# housing
## The digital revolution

Building **Alliance** BA

**BIRMINGHAM CITY** University

# Contents

**The Building Alliance and the Digital Construction Research Centre  at Birmingham City University recently worked with 50 key stakeholders, to identify the  opportunities that digital construction can offer to improve the process of building  and living in new homes.**

The participants concluded that digital construction offers the housing industry enormous opportunities to improve their financial return and customer satisfaction. This can be achieved through efficient design and construction processes, an enhanced customer experience and pro-active management of whole house performance and maintenance.

This 'Digital Revolution' will see the introduction of new techniques and efficient processes. It can positively influence how the industry is seen and how it operates. BIM is slowly emerging as the key driver for the digital shift as it helps in collating materials, objects and process information, and uses this data to provide better visualisation, communication and process improvement.

A well planned approach to digital construction can help the housing industry in reducing the time required to develop and market new housing projects. At present the design and approval phases require a long lead time.

Adoption of emerging technologies, such as BIM, will provide better opportunities for the supply chain partners to collaboratively address and manage changes raised by planning authorities, customers and site staff. 3D visualisation of the construction sequencing will improve confidence in work programmes and schedules. Both human resources and materials can be efficiently managed, helping the industry to mitigate financial and delivery risks associated with skill and material shortages and alterations to the site program.

Digital construction can help in improving customer experience by making a new house purchase an engaged choice rather than a direct sell. Customers will be able to pick and choose options such as floor layout and materials to suit their preferences. The benefits of energy and environmental features along with their long term significance can be easily communicated through visual representations.

Mobile apps combined with sensors can help develop 'house dashboards' for reporting performance, ageing and repair needs. The house builders will be able to create a long term relationship with their customers by providing value added options around periodic maintenance services and assisting with the design and specification of modifications and extensions. There is a potential to make a new house purchase the preferred choice of customers in a market where many consumers actively seek to purchase a used home rather than a new one.

House builders and other businesses operating in the housing industry should take deliberate steps to proactively manage the shift to digital construction. By doing so, they will be able to control the pace of the transition. Otherwise, businesses may have to reactively adjust to the change that may be imposed on them by emerging market expectations or by forward-thinking early adopters.

The challenge is to manage the transition in the least disruptive way. The shift from the 'current state' to the 'digital world' may take time and may require modifications in the current operating models. However, if planned properly, businesses can expect a good return on their investment.

Most of the savings will come from the improved operating model. The wider housing industry and the supply chain will have to transform not only to reduce the cost of building new homes, but also to become an attractive career option for bright youngsters with a wide variety of skills. This will eventually help in addressing skill shortages in the industry.

Led by the Building Alliance and Birmingham City University, a cross industry working task group has been formed to identify opportunities and evaluate the business case for their introduction. The overall aim is to accelerate the participation of the housing industry and its supply chain in the Digital Construction Revolution.

# The Top Ten Benefits of Digital Housing

## Digital Housing Workshop

The Building Alliance delivered this unique event in association with the Digital Construction Research Centre at Birmingham City University. This group worked with 50 major players in the house building industry on the opportunities that BIM can offer to the industry, its customers and society. The event was attended by major developers, planning consultants, sub-contractors, material manufacturers and management consultants. Bringing together such a cross-section of the industry who in other circumstances can be competitive and adversarial, heralds the idea that BIM stands for collaboration.

Led by Professor David Boyd and a team from the Birmingham City University, the event presented a live demonstration of BIM. The team demonstrated that 3D graphical models can be easily created and modified in a BIM environment. The demonstration included the live creation of walls, openings, floors, and mechanical and electrical ('M&E') systems.

A virtual model of a house was created and used for walk-throughs, energy analysis, costing and time lapse construction programming. Participants brainstormed on how the virtual model of the house, created during the BIM demonstration, could be adapted to the emerging needs of a potential customer purchasing a new house in 2020. During the presentation, live adaptions were performed and the virtual model was progressively improved by upgrading its layout, functions and its energy use.

Workshops were also held to explore the improvement opportunities that BIM offers to development planning,building regulation and control, customer experience and supply chain management. Participants voted on the top ten benefits that BIM offered, and explored how the industry should work together to make the most of these benefits.

