The Earthworks Tiger Team Project

Improving Innovation and Productivity In Earthworks

September 2021

Executive Summary

Between £1bn and £1.5bn is spent each year on Earthworks by infrastructure clients. Supply chain practices have been largely unchanged for decades. There is therefore considerable potential for innovation and improvements in efficiency. In mid-2020, i3P brought together a Tiger Team to look at and identify opportunities for improving efficiency in the Earthworks sector. This identified 24 opportunities which, if implemented, have the potential to save £100m–£300m per annum. This would be a 10–20% productivity improvement.

Productivity in the UK construction sector has barely improved over the past 20 years. There are a variety of reasons for this, including the different character and behaviour of the major clients in the construction sector and lack of cohesion across the supply chain. i3P has set up a programme of Tiger Team projects to take a client-led and highly collaborative approach to solving some of the efficiency challenges of the sector. The Earthworks Tiger Team Project was launched in mid-2020 and was led by Expedition Engineering with HS2 funding their work. A 'Community of Practice' (COP) of sector experts was set up by i3P and was key to both developing a thorough understanding of the current situation and the identification and evaluation of potential solutions.

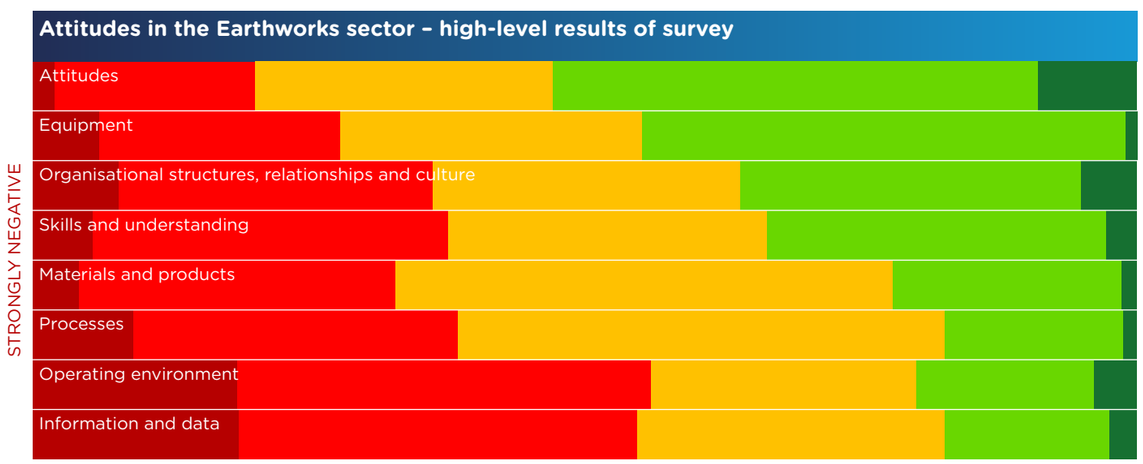
An Earthworks Sector Analysis was developed, based on a combination of desk studies, workshop discussions, interviews and an online questionnaire sent to the i3P Earthworks COP. The high-level results of the questionnaire are shown below.

The i3P Earthworks Tiger Teams Project has identified 24 opportunities with the potential to save £100m—£300m per annum.

Weather-related factors mean that Earthworks can only be carried out for around eight months of the year. Yet procurement delays regularly reduce this productive period substantially.

About i3P
Established in 2016, the Infrastructure Industry Innovation Partnership (i3P) is a community of client and supply chain organisations that have made a commitment to delivering collaborative innovation.

About Tiger Teams
Tiger Teams are groups of experts brought together to solve difficult engineering problems. They are particularly useful for the sort of complex, multi-stakeholder challenges that are found in infrastructure.



The main results of the analysis show the need for:

- Measures to address a growing skills shortage in the Earthworks sector,
- The importance of clients sending a clear 'demand signal' for innovation and in supporting R&D,
- The need to improve the way in which data is collected to support better decision-making,
- Improvements in primary plant, planning tools, soil testing, environmental protection technology and the processing of material.

The Project identified a number of innovation opportunities, grouped into six categories. These were evaluated using an initial benefits assessment based on the Five Capitals model. A preliminary cost/value assessment was carried out – and 24 opportunities (listed in the box opposite) were found to be worth developing further.

The Project also recommended organising and delivering the opportunities through four innovation programmes:

1. Market Accelerator Programme
2. Best Practice Programme
3. Skills Development Programme
4. Tiger Team Programme

The benefits of a concerted and determined innovation and improvement programme for Earthworks of this nature are expected to be in the range of £100m–300m per annum, based on a 10–20% productivity improvement.

Through its community and network, i3P will continue to champion the changes required.

Change across the Earthworks sector will only be possible with the input and support of infrastructure clients and their supply chains.

To get involved with the Earthworks Tiger Team initiative and find out how you can contribute to the opportunities identified in this report, please contact: i3pideas@ktn-uk.org

24 opportunities to improve innovation and efficiency in the Earthworks sector.

