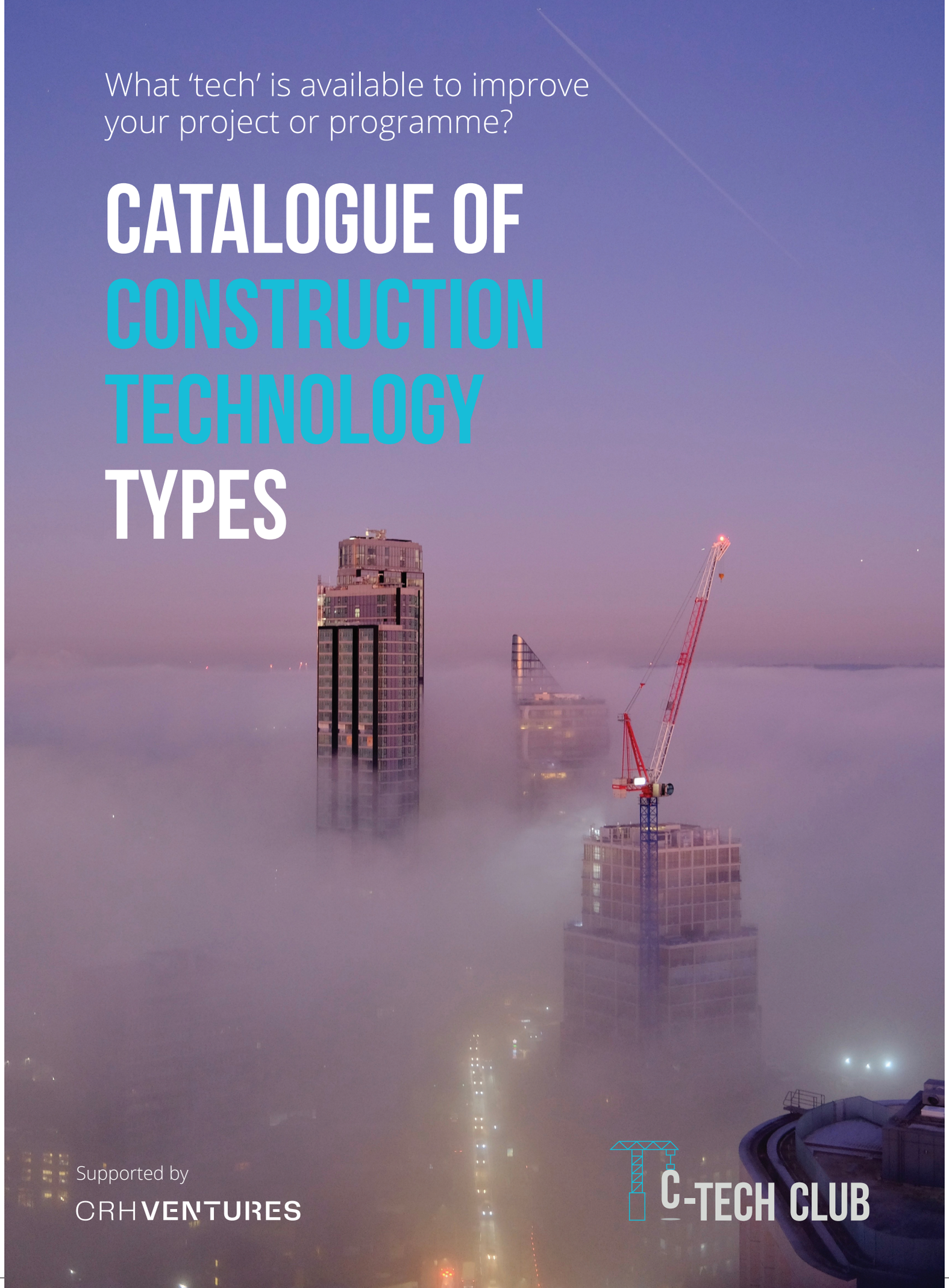
What ‘tech’ is available to improve your project or programme?

CATALOGUE OF CONSTRUCTION TECHNOLOGY TYPES



Supported by

CRH VENTURES

C-TECH CLUB

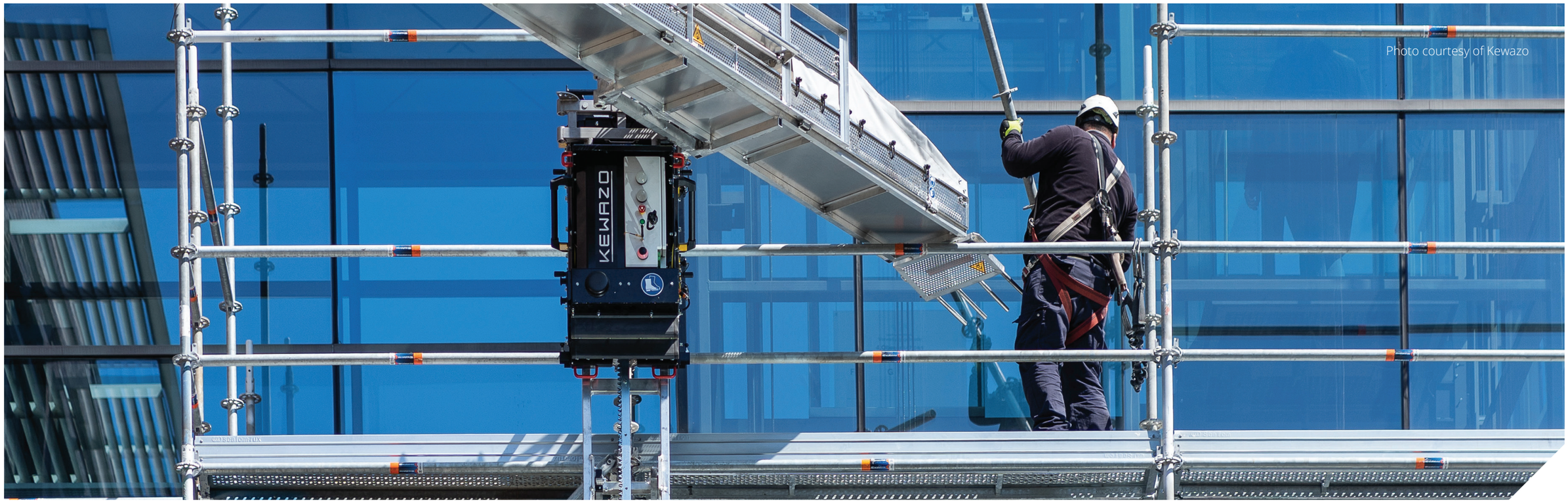


Photo courtesy of Kewazo

The production of this document has been kindly supported by CRH Ventures.

CRH Ventures is the venture capital unit of CRH, the leading building materials business in the world.

With access to a $250 million venturing and innovation fund, CRH Ventures supports the development of new technologies and innovative solutions to meet the increasingly complex needs of its customers and evolving trends in the construction industry.

It does this by investing in and partnering with 'Contech' and 'ClimateTech' start-ups across five focus areas: decarbonisation, industrialization, 'NextGen Products', digitalization and 'marketplaces'.

Launched in December 2022, CRH Ventures leverages CRH's global reach and 50+ years of operational expertise to form bold new partnerships, including with the C-Tech Club, to help shape the future of the construction industry.

CRH VENTURES

Contents

Cover photo courtesy of Sensat

Construction technology is transforming the way in which we plan, design, build and manage our built environment.

But what exactly is ‘contech’? And what types of technology are available to help you improve your project or programme?

There are many definitions of construction technology. The US Construction Industry Institute (CII) defines[1] it as:

“...the collection of innovative tools, machinery, modifications, software, etc. used during the construction phase of a project that enables advancement in field construction methods, including semi-automated and automated construction equipment.”

