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CONSTRUCTION IT IN 2030: A SCENARIO PLANNING APPROACH

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SUMMARY: *This paper presents a scenario planning effort carried out in order to identify the possible futures that construction industry and construction IT might face. The paper provides a review of previous research in the area and introduces the scenario planning approach. It then describes the adopted research methodology. The driving forces of change and main trends, issues and factors determined by focusing on factors related to society, technology, environment, economy and politics are discussed. Four future scenarios developed for the year 2030 are described. These scenarios start from the global view and present the images of the future world. They then focus on the construction industry and the ICT implications. Finally, the preferred scenario determined by the participants of a prospective workshop is presented.*

KEYWORDS: *Future studies, scenario, scenario planning, ICT vision, construction industry*

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1. INTRODUCTION

From the earliest times, there has been an interest to know what the future might bring. Anticipating the future is considered as a useful way to align and improve current strategies and this interest has been reflected in future studies, strategic planning, scenario thinking and planning, foresight, and futurology. There are many examples for previous foresight research at the industry level. Harty et al (2007) provided a good review of thirteen future studies focusing on the construction industry and investigated the methodologies adopted. Bringing together the key themes and areas addressed in these studies, two future construction scenarios were developed for year 2025. Latham (1994) and Egan (1998) reports, produced in UK, identified construction areas which required improvement whilst determining the potential drivers and issues which might change the future of construction.

Department of Trade and Industry, which was disbanded with the formation of Department for Business, Enterprise and Regulatory Reform, carried out many foresight studies addressing the UK construction industry (DTI 2001; DTI 2002; Fairclough 2002). In a recent study carried out for European Construction Institute (ECI), where the European construction industry will be in 2030 was pictured and a preferred future was developed (Goodier et al. 2008). Collaboration, innovation, people, natural sources and stewardship were identified as the key areas which should be focused in order to achieve this future.

Some of the future studies approached the future of construction industry from a particular angle. For example, the Big Ideas Project, a UK government-sponsored collaborative research project between the universities of Loughborough, Reading and Salford, focused on the sustained competitiveness in the UK construction industry. Engaging with the industry the project identified the issues and factors that might change the construction industry's future, developed grounded models of sustained competitiveness, and produced possible future scenarios (Goodier et al. 2007). The Government Office for Science recently completed a foresight study on the role of built environment for a future targeting a sustainable energy management (Foresight 2008).

Since information technologies (IT) have become a very important part of the construction processes, many research efforts approached the future of construction from IT implementation point of view. Sarshar et. al (2000) developed a vision for construction IT for the years 2005-2010 following a research methodology based on literature search, academic experts workshops, industrial experts workshop and feedback from industry. The vision was developed around seven major themes:

1. Model driven, as opposed to document driven information management on projects
2. Life cycle thinking and seamless transition of information and processes between life cycle phases
3. Use of past project knowledge (/information) in new developments
4. Dramatic changes in procurement philosophies, as a result of the internet
5. Improved communications at all life cycle phases, through visualisation
6. Increased opportunities for simulation and what-if analysis
7. Increased capabilities for change management and process improvement

In order to inform future research, Amor et al (2002) tried to withdraw a vision of future IT-enabled construction projects by reviewing the activities of the working commission of CIB (International Council for Innovation and Research in Construction) till 2002 and the key research issues addressed in these activities. The ROADCON project developed a vision for agile, model-based, knowledge driven construction and prepared a roadmap (Hannus et al. 2003). The vision for future ICT in construction was defined as "the construction sector is driven by total product life performance and supported by knowledge-intensive and model based ICT enabling holistic support and decision making throughout the various business processes and the whole lifecycle by all stakeholders". The Strat-CON project focused identified the strategic actions in the short, medium and long term in order to achieve the ROADCON vision (Kazi et al. 2007). Processes, products, projects and enterprises were the four thematic areas addressed in the project. Whilst the mentioned research efforts focused on the general IT implementation in construction, others focused on developing a vision or a scenario of how specific IT tools may enable future construction processes. Examples include an nD enabled construction vision (Lee et al. 2003), an nD modeling roadmap proposed for the time span of 2004 to 2012 (Lee et al. 2005) and a scenario for mobile IT enabled future construction site (Bowden et al. 2006).

This paper presents the up to date findings of the ICT Vision Development research project, which is aimed at anticipating what futures the construction industry and construction IT may face and developing a preferred construction IT vision considering the forces driving the future. This research can be distinguished from the previous IT vision planning research efforts based on the adopted methodology which does not only focus on the future of construction IT but pictures the future world and the future construction as well as future IT. Depending on its aid to understand the nature and impact of the driving forces affecting the world, a scenario planning approach has been employed in order to achieve the research aims. The scenario planning approach and its evolution in time is presented in the next section.

2. SCENARIO PLANNING

Anticipating and planning for the future is an essential element in the development of strategies. Scenario planning is a key technique used by futurists to develop future models in order to help this process and to

develop strategic action plans and policies or to create a vision for the future. The term scenario is a fuzzy concept with many different definitions and many different meanings attached to it. According to Porter, a scenario is "*an internally consistent view of what the future might turn out to be- not a forecast, but one possible future outcome*" (Porter 1985). Selin (2006) defines scenarios as stories describing different but equally plausible futures that are developed using methods that systematically gather perceptions about certainties and uncertainties. Scenarios generally come in two forms: exploratory and normative. Exploratory scenarios represent plausible self-consistent future worlds that would emerge from the present through credible, cause, effect and feedback developments whereas normative scenarios represent desirable future worlds (Ratcliffe 2003).

When initially developed, scenario planning helped companies understand external change, change in markets, the competitive arena, technology and demographics (Van der Heijden, 1996). Due to its aid to understand the nature and impact of most uncertain and important driving forces affecting our world, scenario planning is considered as a strategic planning tool enabling the development of flexible long-term plans (JISC 2008). Despite some variations in scenario planning, scenarios essentially address three major issues (O'Brien 2004):

- the synthesis of information about what is important for an organization, a necessary foundation for futures thinking;
- the development of a consistent and plausible set of descriptions of possible futures, or scenarios, through the use of a structured methodology; and
- the evaluation of the implications of these scenarios for the organization today.