Better Data

- Utilising new surveying and testing techniques
- Mobile or pop-up labs for materials testing
- Advanced testing technology – use of real-time performance indicators in Earthworks installation
- Improving the specification of ground investigations

Better Communication

- Use of digital technology to improve communication
- Unified ground model
- Site safety and communication
- Earthworks conceptual design training

Optimising construction operations

- Reimagining Earthworks
- Earthworks plant
- Optimising the environmental regulations of Earthworks activities
- Earthworks environmental protection

Optimising design

- General skills development across the sector to address skills shortages
- Optimisation of alignment and land acquisition
- Optimal Earthworks section design
- Optimise settlements and track interfaces
- Observational design

Optimising the requirements

- Non-standard materials reuse
- Optimal use of design parameters
- Ground improvement

Changes in the delivery strategy

- Procurement for Earthworks
- Utilities collaboration
- System-wide plant procurement and allocation
- Risk management in Earthworks

The Earthworks Tiger Team Project

Driving innovation and efficiency in the Earthworks sector

Framing the challenge
Productivity in the UK construction sector has barely improved over the past 20 years.[1] The key reasons for this relate to the scale, complexity, fragmentation and variability of the construction sector. A particular challenge is the different character and behaviour of the major clients in the construction sector and lack of cohesion across the supply chain.

i3P has set up a programme of Tiger Team projects to take a client-led and highly collaborative approach to solving some of the efficiency challenges of the sector. The idea is that, by focusing on:

- Asset systems (e.g. earthworks and bridges);
- Technology types (e.g. reinforcing steel and concrete) and
- Cross-sector themes (e.g. net zero carbon)

Substantial and rapid progress can be made. i3P is working with infrastructure clients and their supply chains to embed Tiger Teams as an established methodology for 'soft-system' engineering problems – that is, where the problem definition is subjective and solutions depend on a complex interplay between human, technological and environmental factors.

Potential scale of benefits
The UK annual spend on Earthworks is of the order of £1bn–£1.5bn per annum.

Research for this Project has showed that:

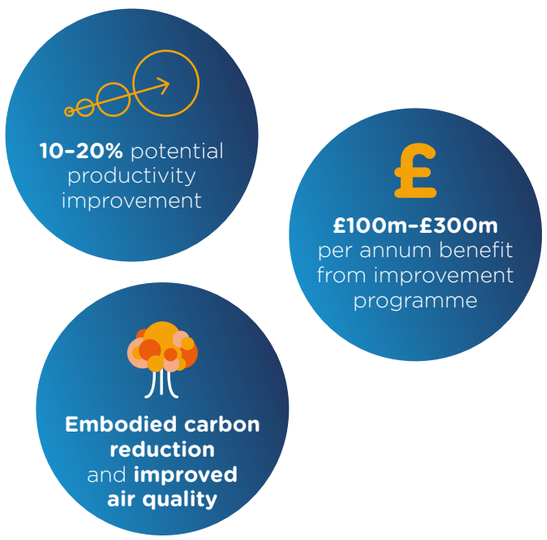
- Potential productivity improvements of 10–20% are achievable.
- The potential benefits of a concerted and determined innovation and improvement programme for Earthworks across the UK are expected to be in the range £100m–£300m per annum.
- The potential benefits in terms of embodied carbon reduction and improved air quality are of the same order of percentage change, due largely to the significance of fossil fuel in Earthworks operations. Even more could be achieved with developments in electrically-powered plant.

"Earthworks is a civil engineering process that includes extraction, loading, transport, transformation/improvement, placement and compaction of natural materials (soils, rocks), and/or secondary or recycled materials, in order to obtain stable and durable cuttings, embankments or engineered fills.

Earthworks are commonly associated with transport infrastructure, but there are many other important applications:

- Platforms for industrial, commercial and residential buildings,
- Water engineering, flood defence and coastal protection works,
- Other civil engineering projects."

Earthworks definition (source BS 6031:2009 Code of Practice for Earthworks).



1: Reinventing Construction: A route to higher productivity, McKinsey Global Institute, February 2017

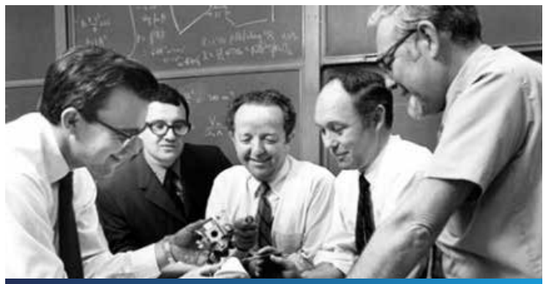
The supporting material for these productivity improvements and savings comes from a range of sources, including the following:

- An HS2 Earthworks Review (2019), which produced an estimate of 12% for the potential savings from the design, procurement and delivery of the Phase 2 Earthworks.
- Confidential work done by contractors within the HS2 supply chain, which shows a potential 27% saving on benchmark Earthworks construction costs through the adoption of digital engineering techniques.
- Get It Right Initiative (GIRI) research[2], which identifies waste due to errors in the design and construction process as falling in the range of 10–25%, with simpler operations such as Earthworks at the lower end of the range.

Establishing an Earthworks Tiger Team
The Earthworks Tiger Team Project was launched in mid-2020 and was led by Expedition Engineering, and funded by HS2. The aim was to: "identify and develop innovations that improve the efficiency in delivery and quality of outcomes associated with Earthworks, working collaboratively with the wider i3P community to share experiences and learning".

As with all Tiger Team studies, the Earthworks Tiger Team Project followed a three-stage methodology, based around discovery, development and delivery. This last stage is particularly important as it is intended that the output should lead to improvements that can be executed across the sector as a whole and provide substantial, large-scale benefits.

An important part of the Tiger Team methodology is the extensive collaboration with relevant clients and members of the supply chain. This is done through the creation of a Community of Practice (COP) – that is, a group of experts and practitioners to guide, support and challenge the direction, analysis and conclusions of the project. The Earthworks COP was made up of individuals from 27 organisations (clients, asset owners, policy makers, consultants and regulators).