The participants realised that there are tremendous opportunities in managing the whole lifecycle cost of housing. This will improve customer experience and at the same time emphasise the societal and environmental benefits of the housing industry.

**The participants in the workshop determined that the top ten benefits of BIM for housing are:**

- **An opportunity to collaborate**

- **Visualisation of design and production**

- **Enhancing the new build brand**

- **Improved customer experience**

- **Single point for information**

- **Design accuracy**

- **Managing whole life cycle information**

- **Improved stakeholder engagement**

- **Efficient supply chain delivery**

- **Improved building performance**

## What is digital construction?

The essence of digital construction lies in managing information. A very good understanding and management of information is required such that useful information can be generated, transformed and used in a smooth and efficient way. All aspects of the industry, whether physical, organisational or economic, can be represented as information.

This information is gathered throughout the whole housing delivery process, and should be in a form that can be easily presented and measured. Separate design, construction and operation information can be combined to meet the expectations of the various stakeholders in the building process and bring about affordable homes, better performance, sustainability and faster delivery.

Information technology can be used to close the gaps in the process and to improve the performance, sustainability and efficiency of housing delivery. BIM is one of the key developments in digital construction.



It provides opportunities for doing more complex housing developments by providing both geometry of buildings, as is the case with 3D CAD, and its component data, such as specifications and internal dependencies. This exemplify BIM's potential, as BIM is not just an enhanced version of 3D CAD models. The information stored in the model can be used for time programming, design coordination, supply chain operations and project economics. Additionally, future costs such as energy costs during the housing operation and components' life span can be forecasted in BIM.

A number of hardware and software tools could be used to collect and manage information. For example, sensors could be used to collect information related to the building and its components' performance. Internet and other communication tools can help make the information accessible to both home owners and supply chain partners.

Thus BIM, combined with other technologies, can help make better decisions and progressively improve building design in the long term. This digital shift heralds a change that sees house building and operation not as a series of tasks with fragmented deliverables but as a flow of information with processes that need to be coordinated.

## The essence of digital construction lies in managing information.

# Parametric design

Parametric object modelling is one of the important features in BIM. It goes beyond just geometry as it holds information about what the objects are and how these relate to other objects. Parametric object modelling is different from CAD, where components such as walls, floors and windows are only held as ordinary lines and volumes.

It not only ensures the correctness of geometric connections, but also has further 'intelligence' which ensures that the object maintains its relationship with other objects automatically. For example, a window frame with configurable length and width parameters can only have a particular relationship with the wall it is in; this correct relationship will be maintained if the window and wall are changed. The advantage of parametric object modelling is its ability to manage the changes in real time as objects are created and moved.

A BIM model identifies and characterises all house components as objects with their own spatial integrity connected through design to create the complete building.

Given this information, software can determine 'clashes', which are spatial incongruities and may result from inadequate object connection information. These 'clashes' can then be worked on by the design team to facilitate a more accurate model. A model is typically worked on separately by the different disciplines (e.g. structures and M&E) but always to the unique reference model, thereby allowing fully integrated-design team-working.

A number of BIM design tools work in their proprietary data structures, but the information can be easily extracted to common formats. Industry Foundation Classes ('IFC') is a widely recognised universal interchange format within the Architectural, Engineering and Construction ('AEC') domain. Interoperability between different design tools is still an issue but over the years the design tools have matured and provide a number of options to transfer information from one format to another.

# Structural analysis and design

With objects storing their identity and functional characteristics, it is possible to analyse the structural integrity of a design. An architectural model can be adapted to include loads and structural member support conditions.

This is often done in a separate but interconnected structural analysis and design software. For more sophisticated structural analyses, object data is transferred from an architectural design software to a specialist structural software. Specific structural engineering data may be added to the architectural model for simulating different scenarios that may impact the structural integrity of a model.

However, the data exchange has to be planned at the outset so that the exchange can be undertaken reliably and accurately with the structural implications fed back to the architectural design.

