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Purpose of the Series

The aim of this publication is to provide an opportunity for students to publish the findings of their undergraduate or postgraduate work. Guidance on publication will be given by staff who will act as second authors. It is hoped that by providing a guided transition into the production of papers that students will be encouraged throughout their future careers to publish further papers. Guest papers are welcomed in any field relating to the Built Environment. Please contact E.A.Laycock@shu.ac.uk. A template will be provided on request.

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EDITORIAL

Welcome to the Fifth edition of BERT (the Built Environment Research Transactions). Since the last edition, changes in the Faculty have resulted in the creation of the Department of the Natural and Built Environment. This new organisational unit will cover disciplines including architecture, planning, housing, geography and the environment as well as the existing Built Environment portfolio of construction, building and surveying. The Department aims to enhance and sustain the quality of human and natural environments. This broader portolio is reflected in this edition and, it is hoped, will be in later editions.

It is always a pleasure to see the papers submitted to the journal and reflect on how far the students have come through their academic journey while at Sheffield Hallam. This reflects the huge amounts of time and effort put into the whole process by students and staff and I would like to take this opportunity to thank them for the additional efforts made to prepare papers for the journal. Your efforts help to inspire the next generation of students.

I look forward to seeing future contributions from students which reflect on the larger picture of the Built Environment and its interactions with people and the wider environment.

Dr Elizabeth Laycock

Editor, Built Environment Research Transactions

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FIRE SAFETY IN RESIDENTIAL CARE HOMES

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Jonathan Took graduated from Sheffield Hallam University in 2012 with a First-Class Master's Degree in Building Surveying. He has 12 years of construction/surveying experience, owns a Surveying and Real Estate Investment Company and lectures at Sheffield Hallam University in the Department of the Natural and Built Environment.

This paper presents findings from a research report that investigated whether fire safety was prioritised in Residential Care Premises and what factors were limiting the importance of fire safety to the operators. Secondary data was collected via a literature review and triangulated with primary data, which was collected through 12 semi-structured interviews with owners and senior staff at Care Homes. This enabled a live view of the perception of fire safety to be collected amidst the myriad other requirements and obligations upon these people. The conclusions to the research were that Care Homes are almost unique amongst businesses in that better performing ones are not necessarily more profitable, due to the payments system that is currently in place. This has engendered a culture where only the minimum standards are adhered to, resulting in fire safety not being prioritised, despite the potential risk to life. The results are necessarily subjective; though do provide grounding for further empirical research.

Keywords: Fire, Fire Safety, Disability, Escape, Management, Business

INTRODUCTION

Rationale

An earlier Research Proposal had outlined that Care Homes were more deficient than other businesses as regards fire safety. This research aimed to determine why this might be so, without testing quantitatively. Whilst empirical research and generalizable results can be desirable, it was this researcher's position to assess the subject qualitatively and it was perceived by this researcher that there was insufficient time or scope to undertake a wide-ranging quantitative study. As such, the aim of this research was to generate a theory which could later be tested empirically during a follow-up study or by another researcher. A phenomenological paradigm was

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adopted, in order to derive the phenomena that were at play, by allowing experienced professionals to describe their experiences in Care Homes.

Background

There are a number of fires in Care Premises each year, although serious fires with multiple losses of life are rare: the last one was in 2004 at the Rosepark Care Home in Scotland (SSSDG, 2011). The residents of Care Homes are almost always disabled and are unlikely to be able to escape unaided in the event of fire. When a Home is commissioned, it must comply with the current Building Regulations, but these are not always sufficient for such premises and have not been for some time. In 1972, there was a similar fire at the Fairfield Home and analogous inadequacies in the Building Regulations and their enforcement by the Local Authority were cited by Cheyne (2011), who also said: "*The one thing we learn from history is that we never learn from history.*"

In addition to a Home complying with current Building Regulations at commission, it must also undertake rigorous management to keep it compliant with legislation, notably the Regulatory Reform (Fire Safety) Order, 2005. The most important element of this is the annual Fire Risk Assessment (FRA) which can be undertaken by a member of staff at the home, or an external fire risk assessor. There should be a written record of the FRA, as well as logs of maintenance checks and work. The Fire and Rescue Service (FRS) regularly inspects Homes for compliance and good housekeeping; approximately 25% of the 29,000 Homes in England & Wales are inspected annually (DCLG, 2011). Homes are also inspected for compliance to other requirements, mainly by the Care Quality Commission (CQC).

Whilst Care Homes are essentially businesses, they are paid in a unique manner, depending on the level of care they provide. Homes are allocated residents by the NHS (Primary Care Trust), which also provides payment to the home, per bed, per night. Every Home is paid the same if their level of care is the same. Only privately run Homes (90% of the pool) that accept NHS funded residents were considered; Homes run directly by the NHS and Homes that only accepted privately paying residents were not considered by this report.

METHOD

Data Collection:

The research began with a detailed literature review analysis of which continued parallel to primary data collection as interviews yielded further avenues of exploration. Primary data was collected through 12 semi-structured interviews carried out between June and September of 2012. Twelve Homes were selected randomly from an area located between Goole and Scunthorpe in North Lincolnshire and senior managers/staff were asked to participate.

The literature review informed the primary data collection: a series of question prompts were decided upon and these were used to structure a pilot interview with the manager of a Care Home, as well as to serve as a checklist of points to cover. The pilot interview was allowed to commence and progress at the pace of the interviewee;

the prompts were mainly used after the interviewee had ceased to volunteer information, in order to cover the remaining issues. The list of prompts was not amended after the pilot.

A further 11 interviews followed: some respondents replied in writing rather than submit to a face-to-face interview. Face to face interviews were recorded via a digital personal Dictaphone and transcribed manually into MSWord; written responses were all given in MSWord. After all of the responses had been made, a follow up telephone call was made to all 12 interviewees so that issues that had arisen in later responses could be addressed by earlier interviewees and to ensure that the written responses had covered the same points as oral ones. Additions to transcripts were made where necessary.

As data saturation had effectively occurred by the final interview and the investigation was deep and narrow, the results demonstrate high validity, as well as high reliability. The generalizability of the data would be low: conducting research over a small sample size and in a geographically restricted area meant that the results would not be transferable to the wider population of 29,000 Care Homes.

Data Handling:

All transcripts were manually coded twice with codes being refined between the two stages: new ones were introduced and some original codes became obsolete. The codes were manually condensed into themes, as described in Collis & Hussey (2009). The themes were continuously reviewed until they conformed to a set of pre-requisites, namely that there should be five or six themes, that all codes must be used and that the themes should form a narrative.

LITERATURE REVIEW

The literature review sought to collect the current understanding of fires in Care Homes from the media, researchers and Professional Bodies; to collect and analyse statistical data on the matter and to cross-reference the two.

Fire Safety in England

All new buildings in England, as well as those that undergo a "material change of use" (ADB, 2010) must be reasonable safe in the event of a fire. The Building Regulations (2010) as amended provide for Building Control Surveyors employed by the Local Authority or Approved Inspectors to inspect works under the Building Regulations part B (which pertains to fire safety). Most simple buildings follow an Approved Document (for fire safety it is Approved Document B), which is a code of practice that demonstrates how a building can comply with the Regulations. A designer has other options, namely to use BS9999, or BS 7974 (Fire Safety Engineering), either of which can be more flexible than the Approved Document.

Once a building has been commissioned and issued with a completion certificate, it does not have to upgrade its fire safety features if the Building Regulations and Approved Documents are updated. However, an older building would be much less safe in the event of a fire than a newer building. Good management is a key issue, where a building's under-performance can be compensated for by intelligent use of human or other resources. In part, the FSO (2005) requires good management and record-keeping, through the use of annual FRA's, monthly checks on emergency lighting and weekly checks on the fire alarm sounders.

Whilst some buildings can avoid fires or reduce the severity of fires through good management, there are a number of factors that mean that the dangers posed by fires in Care Homes are greater than for the average building; these include (but are not limited to):

- Care Homes are often residential and sleeping accommodation is high risk (BS9999)
- Residents are often disabled, reducing the available escape time (DCLG, 2006)
- Residents are often slower to respond when an alarm is raised and often require physical assistance
- Residents are likely to be physically weak, meaning that any smoke inhaled or burns suffered are more likely to be life-threatening
- In some ways, a Care Home is classed as a home, so smoking is often permitted and this is often a cause of some minor fires each year (DCLG, 2011)

Essentially, Care Homes are significantly high risk buildings in the event of fires.

The most recent major fire in a Care Home was at the *Rosepark* Care Home in Scotland in 2004; the findings recently published in an official inquiry (SSSDG, 2011). There were a number of factors that contributed to the deaths of 14 elderly residents. Whilst smoke inhalation was the official cause of deaths, some of the factors that contributed to so many frail people inhaling a lethal amount of smoke were as follows:

- The fire was caused by a faulty distribution board which had been incorrectly installed some years before, but had been approved by Building Control (who had little appreciation of the difficulties posed by many elderly residents)
- The cupboard containing the distribution board had flammable chemicals and rags stored in it
- The cupboard containing the distribution board was on a main fire escape corridor
- A Fire Risk Assessment had not been carried out at the premises (although at the time this was not a statutory requirement)
- The Responsible Person had had no official fire safety training
- The staff who first responded to the fire alarm had had no training as to how to read the fire panel and had mis-identified the fire as being in a lift shaft, not a corridor

- The staff took too long to phone the Fire & Rescue Service, who had responded to a less urgent call-out in the interim
- The postcode of the Home directed the FRS to the wrong street, so when they did arrive, they couldn't access the driveway to the Home and had to spend time driving around

Many of these issues resulted in the FRS being delayed. A typical serious fire can become lethal after two minutes and decays after ten, so any delay in response is potentially lethal (Furniss & Muckett, 2007). It should be noted that *Rosepark* had passed all of its statutory inspections and was not under any Notice by the FRS. Had the fire occurred a couple of years later, there may have been some successful prosecution, but at the time of writing no successful prosecution attempt has been made.

A serious fire also occurred in 1972, at the *Fairfield* Care Home. In a similar sequence of events a number of elderly residents died (Cooke, 2011); the survival rates between *Rosepark* and *Fairfields* were very similar. Between *Fairfield* and *Rosepark*, there have been a number of fires in Care Homes, with either much less loss of life, or none. In each case, the same generalised factors have been seen:

1. Structural Inadequacy
2. Poor Management Procedure
3. Inadequate staff reaction, especially at night
4. Inadequate enforcement action by the inspecting agencies

There have been a number of media reports into fire safety in Care Homes, many repeating the factors derived from official reports (Telegraph, 2012; BBC, 2012, 2012a, 2011, 2011a, 2010, *etc*.).

Structure:

As the Building Regulations are often cited as inadequate for Care Homes, there should be some thought given to their application. In many Homes they are applied through the Approved Documents, which may be the root of their "*inadequacy*". Hospitals use their own Technical Manuals, so the Approved Document Route may not be suitable: there is the option to not use this (alternative routes are BS9999 or BS7974), but it is more expensive to follow an alternative route and may contribute to further claims of inadequacy if not fully understood by the Building Control Inspector (Ware, 2012).

Although all premises must be designed for Access (ADB, 2010; ADM, 2010; Equality Act, 2010), they are not often well designed for escape (Cherwell, 2011)

Many new Homes are fitted with sprinklers, which according to the BRE (2006) are effective at containing fires and preventing multiple deaths, but do not save the life of the resident if they are responsible for starting the fire (usually through smoking in bed). The Chief Fire Officers' Association (CFOA, 2010) promote the fitting and retrofitting of sprinklers in all Care premises.

Management:

Ultimately Care Homes are businesses and must make profit or close (Bannatyne, 2007). The requirements of maintaining a fire safe environment were too much for at least the *Rosegarth* Home (Williams, 2011), which chose to close rather than upgrade, following a poor inspection report by the FRS. Sammons (2012) says that funding cuts and lower occupancy rates will force Homes out of business, or to cut corners.

Staff:

Staff are generally poorly paid (PJD, 2012; Sammons, 2012) and poorly trained (Williams, 2011) and this contributes to them being unable to adequately respond if there is a fire. In addition, they are also expected to undertake a number of duties outside of the care of residents (Undercover Boss, 2012). Staff may not always respond to the signs of a fire, such as smoke, due to the behavioural conditioning, the "*Bystander Effect*" (Brown, 2010). In addition, there have been a number of cases where staff have set fires in Care Homes (BBC, 2011a; Telegraph, 2012).

Enforcement:

This is usually undertaken by the FRS, approximately every 4 years (25% inspected each year). Since the FSO was enacted, the number of Homes found to be satisfactory has been approximately 58% annually and of the 42% found unsatisfactory, most were dealt with by Informal Notices. Formal Enforcement/Prohibition/Alterations Notices or Prosecutions total less than 5% of the action taken per year. Of the Home found unsatisfactory, only about 40% go on to improve at a follow up inspection (DCLG, 2011; DCLG, 2008), although this has improved since 2006. This corresponds to the assertions in QCM (2012) where it is stated that approximately 50% of Homes fail to meet their statutory obligations.

Where Homes are penalised, there is little severity: one Home was fined £11,000, for being so dangerous that the local FRS believed many lives were at risk if a fire did start (SM & MS, 2012).

RESULTS & DISCUSSION

The interviews were conducted having been informed by the literature review and initially assessed to what extent Structure, Management, Staff and Enforcement were to blame for inadequacies and which elements could be targeted in the most cost-efficient manner. By addressing this in a commercial manner, it became evident that there were a number of themes that were recurrent throughout the interviews, despite the interviewees having a wide range of backgrounds and levels of experience in fire safety.

The themes were arranged in this manner:

Figure 1: Themes Derived from the Research

Operating Difficulties:

Operating Difficulties represented the obvious distractions to fire safety: the usual running of the Home and the attendant difficulties, as well as the requirements of other bodies, such as the CQC, which were perceived to be of greater importance than the fire safety features. Within this Theme, the ideas that there were minor structural work to do, that residents and staff posed operational problems (like staff not turning up for work) that took the manager's or owner's time away from issues of fire safety. If the running of Homes was about profit and survival, then all issue became tick-box exercises and genuine care became irrelevant.

Inadequate:

As fire safety training is not a statutory requirement of any staff member at a Home, the requirements are Inadequate to allow Homes to fully provide for safety in the event of fire. This was also linked to the rarity of serious fires and the lack of severity for non-compliance. Many interviewees cited that other Homes did things differently and that there was little consistency in the law and also questioned whether the requirements they were trying to achieve actually made the building fire safe. Even when a Home was newly built and compliant with modern standards, these may be insufficient, considering that the escape in a fire would have to be done with every resident being assisted by one member of staff: in some cases, this would have meant that three people had to get 50 residents out of the building within minutes, when it took two of them to lift some bedbound residents.

One quote from a transcript said:

"...it would make it easier if we had somebody in-house or for the company who did all of the assessing [and training]."

This relates to a quote from the literature:

"I feel the only way to avoid such [enforcement] action in the future is to employ fire safety professionals to advise us."

SM & MS (2012)

Minimum Standards:

These factors led Homes to only attempt to come up to the *Minimum Standards* required of them by the FSO, in order to simply pass inspections. Fire Safety, despite its potential for reduction in loss of life, was seen as a tick-box exercise. This was evidenced by written records being seen as a priority and this leads to the possibility that records could be falsified. It was identified that the most serious risk and incidence of severe fires would be at night (*Rosepark* and *Fairfield* both occurred at night), but this was the time when the least staff are required, typically half of the daytime staffing levels: no Homes attempted to improve on this and very few Homes attempted to increase the amount of training given to staff, to involve residents, to purchase additional fire-fighting equipment or to go beyond the minimum requirements: to do so was seen as wasteful.

We Can do Better:

Many Homes recognised that they could do better, but due to lack of time, investment or reward they didn't. Many Homes stated that having an in-house fire risk assessor and trainer would be the best improvement to be made, with structural improvements (like sprinklers) being of lesser importance. Well managed premises that are poorly constructed are usually better than well constructed premises that are poorly managed, so these statements weren't unexpected, but this did reinforce the idea that structure and management are two sides of the coin and that perhaps there shouldn't be minimum standards for each: maybe a holistic view is required.

Business Drivers:

The *Business Drivers*, i.e. those things that improved turnover, but reduced expenditure were seen as the barriers to making improvements. As Homes are paid through a set structure, only the factors that reduced expenditure were seen as important. This was why only the minimum standards were met; making improvements beyond the minimum standards conferred only one advantage: a higher occupancy by private residents. Staff were paid as little as possible, so that the Home wasn't disadvantaged: this may have resulted in only attracting a lower quality of staff, which in turn resulted in frequent absences and poor care. Either of these would take up the manager's time and result in there being less effort spent on fire safety: a vicious circle of events. When Homes have a large proportion of NHS residents, there is little impetus to change if it costs money.