To that definition we would add design and other pre-construction activities, which impact on construction productivity and are an inherent part of the process.

However, beneath this overarching definition lies a myriad of tools, techniques and technologies – some well established and others new and rapidly evolving.

The successful deployment of construction technology requires a partnership between clients, designers, contractors, operators, data specialists and technologists. Often some or all of these are unaware of the various types of construction technologies that are available.

They are then less able to make the best decisions on what technology to deploy and what problems to try to solve. This Catalogue is an attempt to help.

Written in conjunction with C-Tech Club members – that is, founders and CEOs of construction technology start-ups – this Catalogue is a practitioner’s view of the types of technology that are being developed. Many of the example technologies that are mentioned are C-Tech Club companies, but not all. And we could not hope to feature all the start-ups linked to the C-Tech Club in this document: there are more than 300 of them.

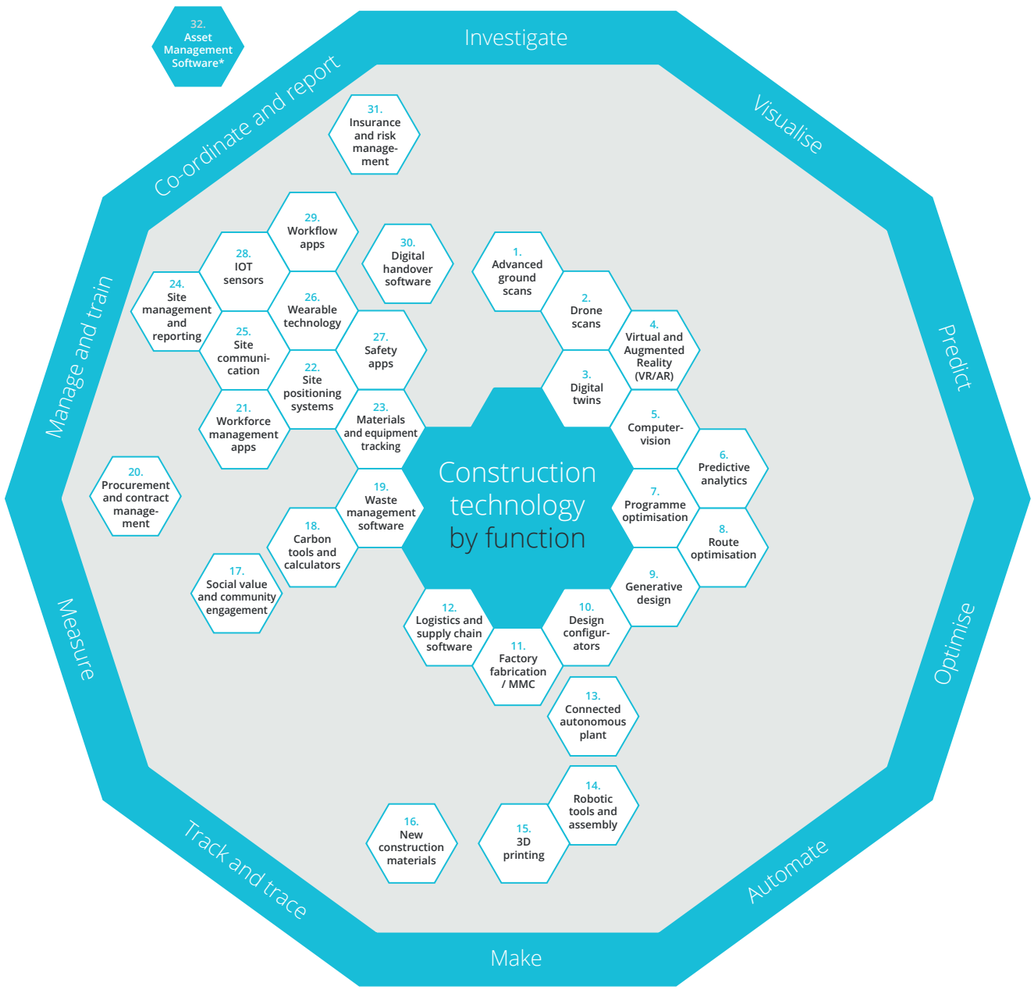
What we have produced will, we hope, be a useful signpost for those looking to promote and deliver innovation in construction. It will inevitably be an incomplete list – so views on errors and omissions will be gratefully received. We expect to produce an updated version of the Catalogue in due course: by that point, the technologies being used in construction will be even more advanced and exciting than those being used today.

[1] *https://www.construction-institute.org/resources/knowledgebase/knowledge-areas/construction-tech*

Photo courtesy of Fologram

Construction technology functional map.

We can divide construction technology up into ten functions (i.e. descriptions of what we do with the technology) and **31* categories** of technology. Some technology types provide more than one function; and many work well with and overlap with others.

