Connected Autonomous Plant

CECA - AI in construction

Improving people's lives.

Costain at a Glance

Founded
In Liverpool in 1865 by Richard Costain

Employees
c. 3,500

Services
Strategic consultancy, digital technology solutions and complex programme delivery.

Sectors
Rail, Road, Integrated transport, Energy, Water, Defence and Nuclear energy

Successes

- One of the first to achieve the BSI Kitemark for innovation. Costain worked in partnership with BSI, the business improvement company, to help design and pilot the new global certification scheme for innovation
- All relevant contracts now have a carbon baseline target and implementation plan on how they will achieve their target in line with PAS 2080.
- In 2022, HS2's site Canterbury Road Vent Shaft in South Kilburn, became the first diesel-free site, while the Euston Approaches and Victoria Road Crossover Box sites also achieved diesel-free status.
- In an industry first, Costain launched its detailed climate change action plan in February 2020 in which it committed to deliver low carbon solutions, including tackling 'Scope 3' emissions, to every client by 2023 and to be net zero by 2035.

Clear purpose, vision and mission

Complex Programme Delivery

Our purpose is **to improve people's lives**

Our vision is to **create connected, sustainable infrastructure enabling people and the planet to thrive**

Consulting

Digital

Our mission is to **shape, create and deliver pioneering solutions that transform the performance of the infrastructure ecosystem**

Our plan to achieve net zero whole life carbon supported by plant automation

Our climate change objectives are clearly linked and contribute to the United Nations Sustainable Development Goals (UN SDGs) both strategically and operationally. We already directly contribute to several of the SDGs through our core purpose of improving people's lives through smart and sustainable energy, water, defense and transportation infrastructure. Our climate change action plan strengthens and enhances our contribution to several goals, specifically Goal 13 Climate Action.

Our targets and objectives are clearly ambitious and achieving net zero emissions by at the latest 2035 will require considerable effort from our people and many others within our value chain, from clients to our supply chain. We are however confident that with effective support from government, close collaboration and industry knowledge sharing with our value chain, we can achieve these goals.

2020

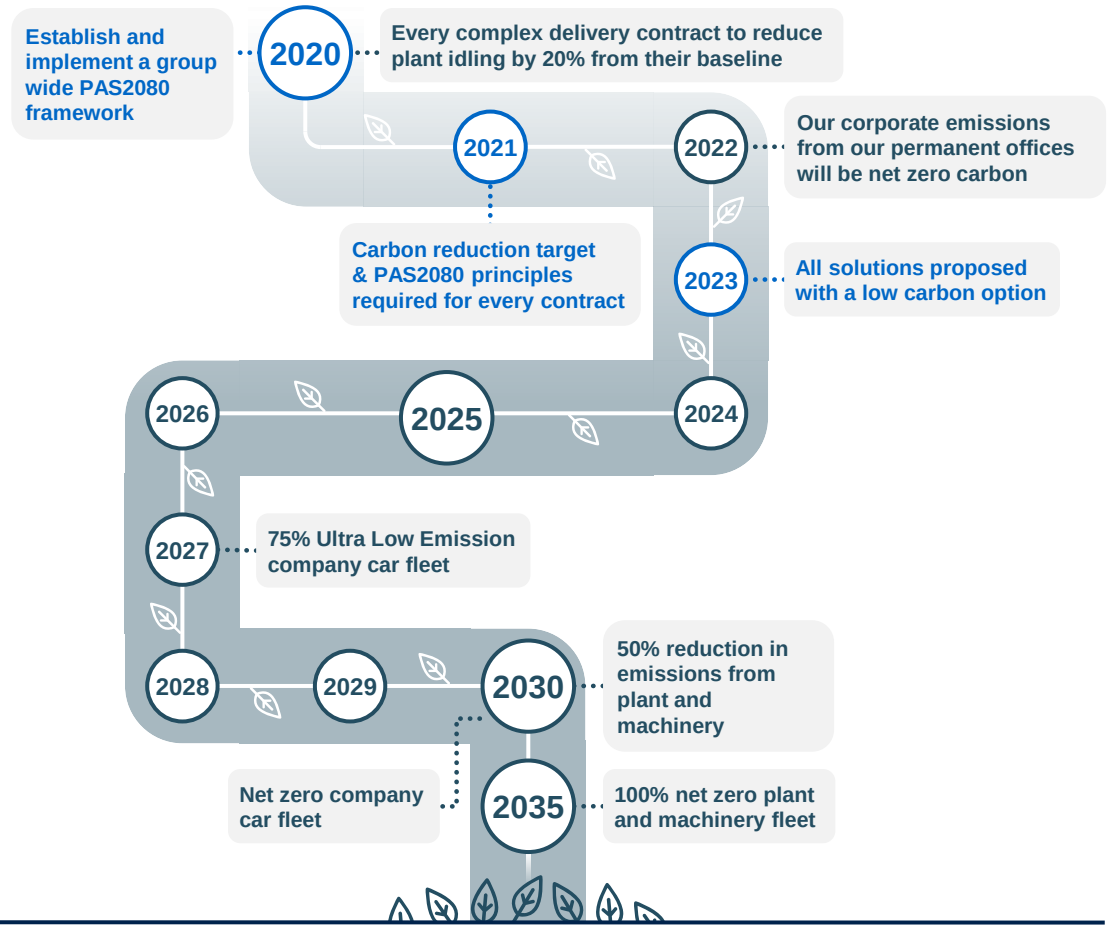
Further development of our hydrogen-based energy solutions to enable the UK hydrogen economy

Enabling further trials and delivery of technology and infrastructure for connected and autonomous mobility (CAM)

Embedding PAS2080 principles throughout the industry value chain: from clients to our supply chain to deliver low and zero carbon infrastructure

Providing innovative, technology-based solutions to deliver smarter, sustainable energy networks for a low carbon future

2035



Costain Values

Our strong culture and embedded values and behaviours underpin everything we do.

The Vision

What good looks like? What are our clients asking for?

Automate and digitize construction and infrastructure related activities sustainably, leading to improved safety, enhanced productivity, reduced costs and a lower carbon footprint.

Create a greener future

Carbon net zero on or before 2035, for all operations

Eliminate waste and carbon emissions

Find more sustainable methods to carry out engineering and complex operations

Safety

Reduce the need for manual labour and the workforce out on site.

De-risk site activities and eliminate hazards before any incidents can occur

Automate working

Productivity and Digitalisation

Reduce time on site

Reduce the cost of project delivery contracts

Telerobotic operations and remote monitoring/presence on site

Digitize the industry and enable effective/efficient capture and use of data

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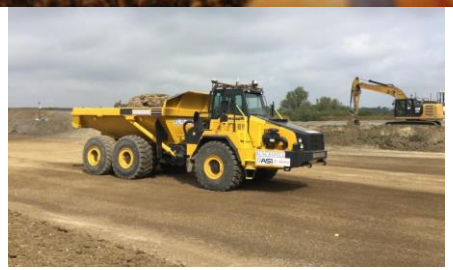
Autonomy in Construction



Smart Motorways Alliance - M6

- Anomaly or change detection; and Localisation within 3D models
- Automated & real time data capture.
- Plant person interface monitoring
- Culvert inspection/survey
- Bridge inspection and Telecoms cable monitoring
- Ecological survey along embankment/slope
- Construction site survey
- Sewer Inspections

RDP Framework – A30 scheme

Use of drones for survey data capture, progress monitoring, media capture and asset data capture.
3D machine control is used across a variety of tasks and machine types.

