



TRANSFORMING HOW WE BUILD HOMES

year three - final project report april 2022



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Introduction

Advanced Industrialised Methods for the Construction of Homes (AIMCH) has been a three-year housing innovation project set up and delivered by leading industry and academic partners.

The project is a collaboration between Stewart Milne Group (SMG), Barratt Developments PLC (BDW), L&Q, the Manufacturing Technology Centre (MTC), Built Environment – Smarter Transformation (BE-ST, formerly Construction Scotland Innovation Centre) and Forster Group (FG). It has been managed by Limberger Associates.

Its goal has been to tackle challenges in the housing sector using industrialised housing techniques like digital working, standardisation and offsite construction and advanced manufacturing to transform how we deliver homes across the UK.

The innovation challenge was to industrialise the way the housing industry operates. It focused on developing and scaling up mainstream viable solutions in panelised Modern Methods of Construction (MMC) to meet current and future housebuilding demands.

Some of the AIMCH solutions are already in trial on live housing projects across the UK. Successful new methods developed by AIMCH will continue to be commercialised and brought to market on a large scale.

New digital design tools, standardisation techniques, advanced manufacturing and pattern book housing designs are already in use. Clear opportunities are being realised to scale up near-to-market offsite systems and lean site processes.

This project has potential to impact the 35,000 homes delivered each year by AIMCH partners across the UK and more. Industry engagement and participation, information sharing and dissemination and active publicising of findings and results is helping to ensure housebuilders, suppliers and stakeholder influencers across the industry can adopt and benefit from results.

The ultimate goal of the project is to support the entire housing sector as it strives to deliver the UK Government's new homes targets. That includes transitioning to zero carbon housing while reducing costs, improving quality and building homes more quickly and with minimal defects.

AIMCH was conducted across eleven work packages. This report summarises key achievements over each of the three years, summarises the individual work packages and their conclusions, shares industry learnings and demonstrates industry engagement.



Kings Quarter development, Stretton, Warrington, Barratt Development PLC

Summary achievements - year one:

- Research report on MMC productivity measurement, to inform methods and metrics
- Onsite monitoring to set benchmark for productivity
- Data mapping to develop digital business enterprise system
- Partners reviewed house types to find opportunities for standardisation and standardised product families
- Installation of trial homes with advanced panelised MMC build systems on a live Barratt Development/Homes England site near Warrington
- Identified robotic and automation technology opportunities in three key manufacturing operations, to produce panelised timber MMC build systems
- Examined bills of quantities for various UK house types and developed regional cost benchmarks for commercial viability
- Established AIMCH profile, stakeholder engagement and regular communications across the construction industry

*Affordable Homes Pattern Book,
Stewart Milne Group*



Summary achievements - year two:

Despite the challenges created by the global pandemic, the project gained significant momentum in its second year. Several outputs were completed, two new workstreams were added and activity continued across the entire project. In fact, the pandemic only accelerated the need to transform the way homes are constructed. AIMCH offers a real opportunity to innovate, recalibrate and exploit outputs as recovery continues.

- Monitoring on 42 plots, recording more than 100,000 operative observations and collecting 500,000 pieces of data to evaluate masonry, open panel timber frame and advanced closed panel MMC methods
- Barratt completed advanced closed panel timber frame units, including novel pre-tiled roof systems and scaffoldless erect MMC construction, achieving a weathertight, insulated, and secure superstructure in one day
- L&Q completed trials on seven of nine onsite MMC initiatives
- Study began to measure and profile Embodied Carbon (EC) and Whole Life Costing (WLC) of panelised MMC systems across four housing types to current and near zero carbon/energy standards, compared to conventional construction methods
- Guide to Creating a BIM Housing Manual produced, providing a framework for developers to transition to 3D digital working
- Developed methodology for and carried out housing standardisation studies, determining standardisation opportunities specific to housing
- Created product families and concept recommendations for engagement with supply chain and use in future industrialised housing pattern books
- Completed requirements mapping, analysis and vendor engagement for development of a digital business Enterprise Resource Planning (ERP) System suitable for Offsite Manufacturing (OSM)
- Created a Design for Manufacturing and Assembly (DFMA) Guide for Timber Panelised MMC Systems to optimise housing designs suitable for panelised MMC systems
- Developed an advanced factory modelling tool (mathematical, 2D & 3D) to configure different solutions for future MMC factory investments

- Completed proof of concept trials and progressed design solutions for advanced MMC robotic manufacturing work centres for panelised sheathing, insulation, and window fitting, suitable for offsite factory applications
- Analysed regional build costs for all construction methods across all areas of England and established full monetary values, £ per square feet and percentage differences
- Captured detailed requirements and evaluated solutions for a proof of concept Augmented Reality (AR) as part of an advanced roof tiling solution to assist in selection, orientation and installation of roof coverings and Solar PV technology
- Developed innovation challenges and supplier sandpit selection process for engagement with supply chain sector to identify potential solutions for advanced MMC, standardisation and zero carbon future technologies
- Developed strategy for proof of concept near-zero-carbon home trial with Barratt Developments PLC in conjunction with AIMCH
- With a lifting technology partner, developed and trialled a novel, demountable roof beam system for lifting pre-tiled roof structures
- Undertook and completed several fire tests, including

BS 8414 full-scale testing, to evaluate panelised timber MMC systems and non-masonry façade solutions, future casting new technology and fire safe MMC systems

- Presented at several high-profile events to disseminate ongoing learning and progress
- Kept AIMCH up to date to promote shared learning, and undertook several stakeholder engagement meetings with key sector influencers
- Connected through press and social media channels, as part of wider industry benefits and awareness
- Mark Farmer appointed as AIMCH Chair in December 2020 on the retirement of Sir Edward Lister.



Augmented Reality Roofing System, Forster Group & MTC

Summary achievements - year three:

- AIMCH named MTC's Collaborative Project of The Year 2022
- AIMCH winner of the Innovation of the Year (Transition to Net Zero) award at Homes for Scotland 2022
- Barratt Developments PLC, at Salford University, completes and opens to stakeholders the UK's first zero-carbon prototype home of the future
- Completed final analysis, conclusions and recommendations to inform investment in Digital Business Enterprise System (ERP), highlighting benefits and return on investment case
- Developed a scaled-down digital business enterprise system proposals for SME offsite manufacturers
- Stewart Milne Group (SMG) commits £750k investment in new ERP system for panelised MMC manufacturing and installation on site
- Forster Group commits investment to deploy new ERP system for their roofing technology and growing business
- Studies completed on robotic production processes with preferred technology partner. Recommendations developed to inform case for investment on new MMC production lines and robotic work centres
- SMG commits £8.3m investment in new, world-leading robotic production lines for production of wall and floor panelised timber MMC building systems
- Completed mathematical modelling and factory simulation, developing blueprints and recommendations for future MMC factories based on hub and spoke principles, to inform future investment case
- SMG commits to building new 100,000ft² panelised MMC factory to service growing demand for open and closed panel MMC systems, based on Future Factory blueprints and simulation developed by AIMCH
- Supplier sandpit process successfully concluded, feedback given to suppliers and final report published on AIMCH website
- Selected suppliers remain engaged with AIMCH partners beyond the project, significantly benefiting the housebuilding industry

- Completed proof of concept trials for an advanced roofing system using augmented reality technology (AR) for future market introduction
- Completed and published whole life carbon assessments for common house type suite, comparing masonry and panelised timber MMC methods, engaging stakeholders to share learnings
- Completed and published whole life cost assessment, reviewing capital and repair and maintenance whole life commercial outcomes, comparing masonry and timber panelised MMC systems
- Completed and analysed data captured from site productivity studies to evaluate the productivity benefits of a range of MMC solutions used on trial homes as compared to masonry built homes. Published final report findings
- Completed Affordable Homes pattern books for exploitation on AIMCH developer future projects, maximising standardisation, DFMA and BIM principles
- Developed a pre-configured affordable homes pattern book for third party developers through Donaldson Timber Systems (formerly Stewart Milne Timber Systems), for market introduction summer 2022
- Completed end of project dissemination event at Future Build to share learnings and outcomes with a wide range of stakeholders
- Maintained industry engagement through speaking opportunities at industry events, press and social media channels
- Committed to retention and update of AIMCH website for two years after project end, ensuring documentation and collateral are available to industry as a legacy value.



