

The influence of BIM on the responsibilities and skills of a project delivery team

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Abstract

Building Information Modelling (BIM) is an emerging approach to construction that combines the use of virtual models and the principles of mutual information sharing to establish a collaborative environment in built environment projects. It is currently the subject of much discussion, among which is how it might affect the interaction between traditional construction project roles. This study focused on viewing the demand for positions that operated in a BIM setting to evaluate a set of roles that will be found in teams in the future. By analysing over 300 job adverts and comparing the findings with observational and conceptual literature, the research determined a set of management, coordinating and technical role types that interacted with BIM either directly or by proxy. The summary of this set should provide an increased understanding of the changing shape of built environment project teams.

Keywords: Building Information Modelling (BIM), Project Teams, Collaboration, Project Roles, Team Interaction

1. Introduction

The Cabinet Office (2011) states that BIM utilises "a fully collaborative 3D environment, so that all of those involved in a project are working on a shared platform with reduced transaction costs and less opportunity for error". It is being officially encouraged by the Cabinet Office (2011) as a route to improving efficiency in the industry: "Government will require fully collaborative BIM level 2 as a minimum by 2016."

BIM is a worldwide initiative that is being adopted to varying extents internationally; Figure 1 below conveys a design consultancy's assessment that the UK is not among the leaders in embracing the process. The WSP Group (2013) currently consider that Britain lacks enthusiasm relative to some other nations and attributes this to construction firms expressing "scepticism" of the government's implementation policy and doubts about the software packages currently available. Francis and Quigley (2010) agree that while there is plenty of dialogue the actual uptake by contractors is limited, asserting that "there are often misconceptions about what BIM truly means".



Figure 1: A view of international BIM uptake (Source: WSP Group, 2013)

Among the list of explanations for a muted interest and implementation such as difficulty of investment, one noted explanation is the complexity of transitioning an established firm away from its existing methods. Despite this, Aouad and Arayici (2010) claim that "networking, collaboration, information sharing and communication will become popular and critical issues in the future", which Arayici et al. (2011) build on by emphasising as a central theme the argument that "implementing BIM effectively requires significant changes in the way construction businesses work at almost every level within the building process". With this

understanding, this research seeks to utilise theoretical study to investigate the extent of change required.

2. Aims and objectives

The aim of this research is to study existing BIM jobs in today's UK-based built environment to infer and examine the present and short-term future structure of BIM, with particular reference to responsibilities and skills of a delivery team during the construction phase. In order to consider how a typical BIM-handling portion of an organisation could be shaped when the principles become more universally adopted this research will explore and interpret existing studies and documented knowledge of BIM-related skills and critically analyse the functions and overall skill coverage of a projected "BIM delivery team" by utilising and amalgamating the findings of the literature review with the research findings.

3. Literature review

3.1 The uncertain maturity of BIM

When integrated into a typical project delivery team, the scope of change BIM will bring is a topic of speculation among industry members seeking to meet the Cabinet Office's implementation requirements. Cramer and Quigley (2009) refer to industry analysts expecting that its adoption "will be the most significant new technology change since the transition of paper design to two-dimensional digital data". While outlining what would become the recognised Maturity Model, Bew (2010) calls BIM adoption an evolutionary process, while Khosrowshahi and Arayici (2012) put forward a roadmap to meeting maturity needs that features people issues and organisational culture.

BIM-caused differences will affect organisational structure and the responsibilities of the roles that make it up. This is a subject of particular concern for existing team members looking to adapt and survive. Hannon (2007) hopes that Estimators will be able to transfer their skill set to perform a foreseen "Cost Engineer" role, while Osan (2012) names aspects that BIM's existence cannot replace, including planning, management, and validation/quality control. Gallelo (2008) describes qualities and lists skills to justify a titular assertion that a BIM Manager role is a "must have", and prior to referencing this Mihindu and Arayici (2008) suggest that early BIM adaptation places an emphasis on experienced project managers, designers and architects, but that the new specialised courses could make graduates appealing in these areas and resolve the skill gap.

