

Institution: University of Salford
Unit of Assessment: C16 Architecture, Built Environment and Planning
Title of case study: Integrated and Collaborative Approach to Lifecycle Management in the Built Environment
<p>1. Summary of the impact</p> <p>Building Information Modelling and Management (BIM(M)) research at the University of Salford has contributed to the concept and development of an integrated approach to improved efficiency in the construction sector:</p> <ul style="list-style-type: none"> • Adopted in 2011 by the UK Government through its <i>Building Information Modelling and Management (BIM (M)) Strategy</i>, Salford research in BIM(M) has supported the development of this strategy, through demonstrating the approach and its benefits through several live projects and UK/EU government funded research projects, including: <ul style="list-style-type: none"> ○ Establishing the concept of 'nD modelling'; ○ Developing and demonstrating the concept of integrated multi-user distributed construction project databases, developing the virtual workspace for collaborative working; ○ Developing process improvement protocol/frameworks; ○ Supporting the development of the international standardisation for the representation and exchange of building information.
<p>2. Underpinning research</p> <p>The key researchers and positions they held at the institution at the time of the research are as follows: Professor Mustafa Alshawi, (from 1989), Dr Yusuf Arayici (from 2004), Professor Ghassan Auoad, (1984-2011), Professor Peter Brandon (1985-2010), Professor Terrence Fernando (from 1997), Professor A.J. Hinks , (2004-2010), Professor Mike Kagioglou, (from 2001), Dr Angela Lee (from 2001), Professor Marjan Sarshar (1996-2003), Dr Jason Underwood (from 2001), Dr Song Wu (from 2001) , Professor Vian Ahmed (from 2004). The research that has contributed to impact in the area of an integrated and collaborative approach to lifecycle management, Building Information Modelling (BIM) in the built environment has progressed over the last 20 years. The impact of this case study is underpinned by the following research:</p> <ul style="list-style-type: none"> • 1992-1998: Early pioneering research led to the development of frameworks and data models that could support the concept of integrating building and construction project information over its life cycle, through such UK government funded projects as <i>ICON</i> [7], <i>SPACE</i> and <i>OSCON</i> [12]. <i>SPACE</i> [8] and <i>OSCON</i> built on the outputs from <i>ICON</i> to focus on technological aspects and early prototypes, demonstrating the concept of integrating 'commercially available' construction applications, through a shared, object-oriented project database. • 1995-1998: The collaborative industry-led EPSRC funded <i>COMMIT</i> [10] project, defined the mechanisms (object models, tools, system architecture, methodology) needed to handle the management of information to support decision-making in collaborative projects. Funded by the EPSRC, Salford researchers developed a framework of common definitions, documents and procedures using manufacturing principles as a reference point to assist construction project participants' work together seamlessly in the <i>Process Protocol – GDCPP</i>, a high-level process map that aimed to provide a framework to help companies achieve improved design and construction processes. • 1996-1998: Through <i>WISPER</i> [11], the UK government funded <i>Partners in Innovation</i> project, Salford researchers developed an integrated multi-user distributed construction project database, implementing web-based technologies together with product data (Industry Foundation Classes information standard - <i>IFC</i>) technology. The project focused on developing a system capable of demonstrating the future direction of information integration with the collaborating industry partners' (Laing) businesses. • 1999-2000: EPSRC funded research focused on 'process improvement', developing an evolutionary step-wise process improvement framework through utilising experience from the IT sector in meeting the challenges of the Latham and Egan reports (<i>SPICE - Structured Process Improvement for Construction Enterprises</i> and <i>SPICE 3</i>). [14]

- Industry collaboration with Galliford, Welsh Waters, EC Harris and Stamford Homes (*Gallicon*) demonstrated the benefits of applying integration technologies to different sectors of the construction industry; water treatment and housing. Two integrated systems were subsequently developed for improving the conceptual design of waste water treatment plants, minimising development costs and enhancing customer relationship management in housing projects. Salford researchers focused on developing a virtual workspace to improve client briefing, design review and construction, achieved through a distributed architecture to support concurrent engineering practices in the collaborative EU Information Society Technologies funded programme, the *DIVERCITY* project.
- **2001-2005:** The concept of '*nD modelling*' (having been subsequently widely adopted at an international level) was devised by Salford researchers through the *3D to nD Modelling* [5] UK government funded project, which focused on enabling and equipping the design and construction industry with a tool that allows users to create, share, contemplate and apply knowledge from multiple perspectives (dimensions) of user requirements.
- **2006-2013:** Salford researchers are developing organisational models and distributed technologies for collaborative workspaces for individuals and project teams within distributed virtual manufacturing enterprises enabling effective partnerships, innovation, improved productivity, and reduced design cycles via *CoSpaces*, an EU funded collaborative project that further builds on the virtual workspace theme developed in *DIVERCITY*.