According to Wack (1985), scenario planning is a discipline for rediscovering the original entrepreneurial power of creative foresight in contexts of accelerated change, greater complexity, and genuine uncertainty. Scenario planning does not focus on accurately predicting the future (Hodgkinson and Wright, 2002) but rather is a process that produces a number of possible futures that are credible however not certain (Brauers and Weber, 1988; Simpson, 1992; Schoemaker, 1995; Schwartz, 1996; van der Heijden *et al.*, 2002).

Scenarios and scenario planning have been a part of life since early ages with the aim of exploring the future of society and its institutions. Use of scenarios can be traced back to Plato's ideal Republic description in 4th century BC. or visionaries from Thomas More in 1516 (Bradfield et al. 2005; von-Reibnitz 1988). Molina, a Spanish Jesuit theologist and scholar in the 1500s, is known to have introduced the concept of "conditional future contingents" or "futuribilia" as an explanation of free will, foreknowledge and predestination (Malaska and Virtanen 2005). Scenario techniques have been used as a strategic planning tool in the military for a long time, however, the modern day scenario techniques only emerged after World War II, mainly by the research efforts in the USA and France (Bradfield et al. 2005).

Scenario Planning Efforts in USA

Following World War II, the US Department of Defense realized the need for a methodology to capture the reliable consensus of opinion of a large group of experts and the need to develop simulation models of future environments enabling the investigation of various policy alternatives and their consequences (Bradfield et al. 2005). The studies carried out to respond to these needs resulted in the development of the "*Delphi Technique*" and "*Systems Analysis*" in the 1950s by the Rand Corporation. In the Delphi Technique, in order to gather information about the future, experts in their various fields are approached for their individual estimation on the probability of occurrence for certain events. The approach aimed to get experts to converge on future views by comparing their answers with the other experts' answers (Ringland 1998). Delphi Technique became a part of Rand's formal planning techniques in the 1970s.

Systems Analysis is an analytic study aiming to enable decision makers to identify a preferred choice among possible alternatives (Quade 1966). The essence of the method is to construct and operate within a model in the form of a computer simulation, a verbal scenario or an operational game. Using a systematic and rational approach, the participants in the study use their judgement and intuition on the model and revise their earlier decisions based on the feedback from the model.

Herman Kahn in Rand was working on possible scenarios associated with the thermonuclear war. In 1961, Kahn left the Rand Corporation and established the Hudson Institute. In this institute, he started to apply his scenario methodology to social forecasting and public policy. He demonstrated the use of scenarios as a methodological tool for policy planning and decision making in complex and uncertain environments (Raubitschek 1988). He is very well known for the phrase he coined "thinking about the unthinkable" and is considered as the founder of

scenario based planning.

After Kahn, further research in the USA on scenario based planning resulted in a number of alternative approaches. These approaches can be categorized under three major groups (Huss and Honton 1987):

1. Intuitive logics-described by Pierre Wack and used in Stanford Research Institute (SRI) International and Shell;
2. Trend-Impact Analysis practiced by The Futures Group;
3. Cross-Impact Analysis practiced by Center for Futures Research (INTERAX) and Batelle (BASICS)

When the American scenario analysis techniques are investigated, it is seen that regardless of the differences, some stages are common in all of them: identifying the topic, determining the influencing factors, analysis of these factors and developing scenarios. SRI and BASICS take the scenario planning one step further and focus on the implications of the scenario as well. The comparison of the steps included in each scenario analysis technique is given in Table 1.

TABLE 1. Comparison of the steps included in each scenario analysis technique (Huss and Honton 1987)

Generic scenario generation steps	**SRI**	**The Futures Group**	**BASICS**	**INTERAX**
The topic	1.Analyzing the decisions and strategic concerns	1. Identify key scenario drivers 2. Create a scenario space	1. Define and structure the topic	1. Define the issue and time period of analysis
Key decisions	2.Identifying the key decision factors			2. Identify the key indicators
Trend extrapolation		3. Collect time series data; 4. Prepare naive extrapolation		3. Project the key indicators
Influencing factors	3. Identifying the key environmental forces	5. Establish a list of impacting events	2. Identify and structure areas of influence	4. Identify impacting events.
Analysis of factors	4. Analyzing the environmental forces	6. Establish probabilities of events occurring over time	3. Define descriptors, write essays; assign initial probabilities	5. Develop event probability distributions
Cross-impact			4.a. Complete the cross-impact matrix	6. Estimate cross impacts. 7. Complete cross-impact analysis
Initial scenarios	5. Defining scenario logics	7. Modify extrapolation	4.b. Run the program 5. Select scenarios for further study	8. Run the model.
Sensitivity analysis			6. Introduce uncertain events; conduct sensitivity analysis	
Detailed scenarios	6. Elaborating the scenarios	8. Write narratives	7.a. Prepare forecasts	
Implications	7. Analyzing implications for key decision factors 8. Analyzing implications for decisions and strategies.		7.b. Study implications	

Scenario Planning Efforts in France

The second major thrust for scenario planning research has been in France. Here, scenario planning research mainly focused on the 'scientific and political foundations of future'. In 1950s, Gaston Berger, a French philosopher, founded the Centre d'Etudes Prospectives and developed a scenario approach to long-term planning, which is known as prospective thinking or La Prospective. The prospective attitude defined by Berger meant (Godet and Roubelat 1996) :

- to look far away-because la prospective is a long-term preoccupation;
- to look breadth wise-to take care of interactions;
- to look in depth-to find the factors and trends that are really important;
- to take risks-because far horizons can make us change our long-term plans;
- to take care of mankind--because la prospective is primarily interested in human consequences.

