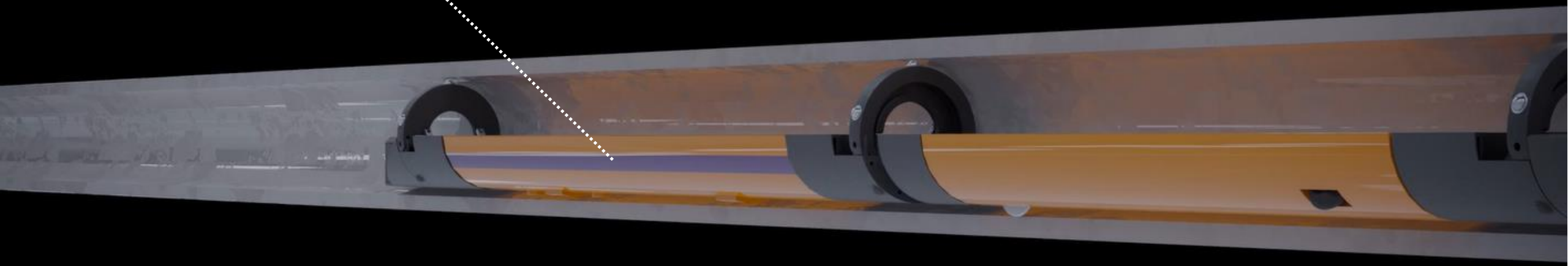
The hyperTunnel Method



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

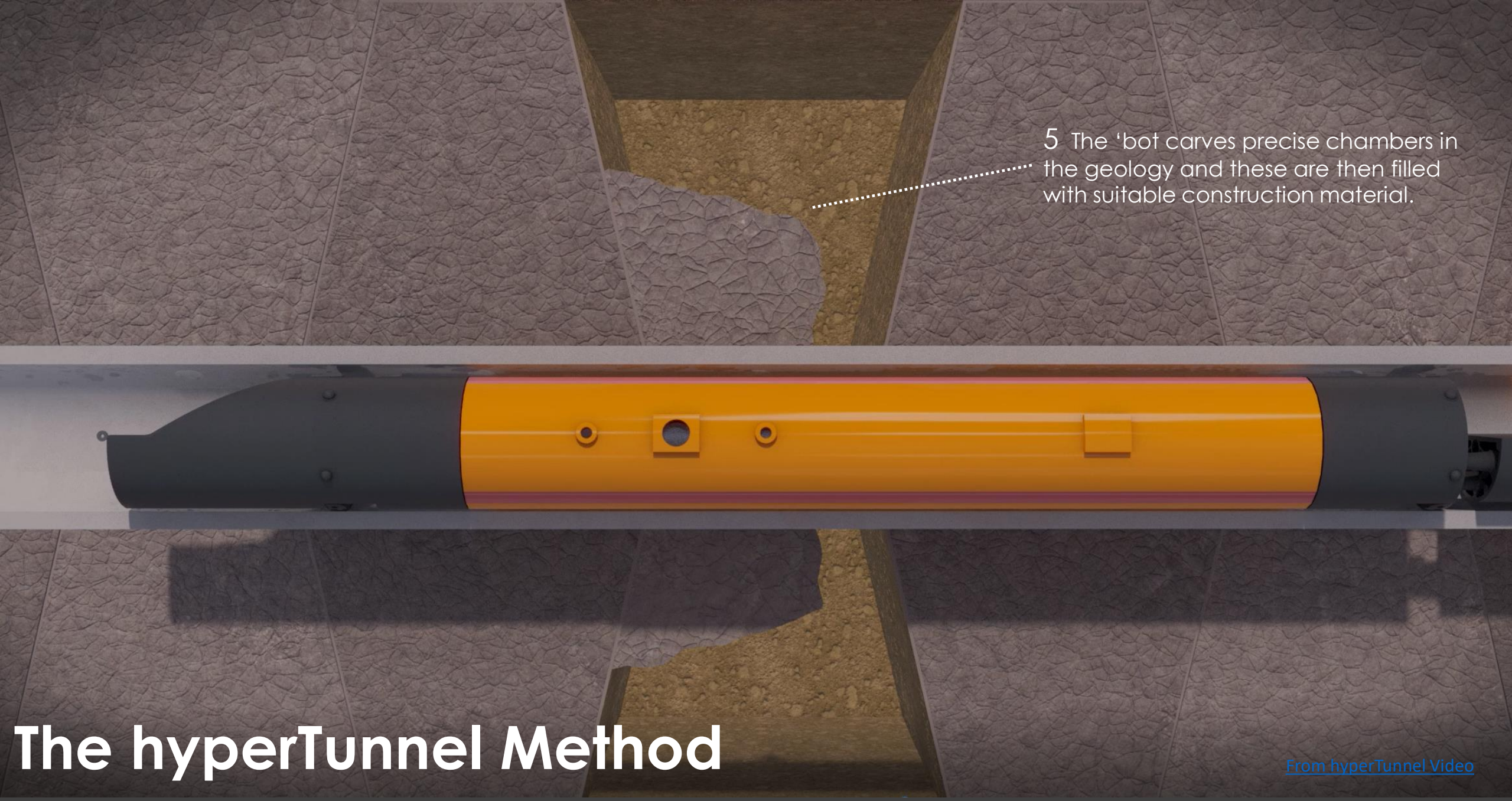
From hyperTunnel Video

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