HFS Award Image - AIMCH winner of the Innovation of the Year (Transition to Net Zero) award at Homes for Scotland 2022

Working with UKRI

AIMCH partners are indebted to Innovate UK for innovation funding received as part of the Transforming Construction innovation call. This is a challenging project and would not be possible without the financial support of UKRI.

The partners have invested their own financial capital and resources to deliver outcomes that are near to market, scalable solutions, which we believe will shape the future of housing delivery. Through exploitation, AIMCH will benefit the partners, UKRI and the overall housing sector, yielding economic benefits and transforming how homes are delivered over time.

Independent research commissioned by UKRI on the economic value creation of projects funded through the Transforming Construction call, has shown AIMCH will generate £2bn of economic benefit, impacting on 7,500 homes in the near future and up to 35,000 homes long term. It is by far the most economically beneficial project within the UKRI funded project portfolio and AIMCH partners are proud to have played their part.



Saxon Reach, Milton Keynes, L&Q

The work packages

The AIMCH project was divided into eleven work packages, each led by a specific project partner with support from other partners and external sources where needed. These work packages are shown below and summarised in the reports that follow.

WP1 – Project Management

The project was managed by Limberger Associates, ensuring governance of AIMCH, on behalf of AIMCH industry lead partner Stewart Milne Group. This vital work package ensured controlled and effective project management by monitoring time, cost, risk, scope, and quality and ensuring deliverables, milestones and reporting were managed and executed as planned and in accordance with Innovate UK funding requirements.

WP1 deliverables included the creation of a Master Schedule, from which the Second Level Plan was created and maintained throughout the project. Limberger Associates also created the Project Management Plan, a key document describing the governance and management processes for

the project. Additionally, they were responsible for the creation and maintenance of several vital documents such as the Exploitation Plan, Risk Register and issuing quarterly reports to Innovate UK. Further deliverables included the facilitation and reporting of the WP6 Sandpit process and the development of the risk assessment methodology in the WP6 MMC Risk Profiling report, which was co-written with Stewart Milne Group.

Limberger Associates were an integral part of the project, managing change requests to Innovate UK on behalf of the project partners and successfully ensured the £6M budget was correctly managed, assigned and reported.

WP2 – Productivity mapping and literature review

Commissioned by Built Environment – Smarter Transformation (BE-ST, formerly Construction Scotland Innovation Centre) on behalf of AIMCH partners, The University of Dundee and Whole Life Consultants Ltd undertook a wide-ranging literature research analysis and compiled a report focused on construction productivity measurement studies, protocols, and metrics. This has helped project partners to understand the current landscape and key monitoring tools, techniques, and metrics. Outputs were used to inform and influence how partners measured on-site activities.

[Read the report summary](#)

WP4 – Digital business enterprise system

This work package was led by and focused on the AIMCH MMC supply chain partners. A key challenge in the MMC sector is an integrated ERP system that covers both manufacturing and installation on the building site. The work delved into detail, developing approaches and making recommendations to aid large and small MMC manufacturers adopt an integrated digital enterprise system. The partners involved investigated how integrating digital business systems can help increase manufacturing productivity and quality and reduce lead time, downtime, and processing time in Off Site Manufacturing (OSM) and the connected supply chain. Outputs were used to inform and influence how partners invest in future digital business enterprise systems.

[Read the report summary](#)

WP5 part one – MMC design standardisation, DFMA, BIM and product families

This work package was led by AIMCH developer partners across two distinct areas: MMC design standardisation, DFMA, BIM and product families and the creation of Affordable Homes Pattern Books. The first required the team to study their existing housing portfolios in order

to understand current levels of and future opportunities for standardisation by developing common components/sub-assemblies or design parameters. This involved managing developer attitudes, approaches, ideas, supply chains and brand characteristics as well as delivering a standardisation methodology and ranking system and suggesting standardised components or sub-assemblies known as product families. Partners also investigated DFMA and BIM 3D design requirements for timber panelised MMC systems, developing guides to inform future approaches to housing design. Outputs were used to inform and influence how partners embrace design standardisation, DFMA and product families in the development of current and future new home portfolios.

[Read the report summary](#)

WP5 part two – Affordable Homes Pattern Books

This second part of WP5 utilised the learnings from the standardisation assessments, DFMA and BIM guides and product family recommendations to develop house ranges suitable for the affordable homes market. These were developed by two AIMCH developer partners for in-house use on their own developments and through the MMC supply chain via Donaldson Timber Systems (formerly Stewart Milne Timber Systems). Pattern book designs are an effective way to deliver

attractive, efficient, and cost-effective housing design using an industrialised approach, much like that adopted by the motor vehicle industry.

[Read the report summary](#)



Kings Quarter development, Stretton, Warrington, Barratt Development PLC

WP3/6 – Advanced MMC prototyping

This work package focused on advanced panelised Modern Methods of Construction (MMC) prototyping, undertaking proof of concept trials and building homes for consumers to buy or rent on live housing developments. This was a large workstream and trialled many new solutions, including prototyping near to market, scalable and potentially viable panelised timber MMC advanced closed panel systems and lean construction techniques like pre-tiled roofs and scaffoldless erect solutions. It included a 'supplier sandpit' activity to identify and develop innovations across the supply chain that had the potential to impact and improve future housebuilding, as well as deep-dive health and safety risk profiling studies, comparing crane and forklift erect build elements. Outputs were used to shape, influence, and inform viability and scalability of the MMC systems trialled.

[Read the report summary](#)

WP7 – Advanced MMC manufacturing – future MMC factory and robotics

This work package sought to develop manufacturing processes for panelised timber-based MMC wall panel production by assessing the use of automation and robotics. Led by SMG in partnership with MTC, the work involved

utilising car industry expertise with modelling and simulation technology to reduce planning and analysis for future OSM factory investments and generate a factory 'blueprint' and specification for business case investment. This also work benefited Forster Group, who worked with MTC to develop a similar approach for SMEs considering smaller scale manufacturing investment, helping them prove the case for investment and justify the designs being developed. In relation to automation and robotics, the partners investigated solutions with manufacturing technology partners, exploring specific MMC-related work centres suitable for full/part automation and/or robotics. This led to proof of concept technical studies, developing processes and recommendations to aid shift towards advanced automation/robotics within the factory. Outputs have greatly helped partners make business decisions and commit to future factory investments.