A14 – Cambridge to Huntingdon Scheme

Self-driving trucks were tested on the UK's biggest road upgrade, the A14 improvement scheme between Cambridge and Huntingdon, which was delivered by a joint venture comprising Costain, Balfour Beatty and Skanska. One autonomous dump truck was tested in a controlled environment for the first time in England, having previously been tried and tested in the mines of Australia.

Future Flight Challenge, Phase 2

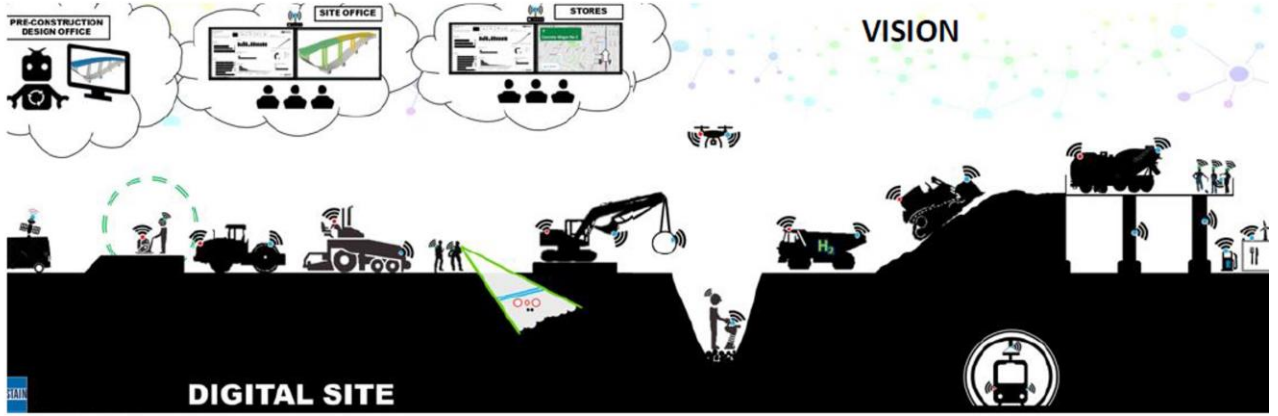
A consortium of 16 entities led by specialist drone command and control solution developer, sees.ai, including road, rail and telecoms infrastructure giants, Skanska Costain STRABAG working in partnership with HS2, won a competition to develop and test a remotely operated drone system for industrial and urban environments.

Costain
Connected Autonomous Plant

Phase 1: Roadmap Development and launch

This phase was led by TRL and supported by Costain who were able to provide our complex programme delivery and site management expertise to help guide the development of the roadmap which was split into the following workstreams,

Legislation, regulation and policy
Finance, business and investment
CAP Training Framework
Ubiquitous Connectivity
Remote Survey and Operation
Autonomous Plant
Algorithms in Autonomy
Interoperable Telemetry
Common Data Standard



Phase 2: Levels Development

Led by Costain and supported by TRL to develop a standardized set of autonomy levels for use by industry. This was split into the following areas,

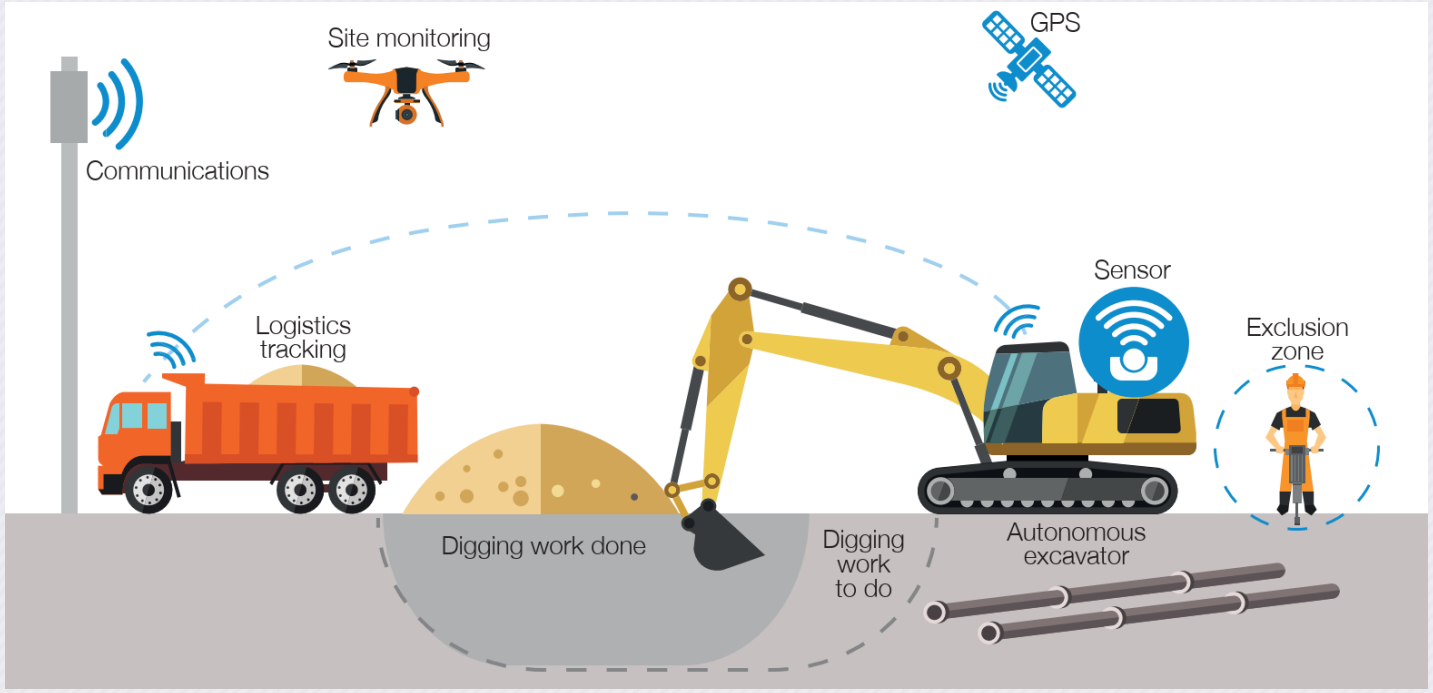
- To develop a common method of talking about autonomous capability of plant or their sub-systems.
- Similar goals to the Society of Automotive Engineers (SAE) levels development.

Phase 3: Design for Machines

This phase was also led by Costain and supported by TRL, this phase was split into 3 tasks, Legislation & Ethics / Commercial & Standards Review, Design for Machines and development of a virtual testbed framework.

Connected and Autonomous Site (CAP) – Connected Site

*"By 2040, National Highways aspires to realise a step change in efficiency, with roads projects and maintenance delivered **30% - 50%** cheaper than today."*



"If the benefits to manufacturing are mirrored in construction, productivity improvements achieved via CAP could exceed £200Bn by 2040."