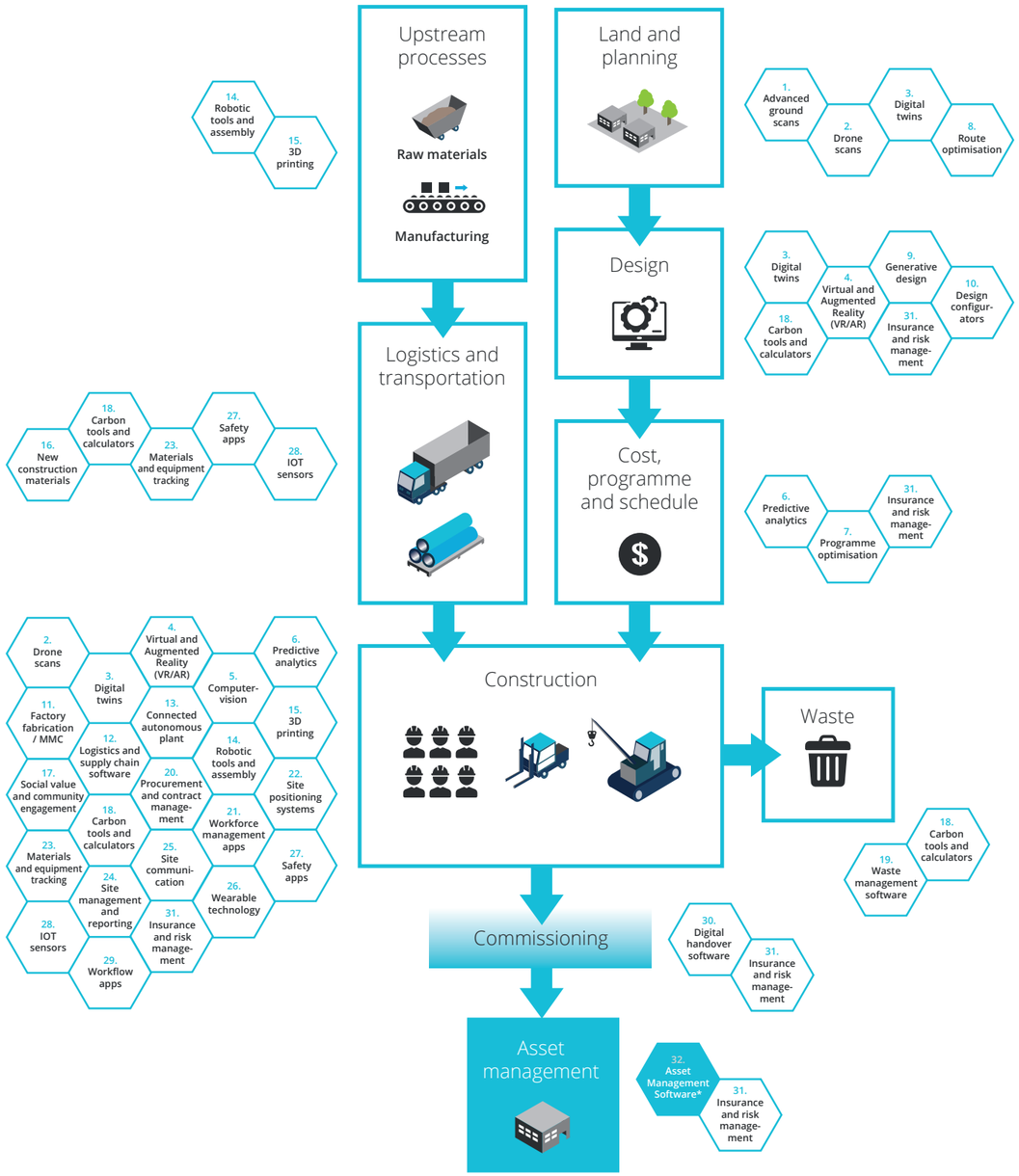


**Asset Management Software is the 32nd category for completeness. Strictly speaking it falls in the 'operate and maintain' phase of the asset lifecycle, so is beyond the definition of construction technology.*

Construction technology is evolving all the time. So this is just the start! Please tell us your thoughts and observations on this taxonomy, so we can add to it and update it. Email us at: **info@c-techclub.org** and help us develop the Catalogue further.

Technology by project stage.

We can also map the construction technology types by the stage of the project to which they relate...



...and even by the type of client, project and user persona to which each category of construction technology relates.

	By type of client						By type of project				By user persona*								
	Investor	Asset owner	Designer / consultant	Tier 1 contractor	Tier 2 contractor	Asset operator	Residential / housebuilding	Commercial building	Industrial and energy construction	Transportation and infrastructure	Ro_10_30_50 Asset manager	Ro_30_10_22 Cost consultant	Ro_30_10_36 Health and safety consultant	Ro_30_10_42 Information manager	Ro_30_10_67 Project manager	Ro_70_30_85 Sustainability consultant	Ro_70_10 Surveyor and planner roles	Ro_70_50 Building trades	Ro_50 Design roles
1. Advanced ground scans		●	●			●				●	●						●		●
2. Drone scans		●	●	●		●	◖	●	●	●	●		◖				●		●
3. Digital twins		●	●	●	◖	●	◖	●	●	●	●			●	●		●	●	●
4. Virtual & Augmented Reality (VR/AR)		◖	●	●	●	●	●	●	●	●	◖				●			●	●
5. Computervision		◖	●	●	◖	●	◖	●	●	●	◖								●
6. Predictive analytics	◖	●	●	●		●	◖	●	●	●	●	●	●	●	●	●	●	●	●
7. Programme optimisation		◖	●	●		●	◖	●	●	●	◖				●				◖
8. Route optimisation		●	●			●				●	●								●
9. Generative design		◖	●			●	◖	◖	◖	◖	◖								●
10. Design configurators		◖	●	◖		●	●	◖	◖	◖	◖								●
11. Factory fabrication / MMC		●	●	●	◖	◖	●	●	◖	◖	●							◖	●
12. Logistics & supply chain software		◖	◖	●	◖	◖	●	●	●	●	◖				●			●	◖
13. Connected autonomous plant		●	●	●	●		◖	◖	●	●	●		◖					●	◖
14. Robotic tools & assembly			◖	●	●		◖	●	●	●			◖		●			●	◖
15. 3D printing			◖	●	●		●	●	●	●								●	◖
16. New construction materials		◖	●	●	◖		◖	◖	●	●	◖							●	●
17. Social value & community engagement		●	●	●			●	◖	●	●	●					●			●
18. Carbon tools & calculators	◖	●	●	●	◖	●	●	●	●	●	●	●			●	●		●	●
19. Waste management software		●	◖	●	◖	●	●	●	●	●	●					●		●	◖
20. Procurement & contract management		●	◖	●	◖	●	●	●	●	●	●	●			●				◖
21. Workforce management apps		◖		●	●	●	●	●	●	●	◖			●	●		●	●	
22. Site positioning systems		●	◖	●	●	●	◖	●	●	●	●			●			●		◖
23. Materials & equipment tracking		◖		●	●	◖	◖	●	●	●	◖			●	●			●	
24. Site management & reporting		◖	◖	●	◖	◖	●	●	●	●	◖	◖			●		●	●	◖
25. Site communication		◖	◖	●	●		●	●	●	●	◖				●		●	●	◖
26. Wearable technology				●	●	◖	●	●	●	●			●		◖			●	
27. Safety apps		◖	◖	●	●	◖	●	●	●	●	◖		●		◖		●	●	◖
28. IOT sensors	◖	◖	◖	●	●	●	●	●	●	●	◖							●	◖
29. Workflow apps			◖	●	●	◖	●	●	●	●				●	◖		●	●	◖
30. Digital handover software	◖	●	◖	●		●	◖	●	◖	◖	●		●	●	●				◖
31. Insurance & risk management	◖	●	◖	●	●	●	◖	●	◖	◖	●	●			●				◖
32. Asset management software						●	◖	●	●	●	●			●			●		

*Based on selected Uniclass categories

Photo courtesy of innDex

List of construction technologies

1. Advanced Ground Scans

Description:

Understanding ground conditions and voids etc. is very important on infrastructure projects. Electromagnetics works by sending an electromagnetic wave from a helicopter, such that when the wave hits the ground, an electric current is induced in conductive materials located in the subsurface. The currents move downwards and create a secondary magnetic field, which can then be registered by the equipment hanging below the helicopter. The force of this field is dependent on what the subsurface consists of – and this can be used to get an understanding of ground conditions to a greater extent than through conventional methods. Ground penetrating radar (GPR) follows a similar logic, albeit using a reflected radar pulse, rather than inducing an electromagnetic wave.

Example providers:

EMerald Geomodelling (Norway) is an innovative provider of geological and geotechnical models crafted from electromagnetic data and conventional GI combined through AI. At present, helicopter electromagnetic data is used, but there are plans for a drone-based workflow in due course. **Hacarus** from Japan are linking GPR and AI to improve the accuracy of identifying the position of buried pipes.

2. Drone Scans

Description:

Drones, equipped with a variety of payloads, can capture images and measurements to almost topographical quality. These can be in the form of photogrammetry models or point cloud scans. When combined in appropriate data environments, the images can be overlaid with other 3D information – BIM models, LIDAR scans, IOT information, Geospatial Information System (GIS) layers etc. For an existing asset, a drone scan can often be a much more effective way of creating a 'visual twin' than the development of a BIM model.

Example providers:

Sensat (UK) and **Aerologix** (Australia) are examples of start-ups that combine drone scan information with data visualisation environments to provide insights for construction projects. GHD's **Digital Twin Online (DTO)** platform does something similar. **Herotech8's** (UK) 'drone-in-a-box' system enables drones to be automatically deployed, recovered and recharged without the need for an on-site pilot. **Civ Robotics** (US) have moved on from drones to use a wheeled robot to which 360° cameras can be mounted. 'CivDot' is useful for topographic surveys as it measures the ground elevation in each coordinate it marks, and it can help support the site layout process.

3. Digital Twins

Description:

'Digital twin' is something of a catch-all term for a digital representation of a physical asset. The purpose of a digital twin, though, is to allow the user to make better decisions (e.g. design or construction management choices) and/or to collaborate and co-ordinate better across the project team (e.g. clash detection or in an 'immersion' environment) and/or to allow information to be displayed more effectively. Digital twins span urban planning, design, construction and operations.