Before examining roles the working environment itself needs consideration; as an unseasoned process there is yet to be a standard method of BIM operation. Lu and Li (2011) surmise that BIM's usage has yet to reach a "tipping point", while Jung and Joo (2011) draw parallels with

earlier attempts of Computer-Integrated Construction (CIC) to highlight and discuss a need for practical implementation. Horwitz-Bennett (2012) provided instances where team composition depended on which fledgling BIM software was used, highlighting that analysis of future roles should consider the probable standardisation of such systems. Day (2011) challenges the current expectation of a single comprehensive model by calling it "a dream", segregating architectural and construction BIM models and remarking that today's clients expect to see 2D plans requiring an AutoCAD user to "tart up" each drawing that is exported from a model. Devaney (2013) goes a step further by claiming drawings are faster, cheaper and "in most cases ... capable of including everything necessary for the typical client's needs".

3.2 Provisional BIM team qualities

The prevailing theme is that there is yet to be a conclusive understanding of the specific roles comprising a BIM team of the future. Taking a broad outlook, Frederiks and van der Weide (2005) split the performance of an information modelling project into two areas of expertise; Domain Experts who convert information into an "informal description" and System Analysts who "abstract from this description" to provide a formal explanation. A theoretical exploration of their communication suggests that over time the competencies of each develop and begin to overlap to the benefit of discourse. In a similar vein Sebastian (2011) investigates how processes are reorganised and roles changed by the inclusion of BIM, deriving five factors including synergy and consolidation for a successful collaboration that apply to a team structure as a whole instead of individualised functions within it.

Succar (2009) reverses the examination; instead of identifying a team-based set of human qualities and then scrutinising the skills required for each, he distinguishes three types of competency set (Technology, Process and Policy) for individual development with a view to BIM maturity so in a sense they could be viewed as the three pillars of BIM development, each partitioning into subsets of multiple low-level skills against which the composition of a project team could be measured.

3.3 Roles and responsibilities

One route to an understanding the requisite functions in a BIM-based team is to recognise the existing tasks that are likely to either remain largely unchanged, or evolve into correlating roles. Kymmell (2008) surmises "the three primary BIM-related roles that emerge from (a team selection process) are the BIM Manager, the BIM Operator, and the BIM Facilitator", correlating the first two to the existing Project Manager and Project Engineer roles (respectively) and terming the third to be "a bit like a knowledgeable BIM tour guide" to exist during an estimated transition period of 10 years before BIM is sufficiently adopted.

Ahamed (cited in Meckbach, 2011) disagrees that dedicated technical guidance will be necessary, while Barison (2010) agrees with the need for a BIM Manager as a "special role in

the project team", listing a number of alternative job titles it has been known as. To diverge from Kymmell's notion of Operators and Facilitators, she dubs all BIM-using roles as BIM Specialists, before breaking these down into roughly eight defined positions – such as Modeller, Analyst and Consultant – and discussing the responsibilities of each.

Another necessary consideration for a BIM team's composition is to identify needs that shall emerge from its implementation. Azhar *et al.* (2007) consider that a centralised framework introduces issues relating to ownership of both a project's design as a whole, and information contributed towards it that may be licensed or proprietary. They conclude that these would need to be resolved to avert the risk of useful information being withheld. Porwal and Hewage (2013) explore this by reflecting on the productive and legal ramifications of construction parties' reliance on information contributed by other parties, and Reddy (2012) adds that a need for qualified approval of varying information will remain. These studies suggest a need for rights management, authorisation or oversight that was not as prominent in the traditional employer-contractor-subcontractor setup.

Emergent needs will not necessarily arise from interoperability or facilitation. Shennan (2012) notes that the responsibility for selecting and procuring construction items and materials has become increasingly delegated to contractors and subcontractors over time, but that the prospective use of BIM to specify these as part of a building's design model will see the task revert to being more centrally managed once again. Robson *et al.* (2014) agrees with his assertion that this will reduce costs, stating that 80% of a contractor's costs are from the supply chain, and highlighting that existing management functions in a multi-organisational process could be redistributed and may define jobs such as a redeveloped procurement role.