The term 'Tiger Team' was made famous by NASA. During the Apollo 13 mission, NASA formed a select technical team tasked with solving the issues and bringing the astronauts safely home. This Tiger Team was awarded the Presidential Medal of Freedom for their problem-solving skills.

Today, a Tiger Team is taken to be a specialised, cross-functional team brought together to solve or investigate a specific problem or critical issue.

Tiger Team projects follow a three-stage methodology:

Part 1: Discovery

Frame the challenge and potential solutions and confirm the overall TT business case

Part 2: Development

Develop and evaluate a comprehensive suite of systemic solutions

Part 3: Delivery

Develop and deliver individual solutions

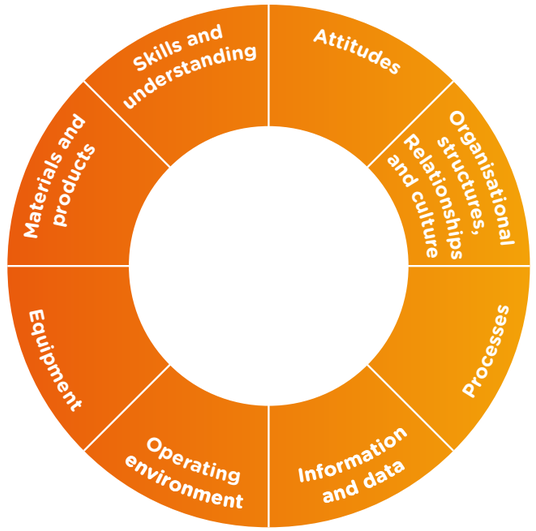
2: A Strategy for Change, Get it Right Initiative (GIRI), June 2019.

Earthworks Sector Analysis
A key activity within the Project was to undertake a comprehensive Earthworks Sector Analysis. This was done using a 'socio-technical system' approach, which allows the consideration of complex situations where there are divergent views about the definition of the problem.

A Maturity Framework was developed, based on a review of the specific processes, human factors, organisational structures and external circumstances relevant to the Earthworks sector.

A questionnaire was developed, based on the Maturity Framework, to explore sector performance against these themes. The aim was to obtain responses that would provide insight into the areas that needed innovation.

The questionnaire was issued to the Earthworks COP and the responses are shown in the graphs that follow.



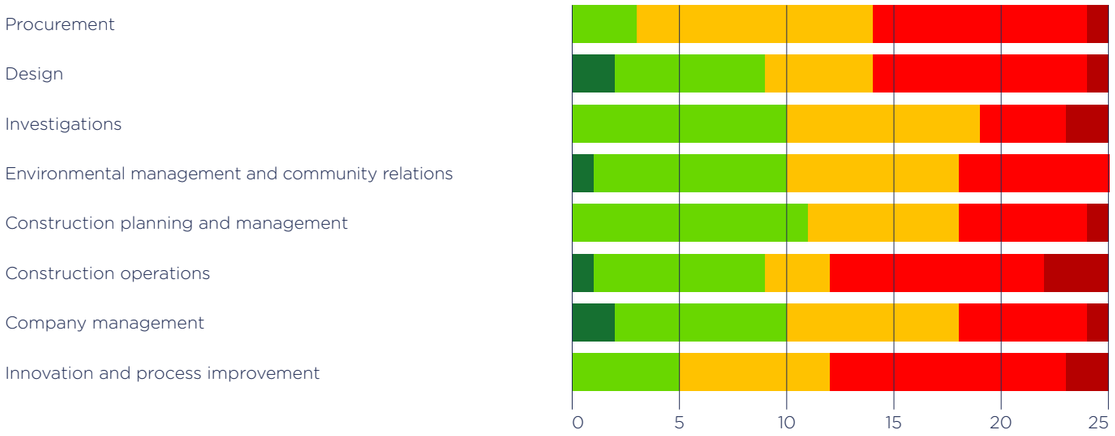
Results of the Earthworks Maturity Framework Questionnaire

The questionnaire was sent to 40 participants from a diverse set of organisational backgrounds across the COP.

There were 25 respondents who specified their level of agreement or disagreement on a symmetrical agree-disagree (five-point Likert-type) scale for a series of statements.

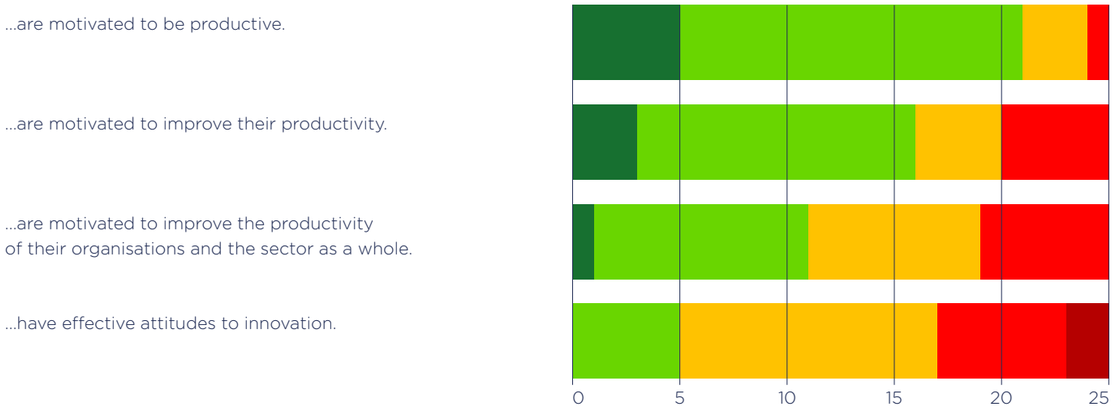
Statement 1: Skills and understanding

The Earthworks sector has enough people adequately skilled in the areas listed in the bar chart below to ensure the sector can maintain current levels of productivity.