Example providers:

Invicara's (Ireland) Twinit.io enables consultants to compose solutions for developers, owners, occupiers and operators of buildings, infrastructure and cities. **Asbuiltdigital** (New Zealand) has developed Vault as a '3D Spatial Intelligence Platform', able to combine spatial accuracy with live insights. **Sync Technologies** (Australia) offers construction companies external/aerial and internal/ground-based digital twin solutions, field-to-BIM services, and a platform to manage and analyse visual data. **Sensat** (UK) helps programme managers to make better decisions by seeing their project data in context of the real-world environment. **GHD's** (UK) **DTO** is a visual twin platform for 3D data from multiple sources, including photogrammetry laser scans, BIM, GIS and IoT.

4. Virtual / Augmented Reality (VR/AR)

Description:

Virtual reality (VR) uses headsets to take over your vision to give the impression that you are somewhere else: on the construction site or looking at the details of the bridge design. The technology can improve design, safety and training. Augmented reality (AR), on the other hand, adds to your vision by offering a data overlay or 3D images in addition to what you are already seeing in front of you.

Example providers:

Yulio Technologies (US) is a program that allows designers to turn their 3D designs into VR-compatible renderings that they can show collaborators and clients. **Woodhouse Workspace** (UK) is an office design firm that uses VR technology to show clients potential office layouts and different ways to utilise their building's space. **Virtual Walk** (Belgium) allows users to 'walk' around a building before it has actually been built. **XYZ Reality** (London) has developed the Atom™, an AR headset that allows construction teams to view and position holograms of BIM onsite to 5mm accuracy. The Atom enables real-time validation of works and helps eliminate error and rework. **Real Wear** (Canada) have released the second version of their assisted reality 'smart sunglasses' headset, the RealWear Navigator 500.

List of construction technologies

5. Computer vision

Description:

Computer vision is a field of artificial intelligence that focuses on the ability of computers to derive meaning from visual inputs, such as photos and videos. Applications in construction include: improving workplace safety, analysing productivity and improving efficiency, monitoring progress, helping with quality management and making better planning decisions.

Example providers:

Buildots (Israel) uses hardhat-mounted cameras to capture imaging of every detail of an ongoing project. The data is then analysed using AI models to give on-site teams a fast way to capture what is happening on the project. **Presien** (Australia) puts sensors on heavy plant and equipment so that computer vision linked to a haptic interface can prevent accidents on site and capture 'near misses' better. **INTSITE** (Israel) similarly enables mine operators and general contractors using heavy machinery to improve productivity and safety. **ArchAI** (UK) uses computer vision from LIDAR data to make predictions as to the location of archaeological features such as burial sites. **OpenSpace** (US) combines a simple off-the-shelf 360° cameras, computer vision, and AI to make it incredibly easy to capture and share a complete visual record of a job site.

6. Predictive analytics

Description:

Predictive analytics is the use of data, statistical algorithms and machine learning techniques to identify the likelihood of future outcomes based on historical data. The goal is to go beyond knowing what has happened to providing a best assessment of what will happen in the future. Within construction, predictive analytics can help anticipate delays, project overruns and safety and risk issues – thereby allowing preemptive action to be taken and improvements made.

Example providers:

Kwant.ai enables users to rank high-risk activities related to schedule, cost, manpower, and safety using proprietary AI-powered algorithms to make proactive decisions. **nPlan** (UK) leverages machine learning on data from over 600,000 projects to quantify delay risk, with powerful suggestions/options on improvements available. **Oracle's Construction Intelligence Cloud** (US) uses predictive analysis to help identify and address issues across the project lifecycle before they can adversely impact the project.

Although more in the operations phase than construction, predictive/condition-based maintenance also falls into this category – with providers such as **Schneider Electric** and **Siemens** offering leading systems.

7. Programme optimisation

Description:

Better construction schedules can lead to huge savings in terms of time and cost. Improvements in the approach can come from being able to co-ordinate better across design and cost (5D BIM) and through better visualisation (e.g. digital rehearsals). 'Generative construction' is a new field that uses evolutionary algorithms to optimise construction programmes by running millions of different sets of assumptions and selecting the 'best' one (in terms of either time or cost).

Example providers:

ALICE Technologies (US) is leading the way on generative construction with an optimisation system that captures construction processes and links them to BIM models so that it understands space constraints. **Visilean** (Finland/UK) is applying last planner/lean planner thinking to programmes using a digital platform and links to a BIM model. **Synchro,** now owned by Bentley Systems (US), is a popular way of linking programmes to BIM models, supporting better visualisation of schedules. **Bexel Manager** (Serbia) is a good example of a 5D BIM system that enables construction simulation and schedule optimisation **Nodes & Links** (UK) uses AI to help teams access critical project knowledge more easily and automates project processes.

8. Route optimisation

Description:

Another use case for generative AI / evolutionary algorithms is route optimisation – that is, for a linear asset such as a pipeline or electricity transmission line, to find the 'best' way of getting from point A to point B. This requires the ability to understand and combine information about cost, land use and some of the engineering challenges around development.

(Route optimisation is also a term used in construction logistics for deliveries of equipment and materials – to determine the most cost-efficient route and it sometimes involves a 'hubs' model. Optimisation of 'mass haul' (earthwork movements) would be a specific example of this sort of route optimisation).

Example providers:

Continuum Industries (UK) has developed an optimisation engine ('Optioneer') that lets users automate their existing design process for infrastructure projects, capture as much geospatial and engineering detail as they want and iterate through millions of design options to find the 'best' ones. Trimble's (US) **Quantm** alignment planning tool helps road and rail planners generate and select 3D corridors and alignments by generating millions of different variations.

List of construction technologies

9. Generative design

Description:

Generative design is a way of creating and optimising 3D models of objects, based on constraints and ‘trade-offs’. It can be used to improve design elements – for strength, cost, carbon etc. It often uses evolutionary algorithms.

Example providers:

Autodesk (US) has produced a generative design extension to its Fusion 360 package. **Bentley Systems** (US) has developed Generative Components. **Archistar’s** (Australia) Generative Design Engine allows users to create conceptual building designs based on their requirements. The ability to create building concepts almost instantly can shave weeks off the planning process.

One of the challenges of generative design is finding a way to fabricate the optimised design. In addition to parametric and generative design tools, **Soliquid** (France) has created a concrete 3D printing technique that uses a suspension in a gel matrix method that aids freeform printing. This combination of a patented large-scale additive manufacturing process and a generative design approach enables a fully integrated design-to-production workflow.

10. Design configurators

Description:

Design configurators allow users to customise standard designs based on a small number of inputs - using pre-engineered components and according to pre-determined topology and/or assembly rules. They therefore effectively automate (or even, arguably, eliminate) the design process. They are particularly effective for repeatable built environment projects such as apartments, schools, petrol stations and bridges.

Example providers:

Testfit (US) helps developers, architects and contractors by preparing rapid concept design options based on parametric inputs. **Spacemaker** (US), which was acquired by Autodesk in 2020, enables users to generate, optimise and improve design alternatives, taking into account design criteria like terrain, maps, wind, lighting, traffic and zoning. **Laing O’Rourke’s** (UK) Digital Bridge Configurator has automated the design process for typical bridge types and is based on dimensional and load inputs. **Kreo** (UK) has developed products that allow owners, design teams and cost consultants (‘Kreo Design’) and developers, manufacturers and contractors (‘Kreo Modular’) to create and optimise concept designs and projects in a few hours. They also help automate quantity takeoffs, BoQs and cost estimates.