Published to industry June 2020 via Webinar

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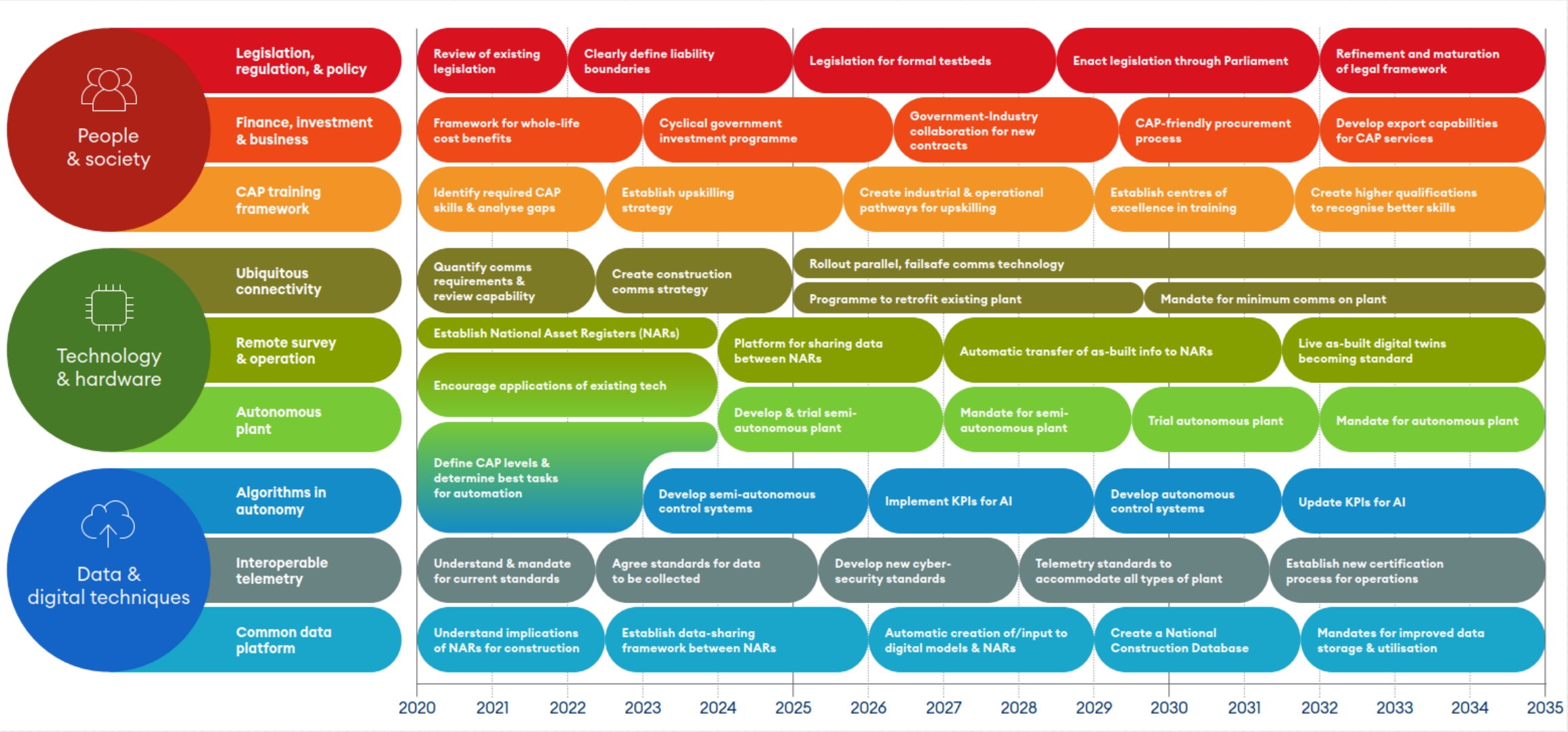
CAP Phase 1 – Roadmap



Published to industry June 2020 via Webinar

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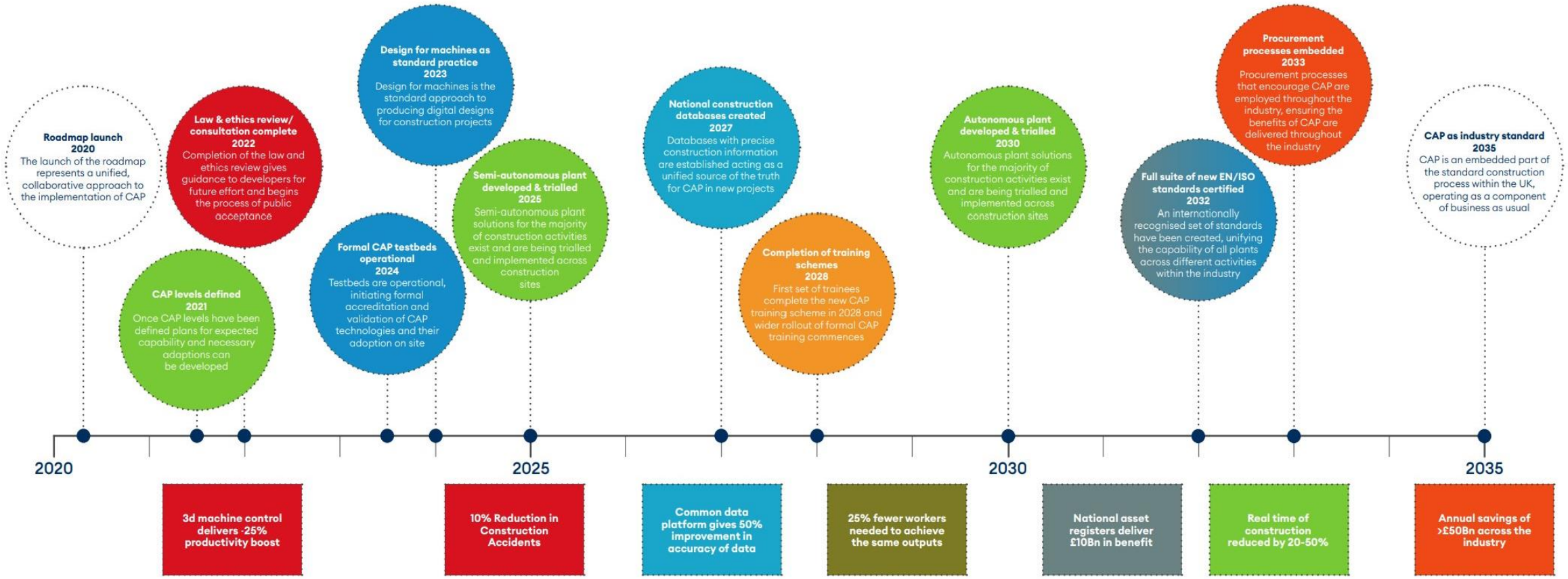
CAP Phase 1 – Key milestones

Each milestone marks a turning point in the Roadmap, or the establishment of a key enabler that unlocks the next stage