4. Methodology

This study used an alternative source of primary information to remove the shortcomings of conveyance and time limitations. Firms that are looking to recruit and restructure their operations with a view to increasing adoption of BIM advertise job vacancies for roles involved in its use. These listings are directly addressed to the people they seek to recruit, so their detail and wording will be a more thought-out "honest" statement of the competencies they require for the positions and the duties that these jobs are required to perform. By collating a significant number of advertisements as a matter of precedence and interpreting those by categorising their details into a set of inferred roles, this undertaking utilised desk-based research to achieve a more comprehensive understanding of its second and third objectives. This was realised by sorting the skill requirements needed for each role so they could be analysed further both individually and as part of an overall BIM team.

The study formed a quantitative text analysis as defined by Roberts (2000) to translate written information into data for the purposes of conceptual evaluation. This is useful to help eliminate concerns over ambiguous intent or meaning as the text being assessed originates from a high volume of different sources. Performing such an analysis using job advertisements is an atypical

research approach, but not pioneering; Bellis (2012) employed the method to examine the role of Quantity Surveyors, viewing a smaller sample size in greater detail to fulfil a comprehensive appraisal of one role whereas this study requires a significant representation of multiple positions to assess them all.

An important understanding with this method is that the frequency of results are not a broad indicator of role spread; should half of the findings have been for positions described or allocated as a "BIM Co-ordinator", that would not suggest that half of a BIM team would be comprised of co-ordinators. By the same reasoning, it was necessary for the research to avoid making duplicate entries for one position advertised in multiple places. For this purpose a separate set of records was created to track a selection of identifying details (job titles, employers or recruiters, reference numbers, work locations and the start of job descriptions) against which every new result was checked.

4.1 Research process

The core procedure of the study was to locate unique job advertisements for positions within or related to the UK construction industry that made specific inclusion of BIM as Building Information Modelling. This was substantially conducted in two tranches covering an overall period of approximately 3½ months in order to obtain a sufficient volume of results within the allocated time period. Once a suitable role was identified its supplied information was interpreted to determine which identified responsibilities it had and which proficiencies applicants were required to possess, which were then logged onto a table of standardised categories so all findings could be compared in a controlled manner. This allowed a set of roles to be inferred where multiple results held recurrent patterns of sharing the same categories, which in turn allowed observations to be made using others.

The scope of the research dictated that its findings should not be limited to those with BIM included within their job titles or as the principal theme of their description. By its collaborative nature BIM is hoped to be widely involved among a project's parties from a topographical surveyor whose reports would be entered into a model to a project manager with responsibility for a development that is accomplished using it. Thus the study was carried out with the main criteria for inclusion being any built environment related position that mentioned participation in the BIM process either at present or with the intent to develop this as part of the role.

4.2 Procedural clarifications

In some instances firms or their approved agencies would issue multiple advertisements for roles located on the same site. Of these the textual descriptions from which the skill and responsibility classification was made were sometimes identical throughout the set; when this was the case they were recorded as a single entry with the differing job titles included so as to not create false patterns. Conversely when the descriptions differed the positions were logged as

separate records as they were not only demonstrably separate roles but interrelated and co-operative with each other by the employer's intent which is beneficial to the research purpose.

Certain regular inclusions in a job description have been omitted from the categorisation process for the purpose of maintaining research focus. The most common of these are requirements pertaining to travel such as "car owner" or "driving license holder", which have been excluded as it is unlikely they could be related consistently to particular BIM based roles, and the function or experience requirement of "participating in projects" has too broad a range of interpretations to warrant inclusion, and could be considered implicitly true for virtually any built environment role.

Other categories have been simplified: When outlining an applicant's qualities adverts expressed phrasing ambiguity, many used separate lists for essential and desirable traits but most also provided others with textual descriptions such as "should possess" or "the ideal candidate would have" so as these cannot be objectively measured in terms of sufficiency all qualities mentioned shall be considered adequate for inclusion. Similarly the category for academic progress has been truncated to degree-level or above to the exclusion of the rarely-mentioned HNC requirement, and includes membership of any of the numerous professional bodies mentioned as those cannot be quantified against each other but typically require a degree. Lastly select software packages that were often stated to be "BIM software" or "BIM authoring tools" have been considered as such universally in this study.

5. Results and discussion

Each result was recorded by whether it met each of the job responsibility and skill / competency categories chosen by the study. These were initially identified from their presence in the first tranche of positions found and later refined by assimilating categories. Merges were made when two conditions were satisfied: When the matching jobs were near-identical, and when the functions were essentially inseparable in terms of their relation to the BIM environment, such as "staff training" and "staff testing". This ultimately provided for 42 responsibility and 20 skill categories which were allocated using the conceptual maps shown in Figure 2 and Figure 3 below into groups to provide an overview.