[Read the report summary – Future Factories](#)

[Read the report summary – Robotics](#)

WP8 – Commercial viability

An important aspect of any innovation project is the commercial viability and scalability of near to market solutions like panelised MMC methods. This was assessed in terms of private for sale and affordable for rent sectors, where capital costs are often viewed differently. This work, led by AIMCH partner Barratt Developments PLC, evaluated the

capital costs of a range of timber-based panelised MMC systems compared to masonry built homes in several geographical areas and across a range of commonly-built homes in the private housing sector. Speed benefits were also investigated, using learnings from the live site trials to evaluate commercial savings in the cost of development preliminaries to provide a net commercial outcome.

The work determined that regional location, typology, and speed all have a commercial bearing on the viability of timber based MMC systems. In general, however, the systems evaluated range in their commercial viability, with cost acceptability being achievable subject to location, speed, and typology. In the affordable for rent sector, for example, investing in higher capital costs for improved fabric-first fit and forget methods is likely to be offset by ROI over the lifetime of the home and the energy saving fuel poverty benefits achieved. Output from this work has allowed partners to identify areas of maximum commercial benefit and to identify future cost-saving opportunities where volume adoption can be leveraged. For affordable housing, outputs have informed the case for capital cost investment, where whole life benefits and fuel poverty overtime are more valued.

WP9 – Dissemination

A key requirement of the project was to inform the wider housing sector, maximising and sharing non commercially sensitive learnings to increase wider business benefit and ensure that the whole housing sector moves in a similar way. This work, led by BE-ST, included a dedicated website where all content developed is freely available. Partners have presented at many events on the project and posted learnings through press and social media channels. An important aspect was the creation of a stakeholder group chaired by Mark Farmer, Government MMC advisory and CEO/Founder Cast Consultancy. Meeting twice a year, this group included key stakeholders from warranty providers, government, lenders, industry, property valuation and insurance bodies.

[View AIMCH website](#)

WP10 – Augmented Reality (AR) proof of concept for roof coverings

AIMCH SME partner Forster Group, in partnership with MTC, started developing an advanced roofing solution with the potential to significantly reduce site installation times and increase productivity, as well as offering a range of health and safety benefits. The solution investigated a range of AR technology solutions to improve worker productivity and reduce error. Successful trials

were performed at MTC's workshop and on Forster's live construction sites. Outputs from this work has led to Forster Group investing to scale up and take the solution to market once the AIMCH project is complete.

[Read the report summary](#)

WP11 – Embodied carbon and whole life costing

AIMCH housing developer partners commissioned a whole life carbon assessment across four homes. The purpose was to evaluate the embodied carbon impact of concrete masonry-built homes compared to open and closed-panel timber frame construction under current English building regulations. This work utilised the RICS embodied carbon calculation protocols and was completed by Verco Consulting. The outputs have shown the differences between the construction methods and highlighted areas where future analysis and material development is required to further reduce embodied carbon content of materials used to build AIMCH homes.

[Read the report summary](#)

A further piece of work commissioned whole life cost assessment, comparing conventional masonry-built homes against panelised timber MMC build systems, evaluating repair and maintenance costs over 60 years. This work, completed by Whole Life Consultants, provided

insight into similarities in whole life costs, an important consideration for affordable homes providers and long term housing asset managers.

[Read the report summary](#)

Learnings for industry

Each of the work packages offers key learnings for the UK housebuilding industry and supply chain.

Productivity mapping and literature review

The report provides evidence and recommendations on which to base productivity measurement decisions. Initially planned as a piece of work that would inform and influence future AIMCH outputs, its findings are already proving of interest across the construction industry and in wider sectors. It's hoped that aligning metrics across the housing sector will enable large and small scale developers and supply chain businesses to capture data that will inform and influence the value proposition of MMC, and to respond consistently to future data-driven demands.

Onsite monitoring

The collection of this site monitoring data will allow project partners and industry to understand construction site productivity and other key related metrics when comparing current and future build methodologies, informing decisions about how homes are built. It is hoped that through data-driven decisions the housebuilding culture will be transformed, and in the future will move away from perceptions and beliefs that are currently common within the sector.

Digital business enterprise system

The project highlighted that there are a limited number of digital ERP solutions that combine manufacturing, project-based costing and construction activities into an integrated system. Prioritising which requirements are most important is essential, as is discussing requirements with as many potential vendors as possible. The down selection process developed in this project will be suitable for all MMC systems providers.

Design standardisation and product families (including BIM housing manual)

This work analysed, in detail, the barriers and opportunities for standardisation as well as

Modular roof lift, Milton Keynes, Stewart Milne Group



highlighting the benefits to be gained across the housing providers and supply chain. It presents standard product family recommendations that can be used by developers to review current and future housing portfolios. Partners are already seeing opportunities to exploit this work. In the case of Stewart Milne Group, for example, recommendations have been used in the creation of a new housing range for deployment within the next 12 months. L&Q have also adopted the information for their emerging housing portfolio.

BIM housing manual

Through the creation of the Guide to Creating a BIM Housing Manual, the AIMCH project delivered:

- A framework to help housebuilders create

their own BIM housing manuals

- Recommendations on technical, people, cultural and leadership requirements for BIM digital working
- Templates to help housebuilders create delivery plans for upskilling, competency and knowledge
- Guidance to help housebuilders consider cultural development, change management and organisational capability
- A structure and content to help users navigate their way through BIM adoption

Advanced prototyping

Early analysis recognises the benefits of advanced panelised MMC systems and offers hard data to back those up. The trialling and monitoring not only allows recognition of the benefits of the advanced panelised MMC systems in relation to resource and waste, but also highlights areas of opportunity where systems and operations could be improved further.

Advanced manufacturing - future MMC factory & robotics

The project has provided agile and accessible tools for immediate use. This has helped model (and remodel) scenarios quickly and without external consultant support. The wider OSM supply chain

and the construction industry can benefit from adopting modelling methods and technologies to improve agile, scenario-based decision making. Close collaboration showed that modelling and simulation can be simplified and more accessible than previously thought. There is potential to expand the use of modelling from factory systems to further areas of application such as supply chain, resource management and material/product management.

Commercial viability

As traditional labour and material resources become more expensive and limited while we continue the journey towards greater energy efficiency and carbon neutrality, it's more important than ever to achieve cost certainty, better quality, speedier build and carbon footprint reduction. This commercial viability study will help the industry achieve those goals, providing commercially acceptable solutions that can scale over time to yield further savings.

Augmented reality for roof coverings

AR technology is available but rarely used in the construction industry. This proof-of- concept work shows how adopting these technologies can benefit subcontractors on site and increase worker efficiency and productivity, as well as improving

information sharing between offices and site-based teams.

Embodied carbon & whole life costing

This additional element to the project considers the future needs of the industry, highlighting the importance of embodied carbon and whole life costs of the construction process and offering housebuilders the opportunity to consider ways to maximise carbon efficiencies and manage carbon costs. The findings from AIMCH have already been shared with material sectors, government, and Future Homes Hub.

Engaging industry

A major aim of AIMCH is to ensure industry can benefit from dissemination of its work. Thousands of people across the industry have engaged with AIMCH project over the last three years. Key achievements and activities include:

- Mark Farmer (Founding Director & CEO of Cast Real Estate & Construction Consultancy and Government champion on MMC) appointed AIMCH Chair
- AIMCH project halfway industry webinar
- Findings shared with key stakeholders
- Keynote at Innovate UK's Future of Building Week with the Financial Times, plus five other

industry events

- Creation of new video and animation to highlight specific project outputs on AIMCH website and social media channels
- 21 pieces of coverage in the construction press
- Keynote at Futurebuild 2022 main stage on key findings from the project
- Hosted an all-day event on key findings at Futurebuild
- 381,521 impressions on social media throughout the project, resulting in 14,371 engagements and 7,355 link clicks.
- AIMCH website visited more than 10,000 times with over 50,000 page views during the project.

