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SCRI Research Report 1



Future Generation of IT: Vision Planning Workshop Report

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Executive Summary

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. It was led by Prof. Ghassan Aouad, Dr Sami Kazi and Prof Andrew Baldwin and organised by Mr. Carl Abbott and Dr. Bilge Erdogan. Prof. John Ratcliffe and Dr. Ela Krawczyk facilitated the event.

28 world leading experts from different disciplines were brought together for this workshop. The participants attended from Australia, Canada, Denmark, Finland, Netherlands, Norway, Turkey, UK and USA. The companies represented were Arup, Integrated FM, CMIT & FIATECH, NG Bailey and Halcrow. The workshop had an interactive methodology which enabled a productive environment for brainstorming, exchanging ideas and stimulating discussion.

The driving forces of change and main trends, issues, factors and actors were determined by focusing on factors related to society, technology, environment, economy and politics. Keeping these in mind, four scenarios were developed using 'economic model' and 'environment and resource management' as scenario axes. The scenarios started from the global view and presented the images of the future world. They then focused on the construction industry and imagined how the future world will shape the construction industry. The last step was visualizing the ICT implications of the future world and future construction.

After the scenario building stage, a preferred future for 2030 was determined based on four strands: People, process, technology and places. By taking this wider view, the aim was that the construction industry in 2030 would 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, pick and mix 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 was also another vision for 2030.

In order to achieve this 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. This vision will be revisited in the follow up events and will inform the future research activities.

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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. Many studies focused on the technology foresight at the national and governmental levels. Martin and Johnston (1999) approached the technology foresight from innovation angle, examined the political background to the technology foresight in the United Kingdom, Australia and New Zealand, and proposed a new rationale for technology foresight focusing on the 'wiring up' which refers to the means of communication. Grupp and Linstone (1999) and Salo (2001) provided a comprehensive review of the foresight activities and methodologies adopted. Havas (2003) discussed the relevancy of foresight exercises to a transition country focusing on the first Technology Foresight Programme launched in Hungary in 1997 and provided the policy conclusions and methodological lessons obtained through the implementation of this programme. Saritas et al. (2007) analyzed and discussed the Vision 2023 Technology Foresight Program for Turkey from a contextualist perspective and proposed that any change activity should be planned and implemented considering the context, content and process of change. Wonglimpiyarat (2007) carried out national foresight exercises in Thailand in order to contribute towards the formulation of technological and industrial policies through which a more competitive position can be enabled for the country.

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). Hampson and Brandon (2004) developed a vision for the Australian property and construction industry in year 2020 and identified eight key areas under this vision. 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 review, academic experts workshops, industrial experts workshop and feedback from industry. The vision was developed around seven major themes:

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

ICT Vision Development is a research project carried out under the Seamless Delivery Research Theme in the Salford Centre for Research and Innovation (SCRI) at University of Salford. It is aimed at anticipating what futures the construction industry and construction IT may face and developing an IT vision that takes into consideration the forces driving the future. In order to achieve the aims of the project, a scenario planning approach is employed and is supported by literature review, workshops and interviews. The ICT Vision Planning Workshop was the first of these workshops.

This workshop, held on 26th January 2009, brought together technical and non-technical researchers and industry professionals from different disciplines in order to determine possible futures that the construction industry and construction IT may face and to identify a construct IT vision for 2030.

The specific objectives of the workshop were:

- To identify the driving forces of change;
- To identify the main trends, issues, factors and actors ;
- To develop future scenarios for construction;
- To develop a preferred future for construction and construction IT; and
- To propose a set of recommendations and suggestions for action to achieve this vision.

The workshop was a collaborative research initiative between ITcon Journal, VTT, SCRI at the University of Salford, Loughborough University and ConstructIT. It was led by Prof. Ghassan Aouad, Dr Sami Kazi and Prof Andrew Baldwin and organised by Mr. Carl Abbott and Dr. Bilge Erdogan. Prof. John Ratcliffe and Dr. Ela Krawczyk facilitated the event.