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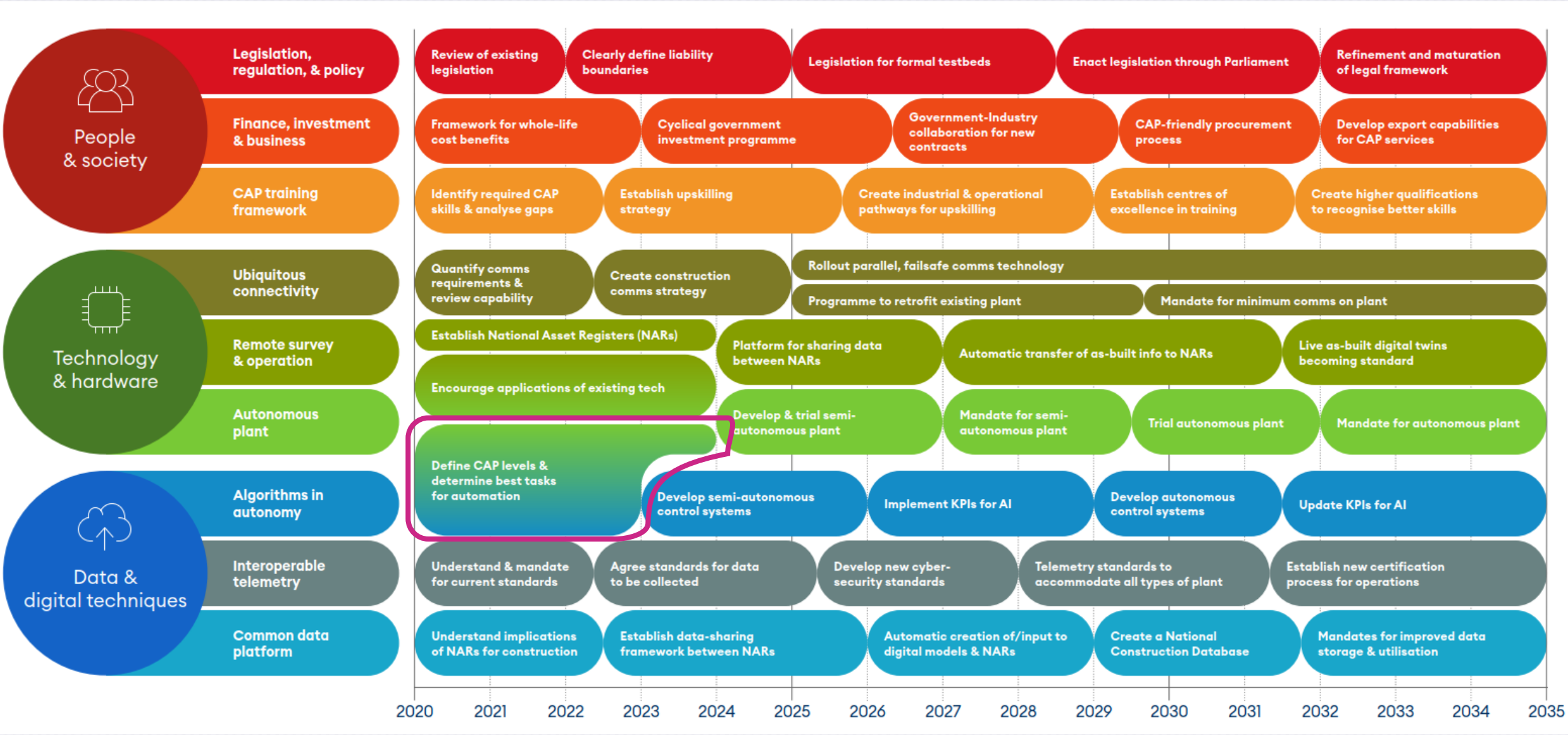
Disseminated via webinar to capture wider audience & legacy piece.

i3P served as the conduit to deliver the message to relevant stakeholders.

Why we did it

*** Leadership**
*** Bring Industry together**
*** Set direction of travel**

Huge opportunities to improve safety, productivity and carbon agenda



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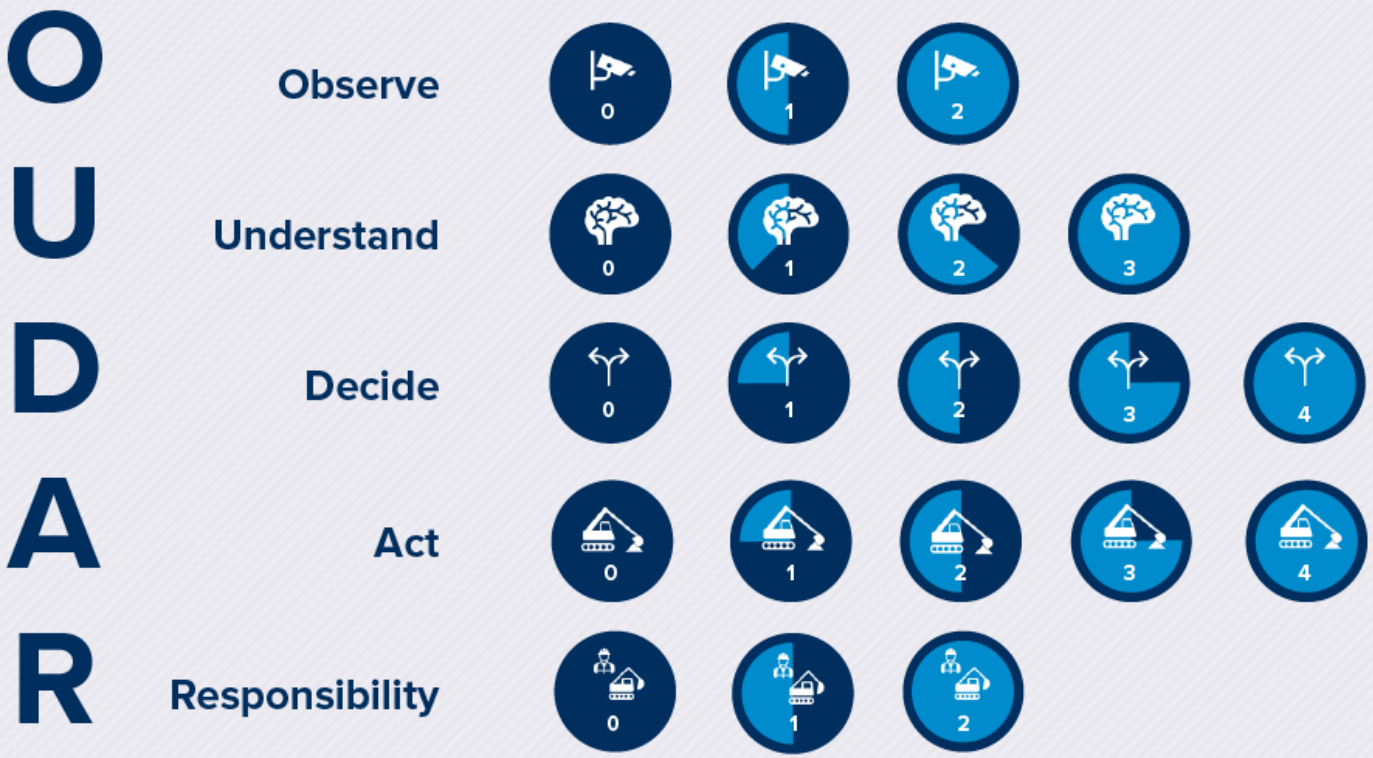
CAP Levels

The levels enable a standarised measure to describe machine capability. They can be used across the industry and throughsupply chain to track and specify autonomous machines. There are 5 factors that are scored, based on the same process that humans use to carry out tasks - these are described below.



Note: this is the 1st iteration of the CAP Levels. Further work is required to establish their application, including certification scheme.