C'est la Vie

This resulted in a level of despondency amongst the Homes, amounting to little desire to radically improve their premises, as the benefit to the Home and to the interviewee personally, would be minimal. There was no incentive to improve; "*C'est la Vie*". One quote from a transcript illustrates this point:

> *"There are always improvements that can be made. I just meant that there are maybe too many sticks being used and not enough carrots."*

General Comments

Whilst there was a specific rationale behind the lack of improvements, there were also other commonalities derived from the responses.

- Good management would be better than improvements to structure: although the benefit of sprinklers was recognised, the likelihood of them being needed is low if the premises are well managed
- Good management requires a high level of occupational knowledge, such as detailed knowledge of the premises, its construction, the routes through it, experience of the profession and some good quality fire safety training
- Management and Structure are assessed separately (by the FRS), but it would be better to assess them together; older Homes inevitably have a poor structure and new-built ones have a better construction, so the management requirements are different for each Home

CONCLUSIONS

The results were initially consistent with the literature, agreeing that the Structure, the Management, Staff and Enforcement were all collectively to blame for a general lack of improvements to the state of Fire Safety in Care Homes. The research also opened up avenues for further research by suggesting that the payment method should be more in line with that of purely private Homes, i.e. decide your own charges and attract residents on your own or that requirements of Homes are rigid, specific and rigorously enforced. As the latter would be more expensive to the taxpayer, the former should be more desirable.

Changing the mode of payment of Care Homes in light of a single research report would be somewhat excessive, but there is scope for further research to be done to determine whether the general standard of Homes could improve and whether this would also improve the standards of fire safety in Homes at all. There is also potential to improve fire safety features in Homes by introducing a financial incentive to well-performing Homes.

Although it is unusual for research to recommend that less onerous regulation and a free-market attitude should be implemented, these were the findings of this research. As the research was ultimately subjective and on a small, localised scale and could only be reliable at the time it was collected, the data is not transferable to all of the Care Homes in England. Whilst further study could determine whether the issues detected by this research are endemic to other Care Homes across the country, if these reasons are substantiated, the changes to the Care System that would have to be made to "solve" the problems would be so massive as to be financially prohibitive.

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ASSERTAINED BENEFITS OF USING BUILDING INFORMATION MODELLING (BIM) IN THE UK CONSTRUCTION INDUSTRY

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Robert Horan is a Civil Engineer who currently works for KMI as a design co-ordinator. At the time of writing his dissertation his duties involved delivering detailed design documentation for United Utilities in the waste and clean water sector. Robert has worked in the construction industry for 7 years and has recently received his honours degree in Construction and Commercial Management from Sheffield Hallam University.

Innovations in design and construction techniques have led to improvements in the way projects are designed, procured and constructed with modern day emphasis turning to building sustainability, building end users and building demolition at the end of its life cycle. One of the main advances that have aided the construction industry is the advent of information technology. Further, computer technology although comparatively young in relation to the construction industry has seen prodigious advances in the last 50 years, and one of the latest advancements, still very much in its adolescence is Building Information Modelling otherwise known as BIM.

Keywords: Building Information Modelling, BIM, 3D CAD.

INTRODUCTION

The UK construction industry currently employs some two million people in more than 250,000 different companies (ONS, 2011), has an annual industry turnover of £100 billion and accounts for almost 10% of the country's GDP (Construction Commitments, 2012).

Computers allow the drawing, modelling and near instant change of elements of a building's design at the click of a button they also allow communication and sharing of information in ways that could not have been imagined by builders and architects of the past. Computers have revolutionised the way in which construction projects are designed and detailed and are able to not only reproduce accurate, detailed, scaled models but simulate how component elements of a building will react.

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This paper identifies and analyses the main benefits of, and barriers to, using Building Information Modelling, looking at potential reduction in project costs, construction programmes and potential impacts on site Health and Safety in addition to identifying the factors behind its perceived slow uptake across the industry.

METHODOLOGY

The early stages of this project consisted of an extensive literature review on material and gave an understanding of BIM and how its development and use in the construction industry has grown, as well as identifying the benefits from adopting BIM on construction projects. An online questionnaire was developed to collect relevant data from both construction professionals currently working in the industry but not involved with the use of BIM and construction professionals who use BIM in their current job role. These questions were developed in order to examine trends and ideas that were identified by the literature review. To support the findings of the questionnaire, two semi-structured interviews were carried out with industry professionals currently using BIM within their employing organisations. The purpose of undertaking this additional research in a semi-structured format was to guide the interview along the lines of the questionnaire so relevant data could be obtained whilst allowing scope for elaboration on the questions to gain additional insight.

LITERATURE REVIEW

Building Information Modelling (BIM) was first introduced to the construction industry around ten years ago; its aim was to distinguish information rich architectural 3D modelling from the traditional 2D drawing. The abbreviation ‘BIM’ is used to refer to the process of Building Information Modelling is a building design methodology characterised by the creation and use of coordinated, internally consistent computable information about a building project in design and construction (Solibri, 2013). BIM has the ability to integrate plans, sections, details, graphics, and data in ways not possible in a 2D representation. The use of BIM is not to be confused with the generation of 3D drawings; the production of 3D drawings is just one facet of the building model, BIM is a process of collaborative working, allowing multiple members of the design team to input into a central digital model simultaneously, improving the work flow and the exchange of information across the project team.

A BIM model can assist with visualisation, clash detection, fabrication and production of shop drawings, code checking, forensic analysis and facilities management (Eastman, et al, 2008). Thus one model is able to contain all the necessary information about a project (Maya et al. 2012). Eastman et al (2011. Pg.1) describes BIM as one of the most promising current developments in the architecture, engineering and construction (AEC) industries. With BIM technology, one or more accurate virtual models are constructed digitally. These models support design through its phases, allowing better control than manual processes.

The Benefits of Using BIM

The benefits of using BIM are wide, varied and can have an impact on a project at all stages of its life cycle. BIM can be used through conception, design, construction and facilities management and thus has a greater potential to bring savings and improvements in processes compared to traditional methods. Figure 1 shows various BIM applications and how they can be applied during different phases of an AEC project.

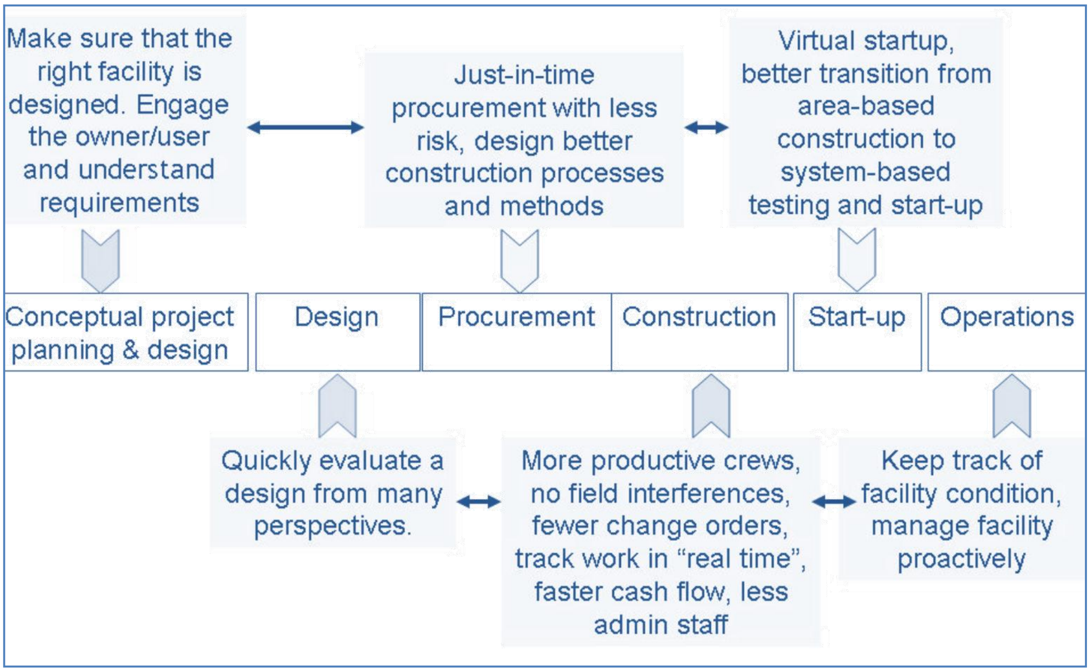

Figure 1 - BIM applications in the different phases of an AEC project (Hartmann & Fischer, 2007)

CRC Construction Innovation (2007) states that 2D CAD describes a building using independent 2D views such as plans, sections and elevations. Editing one of these views requires that all other views must be checked and updated, an error-prone process that is one of the major causes of poor documentation. With normal 2D architectural drawings, any change or edit must be manually transferred to multiple drawing views by the designer resulting in potential human errors from not updating all drawings correctly (Eastman et al. 2011. Pg.24). In precast concrete construction, this 2D practice has been shown to cause errors costing approximately 1% of construction costs (Sacks et al. 2003).   Currently the use of traditional 2D based drawings means that the various departments involved in a construction project work independently of each other, where drawings are passed back and forth for review and changes are updated as comments are made between the client, contractor and designer. This is a fragmented approach and is a time consuming operation. At an early stage, the estimator will produce an estimated cost for the project, usually from drawings that do not represent the finished detailed design and can lead to inaccurate forecasts that leave the project struggling if funding has been secured on the back of inaccurate estimates. In the United States, using DProfiler, a BIM based software capable of producing accurate cost estimates from a digital model, architect Beck Group was able to produce estimates on the Hillwood Commercial Project within 1% of that of a manual estimate but at a 92% reduction in time (Eastman et al. 2011 Pg.559).

The BIM model is the source of all 2D and 3D drawings, so design errors caused by inconsistent 2D drawings are eliminated. The BIM also has the ability to bring together federated models from several disciplines, allowing checks to be made between multidisciplinary interfaces for clash detection, both hard clashes (physical) and soft clashes (spatial/clearance). Conflicts and constructability issues are identified before they are detected in the field. Co-ordination between participating designers and contractors is enhanced and errors or omissions are significantly reduced. This speeds up the construction process, reduces costs, minimises the likelihood of legal disputes and provides a smoother process for the whole project team (Eastman et al, 2008. Pg.26).

According to a recent survey by McGraw Hill Construction (2009) BIM creates efficiencies and users realise some of the greatest value of BIM is through its potential to cut down on duplicate work such as re-entering of information into models or making changes in the field. As users become more proficient, the opportunities to improve productivity are more pronounced. Reducing work is the highest rated business benefit among experts with four out of five experts saying it brings high value.

Reduction in project costs are one of the main benefits that has to be recognised for BIM implementation if it is to be successful within the UK construction industry. Clients are looking for added value and companies will be looking for a Return on Investment (RoI) made into BIM. Below are figures from the Stanford University Centre for Integrated Facilities Engineering (CIFE) based on 32 major projects using BIM which accrording to CIFE (2007) indicate benefits such as;

- Up to 40% elimination of unbudgeted change
- Cost estimation accuracy within 3%.
- Up to 80% reduction in time taken to generate a cost estimate.
- A savings of up to 10% of the contract value through clash detections.
- Up to 7% reduction in project time.

To demonstrate cost savings at a project level a case study by (Azhar *et al* 2007) for a hotel complex and car park built in Atlanta Georgia by Holder Construction Company is summarised as follows.

- Project name: Hilton Aquarium, Atlanta, Georgia
- Project scope: $46M [approx. £28M], 484,000 Sq Ft hotel and parking structure
- Delivery method: Construction manager at risk
- Contract type: Guaranteed maximum price
- Design assist: GC and subcontractors on board at design definition phase
- BIM scope: Design coordination, clash detection, and work sequencing
- File sharing: Navisworks used as common platform

- BIM cost to project: $90,000 [approx £55,000] - 0.2% of project budget ($40,000 [£24,000 approx.] paid by owner)
- Cost benefit: $200,000 [£121,000 approx.] attributed to elimination of clashes
- Schedule benefit: 1143 hours saved

Holder Construction created 3D models of the architectural, structural and MEP systems of the proposed building. These models were created during the design development phase using detail level information from subcontractors based on drawings from the designers. Through frequent 3D co-ordination sessions, the project team was able to quickly identify and resolve system conflicts, saving an estimated $200,000 [approx. £121,000] in extras and avoiding months of potential delays as shown in Table 1. This shows that just through the use of clash detection the number of man hours saved constituted a considerable saving to the project in addition to a better finished project through reduced reworking and non abortive works.

Collision Phase	Collisions	Estimated Cost Avoided	Estimated Crew Hours		Coordination Date
100% Design Development Conflicts	55	$124,500	NIC		*June 30, 2006*
Construction (MEP Collisions)					
Basement	41	$21,211	50	hrs	*March 28, 2007*
Level 1	51	$34,714	79	hrs	*April 3, 2007*
Level 2	49	$23,250	57	hrs	*April 3, 2007*
Level 3	72	$40,187	86	hrs	*April12, 2007*
Level 4	28	$35,276	68	hrs	*May 14, 2007*
Level 5	42	$43,351	88	hrs	*May 29, 2007*
Level 6	70	$57,735	112	hrs	*June 19, 2007*
Level 7	83	$78,898	162	hrs	*April 12, 2007*
Level 8	29	$37,397	74	hrs	*July 3, 2007*
Level 9	30	$37,397	74	hrs	*July 3, 2007*
Level 10	31	$33,546	67	hrs	*July 5, 2007*
Level 11	30	$45,144	75	hrs	*July 5, 2007*
Level 12	28	$36,589	72	hrs	*July 5, 2007*
Level 13	34	$38,557	77	hrs	*July 13, 2007*
Level 14	1	$484	1	hrs	*July 13, 2007*
Level 15	1	$484	1	hrs	*July 13, 2007*
Subtotal Construction Labor	590	$564,220	1143	hrs	
20% MEP Material Value		$112,844			
Subtotal Cost Avoidance		**$801,565**			
Deduct 75% assumed resolved via conventional methods		($601,173)			
Net Adjusted Direct Cost Avoidance		**$200,392**			

Table 1: Building Information Modelling for Hilton Aquarium, Atlanta, GA Estimated cost saving Through BIM Use

A McGraw Hill survey (2009) reported that contractors see the highest RoI with 71% reporting positive returns closely followed by owners with 70% and architects/designers on 58%. It is reported that contractors are likely to see more tangible benefits such as savings through clash detection, while clients realise the combined benefits from all team members that experience positive RoI.

Project Management Institute (2001) defines stakeholders as “individuals and organisations who are actively involved in the project, or whose interests may be positively or negatively affected as a result of project execution or successful project completion.” This means that stakeholders in the project are not just the client, architect and the construction team but also the facilities end users and third party members such as the public. BIM can be effectively used to market potential projects to members of the public to aid with planning applications through its 3D visualisation.

BIM also lends its self to lean processes and Integrated Project Delivery (IPD). Lean processes and digital modelling both revolutionised the manufacturing and aerospace industries. Early adopters of these production processes and tools, such as Toyota and Boeing achieved manufacturing and commercial success (Laurenzo, 2005). Late adopters were forced to catch up in order to compete; and although they may not have encountered the technical hurdles experienced by early adopters, they still faced significant changes to their work processes. Eastman et al. (2011 Pg.153) believe the construction industry is facing a similar revolution, requiring both process changes and a paradigm shift from 2D based documentation and staged delivery processes to a digital proto-type and collaborative workflow. Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimise project results, increase value to the owner and maximise efficiency through all phases of design, fabrication, and construction. In all cases, integrated projects are uniquely distinguished by highly effective collaboration among the client, designer and contractor commencing at early design and continuing through to project handover (AIA 2007). A survey of BIM users by McGraw Hill Construction shows that establishing a collaborative environment among team members is by far the highest priority investment for clients with experts also ranking collaboration among their top priorities. This shows that that the industry is moving beyond development of basic internal processes and is now looking to integrate with others. All users said collaboration with other team members will be among their highest priority investment within five years (McGraw Hill 2009).

The ability to identify clashes at the design stage reduces potential delays during the construction phase and the costly effects of these clashes; it also allows informed decisions to be made when developing design. Clash detection is an important and integral part of the BIM modelling process. Clash detection arises out of the fact that, in BIM modelling, there is not just one model, but several, that are in the end integrated into a composite master model. Each discipline; structural engineering, MEP engineering, environmental engineering, etc., creates a federated model independently of all the others based upon the architect’s original model. After each of the disciplines has finished their work, the next step in BIM modelling is clash detection, which is the process of finding where elements of separate models either occupy the same space, have parameters that are incompatible, or in 4D BIM modelling have a time sequence that is out of order. Finding these inconsistencies is vital, as they would severely impact the construction process, causing delays, design changes, materials cost and a cascade of headaches and budget overruns (BIM Journal

2013). Figure 2 shows the relationship between the cost of change on a project and the time that change is made.

