FEASIBLE FUTURES: Robot Adoption – the SME Challenge
On the catwalk of construction improvement, there is no doubt that robotics and automation are the ‘new black’, next in line to building information modelling (BIM), modern methods of construction (MMCs) and other purported solutions to the challenges the construction industry faces.

Whether solving the efficiency, quality, integration or productivity challenges of the sector, the technological allure of an automated future continues to attract significant interest from designers, manufacturers and policy-makers. But as promising as this may be, the shape of a future construction industry dominated by robotics and automation is far from certain.

We can speculate about technology but without also thinking through the various impacts on organisations, supply chains, relationships, and business models, the conversations about robotics will continue to remain somewhat in the realm of science fiction.

So, what are these impacts — on current organisations, professions, skill requirements, contracts and supply chains? What value do robots bring, and to whom? Whose interests do robots serve? Who will be the winners and losers in the adoption of robotic technologies?

This research project, Transitioning to an automated construction supply chain: future business models for SMEs developed these ideas with our industry partners. We posed and explored these questions with industry experts and SMEs in the sector, and were able to assess possible impacts and requirements, moving on to discuss and trace how these futures might play out. By imagining the future and then trying to link it back to the present, potential paths of transformation can be considered, and plans for action developed.

We have used such techniques before to great effect — importantly, the central idea is not to predict the future, but to rehearse — sometimes radical — possibilities, and to turn technological promise into potentially very substantive change.

To account for barriers to adopting robots such as the inflexibility of coping with product variation, a shortage of maintenance skills, and high implementation costs, this report showcases four scenarios developed during this research project to recast discussion surrounding automation in construction. We focused on the following:

- Value propositions of automating manufacturing processes for SMEs
- Constraints and opportunities for tier 2 and 3 SME firms adopting robotics and machine-based automation
- Potential implications for SMEs operating in future scenarios where supply chains include characteristics of automation

TRANSFORMING CONSTRUCTION NETWORK PLUS

The project Transitioning to an automated construction supply chain: future business model innovation for SMEs is supported by The Transforming Construction Network Plus (N+) which is funded by UK Research and Innovation through the Industrial Strategy Challenge Fund. The N+ unites construction’s academic and industrial communities to create a new research and knowledge base, dedicated to addressing the systemic problems holding back the sector. The N+ is a joint project between UCL, Imperial College London and WMG, University of Warwick.
Introducing the scenarios

The following pages illustrate four future scenarios. Each scenario is presented through a collection of illustrations and descriptors to help convey the key themes and issues. These include newspaper articles, screenshots of websites, social media snapshots, and case studies of SMEs operating in these scenarios. The scenarios put forward present the technology as stable, and are there to explore the potentialities of non-technological innovations (e.g. business model innovations) to implement robotics with Tier 2 and 3 SME firms.

A ‘Thematic Equaliser’ (see right), showing the potential characteristics of a particular automated supply chain of the future, accompanies each of the four scenarios. Each of the five faders represents a transition theme relevant to an area of impact robotics and automation will have on the industry. These are:

1) **Workforce** – how might skills be spread throughout the industry?
2) **Ownership** – how might different ownership models shape the industry?
3) **Regionality** – where might elements of the supply chain be located?
4) **Development** – how might operating logics vary depending on the portfolio of projects?
5) **Standardisation** – to what extent is the built environment standardised?

Collectively, the faders represent the overall shape of the future construction industry and the interconnectivity between transition themes. If we modify one aspect of a scenario in a particular theme, we need to consider the range of future possibilities and modifications in other themes.

Introducing the scenarios

Albeit tempting, to think of these scenarios as potential pathways to a future state is not the intention. Instead we aim to reinforce how adaptations to themes have widespread implications, and how speculating about feasible futures involves acknowledging these broader transitions in the built environment. These are imagined scenarios based on research conducted (see ‘About the team’). Try to imagine yourself in these scenarios by moving between the different illustrations, descriptors, and thematic mixer. These will catalyse discussion and dialogue about how contemporary business models in construction might change in concurrence with the industrial landscape.

