USING LOCATION AWARENESS TECHNOLOGIES FOR INNOVATIVE CONSTRUCTION MANAGEMENT IN URBAN CENTRES: STUDY OF THE CBD, CAPE TOWN, SA

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The continued growth of inner city construction coupled with the mounting costs of land in the urban centres puts pressure on inner city construction management. The complex nature of construction in urban centres requires innovative methods for site management. Confined space, congested access and the proximity of an over crowed public place pose challenges when it comes to inner city construction. Many construction firms in South Africa tend not to be innovative or dynamic when it comes to improving building production processes. This is problematic as the success of building construction in urban centres hinges upon the ability of the construction firm to be strategic, which is to know better than others, what direction to go in, what risks to take, the available resources, and what capabilities need to be developed in order to fulfil a planned goal. Using the latest remote sensing technologies to provide real-time access to the location of materials, equipment and workers on a congested construction site could significantly improve the construction process. The confined characteristic of construction sites in urban centres makes location awareness critical. Location awareness technologies (LAT) can improve manual processes and support important decision-making tasks in the field. This paper investigates the competitiveness and innovation of construction firms operating in an urban centre within the Cape Town Metropolis, South Africa and whether construction companies find LAT and geospatial data useful for construction management on confined sites. A sample will be gathered from project managers, registered building contractors as well as building consultants and private owners in the CBD of Cape Town using structured interviews and questionnaire. Empirical evidence shows that the use of automation and integration technologies improves construction productivity and exhibits tight integration of data.

1.0 INTRODUCTION

The importance of being innovative in managing building construction projects in urban centres is vital considering the growth and cost of real-estate in city centres all over the world. The complex nature of construction in urban centres requires disciplined methods of site management. Confined space, congested access and the proximity of an over crowed public pose challenges when it comes to inner city construction. Many construction firms in South Africa tend not to be innovative or dynamic when it comes to improving building production processes. This research investigates innovative practices for the effective management of building production processes within urban centres. Although innovative practice differs from one project to another it is speculated that there are some features in innovative practice that are common. In the last decade there has been a surge of urban development throughout the world. People are moving to urban areas for better opportunities resulting in rapid urban growth that is exceeding rural settlement (Spillane et al, 2011:138). All cities are different and have their own 'personality'. Thus a response to the urban development challenges of any city must take into account its singular configurations of natural and socio-political factors, as well as its historical past and traditions.

This research problem was identified on the basis that generally construction firms appear to be lagging behind in the use of innovative technology that could help improve construction management processes in urban centres. Numerous opportunities exist for utilising remote sensing and LAT that will subsequently generate additional information and knowledge. Furthermore, untapped tacit knowledge can now be effectively managed using web applications which allow people to add, modify, or delete content in collaboration with others. The harnessing of tacit knowledge can improve production in the future. Due to advancements in technology and fluctuation in the world economy, changes in work ethics and the way work is organised must be acknowledged. Knowledge management is considered vital for the survival of organisations and is becoming a key resource in construction management. The construction industry in South Africa is central to the economy yet civil and building construction has low productivity and poor performance. Hence there is a need for innovative practices for effective management of building production processes within urban centres. New solutions are necessary to meet the demands of the economy, conditions in urban centres and new types of buildings and structures (Tobin and Magenuka, 2006:3). The objective of this study is to gain an understanding of the status of the use of technologies by construction firms when building in dense urban areas. The techniques and technologies used for managing projects in congested sites in urban centres are investigated. This knowledge is of benefit to all project managers and others.