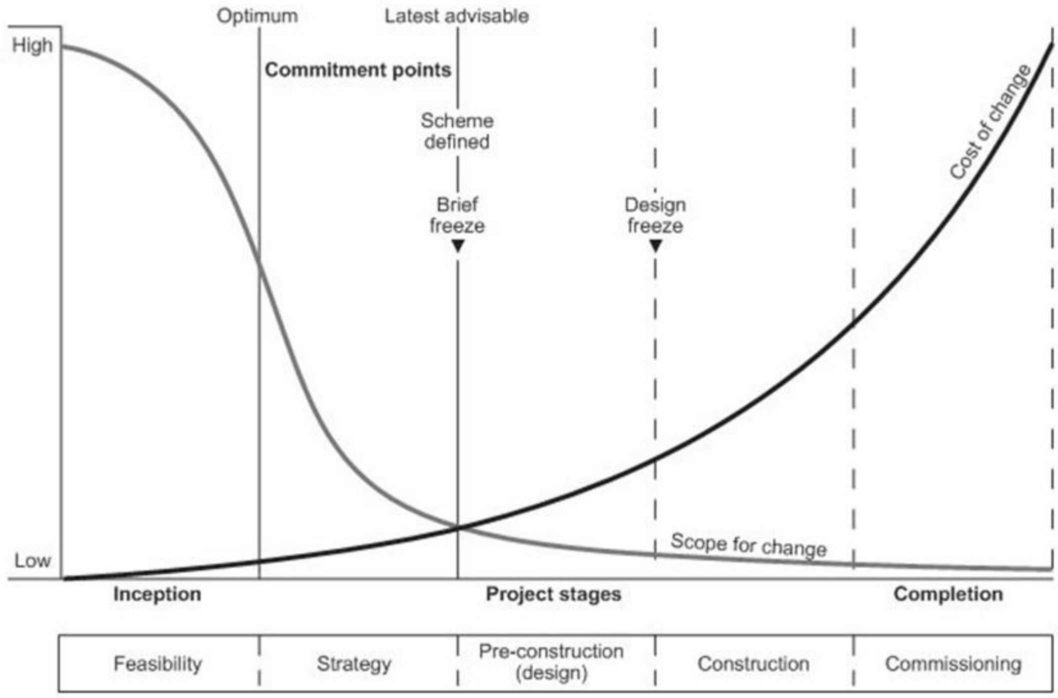

Figure 2: Relationship between Cost of Change and Time of Change (The Charted Institute of Building, 2010, Page 20)

Construction planning and scheduling involves sequencing activities in space and time considering many variables such as procurement times, resources, spatial constraints and site specific restrictions. Traditionally Gantt charts are used to show a construction projects critical path, indicating which activities, if delayed, will have an impact on the project completion date. Traditional methods however, do not adequately capture the spatial components related to these activities, nor do they link directly to the design or building model. Scheduling is therefore a manually intensive task, often out of sync with design and creates difficulties for project stakeholders to easily understand the schedule and its impact on site logistics (Eastman *et al*. 2011 Pg. 281). The ability to see the element in 3D can lead to identification of construction sequencing issues or spatial clashes such as the formwork required to construct a reinforced concrete wall blocking an access route, allowing planners to identify that for the duration of that elements construction an alternative access route will be required. When relying on 2D drawings, multiple plans and sections are required in order to gain a 3D understanding of what the drawings are trying to represent, this leaves them open to errors and misunderstanding (Eastman *et al*. 2008).

4D modelling provides a powerful visualisation and communication tool that gives project teams, including owners and building users, a better understanding of project milestones and construction plans. 4D simulation can help teams identify problems well in advance of construction activities, when they are much easier and less costly to resolve. BIM models can be linked with construction activity schedules to explore space and sequencing requirements. Additional information describing equipment locations and materials staging areas can be integrated into the project model to facilitate and support site management decisions, enabling project teams to effectively generate and evaluate layouts for temporary facilities, assembly areas, and material deliveries for all phases of construction (Autodesk n.d.).Additionally 4D-BIM means improved chances to make alternative preliminary plans of different construction stages and tasks (Sulankivi et al. 2010).

The Barriers to Adopting BIM

Despite BIM clearly having a potential benefit to the construction industry, it faces a perceived financial barrier; the cost of buying or upgrading software for smaller companies can be a major deterrent as explained by Riskus, (2007) "Smaller firms may be more hesitant to start using BIM due to the expenses associated with the initial software investment. They also may be waiting to see if one dominant software provider emerges, to avoid purchasing a software program that may be obsolete in a few years".

A recent study by Gledson *et al*. (2012) explored the experiences and perspectives of large and SME construction contractors towards the implementation of Building Information Modelling (BIM) within their organisations. The results confirmed that both groups were equally aware of the perceived benefits of BIM, but found that the largest barriers to implementation were the costs associated with the technology and training requirements. The results highlighted an agreement between the groups of respondents that the biggest barrier to implementation was the associated costs issues, with a high level of concern that clients will not pay extra for the use of BIM closely followed by the expenditure involved in the people, process and technology changes involved in an organisation.

According to the results of questionnaire carried out by Yan (2007); about 40% of respondents from USA and about 20% respondents from UK believe that their companies have to allocate lots of time and human resource to the training process. However the National BIM Report (2013) shows that of the 1350 respondents the number of 3D CAD users has increased from 13% in 2010 to over 40% in 2013. However 74% of respondents feel that the industry is still not clear on what BIM is and this figure has risen since the first National BIM Report in 2011. Another barrier faced by BIM is with the software its self. Eastman et al (2011) describes interoperability as the ability to exchange data between applications and for multiple applications to jointly contribute to the work at hand. Interoperability has traditionally relied on file based exchange formats limited to geometry, such as DXF (Drawing Exchange Format) and IGES (Initial Graphic Exchange Specification). The use of Industry Foundation Classes is one way the software suppliers can overcome some interoperability issues. IFC is known by most professionals as a data model developed by buildingSMART to facilitate interoperability in the building industry. Currently issues of interoperability restrict the exchange of information between different BIM software and tools. Interoperability at a minimum eliminates the need to manually copy data already generated in another application which smoothes workflows and sometimes facilitates their automation. Lack of interoperability acts as a barrier to smaller companies who may not have the finances to invest in multiple software's to open up access to potential clients. The benefits of BIM will materialise only through sharing information across organisations, departments, IT systems and databases. IFC standard is the key to facilitating this cost-effectively and without becoming dependent on product or vendor specific file formats Solibri (2012).

BIM also faces a major challenge in training construction professionals in its use in addition to also raising awareness of the subject. Eddie Tuttle, public affairs and policy manager at the Chartered Institute of Building stated that "The industry faces huge challenges on training and up-skilling to operate in a BIM-enabled world" (Construction Manager, 2012). It is apparent that confidence in the technology is lacking in some areas of the construction industry and this could be directly related to the amount of awareness and training being undertaken by the industry. This will only be exacerbated by the fact that government standards are still being developed. The Cabinet Office needs to co-ordinate Government's drive to the development of standards enabling all members of the supply chain to work collaboratively through Building Information, this will need to be a phased process working closely with industry groups, in order to allow time for industry to prepare for the development of new standards and for training (Government Construction Strategy 2011) .

Government Drivers

A key driver is the governments Construction Strategy released in May 2011. This report states that 'At the industry's leading edge, there are companies which have the capability of working in 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; but construction has generally lagged behind other industries in the adoption of the full potential offered by digital technology' (Government Construction Strategy, 2011). The Government will now require fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016 from its supply chain.

In 2010, the UK government formed The Building Information Modelling (BIM) Task Group to support and help deliver the objectives of the Government Construction Strategy and the requirement to strengthen the public sector's capability in BIM implementation, with the aim that all central government departments will be adopting as a minimum, collaborative Level 2 BIM by 2016. It released a report in 2011 titled 'Strategy Paper for the Government Construction Client Group'. Within it makes recommendations on a two stage strategy the government should implement which it calls a 'Push-Pull' strategy. It defines the 'Push' element of the strategy as applying to the supply chain (private sector) and the methods by which the government could make it easier for it to adopt BIM use, such as by using package products, issuing standards, guides and training to support clear simple delivery and the 'Pull' element applying to the client (Government) and how the client should be very specific and consistent about what it requires. This includes the need to specify a set of information (data) to be provided by the supply chain to the client at specific times through the delivery and operational life of an asset. The report also outlined what is probably the most important information for the UK construction industry by defining the government's BIM level requirements. The UK government split BIM into three levels with level two being the requirement by 2016. The report states; To simplify and aid understanding, a maturity 'level' index has been developed which can be used to articulate groups of technology, processes and their inherent capabilities. It is a key recommendation that all public procurement should be carried out at level 2 or higher by the conclusion of the 5 year strategy. Figure 3 shows the maturity index which is broken down into the following levels:

- Level 0 – Unmanaged CAD, probably 2D with paper (or electronic paper) as the most likely data exchange mechanism.
- Level 1 – Managed CAD in 2D or 3D format using BS1192:2007 with a collaboration tool providing a common data environment, possibly some standard data structures and formats. Commercial data managed by standalone finance and cost management packages with no integration.
- Level 2 – Managed 3D environment held in separate discipline BIM tools with attached data. Commercial data managed by an Enterprise Resource Plan. Integration on the basis of proprietary interfaces or bespoke middleware that could be regarded as 'Proprietary BIM'. The approach may utilize 4D programmed data and 5D cost elements as well as feed operational systems.
- Level 3 – Fully open processes and data integration enabled by 'web services compliant with the emerging IFC standards, managed on a collaborative model server. Could be regarded as 'Integrated BIM' potentially employing concurrent engineering processes.

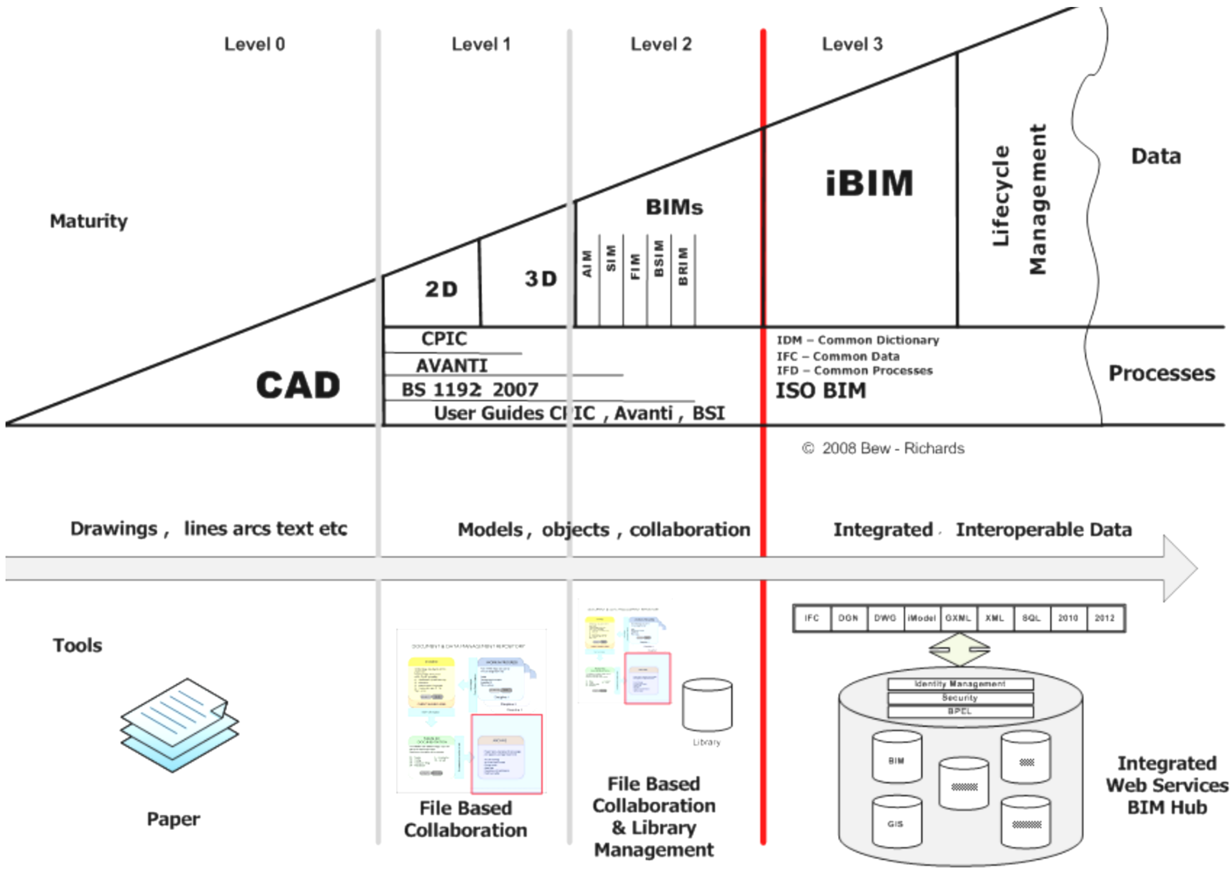

Figure 3: UK Government BIM Maturity Index from the Building Information Modelling Task Group

After defining its maturity levels and requirements the government has recently released its supporting specification: PAS1192:2 Specification for Information Management for the Capital/Delivery Phase of Construction Projects using Building Information Modelling. The purpose of the PAS is to specify requirements for achieving Level 2; setting out the framework for collaborative working on BIM enabled projects and providing specific guidance for the information management requirements associated with projects delivered using BIM. PAS1192 and its sister standard BS1192:2007 support the Construction BIM Strategy to achieve Level 2 compliance and the desired reduction in capital expenditure (CAPEX) out turn cost. (BIM Task Group 2013) The infancy of the PAS British Standard means it is yet to be seen if this new standard is the answer to the industries questions on how to effectively implement BIM to achieve the Government's requirements, only time will tell.

In addition to PAS1192:2 and to aid with the transition to a digital design construction industry, a number of work plans are being developed by professional bodies such as the RIBA (Royal Institute of Builders and Architects) Digital Plan of Work 2013. This is one of a number of long standing work plans that have been established for various sectors of the industry when undertaking traditional design and construction methods. The Outline Plan of Work organises the process of managing and designing building projects and administering building contracts into a number of key work stages. With the advent of BIM these processes are required to be refined but are an example of how the construction industry is embracing the move into digital design. The RIBA Plan of Work 2013 advocates the consideration of who does what, when and how (National BIM Report, 2013 Pg. 16-17).

ANALYSIS OF RESULTS

A total of 94 respondents replied to the questionnaire, of these 28 responded that they were users of BIM with the remaining 66 being non-users. The number of respondents is deemed sufficient with which to carry out analysis. Responses were largely received from engineers (36) and others (39). Of the other respondent's job roles, the most prevalent were from CAD or BIM technicians including a draughtsman (8), no Quantity Surveyors responded to the questionnaire, the remaining were Architect (1), Project Manager (7) and Designer (11). Cross tabulation of the results with job roles of people that are currently using BIM are Architect (1), Designer (7), Engineer (5) and other (15). This shows that users of BIM who responded to the questionnaire come from a variety of project roles which provide varied perspectives on later questions.

Of the 94 respondents 66 were familiar with the term BIM with 28 unfamiliar. It would be reasonable to say that respondents who answered that they are currently using BIM (28) are familiar with the term; taking this into account the number of respondents to this question who are not using BIM and familiar with the term would be 38, this amounts to a 58% yes 42% no split. This is consistent with the National BIM Report (2013) that revealed 54% of people surveyed were aware of the term BIM but not using BIM.

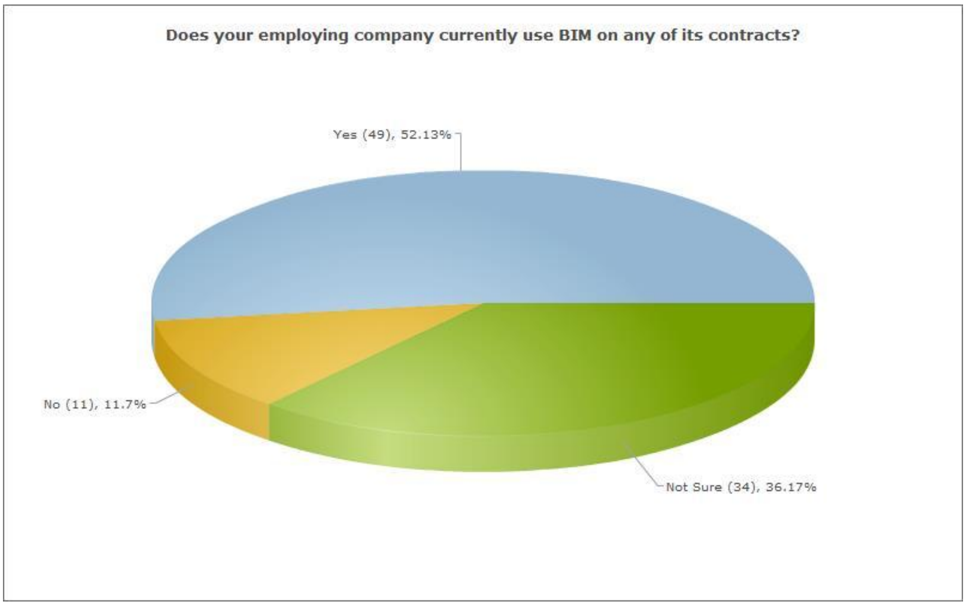

Figure 4: Pie Chart Showing Respondents Company BIM Use

From Figure 4 it can be seen that 52% of respondents currently work for companies who are using BIM. This is slightly higher than the results of the national BIM Survey which shows 43% of respondents were currently using BIM.