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<tr>
<th>STATE</th>
<th>MARKET</th>
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<tr>
<td>REGULATED MARKET AND STATE-OWNED ASSETS</td>
<td>NEOLIBERAL POLICIES FACILITATE VERTICAL INTEGRATION</td>
<td>LOCALISED OPERATIONAL ACTIVITIES</td>
<td>NEW BUILD &amp; GREENFIELD</td>
<td>HIGH LEVEL OF STANDARDISATION AND INCREASED PREFABRICATION RATIO</td>
<td>DESEGREGATED SKILL BASE WITH MINIMAL PREFABRICATION A HIGH VARIETALITY IN PRODUCTS AND SERVICES</td>
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<td>PROFIT-MAKING ACTIVITIES ARE PROTECTED</td>
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<td>LAND ACQUISITION AND DEVELOPMENT TARGETED TOWARD BUSINESS NEW BUILD AND GREENFIELD SITES</td>
<td>HIGHLY SKILLED YET DELIMITED WORKFORCE SKILL SET ORIENTED TOWARDS CONSTRUCTION AS MANUFACTURING</td>
<td>DIVERSE SKILLED SKILL BASE OF SPECIALISTS INCLUDING THE EDUCATION SYSTEMS THAT SUPPORT THESE</td>
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Scenario 1: Tier 1 oligopolies

Incumbent firms have lost out to new market entrants

Large contractors have bought up parts of the supply chain and control end-to-end production of buildings and infrastructure. Standardised product platforms and design templates needed for automation/robotics led the Mega 5 to bring design, construction and manufacturing in-house.

A focus on vertical integration...

The tiered systems of construction supply chains have been replaced by 5 companies – the Mega 5 – which employ the entire construction and manufacturing industry in the UK resulting in the end of the multi-tiered system. The Mega-5 operate in the form of a cartel whereby each company focuses on particular sectors of the industry – residential, commercial, heavy civil, industrial and environmental – ensuring profits for each company.

Each of the Mega-5 is focused on providing a consistent approach to delivering their sector-specific projects. The workforce remains relatively diverse and holds on to traditional construction roles with the combined knowledge and experience of the parent company and newly acquired SMEs, but automation skills begin to develop as planning and design functions become standardised with each company.

SME case study in Chronos Corp internal newsletter

As one of the 700,000 SMEs that have become part of Chronos Corp, Hestia Steel have embraced the opportunities that have become available to them. Product platforms and design templates needed to capitalise on automation and robotics were unattainable before for Hestia Steel became part of Chronos Corp. Chris, CEO of Hestia Steel came to the Chronos Corp headquarters for an interview where Olivia from Marketing asked his about his experience of joining of the Mega 5. Here’s a transcript of the interview:

Olivia: How’s Business since joining Chronos Corp?

Chris: By being the sole supplier of residential, Chronos Corp appreciate the value in small localised contracts helping Hestia Steel to maintain and maximise relationships with their contacts. We’ve incorporated their operations and are utilising the resources and capabilities of Chronos Corp while retain some of the parts of the company that we’ve grown to love.

Olivia: What do you like about being part of the Chronos Corp Family?

Chris: We know our customers and we also know the region – we didn’t have the capacity to expand in terms of employment space. Even if we had the space, it was getting difficult to recruit - our machine space, it was getting difficult to recruit - our machine workforce was losing skills that we couldn’t replace.

Olivia: How would you characterise Hestia Steel?

Chris: Dennis to focus on end-to-end automation of the construction process as its top priority … continued on page 46

Construction’s “Mega 5” make their final acquisition

One of construction’s “Mega 5” – Cronus Corp - is getting its second acquisition-fuelled jolt of the past few weeks. The company made the announcement on Friday that it is acquiring 30-year old SME Demeter-Fabrications for £27.5 million.