The centre aimed to develop positive images or normative scenarios of the future to be used as a guiding vision in the political arena to develop policies (Bradfield et al. 2005; Vanston et al. 1977). Pierre Masse and Bertrand de Jouevenel followed Berger's work in the 1960's. Masse led the use of the prospective scenario approach in the development of the French National Plan and national economic plans. De Jouvenel, French political philosopher, used the prospective scenario approach to construct the positive images of the future or 'scientific utopias' and to specify ways to achieve these futures with the aim to improve ordinary people's lives (Bradfield et al. 2005). Combining futuribilia concept (Molina) with the possibility concept, de Jouvenel created the "futurible" term to refer to "a fan of possible futures" (Godet 2000). The concept is based on the argument that '*the mind cannot grasp with certainty...but it can conjecture possible alternatives*' (de-Jouvenel 1967).

In the mid-1970's, the French School gained a new member, Michel Godet. Godet and Roubelat (1996) used the Greek triangle to explain the prospective scenario planning approach, where the three components would be Logos (thought, rationality, discourse); Epithumia (desire in all its noble and not so noble aspects); and Erga (action and realization). He explained that the prospective thought gives consent to mobilization, maintains motivation and nourishes strategic will. Following the prospective method, he began to develop a mathematical and computer-based probabilistic approach to scenario development and classified problem solving methods (some were developed by himself) for different stages of the scenario planning approach (Bradfield et al. 2005; Godet and Roubelat 1996). Godet is considered to have had a great influence on the cross-impact analysis employed by Batelle in USA (Ratcliffe 2000). The prospective approach generally focuses on an integrated scenario planning and strategic planning approach.

In this research, a methodology adopted from prospective scenario planning is followed. This adopted methodology is explained in the next section.

3. SCENARIO PLANNING APPROACH FOR ICT VISION PLANNING

The research for ICT Vision Planning follows a scenario planning approach adapted from La Prospective to suit the aims of the research. The prospective approach was chosen due to its track record of developing more effective policy and strategic decisions and tactical plans of action. The steps followed for the vision planning is shown in Figure 1. Through these steps, it is aimed to identify possible futures , and to develop a preferred future scenario .

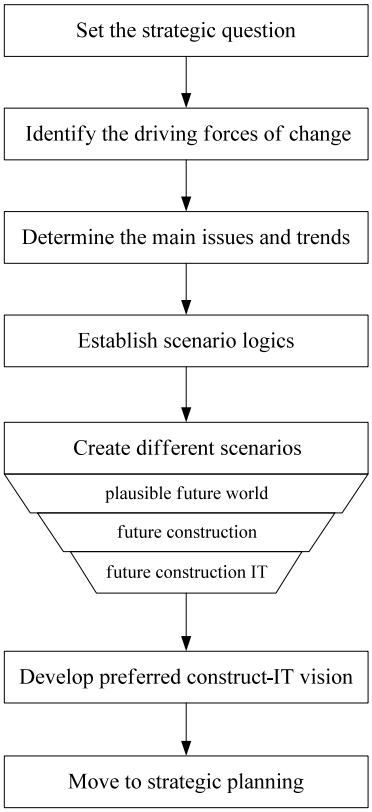

FIG.1: ICT Vision Development Scenario Planning Approach

These steps are explained below in details.

1. *Set the Strategic Question*

The first stage aims to identify the problem posed and define the system under examination. This stage might be considered a general examination of the position of an organisation within its external environment, the more particular identification of a key gap in an organisation's knowledge, or the interrogation of a very specific business idea (Kelly et al. 2004). In this research, the focus is on future ICT implementations in the construction industry. The research question was defined as "*What are the IT implications of possible futures that construction industry might face? How should we prepare for them?"*.

2. *Identify the Driving Forces of Change*

The driving forces of change can be identified by continuous monitoring through 'horizon' or 'environmental' scanning; in-depth interviews with acknowledged experts; targeted questionnaire surveys; and brainstorming workshops at the start of the prospective process (Kelly et al. 2004). They are usually categorized by techniques such as DEGEST, PESTE or STEEP, which are explained below.

DEGEST: Demographic, Economic, Governance, Environmental, Societal and Technological

PESTE: Political, Economic, Social, Technological, Ecological

STEEP: Societal, Technology, Economic, Environmental, Political

In this research, the driving forces are determined using a number of methods: Firstly, similar previous research is investigated and the forces proposed in those are noted. Secondly, through short questionnaires, the views of the key actors in the sector are obtained regarding which forces might play an important role in shaping the future. Thirdly, the forces determined in the previous two methods are revised, categorized according to DEGEST and finalized in scenario planning brainstorming workshops.

3. *Determine the Main Issues and Trends*

This stage focuses on the main issues and trends that might shape the construction industry's future considering the drivers of change identified in the previous stage. Like the previous stage, literature review, short questionnaire and prospective workshops are the methods adopted for this stage. The identification of the main issues and trends and the associated impacts and uncertainties will be followed by the clustering process where the forces, issues and trends are grouped into a number of high level concepts. Clustering is a critical part of this stage since it informs the scenario logics.

4. *Establish Scenario Logics*

Scenario logics refer to a logical rationale and structure for the scenarios enabled by intuition, insight and creativity (Ratcliffe 2000). With this stage, the themes for a scenario are defined. The scenario logics might me articulated by laying-out in simple narrative form, or by using the 2x2 matrix approach, or by depicting the logics and their interactions or relationships diagrammatically showing causal connections (Ratcliffe and Sirr 2003). The scenario logics are decided according to the results obtained in the previous stages and the number of scenarios is restricted to four.

5. *Create Different Scenarios*

Scenarios can be created in many different ways depending on the circumstances, timescales, organizational or sectoral cultures, facilitation methods and available resources. Regardless of the method of generation, each scenario should have four characteristics (Vanston et al. 1977): plausibility; self-consistency; inclusion of all critical, relevant factors; and similarity to other scenarios in form and scope. Kelly et al (2004) expanded the list and stated that each scenario should be:

- plausible: credibly capable of happening;
- robust: internally consistent and coherently defensible;
- divergent: structurally differentiated, not simply variations of the same theme;
- challenging: testing the conventional wisdom of the organisation and providing novelty of thought; and
- useful: contributing specific insights into the future that help tackle the strategic question

According to Godet (1987), scenarios should aim to detect the key variables that emerge from the relationship between the many different factors describing a particular system, especially those relating to the particular actors and their strategies.