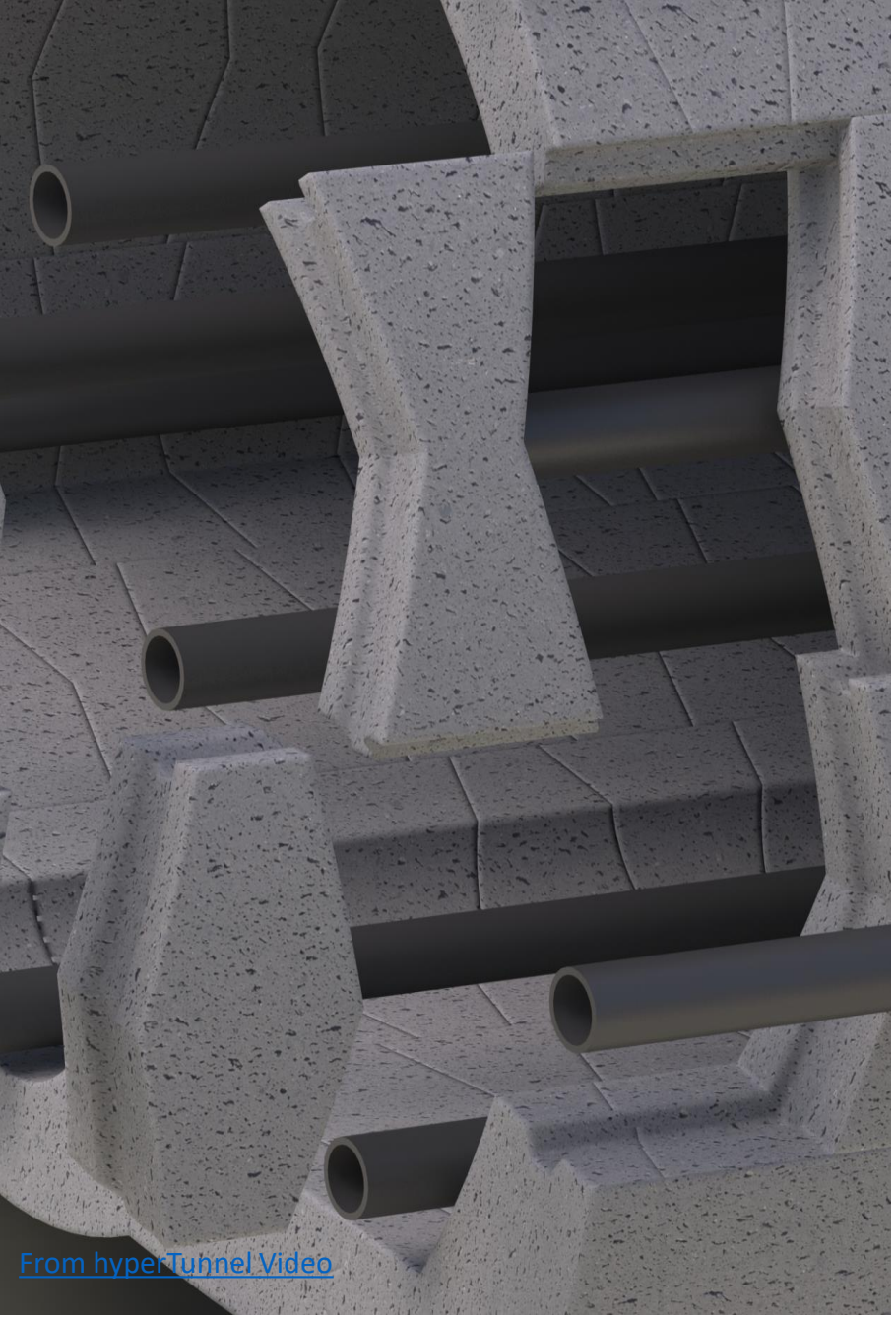
From hyperTunnel Video



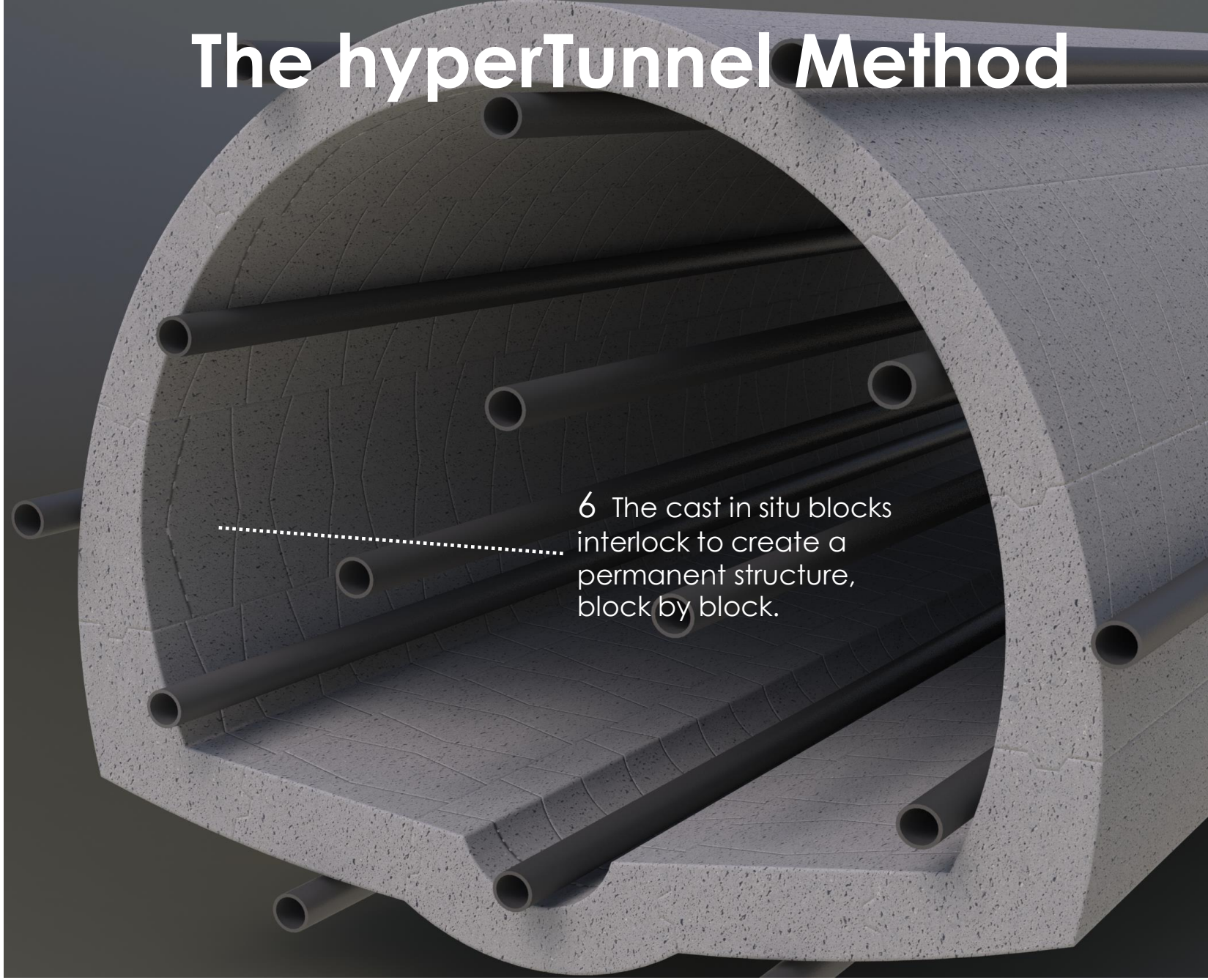
The hyperTunnel Method

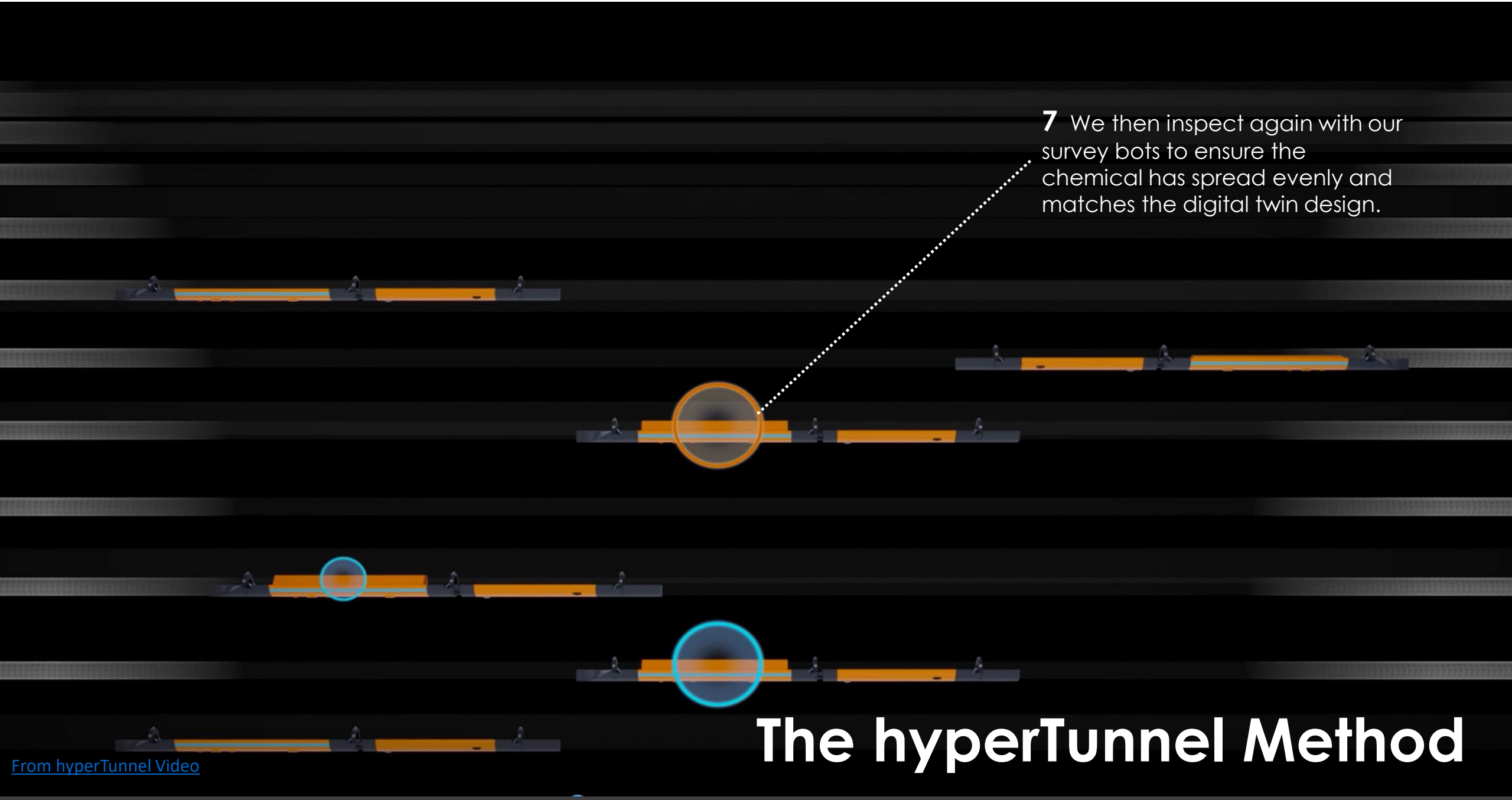
From hyperTunnel Video

The hyperTunnel Method