The acquisition of Demeter Fabrications comes exactly one month after Cronus Corp announced plans to acquire Hestia Steel, another SME manufacturing firm, for £36 million in November (the deal closed today). Together, the two acquisitions mean South East-based Cronus Corp has paid £63.5 million in a month. Acquiring Demeter and Hestia, both based in the NW, pours some fuel on the fire of Cronus’s strategy under CEO Peter Dennis to focus on end-to-end automation of the construction process as its top priority … continued on page 46
Scenario 2: Software vendor and OEM dominate

Incumbent firms have lost out to new market entrants

Software and robotic development corporations dominate the construction industry. Software vendors have acquired factories, fulfillment networks, and knowledge required to deliver a fully automated design, manufacture, and construction process. Construction Robotics Inc are a robotic firm specialising in automation. Designed by robots for robots manufacturing in mega factories ensures that Construction Robotics Inc can secure availability of buildings within 5 working days.

Technology takes the lead...

Construction Robotics Inc offer various Robotics-as-a-Service options such as Click & Deliver whereby clients specify buildings based on a sliding scale of alternatives from a defined set of styles. Modular elements are subsequently manufactured and either delivered to regional distribution hubs for collection or delivered directly to site. Customers also have the option to buy add-on packages and upgrade their service to Click & Construct where Construction Robotics Inc draw on the service to Click & Construct where customers can secure availability of buildings in mega factories ensures that Construction Robotics Inc can secure availability of buildings within 5 working days.

SME case study on Construction Robot Corp’s (CRC) website

ABC Assemblies International are taking advantage of the heavy investment in AI technology provided by Construction Robot Corp (CRC). We talked to the Digital Design Manager at the SME to find out more about becoming one of CRC’s leading suppliers.

“Construction Robot Corp are very data-driven – through a bootstrapping initiative our company has engaged with the deep learning-powered analysis of our company operations. We’ve engaged with the order fulfilment network contract (OFN) CRC offer creating the capacity to increase production threefold. We now supply for nationwide projects by feeding our repeatable products into the modular mapping service CRC provide.

The fees can be quite high depending on the type of projects currently underway and you do hear of some OFN contract nightmares on the supplier forums where companies have had their products mis-specified for project requirements, but without the ability to store our products throughout the fulfilment network investing in a robotic system would not have been feasible for us. For a small fee we are able to store our products close to where we supply. We also pay an additional fee to make use of the AI school so we are better able to forecast trends in supply and order type.

The one negative, I suppose, is that once the product has left the production floor, we lose a degree of control and communication with the buyer. We’re then left to the mercy of the quality control consultants. Quality control is maintained through tracking technologies, but we have received a few more returns than we would have had we been distributing ourselves. Technologies, but we have received a few more returns than we would have had we been distributing ourselves.

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Scenario 3: SME robotic collectives

Equitable sharing of risk and reward supports collaboration

The construction industry is dominated by networks of SMEs. Through shared rental of robotic systems, SMEs in the case study are able to adjust their organisations to benefit from robotic systems with less substantial upfront capital costs. In this scenario, SMEs pay an annual fee and are allocated a share of the robot’s time. The time periods are determined democratically by the overall collective. The collectives distribute risk and reward through shared rental of robotic systems. An annual fee is paid by individual companies, affording them access to a share of the robot’s time.

Skills diversify in the workforce...

Within a cooperatively owned manufacturing hub, reconfigurable robotic systems are scheduled to move between organisations in order to aid batch runs when needed and allow employees to focus on bespoke aspects of particular projects. While SMEs were previously unable to capitalise on robotics, the robotic collectives allow organisations to diversify their portfolios whilst maintaining repeat work. This allows expertise and craftsmanship to flourish which in turn encourages new generations into the industry. The collectives are locally organised through regional manufacturing training centres and advisory services and supported by the public sector in response to a lack of employment space.

Entrepreneurship competencies are fostered through apprenticeships in close collaboration with local colleges and Universities. SME collectives are well placed to serve localised development issues. The manufacturing hubs enable extension to current capacity for temporary periods enabling SMEs to bifurcate their value streams into bespoke and standardised products. Advantage of SMEs having autonomy over what they choose to standardise means that the existing building stock is maintained through retrofit.