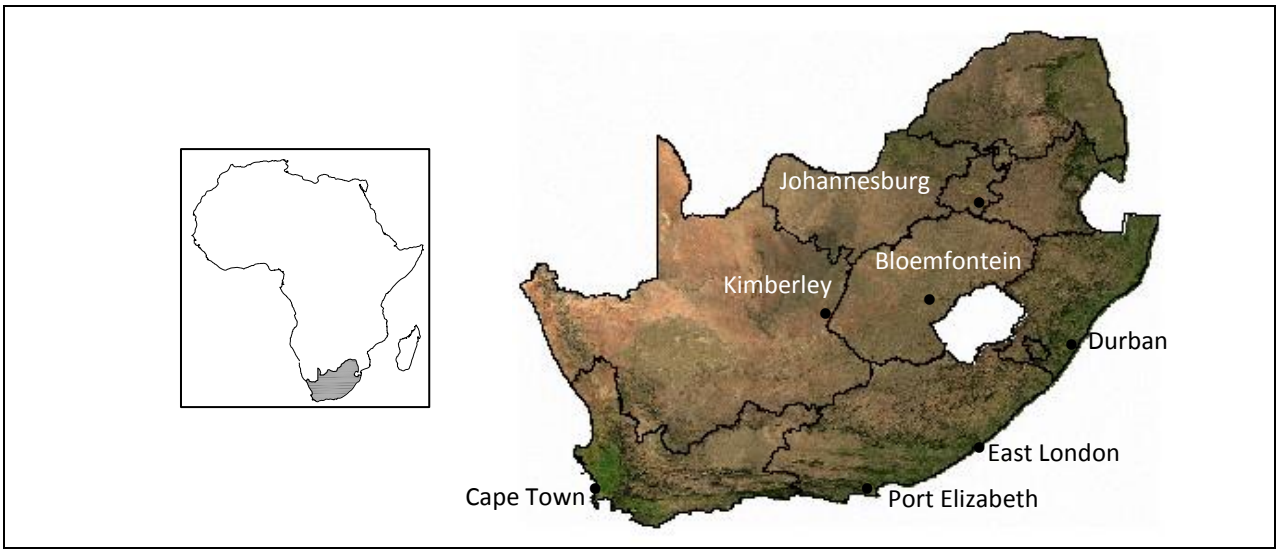

Figure 1: Location of Cape Town Metropole

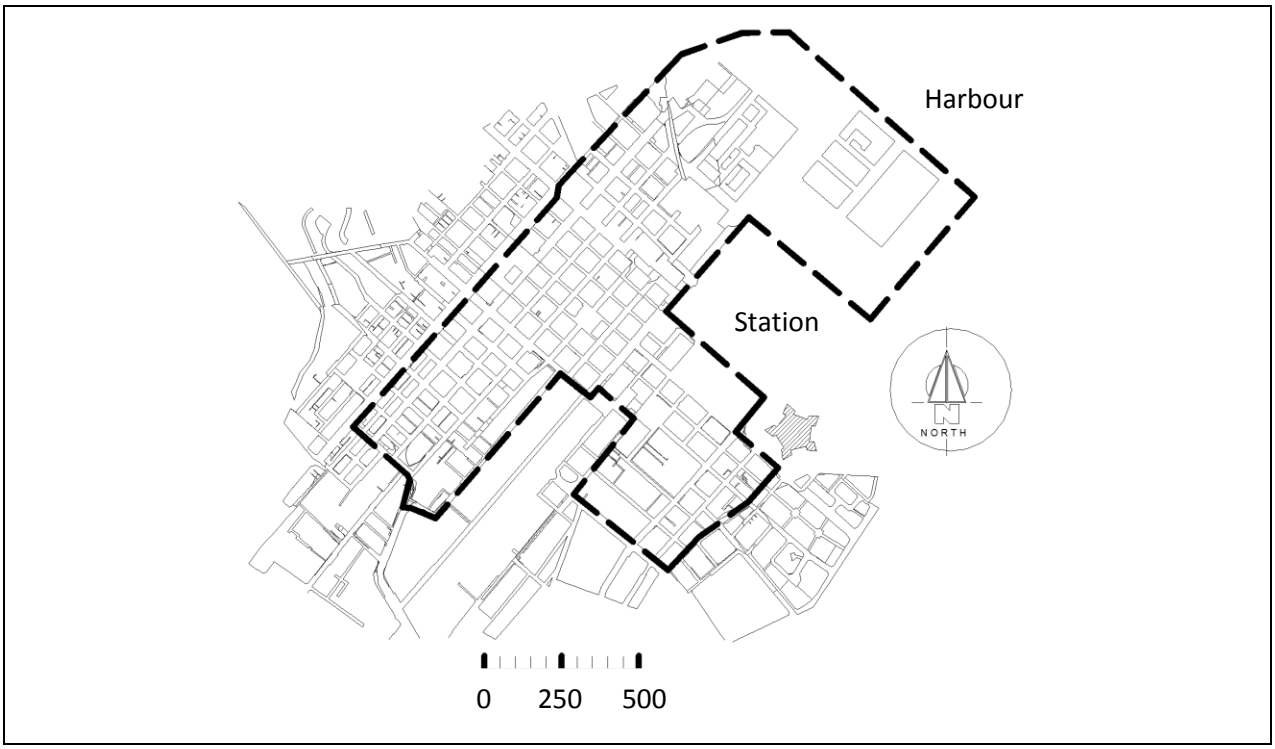

Figure 2: Cape Town Central Business District

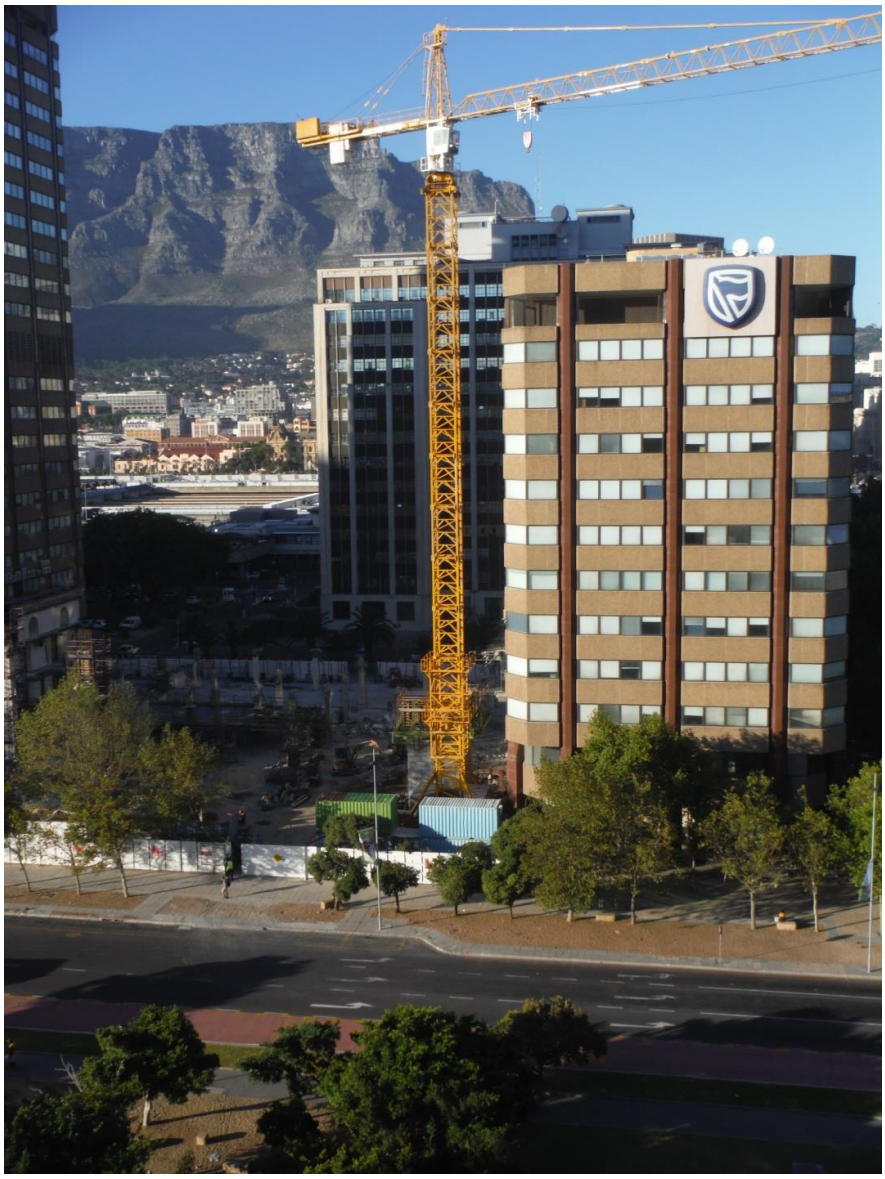

Figure 3: Cape Town Urban Centre - Standard Bank Building

1.1 DEVELOPMENT OF SOUTH AFRICAN CITIES

The City of Cape Town is located in the south west corner of South Africa in the Western Cape (Figure 1) and covers an area of 2 479 km^2 (SA, 2006). Cape Town CBD is historically located adjoining the harbour and is connected to the city and transport links (Figure 2). Urban development in Cape Town began in 1861 with the advent of trains. In the 1950s and 1960s the inner city neighbourhoods of Cape Town become dilapidated as the wealthier people left the inner city to settle in newly created suburbs; this resulted in the start of the urban decay in the older residential areas within and around the CBD. The

urban centre of Cape Town is characterised by a mix of old factories, shops and houses; most of these buildings were built in the 19th century when there were no cars and most people walked to work. In the 1970s the construction of the freeway system, along with market forces, facilitated the exodus of people from the urban centre.