# Mechanical, electrical and plumbing: Design and analysis

Mechanical, electrical and plumbing ('MEP') services can been seen as flows of fluids or currents so that in modelling they can be represented as closed systems. These simulations can be referenced to a BIM model so that the MEP services system can be developed simultaneously along with the architectural model.

Again, as this logic is different from geometric design logic, it is conducted in separate but interconnected software. Specialist MEP software allows analysis of loads within the system in relation to the scale of the pipes, ducts and wires.

Like structures, BIM enables the transfer of geometric information to separate MEP software, where additional information can be added to MEP analysis and design.

This may include energy consumption, lighting requirements and environmental impact for separate functional spaces within a building.

A BIM model identifies and characterises all house components as objects with their own spatial integrity connected through design to create the complete building.

**Design as intelligent information creation**

**Project planning involves the creation of a time programme based on activities that have to be performed to complete the construction.**

# Digital procurement

## Delivery

Project planning involves the creation of a time programme based on activities that have to be performed to complete the construction.

Many of these activities may be common for every building project but their order and time duration depend on the site conditions, the site set up and the project delivery method used. Such activity planning has been done using computers for many years.

The project planning and scheduling process can be enhanced by using digital construction to visualise the construction process. This involves connecting the project programme to the building model, so that the sequence of construction, or placing of building components, can be simulated.

This requires each of the building components to be allocated to a project activity. Part of the allocation can be done automatically, as building components are categorised by their functional characteristics such as walls and floors.

Manual intervention may be required for some tasks. For example, a cavity wall will involve slicing the building components in the digital model into sub-elements and connecting them manually in a specific sequence.

The sequencing of construction tasks in practice can be enhanced by considering shipping and storage requirements of the components at the project site. It is possible to simulate different scenarios to decide upon the most suitable options.

This is particularly useful for congested and complex sites where a certain activity may interfere with other parallel activities. Both permanent and temporary structures can be simulated to communicate the plan of construction to all supply chain partners. Such simulations are not just useful for optimising work but also for ensuring compliance to health and safety standards.

Supply chain partners can use visualisation, simulation and communication aspects of digital construction to collaborate and improve the construction process.

Different organisations come together on a temporary basis to construct a building and information on interdependent activities has to be properly communicated.

A better visibility on such activities may increase the overall effectiveness and the certainty of project delivery.

## Costing

In BIM, it is possible to list out every object that has been used in the design, and the information may be used for scheduling and costing. A number of software packages already calculate the areas and volumes associated with objects, and how the objects interconnect to form spaces. This quantification of objects is generally known as Quantity Take Off ('QTO'). QTO can take component information from the model and transpose it into a spreadsheet. The spreadsheet could then be used for ordering manufactured components and/or raw materials. It is also possible to attach a cost to each object in the spreadsheet, and through simple calculations, to build up a total bill for a building.

Specialist costing software may be used instead of spreadsheets and can be linked directly to BIM. These software programmes could be used by cost consultants to group similar objects into different costing structures and process costs in a more accurate and standardised way. Cost consultants can then evaluate different alternatives and inspect the model to check that all objects have been accounted for, ensuring the cost output is complete and accurate.

# Digital housing for developers and occupiers

### Visualisation

The object information and their 3D connections allows a federated design model to be presented visually in a 3D graphic format. These graphics are available during the design process and can be generated for any viewpoint. It is also possible to present 2D views such as plans and sections, and the process of design in BIM involves switching between these views to progressively improve the design.

3D models can be rendered to produce more realistic images by providing surface properties to various objects. Other objects can be included such as furniture, people and landscape. Thus a virtual environment can be produced for exploring and appreciating the design particularly by the customers and regulators. Some software packages allow the design to be walked through. This takes the viewpoint of someone inside the building and allows them to select how they move and view the interior and exterior details. These walk-throughs are useful for the designers to understand the spaces they are creating and to assist with the coordination of structures, services and fittings.

**Digital can unlock development opportunities
and enhance the customer experience**

Walk-throughs and real time rendering of objects takes considerable computing power, hence the display has to be optimised based on the viewing position requested. Like computer games, the rendering tools typically process only relevant details needed for a particular viewing application.