For the ICT vision planning, scenarios are initially developed by the participants attending the first prospective workshop. Each scenario needs to have an approximate timeline, early indicators of change and a memorable title describing the essence of the scenario. The scenarios are expected to start from the global view and present the images of the future world. They should then focus on the construction industry and imagine how the future world will shape the construction industry. The last step is visualizing what the ICT implications of the future world and future construction. The draft scenarios should be revised during the follow on workshops.

6. *Develop preferred construction IT vision / Produce the 'Prospective'*

This stage aims to develop a single preferred future for construction ICT. It is based on the principle that the future can be influenced if we know what we want it to be. The previous exercises to identify the drivers, trends and issues and their relationships and to develop scenarios will enable thinking outside the box and initiate the development of a preferred construction ICT vision.

7. *Move to Strategic Planning*

The last stage of the research focuses on what should be done to achieve that vision. For this reason, the barriers and enablers of the ICT vision need to be identified and strategic policy and action areas will be determined. The draft framework of this strategic plan will be developed during the first brainstorming workshop and the plan will be detailed during the follow-up workshops and according to the results of the interviews carried out with the key actors in construction and construction ICT.

The following section presents the research findings obtained so far.

4. ICT VISION PLANNING EXERCISE

4.1 General Information

The research started in February 2008 with the review of previous research on ICT future studies and the forces, issues, trends that might shape the future. This was followed by the pre-workshop questionnaire and the prospective workshop.

The questionnaire was aimed at engaging the workshop participants in the definition of the strategic question as well as raising awareness on today's events which might be shaping the future and initiating thinking before coming to the event. The short pre-workshop questionnaire consisted of two questions:

1. Please list up to six events which you consider might shape the future of the world and in what way.
2. What in your opinion are the key factors that might shape the future of the construction industry?

The responses to these questions and literature review findings were used to prepare a slide show in order to enhance and stimulate thinking in the beginning of the workshop. The slides presented some pictures and newspaper headlines of the past 15-20 years which had an effect on today's world and some recent headlines which might shape the future world.

The ICT Vision Planning Workshop, held on 26th January 2009, aimed to identify possible futures that the construction industry might face and to start developing a construction IT vision for the year 2030. It was a collaborative research initiative between *ITcon* Journal, VTT, SCRI at the University of Salford, Loughborough University and ConstructIT. 28 world leading experts from different disciplines were brought together. The participants were technical and non-technical researchers and industry professionals attending from Australia, Canada, Denmark, Finland, Netherlands, Norway, Turkey, UK and USA. It was aimed to benefit from the synergy between different expertise and working cultures of the attendees. The workshop had an interactive methodology which enabled a productive environment for brainstorming, exchanging ideas and stimulating discussion. The workshop was scheduled for the whole day and consisted of many breakout sessions allowing the participants to work in groups. A cartoonist was present during the breakout sessions. A number of cartoons were created encapsulating the discussions during the breakout sessions in a thought provoking way. These were presented during the breaks stimulating further conversations.

The workshop finalised the driving forces of change, main issues and trends which were initially identified through the literature review and pre-workshop questionnaire. This was followed by the development of four future scenarios. A draft for ICT vision was created and key areas to focus on to achieve this vision were determined. The following sections present these findings.

4.2 Forces of Change, Issues and Trends

Whilst developing a future vision, it is important to understand the forces, issues and trends which might shape the future. For this reason, the main continuities, major trends, most important change processes, most serious problems, new factors and main sources of inspiration and hope were investigated in order to identify the driving forces of change. The driving forces of change were considered at the global level in five main areas: Society, technology, economy, environment and politics (STEEP). 14, 19, 18, 10 and 17 change driving forces were identified for these five areas respectively.

After the identification of the driving forces, it was aimed to identify the issues and trends by looking at three levels: Meta, Macro and Micro. These reflect the issues related to the global, construction industry and IT in construction respectively. The issues and trends were also investigated in the STEEP areas. Each of the forces, issues and trends identified during the breakout sessions were written on post it notes which were placed on the charts put on the wall shown in Figure 2. A total of 38, 32, 11, 28 and 19 trends and issues were identified for the STEEP categories respectively.

	SOCIETY	TECHNOLOGY	ECONOMY	ENVIRONMENT	POLITICS
Driving forces					
Issues & trends					

FIG. 2: The charts used for the presentation of the driving forces and main issues and trends

The third stage was categorising the forces, main issues and trends identified into a number of high level concepts. For example, the items shown in Figure 3 were clustered as global environmental change.

When the same procedure was applied to all 78 forces and 128 main issues and trends listed in the chart, eight main themes were agreed on that will change the future:

1. Global environmental change
2. Future financial framework
3. Seismic power shift (west to east)
4. Demographic change
5. Knowledge generation/ education
6. Behavioural change
7. Technological progress
8. Law& Order/ Political stability

	SOCIETY	TECHNOLOGY	ECONOMY	ENVIRONMENT	POLITICS
Driving forces				Society appreciation of environmental issues will continue to grow Recycling processes Tokenism in response to problems i.e. plastic bags in supermarket Reduced energy consumption Bio-inspired ideas	Corporate sustainability Corporate social responsibility
Issues & trends	Emphasis on low carbon solutions Emphasis on renewable resources	Local generation of hydrogen for power 'Fusion Power' Power consumption Waste and energy savings by using BIM	Cost of carbon (£) What carbon footprint means	Legislation of carbon leads to renovation of existing buildings Carbon reduction and wise use Change material Changing energy consumption Reuse of recycle Reduce waste Reduce carbon waste Balance- use produce (electricity) Sustainability Fuels innovation	Fuels innovation Prescriptive sustainability performance Through sustainability planning regulation Design for sustainability compliance Measure resource consumption relative to community as a whole How to trade off decision costs versus environmental trade off

FIG. 3: The driving forces and main issues and trends clustered as 'Global environmental change'

4.3 Scenarios for Year 2030

When the eight themes determined to change the future were reinvestigated, global environmental change, future financial framework and seismic power shift were found as the most critical ones and therefore were decided to use in order to develop scenarios. After some thinking on how these three themes can be best reflected, the two scenario axes were identified as 'Economic model' and 'Environment and resource management', where the economic model takes values as interventionist or market driven; and environment and resource management as fragmented and integrated (Figure 4).