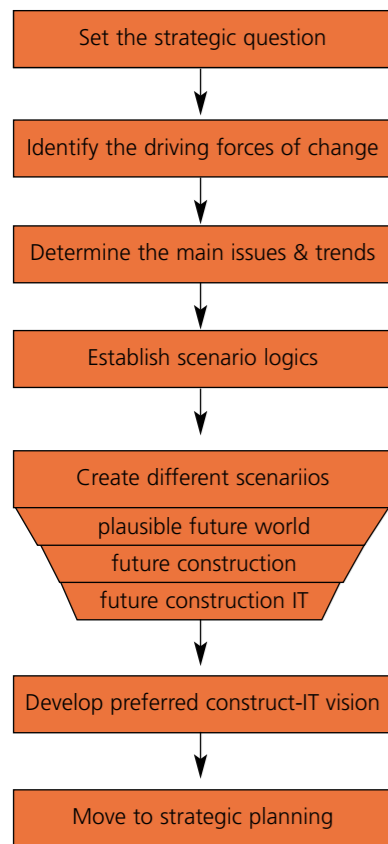
Bringing together world leading experts from different disciplines for a common reason, it was aimed to benefit from the synergy as well as initiating future collaboration and partnership between the attendees. Twenty eight invited experts attended from Australia, Canada, Denmark, Finland, Netherlands, Norway, Turkey, UK and USA. The companies represented were Arup, Integrated FM, CMIT & FIATECH, NG Bailey and Halcrow. The workshop had an interactive methodology which enabled a productive environment for brainstorming, exchanging ideas and discussions.



2. Methodology

The workshop followed a scenario planning approach adapted from La Prospective to suit the aims of the research and consisted of the steps shown in Figure 1. The prospective approach was chosen due to its track record of developing more effective policy and strategic decisions and tactical plans of action. Following the steps of the methodology, the agenda for the day was set as shown in Table 1.

The workshop consisted of many breakout sessions allowing the participants to work in groups interactively. A cartoonist was present during the breakout sessions. Wandering around and listening to the discussions, he created a number of cartoons that encapsulated the discussions in a humorous way. The cartoons were presented during the coffee breaks and at the end of the day. These cartoons stimulated further conversation.



08:30 to 09:00	Registration and coffee
09:00 to 09:10	Welcome & housekeeping and purpose
09:10 to 09:30	Thought Provocateurs Tim Broyd, Joe Tah, Matthew Bacon
09:30 to 09:35	Present the strategic question
09:35 to 10:10	Identify the driving forces of change
10:10 to 10:30	Group presentations
10:30 to 10:45	Coffee Break
10:45 to 11:45	Determine the main issues and trends
11:45 to 12:10	Group presentations
12:10 to 12:45	Establish Scenario Logics
12:45 to 13:45	Lunch
13:45 to 14:45	Create Future Scenarios
14:45 to 15:15	Group presentations
15:15 to 15:30	Coffee Break
15:30 to 16:10	Develop preferred construct-IT vision
16:10 to 16:30	Group presentations
16:30 to 16:50	Identify policies and actions

Table 1: ICT Vision Development Workshop Programme

Figure 1: ICT Vision Development Scenario Planning Approach

3. Workshop Findings

3.1 Summary of the Introduction

This section summarises the pre-workshop activities and the first part of workshop till the first breakout session.

Prior to the workshop, the participants were asked two questions in order to initiate thinking before coming to the event:

Please list up to six events which you consider might shape the future of the world and in what way.

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 stimulate thinking. A slide show was prepared using the responses and it was run as a loop during the introduction session 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. It was aimed to enhance thinking.