Clearly, these visualisations are useful for presenting the building to customers and clients in a way that has never before been so easily available, far exceeding any perspective image. It is also possible to incorporate the digital design within a landscape either through digital maps or 3D digital landscapes. Such techniques can be useful for planning applications and public meetings as well as influencing prospective customers.

**Home management**
Buildings can be seen as machines that require monitoring and maintenance for efficient operation. Currently, many of the energy systems in buildings are controlled by computers which provides an opportunity to communicate their operating data.

For example, energy consumption can be easily recorded and displayed by Building Management Systems ('BMS').

Such data may be useful for commissioning as well as monitoring against expected performance based on occupancy patterns. This can ensure that energy systems can be adjusted to work at an optimal level.
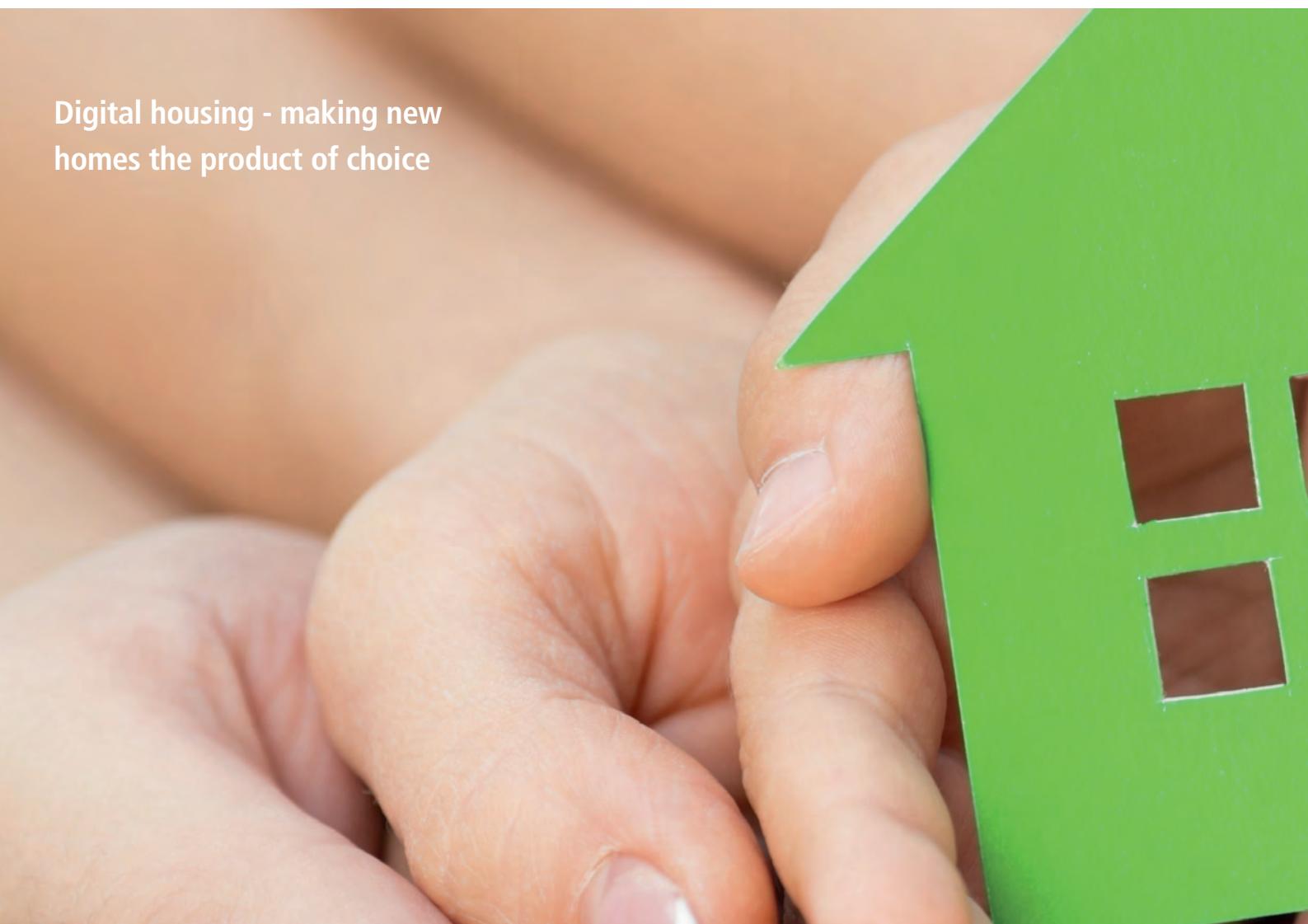
Beside this, it is possible to place many other sensors within buildings and to access data from the other systems (e.g. CCTV, water, lifts, fridges, access systems, security systems). Data from multiple sources could be collated and presented on a 'dashboard', via a 'Mobile App' or a dedicated display unit. Home users could ultimately use this information to customise the operation of all systems in their property based on their own specific requirements.