Figure 5: Column Chart Showing Respondents Company Maximum Contract Value

Figure 5 shows that the most common response to the question on Company maximum contract value was greater than £5millon with 62 out of 91 responses. The next most common response was ‘not sure’ with 17 out 91. The results showed that 27 users who responded to the contract value question were current users of BIM. Of these 51% (14) worked for companies whose contract value was over £5millon with the next largest response being those whose contract value was £2millon - £5millon with 14% (4). These results would suggest that currently there is a link between contract value and BIM use which would also tie in with the findings of the literature review which revealed smaller companies are concerned about the cost of implementing BIM within their organisation.

Figure 6 illustrates which of the respondents were currently aware of BIM and using BIM. Of the 94 respondents 30% (28) were users of BIM, 46% (43) were aware of BIM and 22% (21) were neither aware of BIM nor using it. This is just slightly lower than the National BIM report (2013) with 39% using, 54% aware and just 6% neither aware nor using. The results show that 42% of respondents deem themselves to have an intermediate level of experience using BIM, with a further 25% being of an expert level. This level of knowledge and understanding of the issues and topics of respondents to the questionnaire is considered to add weight to the validity of the survey.

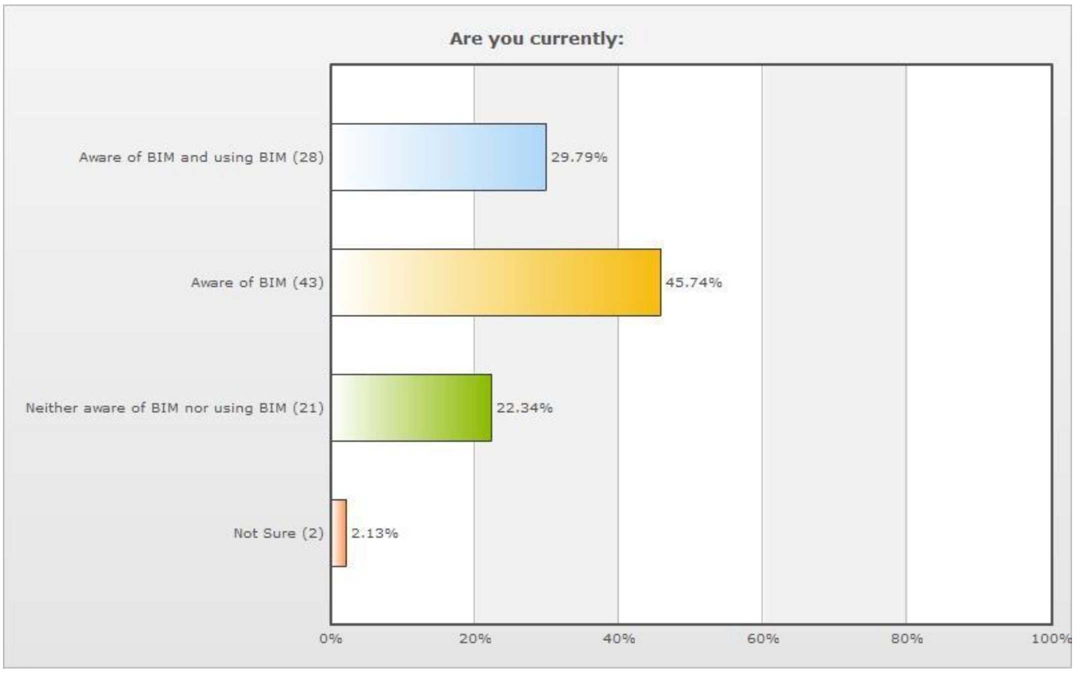

Figure 6: Bar Chart Showing Respondents Awareness of BIM

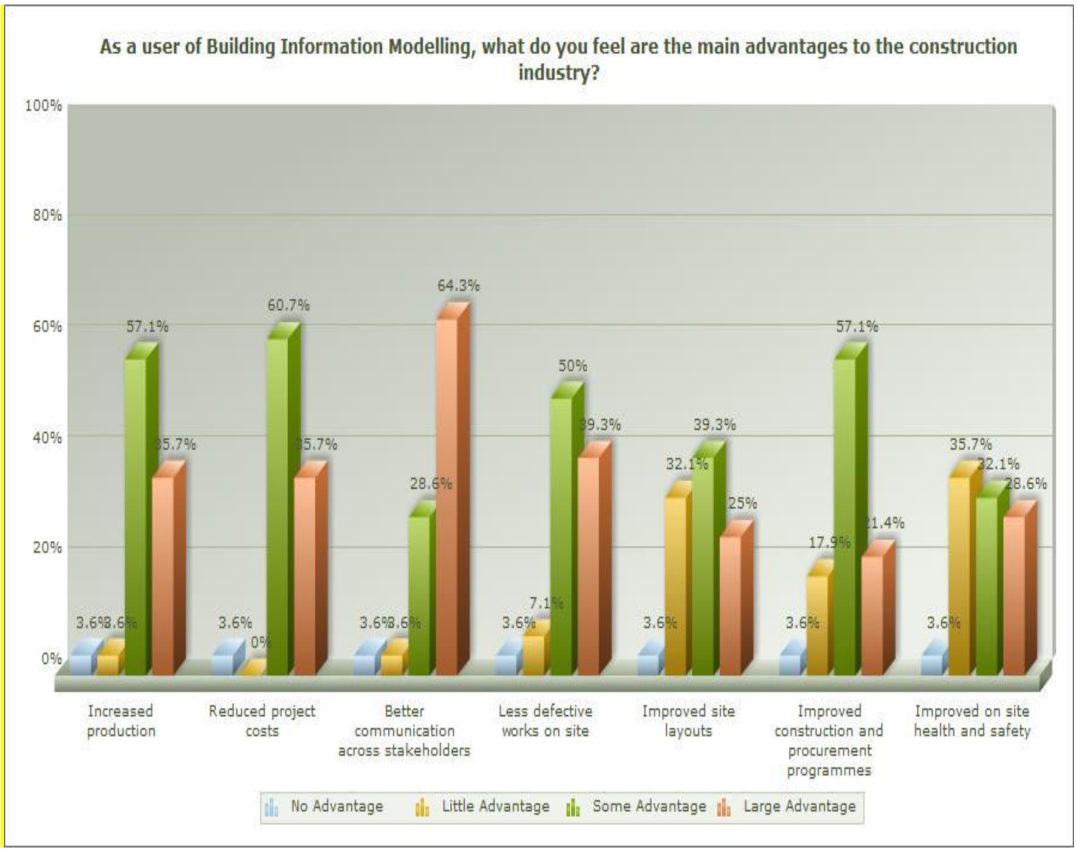

Figure 7: Matrix Chart Showing Responses to Main Benefits of Using BIM

The results (Figure 7) show that the largest perceived advantage is better communication across stakeholders (63% believing this is a large advantage), while only 25% thought improved site layouts was a large advantage of BIM software. This could explain the low scores for improved onsite health and safety as these two were closely linked in the literature review. Most significantly is the fact that all categories scored only 3% for no advantage showing all the options are perceived to have some advantage by industry BIM users.

During the literature review, it was also established that there are a number of barriers to BIM adoption across the industry. The results in Figure 8 show that although all the options were agreed to be slight barriers, and in some cases considerable barriers, the highest significant barrier was lack of knowledge surrounding BIM with 18%, this category also scored high on considerable 40% and significant barriers 42%. It would seem that a lack of knowledge is the main barrier surrounding BIM which is also echoed in the National BIM Survey which recorded 74% of people agreeing that the industry is not clear on what BIM is yet. In the survey the majority either agree 57% or strongly agree 33% that the construction industry is yet to realise the full benefits of BIM

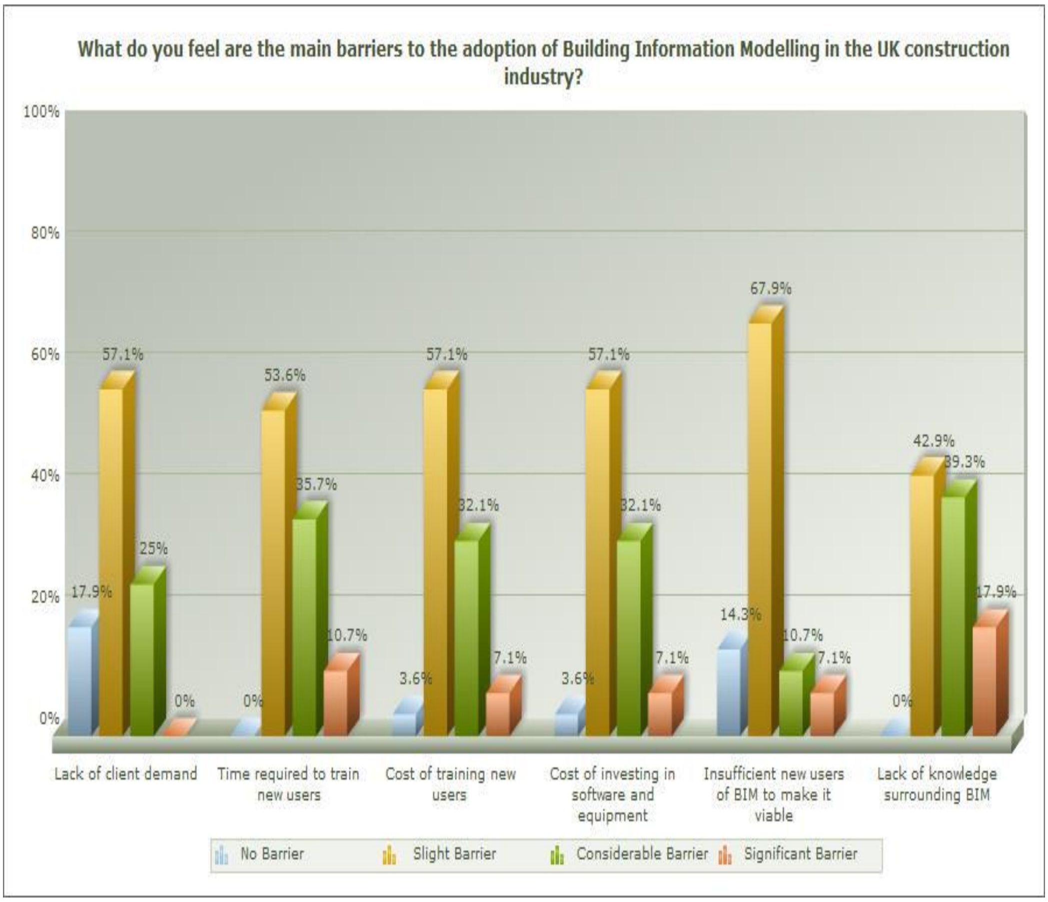

Figure 8: Matrix Chart Showing Responses to Main Barriers to BIM Adoption

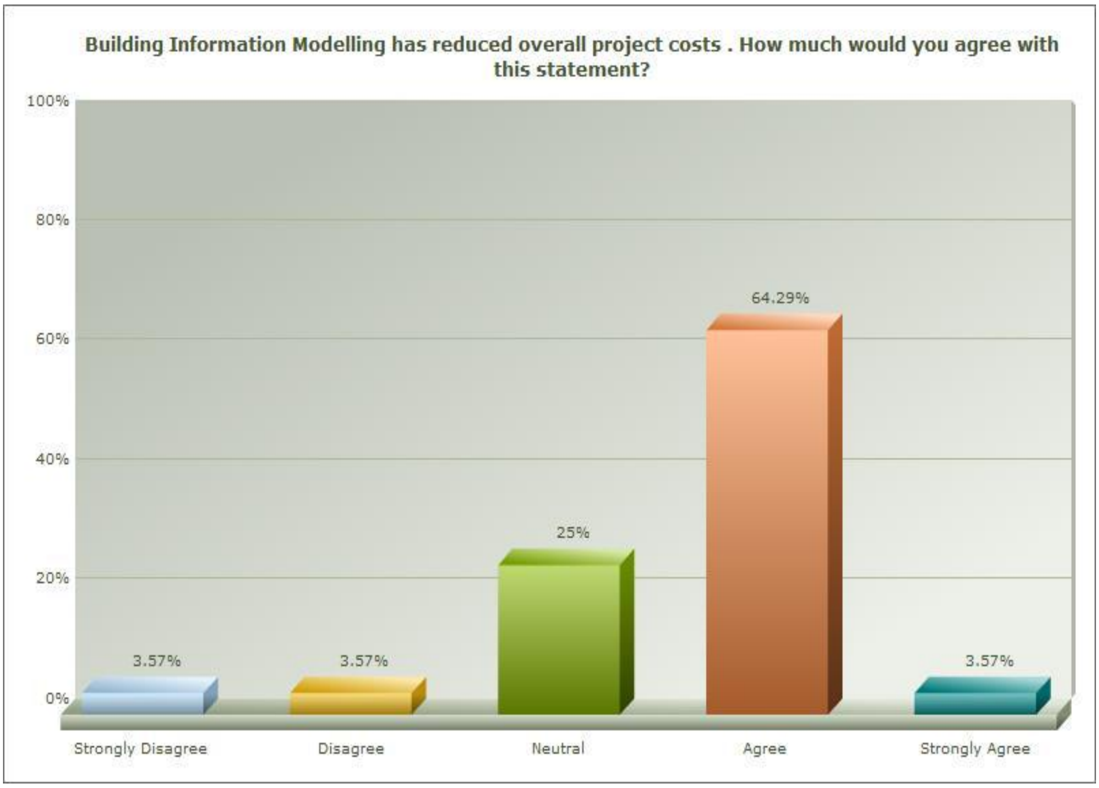

Figure 9: Column Chart Showing Responses to Reduction in Project Costs

Figure 9 shows that 64% of respondents agree BIM has reduced overall project costs. This is supported by the McGraw Hill survey (2009) which reported that 41% agreed that BIM had increased project profitability. Reduction of design changes has the potential to save project costs if they are caught early in the design phase. The link between late design changes and increased costs of those changes is highlighted in the literature review and shown in Figure 2. The results above indicate that industry users of BIM agree (46%) and strongly agree (25%) that BIM can reduce the number of design changes at an early stage. This will give the added advantage of not only reducing rework but also reducing unnecessary increased costs through those changes later in the project. A comment made on the survey makes it clear that the success of this aspect of the BIM is dependent on all stakeholders adopting its use at an early stage.

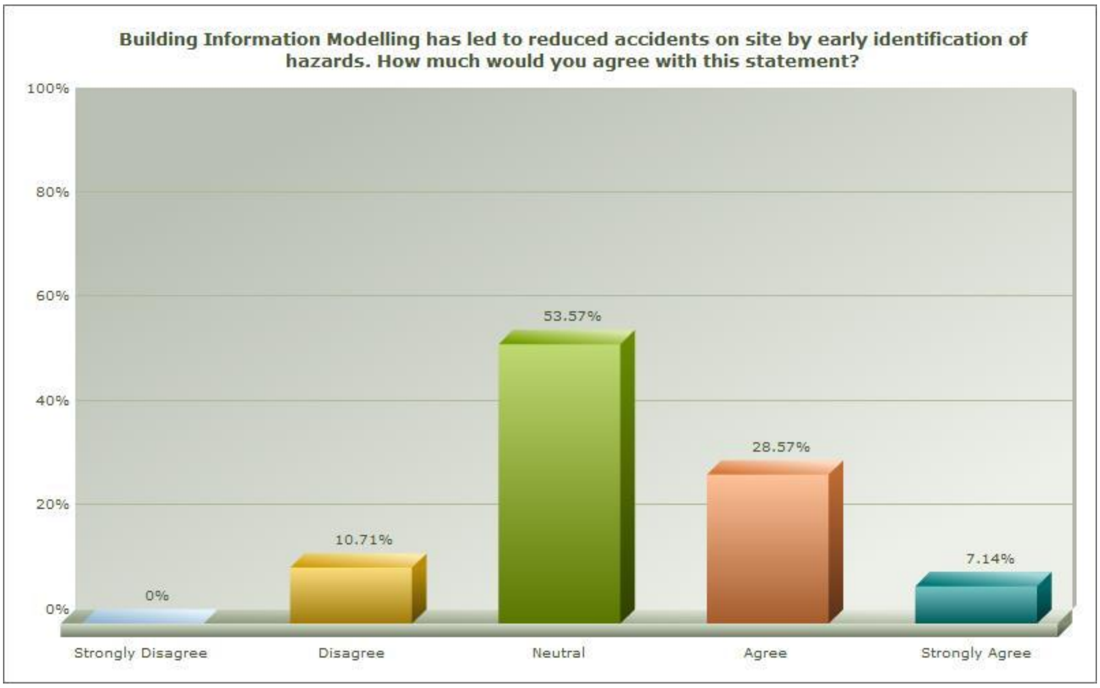

Figure 10: Column Chart Showing Responses to Reduction of Accidents

The use of BIM to reduce accidents on site is a benefit that the author does not feel is fully appreciated and this is reflected in the results of the survey with the largest number of respondents being neutral (54%) when answering if BIM has led to reduced accidents onsite (Figure 10). During the literature review there was very little tangible data to support this theory however the rationale behind it seems sound. This is agreed by a comment on the survey that there is no data to support such a statement. If a direct link between BIM and Health and Safety could be proved, the appeal of BIM would greatly improve and give another major benefit for its widespread adoption in the industry.   The response to the question that BIM has increased quality on site by reducing defects through clash detection is a resounding agreement. 57% of responders agreed with the question with 29% strongly agreeing. No responders disagreed with this question. The benefits of clash detection are a major selling point of BIM software, having the ability to reduce costs and speed up production in addition to improving quality onsite.