Prof Ghassan Aouad, Mr Carl Abbott and Prof Sami Kazi welcomed the participants, summarised the aim and objectives of the day and introduced three thought provoking speakers who gave brief speeches on their view of the future for construction. Three diverse views were present in these speeches. According to Prof Joe Tah, the construction industry would have a process-driven, autonomic, IT enabled future where the processes would be transformed beyond vision and problems would be solved much more intelligently due to the advanced use of networking, nanotechnology, virtual reality and computing tools. Prof Matthew Bacon used a monopoly game and the chance cards to picture different alternatives for how the future might turn out to be. Some of the chance cards were "significant Chinese investments in the UK", "serious financial meltdown situation leading to a massive loss of construction industry jobs with skills", and "European Union setting new standards". Tim Broyd from Halcrow presented a measured view on the previous speeches and underlined that despite all our efforts there had not been much change in most of the construction processes within the last 10 years. He stressed that we should be aware of the practicalities of the situation and carry out planning and implementation of changes carefully if we are to create a better future.

After the thought provoking speeches, the facilitators of the workshop, Prof. John Ratcliffe and Dr. Ela Krawczyk, took over and presented the strategic question of the day, which identifies the problem posed and defines the system under examination.

What are the IT implications of possible futures that construction industry might face? How should we prepare for them?"

3.2 Identify the driving forces of change

This was the second stage of the workshop and aimed to identify the forces, continuities, and trends which might shape the future. In order to help the participants, the following questions were provided.

- What are the main continuities?
- What are the major trends?
- What are the most important change processes?
- What are the most serious problems?
- What are the new factors 'in the pipeline'?
- What are the main sources of inspiration and hope?

This stage focused on the global level and in order to identify the driving forces of change five main areas were investigated: Society, technology, economy, environment and politics (STEEP). The participants worked in five groups during the breakout session where each one focused on the driving forces related to one of these key areas. Groups were asked to write the driving forces they found on post-it notes. After the breakout session, each group presented their findings and placed the post-it notes on the charts put on the wall (Figure 2 & 3). The driving forces of change obtained during the first breakout session are listed in Table 2.

	SOCIETY	TECHNOLOGY	ECONOMY	ENVIRONMENT	POLITICS
Driving forces					
Issues & Trends					

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



Figure 3. Workshop charts presenting the driving forces, main issues and trends



SOCIETY	TECHNOLOGY	ECONOMY	ENVIRONMENT	POLITICS
Growth in households Growth in consumption Population growth Social inequalities Better education tailored for the needs of individuals Free movement/ open borders Increase in mobility Aging population Emerging economies/ shift in the economic balance (i.e. China and Brazil) Communication Technology facilitating connectivity Credit crunch More happening in the home (ie. healthcare delivery, people working from home) People living longer and working longer	Processing power devices Interoperability Current interest in BIM and new technology Usability (user interface) Standardisation Band width availability Eternal nature of knowledge Fusion of human skills and computing power Seamless communication Regulation of technology Archaic education systems Cloud computing IT tool disposal/ sustainability as a disposal of IT tools Integration of BIM, GPS&GIS Robotic construction Pervasive computing Ubiquitous computing Education and future generation of workforce Legacy culture	Resource scarcity Environmental constraints Balance of basic needs Global vs. national interests International democratization Free trade vs. protectionism Increasing distrust in the financial institutions More government ownership of banks No trade in cash in goods only Recession – centralisation and decentralisation Global corporations act in self interest not society interest Obama effect on international capitalism Investment capitalism replaced by production socialism Only 2 to 3 global contractors that can serve clients Eastification Technology breakthrough Behavioural change at the house and community level Loss of apprenticeship	Society appreciation of environmental issues will continue to grow Recycling processes Tokenism in response to problems i.e. plastic bags in supermarket Continuing degeneration for foreseeable futures Change in people behaviour and attitude Reduced energy consumption Bio-inspired ideas Advances in technology Export of issues : i.e. to China and India	Regulation Corporate sustainability Corporate social responsibility Greater regulation driving-new levels of performance Greater public investment Continuity of standards New US president as a change process Relationships Safe guarding of trading interests United States of Europe as a change process Energy independence as a new issue Assertiveness of Russia regarding gas Financial meltdown New issues Greater public investment Nationalisation Greater accountability