The AIMCH team is happy to share the project's findings at industry events or meetings. Please contact hmaguire@be-st.build with any speaking requests.

Further information on AIMCH can be found www.aimch.co.uk

WP2 | Productivity Mapping and Literature Review

WP leads

- Built Environment - Smarter Transformation

Background:

Built Environment - Smarter Transformation (BE-ST) on behalf of the AIMCH partners, commissioned the University of Dundee and its spin-out company Whole Life Consultants Ltd to undertake literature research analysis and compile a report focused on construction productivity measurement studies and protocols.

The aim was to help AIMCH partners understand current productivity metrics and future trends, as well as key monitoring tools and techniques.

Specifically, the objectives were:

- To produce a research report on previous construction performance measurement studies covering productivity, quality, cost and efficiency, to identify gaps and examine monitoring protocols

- To look at different ways of measuring productivity, considering what worked well and why
- To prepare recommendations that will inform future AIMCH measurement studies

In April 2019 the project steering group added safety, time and milestones, predictability of time and cost and material waste. The final list of metrics included in the report is therefore:

- Safety
- Productivity including labour productivity
- Quality including rework, defects and reliability
- Cost including cost/m2, cost per unit, cost effectiveness
- Time including duration (normalised to take account of differences in design) and percentage of milestones achieved (including planned completion dates)
- Predictability of time and cost
- Efficiency
- Material waste

There is also an appendix on emerging technologies in the construction sector.

The AIMCH project team was keen to measure a number of activities and outputs, in particular comparing the performance of houses built traditionally and houses built using modern methods of construction. We were asked to review all the literature in all those areas and make recommendations about the metrics and measurements partners should use to make that comparison.

Malcolm Horner

Founder, Whole Life Consultants Ltd



Kings Quarter development, Stretton, Warrington, Barratt Development PLC

Approach:

Whole Life Consultants reviewed site and factory measurement studies across a range of sectors and countries, primarily focusing on construction but also exploring other industries. The studies related to the specific metrics outlined above.

Uniquely, the team developed a highly structured approach to the assessment of the relative merits of alternative metrics to ensure that the outputs were robust, objective and transparent.

For each metric, the report examines the approach taken in a range of studies, providing examples and evaluating what worked well and why.

In each case, that evaluation is accompanied by background information that explains the measurement metrics chosen, a summary of results and a series of recommendations, creating a detailed overview of performance measurement systems and their potential effectiveness.

Separate evaluation of metrics relating to emerging technologies that could be used in the measuring process appears in appendix F and are referenced in appendix G.

Outputs:

The report highlights the need for careful consideration of metrics used to measure performance under the eight headings listed above. It states that each should relate to strategic objectives and the efficient operation of the entire system, rather than individual sub-systems.

It also identifies a blend of leading (future-focused) and lagging (previous or current achievements) metrics. That way any measurements will identify trends, preventative measures and changes that can be made to achieve strategic targets, as well as providing valuable information about current performance.

The report offers recommendations for monitoring and management of each metric, together with detailed explanations of how they might be useful to the industry.



The metrics reviewed are not a comprehensive list. Each partner within AIMCH, and operators in the industry as a whole, have individual strategic objectives that will require individual metrics. This report does, however, provide comprehensive evidence about which metric could be used in which

circumstance. That allows partners and others to review the recommendations and use those metrics that satisfy their strategic objectives and internal constraints.

The report has validity that extends beyond the AIMCH project. There's a wealth of knowledge in there, and it's in the public domain. We've referred a few people to it over the last year or so, and they've found it incredibly helpful.

Doug Forbes

Director, Whole Life Consultants Ltd

Overall, however, the report provides a useful tool for businesses of all sizes and demonstrates how to use data more effectively to demonstrate the value of MMC and respond to future sector demands.

It has generated external interest from the Construction Leadership Council, the Department for Transport and Homes England.

Media coverage of the report's release was featured in Professional Housebuilder and Property Developer, Infrastructure Intelligence, Build Scotland, Specification Online, Scottish Housing News, Project Scotland, Construction Index, Scottish Construction Now and PBC Today.

[Read the full report](#)

WP4 | Digital Business System

WP Participants:

- Stewart Milne Group
- Forster Roofing
- Manufacturing Technology Centre

Background:

The Digital Business System work package examined how digital business systems might lead to improved business productivity and quality, and reduce lead times, downtime and processing time in offsite manufacturing (OSM).

Its key objectives were to develop ERP system recommendations suitable for large and SME offsite MMC suppliers, whereby users could identify digital processes and systems that would:

- Increase business efficiencies by eliminating multiple manual administration tasks
- Reduce the level of on-premise hardware, decreasing system down time and improving system performance
- Improve customer service and provide closer integration for clients and supply chain

The current business model for the offsite MMC construction supply chain combines elements from design, manufacturing, logistics and sub-contractor construction and installation. No generic ERP system meets these hybrid needs, favouring instead either manufacturing or construction-related business models.

The AIMCH challenge was to develop a requirements and selection process that could be built into an ERP solution specifically configured for the whole MMC supply chain.

Taking a high-level view of the AIMCH project was beneficial and enabled project preconceptions to be re-evaluated.

Approach:

The project team took a phased development approach, which allowed exploration and development of different tools. While the primary focus was on a large-scale system for mature MMC producers, the intent was also to feed this work into a scaled-down system for SMEs who were new to MMC and offsite construction components or systems.

A series of workshops and remote meetings with AIMCH project partners, facilitated by MTC, resulted in a list of digital requirements. It also created an improvements template that provided a crucial insight into how and where digital systems would benefit OSM businesses, demonstrating their potential impact and ROI.

A list of potential system vendors was created, and the shortlisted vendors were invited to tender for the system scoped out. The report outlines the shortlisting, evaluation and selection processes that followed, concluding that it is possible to create a single ERP system to manage offsite MMC design, manufacturing, delivery, construction and project management, but that there are few vendors who offer targeted offerings in that market.

The improvements template helps to:

- Give vendors clear expectations of how their system should impact the organisation.
- Inform internal stakeholders how the new ERP system will impact the company and themselves.
- Provides a method of calculating ROI and potential future financial benefits if the identified improvements are achieved.

Outputs:

While the scale of benefits offered by a new digital business system depends on various factors, the report highlights specific areas that have the potential to provide significant benefits in areas like business efficiencies, IT infrastructure and maintenance and business differentiators.

It recommends that, in order to fully realise benefits, businesses should work closely with vendors to show where digital systems would be most useful and recommends collating potential benefits into a matrix that shows where the greatest impacts and benefits will land.

Project partners Stewart Milne Group, Forster Roofing and the Manufacturing Technology Centre worked with consultants from the digital business management sector. Together they have reviewed and presented a process that will help OSM businesses choose digital business and ERP systems to streamline their operations from concept design to completion. That means increased efficiency and quality and reduced lead times, downtime and processing time.

[Read the full report](#)



Witney Factory, Donaldson Timber Systems
(formerly Stewart Milne Timber Systems)

WP5 | Design standardisation studies, product families, BIM and affordable homes pattern book

WP members:

- Stewart Milne Group (Lead)
- L&Q
- Barratt Developments
- MTC

Background:

Work package five centred around the concept of standardisation for the housebuilding industry. Drawing from learnings in the automotive industry, it resulted in four separate but connected outputs:

- Design standardisation studies and product families.
- Design for manufacture and assembly (DFMA) guide to timber panelised MMC systems.
- Guide to creating a Building Information Modelling (BIM) housing manual.
- Affordable homes pattern book.