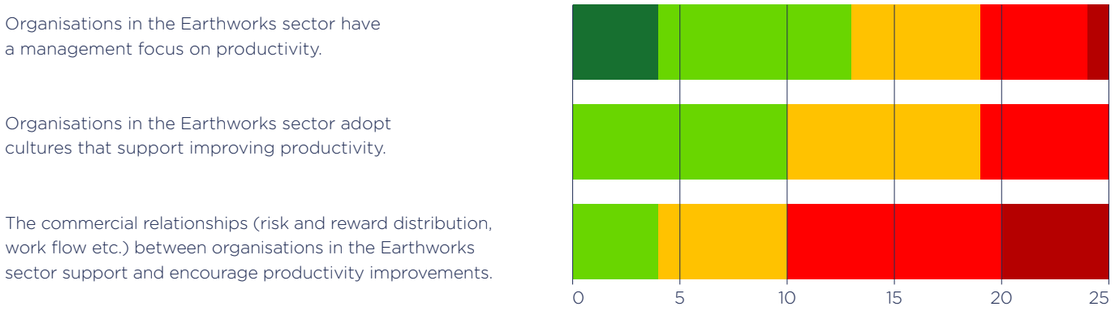


Statement 2: Attitudes

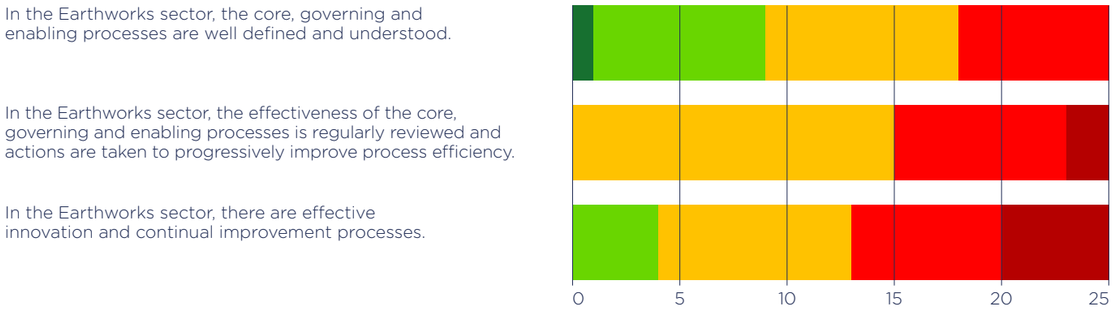
Individuals in the Earthworks sector...



Statement 3: Organisational structures, relationships and culture



Statement 4: Processes



The following definitions were provided above the question:

- Core processes include extraction, transport, storage, processing, placement, disposal and associated activities (e.g. constructing retaining walls, soil nailing, blasting etc.)
- Governing processes include project and risk management, quality assurance, regulatory and contractual approval etc.
- Enabling processes include procurement, training, recruitment, welfare provision, innovation management, continual improvement etc.

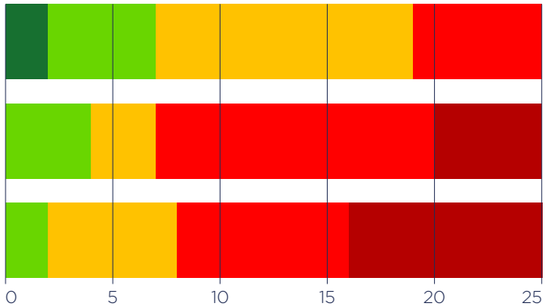
Strongly agree | Agree | Neutral | Disagree | Strongly disagree

Statement 5: Information and Data

In the Earthworks sector, general practice guidance, technical standards etc. are adequate to enable productivity to be maintained and improved.

In the Earthworks sector, systems and processes related to project specific information and data are effective, allowing efficient and reliable decision making at all stages of the project.

In the Earthworks sector, there is an effective exchange of information about innovations from within the sector and from other relevant sectors.



Statement 6: Operating Environment

In the Earthworks sector, general practice guidance, technical standards etc. are adequate to enable productivity to be maintained and improved.

In the Earthworks sector, there is no room for improvement in controlling the primary operating environment.

In the Earthworks sector, working environments support innovation and productivity improvement.

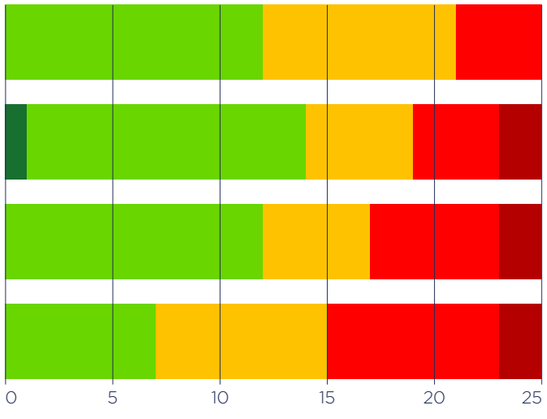
Statement 7: Equipment

In the Earthworks sector, **primary plant*** are continually developed and deployed to improve productivity.