Published to industry March 2022 via Futureworx event, Peterborough

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CAP Levels – examples

Autonomous Compaction Plant

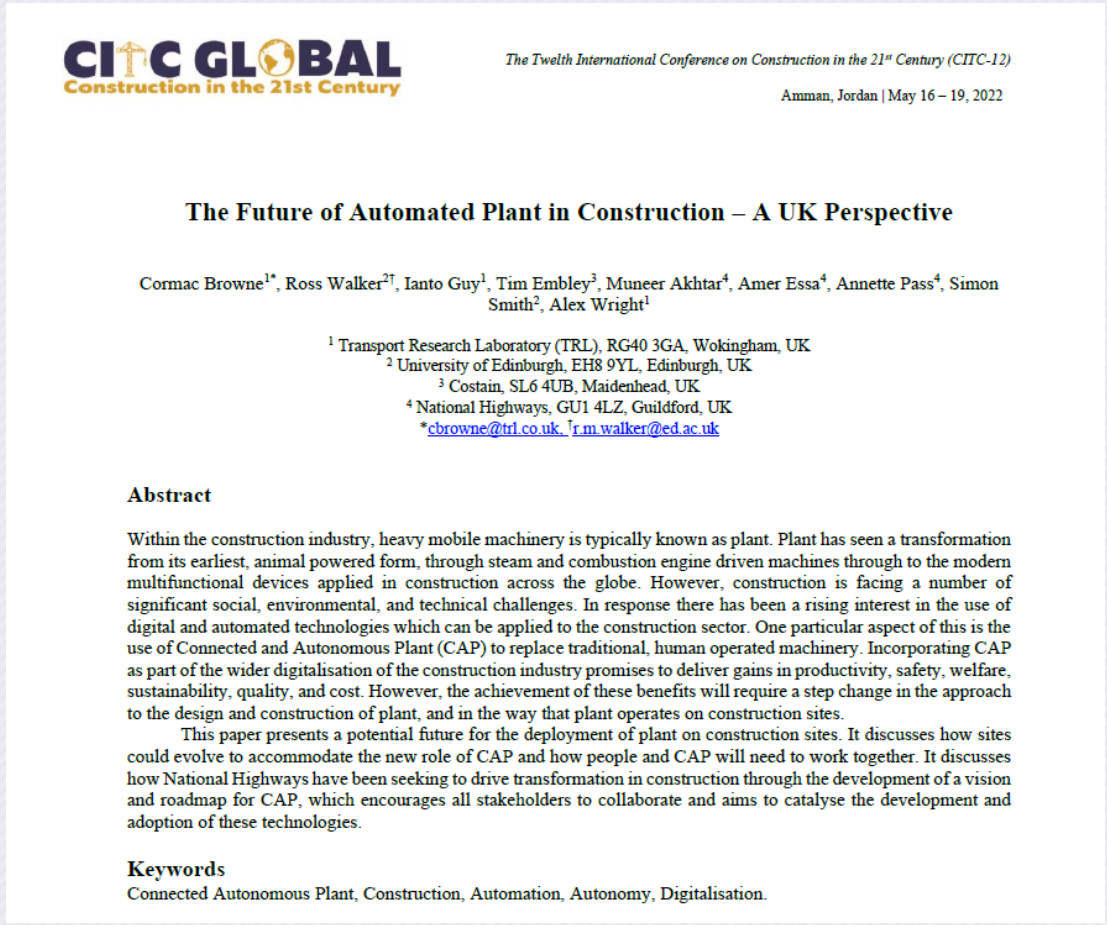
CAT Command for Compaction

BOMAG ROBOMAG

Published to industry March 2022 via [Futureworx](#) event, Peterborough

CAP Levels – International Reach

Construction In the 21st Century Conference (CITC) - May 2022, Jordan
(General focus)



CITC GLOBAL
Construction in the 21st Century

The Twelth International Conference on Construction in the 21st Century (CITC-12)

Amman, Jordan | May 16 – 19, 2022

The Future of Automated Plant in Construction – A UK Perspective

Cormac Browne[1*], Ross Walker[2†], Ianto Guy[1], Tim Embley[3], Muneer Akhtar[4], Amer Essa[4], Annette Pass[4], Simon Smith[2], Alex Wright[1]

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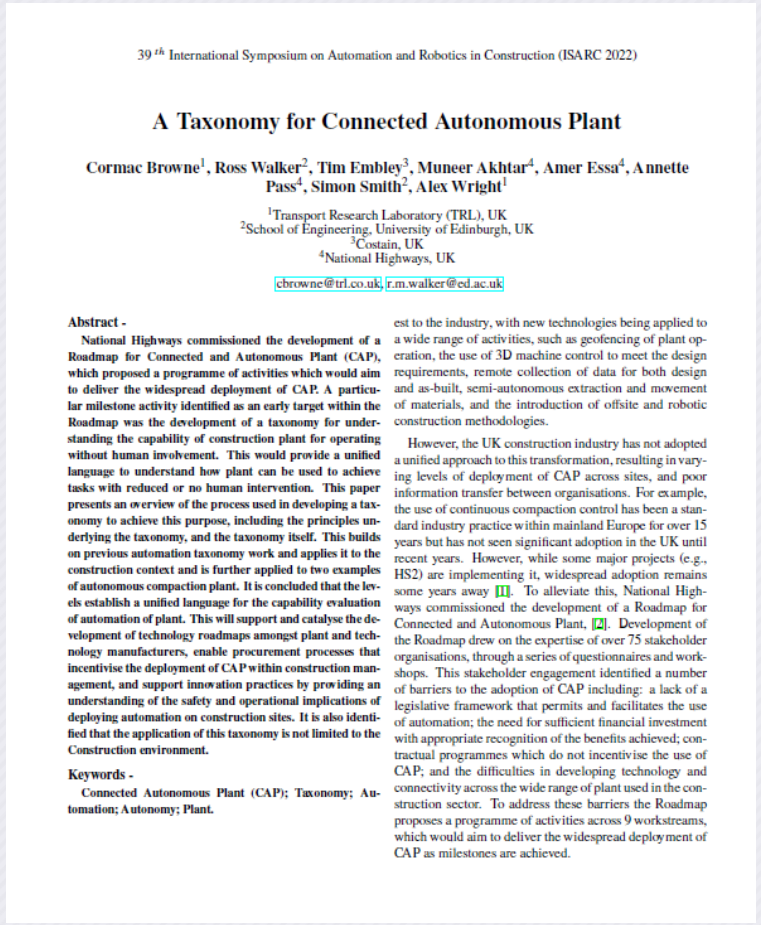
Abstract

Within the construction industry, heavy mobile machinery is typically known as plant. Plant has seen a transformation from its earliest, animal powered form, through steam and combustion engine driven machines through to the modern multifunctional devices applied in construction across the globe. However, construction is facing a number of significant social, environmental, and technical challenges. In response there has been a rising interest in the use of digital and automated technologies which can be applied to the construction sector. One particular aspect of this is the use of Connected and Autonomous Plant (CAP) to replace traditional, human operated machinery. Incorporating CAP as part of the wider digitalisation of the construction industry promises to deliver gains in productivity, safety, welfare, sustainability, quality, and cost. However, the achievement of these benefits will require a step change in the approach to the design and construction of plant, and in the way that plant operates on construction sites.

This paper presents a potential future for the deployment of plant on construction sites. It discusses how sites could evolve to accommodate the new role of CAP and how people and CAP will need to work together. It discusses how National Highways have been seeking to drive transformation in construction through the development of a vision and roadmap for CAP, which encourages all stakeholders to collaborate and aims to catalyse the development and adoption of these technologies.

Keywords
Connected Autonomous Plant, Construction, Automation, Autonomy, Digitalisation.

International Symposium on Automation and Robotics in Construction (ISARC) Conference in July 2022; Colombia
(Technical focus)



39th International Symposium on Automation and Robotics in Construction (ISARC 2022)

A Taxonomy for Connected Autonomous Plant

Cormac Browne[1], Ross Walker[2], Tim Embley[3], Muneer Akhtar[4], Amer Essa[4], Annette Pass[4], Simon Smith[2], Alex Wright[1]

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Abstract -

National Highways commissioned the development of a Roadmap for Connected and Autonomous Plant (CAP), which proposed a programme of activities which would aim to deliver the widespread deployment of CAP. A particular milestone activity identified as an early target within the Roadmap was the development of a taxonomy for understanding the capability of construction plant for operating without human involvement. This would provide a unified language to understand how plant can be used to achieve tasks with reduced or no human intervention. This paper presents an overview of the process used in developing a taxonomy to achieve this purpose, including the principles underlying the taxonomy, and the taxonomy itself. This builds on previous automation taxonomy work and applies it to the construction context and is further applied to two examples of autonomous compaction plant. It is concluded that the levels establish a unified language for the capability evaluation of automation of plant. This will support and catalyse the development of technology roadmaps amongst plant and technology manufacturers, enable procurement processes that incentivise the deployment of CAP within construction management, and support innovation practices by providing an understanding of the safety and operational implications of deploying automation on construction sites. It is also identified that the application of this taxonomy is not limited to the Construction environment.