The information available with BMS can be combined with BIM to augment the effectiveness of these sensors and improve the quality of information provided to the home users.

# Digital Revolution in Housing

**Digital housing - making new homes the product of choice**

## Customers for life

More than just a tool for construction, digital construction is a tool to increase customer satisfaction both in the commissioning and in the ultimate delivery of houses.

Digital construction can reduce uncertainties around delivery and increase confidence on expected building performance, reducing the likelihood of complaints and rework. This will enhance the reputation of the industry, improving its political profile and will also make new homes more attractive to buyers.

Digital construction tools may make sales off-plan easier because of the ability to visualise the individual houses. Customers can virtually experience the property before occupying it. This digital environment enhances the show house experience by allowing customers to customise furniture and fittings to their liking.

Furthermore, digital construction may also provide house builders with the opportunity to co-design a house with the customer prior to its construction and customise the design to the preferences of the home user. Set within effective constraints, customers may be able to interactively modify interior designs and other housing components to suit their individual preferences. Digital representation would allow alternative design scenarios, along with their costs, to be presented in real time. The changes can be propagated to the delivery programme, which would involve placing new orders for materials and commissioning new subcontractors' activities.

A new role for house builder can emerge as the whole life maintenance organisation, where customers may want their property to be serviced by the house builder. This wider service presents new opportunities for the industry to delight its customers whilst overcoming some negative perceptions associated with the construction industry.

**More than just a tool for construction, digital construction is a tool to increase customer satisfaction both in the commissioning and in the ultimate delivery of houses.**

It will be possible to highlight building performance as a key selling point as more accurate operational costs can be predicted through performance modelling. This prediction could then be tied to the monitoring of utilities and benchmarking against other properties. Attaching this aspect to the whole life maintenance can provide new opportunities for the industry to work with customers to deliver improved performance and lower running costs.

Over their lifetime, houses need to be adapted and extended to keep them up to date with the changing home users' requirements. Digital construction facilitates this by making the building design model readily available and providing quick and easy design modifications. The proposed changes may be easily validated against regulations and bring down the cost of changes for the home owner.

A well designed information framework will ensure the successful delivery and maintenance of the home throughout its life cycle. Together with a personalised approach from start to finish, this will bring about a positive customer experience, thereby also creating more opportunities for the business and improving the image of the industry.

# Delivering the smart environment

Delivering housing involves extended interaction with regulators both for development planning and for construction integrity.

Digital construction offers the opportunity for the industry to have early regulator involvement, particularly during development planning, such that consensus could be built up earlier in the design phase.

Digital models can be used to include environmental, infrastructure and transport planning considerations as well as visualising the development in the context of the Neighbourhood Development Plan. In this way, the process of regulatory permissions will be more transparent and reduce the likelihood of delays in obtaining necessary permissions from local authorities.

Changes suggested by the regulatory authorities can be rapidly modelled along with their cost implications thus allowing fact-based discussions and effective decision making. House builders will be able to better manage the design and delivery process for stakeholders thereby satisfying existing communities, regulators and customers.

In a similar way, adherence to building control regulations and the time required to obtain associated sign-offs should become much easier. This means that exceptions and problems can be identified earlier, and before going on site, so that inspections can be planned as part of the sequence of work.