Design standardisation studies and product families

This element of the work was delivered by AIMCH developer partners Stewart Milne Group, Barratt Developments and L&Q in conjunction with Manufacturing Technology Centre (MTC). It explored and made recommendations about standardisation in the housebuilding sector by:

- Identifying and prioritising opportunities for standardisation.
- Producing detailed studies of priority areas based on project partners' existing housing portfolios and specifications.
- Created 'product families' that could be adopted in future housing designs.

These product families could then be developed further in collaboration with supply chains. The long term aim is to produce an industrialised "kit of

parts" that can be used for future housing designs and to create industrialised housing pattern books.

Design for manufacture and assembly (DFMA) guide to timber panelised MMC systems

DFMA optimises and maximises the use of panelised MMC systems by working with its strengths. At the same time, it recognises weaknesses, designing out limits and constraints where possible.

This element of the work package was delivered by AIMCH MMC manufacturing partner Stewart Milne Timber Systems (SMTS), part of Stewart Milne Group (SMG), in collaboration with developer partners. Together they drew from current DFMA guidance to create a guide specific to timber panelised MMC systems and use.

The guide covers six core areas, offering a cost-effective strategy for designing affordable homes.

Sigma II Closed Panel Build System, Donaldson Timber Systems (formerly Stewart Milne Timber Systems)



“This piece of work was a real eye opener. It's probably the deepest dive study the sector has ever done. It gave us the data we needed to say loud and clear that there's a real opportunity to embrace standardisation in our industry”.

Stewart Dalgarno, Stewart Milne Group.
AIMCH Project Director.
Director of Innovation & Sustainability SMG

Guide to creating a BIM housing manual

While Building Information Modelling (BIM) is not a new concept, it has not yet been widely implemented in the housebuilding sector. It means adopting new standards and processes that have more usually been applied to one-off commercial projects, as well as learning a new vocabulary.

Both the UK and Scottish Governments have mandated BIM standards adoption as part of the public procurement process. This guide is intended to help developers, housebuilders and stakeholders to make the move to BIM-enabled 3D digital design by developing their own tailored approaches to BIM workflows and processes.

Affordable homes pattern book

This collaboration between developer partners drew from learnings across the work package in DFMA, design standardisation and product families and BIM. It created two affordable homes pattern books, tailored to each partner's requirements, for future exploitation by partners.

These pattern books can now be used by AIMCH developers on future projects. Stewart Milne Timber Systems (SMTS) is also offering them to affordable housing providers via a free-to-use licence agreement when using SMTS timber-based panelised MMC systems. That offers unparalleled access to knowledge, documentation and experience to SMEs and new entrants to the housing industry.

AIMCH Partner Launch event



Approach:

The detailed approach for each section of this work package can be seen in the individual reports, however they had in common the need for a collaborative approach between all partners. To consider standardisation at individual and AIMCH consortium level, it was necessary for all partners to share information and intellectual property about house design portfolios, technical specification, supply chains, construction preferences and brand.

MTC had significant expertise of standardisation within the automotive industry. They acted as project facilitator, helping the partners to identify key areas of focus, share information, reach agreement on standardisation and so on.

The varying degrees of expertise, brand maturity, business focus and operational systems was particularly useful in identifying and resolving barriers and difficulties as well as finding points of similarity. It meant that the resulting findings and outputs were considered and adaptable, therefore

usable by both large housebuilding businesses and smaller, more local developers.

Outputs:

Design standardisation studies and product families and DFMA guide to timber panelised MMC systems

AIMCH partners are already seeing opportunities to exploit this work. Stewart Milne Homes have used its recommendations to create a new range of private and affordable homes for deployment in the next few years. L&Q have adopted the information for the standardisation of their medium/high rise apartment developments, specifically in terms of offsite manufactured bathroom pods.

AIMCH believes this work could contribute significantly to delivering more homes at an affordable cost through the creation and exploitation of a future industrialised housing design approach that embraces standardisation and MMC.

"Standardisation is not a nasty word. It's a good word. But we're not saying it's the only way to do it. It's a smart way to do it, but it's not stifling people's choice. If they want to do their own thing that's still fine. But this is a way to reduce costs, improve efficiencies and quality and make life easier. It's a model that can be used for many different developers and stakeholders".

Stewart Dalgarno, Stewart Milne Group.

AIMCH Project Director. Director of Innovation & Sustainability SMG

Guide to creating a BIM housing manual

This guide offers housebuilders of all sizes a way to navigate the change from traditional 2D design processes to the 3D BIM standards mandated by the UK and Scottish governments within their procurement processes.

Crucially, it focuses on 'people' aspects as well as on technical information. It aims to create the skillset, knowledge, culture and collaboration the process requires, as well as to ensure the right change management procedures and support are in place.

The finished guide provides a framework that housebuilding companies can use to create their own BIM housing manual specific to their businesses. It offers structure and content to help users navigate their way through BIM adoption and implementation.

Affordable homes pattern book

The final pattern book brought together many of the learnings from the other three elements of this work package. It built on the collaborative approach shared by developer partners to create a functional, compliant, efficient and user-centric range of standard affordable house types in the form of two pattern books for use by SMG and L&Q.

These have the potential to shape future housing design and developments for each of the partners. They can also, however, be used in strategic partnerships within the MMC supply chain or under licence by third parties. In fact, SMTS is already offering a free-to-use licence agreement to third parties who use their timber-based panelised MMC systems.

"We're not the first to use standard housing pattern books, they've been around for a while. But the thinking behind this is really strong. It's a model that many companies could use. And that should be a model that government, housing agencies and developers will support".

Stewart Dalgarno, Stewart Milne Group.

AIMCH Project Director. Director of Innovation & Sustainability SMG

[Read the full report - DFMA Guide to Timber Panelised MMC System f.pdf](#)
[read the full report - Affordable Homes Pattern book.pdf](#)



Charleston Cove, Aberdeen, Stewart Milne Group

WP3/6 | MMC Prototyping - Supplier Sandpits and MMC H&S Risk Profiling

WP Participants:

- Barratt Developments
- Stewart Milne Group
- L&Q
- Forster Roofing
- Manufacturing Technology Centre

Background:

AIMCH work package 6 (WP6) focused on advanced Modern Methods of Construction (MMC) prototyping. It was led by Barratt Developments with significant contributions from Stewart Milne Group (SMG), L&Q, Forster Roofing and the Manufacturing Technology Centre (MTC).

This two-year work package included a 'supplier sandpit' activity and significant HSE risk profiling.

Modern Methods of Construction (MMC) are critical to an effective and safe industrialised housing approach.

Approach:

Supplier sandpit

The supplier sandpit process invited stakeholders across the supply chain to submit technically and commercially promising MMC and Net Zero Carbon related components, products, and systems. These were assessed for use in current and future trials. The aim was to identify and support the development of such products and systems most likely to support the future needs of the housebuilding industry.

The initial proposal was created by Barratt Developments and agreed with WP6 partners. Promotion through aimch.co.uk, with support from Construction Product Association (CPA) and other AIMCH stakeholder supporters, invited submissions from across the supply chain in three main categories:

- Advanced Modern Methods of Construction (MMC) Solutions
- Standardisation
- Zero Carbon



As responses began to come in, the level of interest and number of submissions added two further categories:

- **Future homes**
- **Off-site manufacture/Pre-manufactured value**

Every submission – including a number of submissions from project partners – was reviewed and evaluated according to an agreed scoring matrix. Those that made it through the initial stage then went under further review with proposers and project partners before being rejected or progressed.