Keywords -

Connected Autonomous Plant (CAP); Taxonomy; Automation; Autonomy; Plant.

est to the industry, with new technologies being applied to a wide range of activities, such as geofencing of plant operation, the use of 3D machine control to meet the design requirements, remote collection of data for both design and as-built, semi-autonomous extraction and movement of materials, and the introduction of offsite and robotic construction methodologies.

However, the UK construction industry has not adopted a unified approach to this transformation, resulting in varying levels of deployment of CAP across sites, and poor information transfer between organisations. For example, the use of continuous compaction control has been a standard industry practice within mainland Europe for over 15 years but has not seen significant adoption in the UK until recent years. However, while some major projects (e.g., HS2) are implementing it, widespread adoption remains some years away [1]. To alleviate this, National Highways commissioned the development of a Roadmap for Connected and Autonomous Plant, [2]. Development of the Roadmap drew on the expertise of over 75 stakeholder organisations, through a series of questionnaires and workshops. This stakeholder engagement identified a number of barriers to the adoption of CAP including: a lack of a legislative framework that permits and facilitates the use of automation; the need for sufficient financial investment with appropriate recognition of the benefits achieved; contractual programmes which do not incentivise the use of CAP; and the difficulties in developing technology and connectivity across the wide range of plant used in the construction sector. To address these barriers the Roadmap proposes a programme of activities across 9 workstreams, which would aim to deliver the widespread deployment of CAP as milestones are achieved.

Also presented to Brussels Knowledge Day (March 2022), publications in ICE/NCE, CIHT, etc.

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CAP – (Current) Phase 3; NorthStar statements

Task 1: Legislation & Ethics / Commercial & Standards Review

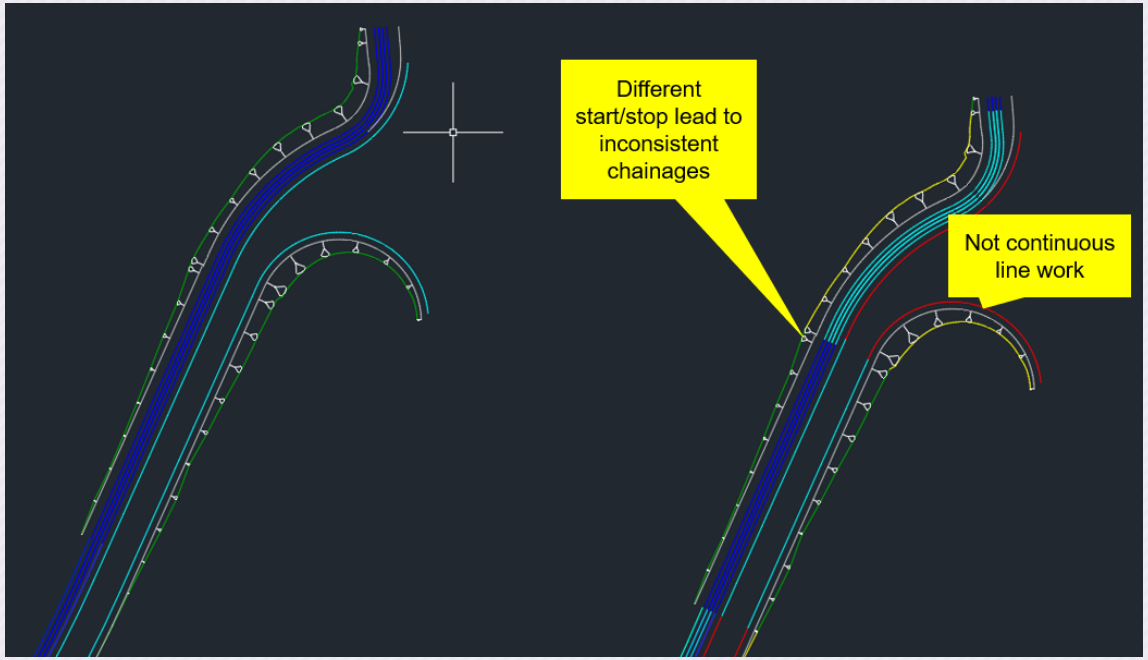
To answer…'If a fully autonomous plant fleet was available tomorrow, what would the barriers be to adoption in terms of standards and commercials?'

Task 2: Design for Machines

To provide good practice guidelines to maximise adoption of 3D machine control, removing barriers to getting compatible designs into machines. This could include the adoption of a standard design approach.

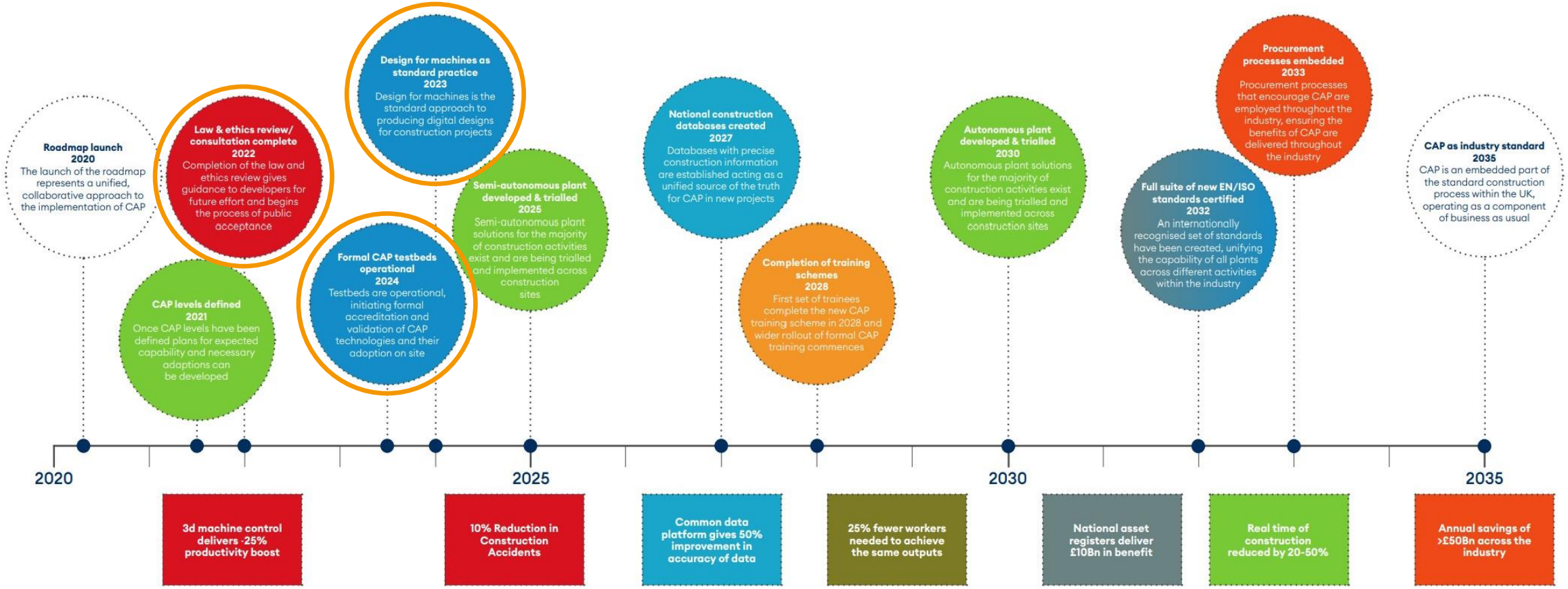
Task 3:Virtual Testbed creation

To provide a report to highlight how we could have a real-time and over-time view of CAP maturity on National Highways sites.