In total 508 advertisements were logged, which yielded 304 unique positions that could be recorded as results. Of the remainder 166 were duplicate listings and 38 were discarded; the majority of these were for jobs located outside of the UK or which used an alternative unrelated BIM acronym such as Budget Impact Models or Buying In Margin, although there was one instance of an advert with no description at all whose addition would have been pointless.

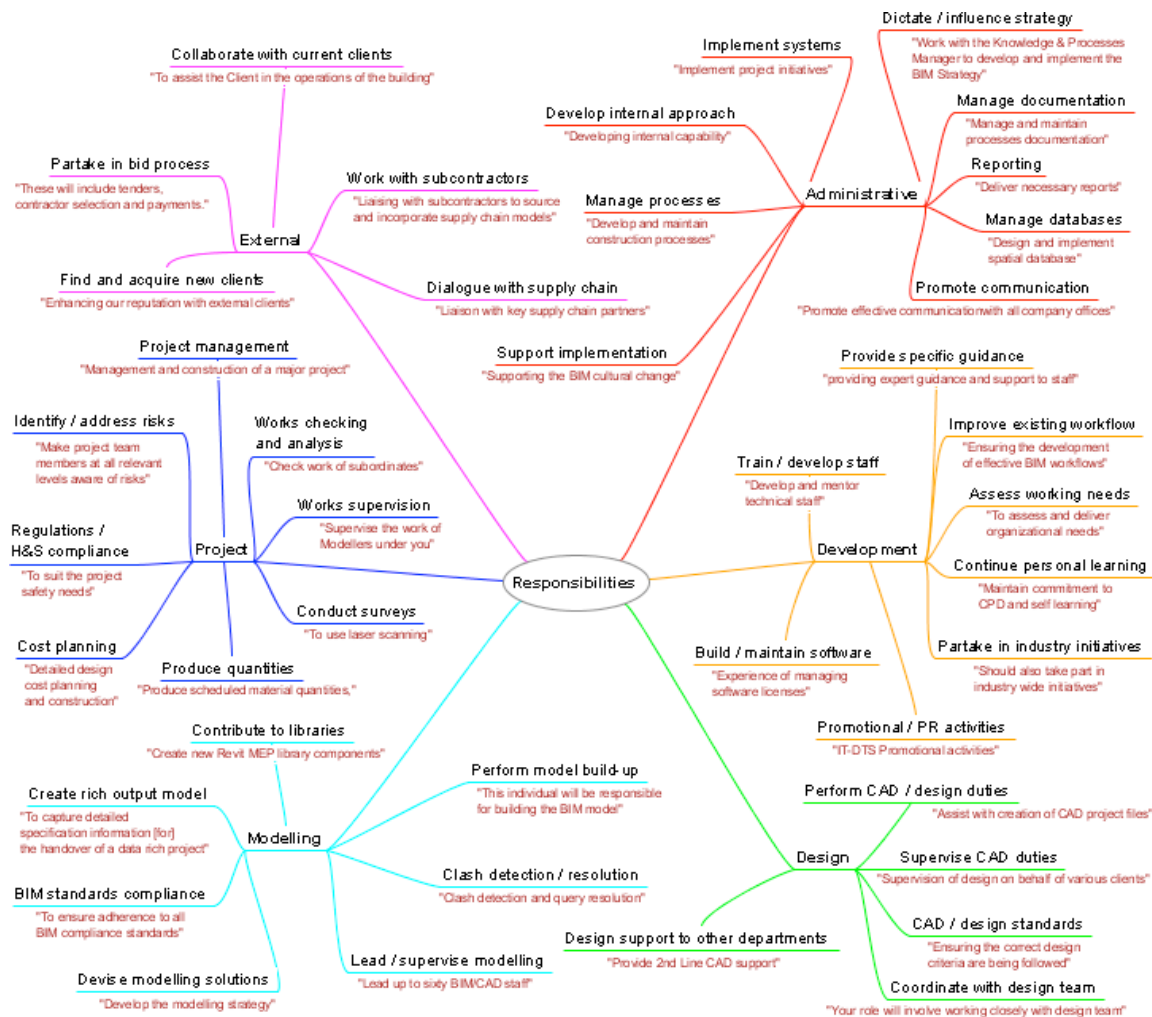


Figure 2: Responsibility concept map

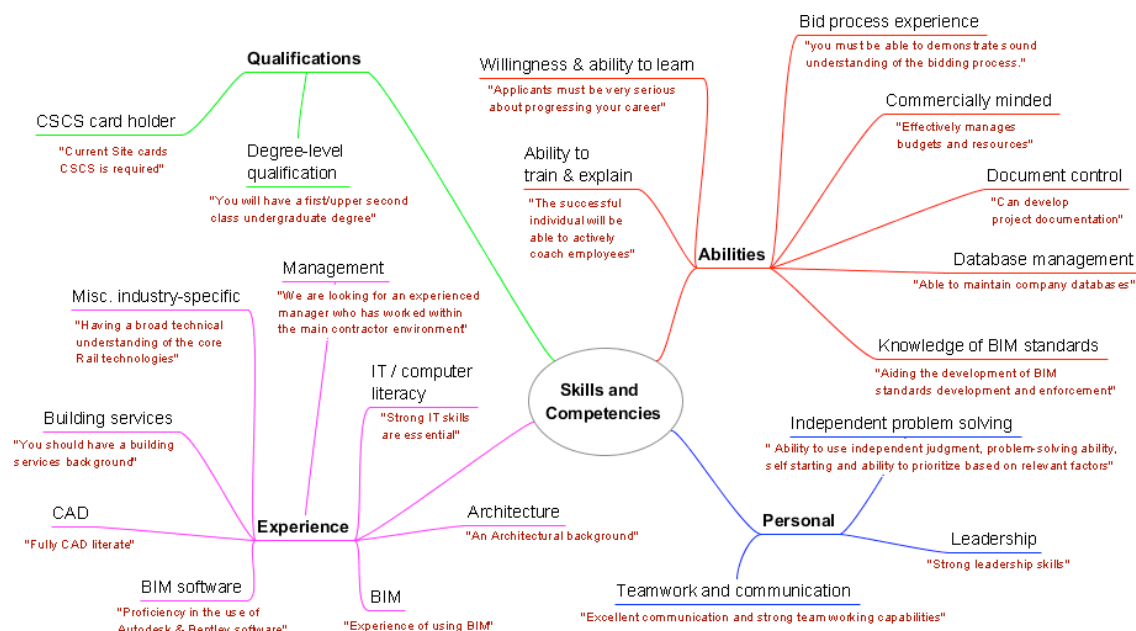


Figure 3: Skills and qualities concept map

5.1 BIM-targeted positions

79 of the unique positions recorded contained BIM in their job title, representing just over 25% of the collection. As these are the most purposefully stated to be BIM roles, they shall be used as a basis for comparison; after adjusting subtleties in their titles such as considering "BIM Revit Technician" as "BIM Technician", the initial breakdown of these jobs are shown in Table 1 below.

Table 1: BIM job title summary

Job title	Qty
BIM Manager	25
BIM Coordinator	16
BIM Technician	13
BIM Leader	5
BIM Engineer	4
BIM Architect	3
BIM Integrator	2
BIM Operator	2
BIM Consultant	1
BIM Designer	1
BIM Discipline Head	1
BIM Implementation	1
BIM Modeller	1
BIM Practitioner	1
BIM Sales Director	1
BIM Specialist	1
BIM Structural Draftsman	1

These were assessed by considering the spread of responsibilities to identify which appeared most frequently in the prospective employers' specifications. Shown graphically below for the three most prevalent titles, Figure 4 demonstrates adherence to the traditional notion that managers are primarily responsible for a range of organisational duties, and also agrees with Kymmell's (2008) assertion that a BIM Manager "can also include leading the project team through the BIM process on a personal level". Meanwhile Figure 5 depicts technicians as largely focused on a specific performance aspect, in this case modelling, akin to Kymmell's BIM Operator.