The digital management of delivery makes it easier to manage an accredited supply chain and material source documentation. This allows the demonstration of, for example, sustainability integrity, but may also cut the costs of insurance and warranties by reducing the calls on these and making any resulting claims more easily processed. Again, the step change that digital construction makes, releases more time for the industry to spend on value adding activities such as improvements to product and service delivery.

Delivering housing involves extended interaction with regulators both for development planning and for construction integrity.

# High performing industry

Digital Construction will allow better collaboration within the supply chain partners as information can be made readily available and accessible.

This will enable comprehensive planning of delivery schedules and identification of inefficient processes or wastages early on in the design cycle. Supply chain partners can be engaged and incentivised to work towards the profitability of the overall project rather than on their individual financial gains.

This may require a cultural change in procurement and payments. Risks and gains could be easily quantified and shared appropriately among the supply chain partners. There will be opportunities for supply chain managers to manage uncertainties more effectively. A number of options could be simultaneously evaluated to seek and work towards process improvement, and cost and time reduction, whilst still delivering high quality projects.

Digital construction provides the opportunity to manage a wider scope of the material supply and disposal processes. The delivery of materials to site can be better managed, starting from logistics planning with highways authorities, through to effective site operations and construction waste disposal. Digital construction can extend far down the construction supply chain and engage product and raw material suppliers. In the long term, it would help the supply chain partners to manage their inventory better, and use historical data to innovate and prepare for future capacity changes.

The industry will be able to easily document lessons learnt from past projects and apply these in training and recruitment. Issues such as social value, local employment and community support, can be more clearly addressed and solutions can be delivered as part of housing developments. This can help in gaining the trust of local communities for new developments, thereby building a better image for the industry.

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# Digitally changing the industry

## Changing culture

This digital shift involves seeing design, construction and operation of houses not as a set of tasks but as a flow and transformation of information. This will deliver efficiency and effectiveness of the overall housing delivery and operation processes. This is critical as the current tendency is to focus on individual financial gains instead of working towards project improvement as a whole.

Companies will have to concentrate on how they add value to the process in order to compete and have a stake in the successful delivery of a project. It is this collective understanding which has transformed the manufacturing industry, not only allowing it to work more efficiently but also giving it its authority in national discussions and developments.

Like the manufacturing industry, the housing industry can achieve better performance and national recognition through collaboration and focus on long-term gains.

## Changing Opportunities and Skills

The UK Government Strategy paper[1] highlights 'lack of high level skills appropriate to projects and programmes within the project team' as one of the main barriers for BIM adoption in construction projects. There are opportunities to exploit the skills of the young generation brought up on IT and develop these to enhance both supervisory and craft skills.

This will make the industry more attractive such that a larger number of young people will be motivated to join the industry. The digital shift requires the division between generations to be bridged, so that IT skills of young professionals can be complemented and developed through the close collaboration with experienced practitioners.

Therefore, training and education requirements should be carefully identified to up-skill all industry practitioners. While short courses are required to address the current need, the overall digital shift needs long term educational development in order to change the way the industry and potential employees perceive construction and facilities.

[1] BIS (2011), Building Information Modelling: Industrial strategy, HMSO. (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/34710/12-1327-building-information-modelling.pdf

## Next Steps

The Housing Digital Revolution offers a number of game changing opportunities including:

- Customers for Life
- Delivering the Smart Environment
- High Performing Industry

## We call upon the industry to get involved and support the Housing Digital Revolution

- A multi-disciplinary steering group to be put in place to organise and run a series of inter organisational workshops to discuss these findings and collectively agree on an industry-wide plan of action.
- Key house builders to be encouraged to demonstrate a number of sites completed entirely through implementing digital construction, and to share across the industry their experience and the results of working together with regulators and suppliers.
- The industry needs to explore the business opportunity to manage the whole life cycle of houses. This includes providing a service to customers by working on house operation data, structural maintenance services and providing feedback to designers.
- The industry needs to work with colleges, universities and private providers to develop an immediate training plan, but also to prepare a long-term strategy for the development of design and construction education.
- The industry needs to engage positively with the IT sector and create a partnership in the development of software and hardware that will benefit the construction industry

**Housing - the digital revolution**

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