CAP Phase 3 – Key milestones

Each milestone marks a turning point in the Roadmap, or the establishment of a key enabler that unlocks the next stage



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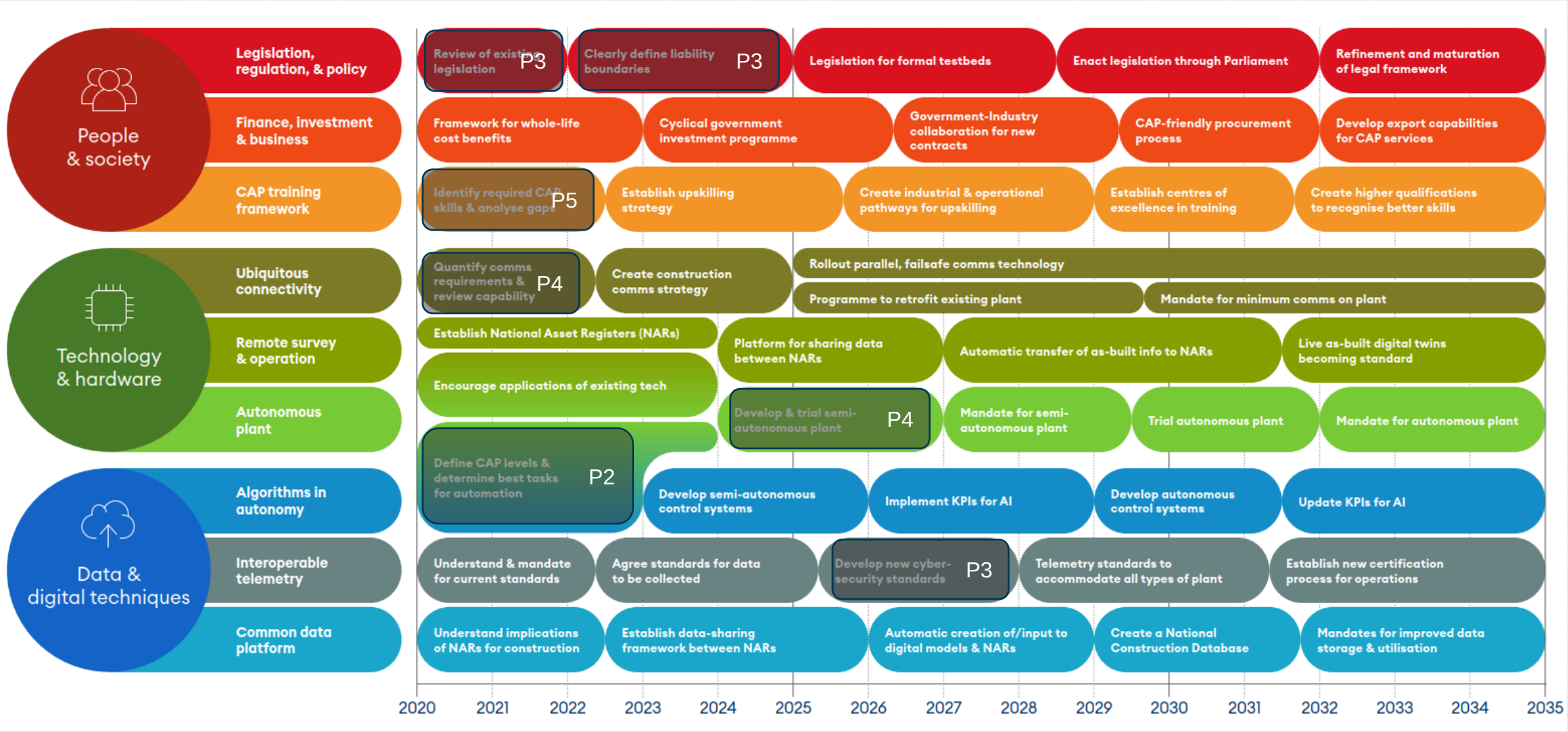
CAP So Far – at a glance

Note: this is not a comprehensive view of all developments in industry, only where NH work has focused.



Phase 4 – Trials & Dashboard

The below workstreams will provide NH with a real-time and overtime view of CAP maturity at an organisational level. This could inform future policy around mandating CAP adoption on schemes, once the benefits are evidenced.

Workstream A: Launch Virtual CAP Testbed

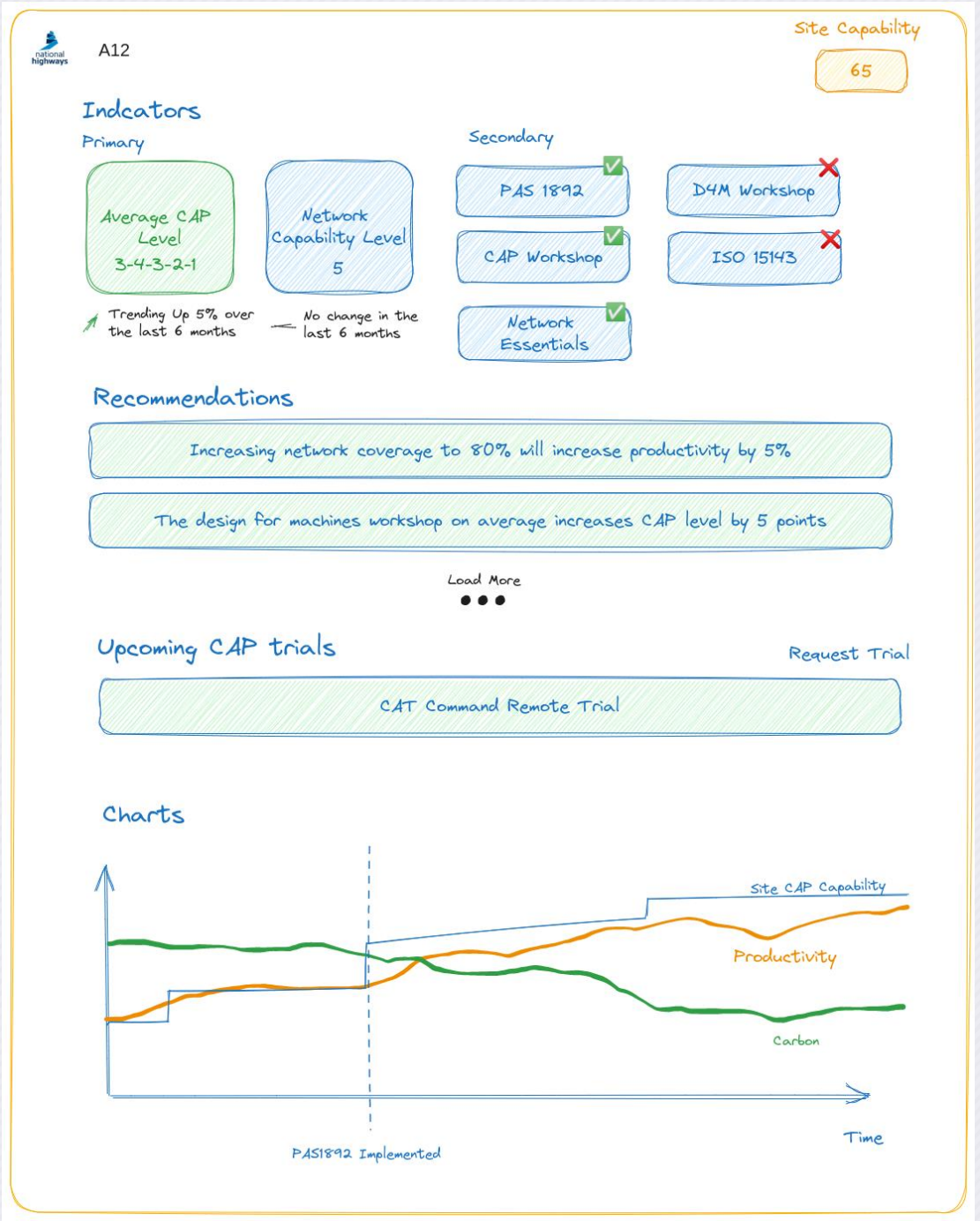
- Launch a virtual, living lab testbed & Dashboard connecting the knowledge and learning from the supply chain's trials of CAP and facilitate access to available testing facilities (e.g. the Manufacturing Technology Centre or NH Development Centre at Moreton-in-Marsh)
- *Deliverables: stakeholder engagement; virtual CAP testbed & dashboard*