On the other hand, Figure 6 depicts an almost even mix of administrative and modelling responsibilities for coordinators. This wide coverage suggests that a coordinator is a position with a universal set of duties required to simultaneously facilitate the transition into and aid the performance of BIM, which also matches Kymmell's (2008) impression of a BIM Facilitator as "a person who will function a little as the superintendent's assistant, someone who is at the construction site most of the time to help out with the model and other BIM-related issues".

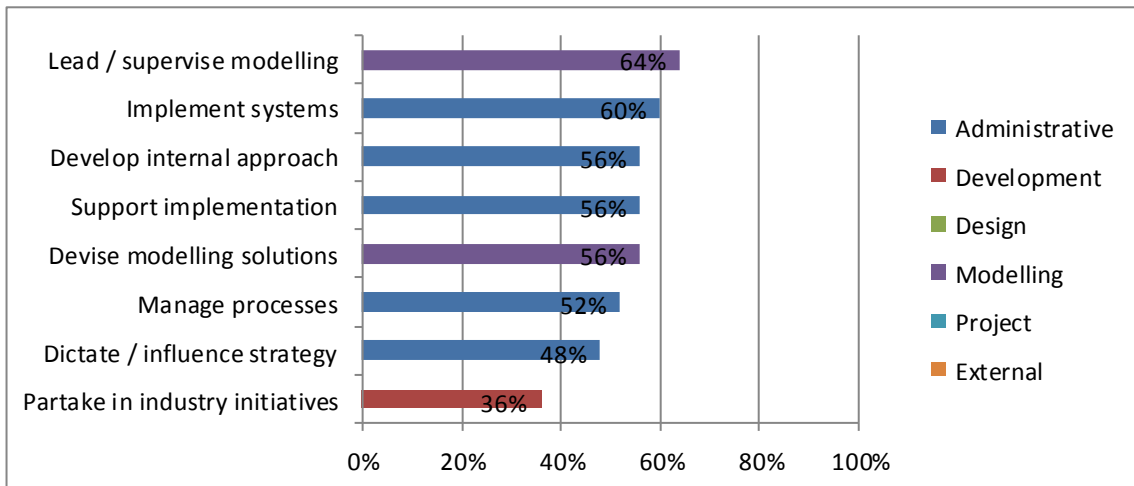


Figure 4: BIM Manager category matches (as a percentage of all BIM Manager results)

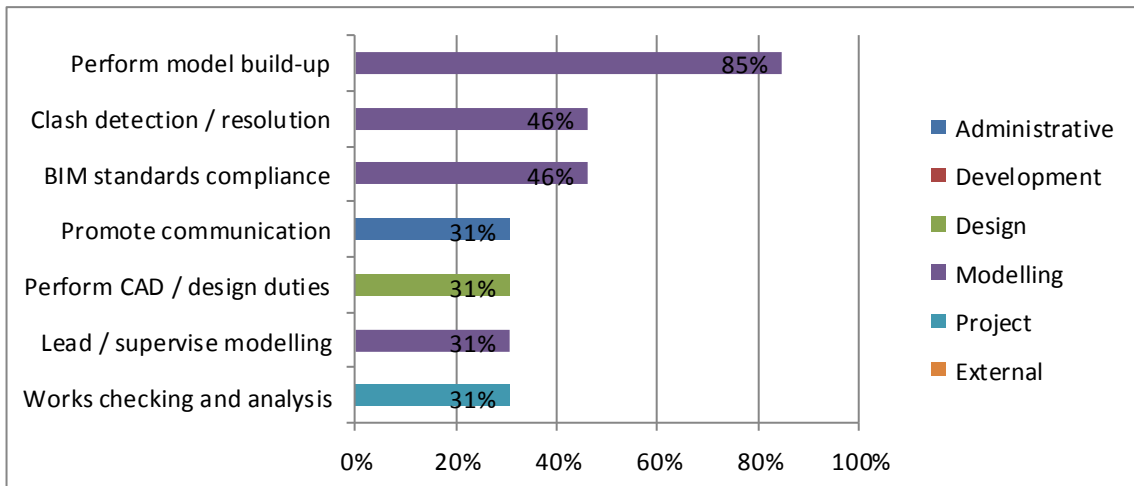


Figure 5: BIM Technician category matches (as a percentage of all BIM Technician results)