H&S risk profiling

Advanced MMC changes the risk profile and can reduce onsite risk exposure by 20% compared with more traditional methods.

AIMCH partners were keen to better understand the H&S risk, benefits and changes associated with panelised MMC systems used for industrialised housing. They wanted to understand risks relating to the use of advanced panelised MMC systems using a crane and homes built using manual assembly techniques with a forklift.

Led by AIMCH partner Stewart Milne Group, in collaboration with Limberger Associates and with support from the Health and Safety Executive, this project developed and carried out H&S risk profiling methodology and assessments, examining

safety requirements and risk profiles associated with the differing techniques and practices.

Two deep dive case studies were developed:

1. GEN3 crane erect, MMC floor cassettes vs GEN1 forklift & loose joists

- GEN 1 loose joists rely on manual labour and material movement on-site and the installation of a safety decking system.
- GEN3 floor cassettes significantly speeds up the process and removes many of the risks associated with GEN1, however it also introduced new risks associated with the movement of large heavy loads.

2. GEN3 crane erect, factory fitted windows vs GEN1 forklift & site fitted windows

- GEN 1 site fitted windows rely on manual labour and material movement on-site and the manual installation on site
- GEN3 factory fitted windows, eliminates manual fitting, and reduces material handling on site. It speeds up the construction process and removes many of the risks associated with manual handling and moving materials, however it also introduced new risks associated with the crane placement of large heavy loads.

In the eyes of the constructor using GEN3 crane erect advanced panelised MMC systems reduces H&S risks/hazard exposure on the building site. However, it also introduces a few high impact risks



Sigma II Closed Panel Build System, Donaldson Timber Systems (formerly Stewart Milne Timber Systems)

on site, associated with crane lifts and displaces risk to the factory environment.

Outputs:

Supplier sandpits

At the time of writing (April 2022), the project has given suppliers the opportunity to promote a unique range of near-to-market systems and solutions that could significantly impact AIMCH goals. 66% of initial submissions remain in review or in progress.

Submissions still under review or being progressed against each category:

- **Advanced MMC solutions**
Of ten entries, three are being progressed.
- **Standardisation Solutions**
Two submissions were received, one – relating to the supply of window and door systems – is under review.

- **Zero Carbon solutions**

Of ten entries, two are still under review and five are being progressed.

- **Future Home**

Two submissions are under review and one is being progressed. All relate to alternative heating solutions. Two are in trial in the zero carbon house being created by Barratt Developments in conjunction with Salford University.

- **Off-site manufacture/PMV**

Of 11 entries, four are under review and seven are being progressed.

Read the full Supplier Sandpit report

H&S risk profiling

The work provided detailed insights into the differing risk profiles created by increasing the extent of prefabrication in MMC systems. Two key conclusions emerged:

- 1. Advanced MMC changes the risk profile and can reduce onsite risk exposure by 20% compared with more traditional methods**

GEN3 crane erect advanced MMC systems can provide a generally safer onsite working environment, reducing by 20% the smaller, more frequent, and lower impact risks that can

lead to health issues over time. However, there is an increased risk of very low likelihood but high impact safety events when using a crane for heavy lifting operations.

- 2. Some risks associated with advanced MMC methods are displaced to MMC factory**

This is beneficial to constructors, however the MMC supply chain must drive safe factory operations to ensure there is no net increase in risk for more advanced MMC-built homes. Risks can be effectively mitigated and controlled within the factory environment, where workplace safety systems are generally well managed.

Longer term, further hazards can be eliminated by MMC suppliers investing in automation and robotics, to reduce the manual working and handling practises that are meantime common within MMC factory facilities.

[Read the full H&S Risk Profiling report](#)

Milton Keynes site,
Stewart Milne Group



WP7 | Advanced manufacturing robotics and future factory simulation

Work Package Participants:

- MTC
- Stewart Milne Group
- Forster Roofing

Background:

The advanced manufacturing work package examined the use of automation in manufacturing processes for MMC wall panels. At the same time, it looked at the possibilities presented by using modelling technology to plan future offsite manufacturing (OSM) facilities.

Stewart Milne Group, in partnership with equipment technology partner Randek, led the development and design of three robotic workstations for sheathing, window fitting and insulation applications.

Forster Roofing, in partnership with MTC, assessed the use of a mathematical model to complete a worked example of a small factory unit, testing its use and applicability in replicating a real industrial scenario.

Stewart Milne Group, working with MTC, showed how modelling and simulation tools can inform investment decisions, reduce the need for external consultation and speed up the development of offsite construction, manufacturing facilities.

Approach:

Advanced manufacturing robotics

This project designed three robotic workstations for sheathing, window and insulation applications.

Sheathing involves picking, placing and fixing sheathing boards onto Category 2 MMC panelised wall panel frames. That meant the design needed to consider how the station would cope with different-sized boards, or trimming in situ, as well as varying board types and weights. It also had to be able to apply a range of fixing methods, delivering a precision result.

The fitting of windows involves assessing supply chain logistics, identification, sequencing and robotic insertion, as well as loading and offloading of windows into panelised external wall systems

Filling wall panels with insulation materials via an automated system meant thinking about the supply of raw insulation material to the system, and accurate positioning and repositioning over a range of panel/void sizes and configurations.

In all cases the partners also had to think about the cycle times needed to positively affect output.

The use of advanced manufacturing techniques has provided AIMCH with benefits including a reduction in labour dependency, lowering of manufacturing costs, increased productivity and capacity, improved product quality and reliability and elimination of manual handling and safety risks.



*Designing a future factory,
Stewart Milne Group*

Future factory simulation

Stewart Milne Group and MTC collaborated to test modelling technology that could be used to speed up investment in future OSM factory planning. Drawing from technology used in the automotive sector, they examined its potential for reducing the planning and analysis needed to support investment. They also considered its use in speeding up the creation of factory blueprints and specifications needed for business case investment.

The partners worked together to:

- Identify appropriate factory production flows and work planning parameters for panelised OSM.
- Model different tools and techniques.
- Created a flexible but relevant mathematical model and simulation tool.
- Undertake the practical assessments and testing needed to ensure robust tools and reliable outcomes.
- Test the tool effectiveness in real-world applications and justifications

They also had to ensure the modelling and simulation tool was flexible and accessible enough for non-expert use, and scalable for any size of business.

Mathematical Model Assessment

A user pilot assessment demonstrated the practical use of the mathematical model to evaluate its usability and functionality. Stewart Milne Group input data for a real-life scenario, then used the resulting development model to build three factory scenarios. This exercise helped assess the model's ability to represent a real scenario and allowed the validation of results by comparing output from the modelling tool with known results from existing factory operations.

The output was a mathematical model, simulating work flows and crystallising future factory layouts and designs for inside and outside spaces, that were then developed into 3D blueprints and walkthrough animations.

Forster Roofing's project made further assessment possible by using the mathematical model to create plans for a new factory unit. The exercise assessed the model's ability to represent a smaller production system. Modelling consisted primarily of:

- Inputting data and assumptions into the mathematical model from the industrial scenario
- Output of model data and 2D layouts
- Assessment of modelling process and performance

The exercise also allowed assessment of user understanding of key components:

- Inputs/assumptions – key data entries for the scenario
- Model exercise/methodology – modelling process and scenario concepts
- Outputs/interpretation – key data output for the scenario

Outcomes:

The **advanced manufacturing robotics team** were able to determine that a multi-robot cell could effectively deliver similar outputs in sheathing operations, but with a smaller footprint and a significant increase in accuracy and reliability.