SME Times

JUNE 2030

ROBOTIC COOPERATIVE LEADS THE WAY IN CONSTRUCTION INDUSTRY

The South West Manufacturing Collective yesterday cut the ribbon on the Dragonfly primary school in Taunton, Somerset. For the first time in UK history the finished building was opened by a robot!

SOUTH WEST COLLECTIVE HAILS DELIVERY SUCCESS

Going by the name of TimeShareTim, the robot moved between many of the different manufacturing spaces involved in the production of the building. Rick from Apex fabrications commented on how “the collective generated a collaborative ethos that will put the South West on the map in terms of how to deliver construction projects efficiently and with improved quality”. This marks a stark change in the traditional construction process in that costly competition to the quality of the project is replaced by equitable sharing of risk and reward. The collective, through the advisory services available at the regional hub won the tender over a London-based Tier 1 contractor.

SME case study subsequent page

from SME times

The cooperative-owned model means that we are able to diversify our value streams. In doing so we have been able to maintain a highly engaged and motivated workforce. We work closely with the local colleges to bring in talented apprentices who work with both the robotic systems and traditional craft.

Members of the cooperative have a direct influence on the strategic direction of the manufacturing hub via the Representative Hub Groups. There is a collective responsibility to maintain competitive advantage through innovation and the hub provides a platform for research and development.

In the early stages of our firm’s move toward robotics we were able to experiment with the technical aspects of adopting robotics but the hub has really allowed us to experiment with the operating model. With the Dragonfly primary school project in Taunton, Somerset, TimeShareTim, the robot moved between many of the different manufacturing spaces involved in the production of the building. Competing for tender is a new and different challenge but the cooperative has provided a more formal channel through which advisory services such as Constructing Excellence can reach us. Complying with the regulations and bureaucracy is a much smoother process as a collective and a number of our hub representatives have provided oral evidence to the Commons Science and Technology Committee contributing to best practice.

South West Manufacturing Hub offers its own degree “in collaboration with the University of Tamar we now offer accredited degree level qualifications in Automated Construction Supply Chains. Students pay no fees and earn a salary of £24,000”.

12:00 PM • Nov 7, 2030

456 Retweets 1.1K Likes
Scenario 4: Government expropriates factories and manufacturing

Publicly funded projects finally deliver

Following the failure of various reform agendas over the years the ‘blighted’ industry is now seen as a major impediment to economic survival post Covid-19. Under the terms of the Construction Act 2030, 65% of factories and associated machinery have been nationalised and handed over to the National Construction Board. Roboticisation is now distributed throughout the UK construction industry to deliver the scale of regional development required to meet the needs of the nation.

Regulation breaks new ground...

Subsidies and employment systems, such as apprenticeships, have been introduced to support skill development for the new types of construction professionals required in the automated construction supply chain. Partnerships between publicly funded services, such as universities and infrastructure, ensure that the capital benefit generated by automation and robotisation is used to maintain the level of innovation required to improve employment conditions and job alternatives.

Targeted funding of courses in alignment with current reform agendas begins to specialise the workforce through closer engagement with technical colleges and Universities. Highly regulated industry whereby tenders are awarded to a select group of companies. Projects include collaboration between government and private companies along with members of municipalities where building professionals are included in planning forums.

N.C.B. Apprentice Scheme

OUR NEW WORKFORCE NEEDS YOU

Do you want to be part of the new nationwide construction workforce to transform the built environment?

By embarking on an apprenticeship you will be putting the UK ahead of the curve on the world economic stage.

Get in touch to find out more!

- Initiating a new housing scheme ensuring housing for all
- Work alongside existing nationalized industries such as rail and air

"The training provided by N.C.B. really helped me to transform our local economy."