Cape Town is South Africa's third largest city with a population of approximately 3.7 million and a mean income slightly above the national average. Wilkinson (2004:218) classes Cape Town as a medium sized city and goes on to say that Cape Town is ethnically diverse and includes a number of foreign nationals. The urban centre has always been a cosmopolitan settlement with the seaport embracing sailors and cultures from all over the world. Cape Town is the economic powerhouse of the Western Cape Province. The areas of economic activity are business and financial institutions, retail and wholesale manufacturing. The growth of the city in the last six years can be attributed to the building of the International Convention Centre, property investment in the central business district, and an increase in the tourist industry due to the 2010 Soccer World Cup and rigorous participation in national development programs such as the Urban Renewal. The strength of the economy is its diversity, however there has been a shift towards the service sectors since 1995 (Figure 3) which is in line with global trends (SA, 2006). There is a large concentration of informal traders in the city. The urban centre has changed significantly in the past decade in line with national governments rejuvenation policy for major cities. The Cape Town Partnership, consisting of the public sector, private sector, community sector and non-government organisations was established in 1999. The CTP has a mandate to manage, promote and develop the Cape Town urban centre and to reverse the urban decay. The partnership has been instrumental in restoring basic urban management systems and has managed to retain and attract both local and foreign investors in the city. In the process of urban renewal many buildings have been renovated and restored. Property investors in the urban centre are extremely fortunate that in the Western Cape old and historic buildings are generally faster and less disruptive to renovate and thus investors can expect a quick return on their investments. Many of these old historically important, but neglected buildings have been converted from derelict commercial properties to beautifully restored residential complexes (Weekend Argus, 23 March 2003).

1.2 MANAGEMENT OF BUILDING PRODUCTION PROCESSES WITHIN URBAN CENTRES

Owing to the complicated nature of a construction project, decision-making becomes a significant but difficult process. The increasing diversity of activity within the sector means that its character is more varied than in the past. Despite these challenges the construction industry internationally has been slow to embrace the potential of innovation and the use of technology for improving building production processes (Hardie, 2010:390).

The tools and techniques specific to project management require ground-breaking ways of application. Project managers need to be made aware of the advantages in technology and the potential benefits of applying this technology to the construction process. Organisations and people that are affected by the project are referred to as stakeholders. It is important to identify the stakeholders and to understand the influence they have on a project and vice versa. Negative stakeholders must be identified as soon as possible so their issues can be mitigated/addressed at the outset of the project. It is important that negative issues be mitigated as soon as possible. Failure to do so can result in extended timelines and the delays that usually result in cost implications. Building construction in urban centres provides a host of unique characteristics that challenge a project management team. Biddy (2009) sited in Spillane et al argues that cities are not expanding, but they are being redeveloped from within, adding to the existing urban fabric. Congested site construction is rapidly becoming the norm when building construction occurs in urban environments.

Space on a construction site is a resource that must be successfully managed to ensure the availability of space requirements on site. Tommelein and Zouein (1993) and Sawacha et al. (1999) sited in Spillane et al (2011: p143) describe space management as essential for accommodating materials on site, personnel productivity and health and safety in close proximity to large plant and machinery. A well-organised site layout design becomes vital. Due to confined space more detail is needed in managing personnel. The coordination of work on site needs to be more precise. The economy of site layouts becomes critical (Elbeltagi et al., 2004; El-Rayes and Khalafallah, 2005; Sanad et al., 2008). Detailed project planning and management of resources must be stringent to ensure the health and safety of personnel. Overcrowding on site has the potential for conflict between personnel and congestion of plant and materials (Spillane et al 2011: p144). Cotton (2009) highlights the fact that when sites are congested any acceleration of the works programme will dramatically impact the health and safety on site. Furthermore, Sanad et al. (2008), emphasises that the more congested the site the more noise is generated.