11. Factory fabrication (MMC)

Description:

Factory fabrication, Design-for-Manufacture-and-Assembly (DfMA) and Modern Methods of Construction (MMC) are terms for ways of creating construction objects (buildings or infrastructure) in a factory environment, rather than on-site. DfMA systems may be ‘volumetric’ – with buildings assembled from fairly large pre-built sections or ‘modules’. Alternatively a ‘componentised’ approach can be used with a much larger number of small sub-assemblies manufactured in the factory and assembled on site. DfMA is being used for a wide range of applications: including private houses to taller blocks, public buildings and bridges.

Example providers:

Tophat (UK) is an example of a volumetric modular housebuilder. **Cuby Technologies** (US) offers a ‘mobile, micro’ factory that arrives in 20 shipping containers and gives customers everything they need to produce factory-built houses. **Ark** (Australia) has created an end-to-end operating system and marketplace for MMC components for public buildings. **PCE’s** (UK) HybriDfma approach combines structural precast concrete, in-situ concrete and steelwork to deliver superstructure and façade in a factory using a systemised, hybrid ‘kit of parts’.

12. Logistics and supply chain software

Description:

Logistics tracking systems can track where a component or item is at all times – from the factory gate to arriving at site. Typically, this can be through the use of QR codes that record progress through each new stage of the journey with radio-frequency identification devices (RFID) or disposable GPS stickers. Route optimisation can make journeys shorter and more efficient in terms of fuel and carbon. The use of ‘hub’ (intermediate set-down areas) and ‘control towers’ to take a holistic view of deliveries can also help.

The category is linked to supply chain software that helps anticipate and mitigate supply difficulties and bottlenecks; reduce inventory and waste and help move to more ‘just-in-time’ working.

Example providers:

Matrak (Australia) and **Voyage Control** (UK) are examples of logistics software systems for the construction sector. **Wincanton** have developed their Winsight Supply Chain Integrator (WSCI) system, which is being used for the complex logistics for Hinkley Point C nuclear power station project. **Propergate** (Poland) assists with the planning, registering, ordering, scheduling, unloading and reporting of material deliveries to site allowing more of a ‘just-in-time’ approach.

13. Connected Autonomous Plant

Description:

Connected and Autonomous Plant (CAP) refers to construction plant that is connected to its environment through sensors or wireless transfer of data (the 'connected' part), while 'autonomous' refers to the vehicle's ability to move around a site under its own control (or the control of a remote operator). National Highways' Roadmap to 2035 set out a goal of making automation business-as-usual in construction by 2035. At present, plant is more 'connected' than 'autonomous'.

Example providers:

MachineMax (UK), now owned by Shell, has pioneered an intelligent data platform for off-highway construction fleets that improves decision-making for jobsite operations. **VisionLink** (US) is Caterpillar's and Trimble's own proprietary platform. **Hiboo** (France) is also able to connect truck fleets, as well as plant and equipment data, to provide a more holistic view of equipment usage. More in the operating system arena, **Built Robotics** (US) has developed Exosystem™, which enables site plant to operate autonomously. It includes proximity radar and 360° cameras. **SafeAI** (US) retrofits heavy equipment for autonomous applications in the mining and construction industries.

14. Robotic tools and assembly

Description:

A somewhat tautological definition of 'construction robots' is that they are automated machines that assist in construction. They may replace human workers, make their roles easier or allow things to be done and information to be gathered in new ways.

Example providers:

The iconic image of construction robots is probably the **Boston Dynamics** (US) robot dog ("Spot"). However, a number of start-ups are genuinely using robots to automate and enhance site processes.

Hausbots (UK) has developed a wall-climbing robot that can be used for exterior painting and infrastructure inspection. **Kewazo's** (Germany) LIFTBOT robot is used to assemble scaffolding more safely and with lower labour costs. **Rebartek** (Norway) uses robots to cut and assemble reinforced steel ('rebar') cages. **Dusty Robotics'** (US) FieldPrinter robot automates the process of layout marking on site. **Baubot** (Austria) is a compact mobile robot that can drive through doors, climb stairs and use elevators/lifts. The idea is to create a flexible fleet of real-world 'bots' to perform a myriad of tasks: welding, screwdriving, sanding and many more. **Hypertunnel** (UK) are using a fleet of 'hyperBot' robots to 3D-print the tunnel shell, with a large gain in cost-reduction and speed. **Raise Robotics** (US) builds robotic equipment to help workers with challenging tasks on construction sites, making jobs safer and preventing rework.

15. 3D printing

Description:

Construction 3D printing (sometimes referred to as 'additive manufacturing') is the computer-controlled sequential layering of materials to create three-dimensional shapes. It is particularly useful for prototyping and for the manufacture of geometrically complex components – for example the output of generative design (see Category 9 above). The most common type of printer is based on a robotic arm that moves back and forth while extruding concrete.

(Subtractive manufacturing is used much less frequently in construction. It is an umbrella term for the process of creating objects by starting with solid blocks, bars, rods of plastic, metal, or other materials and shaping them by removing material through cutting, boring, drilling, and grinding).

Example providers:

Mighty Buildings (US) is creating sustainable homes using 3D printing, robotics and automation. Icon (US) has created the Vulcan 3D printer which, along with its BuildOS software suite, is capable of printing homes and structures up to 3,000 square feet without relocation. **Tvasta** (India) and **Ethereal Machines** (India) design and develop 3D printing technology, machinery and materials for use in construction.

16. New construction materials

Description:

New construction materials refers to the innovations in concrete, insulation, steel, aggregates and other important material inputs to the construction process. The new materials have a range of superior properties – in terms of strength, carbon impact, insulation, fire resistance etc. – as well as, potentially, being lower in cost and easier to assemble/install.

Example providers:

Material Evolution (UK) is creating a new form of sustainable cement based on alkali fusion technology. **ECOncrete** (Israel/Spain/USA) developed a concrete technology for responsible marine construction including a patented admix, texture agents and moulds for nature-inclusive design. Benefits include enhanced carbon storage, superior structural performance and a healthy marine ecosystem. **Thermulon** (UK) are developing aerogels suitable for building insulation. These will be beneficial for applications where space is particularly valuable as less floorspace is lost through additional thermal insulation using aerogels rather than conventional solutions such as mineral wool. **Versarien** (UK) has launched CementeneTM, which is a graphene-based admixture to enhance concrete structures - reducing both costs and the carbon footprint.

List of construction technologies

17. Social value and community engagement

Description:

In the context of the built environment, social value is created when buildings, places and infrastructure support environmental, economic and social wellbeing, and in doing so improve people's quality of life. How this is measured, and how the benefits are quantified is technically difficult and it is also hard to ensure transparency and fairness. Various platforms and calculators have been developed to help make this easier.

Community engagement should involve contractors and consultants (architects, engineers, surveyors, sub-contractors etc.) engaging the community to ensure construction impacts are minimised.

Example providers:

Impact Reporting (UK), **Social Value Portal** (UK), **Thrive** (UK) and **Loop** (UK) are examples of more general social value platforms that are used in construction to measure, evaluate and report an organisation's social value initiatives. We do not know of a social value tool that is specifically designed for construction and infrastructure projects.

Sitepodium (the Netherlands) is specifically focused on construction and offers a better way to manage communications with communities affected by construction projects.

18. Carbon tools and calculators

Description:

Carbon footprinting requires the analysis of a large number of materials, products, processes and assemblies, the data for which is often ambiguous or unavailable. High quality embodied carbon calculators are therefore essential to support any claims of carbon neutrality. Such calculators typically capture details of the object in question and link it to a table of carbon values. By doing this across all the objects for the project, an overall carbon value can be obtained.