Sam Jefferys
N.C.B North West Apprentice

SME case study in Engineering-Word

The long-awaited construction of High Speed 3 is the latest success story of the Central Construction Board’s highly regulated procurement process. After perpetual delays and poor quality delivery of publicly funded projects, the UK Government decided that previous policies on public procurement based on value for money needed an overhaul. The manifesto promise of "projects over profits" was going to come to fruition. Rather than relying on competition to drive down prices, publicly funded projects are now almost entirely completed by government owned and operated companies. In order to tender for publicly funded projects, companies must have minimum level of automation in place. This has encouraged a large proposition of SMEs to adopt robotics.

UBS Aggregates are one of the 55% of manufacturing companies in the South West of England that are state owned. UBS are responsible for the modular concrete Sabtracks used on the stretch between Exeter and London. Engineering-Word went to their manufacturing plant in Southampton to find out more about working on HS3 and working as a government owned company.

Keith Brompton, the CEO of UBS aggregates, showed us around the manufacturing base where he explained how the success of HS3 was largely due to the ease in which repeatability was possible with the company to company sharing platforms.

"At the moment the local council are focussing on the delivery of High Speed 3 that runs through our county and everything is channelled towards high repeatability. We work closely with other members of the supply chain who share the same protocols making the construction of product platforms a breeze."

We asked Keith how the Construction ACT 2030 had changing how they worked, he remembered a need to share design, manufacturing, and installation information.

"At that stress waiting for models and specifications, constantly chasing members of the supply chain for information in order to schedule our operations. Now we simply logon to the centralised server and download information months before we’re due to start manufacturing. Downtime is thing of the past. We’re working non-stop as long as the National Construction Board continues to fund municipalities according to the projects needed in the county."

At the moment the local council are focussing on the delivery of High Speed 3 that runs through our county and everything is channelled towards high repeatability – next we’ll be doing beam and block foundations for social housing.
Developing Feasible Futures

"Construction is the last wild west”
(CEO of SME contributor)

Over the years, the construction industry has and continues to be compared to the manufacturing industry. Technocratic optimists have argued that innovation within the industry is self-sabotaged by its own heterogeneity rather than conceding to the possibility that an overly simplistic solution may have been suggested. The previous scenarios, and the research that supported their creation, has departed from technocentric approaches to the implementation of automation in construction.

Robotics and machine-based automation do have the potential to improve the delivery of construction projects. High-precision robotic systems can undertake repetitive tasks that occur in potentially dangerous onsite environments to improve safety and wellbeing, reduce waste, and increase productivity. With opportunities to reposition workers away from repetitive tasks, robotics and machine-based automation can not only scale up production but overhaul business models and subsequently the industrial landscape. Construction, however, is not a homogenous industry and so the impacts of robotics will inevitably be wide-ranging – attending to how construction currently occurs is needed to achieve the full potential of robotics and machine-based automation.

Resisting the allure of panaceaic technological solutions, we’ve explored how technologies may play out in different characterisations of the industry. This begins to identify important aspects of the industry that we want to keep and foster and which ones may work alongside technological innovations. We’ve started to put potential characteristics out there to ask what these may mean for companies and professionals operating within the industry.

By speculating how SMEs might operate in the future we have invited further exploration of automation in a dynamic construction industry. In aiming to better understand the contemporary configuration of the industry, linkages between different elements and actors that characterise its stability, we might begin to gather our bearings and pursue new value propositions where there are more winners than there are losers.

This report is aimed at all stakeholders along the construction value chain. The scenarios incorporate a wide range of companies from multiple tiers while focused on how SMEs could operate in these scenarios. In doing so our intention is to make the report useful for a wide range of construction professionals, academics, and policy makers. Future research will continue to ask the following questions:

How might SMEs respond to potential changes in the future? How might SMEs use these scenarios to make decisions around changes to operational activities? How might the wider sector want to respond in light of these scenarios? What are the varying implications to the broader built environment if certain actors win over others? What direction do we want to move in? How do we get there?

Making Feasible Futures

The research focused on the cocreation of future scenarios with our collaborators. Industrial partners and participants proved to be key contributors, not only in the design and facilitation of the research, but also of the creation of the scenarios themselves. Participants included organisations that work with SWMAS and its sister company Exelin, and a number of selected professionals with experience of robots in construction supply chains.