Workstream B: CAP Site Trials

- Targeted, co-funded support to promote pilots and trials with our supply chain, utilising Design for Machines specification developed in Phase 3. We will not be investing in development of any specific CAP technology.
- Gather and utilise data from site trials to populate the Virtual CAP Testbed with real world data
- *Deliverables: stakeholder engagement; match funding for 3 site trials; augmentation of site trial data into dashboard*

Workstream C: Engagement with Industry through CAP Community

- Engage with Government stakeholders and the CAP community to stimulate the market
- Participate in regional events and exhibitions to identify industry relevant launch events for deliverables
- *Deliverables: stakeholder engagement; case study published; dashboard demonstrating current CAP maturity on NH sites.*



Phase 5 – Roadmap Review & Workforce of the Future

The deliverables will clarify how the responsibility on NH for site operatives will evolve over time, whilst also allowing operatives to appreciate a realistic view of how their role will develop with an increase in CAP deployment.

Key considerations:

- *Is NH on track to realise CAP sites by 2035?*
- *What will the future operative 'look' like?*
- *What training will be required?*
- *Can we diversify the workforce?*
- *H&S implications of remote working / working from home?*
- *Does NH have a role in this?*
- *Where is the duty of care if we remove operatives from hazardous site environments? Display Screen Equipment Assessments & allowances?*

High level outputs & outcomes:

- *Reviewed CAP Roadmap, assessing current achievement against ambitions*
- *A trend report highlighting the evolving role of operatives up to 2035 and how this impacts NH business as usual activities, relating to delivering schemes.*
- *Recommendations report suggesting the measures NH needs to adopt to ensure organisational resilience.*

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DfT Activities

Past:

Commissioned BSI Group to develop PAS 1892

Defining and specifying the use of Connected and automated plant (CAP) in construction and maintenance works for the purposes of procurement and deployment. ***(July 2023)***

Present:

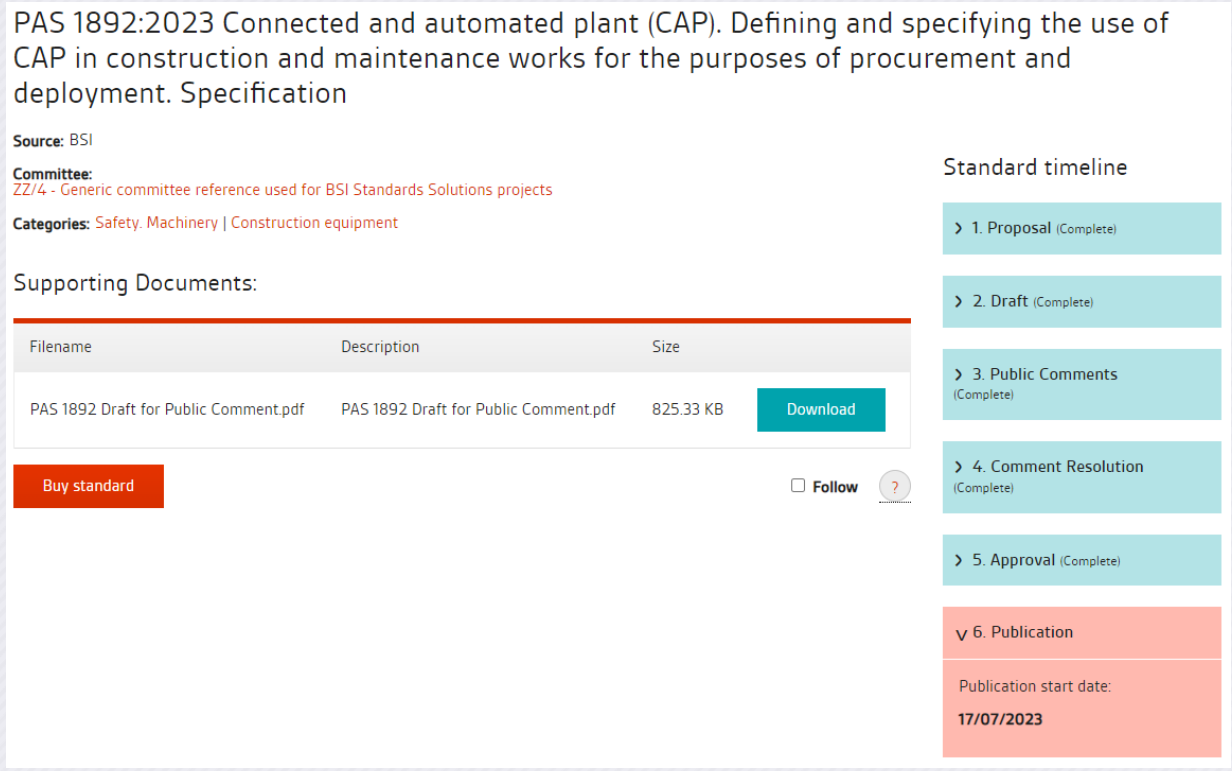
CAP Market Analysis

Costain are leading a project for DfT to understand the marketplace and appetite for CAP in the construction sector. From a UK vs. Global perspective. ***(Nov-23 to Mar-24)***

Future:

Centre for Connected & Autonomous Plant

Dependent on the outcomes of CAP market analysis.



What does success look like for the CAP Programme?

Stakeholder Buy-in

- DfT take ownership of CAP and become the driving force for its adoption
- Deliver compelling use cases of the benefits associated with CAP uptake; provide a 'blueprint' as to how it's done

Collaboration

- Information and knowledge sharing between CAP community and OEM's.
- Industry working collaboratively towards implementation and adoption of CAP

Making CAP BAU

- Effectively report performance and benefits achieved by schemes through CAP maturity / adoption
- Seamless integration between design, construction and maintenance.
- Understanding and mitigation of risks envisioned by the industry.
- CAP becomes BAU on schemes
- Overcome Commercial and Legal barriers for adoption of CAP

Strengthen the sector

- Support the recruitment and retention of skilled workers into the construction industry and change the perception of construction as a career choice
- Help develop technologies in the UK that can be exported
- Drive efficiencies in the sector through CAP
- Demonstrate tangible benefits for all parties in the value/supply chain

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CAP - Looking to the future

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Questions

Thank you

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