In the Earthworks sector, surveying, monitoring and testing technologies are continually developed and deployed to improve productivity.

In the Earthworks sector, **design and planning technologies*** are continually developed and deployed to improve productivity.

In the Earthworks sector, **environmental management and protection technologies*** are continually developed and deployed to improve effectiveness and productivity.



* **Primary plant:** Excavators, Articulated dump trucks, compacting rollers
* **Design & planning technologies:** Data management, design & analysis and operational planning software etc. and the associated hardware
* **Environmental management & protection technologies:** Dust suppression, acoustic isolation, water protection etc.

Statement 8: Materials and Products

In the Earthworks sector, the **key materials*** are obtained, processed, transported, stored, used or disposed of efficiently and effectively.

In the Earthworks sector, enough is done to improve productivity in relation to the way that the **key materials*** are obtained, processed, transported, stored, used or disposed of.

In the Earthworks sector, technologies used to test and classify **key materials*** are efficient and effective.

In the Earthworks sector, enough is done to improve technologies used to test and classify **key materials*** and ensure their adoption.

In the Earthworks sector, **products*** are used productively.

In the Earthworks sector, enough is done to improve **products*** and ensure their adoption.

* **Key materials:** Soils, rocks, water, cement
* **Products:** Geotextiles, soil nails, retaining wall systems, drainage components

The main results of the analysis show the need for:

- Measures to address a growing skills shortage in the Earthworks sector, as a generation of experienced practitioners is retiring without replacement;
- Changes in attitudes towards innovation;
- The importance of clients sending a clear ‘demand signal’ for innovation and in supporting R&D;
- The need to improve the way in which data is collected to support better decision-making;
- Additional ways to improve the visibility and adoption of best practice; and
- Improvements in primary plant, planning tools, soil testing, environmental protection technology and the processing of material.

Identifying and evaluating innovation opportunities

Part 1 (Discovery) of the Tiger Team Project identified a number of innovation opportunities, grouped into six categories. These were developed, discussed and evaluated during Phases 2 and 3 (Development and Delivery). This was done through discussion with the COP working groups (WGs) and evaluation using an initial benefits assessment based on the Five Capitals model[3]. The individual benefits linked to each type of capital are set out below.

Type of capital	Definition	Benefits assessed
Natural capital	The natural environment, natural resources and the ecological services provided.	• Air quality • Land quality • Water quality • Biodiversity
Social capital	Societal groups, communities, schools, businesses, voluntary organisations etc.	• Community – citizens • Community enterprise • Equality • Sourcing
Human capital	The individual health, skills and motivation required for a productive economy.	• Safety & security • Employment • Skills & training • Mental & physical wellbeing
Manufactured capital	Materials and goods/ assets that are required to input to the process.	• Carbon & GHG • Resource use • Production • Productivity • Reliability
Financial capital	Traditional economic measure of value which is intrinsically linked to natural, social and manufactured capital.	• Capital cost • Operational cost • Economic benefits • Revenue

Key		
Development cost	£ ££ £££	= £100k – £1m = £1m – £10m = £10m+
Expected value (p/a)	££ £££ ££££	=£1m – £10m =£10m – £100m = £100m+
Positive impact in a five capitals benefit	+	
Negative impact in a five capitals benefit	–	

3: Measures for Successful Outcomes: the five capitals approach: Association for Consultancy and Engineering (ACE) (April 2020)

List of opportunities identified by the Project and worth developing further

Number	Opportunity title	Difficulty	Development cost	Expected value	Time frame	Natural capital	Social capital	Human capital	Manufactured capital	Financial capital
WG1 Improving decision-making through better data (quality and management)										
WG1.1	Utilising new surveying and testing techniques	Easy	£	£££	2–5 years	+	+	++	++	+
WG1.2	Mobile or pop-up site labs	Easy	£	£££	2–5 years	+	+	++	++	+
WG1.3	Advanced testing technologies – real-time performance indicators in installation	Medium	£	£££	2–5 years	+	+	+	+++++	+
WG1.4	Improving the specification of ground investigations	Medium	£	££	2–5 years	+	+		+++++	+
WG2 Improving efficiency and effectiveness through better communication										
WG2.1	Use of digital technology to improve communication	Medium	£	£££	2–5 years		+	+ +	++	+
WG2.2	Unified ground model	Medium	£	£££	2–5 years			+	++++	
WG2.3	Site safety and communication	Easy	£	££	2–5 years			+++	++	–
WG2.4	Earthworks conceptual design training	Medium	£	£££	2–5 years			++	+++	+
WG3 Improving outputs and outcomes by optimising construction operations										
WG3.1	Reimagining Earthworks	Very hard	£	££££	2–5 years	?	?	?	?	?
WG3.2	Earthworks plant	Medium	££	££££	2–5 years	++	+	+	+++	++
WG3.3	Optimising the environmental regulation of Earthworks activities	Hard	£	££££	2–5 years	++++	+	+	++++	+
WG3.4	Earthworks environmental protection	Medium	£	££££	2–5 years	++++	+	+	++	
WG4 Improving value by optimising design										
WG4.1	General skills development across sector to address skills shortage	Medium	£	££££	2–5 years			++++	+++	+
WG4.2	Optimisation of alignment and land acquisition	Hard	£	££££	2–5 years	+++	+ +	++++	++++	+++
WG4.3	Optimal Earthworks section design	Medium	£	££	2–5 years	+		++	++	+
WG4.4	Optimise settlements and track interfaces	Medium	£	£££	1 year	+		++	++	+
WG4.5	Observational design	Medium	£	££	2–5 years	++++	+	++	+++++	–
WG5 Improving value by optimising the requirements (technical specifications, standards etc.)										
WG5.1	Non-standard materials reuse	Medium	£	£££	2–5 years	+	+	+	+++	+
WG5.1A	Best practice guidance for reuse – excavated coal measures	Very hard	££	£££	2–5 years	+	+	+	+++	+
WG5.1B	Non-standard materials reuse – tunnel spoil	Very hard	£££	£££	10 years +		+	+	++	
WG5.2	Optimal use of design parameters	Medium	£	£££	2–5 years			++	+	
WG5.3	Ground improvement	Medium	£	£££	2–5 years		+	+	++++	+
WG6 Improving value through changes in the delivery strategy										
WG6.1	Procurement for Earthworks	Medium	£	£££	2–5 years		+	++	+++++	++++
WG6.2	Utilities collaboration	Medium	£	£££	2–5 years			+ +	+++	++
WG6.3	System-wide plant procurement and allocation	Very hard	£	£££	2–5 years			+	+++++	+
WG6.4	Risk management in Earthworks	Medium	£	£££	2–5 years	++++		+	+++++	++++