During the workshop, four scenarios were developed for the four quadrants of on these axes. It was aimed to have four challenging, evocative, consistent, imaginative and plausible scenarios for the year 2030. Although the two axes were used to frame the scenarios, all eight themes obtained during the clustering process were addressed in the scenarios. Each scenario was given a memorable name describing the essence of the scenario and included an approximate timeline of the most important changes that will have taken up to 2030.

It was intended that the scenarios would start from the global view and then narrow down to the construction industry, and finally down to ICT in construction. Therefore firstly the images of the future world were presented in each scenario. Secondly, the construction industry shaped by this future world were pictured. The last step was imagining the ICT implications of the future world and future construction. The scenarios created are presented below.

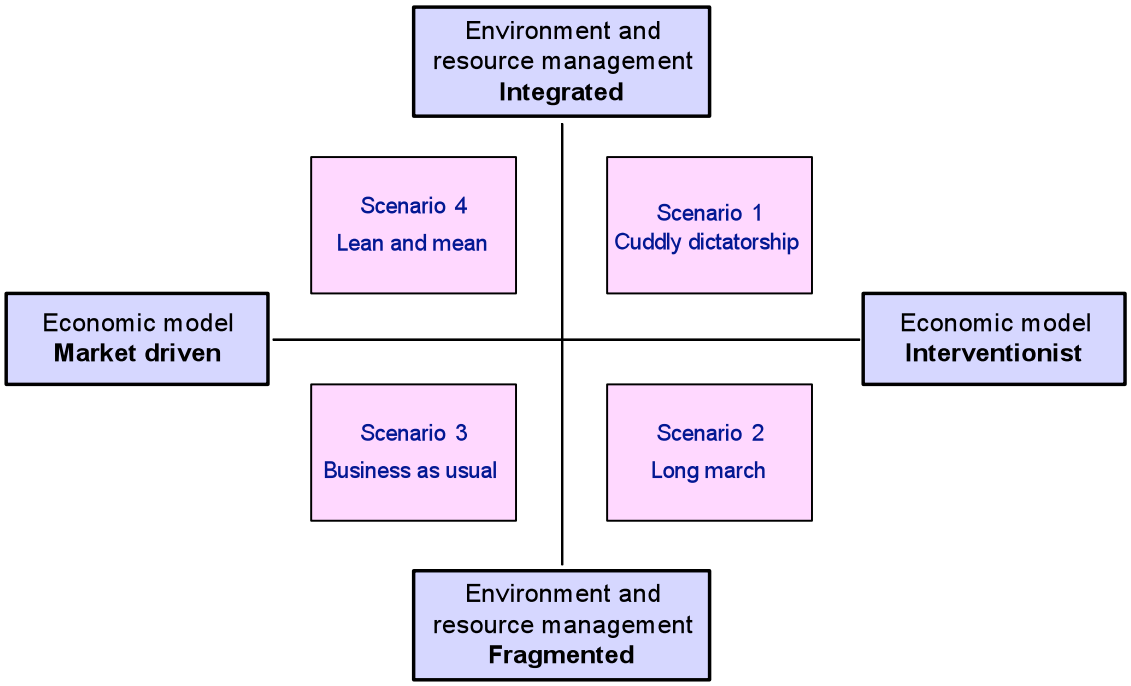

FIG. 4: Four future scenarios for 2030

4.3.1 Scenario One- Cuddly Dictatorship

This scenario pictures a possible future when there is an integrated resource and environmental management system and an interventionist economic model. Since the scenario assumes a regulated regime with a friendly attitude which puts people to the first place; it is named as "Cuddly dictatorship". At the heart of the scenario lies some form of global entity developing visions, setting goals and objectives which cascade down to national and to local level.

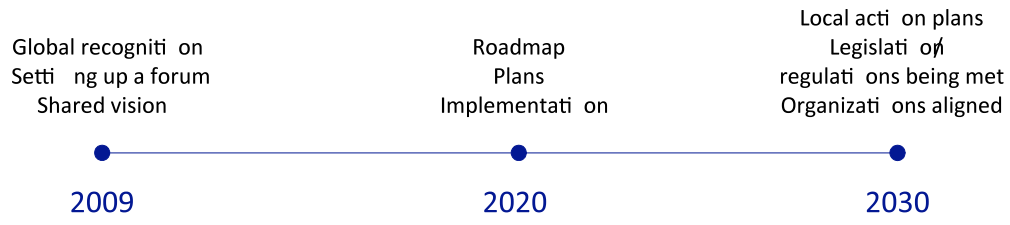

FIG. 5: Scenario 1

The whole process starts with the recognition of the environment and climate change amongst a number of countries. They then decide to work together and set up a forum. Kyoto agreement and global carbon trading are some early indicators of this attitude. This roadmap will continue and an organisation like United Nations will be established to set out goals for climate change and to develop a shared objective, vision and mission. The organization will have a reward and penalty system to encourage the countries to follow the shared vision. There will be countries which do not want to be involved in environmental changes since they have other problems which are more critical to them. These will be rewarded for their contribution. Likewise, there will be sanctions on countries which do not comply.

In the 2020s, the focus will be on converting the shared objective into legislations and standards; and planning to implement. In 2030, there will be well defined local action plans, local legislation which will have cascaded down through a forum which was set up at the first phase.