Investigating BIM Use across Supply Chain to see if this affects a company's BIM implementation shows that the issue of supply chain being a barrier are not as large as the author suspected. The largest number of responses (35%) disagreed with the question; with comments on the survey including 'our supply chain is very active in implementing BIM' and 'more and more clients are requesting BIM'. This was also agreed by a Mouchel CAD Manager who said "Uptake across the supply chain is not a barrier within the industry. Government has now set the tone for BIM uptake and most companies are moving with the times to avoid being left behind". However 18% of respondents agreed with the question suggesting that there is some opinion that there is a barrier created by BIM uptake across the supply chain.

Lack of standardisation across the construction industry is a barrier to the development of interoperability between BIM's. 57% agree that it is an issue with 7% strongly agreeing that it is a barrier, 21% disagree and 15% of respondents are neutral. The responses gathered during the interview process highlighted an issue not picked up in the literature review and that was the requirement for standard file naming conventions. GHA Livigunn BIM Manager commented "The CIC (Construction Industry Council) BIM task group along with the Construction Product Information Committee are currently working on tackling this issue quite effectively". Until standard formats and file exchange language is standardised there will continue to be interoperability issues when using BIM.

Closely linked to its ability to reduce project costs is the importance for users of BIM to realise a Return on Investment. 42% of responders to this question have recognised a Return of Investment with 29% being neutral and 21% disagreeing; some of the comments on the survey to this question would support a neutral answer; 'Yet to fully realise a RoI as still in the early stages of adopting BIM processes'. However the report by McGraw Hill (2009), states that of those BIM users who formally measured if they recognised a RoI, 57% did so.

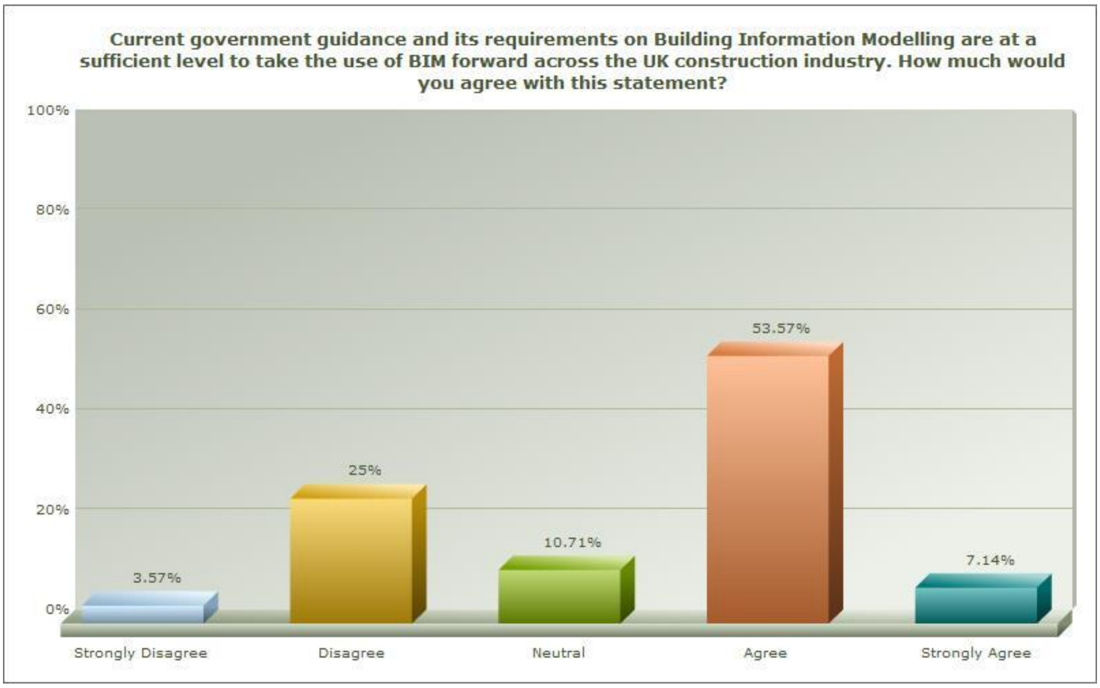

Figure 11: Column Chart Showing Responses to Level of Government Guidance

Figure 11 illustrates that respondents believe that Government guidance is finally catching up with its construction strategy released in 2012. The majority of respondents agreed with 54% in addition to 7% strongly agreeing. However 25% disagreed with this, including 4% who strongly disagreed.

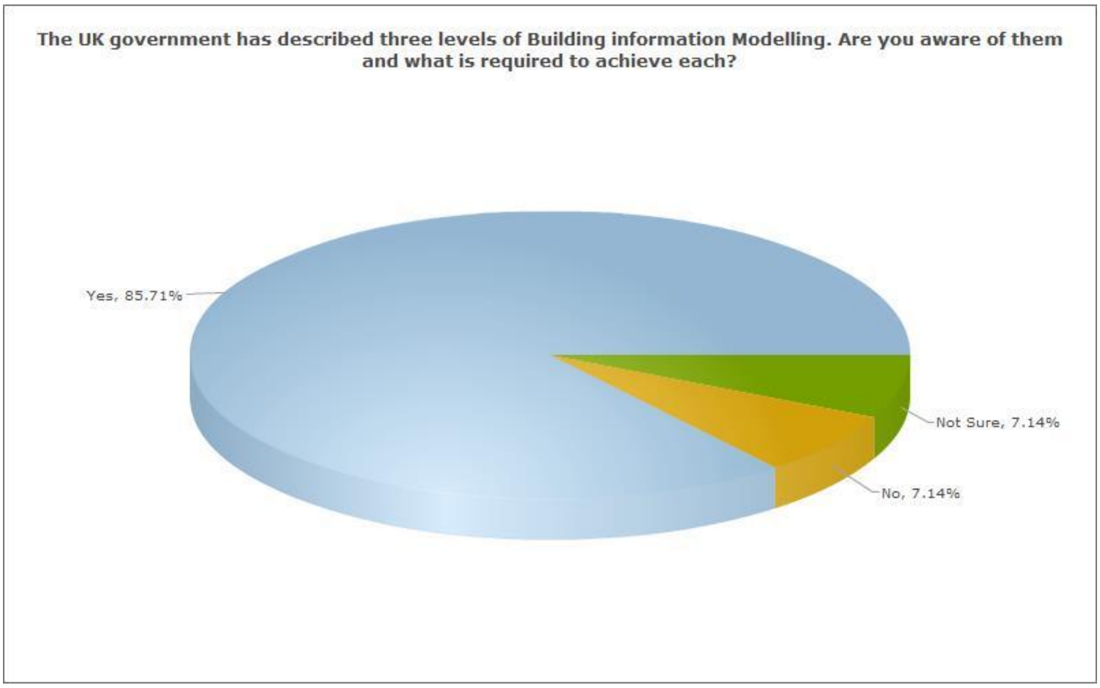

Figure 12: Pie Chart Showing Responses to Awareness of Government BIM Levels

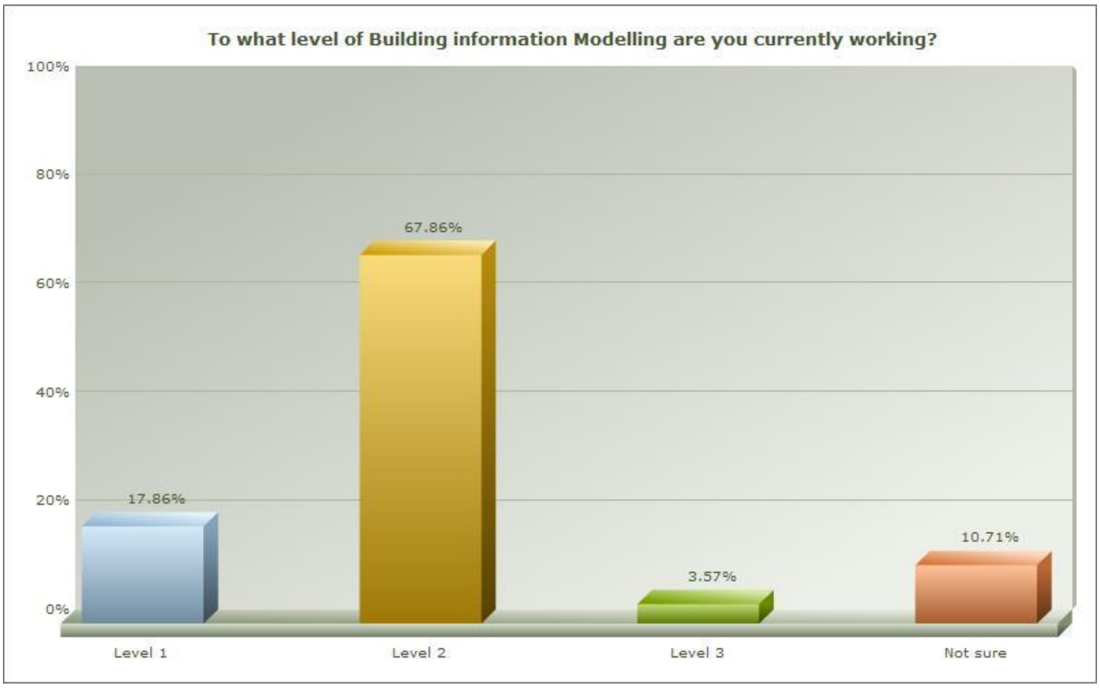

Figure 13: Column Chart Showing Responses to Users Current Level of BIM

Figure 12 show that the majority of BIM users are aware of the governments BIM levels released in its 2011 strategy paper with 86% responding in the positive, with the remaining responses split between no 7% and not sure 7%. This is a good indication that the current government strategies for BIM is at least know by the people it is supposed to affect.

Figure 13 shows that the majority of BIM users (69%) are currently working to the government 2016 target of level 2 BIM with only 18% currently working at level 1, 4% at level 3 and 11% not knowing what level they are working to. This is above the numbers reported in the National BIM Report 2013 which shows 32% of users working to level 1, 47% to level 2, 8% working at level 3 and the remaining 13% who don't know. If these numbers continue and the next three years see an increase in BIM user's proficiency and knowledge, the number of level 2 BIM users should increase.

CONCLUSIONS

During the extensive literature review a number of benefits have been noted that affect a project both from a cost point of view and a quality point of view. In addition to this a number of other benefits have been identified that were not originally considered. The literature review has shown that a project can reduce its costs through better workflows, reducing reworks and costly errors during design. Its 3D visualisation can aid in the design process, giving the client a more comprehensive view of their vision at an early stage. This visualisation of concept allows the client and design team to make faster, better, informed decisions at a stage in the design where changes can be more easily accommodated and as a result are not as costly. Coupled with BIM's collaborative approach to working, designs are able to reach the construction phase free from many of the errors associated with traditional design procedures. Additional software features of BIM such as clash detection capabilities and estimating and planning packages, a BIM represents a new level of potential efficiency in how a project is managed and constructed. The benefits of BIM with regards to health and safety are not touted as a main feature and the author will recommend further study into this avenue but feels it is only a matter of time before this facet becomes a unique selling point for the process of BIM.

Evidence from both secondary research (literature review) and primary research (questionnaires and interviews) have combined to show the author that despite some of the barriers surrounding the uptake of BIM in the UK construction industry it is inevitably going to succeed as the preferred method of project design, construction and building management for clients and contractors. Steps are already well under way by the government to support its goal of all its contracts been supplied to level 2 BIM by 2016, surveys indicate a significant proportion are already achieving this with that number only set to increase. Government steering groups such as the BIM Task Group are providing a vital bridge between its requirements and the contractors who will deliver them. It is only a matter of time before Government BIM requirements for public sector work becomes the norm within the private sector.

Awareness around the subject of BIM is growing year on year with essential and much needed education following close behind. As the perception of what BIM is and what it can offer evolves, it is the authors opinion that this process will only increase in pace. It would appear the time for adoption of BIM is now; failure for companies to invest in BIM technology and educate its workforce, in addition to recognising the benefits it can bring, may result in those that do not adopt its ethos and collaborative working practices getting left behind in what are sure to be the biggest changes in the industry since drawing boards were exchanged for computers.

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THE DEVELOPMENT OF BUILDING INFORMATION MODELLING AND THE IMPACT IT IS EXERTING ON THE PROFESSIONAL ROLE OF THE QUANTITY SURVEYOR

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The research undertaken was an investigation in to the development of Building Information Modelling and an analysis of the way in which this has impacted upon the role of the Quantity Surveyor. A critical examination of all available literature and further investigations by way of in-depth interviews enabled a conclusion to be formed as to the impact BIM has had on the Quantity Surveyor. The results show that BIM is mainly being seen as a great opportunity for the industry and an excellent chance for the Quantity Surveyor to become more efficient in their role. It has been noted that BIM should not be seen a threat to the role of the Quantity Surveyor, however in order to emphasise the importance of your role to respective clients, a clear and concise service delivery should be given. Critically, the research found that many Quantity Surveyors are apprehensive as to the benefits of BIM due to the difficulties surrounding the implementation and any return on investment. Initial discoveries describe the impact of BIM as an evolution of the QS role. Some of the changes in the role will be the early involvement of the contractor and the associated alterations to the tender and procurement process, along with a focus towards value, risk and lifecycle analysis. Any improvement in efficiency that has been found as a result of working under a BIM platform can be injected in to further ensuring the client is obtaining best value.

Keywords: BIM, Procurement, Quantity Surveyor.

INTRODUCTION

The aim of the investigation was to analyse the development of Building Information Modelling and assess the impact the process is exerting on the professional role of the Quantity Surveyor. In defining the traditional roles of the Quantity Surveyor (QS) and establishing the way in which Building Information Modelling (BIM) is driving a

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new way of working upon the construction industry, the degree of influence on the QS could be determined.

The British Standards Institution (2012) class BIM as a process of managing information relevant to a project in order to coordinate multiple inputs and outputs, irrespective of specific implementations. BIM is a broad term often used to represent two things; the process of information management and the central 'model' used as a 'hub' of information. BIM is often mistaken for a piece of software, frequently described as 3D modelling. Both of these explanations are incorrect and BIM should not be confused with the number of dimensions used to represent a building. At its simplest level, BIM provides a shared environment for all information defining a building (Pittard, 2011). The central hub of information, i.e. the model, should hold all information associated with a project from building shape and design, to the construction programme and logistics.

The Quantity Surveyor has for a long time been a very traditional role which saw bills of quantities and schedules of rates documents being prepared regularly with cost planning, control and payments also a key aspect of the role. Implementing a whole new way of working on an industry wide scale could be very difficult however the extent as to which this impact is developing will be assessed in this research.

PRIMARY RESEARCH

In order to investigate the impact of building information modelling upon the role of the Quantity Surveyor (QS), a number of research methods were considered. Due to the requirement to obtain in depth responses from Quantity Surveyors in the industry, it was decided that a series of interviews would be the most suitable form of field research to undertake. This will give me a factual insight in to the actual use of the Building Information Modelling (BIM) processes and technology in the industry, enabling me to make assessment and judgement across the industry based upon the sample obtained. In critically analysing the primary data against the secondary data collected during the literature review, arguments could be drawn.

The main constraint in undertaking the research was the theory of Building Information Modelling (BIM) being relatively new to the UK construction industry. This provided a succession of issues in the attempt to obtain relevant secondary data and reliable primary data. As the aim of the research was more specific than the impact BIM processes have had on the UK construction industry generally, this further limited the opportunities available to gather information. Due to the scale of the investigation in terms of sample size, it was difficult to locate Quantity Surveyors that had worked on a BIM platform. Whilst this did hamper the assessment of the impact of BIM upon the role of the QS slightly, the development from traditional Quantity Surveying to working as the QS on a BIM platform project of any level could still be critically analysed.