Developing and reviewing opportunities
Community of Practice members were invited to join working groups looking at one or more thematic areas identified in Part 1 of the Project Each working group participated in either two or three facilitated online workshops to:

- Explore problems and root causes associated with their thematic areas to inform the sector analysis;
- Review the opportunities developed in Part 1 of the Project and generate new ones;
- Develop and evaluate the opportunities;
- Comment on the sector analysis; and
- Review the potential for investment.

Several working group members were also consulted on a one-to-one basis and provided additional information and insights. We also made preliminary assessments of the range of costs and benefits, required time frames and barriers to implementation for each of the opportunities.

Feedback from the COP has been very positive with many commenting on the quality of the discussion and value of having an open dialogue with such a diverse group of interested parties. The online approach made the workshops relatively accessible even for very senior professionals. The small group sizes enabled good levels of participation and engagement.

More detail about the 24 opportunities developed by the working groups is given in the boxes to the right. (Opportunity WG5.1 has two additional elements, WG51.A and WG5.1B, so strictly there are 26 opportunities.)

Details of the opportunities identified and developed by the project

WG1.1: Using new surveying and testing techniques

New surveying and testing methodologies can provide more accurate and detailed geotechnical information. This can, in turn, better inform early-stage design and construction planning, allowing designs and plans to become more efficient.

Benefits: Improved understanding of soil properties; and reduced operational costs through early prevention of failures and reduction in utilities costs.

WG1.2: Mobile or pop-up site labs

Delays in receiving laboratory results about soil samples can lead to material being moved multiple times or being incorrectly classified. 'Pop-up labs' can improve the rate at which information about soils is processed, and improve decision-making and site understanding.

Benefits: Reduction in unnecessary construction activities; greater reuse of existing materials; fewer vehicle movements on site and less haulage.

WG1.3: Advanced testing technology – use of real-time KPIs

The current empirical approach to the placement and compaction of soils could be significantly improved with new real-time testing methods. Approaches such as 'continuous compaction control' test the effectiveness of compaction. This can avoid costly later reworking.

Benefits: Reduction in programme activity; improved quality through better feedback; and reduced environmental impact (e.g. noise, dust, pollutants etc.).

WG1.4: Improving the specification of ground investigations

Ground investigations may not capture all the information required for each phase of the design and construction process. Developing the investigation in tandem with other project activities is recommended in industry guidance, but appears to be rarely adopted in practice.

Benefits: Improved understanding of geotechnical risks; reduction in delays and overruns; and more appropriate designs leading to shorter programmes.

WG2.1: Use of digital technology to improve communications

Information about Earthworks is a continuous process of discovery, but is slow to move from source to decision-maker (and across supply chains). Digital technologies (such as digital twins) are a necessary enabler of many improvements in communications.

Benefits: Reduced delay and duplication caused by reliance on existing information – leading to improved and more accurate decision-making.

WG2.2: Unified Ground Model

Research suggests that a 'unified ground model' may offer a solution to the challenges relating to the ownership, interpretation and communication of ground data. Such a model would be owned by the client and made available to all members of the project team.

Benefits: Programme savings implementing risk mitigations more quickly; and cost savings from using less conservative assumptions.

WG2.3: Site safety and communication

The opportunity is to create an accelerator around plant safety, with representatives from clients, contractors, OEMs and start-ups. This could consider the plant-operative interface; plant overturning and remotely operated plant.

Benefits: Improved safety and welfare of operatives; reputational benefits to the industry as a whole; and fewer stoppages on site.

WG2.4: Earthworks conceptual design training

Efficiencies often relate to decisions made during the concept design stage. This would be improved by a programme of training to broaden key areas of knowledge. Client prioritisation of site placements and resident engineer roles would be part of this.

Benefits: Reduction in risk and costs through fewer iterations and better resolution of inefficiencies in scheme design; and reversal of skills gap.

WG3.1: Reimagining Earthworks

Ways of working have remained largely unchanged for 50+ years. The opportunity is to explore completely different ways of constructing Earthworks, and how those new methods might be used to improve industry performance radically.