In 2030, it is expected to see a regulating regime in which a forum sets timelines and plans on the intervention at the economic front. This will have many effects on the construction industry and the IT implementations.

Construction industry will be more focused on off-site construction. It will be possible to include the customers/ clients in the design process –through lego style fashion pick and mix approach- providing them modular design components which will be constructed cheaply and defect free off-site, brought together on site following just in time principles and assembled on site. These modular components will be built enabling the disassembly for reuse elsewhere as demographics change and people move around. A seamless supply chain is targeted.

New technologies will be a part of the construction process. Technologies like nanotechnology will be used to establish a maintenance free environment (i.e. self cleansing glass, self repairing concrete). 3-D modelling will be created prior to building. Technologies enhancing built environment and robots will be a part of the construction process.

The regions will have their own energy sources and will develop their infrastructure to enable a self-sustainable energy. Cascading down from the regional level, each building might also have its own power source like clean nuclear or biomass boiler associated. Intelligent buildings will be very common.

Construction industry's ability to keep up with pace of change, generally in IT, might be a threat. The industry is still not open to new ideas and changing work practices. The need to keep up with the skills and skilled personnel who are able to deliver the buildings will be another major threat. Training needs to be considered more thoroughly in this sense.

4.3.2 Scenario Two- Long March

This scenario pictures a possible future when there is a fragmented resource and environmental management system and an interventionist economic model.

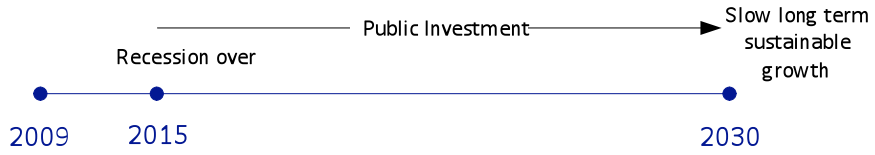

FIG. 6: Scenario 2

The recession will continue till 2015. All countries, regardless of whether they are in the west or east, will be affected during the recession period. It is expected that the traditionally strong economies will be affected from the recession more than the other. Although the emerging economies will also be affected from the recession, they will manage to take advantage of the situation as well. When the recession is over, high public investment will occur everywhere resulting in some new economic partnerships formed in the middle term. These partnerships will shape a new global financial framework. With the intervention and global government investment, some robustness will return to the economy and a long term sustainable economic growth will start.

Due to the fragmented approach, companies will be developing their own tools and technologies for their own interests, which create a power game across the technology process. The increase in the public sector funding will result in the development of new methods and technologies around the public sector contracts. Since the government sets the scene, there could be more punishment for nonconforming clients.

The traditionally strong economies recovering from the recession will put more thinking and effort in CO_2 scrubbing use in energy. The emerging technology will enable cleaning up the gases and hence will be used by the countries having traditionally strong economies. On the other hand, the countries with emerging economies which benefited from the recession period will not put much thinking into this and they will not have enough infrastructure or equipment for the scrubbing since they will have used all their earnings for further investment to grow more.

4.3.3 Scenario Three- Business As Usual

This scenario pictures a possible future when there is a fragmented resource and environmental management system and the economy is market driven. Since this situation is very similar to the economy and resource management system today, the group called this scenario as "Business as usual".

FIG. 7: Scenario 3

The current recession period is expected to continue till 2012 and then be over. However there might be other boom and bust periods till 2030. During this period, companies will be more focused on the survival. The recession will affect most of the small and medium enterprises and the future will be left to strong big scale companies only. Since the focus will be more on the survival, the environmental issues will get worse each year.

The future will be driven by money; therefore the only value considered by construction business will be the price. Likewise, individuals will be considered as commodity and the big institutions will be leading the future. Everything will be at the power of big corporations, mainly strong specialised contractors. This can be interpreted as an opportunity as well as a threat. On one hand, it will be clear which contractors are experienced in which area and the quality of the work will be better since they are specialised in that area. On the other hand, these strong contractors will be working in a kind of silo system. Small and medium enterprises will be having really difficult times if they will have survived till 2030 considering the supply and demand situation during the boom and bust period.

In the same context, the client power –whoever is on the top of the supply chain tree- will have a huge power over the others since everybody will serve to and take orders from this particular client.

There will be fragmented ways of looking at sustainability since the environment and resource management is also fragmented. Each company will have their own methods to define and measure sustainability as well as different ontology. If compared to the extent of sustainability approaches in construction today and their efficiency and effectiveness, it is very unlikely that construction industry will move forward with these issues in 2030. On the contrary, there will be an enormous amount of increase in the environmental issues because of the different ontology, different interpretation of what is meant by the environment, and different methods of measurement. Lots of problems will be compounded in the years to come.

4.3.4 Scenario Four- Lean And Mean

This scenario pictures a possible future when there is an integrated resource and environmental management system and a market driven economic model. Part of the vision seen in this scenario is a merger between the integrated global carbon economy and the market driven economic model. This merge inspired the title of "Lean and mean".

In terms of the timeline, this workshop is considered as a crucial point in time which starts the whole process. In the very near future, the financial markets will entirely collapse creating a major shock. Following this, changes will be carried out in the development policy in terms of constructing the balance of resources associated with the construction industry. These changes will lead to tension in resources, development and generation of knowledge, and real time assessment and control of carbon involvement. The picture seen in 2030 is a construction industry operating in a global carbon economy, which has developed related interoperable processes.

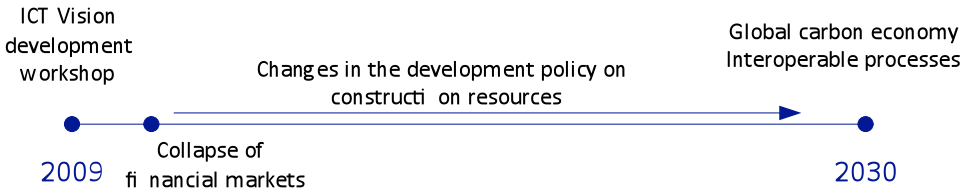

FIG. 8: Scenario 4

The entire collapse of the financial markets and other major change driving forces will lead to the development of an international framework of a carbon economy. It will start with carbon trading goods and having small environmental footprint which will be developed more and more every coming day following the better understanding of the concept and conceiving its importance. A small energy footprint will be maintained and processes will become more streamlined and effective.