3. References to the research

Key outputs

1. Bassanino, M., Fernando, T. & Kuo-Cheng Wu, K. *Can virtual workspaces enhance team communication and collaboration in Design Review Meetings?* Journal of Architectural Engineering and Design Management, 2013, [DOI \(REF 2\)](#)
2. Arayici, Y., Ahmed, V. and Aouad, G. *A requirements engineering framework for integrated systems development for the construction industry*, Journal of Information Technology in Construction (ITCon), 11, 2006, pp. 35-55. [URL](#)
3. Aouad, G., Lee, A. & Wu, S. *nD Modelling in Construction: An Integrated Approach*. Journal of Architectural Engineering & Design Management, 1(1), 2005, pp. 33-44. [DOI](#)
4. Faraj, I., Alshawi, M., Aouad, G., Child, T., Underwood, J. *An Industry Foundation Classes Web-Based Collaborative Construction Computer Environment: WISPER*, Automation in Construction, 10 (1), 2000, pp. 79-99. [DOI](#)
5. Underwood, J., & Alshawi, M., *Towards an Integrated Application for Forecasting Building Element Maintenance*, International Journal of Computer-Integrated Design and Construction (CIDAC), 1 (1), 1999, pp. 39-48. ISSN: 1092-5902.
6. Aouad, G., Hinks, J., Cooper, R., Sheath, D.M., Kagioglou, M., & Sexton, M. *An IT Map for a Generic Design and Construction Process protocol*. Journal of Construction Procurement, November 1998. 4(1), pp. 132-151. [PDF available](#)

Key grants

7. Professor Peter Brandon, Integrated Database for Building Design Procurement & Construction Management (*ICON*), EPSRC, 1992–1993, £199,782.
8. Professor Mustafa Alshawi, Manipulation of Object Hierarchies in Virtual Environments through Internal and External Applications (*SPACE*), EPSRC, 1995–1997, £75,539.
9. Professor A.J. Hinks, Development of a Generic Design and Construction Process Protocol (*Process Protocol*), EPSRC, 1995–1997, £278,663.
10. Professor Peter Brandon, Intelligent Integration of Information for the Construction Industry (*COMMIT*), EPSRC, 1995-1998, £217,224.
11. Professor Mustafa Alshawi, Integrated Engineering Environment (*WISPER*), Department of the Environment (Partners in Innovation), 1996-1998, £700,000.
12. Professor Ghassan Aouad, *OSCON* integrated database, EPSRC, 1997
13. Professor Ghassan Aouad, Integrated Information Exchange toward an Industry Wide Process Improvement on Water and Housing Industries Projects (*Gallicon*), DETR, 1999-2000, £144,000.

14. Professor Marjan Sarshar, Standardised Process Improvement for Construction Enterprises (*SPICE*), DETR, 1998-2000, £102,916.
15. Professor Ghassan Auoad, From 3D To nD Modelling In Support of An Integrated Buildable, Sustainable, Maintainable and Accessible Built Environment, EPSRC Platform, 2001–2005, £445,679.