Table 2. Driving forces of change

3.3 Determine the main issues and trends

This stage focused on the main issues and trends that might shape the future considering the drivers of change identified in the previous stage. For this reason, the participants were asked to examine the trends by looking at three levels: Meta, Macro and Micro where they reflect the issues related to the global, construction industry and IT in construction respectively. The groups remained the same as for the first breakout session. Each group identified the main issues and trends for the STEEP category they had worked in during the first breakout session and presented the findings by placing the post it notes on the second row of the table chart (Fig.2 & 3) on the wall. The main issues and trends are listed in Table 3.

3.4 Establish Scenario Logics

Based on the preceding issued and trends, this stage identified a logical rationale and structure for the development of future scenarios. For this reason, each group was asked to agree on three themes that describe the most important variables that will change the future. Eight variables were obtained from the groups as shown in Figure 4.

When these themes were reinvestigated, global environmental change, future financial framework and seismic power shift were found as the most critical ones and hence were used to determine the scenario logics. Finally, the axes to be used to frame the scenarios were identified as 'Economic model' and 'Environment and resource management' as shown in Figure 5.



Figure 4. Themes proposed for scenario building

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	SOCIETY	TECHNOLOGY	ECONOMY	ENVIRONMENT	POLITICS
META	Emphasis on low carbon solutions Emphasis on renewable resources Emphasis on use of local materials Clear invitations for a surveillance society Common forms of identification New technologies New methods delivery Global standards for education Bespoke delivery Faster, cheaper mobility Harmonisation of laws, tax regimes, norms Scarcity of resources Urbanisation and the problems coming with it (ie pollution, healthcare delivery)	Adoption of technologies New processing power, reduced costs, new technology Move robots out of the environment Manufacture, use and disposal of equipment 'Bio-computing' Local generation of hydrogen for power 'Fusion Power' Power consumption Efficiency Cooling of the processes Automation increases security risk Encryption Bio-metrics Internet of 'Things' /Everything connected (objects, people etc) Freedom of information versus Data protection Rapid advance of technology increases dependency and 'removes' users from understanding of technologies	Trade in gold Cost of carbon (£) What carbon footprint means Have definitions, metrics, benchmarks to know risk value streams resource pools	Legislation of carbon leads to renovation of existing buildings Carbon reduction and wise use Change material Changing energy consumption Reuse of recycle Reduce waste Population change Change demographic Telecommunication Offsite manufacturing Integrate supply chain	Emergence of integrated policies Convergence of regulations Each country interprets the regulations according to them Common energy policy (CEP)(similar to the common agricultural policy) Trust- openness v privacy Community responsibility regarding sustainability Recession/ financial meltdown Fuels innovation