Example providers:

One Click LCA (Finland) provides a range of different tools for calculating environmental impacts according to 60+ different standards, regulations and certifications. **Cercula** (UK) uses natural language processing to interpret the object referred to in a bill of materials and link it automatically to the relevant carbon factor. **nZero** (US) links utilities, fleet and metering data into a single platform that reports water and energy use and carbon information. **Preoptima** (UK) links design choices to their implications in terms of carbon. **Emidat** (Germany) is a carbon API that integrates directly into existing construction software tools to calculate emissions.

19. Waste management software

Description:

Construction waste is any unwanted material created by the construction and demolition industries. All construction companies are legally required to reduce, reuse and recycle demolition and building waste before disposal. Software and data can help automate and optimise the steps necessary to ensure compliance, and improve transparency and reporting. They can also make it easier to access waste resources and promote reuse and recycling through collaboration.

Example providers:

Teamoty's (France) Recycle software helps with better traceability of construction waste, promoting selective sorting and improving waste reuse. **Qflow's** (UK) tracks and audits and all materials and waste going on and off site, to support material management, reduce construction waste and support the circular economy. **Skrap** (UK) is a procurement app marketplace for construction waste management, able to track, audit and report on finances, waste and carbon footprint. **Enviromate** (UK) has created a marketplace where people connect with one another to buy, sell and search for leftover building materials. **Loopfront** (Norway) helps building owners and contractors to reuse construction materials more easily.

20. Procurement and contract management

Description:

Procurement platforms help construction companies manage their entire procurement process from beginning to end; and contract management software helps automate change management and payment. Subcategories include: procurement for general contractors and materials/inventory procurement for subcontractors.

Example providers:

Cosuno (Germany) allows general contractors to publish tenders, negotiate for the best prices and mange their subcontractors through to payment and close-out. **ProTenders** (UAE) is a construction intelligence and e-Tendering platform that enables developers, consultants, contractors and suppliers to showcase their work, find new opportunities and streamline their processes. **ProcurePro** (Australia) helps enhance subcontractor engagement and allows better comparisons between potential suppliers and can generate subcontracts almost automatically. CEMAR, one of **ThinkProject's** (Germany) range of applications, is a dedicated contract management solution for NEC, FIDIC and other contract types. **Kojo** (US) is a materials procurement platform; and **StructShare** (US) also handles material management, along with procurement and accounts payable.

List of construction technologies

21. Workforce management apps

Description:

The purpose of construction workforce management is to ensure that a construction company has the necessary team members doing the right things at the right time. This can be supported by software and data management tools that support recruitment, onboarding, onsite management and safe working (see Category 27) to help increase the productivity, efficiency and safety of team members and the site.

Example providers:

Rhumbix (US) helps capture time and utilisation data around labour, equipment, and materials to provide rapid daily and weekly reports around issues such as timekeeping. **Assignar** (US) offers workforce and asset scheduling, project planning and compliance reminders and inspections. **innDex** (UK) began as a fast-track onboarding solution for new workers on site. The range of services now extends to digital inductions, access control and on-site briefings. **Fieldwire** (US), which is now owned by Hilti, connects the field to the office, enabling efficient and real-time information sharing across the team. **Fixed** (UK) is an example of a construction recruitment marketplace – to put construction workers and employers in touch based on competencies.

22. Site positioning systems

Description:

Applications such as progress tracking using 360° cameras and materials require suitably accurate systems to track position on site. Measuring position on the 'z' (vertical) axis can be particularly problematic and is something that GPS cannot achieve. A variety of technologies are being developed to solve this problem.

Example providers:

Indoor Atlas's (Finland) patented magnetic technology uses natural anomalies of the geomagnetic field to pinpoint locations indoors. **Advanced Navigation** (Australia) offers a range of navigation systems, including some that use inertial navigation (dead man's reckoning) to provide an accurate position, velocity, acceleration and orientation. Construction is one of their 'use cases', although it is not a main one. **Zerokey** (Canada) has developed a hyper-accurate positioning system to provide building-scale millimetre-level 3D localisation of objects using a convenient coin-sized IIoT sensor. **Oriient's** (Israel) cloud and geomagnetic-based indoor positioning application enables users to locate, monitor, analyse and navigate indoor locations through mobile applications.

23. Materials and equipment tracking

Description:

It is clearly useful to know where materials, plant and equipment is on site, and to have better control over its planning, management and use. In terms of location, this is done through GPS or other more advanced techniques – see Category 22. There is also crossover in terms of equipment tracking with Category 13 (Connected Autonomous Plant) and Category 12 (Logistics & Supply Chain Software.)

Example providers:

Ynomia (Australia) tracks and reports on the progress of all building components, predominantly high-value off-site fabricated elements. **Intelliwave's** (US) SiteSense® Materials Management software manages and tracks the quantities and locations of construction materials, tools and equipment on infrastructure and buildings projects.

In terms of tools and equipment, **Embneusys** (Greece) is an IoT platform that helps construction and rental companies to monitor their machinery and equipment regarding location and working conditions. For larger plant and equipment, **Hiboo** (France), (UK) and others provide tracking solutions – see Category 13 (Connected Autonomous Plant).

24. Site management and reporting

Description:

Although overlapping with some of the other categories, site management and reporting software brings together data from other sources into a single 'dashboard' and allows better decisions about the site to be taken in both real time and from the perspective of longer-term trends.

Example providers:

Planradar (Austria) is a global SaaS platform that digitises daily processes and communication, enabling time savings, cost savings and allowing projects to be completed to a higher quality. **Sitemate** (Australia) streamlines reporting and analytics. It provides custom dashboards and automated charts. **Sablono** (Germany) enables project partners on and off the site to track and share detailed progress information to enable real-time supply chain collaboration. **Foresight Works** (UK/Israel) has created Knowledge Concierge as a data integration platform to deliver insights at all levels, including as a C-Suite dashboard. **Xpedeon** (UK) is more of an ERP system for construction and engineering applications, so its reporting covers budgets, costs and cashflows. **CONQA** (ANZ) is software that helps contractors to plan and execute quality assurance in the field: minimising rework, increasing productivity, and substantiating claims.

List of construction technologies

25. Site communication

Description:

This category covers applications that support communication and collaboration – between workers or with the client. This can be the integration of existing communication means – messaging, texts, emails, calls etc. – or new ways of communicating.

Example providers:

SymTerra's (UK) platform allows easy, instant, and intuitive communication across multiple contractors on the same project. **Letsbuild** (Belgium) helps to centralise all project communications, allowing everyone to focus on the schedule and report progress to the stakeholders who most need to know. **CoConstruct** (US), now owned by Buildertrend, is particularly good for communicating with clients. **JobNimbus** (US) allows managers to assign tasks, jobs, and work orders to employees using @mentions. They can then send messages and reminders to the assigned employee to help ensure that the job gets done. **Mobilus Labs** (UK) has pioneered a two-way bone conduction communication system, built into a construction hard hat, that provides a hands-free, ear-free voice experience. **Fieldlens** (US), now owned by RedTeam, allows users to share safety information, such as hazard alerts or upcoming work schedules, with their team in real-time.

26. Wearable technology

Description:

Wearable devices can be worn physically by people at a construction site. These devices can automatically collect real-time data from the environment and provide information to those wearing them. Wearables can range from 360° cameras to smart helmets and bionic suits (!). Sometime PPE is technology-enhanced, so there is a link with Category 27 (Safety Apps).

Example providers:

WakeCap (Saudi Arabia) builds its wearable into the tightening knob on a helmet so that workers can be tracked around the site to improve visibility, workforce plan versus actual and vendor control. It also helps to speed evacuations and with emergency management. **XYZ Reality's** (UK) ATOMTM is another example of a smart headset. **Swanholm Technologies'** (Sweden) has produced a connected safety vest that, by sensing the movement of the person, triggers an alarm in the event of a fall and lights up when the worker is in an exposed position – such as exiting a vehicle. **Kenzen** (US) has launched a body heat system that uses physiological monitoring for the prevention of heat injury and death among workers. **Reactec** (UK) is combating Hand-Arm Vibration (HAV) in construction workers through its wearable smartwatches.