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

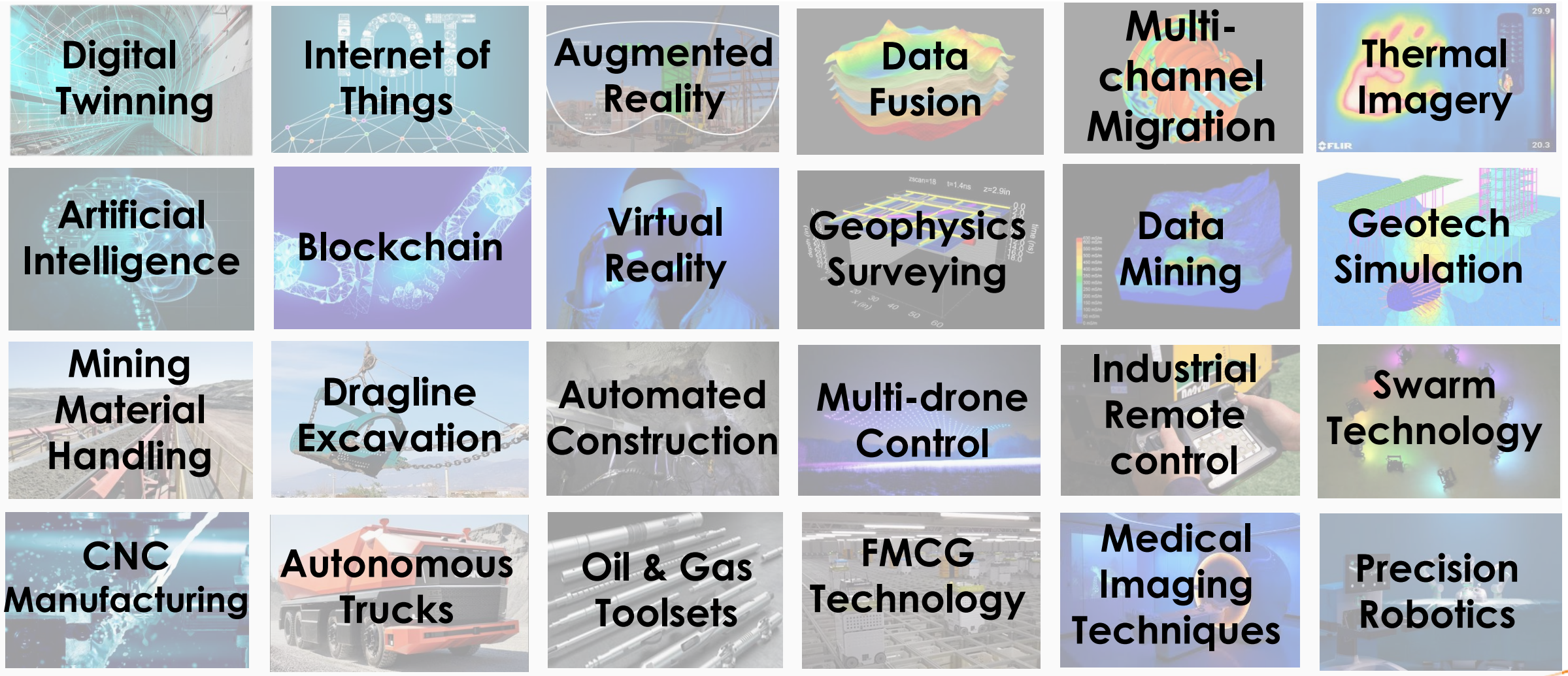
From hyperTunnel Video

The hyperTunnel Method

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

From hyperTunnel Video