An area of concern researched by Spillane et al, (2012) is labour productivity. Labour productivity is defined as the ratio between inputs and outputs. Hanna, (2008) sited in Spillane et al, 2012, defines productivity as the 'ratio between earned work hours and expended work hours'. Spillane et al, (2012) identify some factors that influence productivity of labour as over- manning, stacking of trades, insufficient materials and extended overtime. Documenting the factors which impact personnel productivity on a confined construction site will aide on-site project managers to identify the critical factors and in doing so, will assist in the implementation of mitigation counter measures to reduce or eliminate the resulting reduction in productivity on site.

1.3 ENHANCED LOCATION AWARENESS TECHNOLOGY (LAT) TO IMPROVE BUILDING PRODUCTION PROCESSES

Tommelein and Zouein (1993) and Sawacha et al. (1999) in Spillane et al (2011: p143) all point out that space management on a congested construction site is a key issue. Yun-Yi Su (2010:1) suggests that innovation using enhanced LAT to improve building processes and to support important decision-making tasks in the field is important. Razavi et al. (2012:239) goes on to say that LAT is pertinent to decision making, tracking progress and safety. Using LAT indoors presents further challenges, as opposed to using it outdoors. The Global Positioning System (GPS) used for outdoor tracking has its limitations being restricted by buildings and tree canopies; satellite technology cannot receive radio signal in these environments. According to Razavi et al. (2012:239) indoor LAT's are rapidly becoming a reality for construction practices; radio frequency identification (RFID) is being widely used for this application. Razavi et al. (2012:239) goes on to say that the accuracy of RFID is dependent on a wide range of protocols needed and therefore it is imperative that these protocols continue to be developed. Location technology has vast potential to assist with data collection on confined construction sites in urban areas. Yun-Yi Su (2010:4) believes data collection is difficult and that it is nearly impossible to observe and record details of on-going construction work, manually. As a result only approximate estimation of proceedings is possible which does not achieve the desired accuracy. Tracking and monitoring has many advantages on a confined construction site. This technology can assist in operation and critical decision making, materials management and productivity tracking (Razavi et al. 2012:239).

Cavanaugh and Amendolare (2010), Schiffbauer (2001), Teizer et al. (2008, 2010) and Zhang et al. (2009), cited in Razavi et al. (2012), feel that remote sensing and monitoring personnel in real-time can improve construction safety by warning equipment operators and personnel on foot of a potential risk.

Yun-Yi Su (2010:7) highlights the importance of timely and accurate feedback information which describes actual operational data on the construction site. Without timely and accurate feedback the accuracy of updating a project database is effected; hence many critical decisions cannot be made in a timely manner.

2.0 RESEARCH PROBLEM

Generally construction firms are not innovative or dynamic when it comes to improving building production processes within urban centres. This is problematic as the success of building construction in urban centres hinges upon the ability of the construction firm to be strategic, which is to know better than the competition, what direction to go in, what risks to take and if new technology can mitigate problems in production.

The literature reviewed during this research tells a great deal about the opportunities for LAT and remote sensing scanners in construction, however the extent to which construction firms are using this innovative technology in the Cape Town Central Business District (CBD) has not yet been documented. Building construction in the CBD is competitive and challenged by limited space and congestion.

3.0 RESEARCH QUESTION

- Why are construction firms reluctant to use both new management practices and new technologies to enhance building production processes in urban centres?
- Do construction companies find LAT and geospatial data useful for construction management on confined sites?
- Can LAT and geospatial data be used to mitigate weakness in current building production process in urban centres?

4.0 RESEARCH METHODOLOGY

This study documents the usage of innovative technology by construction firms on construction sites in the CBD. The scope of this investigation includes professionals involved in building construction in the CBD. The research method used included both qualitative and quantitative data collection, a mixed approach to provide a comprehensive account of usage.

The questionnaire survey method was used for this research. The sample population consisted of professionally qualified individuals active in construction in the CBD. These professionals are defined as engineers, architects, designers, technicians and land surveyors. To ensure that the questionnaire was completed by the professionals mentioned, non-probability sampling was used to purposefully select the desired sample. The questionnaire consisted of both open-ended and closed questions. Open-ended questions were used for gathering qualitative information to stimulate thought and encourage continued conversation. Snowball sampling was also used; this is where one respondent identified other potential respondents. A total of seven consulting firms were approached.

5.0 METHODOLOGY, DATA ANALYSIS DISCUSIONS OF FINDINGS

This survey sets out to prove the hypothesis that innovative technology, such as remote sensing and spatial location technology can be beneficially applied on congested construction sites in urban centres. Respondents were asked questions concerning the proximity of personnel to plant, overcrowding, communication, the start/stop nature of work, productivity, resource management, storage of materials, movement of materials, negative stakeholder response, air pollution, noise pollution and access.