27. Safety apps

Description:

Safety software and applications is one of the largest categories of construction technology by number. In some cases, these replace current paper-based systems; in others, there is completely new functionality, for example through AI. Some safety-related systems are covered in Category 5 (Computer vision).

Example providers:

1Breadcrumb (Australia) collects, approves, and accesses compliance documents across every worksite – by laptop, tablet and mobile. **Hammertech** (Australia) now has 16 modules that link operational management with improved safety performance. **Evotix's** (UK) safety management system co-ordinates safety data, records and tasks, but also delivers EHS training to staff that need it through the app. **Plinx** (UK) prevents site workers from getting to higher hazard areas of the site, based on role and purpose. **Saifety.ai** (UAE) uses machine learning both to enhance the interactions that site staff have and improve the quality of data captured. It is able to increase engagement with safety management systems, including by 'suggesting' to workers how they personally can improve their safety.

28. IoT sensors

Description:

IoT sensors and devices can help improve worksite visibility at all stages of construction projects in real-time, including post-construction operations. Some of the applications are linked to other categories – such as Category 23 (Materials and Equipment Tracking), but there are plenty of further 'use cases' such as remote operations, activity monitoring and concrete curing.

Condition-based (or planned predictive) maintenance is not strictly speaking a construction technology, but installing the right sensors during construction is important to realise the benefits of this approach.

Example providers:

Converge's (UK) Concrete DNA system uses embedded sensors to help improve concrete curing times and provide materials performance analytics. **Evercam** (Ireland) offers a developer platform for Industrial IoT sensors and cameras, plus various hosted services and a marketplace for apps. **Pressac** (UK) is an example of a business that designs and manufactures smart building sensor technology. **Plumis** (UK) manufacturers and installs IoT sensors connected to a fire suppression system (Automist), which will allow occupants more time to escape from a burning building.

List of construction technologies

29. Workflow apps

Description:

This category covers software that supports communication and collaboration – between workers or with the client. This can be the integration of existing systems – messaging, texts, emails, calls etc. – or new ways of communicating. The category is closely linked to Category 21 (Workforce management apps) and Category 25 (Site communication).

Example providers:

Archdesk (UK) streamlines construction workflows – from the administrative tasks of storing details of projects and clients, through to estimation, accounting, project management, scheduling and programs of works. It is highly customisable. **Revizto** (Switzerland) brings together teams and workflows into one integrated platform and facilitates BIM coordination among all project members. **Ontraccr** (Canada) not only integrates workflows, but helps automate tasks such as sending emails, dispatching workers, managing approvals and transferring data. Workflow creation and integration is also part of **Autodesk's** (US) BIM 360 suite and Autodesk Construction Cloud. **Morta** (UK) enables professionals across the supply chain to streamline processes using a no/low-code tool that is as customisable as a spreadsheet and has the utility of a database.

30. Digital handover software

Description:

The digital handover is the final step of the construction process. It is the moment when the main contractor releases the site to the end-user with the proof that everything has been reviewed and approved.
A handover procedure will typically be made up of: testing and commissioning; defect management; compliance reporting and the handover itself. In the paper era, the process involves hundreds of documents, drawings, plans and certificates. By contrast, digital handover software helps assemble all the necessary documentation and models in a final cloud-based package that can be accessed and shared by multiple users across various locations.

Example providers:

Invicara's (Ireland) 'Asset Twin', built on Twinit, includes required templates, process framework, data management tools, training and support for the contractor to produce and deliver an Asset Twin at project handover. Now owned by BuildData Group, **Zutec** (Ireland) provides a cloud-based platform for documentation management and asset information across the entire construction lifecycle, including digital handovers. **Inndox** (Australia) provides software for developers, builders, agents, inspectors and owners to handover, manage, maintain and perform due diligence.

31. Insurance and risk management

Description:

Construction operates through a complicated arrangement of insurance, warranties and bonds. Start-ups are finding ways to challenge and change some of these approaches, thereby reducing transaction costs. They are also applying novel approaches to risk management and mitigation.

Example providers:

BILD (Australia) is developing an insurance product that can replace the bank bond that contractors and subcontractors are required to provide before commencement of a project. **Rosetta Risk Management** (UK) aggregates construction risk performance data for insurers, brokers, contractors, developers and lenders. The insights can help reduce premiums and increase the speed of settling claims.

Riskwell's (UK) rich personally customisable dashboards help companies manage their decision-making and risk management, improving ROI. **Beawre** (Spain) links monitoring to each business process in real-time to anticipate operational risks based on AI-driven predictions. **Avetta** (US) helps companies manage their supply chain risks, as well as offering a commercial marketplace platform.

32. Asset management software

This is not strictly speaking a category of construction technology (as it clearly relates to the operational phase of an asset) but we include it in this list for completeness.

Description:

Computerised maintenance management software (CMMS) is used to streamline and automate maintenance tasks, providing communications for maintenance-related activities. In buildings and infrastructure this may be linked to a (digital) Asset Twin or sensors that enable condition-based (or preventative) maintenance, as well as support better general maintenance and compliance.

Example providers:

UpKeep's (US) Asset Operations Management Platform streamlines the work order process to help move from reactive to preventive maintenance. **Passivelogic** (US) has developed a platform to control building systems autonomously.This replaces legacy control logic with real-time control decisions at the edge. **Trendspek** (Australia) provides Precision Asset Intelligence software which it says can create the most accurate virtual asset models in the world. This extra accuracy, along with a suite of tools, enables engineers and asset managers to take better decisions about risk, maintenance and other crucial actions.

Final summary

The importance of construction technology.

Construction is big business. Total construction output is estimated to reach US$14.4tr by 2030.

Building and infrastructure materials and construction (typically referred to as embodied carbon) are responsible for 13% of global CO2 emissions annually, and construction creates an estimated third of the world's overall waste.

This is why construction technology matters. Tech solution by tech solution we can find new ways of tackling the problems that construction causes and help to improve the quality of the built environment around us.

The C-Tech Club is playing its part.

About the C-Tech Club

The C-Tech Club is a global community of more than 350 founders and CEOs of construction technology start-ups. It is a global, not-for-profit group spanning 28 countries. We are here to help founders succeed and support the development and use of technology.

The community grows largely through recommendations and referrals – always keeping true to the spirit of a 'by-founders-for-founders' group.
www.c-techclub.org

About this study

Nearly 30 members of the C-Tech Club – all founders and/or CEOs – were involved in the development of this document. They contributed ideas and feedback on the categories of technology to be included, the way each should be described and the example providers to be mentioned.

They did this through a series of 'round table' discussions and through online feedback. We are very grateful to all those who gave up their time in this way (a list of founders and CEOs who contributed is included on the back page).