There will be an increased localization of the factors for potential stages of design and manufacture use. Decommissioning will occur if these elements need to be in particular locations. This localization refers to the goods only i.e geographically closed products. The teams involved in the design can be globally dispersed. Free access to information will start to emanate from society and from the industry. Collaborative workspaces will enable sharing knowledge between people with the knowledge throughout the world. Analysis tools and decision making tools can help to decide what to do with the knowledge within the context of the carbon market trading scheme coming into existence.

Ultimately there will be a global access to resources, everyone being able to share the resources and share the understanding. Clients will be fully satisfied with products. The evaluation and measurement of behaviour will be fully integrated into the design process and the operation.

All of these will be possible because of the flexibility in construction which some industries do not have. Development of interoperable processes will make it even more advantageous.

4.4 ICT Vision for Year 2030

This stage focused on developing a single preferred future for construction ICT. It was based on the principle that the future can be influenced if we know what we want it to be. The previous exercises identifying the drivers, trends and issues and their relationships and developing scenarios enabled the workshop participants to think outside the box and initiate the development of a preferred construction ICT vision. The participants were asked to describe what the desirable future scenario was for IT in the construction industry for year 2030. The vision was built from four strands: People, processes, technology and places. Figure 5 presents the ICT vision developed for 2030.

Defining the ICT vision for construction, IT is considered as means or an enabler to deliver projects not the end goal in itself. Therefore people and processes constitute a very important part of the planning. Future construction industry will consist of best practice of new integrated business processes which are consistent and compatible. The best use of emerging technologies will be enabled through adaptable processes. Technology, process, people and culture are very much linked to each other. For the technology part of the vision, it is aimed to achieve tools and technologies compatible with and supporting each other, software developed on open standards. Regarding the technology and place relationship, the following were found as the key areas to focus:

1. Ubiquitous delivery of high bandwidth data (ie. BIM models)
2. Interoperability
3. Data integration
4. Ontologies
5. User interaction within the spaces
6. Innovative methods to display complex data in understandable ways: i.e. spider diagrams to overlay data across modal of the axes where it is easy to pick up the differences and use to make a sensible solution (till technology like the star wars holograms are discovered)

7. Cloud computing/ locationless computing: as a prerequisite to support the analysis of complex data:
8. Good tools for decision support:
9. New technologies, tools and visual methods to simulate, compare and evaluate alternatives

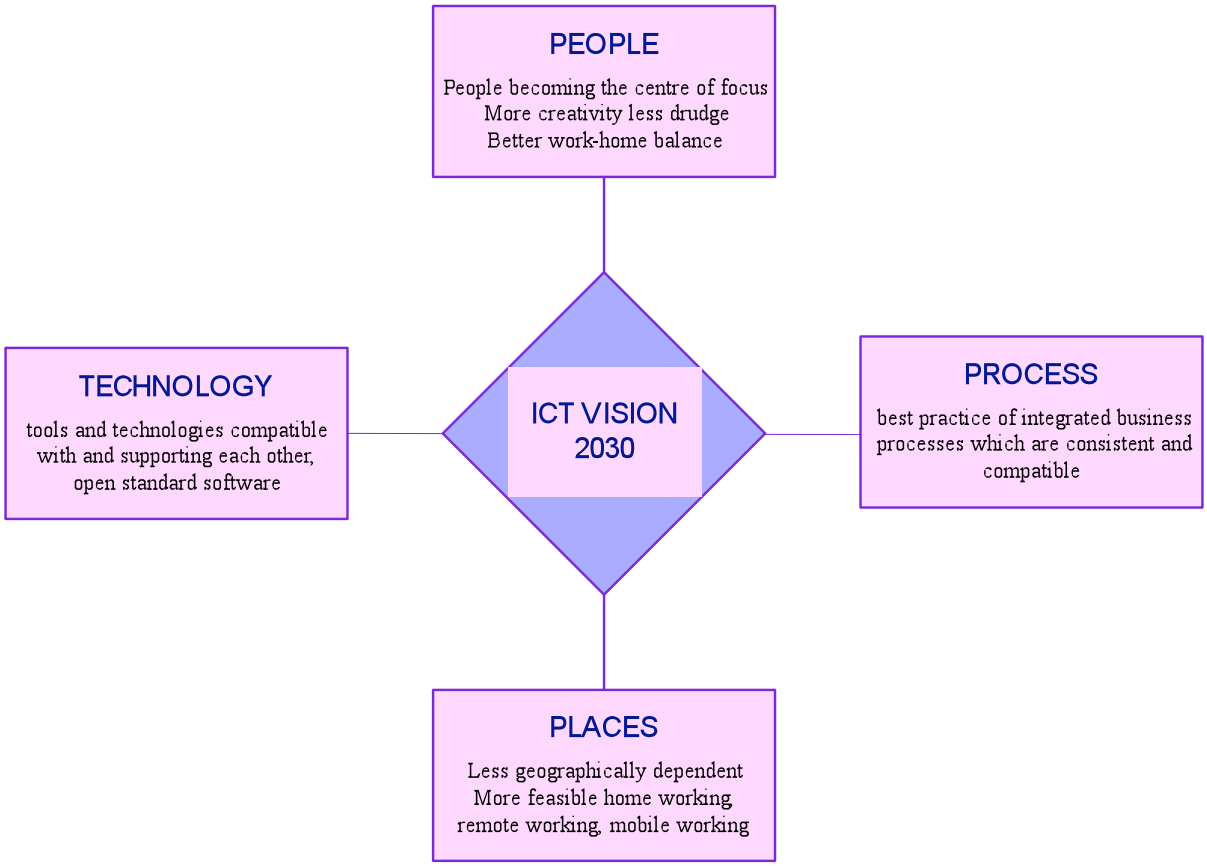

FIG. 9: General ICT vision for 2030

It is aimed to have less geographically dependent work practices in future. Collaboration between dispersed teams will be more possible as the virtual reality and possibly holograms becomes a common working practice. The improvements on the videoconferencing and holograms will better enable design meetings and project planning between globally dispersed teams. Technologies like second life might provide the means for the interaction of the whole supply chain and design teams.