Table 3. Main trends and issues that might shape the future

	SOCIETY	TECHNOLOGY	ECONOMY	ENVIRONMENT	POLITICS
MACRO	Emphasis on standardisation/ modularisation/ off-site Emphasis on rapid solutions Emphasis on more cost-effective solutions Resilient buildings and technologies Different need or no need for school buildings Life long learning Multi skilling Flexible workforce Mobile workforce 24/7 working Need security Demand growth Clear need for resource efficiency	Robotic construction Fragmentation of industry Cooperative working methods Early involvement of the team fosters understanding and builds trust Better, more efficient working virtual processes Technology use to develop new products and processes Data interoperability through imposed regulation or standardisation Market forces Waste and energy savings by using BIM More off-site work than on-site Failure to exploit and adopt new methods and technologies due to culture	Private vs public financial models Project governance Company structure - Centralized vs decentralised SMEs take initiative in implementing changes Changes driven by big companies Company specialization according to client type i.e. healthcare, car manufacturing factory, energy	Use of IT in construction can change the supply chain in a way that could lead to environmental industry less waste and better use of resources Organization structure Technology, barriers change Legal liability /organization (permission) Not use properly Education Technology improve service Reduce carbon waste Balance- use produce (electricity) Attitude change Sustainability Prescriptive performance Fuels innovation	Prescriptive sustainability performance Through sustainability planning regulation Design for sustainability compliance Methods to check compliance of the suppliers to the standards Map supply chain- industry association and self policing Cost v environmental trade off How to use existing stock of buildings
MICRO	Greater role for IT in manufacturing and construction Liability resolution in BIM Access control to construction processes Collaborative education programme All to be IT literate Simpler IT Simpler interfaces Need for ontologies/ taxonomies Standardisation Distributed working Greater user diversity Proliferation of information	Complex, advanced models & simulations on smaller mobile devices Integration of GPS, wearable computers, augmented reality, high speed communications Skilled in use of new IT Instinctive understanding Reduced training Open source/ iso-standard IT	Construction IT is economic driver itself	Project level integration of technology and internet telecommunication Load dispersion Rationalisation of sustainability metrics Measure resource consumption relative to community as a whole	Measure resource consumption relative to community as a whole Automotive checking Simulation specification How to trade off decision costs versus environmental trade off Transparency of information