4. Details of the impact

- Building Information Modelling (BIM) research at the University of Salford has contributed to the concept and development of an integrated approach towards improved efficiency in the UK construction sector. According to the UK Government, “*the initial estimated savings to UK construction and its clients is £2bn pa through the widespread adoption of BIM*” ([UK Government, 2012](#)). By 2016 the UK Government will require Level 2 BIM as a minimum in the delivery of public procured projects: “*The UK Government has embarked with industry on a four year programme for sector modernisation with the key objective of reducing capital cost and the carbon burden from the construction and operation of the built environment by 20%. Central to these ambitions is the adoption of information rich Building Information Modelling (BIM) technologies, process and collaborative behaviours that will unlock new more efficient ways of working at all stages of the project life-cycle*” [BIM Task Group](#). University of Salford research has supported the development of this strategy through developing integrated approaches to improved efficiency in the construction sector, through:
 - Establishing the concept of ‘nD modelling’;
 - Developing and demonstrating the concept of integrated multi-user distributed construction project databases;
 - Developing and demonstrating the virtual workspace for concurrent engineering and collaborative working;
 - Developing the ‘Process Protocol’;
 - Supporting the development of the international standardisation for the representation and exchange of building information.
- **Context: 1993-1998:** Early pioneering research demonstrated the concept of building information integration through the development of a shared project database in supporting the project lifecycle, influencing early work on the development of the international standardisation of effort for the representation and exchange of building information through Industry Foundation Classes (IFC), by buildingSMART (formerly the International Alliance of Interoperability).
- The *WISPER* project was one of the first projects to implement the IFCs and, together with other projects such as *Gallicon*, contributed to their on-going development. Further industry collaboration led to a commercial project collaboration environment being established [4Projects](#), now widely deployed across the global construction industry to facilitate collaboration with 18 of the top 20 UK construction contractors and 3 of the top 5 construction organisations currently using the system, along with the development and deployment of bespoke organisational collaboration systems such as iCosnet used within Costain. In addition, the ‘Process Protocol’ has been widely recognised and adopted by the UK construction sector in facilitating industry process improvement.

2008-2010: A number of key leading industry figures engaged in these projects have deployed the approach and demonstrated its benefits on live projects, such as Heathrow Terminal 5, PalaceXchange, Sellafield and the Royal London Hospital. Moreover, the long-term relationships established with these key leading industry figures have formed the basis of the collaborative effort of driving BIM(M) forward within the construction industry and in leading to the recent UK Government BIM Strategy.
- **2008:** Salford researchers developed the Uniting Construction Information (UCI) initiative sponsored by the UK Government (DTI/BIS) towards uniting the various construction IT network/membership-based organisations under ‘one voice’ in creating closer collaboration between industry and Government and facilitating diversity, while avoiding duplication by pursuing common goals. A number of collaborative activities continue drive progressive

change in the industry, establishing BIM(M) training/CPD courses focused on increasing the awareness and uptake of BIM(M) in the UK construction sector. Many of these activities form part of the seven work stream activities which are on-going and are continuing to inform the UK Government's BIM strategy.

- **2011:** The BIM Academic Forum (BAF) was set up by Salford researchers and brings together the academic community in the UK to focus on supporting the education and training task group activities of the UK government strategy. *"At this point in the evolution of the UK BIM strategy it is of increasing importance that our teaching institutions are equally well informed of the progress that is being made across those Government departments which are spearheading implementation on projects and across its asset base. The BAF has taken great steps by bringing together and providing a focus for UK academia. The agenda supports that of the BIM task group in promoting UK BIM adoption and leadership both home and abroad to ensure that the UK is at the vanguard on new, more efficient ways of working"* Professor David Philp, Head of BIM at Mace, currently seconded to the Cabinet Office as Head of BIM Implementation 2012.
- **2012:** The CIB Integrated Design and Delivery Solutions (IDDS) Working Commission and Task Group has been established and is currently co-ordinated by the School of the Built Environment at Salford, while two recent major European (TEMPUS) funded projects synergised Salford's research competence in this area with those of comparable EU experts to develop unique Research, Learning and Enterprising excellence in a designated developing country: *"Industry [is] already recognising the business benefits of pursuing research into how BIM can help bring improvements to the life cycle of an asset in their own parts of the industry. For example, the British Council of Offices has established a programme with Salford University and HOK Architects to work with investors, designers and constructors to establish the knowledge-base and benefits of BIM across the design, build and operations of offices."* ([Industrial strategy: government and industry in partnership Building Information Modelling](#), HM Government, 2012)
- The formal engagement of leading industry figures is maintained, such as Mark Bew, Chairman of both the UK Government BIM Group and buildingSMART(UK) and currently undertaking a PhD, while Martin Simpson, Associate Director at ARUP, a leading global professional services organisation, and Peter Rebbeck, former Chairman of BSI-KSA and Construct IT For Business and former Strategic Director at BAA are Visiting Professors.

5. Sources to corroborate the impact

- a) Chairman of both the UK Government BIM Group and buildingSMART (UK), and Director of Engineering Construction Strategies Ltd. (*WISPER Project Partner*)
- b) Director, MR1 Consulting (*WISPER Project Partner*)
- c) UK BIM Technical Manager, Skanska (*WISPER Project Partner*)
- d) Former B/555 Committee Chairman, BSI-KSA; former Chairman Construct IT for Business; former Strategic Director, BAA.
- e) CEO 4Projects