Regardless of the client type, the future processes will make the most of new technologies like wireless technologies and ubiquitous intelligent frameworks. As a result of IT, there will be a better work balance. Home working, remote working, mobile working will be much more possible and feasible.

The advancements in ICT will enable the construction professionals to focus on what they do rather than how they do it. The construction industry will be perceived as more around design and innovation rather than manual labouring. The future will be based on people with a broad range of skills who will use IT skills to underpin the areas they are not so expert. Some people will not need to have intelligence in certain areas since expert systems and online knowledge management tools could be used whereas people having in depth knowledge will be developing those expert systems. However, this also brings a risk factor associated with it: engineers or other users might become less and less involved therefore less understanding what they are actually doing because of the 'black-box' style IT tools. On the other hand, IT will enable people having less drudge leading to more creative and more stimulating work.

The way people work in future will be different than today. Most tasks carried out by manual workers now will be carried out by the robots or in the factories, which will increase the health and safety on site. Likewise, off site construction will increase. A lego style construction will be possible through the enhancements in IT. Moreover, it will be possible to move beyond the visual environment and simulate the comfort environment integrating elements such as acoustics and odour.

The processes will become more efficient and streamlined through the help of IT. Intelligent buildings becoming more common in 2030, it will be possible to manage self healing/ self correcting buildings through the embedded sensors in the buildings. Smarter management of facilities and construction spaces will be seen as a result. Rather than sending maintenance people to check whether there is any problem, intelligent built environments will automatically detect the problems. Cutting down carbon, energy and cost of climate will be possible through the IT systems enabling intelligent built environments providing a better future for people.

Project management will be carried out more efficiently with the better integration of the supply chain, resource management and online transaction processes into the project planning and management tools.

Intelligent or semi-intelligent software will improve themselves through automated double loop learning facilities.

IT will be used to train people in any area they need to be trained. Learning will be achieved through games and role plays. eg. site inductions providing a walkthrough in the 3D site models. Rather than sitting in a portacabin and trying to work out which activity needs to be carried out when and where from a blueprint, the information will be accessed much more easily through.

In future, IT will naturally become a part of the life of end-users. IT tools will become much more ubiquitous, pervasive and intuitive. Furthermore, they will have been familiar with IT since their childhood so they will not need to go to an IT training to understand how to use a tool.

The vision determined in the workshop is not the final ICT Vision for 2030. It only provides some key areas which need to be focused on in the follow on workshops and studies. The vision described here should be perceived as a draft vision which will be detailed later on.

5. CONCLUSION

This paper has presented the up-to date findings of the ICT Vision Planning research project, which is aimed at anticipating what futures the construction industry and construction IT may face and developing a preferred construction IT vision considering the forces driving the future. In order to achieve this aim, a scenario planning approach modified from La Prospective was adopted. So far, aligned with the methodology, one prospective workshop was carried out which followed review of previous research on ICT future studies and a short questionnaire targeting the key actors in the sector. The strategic question explored in the workshop was shaped based on the results of the review and the questionnaire. Likewise they were used for the initial identification of the driving forces of change and determination of the main issues and trends, which were finalised later in the prospective workshop. 4 future scenarios were developed, and a draft ICT vision was created. The vision developed in the workshop is only a draft vision and will be revisited and revised in the follow on prospective workshops.

The starting point in the process was determining the driving forces of change and main trends, issues, factors and actors by focusing on factors related to society, technology, environment, economy and politics. Inevitably, some of the issues in the categories were overlapping with the other categories. In order to determine the scenario logics, 78 change driving forces and 128 main issues and trends were clustered and eight main themes were determined. Reinvestigating the themes, the axes to frame the scenarios were identified as ‘economic model’ (market driven or interventionist) and ‘environment and resource management’ (integrated or fragmented). Four scenarios were developed for the four quadrants of the axes.

The scenario building exercises were followed by developing a vision for 2030 based on four strands: People, process, technology and places. The vision included descriptions of how the working practices, people skills, activities, roles, IT-people-process interactions, collaboration and communication will look like in 2030 and provided the IT implications of these. In summary, the construction industry in 2030 is expected to have the best practice of new integrated business processes which are consistent, compatible, streamlined and aligned with the goals related to people, technology and place. Enhancements in technology will enable the construction of smart buildings, lego style design and construction processes, and off site construction. People will have more time to do creative work and the new technologies such as ubiquitous computing, collaboration tools, decision making tools will enable a more flexible working style. Integrated, flexible and adaptable IT which was implemented with a holistic view is also another vision for 2030.

Some key action areas were discussed in the workshop to achieve the defined vision. Recommendations were made in the areas related to change, innovation, communication, collaboration, education and training, streamlining, interoperability, holistic views, automation, sustainability, and user satisfaction.

It was not possible within the time constraints of a single day workshop to produce thorough scenarios and a comprehensive vision. However, the scenario methodology used has resulted in a detailed and a notably wide ranging consideration of the factors that should shape ICT vision of the future construction. Yet, nobody can actually know what the future will bring. However, it is believed that the future scenarios developed in the project will enable the planners become aware of the different possibilities, analyze and understand the forces influencing the future, and work towards achieving a desirable future as well as being prepared for what might be round the corner.

It should also be noted that the vision described in this paper is only a draft vision. The future research steps include revising and detailing of this vision in the follow on prospective workshops and determination of the strategic action plans to achieve this finalised vision. The final IT vision developed after these steps will also inform the future research activities.

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