They also created a proof of concept design for an insulation solution that demonstrated the potential, with additional improvements, to double output. At the same time, the team acknowledges the need for more work and investment with technology partners to fully commercialise the operation.

Looking beyond AIMCH, the proof of concept and learnings gained from the project, will fuel further commercialisation and deployment of new advanced manufacturing applications.

The **modelling technology team** were able to develop four modelling systems:

- A mathematical model to serve as a scalable and adaptable tool that would cope with complex OSM scenarios, provide a structured and practical method for factory design, calculate equipment and labour quantities and visualise the layout of the factory production system.
- A 2D Discrete Event Simulation (DES) Model that balances a user-friendly data management system with scenario testing processes. A user interface was designed to allow users to input data, build models, run scenarios and assess output without having to use the complex software directly.
- A 3D DES model that shows the planned and analysed factory specification that can inform an architectural model and help communicate plans and designs. It also supports collaborative planning between internal and external stakeholders.
- A 3D Revit model to show greater detail in the factory unit and service areas, as well as an animated fly-through that brings the project to life. This also helped to prompt positive challenges and engagement and to improve further design iterations.



Industrial scale KUKA KR Quantec Robotic Arm

Forster Roofing's mathematical model trial highlighted the capability of this type of modelling to help both larger production businesses and SMEs by supporting business decisions and ventures into unknown production type activities. They felt that the modelling could be further refined to increase capability, make it more generic and allow it to be more applicable across the construction sector.

There is proven interest in the repeated use of the model to support other project deliverables and present a standard process for this level of system assessment. The structured and practical nature of the model lends itself to wider use throughout MTC, industrial partners and customers.

This project has created tools that can be used in both construction and other manufacturing industries, and showed that they can be simpler and more accessible than might previously have been thought. They will improve decision making and add value in planning new facilities or remodelling existing factories or processes. There's also huge potential for these tools to be used beyond AIMCH and the construction sector.

The demonstration of these modelling and simulation tools has highlighted the benefits of applying modelling techniques within the construction industry and will hopefully encourage the wider construction community to adopt and embrace this type of technology to improve robust investment and expansion decision making.

[Read the full Advanced Manufacturing report.](#)

[Read the full Mathematical Model Assessment report](#)



WP8/11 | Commercial and Whole Life Cost Assessment

As part of the Advanced Industrialised Methods for the Construction of Homes (AIMCH) project, AIMCH partners commissioned Whole Life Consultants Ltd to compare the whole life costs (WLC) and life cycle costs (LCC) of four different house types, each built using three methods of construction.

The whole life cost assessment has been carried out in the wider context of AIMCH Work Package 11 (Embodied Carbon and Whole Life Cost Assessment), which among its objectives, aimed to:

- Evaluate the benefits and/or impacts on the long term environmental and commercial/ financial impacts of the use of MMC systems in future AIMCH housing and asset management
- Provide data in support of the benefits/ impacts on the procurement of housing, considerate of capital cost vs whole life cost, in the context of MMC panelised construction systems compared to conventional build methods, assessing procuring for value vs procuring on cost.

Summary

According to ISO 15686-part 5: 2017, whole life costing (WLC) is “a methodology for systematic economic consideration of all whole-life costs and benefits over a period of analysis as defined in the agreed scope”.

Life cycle cost (LCC) is “the cost of an asset, or its parts throughout its life cycle, while fulfilling the performance requirements”.

Assessment for WP11 was based on the above, and cost items included were:

- Building elements
- Prelims and site overheads
- Waste disposal
- Life expectancy
- Replacement
- Decoration and redecoration
- Energy consumption and price
- Disposal
- CO2 emissions (quantity and price)
- Financial benefits arising from early completion



Kings Quarter development, Stretton, Warrington, Barratt Development PLC

Journey

Whole life cost assessments were carried out on a range of homes and build methods agreed with the AIMCH partners.

These were three and four-bedroom semi-detached homes from Barratt Developments PLC and two-bedroom semi-detached and three-bedroom townhouses from L&Q.

Methods of construction used in all house types were:

- Traditional - standard masonry, using aerated concrete blockwork and brick cladding
- Open panel - off-site manufactured open panel timber frame with brick cladding
- Closed panel - off-site manufactured closed panel timber frame with brick cladding

A summary report shows the comparison of the four house types and construction methods to England and Wales Approved Document L Building Standards (published Mar 14). The Full Detailed Whole Life Cost Assessment Report is commercially restricted to AIMCH partners.

Additional modelling will be undertaken in the future to assess the implications on compliance to Jun 22 AD-L building regulation changes and Future Homes Standards in England and Wales.

NOTE: Construction cost data refers to late 2019/early 2020 prices. Prices of materials have changed significantly since that data was collected.



Kings Quarter development, Stretton, Warrington, Barratt Development PLC

Conclusions

The study showed that while timber frame solutions are, on average, 2-8% more expensive than traditional masonry solutions, MMC adoption reduces on-site construction duration. As a result build-to-sell business models may benefit from earlier interest repayment of loans, and build-to-rent business models may benefit from earlier rental income, depending on geographic location.

Timber frame construction methods reduce environmental costs. Open panel and closed panel timber frame cost decreases on average by 0.5% and 0.6% respectively when the cost of CO₂e associated with construction is accounted for.

Although not directly quantifiable due to a lack of data, another benefit of the use of timber frame solutions is the increase in quality improvements associated with making MMC components in a controlled environment.



Roof lift, Milton Keynes site, Stewart Milne Group



Milton Keynes site, Stewart Milne Group

In terms of carbon, the benefits of timber frame over masonry construction will become increasingly significant, as will focus on reducing the embodied emissions from cementitious products and operational emissions with the implementation of the Future Homes Standard, continued decarbonisation of the UK electricity grid, and increased electrification.

Future Homes Standard will have a significant impact on both traditional and timber frame specifications, consequently impacting the cost margins between the two systems.

Operational costs of traditionally-built houses are similar to those of open/closed panel timber frame houses of the same type. This is principally because, regardless of the construction method, the houses are all designed to the same energy efficiency standard. Consequently their energy usage, associated emissions, and energy costs are the same.

Geographical location has a significant influence on labour cost, which makes MMC a more viable solution in locations where labour costs are high (e.g. southern regions and L&Q). The cost data used here is from a small sample, therefore further cost analysis would need to be carried out before any business decisions are carried out.

Construction cost data refers to late 2019/ early 2020 prices. Prices of materials have changed significantly since that data was collected. Therefore, it is recommended the models are updated with current cost data before any business decisions are made.

Although not directly quantifiable due to the lack of data, another benefit linked to the use of timber frame solution arises from quality improvements associated with the manufacture of MMC components in a controlled environment (i.e. the manufacturing of closed panels versus the on-site erection of walls).



Kings Quarter development, Stretton, Warrington, Barratt Development PLC

WP10 | AR proof of concept for roof tiling

WP leads:

- Forster Roofing
- MTC

Much of AIMCH is about finding new ways to do things that are faster, more efficient, and more focused on the future. This project was the perfect fit. It's been fantastic to be involved.

Bruce Raffell

Commercial Director, Forster Roofing

Background:

Work package 10 created a feasibility study and a Proof of Concept for the use of Augmented Reality (AR) or Mixed Reality (MR) technologies to guide installation of Forster Roofing's advanced roof tiling systems.