LITERATURE REVIEW

Building Information Modelling and the Construction Industry

It has been reported by many that the construction industry is underperforming due to the inefficiencies that are rife in all areas of the industry. Smith and Tardif (2009) reported that greater productivity and efficiency across the entire life cycle of any building is the foremost reason for deploying new technology. Reluctance to adapt to new processes and technology, in addition to poor standards of information management, has been highly influential in the constant failings of the construction industry. The UK Government has set an aim to "reduce whole-life costs of buildings and infrastructure by 20%" and has "identified Building Information Modelling (BIM) as a key way of reducing costs" (McCann, 2012a). This is a process that is increasing in popularity but has not yet been adopted on an industry wide scale. As BIM has been noticed and investigated by the UK Government, it is expected to be a process adopted on an industry wide scale in the coming years. Following the Government's investigation works, they confirmed in their construction strategy dated 31 May 2011 that they intend to require BIM on all of its projects by 2016 (The Chartered Institute of Building, 2011).

At this stage, due to the UK Government driving forward the take up on BIM, the majority of the involvement has been within the public sector. As outlined within the Great Britain Cabinet Office's Government Construction Strategy (2011), construction work for the public sector accounts for 40% of the construction industry. The majority of public sector construction schemes are vast in scale, therefore it is likely that this roll out will only impact upon larger organisations. On the other hand it may mean the larger entities simply winning work and then outsourcing/sub-letting it to other providers (Hibberd, 2013). This provides great opportunity for companies of all sizes to become involved with Building Information Modelling.

An underlying reason for implementing BIM is to improve collaboration and communication within multidisciplinary teams and the wider industry. This goal can only be commended, particularly as it complements a process that already exists within our profession (McCann, 2012a). McCann is clearly a supporter of the BIM theory and she goes on to write about the inevitability that the process will "build momentum" and anyone that does not adapt will be "left behind". Our respective clients may request greater value for money or higher cost certainty for example; by adjusting our work processes and embracing the theory of BIM, it enables us to fulfil the clients' expectations. Simon Rawlinson of EC Harris (2012) described BIM as a "great opportunity" to "improve efficiency and to add value". There are numerous construction professionals that disagree with the likes of McCann and Rawlinson, however. Saxon (2011) believes that the industry as a whole is "far too fragmented" to accommodate the introduction of this new way of working due to the "culture of risk aversion".

The UK Government have identified their target for 2016 as 'Level 2' BIM to be in use on all of its projects. Bond Bryan Architects Ltd (2012) summarised Level 2 BIM as "Individual discipline models used to collaborate which contain intelligent data". This effectively means that all parties are working on and feeding information in to a useful, central model that can be shared with all members of the project team. Collaboration between a multidisciplinary team will be reliant upon a clear BIM execution plan and a single empowered BIM Manager working across the design team (ISURV, 2012). The content of the 'model' is mainly built from information input by members of the design team, therefore the model should be closely managed to ensure a standard is maintained. The impact this in-depth up-front collaboration has on a project is an extended pre-contract period that focusses on design and coordination. A main aim of this process is to iron out potential coordination clashes that would normally only become apparent during the construction phase of the project.

Traditional Quantity Surveying

The Royal Institution of Chartered Surveyors (no date) identify the core role of Quantity Surveyors as "the cost managers of construction". Whilst the Royal Institution of Chartered Surveyors (RICS) have used a broad term to recognise the Quantity Surveyor; Lee, Willisn and Trench (2005) described the attributes of a Quantity Surveyor (QS) and the skills that they required to be able to undertake the role. They stated that a QS must be able to “describe clearly, fully and precisely the requirements of the designer” and that a QS must have a mind that is “systematic and orderly”.

According to the Royal Institution of Chartered Surveyors (2006); one of the core competencies of a Quantity Surveyor is “quantification and costing of construction works”. The quantification of the works at a pre-contract stage is a traditional, time consuming process that includes taking off quantities from a scaled drawing using a scale rule and take off paper. This is a process defined by the RICS under the New Rules of Measurement (2012) where guidance notes are published with the intention of representing "best practice" and identifying what meets a "high standard of professional competence". Whilst this is one of the core competencies for a QS and all Quantity Surveyors should hold these core skills, there are now a number of 2D software packages available to assist with this procedure that are widely used in the industry. Exactal Technologies (2013) claim that their construction estimating software, 'Cost X' has been proven to reduce take-off time by up to 80%. Writing about the construction industry developments in general, Ashworth and Hogg (2007) believe the "information and communication technology (ICT) revolution" will "increase productivity"; "saving time and increasing speed".

Whilst there are significant benefits to the developments in the tools available to a Quantity Surveyor, there are also a number of downsides to the implementation of such programs, especially for small to medium size enterprises (SMEs). 99.7% of businesses within the construction industry are SMEs (Cabinet Office 2011). The capital cost of purchasing the on-screen take off software may be prohibitive to its implementation. Taking into account the requirement for numerous licenses to serve your entire business, the return on investment must be assessed.

Whilst some may say this measuring ‘assistant' is effectively eliminating a large part of the QS role, it is felt that this is actually increasing the efficiency of the role as the time saved on the quantification process can in turn be injected into providing a more accurate cost appraisal, improving value for the client. Jenkins (2013) spoke of the benefits that speeding up the take-off process had on the role of the QS in "developing efficiency" and providing more time to focus on "value engineering".

Table 1 identifies the traditional activities of a Quantity Surveyor:

- Single rate approximate estimates
- Cost planning
- Procurement advice
- Measurement and quantification
- Document preparation, especially bills of quantities
- Cost control during construction
- Interim valuations and payments
- Financial statements
- Final account preparation and agreement
- Settlement of contractual claims

Table 1.0, Ashworth and Hogg (2007, p9)

According to Ashworth and Hogg (2007) the industry developments over the past 20 years have had a huge impact on the "evolution" of the role of the QS. Further roles have been developed on top of those identified within table 1.0 that have expanded the broad role of the Quantity Surveyor. Due to a Quantity Surveyors "intimate knowledge of projects", Ashworth and Hogg (2007) gave examples of these developed roles; "value and risk management", "whole life costing" and the role of advising the design team on "environmental and sustainable construction costing".

Building Information Modelling and the Quantity Surveyor

For the project Quantity Surveyor (QS), the evolvement of the BIM theory effectively eradicates all form of pre-contract measurement as the quantification of the materials required on a project can be generated automatically from the 'model'. However, as the reliability of this function solely depends on the accuracy of the information input by the design team working on the model, the quantities must be checked in order to ensure precision. Whilst disadvantages of the implementation of BIM upon the overall industry are difficult to find; Crotty (2012) stated that BIM generated information that was "inherently trustworthy and computable". In contrast to Crotty's view, the key risk therefore in the implementation of BIM, is of people placing too much trust in 'the model'.

The most common traditional procurement route for a client designed project would be a 'lump sum contract' where a bill of quantities is collated and a competitive tender undertaken (JCT, 2013). As the idea behind BIM is to improve coordination between all parties, a contractor must be appointed at an earlier stage than when they would be under the traditional process. The contractor should be involved with the design in order to give their experienced advice on the methods of construction. Early involvement is also paramount to achieve 'level 2' BIM, as the construction programme and logistics must be integrated within the central model. Smith (2012) noted a contractors' involvement at the design stage gives them the ability to "present visually, graphically and sequentially" "how they intend to construct a scheme". This will give both the contractors' Quantity Surveyor and the Professional Quantity

Surveyor a strong understanding of the scope of works and the time required to ensure good value is being achieved.

The design may evolve drastically from feasibility stage to construction, therefore ensuring the client is achieving good value when the project is approaching the construction phase is more difficult than if there had been a competitive tender scenario. The process of nominating a contractor is slightly different to the traditional way of working when using the BIM processes. An experienced client may nominate a contractor that they have previously worked with and request their involvement during the early design stage. An inexperienced client may progress the design to a feasibility level where they then undertake a competitive tender based upon the basic design to date and an outline scope of works. With either of the options considered, the most likely process will then be to appoint the contractor under a design and build contract, and through novation the client will pass the employment of the design team over to the contractor. By passing the design risk on to the contractor it avoids dealing with the blurred area of responsibility of the design and apportioning responsibility for aspects of the design to each member of the design team.

Another option for the client is to instruct the Contract Administrator to implement a cost-plus contract whereby the contractor claims all costs expended against the project and applies an agreed level of overheads and profits. Rodriquez (2013) notes the key responsibility for the contractor under a cost-plus contract; "the contractor must justify and present evidence that justifies that the cost is related to the job". This method however reduces the level of risk assigned to the contractor and increases the client's risk with a relatively low cost certainty until the end of the project. The QS, in order to ensure good value is being achieved can reasonably ask for a number of competitive quotations for specified works. This is a time consuming procurement method for the QS as the on-going quantification and costing of the works can take far longer than an initial client designed scheme with a 'lump sum contract'.

RESULTS

Traditional Quantity Surveying

As shown in Table 1.0, Ashworth and Hogg (2007) identified a series of traditional activities attributed to the Quantity Surveyor. This is a relatively narrow view of the Quantity Surveyor according to those Quantity Surveyors that were interviewed. The majority of those interviewed see far more cost and statistical analysis in practice today than drawing up traditional bills of quantities. One of the participants actually listed several activities that they are heavily involved with, that Ashworth and Hogg do not even address. The activities put forward by the participant were; value, risk and lifecycle analysis. According to one of those interviewed, the main reason for these developments in the traditional role of the Quantity Surveyor is to satisfy the needs and wants of clients.

Tools in use by the Quantity Surveyor

The literature offered evidence that the very traditional use of scaled, printed drawings and a scale rule, is near extinct in the industry. It appears the process of gathering quantities is now completed 'on-screen', using measurement software packages. It was found that there were numerous supporters of this process and it was encouraged by many to utilise the software available. When it was asked of those interviewed what tools they used in order to fulfil their role as a Quantity Surveyor, on-screen measurement appeared to be the norm. Many of the respondents recognised the efficiencies associated with the use of on-screen measurement, however, one participant noted that prior to utilising this software, it is important for trainee Quantity Surveyors to learn the basics of how to measure using printed drawings.

Another tool that was suggested as essential in order to fulfil their role as a QS, was the use of Microsoft Office, predominantly Microsoft Office Excel. One of those interviewed stressed the importance for the QS to utilise all of the benefits that Microsoft Office Excel has to offer as, if used correctly, it was a way of providing sound data displayed clearly to the clients requirements.

Inefficiencies in the Construction Industry

The review of the literature available showed that many were reporting that the construction industry is underperforming. It was noted that poor efficiency was holding the industry back and that improvements were essential in order to reduce the whole life costs of buildings and infrastructure. Issues surrounding team work and communication in the industry, in addition to the way in which people are more concerned over protecting themselves, rather than working towards the same goal, was a common finding in both the primary and secondary research undertaken. Improvements to communication and collaboration look to be essential in order to achieve a common goal in a more efficient way.

Early collaboration during the design stage of a project can have a positive effect on the scheme during the construction phase. The majority of the sample identified a key irritant during the post-contract period as clashes between trades. Unnecessary clashes, which could be identified with increased communication prior to commencing the works on site, are a costly, time consuming bane that needs to be avoided.

Building Information Modelling and the Construction Industry

Whilst it was anticipated that some of the participants may describe BIM as "just a model", it was found that all of those interviewed had a sound basic understanding of BIM. In order to gage the understanding the respondents had on the topic of BIM, it was asked of them to give a basic definition; each response included terms that followed the same areas as those identified by the British Standards Institution (BSI). In summary, it was put forward by the sample surveyed that BIM is not just a model, but a process of integrating digital data from a number of parties, collaborating and communicating what is to be the most suitable solution to achieve their common goal. Only 40% of the sample interviewed had had personal involvement in a project that was completed under a 'level 2' BIM platform, with another 40% having worked under a 'level 1' BIM platform where all parties were working and communicating around a central model, however, cost, programme and logistical information was not collated.

All of those that partook in the research could identify benefits associated with working on a BIM platform. Some of the key areas of improvements that were put forward were in the programming and sequencing of the works, reduced risk during the construction phase and much earlier cost certainty. Those respondents that had worked with BIM at ‘level 2’ did make clear that BIM is more useful, the larger or more complex the project. There are some apprehensive parties though such as Waterhouse (2013) who stated that investment costs are still a barrier to the implementation of BIM and concerns remain over the likely returns.

Due to the number of disputes in the construction industry, it appeared sensible to discuss the legal implications of working under a BIM platform. Asking this question of the Quantity Surveyors interviewed discovered much uncertainty. Not one of those interviewed understood who would assume the role of 'managing the model', if this role even needs to exist. In addition to this, the ownership of the model exposed even more ambiguity. Although the entire benefit which BIM is supposed to offer is the theory of working closely as a team towards the same goal, when errors and clashes still appear, the client will inevitably ask the question “who is to blame?”.

Building Information Modelling and the Quantity Surveyor

The survey found that the quantification process was where the QS would feel the largest impact when working under a BIM platform. The process of measurement from drawings, whether by hand, working with printed drawings and a scale rule, or on-screen measurement using computer software, would evolve further. Quantities can be automatically generated from the model which according to those interviewed served to make the QS role more efficient as they could spend more time gathering best rates and ensuring good value for the client. In addition to automatically generating quantities accurately, one of the participants also noted that from their experience the model would also highlight any items that have not been quantified, enabling the QS to pick up on those items and quantify if necessary. As a result of the model automatically generating the quantities, when negotiating costs, the scope for dispute should also drastically reduce. The time saved on measurement of quantities and the common disputes that occur over this subject can be used more effectively.

When working under a BIM platform it is expected that the contractor will become involved from an early stage. Several of those interviewed believe framework and partnering contracts will flourish with the development of BIM, however it can be difficult to ensure value is maintained when a contractor has been nominated. If a contractor is nominated, it means you are effectively losing your key strength to ensure you are obtaining good value; the competitive tender scenario. In order for the client to combat this issue you could employ a contractor, like you would any consultant, to provide you with advice and expertise at the pre-contract stage of a project. Following on from this you could then issue a competitive tender with the completed design to a list of contractors who would bid for the work. It was anticipated by one of the interviewees that this process would be sure to provide better value than even a bill of quantities as the design period has been extensive.

Participant number three felt the reduced design risk when going in to the construction phase would generate a more accurate and defined contract sum with a vast reduction in the amount of provisional allowances; quantities and sums. As a result of this, you would obtain an earlier, more accurate cost certainty that should be more competitive. Another participant also made a similar suggestion and linked this to the difficulties developers are now experiencing when attempting to obtain funding through a third party. By submitting a more accurate cost appraisal to the client based upon the more detailed and accurate design, the project is more likely to go ahead.

Threat or an Opportunity for the Quantity Surveyor

As the subject of fee levels is likely to be at the forefront of most Quantity Surveying organisations, it was asked of the interviewees how they feel BIM will impact upon the fee level of a Quantity Surveyor and whether BIM should be seen as an opportunity, or a threat. Generally, all of the participants see BIM as an opportunity, rather than a threat, however, some did state that the threat may become apparent if the BIM process is ignored. This response was as expected due to this being a common theme across the literature review. With the expectation that BIM is going to go from strength to strength you must be prepared to adapt to whatever BIM has to offer your organisation otherwise you could be left behind your competitors.

Whilst it was anticipated by some of those interviewed that BIM should reduce QS fees over time, this was based upon the expectation that efficiencies in the quantification process would be found. Other participants suggested that it is imperative you adapt your service delivery to focus on services you can offer the client that are extra over the traditional skills identified within the literature review. If the fee levels you agree with your respective clients reduce, but the time you spend working on the unchanged service delivery also reduces, this is due to improved efficiency and time saved. If you refuse to adjust your service delivery however and do not accommodate BIM, then this is where the threat may appear should others around you embrace the process. In addition to this, one of the participants interviewed considered the impact of other consultants absorbing the role of the QS in to their own service delivery. Whilst this rightfully is a threat to the role, this is where you must stand your ground and make clear to your client what your service delivery includes and emphasise that the QS role is not just to quantify construction works.

CONCLUSIONS

Some explain the reasons behind the underperforming construction industry as a result of people looking out for themselves before others or the project at hand, whilst others see poor communication as the predominant reason. A clear outcome of the research was the need for change in the industry to improve efficiency; however, the most suitable method of achieving this was less apparent. The UK Government has recognised the requirement to improve efficiency and has identified Building Information Modelling as a key way of implementing this.