hyperTunnel® leverages existing technologies



Productivity & reliability: Swarms & bots

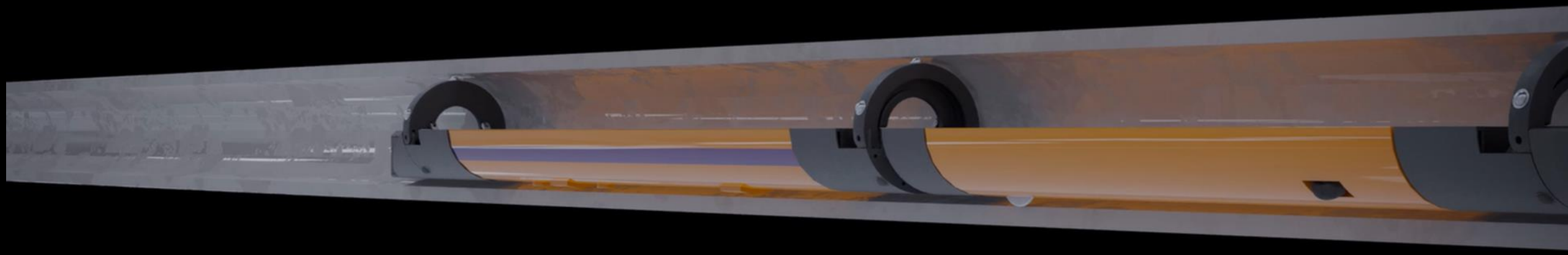
in nature…

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