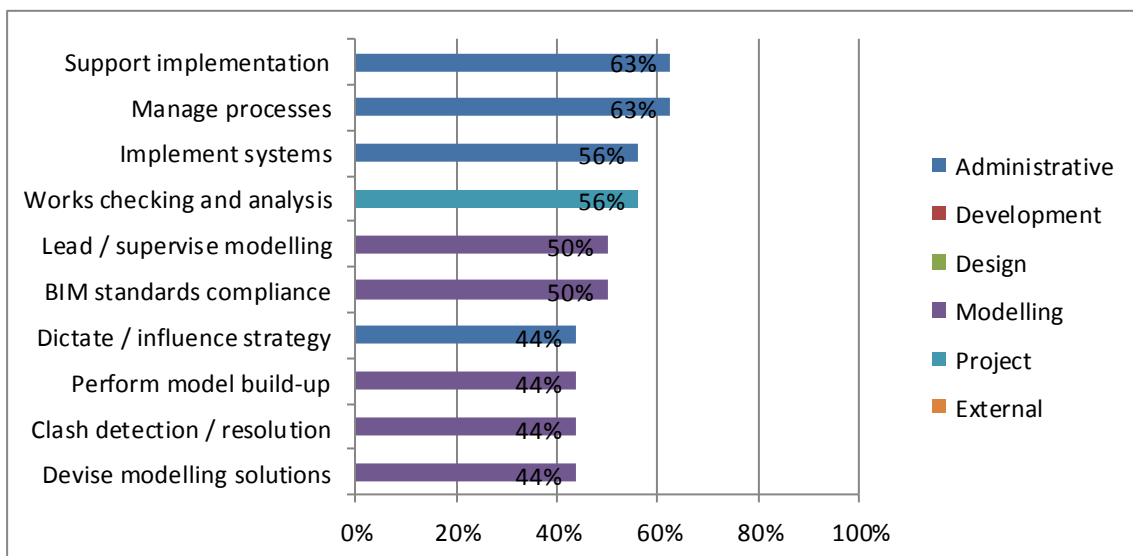


Figure 6: BIM Coordinator category matches (as a percentage of all BIM Coordinator results)

Thus far the findings of the study align with Kymmell's three "BIM Specialist" roles so this shall be adopted although with the Facilitator name replaced with that of the emergent Coordinator. The same form of greatest-responsibility analysis was extended to the remaining BIM-including titles and noted similarities were combined to form an initial profile of roles with distinct characteristics as shown in Figure 9 below. In addition to the three roles that retain the spread of responsibilities shown in Figures 6 through 8 above, this added a fourth form of role with a high use of Design responsibilities but virtually no Administrative or Development duties. Meanwhile one title was left out of this exploration as the BIM Sales Director position is exterior to a construction project team.

Table 2: Role classification of BIM job titles

Role	Kymmell Role	Job titles included
BIM Manager	BIM Manager	BIM Manager, BIM Leader, BIM Consultant, BIM Discipline Head
BIM Coordinator	BIM Facilitator	BIM Coordinator, BIM Implementer, BIM Integrator, BIM Practitioner, BIM Specialist
BIM Technician	BIM Operator	BIM Technician, BIM Modeller, BIM Operator
BIM Engineer	-	BIM Engineer, BIM Architect, BIM Designer, BIM Structural Draftsman

Besides the BIM-titled jobs are other subsets of results, most of which fit into the role classification provided by Table 2 in both name and matching responsibility. In particular there are 34 additional results that have used Revit, a proprietary software package marketed for use in BIM by Autodesk (2013), in their titles as though it were a synonym for BIM of which most translate into BIM Technicians. There are also 19 posts that focus on CAD with notable mention of hoping to evolve or facilitate to suit a greater BIM adoption strategy at a later date; some of these fit the mould for BIM Technicians and BIM Engineers, but others possess no direct BIM responsibilities either at present or in the planned future, meriting the inclusion of a CAD Technician role.

Beyond this the remaining roles are either an assortment of existing positions seeking to progress into attaining BIM operation tasks such as M&E Engineers, or project roles with no aspirations to conduct BIM directly but a recognised need to be conducted in or alongside a BIM environment either at present or in the planned future according to the company's level of development. Similar to the role allocation performed on the BIM, Revit and CAD named titles above, these can be broadly allocated into associative roles to be added to the classification.