Furthermore this survey is to establish empirical evidence that technology improves construction productivity. Respondents were asked if they felt that the congested characteristic of construction sites in urban centres makes location awareness critical. The logistical costs of employing this technology is a major factor influencing the willingness of construction firms to use LAT to improve manual processes and help support important decision-making tasks on site. Construction managers were asked if LAT and geospatial data can improve competitiveness through improved construction management processes. Yun-Yi Su (2010:1) suggests that enhanced LAT improve building processes and support important decision-making tasks in the field. The survey tries to clarify this statement and find out if this hypothesis holds true in the CBD of Cape Town, if so the study can be extended to cover South African. Isikdag et al, (2008) refer to Building Information Modelling (BIM) as a major innovative technology that can mitigate problems of interoperability and information integration. The use of BIM in building construction is investigated and respondents were asked if the construction industry in South Africa has kept up with developments in LAT, BIM etc.

Seven consultants who are involved in building construction in the Cape Town CBD were interviewed, mostly geomatics engineers who specialise in the use of LAT, BIM and other new technologies in

construction. All of these respondents have in excess of 5 years experience in construction management and spend at least 4 days a week on site. The sample building sites include FNB Head Office, Chris Barnard Hospital (Figure 4), Mandela Rhodes Apartments, Cape Town Stadium, Green Market Square Apartments and Glaston House. It was revealed that LAT, remote sensing and knowledge management are not currently being used on any of the sampled sites. Some of the construction consultants have used this technology for certain aspects of construction; no comprehensive investments have been made on any of the projects in this respect. However, the prospect of using this technology in the future was positively expressed by the respondents.

Figure 4: The new Chris Barnard Hospital site

The following analysis shows the results of the survey done to determine the conditions on construction sites in the Cape Town CBD.

Respondents were in agreement that congested construction sites pose some challenges:

- personnel in close proximity
- storage of materials on site

- overcrowding – plant, materials and personnel

Respondents did not agree that the following poses a problem specifically on a congested construction site:

- air pollution
- communication
- reduced productivity – difficult to measure

6.0 CONCLUSION

Respondents were unanimous that BIM is an important technology for building construction projects. Respondents described BIM as a carefully coordinated model that can be used from the design stage, into construction and beyond. The respondents agreed that a database-driven model such as BIM, would be beneficial on site, where project managers and quantity surveyors can count, cost and order material based on updated real-time information. Furthermore respondents felt that a BIM would be useful for programming, construction sequencing and would reduce mistakes on sites. Although some of the respondents described BIM as a just another documenting system, others felt that its use integrates engineering and facilitates collaboration between professionals. Respondents felt that construction managers see BIM as futuristic, referring to it as 'digital engineering'. They felt that project managers and senior engineers in South Africa are generally older and resist change. However, it was noted that younger engineers believe it is rapidly becoming an essential tool that will dictate competitiveness in the future. One respondent stated that South African engineers are up-to-date and are contributing to the development of BIM internationally. No longer is it a niche technology. The suggestion of incorporating cloud storage in BIM was received enthusiastically and respondents agreed that laser scanners are becoming more practical on construction sites. Respondents felt digital engineering should be encouraged at universities so as to produce industry leaders in this regard.

Respondents were excited about LAT on construction sites. People tracking are becoming key on large construction sites and congested urban building sites. Respondents believe that managing the location of personnel, both inside and outside on construction sites would be useful. It will help decrease emergency response times when guiding assistance to an accident scene. It is now possible to know if personnel are on or off the site. Other uses suggested were personnel and plant navigation, mobile digital information and indoor location analysis. It would be helpful in ensuring that project managers find themselves at the

right place at the right time. A general comment was that the future of location technology lies in the combining of technologies on site. Cameras and processors were mentioned as potential innovation areas for indoor construction management. Not all respondents understood what was meant by knowledge management. Those that did, felt that the capturing of individual's experience and knowledge would be very useful. Documenting knowledge ensures that building production processes are improved from one project to the next.

GLOSSARY OF TERMS

CBD - City Business District
CID - City Improvement District
BIM - Building Information Model,
GPS - Global Positioning System
LAT - Location Awareness Technologies
RFID - Radio Frequency Identification

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