Taking in to account all of the information gathered it appears that the theory of BIM is common knowledge among construction professionals. Defined as not just a model, but a process of integrating digital data from a number of parties, BIM is said to be a process that is improving collaboration and communication to achieve the common goal. Improved efficiency in the programming and sequencing of the works, along with a reduction in the level of risk going in to the construction phase are key advantages that have been noted, although some are still apprehensive. The level of return on the early investment required to implement BIM is continually a point in discussion as this is very difficult to verify.

The traditional activities of the Quantity Surveyor that were found within the literature now appear to be out dated, showing how the QS role has developed in recent years. Analysis of the primary research gathered found that the role of the QS had evolved over time, even before the implementation of Building Information Modelling. With an emphasis on cost analysis, all of those interviewed stated that their role had altered over the years; a role that has further advanced to include value, risk and lifecycle analysis. Some of those interviewed went on to describe how the role of the QS has become somewhat blurred, and stressed the necessity to give a detailed service delivery to your clients.

The tools in use by the QS, in order to fulfil their role have evolved in a similar fashion. Whilst traditionally, the key implements in use were the scale rule and the calculator, the development of measurement and computer software has been considerable. All of those interviewed considered computer software as an essential tool today. The efficiencies the software available has to offer made these computer programs appealing to not only the individual and the organisation, but also, the client.

The general efficiency improvements were described by the Quantity Surveyors that had worked under a 'level 2' BIM platform as an excellent way of adapting the service offering to give a better delivery to the client. The QS would save time on the pre-contract quantification of the works and the negotiation process when coming to an agreement on the contract sum. None of those interviewed believed that this change in delivery would diminish the role of the QS, but an improvement to an inefficient process that has been needed for years. The research found that a Quantity Surveyors time was better invested in gathering best rates and ensuring good value for the client. Due to the improved design it was suggested that the level of risk by way of provisional items; quantities and sums, going in to the construction phase of the project, was far lower than it would be when working under a traditional platform. Items that previously could not be measured due to limitations in detail can now be measured far more easily. This will stop the requirement for the QS to expand descriptions to include for additional items that cannot be measured in line with the RICS 'New Rules of Measurement'.

When working under a BIM platform, it was noted that the tender and procurement process is generally different from the traditional route. Nominating a contractor and adopting the cost-plus pricing method was prevalent under a BIM platform, however, the traditional competitive tender scenario can still be implemented. A contractor can be employed like any other consultant to give advice, but the QS can still tender to other contractors for the works at any stage of the design.

It has been determined that BIM should not be seen as a threat to the role of the QS, but more an opportunity to improve efficiency. Whilst it was said that other professionals could attempt to absorb the role of the QS, this would only be acceptable to an inexperienced client that did not fully understand their role. The UK Government's intention to require BIM on all of its projects by 2016 is a target that will be difficult to achieve but is highly unlikely to impact Quantity Surveyors on an industry wide scale in the near future. Those Quantity Surveyors that are not currently working with BIM processes may not feel any impacts for potentially, years to come, or they may never will. It is important however, for all Quantity Surveyors to be prepared and ready to take on board any changes the industry has to offer; otherwise they may be left behind their competitors.

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THE ROLE OF COMMUNITY ENTERPRISE WOOD-FUEL LOTS FOR DOMESTIC FUEL TO SUPPORT HEATHLAND MANAGEMENT

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In recent decades, there has been an upsurge in the use of domestic, wood-burning stoves in England. Consequently, there has been a growing demand for supplies of low-cost fuelwood and this is a separate and distinctive market from that of the big biofuel power stations and other burners. Supplying this demand without damage to valuable and vulnerable habitats such as ancient woodlands is problematic, and unofficial 'harvesting' theft is on the rise. However, there is an alternative approach that is widely adopted in continental Europe and in North America, but which has yet to be applied in Britain. Management of lowland and low-lying heaths around upland moors has been problematic for some decades and the situation is now acute (Webb, 1986; Rotherham, 2009). A basic, fundamental issue is that like similar habitat-types elsewhere around the world, these areas have become separated from their traditional uses and from the economic drivers that helped create them, a process known as 'cultural severance' (Rotherham, 2008, 2011c). Now, with eutrophication, successional change and difficulty in achieving long-term, reliable conservation grazing, many sites are under threat. Ideas of how to re-connect sites to communities and economic function and to address the problems noted must surely be welcomed. This paper suggests the approach applied to North American and continental European wood-fuel lots could provide a mechanism to achieve ecological, economic and community objectives.

Keywords: Wood, Biofuel, Sustainability, Management

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INTRODUCTION: HUMAN UTILISATION AND THE CULTURAL LANDSCAPE

The decline of British lowland heath occurred dramatically during the eighteenth and nineteenth centuries facilitated by parliamentary enclosure (Webb, 1986; Gimingham, 1972; Rackham, 1986). From 1919 to the 1980s, the abandonment of traditional land management practices was compounded by Forestry Commission policy of planting large areas with trees in triggering massive heathland decline. A major part of this change was a breakdown of long-established traditions of site management. A challenge for conservation in the twenty-first century, is to re-connect communities, economies and nature at the local level. A particular example and one with its wildlife now in crisis, is that of lowland heaths and contemporary or former commonlands. Once a cornerstone of local subsistence and economy, these sites are now mostly destroyed and what remains is mostly tragically abandoned and derelict (Rotherham, 2011a; 2009). Some steps have been taken to graze areas with rare breeds of traditional cattle, and even to strip turf to reduce eutrophication. However, a serious problem with almost all these approaches is that they require significant inputs of grant aid and they are unsustainable without it. At its core, the problem is the abandonment of long-term community use of natural resources which, over centuries, created the landscape and its ecology that we now seek to conserve. Some of the grazing impacts can also be highly detrimental when applied wrongly, in terms of timing, to small sites.

Traditional cultural utilisation, whilst not always sustainable, has generated and driven many of the landscapes we now value so highly (Rotherham, 2008). Furthermore and presently neglected in many debates on conservation and the environment, a massive proportion of our most highly valued ecology and biodiversity depended on traditional uses. The reasons and mechanisms are complex and range from direct environmental impacts (like lowered nutrient levels and micro-disturbance), to indirect effects through social and economic impacts (allowing people to remain and live on the land or in a particular region). Consequently, these long-term intimate relationships between people and nature have created complex landscapes and often rich, distinctive ecologies. Many of these evolved through stable, predictable patterns of human utilisation, with biodiversity consequently adapting and evolving. A direct result of these processes is the heritage of biodiversity and landscapes that we inherit today.

So what is 'Cultural Severance'?

We define '*cultural severance*' as the breakdown of the fundamental relations between human communities and their local environment as manifested in the landscape and its ecology as an eco-cultural resource (Rotherham, 2008, 2011a). As noted above, this may be a social and community phenomenon as well as operating at the stratum of the individual and their perceptions. It has elements that are inherently practical in nature but is also strongly psychological at every level. This separation of people and nature has occurred at evolved at various times, in different places and at rates, which vary from dramatically quick and sudden, to relatively slow and drawn out. A key process is the break in local community '*ownership*' and use of the natural resource and the imposition of essentially individual capital-based value and exploitation.

Inevitable Change

Progress in the modern economy generally equates to socio-economic development with rural depopulation and urban growth. There is technological provision of needs, and a separation of people from nature. This process is an on-going part of human cultural evolution, but it has major environmental consequences. In terms of the severance of people and landscape, there has been a rapid de-coupling of communities from their local environment. There are consequences of the cessation of traditional land uses. For individual sites, these can be especially problematic:

- Eutrophication due to non-removal of biomass (for fuel, animal bedding, fodder),
- Lack of micro-disturbance from grazing or other working animals, and from subsistence activities (including transhumance use *etc*),
- Lack of propagule dispersal, particularly seeds through grazing stock moving from site to site,
- Successional change due to abandonment (the rate varying with the landscape and its location, so upland zones in the UK for example are more resilient than lowland one),
- Decreased value for local communities and abandonment or replacement by other uses (building development *etc*),
- Fragmentation and isolation,
- Displacement of native species by exotics.

One consequence of severance is changed land management, such as woodland or heath having lost their social and economic function, being converted to farmland. All the associated species are consequently lost. Alternatively, the traditional management may cease or change radically, but the site remains physically intact (Rotherham, 2008, 2011a). A heath, once central to the local economy, if its function and value to local people is lost is often grubbed up, '*improved*' and so destroyed. Sometimes it might remain physically intact but abandoned to trigger a successional change to birch wood and a gradual loss of open heathland species, or planted with exotic conifers. On the other hand, heath or similar commonland may be maintained as open grazing but without its traditional management such as harvesting gorse, bracken, ling and small wood for fuel, cutting wood for construction, bracken for bedding, or turf for fuel or roofing, holly, bramble, and gorse as fodder, and grass meadows cut for hay. The ecology is changed and a major successional shift occurs with the site nutrient enriched and low, open vegetation replaced by taller more rank species. Rich ecological mosaics are converted to a few distinct landscape areas with limited diversity and stress tolerant species are generally lost.

Moors, Heaths & Commons

Britain's medieval woods, heaths, commons, and bogs supplied most people with fuel, food, and building materials (Rotherham & Bradley (eds), 2011). A major problem for what are generally plagio-climax communities is the abandonment of the drivers that led to their formation and their maintenance, together with fragmentation and isolation of the remaining areas. Until around 1700 through until the late 1800s, moors, heaths, bogs, fens, and commons were the distinctive open landscapes of all parts of England. Many sites probably included extensive, managed, wooded commons (Rackham,1986). At the end of the Parliamentary enclosures, they were reduced in area dramatically to a few lowland groupings of intractable heathland such as the Lizard in Cornwall or the New Forest and Dorset heaths. Extensive upland moors proved resilient to improvement except drainage and some liming, but were now separated spatially and economically from the remaining lowland heaths. However, even in the uplands, traditional functions were abandoned for economically driven sheep grazing and intensive grouse farming.

Woodland encroachment has a great impact on declining heaths, with up to a 60% increase in tree cover recorded across a single site in the late 1900s. Trees shade out the heather and reduce other light demanding species so grasses increase (up to 80% cover under birch woodlands). Overall species diversity decreases rapidly. Birch causes significant encroachment on heathlands due to its high seed production, the light seed allowing wide dispersal on to heathlands by wind (Newton *et al.*, 2009; Bullock & Pakeman, 1996).

Figure 1. Overgrown heath with colonising birch (source: Rotherham)

The End of Tradition

Community harvesting of materials, especially fuel was a key factor in the creation and maintenance of heaths. The dramatic ending of such usage has caused massive problems from loss of sites severed from their subsistence or economic functions, and due to abandonment of those heaths and commons that remain. In the Sheffield area between 1850 and 1890, there was an estimated loss of around 20 km^2 of lower-lying heath, largely through enclosure and conversion. This was from a study area of about 385 km^2. Parry (1977) noted a significant reversion between 1900 and 1935, but found 6,050 ha of Peak District heathland lost between 1870 and 1977.

The Consequences of Severance and Abandonment

Heathland loss and / or abandonment lead to dramatic declines in many typical wildlife species of these habitats. The examples below serve to illustrate the point.

Species declines:

Heathland and grassland birds: Skylark (*Alauda arvensis*), Woodlark (*Lulluala arborea*), Nightjar (*Caprimulgus europaeus*), Cuckoo (*Cuculus canorus*), Red-backed Shrike (*Lanius collurio*), Black Grouse (*Tetrao tetrix*), Stone-curlew (*Burhinus oedicnemus*), & Great Bustard (*Otis tarda*).

Heathland and grassland invertebrates: losses of many species such as Dark Green Fritillary (*Argynnis aglaja*), High Brown Fritillary (*Argynnis adippe*), Large Blue (*Maculinea arion*), Adonis Blue (*Lysandra bellargus*), Chalkhill Blue (*Lysandra coridon*), Glow-worm (*Lampyris noctiluca*), Orb-web spider (*Araneus quadratus*), and Silver-spotted Skipper (*Hesperia comma*), though direct habitat loss and also through successional change following abandonment.

Heathland and grassland flora: specific losses such as Pasque Flower (*Pulsatilla vulgaris*) & Dodder (*Cuscuta epithymum*) but removal of entire flora from most of the lowland landscape and desiccation and degradation of upland areas too.

Heathland and grassland herptiles: Adder (*Vipera berus*), Smooth Snake (*Coronella austriaca)*, Common Lizard (*Lacerta vivipera*), Sand Lizard (*Lacerta agilis*); massive declines of amphibians too.

At the same time as species losses on abandoned heaths, in the absence of traditional management and in the face of increasing biomass and nutrient levels, other species spread aggressively.

Species increases:

Bracken (*Pteridium aquilinum*): across moors, heaths and grasslands as a cultural artefact of changes in management

Birch (*Betula pendula* & *B. pubescens*): massive spread over heaths and moorland fringe because of abandonment of traditional management

Figure 2: Overgrown heath with dense, colonising birch (source:Rotherham)

Encroachment by exotic pines is increasingly problematic but is less so than birch. Additionally, senior officers in some conservation organisations report being pressured to accept grant-aided tree planting on some sites which increases the problem. Site nutrient levels, biomass and pH all increase and conservation target species and typical heathland biodiversity decline. This dramatic reduction in ecological quality is just one part of a wider problem of cultural severance as traditional and customary uses of the landscape have largely ended. These factors in Britain are summarised in Table 1.

The loss or abandonment of lowland and low-lying heaths is one of the most dramatic examples of such catastrophic changes (Rotherham, 2008, 2009, 2011a & b). Yet far too often, when conservationists and ecologists discuss landscapes and nature, they seem to overlook a most basic and deeply embedded aspect of the '*natural*' environment. It is not '*natural*' but '*semi-natural*', an '*eco-cultural*' resource. Within these landscapes, there are often strong links back to a more primeval ecology but also forwards through long time-periods of continuity and predictability. Importantly, the human and natural processes in traditionally managed landscapes centred on micro-disturbance rather than macro-disturbance, on the effective recycling of nutrients within ecosystems, and the extraction of biomass from systems. The ecological habitats produced tend to be predictable, have a strong degree of continuity through time, and are mesotrophic or oligotrophic rather than eutrophic. Human cultural utilisation has often relied on careful management of recycled nutrients sustainably within the system. When this failed, as it sometimes did, the results were catastrophic. Overall, human usage reduced biomass and macronutrients, especially nitrogen, were at a premium. Severance quickly reveres these trends to generate macro-disturbance, major disruption and unpredictability, lack of continuity, and massive eutrophication especially by nitrogen. This favours competitive species and cosmopolitan ones including some ruderals, over stress tolerators and ruderals associated with traditional regular management.

Habitat or aspect	**Status**
Lowland heaths and commons	Many of these have now been lost
Neglect of common and lowland heath	The so-called 'wild fires' which are so damaging on heaths in Dorset and Hampshire or in reality a direct consequence of cultural severance and the build-up of biomass, both living and dead. Former gorse heaths harvested and managed for fuel become overgrown and when they burn it is catastrophic
Loss of lowland wet fens, raised bogs, marshes and wet wood	These have almost entirely been destroyed
Upland moors and bogs	Most upland moors and bogs are drained
Ecological quality, biodiveristy	The collapse of populations of most butterflies, many farmland birds, bats, reptiles and amphibians and more. The extinctions of huge numbers of flowering plants and ferns in many regions
Ancient habitats and traditional management techniques	The removal of most medieval parks and their veteran trees The loss of most ancient unimproved pastures and meadows The cessation of traditional coppice management of woods and the loss of about half the ancient woods in the last fifty years
Disconnection between countryside management and community engagement	Creeping urbanisation or gentrification of much of the countryside – the 'greying of the green' The severance of people's contact with nature to a point where many can no longer recognise or identify even commonplace species
Managing the balance of species	A comprehensive failure to address the wider issues of decline beyond the cosmetic or the desperate – and no wider evidence of any recovery by key indicator species or groups of species Massive spread of invasive species and especially of invasive exotic or alien species

Table 1: Summary of the factors leading to a reduction in ecological quality as part of the wider problem of cultural severance

An effect of cultural severance on these traditionally managed or utilised landscapes is that when they lose economic and local utilitarian value, they may be destroyed by conversion to other uses. These are often disputed territories with competing social and political actors. The ecological consequences of this severance and the ending of social and economic utility is often the complete collapse of the system and / or its transformation to other, often agri-industrial or urban-industrial uses. Oliver Rackham made the point very strongly in his seminal book *The History of the* Countryside (Rackham, 1986; Rotherham, 2011b), when he argued that an ancient wood generally survived in England as long as it had economic value. The same applies not merely to the physicality of the woodland, but also to its traditional management. Lose either or both and the site will be lost and its land-use converted to some other function. This same line of logic is pertinent to all other traditionally managed landscapes too but I develop this argument further to include not just economic value but the social and cultural values too. So a woodland or heath may survive today and be valued highly and so protected, but for its leisure and amenity or nature conservation functions. Whilst this modern cultural attachment to a site and its functions may protect it from destruction and even provide a modicum of management, it is still separated from its traditional origins and vulnerable to a slow decline through ecological succession.