Roles grouped into the Non-BIM Manager and Non-BIM Coordinator roles here comprise positions that have existed since prior to the emergence of BIM; these positions shared characteristics with their BIM-focused counterparts named above with their job descriptions essentially stating that BIM processes need to be adhered to without any specific involvement. 20 roles were grouped "Other" and disregarded as they either lacked project functions, for instance BIM software developers, or had them but did not appear enough in the results to

warrant classification that would be significant. A further 9 had three or fewer responsibilities recorded and were similarly discarded as "Unclassifiable".

The biggest deficiencies found in BIM-led Manager/Coordinator job descriptions compared to "BIM-tolerating" Manager/Coordinator peers were found in cost planning, regulations compliance, risk management and project management. For Coordinators there was also an exceptional difference in client communication, which featured proportionally nearly four times as often for the non-BIM role. These disparities agree with Osan's (2012) reasoning detailed earlier and provide a clear distinction between the identified roles, for example to illustrate divisions between BIM Managers and Project Managers in the decision-making functions. This suggests the former are currently considered to be leaders of a necessary new tool set and not tomorrow's Project Managers; Frederiks and van der Weide (2005) may interpret the pair to behave as Domain Experts and System Analysts respectively.

This does not imply that a BIM Manager is simply an elevated technician with shifted duties, as their differences with other managers are similar to those with technicians in the Administrative and Development groups in which the latter are similarly lacking by their nature. Beyond that the descriptions for BIM Technicians themselves exemplify their independence, with one declaring "This isn't a role for a BIM manager but for a technician that can detail and model to an in-depth level" and another claiming that "Although BIM project experience is an advantage, this role would not suit a BIM Manager as this is a hands-on role which will be very focussed on Revit".

BIM Coordinators are expected to take Modelling responsibilities similar BIM Technicians, which is attributable to the former largely possessing many of them such as BIM standards compliance and developing modelling solutions, while the latter remain concentrated on simply building and administering the model. This is supported by some of the job descriptions themselves: A listed key requirement of one is "Experienced BIM modeller and potentially coordinator", while another position seeks a candidate who "Ideally previously held a post as BIM Co-ordinator ... or a very experienced Technician". It is possible that when the technician role becomes more developed it shall take more of a coordinator's presently assigned responsibilities, for instance clash detection.

The broad range of duties found to be required of jobs currently titled BIM Coordinator requires its own examination. The detail for one of these highlights and attempts to justify this as it begins with the sentence "The Project BIM Coordinator is the most highly competent (BIM knowledge) member of the project team" although the size of the subsequent responsibility list seems more indicative of a "handyman" role. When viewed alongside the other BIM Coordinator descriptions, the lack of any one responsibility that appears consistently among them may also demonstrate a lack of clear consensus among employers about what the role actually entails.

6. Conclusion

The research has identified the three core role types that are likely to be found in BIM project teams. This does not represent a complete BIM team build-up, as that shall be adapted to suit the needs of the project itself. As the most frequent BIM-titled finding in the research, BIM managers already have a place in some project teams, and it seems unlikely that it would naturally decline when a position of authority will always be necessary to command the impending mandated work process. As detailed in current positions, they respond to a Project Manager and are in charge of BIM Technicians; in both instances this relationship is usually direct. Their key responsibilities are to lead modelling and run BIM systems. Similarly, BIM coordinator job title that can be seen regularly at present; however, its location in the hierarchy of a team is greatly varied. The study found some BIM Coordinators that were chiefly responsible for forming models and teams, and others that served a support function and operated alongside BIM Technicians. As such there would be value in breaking this role down further but that would require a fresh and more concentrated study. Answering to BIM Managers or Coordinators, BIM technicians perform the modelling duties and little else. The duties themselves may not be simple; there is no standardised form of model and architectural, structural and services models remain separate. This may explain why this technical role type that actively ignores CAD-based tasks is demonstrably sought. Overall the two key divisions among these types are between "BIM-focused" and "BIM-tolerant" roles and between technical and management roles, with the latter loosely adhering to Frederiks and van der Weide's (2005) narrative of Domain Experts and System Analysts respectively.

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