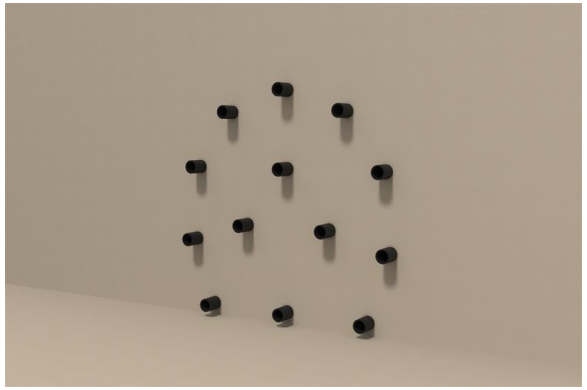
Captive bots operating on a physical grid system

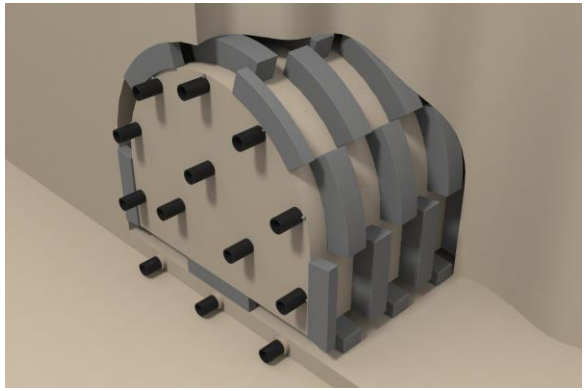
Site Setup

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

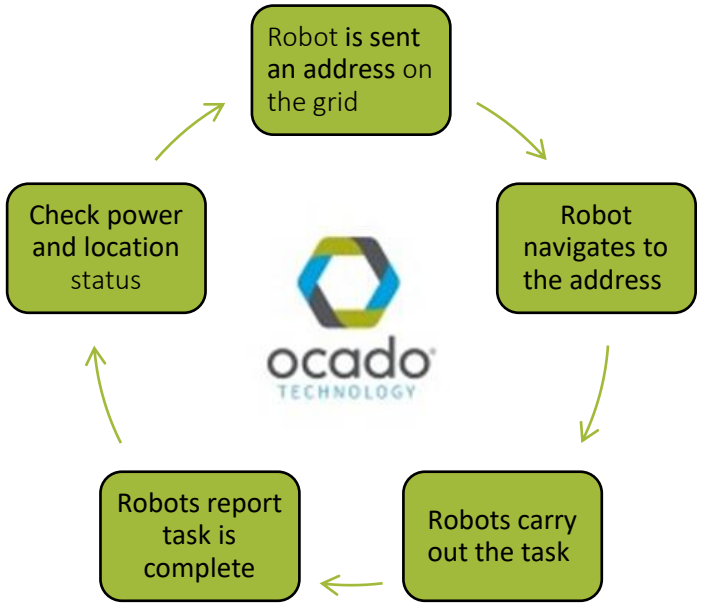