Benefits: Potential for significant reductions in cost, carbon and programme duration; and a new reputation for Earthworks.

WG3.2: Earthworks plant

The opportunity is to develop an Earthworks plant accelerator programme to look at alternative plant fuel types, hybrid and electrified plant; and Connected and autonomous plant (CAP).

Benefits: Reduced carbon emissions, improved air quality, less noise pollution; fewer accidents; and greater productivity from longer shifts and better accuracy.

WG3.3: Optimising environmental regulation

Some environmental requirements can lead to inefficiency working practices. The opportunity is to create requirements that are more effective and efficient, and which allow for more modification and development at a local level.

Benefits: More effective outcomes for all parties - improved project efficiency from not implementing environmental requirements that have no benefit.

WG3.4: Earthworks Environmental Protection

The opportunity is to make better use of existing environmental mitigation technologies, partly through undertaking project-specific efficacy testing and partly through better use of emerging technologies. This can help improve relationships with local communities.

Benefits: Reduced environmental impacts; improved productivity from fewer stoppages due to environmental impacts; and operative health benefits.

Details of the opportunities identified and developed by the project

WG4.1: General skills development to address skills shortages

A growing and impending skills shortage is reported by many in the COP. The opportunity is to develop and implement a Technical Skills Development Programme to increase the level of skill in the profession through better education and training.

Benefits: More innovative design and more effective optimisation; and increasing productivity and skills (including greater job satisfaction).

WG4.2: Optimisation of alignment and land acquisition

New technologies can help with vertical and horizontal route alignment, and help designers better understand topology and ground conditions. Examples include large-scale aerial surveys, new ground modelling techniques and multivariable optimisation software.

Benefits: Reduced costs (from choosing a better route); and reduced programme as getting a better understanding of the constraints can help mitigate risk.

WG4.3: Optimal Earthworks section design

The opportunity is to optimise design calculations, overcoming the tendency of designers to adopt preliminary slope recommendations and conservative retaining wall designs into the final design without further refinement. Soil-structure analysis can also be used.

Benefits: Less conservative design leading to reduced material movements, reduced costs and reduced embodied carbon.

WG4.4: Optimise settlements and track interfaces

Settlement and stiffness criteria are onerous and can lead to high costs. The opportunity is to develop a more holistic approach – in which experts from planning, civil engineering design, track design and construction logistics are encouraged to work collaboratively.

Benefits: Simpler design strategies and less onerous specification requirements; greater reuse of excavated material; less landfill and less embodied carbon.

WG4.5: Observational design

To make safe predictions of critical settlements, designers need to make conservative interpretations of site data. Observational design helps manage the risk of uncertainty in ground conditions, enabling less conservative design strategies to be proposed.

Benefits: Reduced costs and shorter programmes; greater reuse of material; and increasing expertise in actual embankment performance.

WG5.1: Non-standard material re-use

The re-use of site-won materials is not as widespread as it could be. The opportunity is to produce best practice guidance to encourage and support the development of bespoke procedures and specifications for the non-standard engineering use of site-won materials.

Benefits: Lower cost and carbon from the re-use of more of the excavated materials within the site; and reduced environmental and community impacts.

WG5.1A: Best practice guide for re-use (excavated coal measures)

The use of coal measures as engineering fill has yet to be exploited at scale. The opportunity is to produce best practice guidance to encourage the extraction of good quality rock from coal measures for its re-use on site, and to demonstrate the viability of the method.

Benefits: Lower cost and carbon from more re-used materials; and potential extension of the Earthworks season due to the properties of the material.

WG5.1B: Non-standard materials re-use (tunnel spoil)

Tunnel spoil is typically used in low-value landscaping applications. The opportunity is to produce best practice guidance for re-using tunnel spoil in Earthworks applications. This will encourage more widespread re-use and support more innovative techniques.

Benefits: Lower cost and carbon from more re-use of tunnel spoil; and reducing vehicle movements to and from Earthworks construction sites.

WG5.2: Optimal use of design parameters

Designers tend to adopt cautious geotechnical design parameters and assumptions. The opportunity is to produce best practice guidance to set out the requirement (and techniques) to rationalise and refine parameters early in the design process.

Benefits: Ability to use less conservative design parameters; reduction in the number of disputes with contractors and clearer communication of parameters.

WG5.3: Ground improvement

Designers may not be selecting the most efficient ground improvement techniques. The opportunity is to develop a Ground Improvement Accelerator Programme to identify the opportunities and challenges associated with deploying new techniques.

Benefits: Short term - improved overall performance and upskilling of the supply chain. Long term – faster development and adoption of innovative techniques.

WG6.1: Procurement for Earthworks

There is the opportunity to identify and develop best practice guidance for the procurement of Earthworks. This could include: bringing parties together to identify where the value lies, the use of incentives and targets and the use of open book on indicative schemes.

Benefits: Increased and more effective collaboration between various parties on the project leading to improved design efficiency, error reduction and savings.

WG6.2: Utilities collaboration

Many Earthworks activities require communication with utilities, along with commercial agreements. The opportunity is to explore ways to deliver effective and mutually beneficial collaboration between utilities and developers (and their supply chains).

Benefits: Significant reduction in a key area of project risk; and reduction in costs and programme with a streamlined and more engaged process.

WG6.3: System-wide plant procurement and allocation

Plant costs are a major component of Earthworks projects. A co-ordinated approach across a programme or framework can help with low utilisation problems, which say stem from variable workloads for specialist contractors and the seasonal nature of operations.