Reconnecting People and Their Heaths

The UK BAP (UK Biodiversity Action Plan)identifies the need to restore 58,000 ha of heathland, but the delivery of this outside a few key lowland areas remains elusive. A long-term study of the South Pennines, Peak District and Sheffield area, suggests that the problems of severance are leading to major, long-term declines (Rotherham, 2009, 2011a & b). Furthermore, the short-term and generally modest interventions of grant-aided conservation projects are inadequate to halt the losses. In some southern lowland heaths, the conservation stripping of turf is used to remove biomass and to end successional decline. Whilst this can be effective for ecology, it relies on the site being free of larger stones or boulders, and the operations may seriously damage archaeological features. However, whilst biofuel extraction can be immensely damaging to ancient woods, for re-grown birch infestation of a heath, there is great potential for fuelwood extraction. Remarkably, this source of possible biofuel is overlooked in regional energy strategies. Clearly, the use of heavy plant and big machines for commercial extraction would be inappropriate. However, we suggest that small-scale, community-based or Third Sector enterprises could provide a novel solution which might be an attractive proposition. From a conservation perspective, the approach could provide a long-term, economically viable way to address otherwise intractable heathland decline. The birch could be managed on a cycle of re-growth and coppice to produce firewood for local consumption. This was first suggested back in the 1980s, the heaths around the South Pennine and Peak District fringes. However, bureaucracy prevailed and no action was taken. Conservation volunteers and countryside management staff supported by grant aid have cleared small areas of encroaching birch, but this is not enough and it is not sustainable.

Figure 3: RSPB Nature Reserve - Old Moor Farm visitor centre with a wood-chip heater. (source:Rotherham)

Clearly, if tree felling and coppicing work is to be undertaken, there might be issues of health and safety and of appropriate skills and training if the lead is community-based (Countryside Commission, 1992). However, these same issues have been addressed and overcome for community woodlands, and the necessary expertise and training are available (Titterton, 2012). Furthermore, a conservation business or a

Third Sector enterprise could provide skills, training, insurance and a business strategy / plan. With harvested wood marketed for fuelwood, as either wood pellets for biofuel boilers, or firewood for domestic burners, there is a substantial demand for the product. Produced and sold locally this could deliver sustainable heathland landscapes, and environmentally friendly local energy. Fuelwood pellets could be used for heating schools and other community buildings. Furthermore, a summertime market for locally produced charcoal would give a year-round income-stream.

A major problem with current management strategies is the limited and unpredictable nature of grant-aid, and this is likely to get worse. Research suggests that for viability a woodland site needs to be at least two ha in area to be economically sustainable. However, it seems to the authors that the heathland birchwoods easily fulfil these requirements and start-up or training support would be easy to generate from the usual funding sources. Groups might have fee-paying members with fuel-lot allocations on community-owned lands, or else licenses issued by landowners such as local authorities on other sites. Models exist for woodland fuel-lots in both continental Europe and in the United States of America, and the same approach could be taken in England for heathland birchwoods. Community woodland projects easily make £1,000 to £5,000 per annum (Community Woodland Association, 2012) from a woodland fuel project on a small site. With fuelwood process rising quickly as electricity and gas become more expensive, financial savings on fuel bills offset the modest profits for participants.

Importantly the marketing of the process and the product of these community woodland heaths would stress the conservation and community friendly nature of the product. Sites in management would not be cleared of trees but managed as a sustainable cyclical system as heaths have been managed for centuries. This would help to stop the encroachment of woodland at the long-term expense of the heathland ecology. A variety of silvicultural regimes might be applied:

- Clear cut system
- Shelterwood system
- Continuous cover forestry system
- Coppice system
- Patch cut system
- Seed tree cut system

REGIONAL CASE STUDY

A preliminary, regional case study was undertaken around the Sheffield Peak District, the South Pennine and Peak District fringe (Titterton, 2012; Rotherham, & Titterton, 2013). This is a study region, which has been subject to on-going research for nearly thirty years. A number of low-lying heathland sites suffering birch encroachment were identified. From these sites, five were selected for intensive study. The idea was that by applying community woodland principles, invasive birch woodlands on heathlands could provide substantial wood harvest from individual sites. Two study locations, Owler Bar and Fox Hagg at Lodge Moor in the Peak District for example, could sustainably produce 367 and 262 cubic metres respectively of wood per year.

Ideas into Practice - The Case Study of the South Pennine and Peak District Fringes

We have investigated five local sites in detail.

- Fox House, 19.9 hectares SK 252 802
- Holbrook Heath 11.2 hectares SK 444 811
- Fox Hagg, Lodge Moor 20.2 hectares SK 278 871
- Loxley and Wadsley Common 49.8 hectares SK 312 906
- Owler Bar 17.6 hectares SK 287 767

Four of these are upland moorland fringe and the other is a lowland post-industrial heath for contrast. The field and archival research undertaken in 2012, sought to establish the scale of birch invasion and the transformation of the heaths. Furthermore, the fieldwork provided an evidence base for the effects of birch invasion on the heathland flora and hence the fauna. Additionally, the studies assessed the amount of standing '*timber*' available from selected sub-sites and the amount which could be harvested as '*wood*' on a sustainable annual basis.

In addition, all the sub-sites have suffered major birch incursion and heath decline over the past fifty years. The biggest site-specific decline occurred between the 1980s and 1990s, two out of four sites experienced dramatic loss of heathland nature (Owler Bar 19.3% reduction and Fox House 29.1% reduction). Furthermore, the time-sliced landscape surveys indicated a rapidly increasing rate of decline with the most severe losses between 1980 and 2012. Over the study period, the sub-sites all exhibited major transformation of heath to secondary birchwood. The lowland site at Holbrook Heath Nature Reserve had almost 100% loss in the sub-site that was surveyed. The upland fringe area at Owler Bar in the Peak District was the least affected with a heathland decline of 44%, and overall the upland fringe sample sites had declines of from around 40% to 90%. The ecological consequences of these successional changes are immediately shading, eutrophication and increased biomass. Biodiversity plummets and typical or characteristic species of heathland environments are lost. Suffering cultural severance and biomass increase, the flammability of sites increases and on dry sites and in dry summers, many succumb to devastating wildfires. With increased biomass, the burn temperatures are high and massive damage to the ecosystem results. A potential solution needs to address all of these issues. It is important to re-connect people to their common heaths, to reduce biomass and nutrient levels, to open up habitats to sunlight and to limit fire risk.

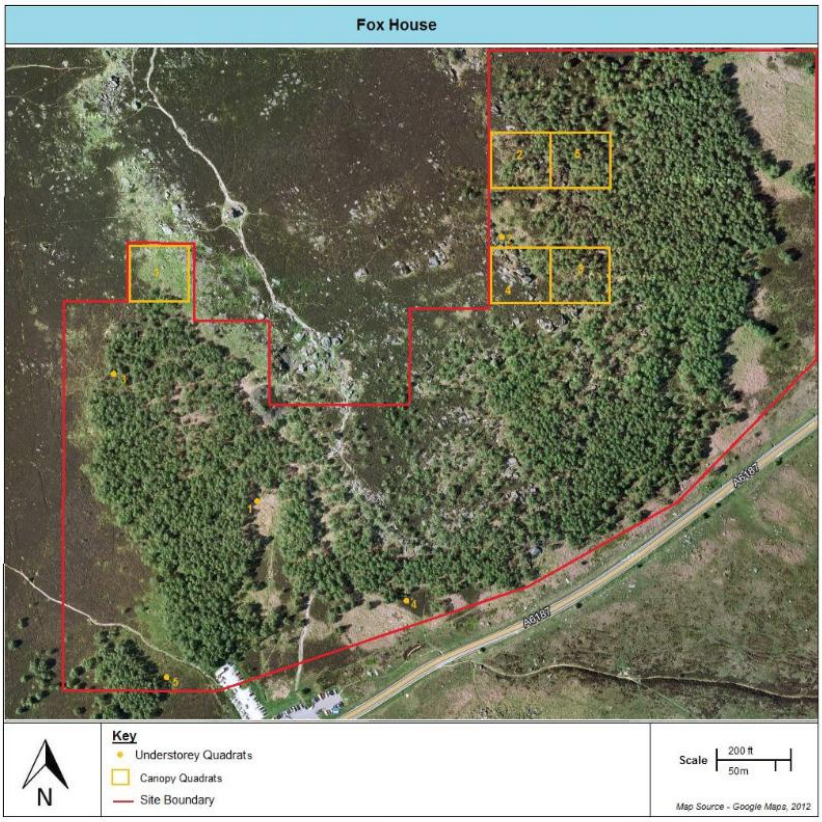

Figure 4. Sample plots at Fox House study site

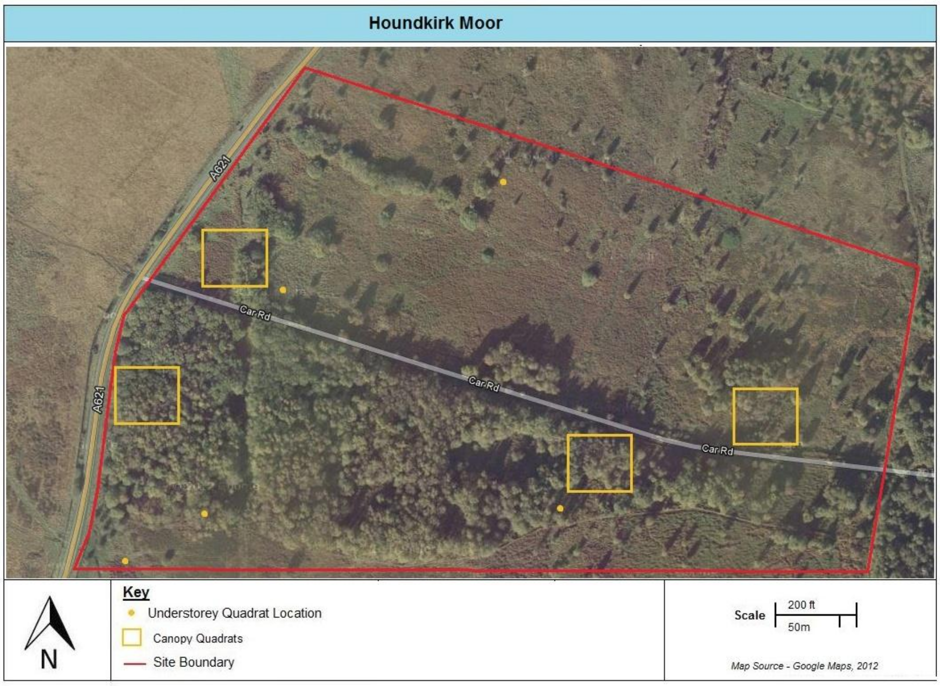

Figure 5. Sample plots at Owler Bar study site

In order to consider the financial viability of a fuelwood enterprise, we calculated the standing crop of timber (wood) within the case study sub-sites. The sample sub-sites ranged from 500 x 500 m for Owler Bar to 200 x 300 m for Holbrook. However, these are parts of much larger complexes with, in some cases, several times the harvestable area nearby.

- **Owler Bar:** standing crop 15,042 cubic metres, 367 cubic metres per year
- **Loxley & Wadsley Common:** standing crop 7,737 cubic metres, 63 cubic metres per year
- **Fox House:** standing crop 1,494 cubic metres, 65 cubic metres per year
- **Fox Hagg, Lodge Moor:** standing crop 10,986 cubic metres, 262 cubic metres per year
- **Holbrook Heath:** standing crop 185 cubic metres, 5 cubic metres per year

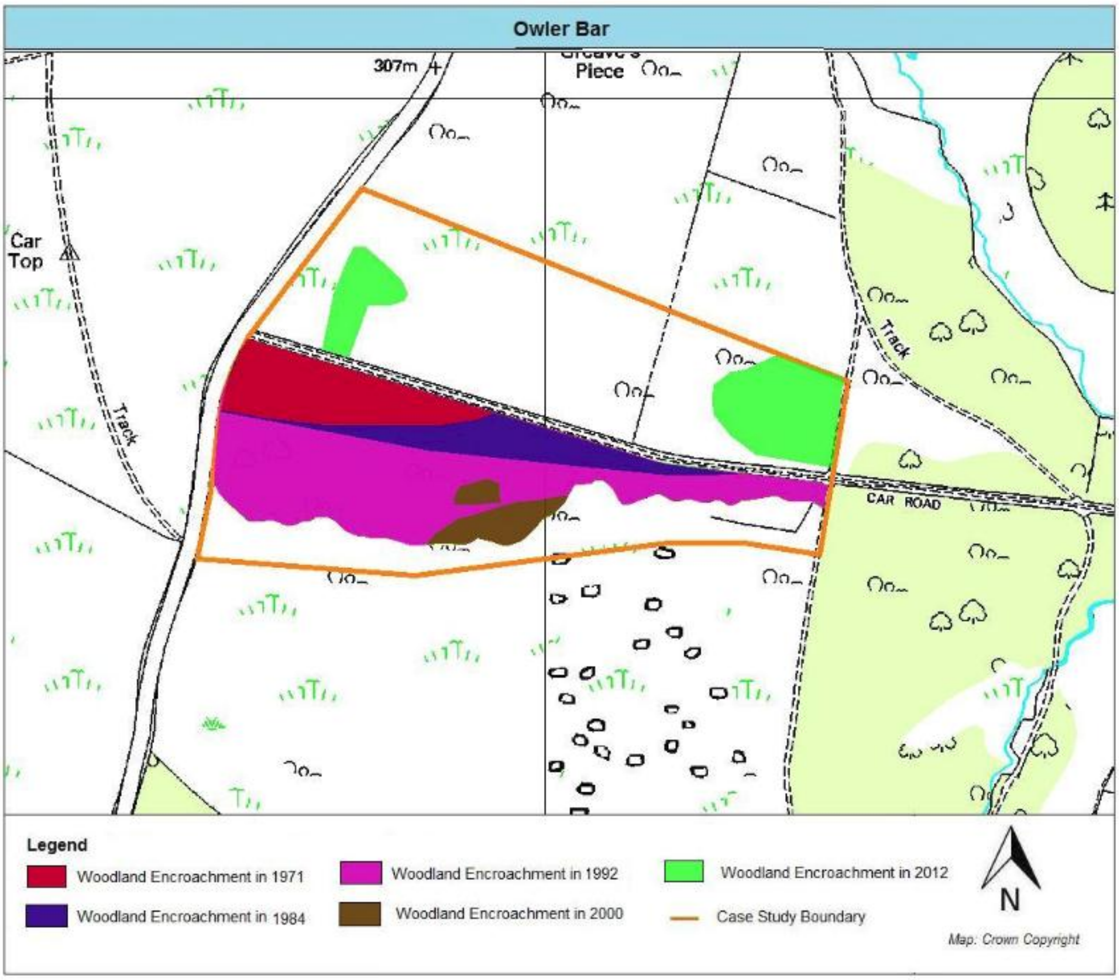

Figure 6. Scrub and woodland encroachment over time at the Owler Bar study site

If we assume a price of between £30 and £50 per cubic metre for firewood (Coed Cymru, 2013), then some quick calculations suggest that the Owler Bar sample site, for example, might generate a sustainable harvest worth £14,680 per year from 17.8

hectares of birch wood and Fox Hagg, £10,480 from 20.2 hectares. These figures are entirely tentative and there would be costs in extraction and processing. Birch wood is not a premium product and its value may be lower. However, if we add the potential of harvesting wood to make charcoal as an '*added value*' product too, then the possibility of a number of heathland sub-sites managed as a rotational crop suddenly seemed a reality. Cutting and processing by hand with chains, and extraction with low impact vehicles would allow an economically driven nature conservation output that engaged locally based community entrepreneurs.

For the case study region and sites, these issues have been recognised for a considerable time (Rotherham, 1995), and there have been some modest successes on isolated, individual sites. However, there is presently no sign of any joined-up, long-term, economically viable approach to resolving the problems. Indeed, by comparison with wider issues of moorland management, or peat bog restoration, these lowland heath sites are conservation Cinderellas. In the face of current austerity measures, approaches such as this might provide a mechanism for effective conservation management to move forward. Grant aid would be a bonus and through associated education projects, we could sell both the product and the process. Importantly, and differing from many industrial biomass projects, if implemented, this approach could begin to re-connect people to nature as a resource. The present neglect of this domestic fuelwood resource is perplexing and perhaps indicates a different relationship between natural resources in England and for example continental Europe of North America. In Sweden, many households own fuel lots in the forest and spend holidays in the summertime cutting and preparing their fuel. In England, the high human population combined with limited land areas, make community fuel harvested problematic. However, the re-establishment of local commons and common usage on heaths would solve many intractable difficulties for conservation. Above all, this approach would re-connect people with nature and thus help to ensure the survival of these important landscapes. If left to decline through severance and ecological successions, the future for many, if not most, of these sites remains bleak.

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