Operation

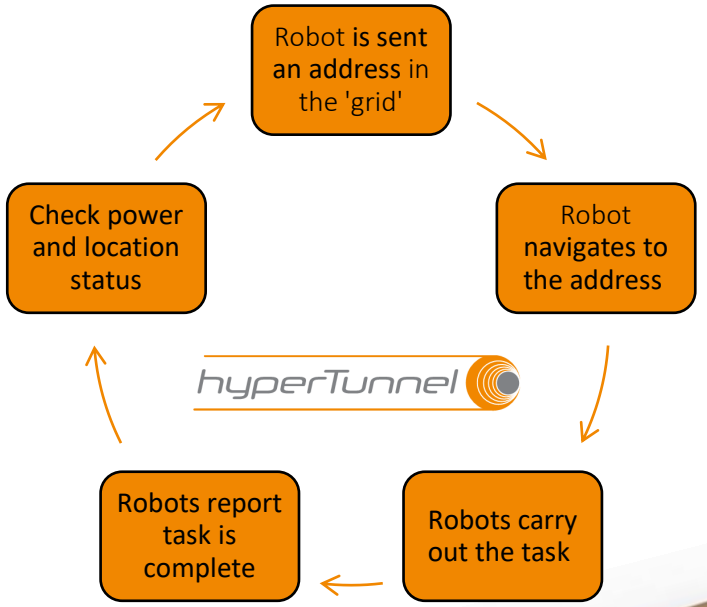
- Robot is sent an address and task
- Robot navigates to the address
- Robots carry out the task
- Robots report task is complete
- Check power and location status
- Repeat cycle