The research consisted of three phases:

1) Scenario creation: Four initial scenarios were created using findings from our previous research into the adoption of prototype robotics. The initial scenarios intentionally included both incremental – such as support with capital costs – and dramatic adaptions – such as robot cooperatives – to the current industrial landscape. These formed part of an online scenario survey whereby participants commented on different aspects of the scenarios that stood out for them.

2) Scenario adaption: Using the expert knowledge and foresight of our participants, the second stage involved: exploring, fleshing out, and extending the scenarios in a virtual workshop. Themes that cut across all scenarios became apparent in the interviews and virtual workshops. As the scenarios gained more detail, themes were dropped, adapted and created.

3) Scenario development: Participants were invited for interview to extend their insights, explore potential business model modifications, and provide fine grained detail on how their company would operate in each scenario. For example, what organisational change would be needed to adapt to an industry in which the participant’s company were part of an SME collective, or where they worked with an industry characterised by 5 tier one contractors.

Overview of research design and intended outcomes:

Phase 1: Scenario creation
Step 1: Define initial robotic future scenarios
Step 2: Expert insights and perspectives
Step 3: Revised scenarios informed by consolidated insights
Step 4: Collective reflections on revised scenarios
Step 5: Co-created final future scenarios

Phase 1: Scenario development
Step 6: Develop and elaborate scenario characteristics

Contributors: University of Reading Participants
About the team

**Dr Ruth Dowsett** is Lecturer in Virtual and Digital Construction. Her research takes a socio-technical systems approach to understanding and advancing the implementation of new technologies, digital tools, and information systems in construction. Her recent research involved investigating the process flow of design, delivery and installation of modern methods of construction within housing developments on the IUK-funded project ‘Supply chain integration to deliver off-site solutions for new housing’. She also explored the challenges of developing and implementing multi-task robotic systems in mobile factory scenarios alongside Prof. Harty on the IUK-funded FRAMBE (Flexible Robotic Assembly Modules for the Built Environment) project.

**Dr Martin Green** is a Teaching Fellow in the Management and Organisation of Construction. His current research interests lie in examining how socio-technical systems emerge with changing forms of social, economic and political organisation. His previous research has focused on organisational challenges and opportunities relating to Modern Methods of Construction on the ESRC-funded project ‘Making the zero-carbon standard home: understanding project-level innovation in UK house building’, and the IUK-funded project ‘Supply chain integration to deliver off-site solutions for new housing’. He was also part of the research team on the IUK-funded project ‘Rethinking the Build process - delivering more for less under the IPI model’, and the Centre for Research in Energy Demand Solutions (CREDS).

**Chris Harty** is Professor of Technology and Organisation and Head of the School of the Built Environment (SBE) at the University of Reading (UoR). He has previously been UoR Director of the HaCIRIC (Health and Care Infrastructure Research and Innovation Centre) and acting Director of Design Innovation Research Centre.

**SWMAS (South West Manufacturing Advisory Service) Ltd** has been providing training and consultancy services to manufacturers and commercial organisations since 2002 including contracts to deliver the Government’s Manufacturing Advisory Service (MAS) and numerous other SME support programmes funded via BEIS, the EU, LEPs and Local Authorities. They work with hundreds of SME businesses across a wide range of sectors, giving them a rare degree of insight into the industry. The main focus of their support is driving manufacturing productivity through the use of new technologies, lean manufacturing tools and techniques, innovation through design best practice such as design for Manufacture and assembly (DFMA) and developing business strategies. Their sister company Exelin has previously worked with members of the academic team from Reading within the IUK-funded ‘Flexible Robotic Assembly Modules for the Built Environment’ (FRAMBE) project looking at routes to commercialisation of FRAMBE from perspectives of construction sector, and automation and software providers. Exelin has also provided support to the IUK-funded ‘Cross-sectoral Robotic Applications For productivity Transformation’ (CRAFT) project exploring the technological innovations required for construction product manufacture.

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