Photo courtesy of Cathago

Companies mentioned in this report:

1Breadcrumb (www.1breadcrumb.com) · **Advanced Navigation** (www.advancednavigation.com) · **AEC+Tech** (www.aecplustech.com) · **Aerologix** (www.aerologix.com) · **ALICE Technologies** (www.alilcetechnologies.com) · **ArchAI** (www.archai.io) · **Archdesk** (www.archdesk.com) · **Archistar** (www.archistar.ai) · **Ark** (www.ark.build) · **Asbuiltdigital** (www.asbuiltdigital.com) · **Assignar** (www.assignar.com) · **Autodesk** (www.autodesk.com) · **Avetta** (www.avetta.com) · **Baubot** (www.baubot.com) · **Beawre** (www.beawre.com) · **Bentley Systems** (www.bentley.com) · **Bexel Manager** (www.bexelmanager.com) · **BILD** (www.bild.company) · **Buildots** (www.buildots.com) · **Built Robotics** (www.builtrobotics.com) · **Cercula** (www.cercula.io) · **Civ Robotics** (www.civrobotics.com) · **CoConstruct** (www.coconstruct.com) · **CONQA** (www.conqa.com) · **Continuum Industries** (www.continuum.industries) · **Converge** (www.converge.io) · **Cosuno** (www.cosuno.com) · **Cuby Technologies** (www.cubytechnologies.com) · **Docuping** (www.docuping.com) · **Dusty Robotics** (www.dustyrobotics.com) · **ECOncrete** (www.econcretech.com) · **EHAB** (www.ehab.co) · **Embneusys** (www.embneusys.com) · **EMerald Geomodelling** (www.emerald-geomodelling.com) · **Emidat** (www.emidat.com) · **Enviromate** (www.enviromate.co.uk) · **Ethereal Machines** (www.etheralmachines.com) · **Evercam** (www.evercam.uk) · **Evotix** (www.evotix.com) · **Fieldwire** (www.fieldwire.com) · **Fixed** (www.fixedconstruction.io) · **Fonn** (www.fonn.com) · **Foresight Works** (www.foresight.works) · **Forsightdigital** (www.forsightdigital.com) · **GHD** (www.ghd.com) · **Hacarus** (www.hacarus.com) · **Hammertech** (www.hammertechglobal.com) · **Hausbots** (www.hausbots.com) · **Herotech8** (www.herotech8.com) · **Hiboo** (www.hiboo.io) · **Hypertunnel** (www.hypertunnel.co.uk) · Icon (www.iconbuild.com) · **Impact Reporting** (www.impactreporting.co.uk) · **Indoor Atlas** (www.indooratlas.com) · **index** (www.inndex.co.uk) · **Inndox** (www.inndox.com) · **Intelliwave** (www.intelliwavetechnologies.com) · **INTSITE** (www.intsite.ai) · **Invicara** (www.invicara.com) · **JobNimbus** (www.jobnimbus.com) · **Kenzen** (www.kenzen.com) · **Kewazo** (www.kewazo.com) · **Kojo** (www.usekojo.com) · **Kreo** (www.kreo.net) · **Kwant** (www.Kwant.ai) · **Laing O'Rourke** (www.laingorourke.com) · **Letsbuild** (www.letsbuild.com) · **Loopfront** (www.loopfront.com) · **MachineMax** (www.machinemax.com) · **Material Evolution** (www.materialevolution.com) · **Matrak** (www.matrak.com) · **Mighty Buildings** (www.mightybuildings.com) · **Mobilus Labs** (www.mobiluslabs.com) · **Modulous** (www.modulous.com) · **Morta** (www.morta.io) · **myComply** (www.mycomply.net) · **Loop** (www.loop.org.uk) · **NeuralRays AI** (www.neuralrays.ai) · **Nodes & Links** (www.nodeslinks.com) · **nPlan** (www.nplan.io) · **nZero** (www.nzero.com) · **One Click LCA** (www.oneclicklca.com) · **Ontraccr** (www.ontraccr.com) · **OpenSpace** (www.openspace.ai) · **Oracle** (www.oracle.com) · **Oriient** (www.www.oriient.me) · **Passivelogic** (www.passivelogic.com) · **Pathw.ai** (www.pathw.ai) · **PCE** (www.pceltd.co.uk) · **Planradar** (www.planradar.com) · **Plinx** (www.plinx.io) · **Plumis** (www.plumis.co.uk) · **Preoptima** (www.preoptima.com) · **Presien** (www.presien.com) · **Pressac** (www.pressac.com) · **ProcurePro** (www.procurepro.co) · **Propergate** (www.propergate.co) · **ProTenders** (www.protenders.com) · **Qflow** (www.qualisflow.com) · **Raise Robotics** (www.raiserobotics.ai) · **Real Wear** (www.realwear.com) · **Rebartek** (www.rebartek.com) · **RedTeam** (www.redteam.com) · **Revizto** (www.revizto.com) · **Rhumbix** (www.rhumbix.com) · **Riskwell** (www.riskwell.co.uk) · **Rosetta Risk Management** (www.rosettarm.com) · **Sablono** (www.sablono.com) · **SafeAI** (www.safeai.com) · **Saifety.ai** (www.saifety.ai) · **Schneider Electric** (www.se.com) · **Sensat** (www.sensat.co) · **Siemens** (www.siemens.com) · **Sitemate** (www.sitemate.com) · **Sitepodium** (www.sitepodium.com) · **Skrap** (www.skrap.co.uk) · **Soliquid** (www.soliquid.io) · **StructShare** (www.structshare.com) · **Swanholm Technology** (www.swanholmtech.com) · **Symterra** (www.symterra.co.uk) · **Sync Technologies** (www.synctech.io) · **Teamoty** (www.teamoty.io) · **Testfit** (www.testfit.io) · **Thermulon** (www.thermulon.com) · **ThinkProject** (www.thinkproject.com) · **Thrive** (www.thrive-platform.com) · **Tophat** (www.tophat.io) · **Trendspek** (www.trendspek.com) · **Trimble** (www.trimble.com) · **Tvasta** (www.tvasta.construction) · **UpKeep** (www.upkeep.com) · **Versarien** (www.versarien.com) · **Virtual Viewing** (www.virtualviewing.co.uk) · **Virtual Walk** (www.virtualwalk.be) · **Visilean** (www.visilean.com) · **VisionLink** (www.myvisionlink.com) · **Voyage Control** (www.voyagecontrol.com) · **WakeCap** (www.wakecap.com) · **Wincanton** (www.wincanton.co.uk) · **Woodhouse Workspace** (www.woodhouseworkspace.com) · **Xpedeon** (www.xpedeon.com) · **XYZ Reality** (www.xyzreality.com) · **Ynomia** (www.ynomia.io) · **Yulio Technologies** (www.yulio.com) · **Zerokey** (www.zerokey.com) · **Zutec** (www.zutec.com)

We are grateful to the following C-Tech Club members who have contributed to the development and preparation of this report:

Niknaz Aftahi (AEC+Tech) · **Stuart Bailey** (Virtual Viewing) · **Lucy Clarke** (Fixed) · **Sarah Crawley** (SymTerra) · **Carolina Dreifuss** (Sync Technologies) · **Teji Gobran** (BILD) · **Josh Graham** (EHAB) · **Jan Tore Grindheim** (Fonn) · **Karim Helal** (Protenders) · **Hussain Hilli** (Skrap) · **Ebrahim Lamkanfi** (Pathw.ai) · **Simon MacArthur** (Docuping) · **Dan Maldonado** (myComply) · **Chris Mortensen** (Modulous) · **Lisa Oberaigner** (Emidat) · **John Priestland** (Priestland Consulting) · **John Roberts** (Priestland Consulting) · **Zigmund Rubel** (Forsightdigital) · **Tony Scott** (NeuralRays.ai) · **Prakash Senghani** (Saifety.ai) · **Mohammad Shana'a** (Morta) · **Philip Smet** (Pathw.ai) · **George Smithies** (innDex) · **Zusanna Stefanska** (Evercam) · **James Swanston** (Voyage Control) · **Mike Turpin** (Priestland Consulting) · **Anna Walkowska** (Propergate) · **Tommy Williams** (Plinx)

Find out more:

To find out more about the C-Tech Club visit **www.c-techclub.org** or email **info@c-techclub.org**

Graphic design by Nick Robertson, Design by Smith (www.designbysmith.com).

C-TECH CLUB