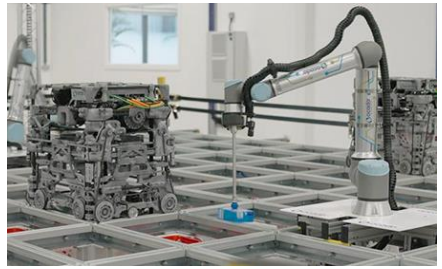


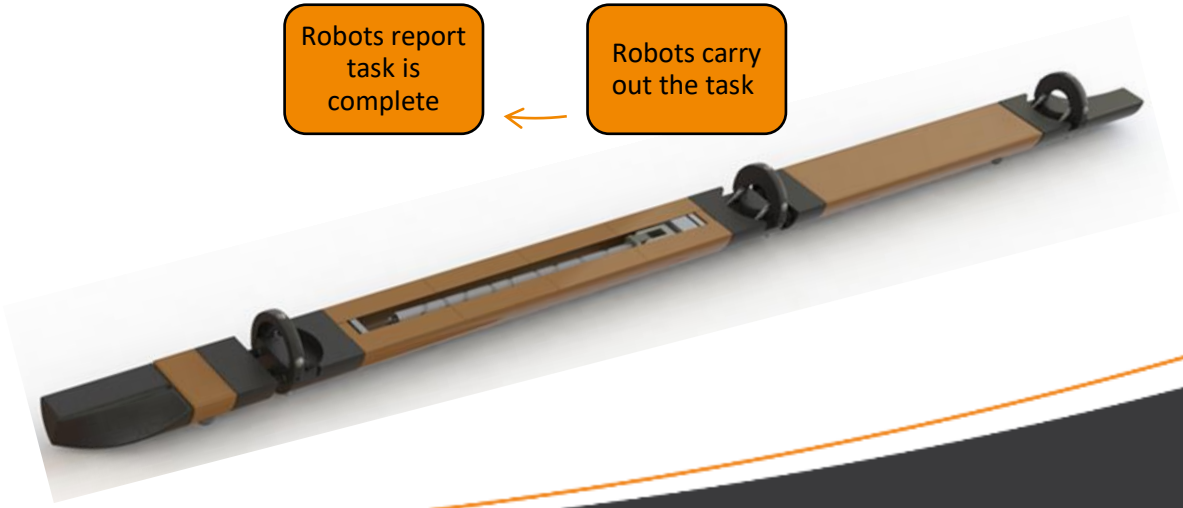


Process Comparison

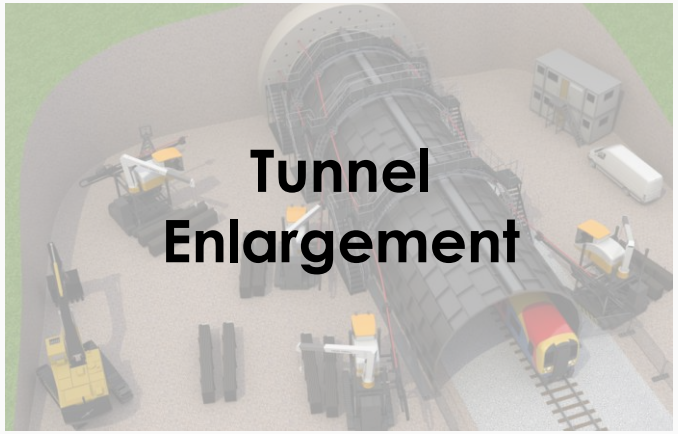


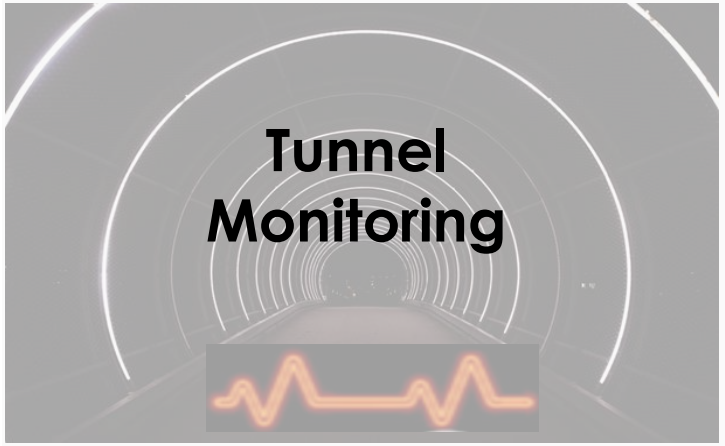


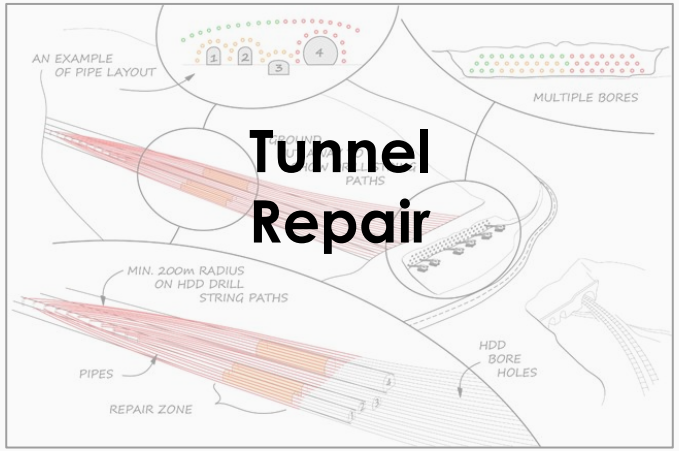


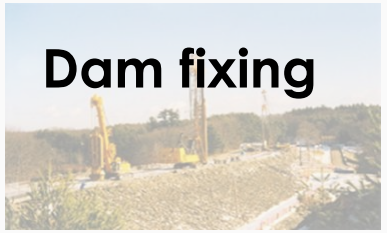


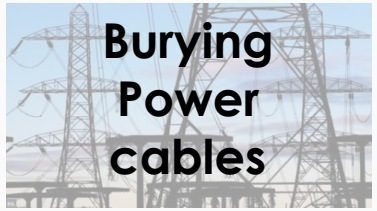
hyperTunnel® applications











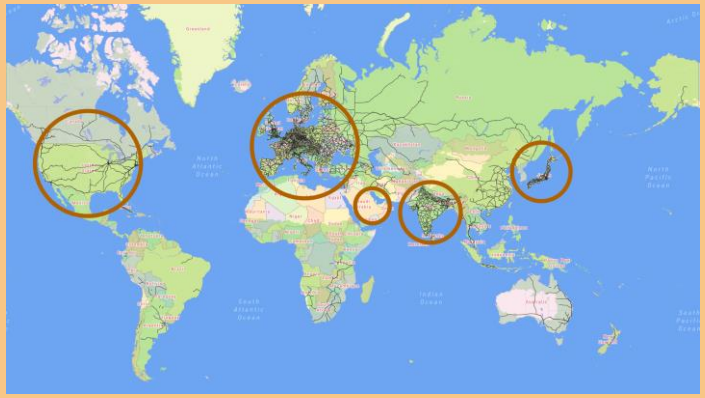
Target industry sectors

Exclusive Distribution Agreements

Key element of hT's GTM strategy

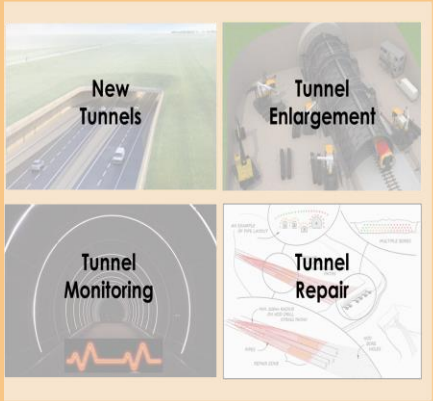
- Description
  - An **annual licence fee** payable monthly in advance, subject to
    - **Discounts** to reflect the level of hT Technology development and
    - Distributor spend on hT Technology and hT Consulting Service
  - **Scope exclusivity** within the relevant **sector** of each **territory**

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

Today	2030s
Tunnelling fragmented	Dominated by scaled autonomous tunnelling solutions … Swarm Construction

…it's hyperTunnel®