The opportunity to research the area came about when one of the AIMCH project partners was forced to drop out in order to deal with the COVID-19 pandemic. Forster Roofing made a bid for the funds that would otherwise have been allocated to that partner's project. That successful bid meant they were able to extend their involvement in AIMCH and study this additional area.

This study, carried out in partnership with MTC, examined the pros and cons of potential hardware and software solutions, including safety, practicality, effectiveness and accuracy.

The aim was to assess:

- Usage of AR or MR technology to help workers during roof installations by providing information about the selection, orientation and installation of roofing products in newbuild housing.
- Development of an application to run on AR or MR device with functionality to read barcodes/labels and deliver instructions for correct installation.

The system also had to be capable of:

- Identifying a point of reference against which to overlay augmented instructions.
- Displaying information for two different common house types.
- Displaying three common types of roof tile.
- Displaying the position of features like integrated solar PV panels.
- Facilitating generation of various roof configurations.

When something goes wrong on site it's usually down to communication. This system acts like an extended instruction manual, helping to make sure all the key components are where they should be and to enhance communications on all sides.

Bruce Raffell

Commercial Director, Forster Roofing

Approach:

The study began by evaluating two device types to see which would be most likely to deliver the desired results: head or hardhat-mounted devices or hand-held iPhone or iPad devices incorporating light detection and ranging (LIDAR) hardware.

While head-mounted devices offered a stable and hands-free solution, low brightness and highly reflective screens made them unsuitable for outdoor environments. Hand-held devices, on the other hand, came with technical risks, which the project partners mitigated by using the latest iPhone iteration, complete with LIDAR sensors and AR Kit.

The next stage, Proof of Concept (PoC) was developed in three steps: concept design, solution design and user experience design.



Augmented Reality Roofing System, Forster Group & MTC

Concept design

The initial step outlined exactly what the solution would deliver – an instant-access system that would allow the user to:

- Choose one of three roof configurations containing the information to be overlaid onto the real environment.
- Identify an AR marker as a reference point for correctly placing AR generated content,
- Use a barcode or QR code to add the right materials,
- Visualise the positioning and rotation of those materials as well as preconfigured PV panels, vent tiles, fire barriers and tiles to be fixed.

UX and solution design

This involved considering exactly how the user would operate the system, and what it would be required to do in use, then designing the technology around those requirements.

Testing and demonstration

COVID-19 restrictions made it difficult to test the developing technology in a live work environment, however MTC created a test rig at their workshop that allowed each iteration to be tested in a way that closely simulated real-world conditions.

Outcomes:

The proof of concept work carried out as part of this project shows that AR can — and does — deliver significant benefits, and has the potential to expand and develop even further, pulling information from remote servers as well as from pre-written information banks.

In fact work is already under way to bring the solution to market, and to take the steps needed to make it an even more flexible and adaptable communications and training tool.

AR is something everyone already knows about, but it hasn't yet made a major impact on the sector. Through this project we've been able to prove the concept, and it has been really well received. We're already taking the next steps towards industrialising it in conjunction with our main area of innovation: our advanced roof tiling system.

Bruce Raffell

Commercial Director, Forster Roofing

[Read the full report Adv Industrialised Methods - Condensed.pdf](#)

Kings Quarter development,
Stretton, Warrington, Barratt
Development PLC


Funding that created a flagship

How Innovate UK's decision to back the AIMCH project benefited everyone involved

Dr Mike Pitts, Deputy Challenge Director, Innovate UK.

In 2018, Innovate UK launched the Transforming Construction challenge. Its aim was to bring manufacturing, digital, and renewable energy approaches into the creation of new buildings. It focused in particular on boosting productivity, cutting costs, delivering projects faster and reducing emissions.

*Saxon Reach, Milton Keynes,
L&Q*



To that end, we ran a couple of waves of competition for industrial collaboration funding.

In the first round we were approached by the AIMCH consortium. Their project didn't quite fit the mould. It was more extensive than the scope we'd detailed, and lasted longer than the time limits we'd set. But it was a great idea. It involved collaborative working between house builders and supply chains. It would generate hard evidence of the differences between traditional build methods and modern methods of construction.

And it wasn't just about collaborating with the existing supply chain. It was also about sharing information with the wider industry. The benefit to the whole of the housebuilding sector would be pretty impressive. So we decided they could apply. If they were successful we would take on the higher costs and extended timeline.

Collaboration between competitors

It's not uncommon for us to work with individual businesses and on small-ish collaborations. But we're quite prepared to take the risk on larger projects and collaborations, especially those that are well thought out — as this one was.

Collectively, the project partners had realised that this was an opportunity. Rather than fight over a diminishing space, they had the chance to do something that could really change the whole sector. You can't do that on your own.

Our programme was about moving the whole construction industry system forward. The current system has evolved into a 'race to the bottom' mentality, where it delivers the cheapest building, not necessarily the one that gives the best value, particularly value over its lifetime. We wanted to look at delivering a system that removes the steps that add cost but don't add value, which is what a lot of MMC stuff does.

There were some really nice examples of that within the AIMCH project proposal. It would be working with the whole of the supply chain to consider key questions like: 'How do we work together to do this differently and so that we all benefit?' That was a clear argument. We were won over.

Overcoming challenges

The key challenge of the AIMCH project was fully engaging across the sector. They've worked hard in terms of dissemination and engagement. Culturally, this is a major shift for everyone involved, from the boardroom to the people working on site.

For me, what was really interesting was the creation of a standardised process. Because the process of building a house isn't standardised. To some degree it doesn't need to be, particularly for private house building. You're not really making money in the build part of the process. So standardisation isn't necessarily going to be a massive win.

But what it does do is create a single process that can be examined and optimised. Bottlenecks can be identified and reduced. That means increased and improved productivity. There are a lot of other knock-on impacts and benefits, and we wouldn't know about them without this project.

Results and the real world

AIMCH became a flagship project. It may have taken a large portion of our competition budget, but it has more than given that back in terms of results and the way those results are being disseminated. There's a brilliantly informative website, very clear reports, all the data is out there, allowing others to benefit from the team's work.

The great thing is that there's so much accessible content explaining what the project partners did. Operating in an economy-wide innovation landscape, it's very powerful to be able to explain why what we do is important to the whole economy. AIMCH is a really good example of that.

It has embraced new technology. It has created wider collaboration and engaged with over 120 supply chain companies. It has adapted to change and challenges. And it is already putting some of its outputs into forward planning – and into current projects. Even before the programme is completely finished, it's already supporting something like £2.5bn of economic activity. Which proves that our initial investment was entirely justified.

AIMCH have been wonderful to work with. And what's really exciting is just the sheer scale of impact the project is having already. It's beyond what we – and the AIMCH consortium – could have hoped for. I look forward to watching it continue to impact the construction sector for many, many years to come.





Project partners



Stewart Milne Group

Lead Industry Partner – Housing and OSM Supply Chain



Barratt Developments PLC

Industry Partner – Private Housing



Forster Roofing

Industry Partner – SME Sub Contractor



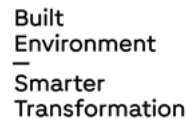
L&Q

Industry Partner – Social Housing



Manufacturing Technology Centre (MTC)

Lead Research Partner



BE - ST

Research and Dissemination Partner



Limberger Associates

Project Managers

Project supporters





TRANSFORMING
HOW WE BUILD HOMES



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