Benefits: Increased plant 'macro' utilisation, reducing overall wastage; and greater likelihood of the most appropriate (specialist) plant being used.

WG6.4: Risk management in Earthworks

Inappropriate risk management is seen as a significant driver in costs. The opportunity is to produce best practice guidance in the effective management of risk, focusing on identification, avoidance, minimalisation, mitigation and control.

Benefits: Improve the distribution of risk between the client and different parts of the supply chain; encourage innovation; and improve confidence in project costs.

Organisations participating in the Earthworks Tiger Team Community of Practice (COP):

- HS2
- Department for Infrastructure (Northern Ireland)
- Laminar Projects
- Graham Construction
- Geotechnical Observations
- Morgan Sindall
- Sellafield Ltd.
- Priestland Consulting Ltd.
- EDF Sizewell C
- Laing O'Rourke
- Highways England
- C.A. Blackwell
- Walters
- Tideway
- Mott MacDonald
- Arup
- A-Squared Studio
- Wills Bros
- CIRIA
- Geotechnical Consulting Group (GCG)
- BAM Nuttall
- Balfour Beatty
- Skanska
- Environment Agency
- Keltbray
- Ferrovial
- CSDI Engineering

Delivery strategy
Because Tiger Teams Projects are about delivering efficiency improvements at scale, it is important to set out how change is to be delivered. The Tiger Teams approach is to base this around three principles:

- Client leadership and active engagement;
- Supply chain participation and collaboration; and
- Programmatic focus, based on coherent themes.

Client leadership is particularly important as the sector is complex, fragmented and presents regulatory and commercial barriers for new product and service providers. Research has shown the importance of clients sending a clear 'demand signal' for innovation.

It is, however, the combination of clients and the supply chain, brought together in small, focused groups to take action and deliver improvements that will best help to deliver change. This can be done through four complementary programmes, with the opportunities set out in this report allocated to the most relevant one.

The different character of the opportunities is such that they fall into one of four different groups for programmatic delivery. The categorisation of programmes is shown in the table below with the opportunities mapped into the different programmes.

Co-ordinated programmatic delivery is important to maximise impact.

The Earthworks TT concluded that clients or groups of clients should use a programmatic approach working with the supply chain and stakeholders to deliver the opportunities.

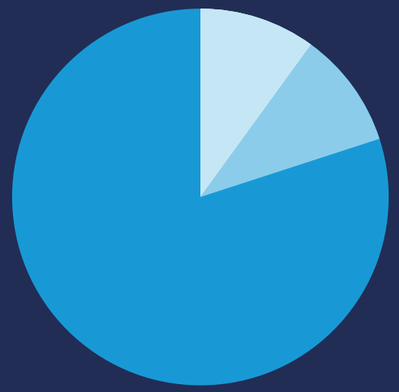
The benefits of a concerted and determined innovation and improvement programme for Earthworks of this nature are expected to be in the range of £100m–300m per annum, based on a 10–20% productivity improvement.

Programme	Purpose	Opportunities that could be delivered by the programme
Market Accelerator Programme	To create an effective marketplace and enable development and adoption of new products and services targeted at improving productivity and outcomes in the Earthworks sector.	• Mobile or pop-up labs • Advanced testing technology • Site safety and communication • Earthworks plant • Environmental protection • Optimisation of alignment and land acquisition • Ground improvement
Best Practice Programme	To establish and ensure adoption and application of 'best practice' to support innovations directed at improving productivity and outcomes in the Earthworks sector.	• Utilising new surveying and testing techniques • Improving the specification of ground improvements • Optimal Earthworks section design • Risk management • Non-standard materials reuse • Optimal use of design parameters • Procurement for Earthworks • Optimising the environmental regulation of earthworks
Skills Development Programme	To ensure that enough people with the necessary skills* are available to support innovations directed at improving productivity and outcomes in the Earthworks sector.	• Earthworks conceptual design training • Error avoidance training (Get It Right Initiative) • General skills development across the sector to address skills shortage
Tiger Teams Programme	To set up and deploy Tiger Teams to explore and address specific challenges related to the delivery of innovation in the Earthworks sector.	• Use of digital technology to improve communication • Unified ground model • Reimagining Earthworks • Observational design • Utilities collaboration • System-wide plant procurement and allocation

* In this context, the term 'skills' covers knowledge, understanding, motivation, ability, competence etc.

Potential benefits identified by the Earthworks Tiger Team Project:

10–20%



potential productivity improvements

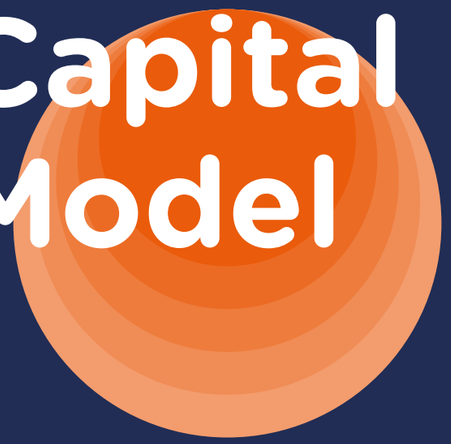
£100m

£300m

per annum benefit from 24 opportunities identified in the report

Benefits across all five 'capitals' from the

Five Capital Model



Embodied carbon reduction and improved air quality

This document is a summary of the full Earthworks Tiger Team Project report, which was finalised in summer 2021.

To find out more about how Tiger Teams can help with your infrastructure project, contact:

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