Table 3 cont'd. Main trends and issues that might shape the future

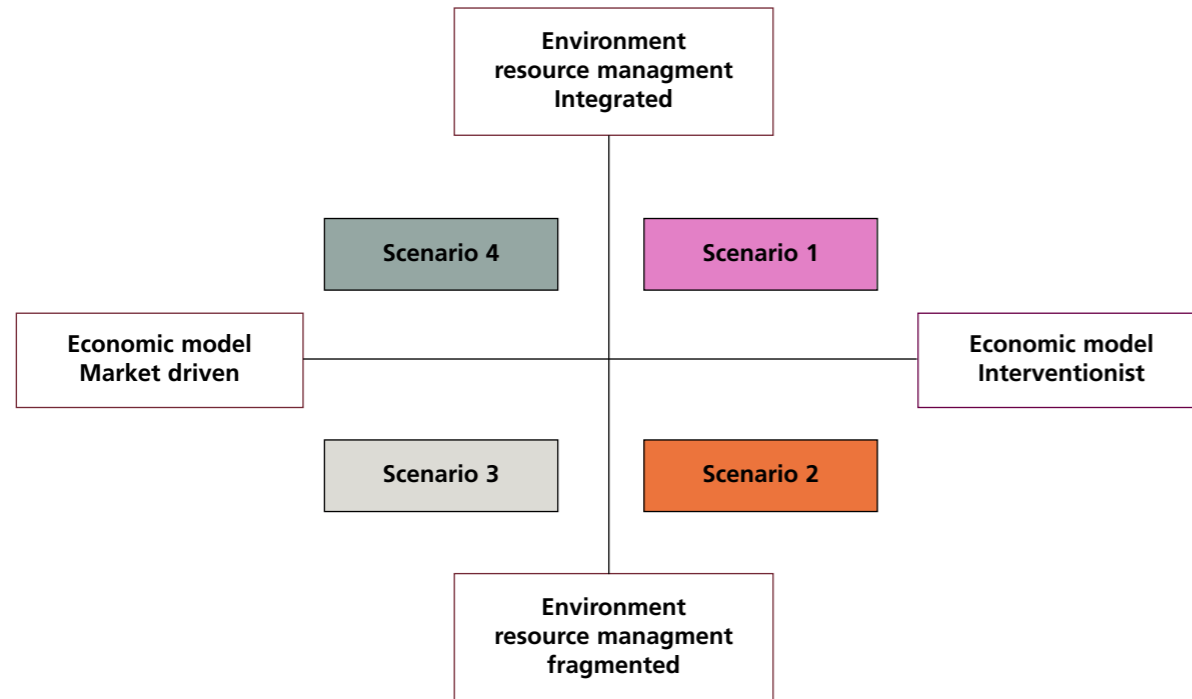


Figure 5. Scenario logics

3.5 Create Future Scenarios

This stage focused on developing the future scenarios using the scenario logics identified in the previous section. The participants worked in four groups where each group was assigned to develop a scenario in one of the quadrants shown in Figure 5. The participants were asked to identify an approximate timeline, early indicators of change and a memorable title describing the essence of the scenario. It was intended that the scenarios would start from the global view and present images of the future world and then they would focus on the construction industry and identify how the future world will shape the construction industry. The last step would be imagining how the ICT implications of the future world and future construction might look like. The groups were told that each scenario should be challenging, evocative, consistent, imaginative and plausible.

In order to help the participants, the following questions were provided to be answered in each scenario.

- What will the construction industry and IT within it be like in the year 2030?
- What are the most important changes that have taken place up to this year?
- What major opportunities has the construction industry had since 2009?
- What threats has the construction industry had since 2009?
- What shocks or 'wildcards' have impacted upon the development of the industry?

Although the scenario axes were chosen as the economic model and environment & resource management, it was stressed that the two variables were not independent from the other six variables (Fig 4) and participants were asked to picture the scenarios with all of the variables in mind. At the end of the breakout session, each group presented their scenarios. These scenarios are outlined opposite.

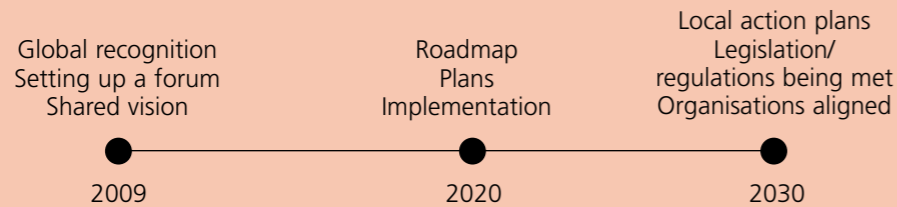


Figure 6: 4 future scenarios



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.



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 a body like UN will be established to set out goals for climate change and to develop a shared objective, vision and mission. This will be a mixture of "carrot" and "stick" approach. 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 middle phase, 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.

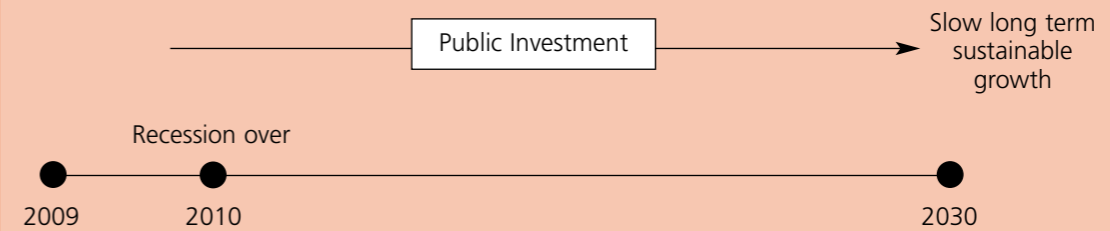
Construction industry's ability to keep up with pace of change, generally in IT, might be a threat. The industry is still not open to new ideas and changing work practices. The need to keep up with the skills and skilled personnel who are able to deliver the buildings will be another major threat. Training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

SCENARIO TWO- BEST AND WORST CASE THINKING

The initial aim was to identify one single scenario picturing a possible future when there is a fragmented resource and environmental management system and an interventionist economic model. However, the group working on this quadrant followed a different methodology than the rest of the groups. They first focused on the recession and considering this as a variable, they came up with two different options -best and worst case scenarios- for how the recovery from the recession might take place. Secondly they tried to picture how the future world, construction and construction IT might look like in each state. They again focused on the extremes and developed the best and the worst scenarios considering a fragmented resource and environmental management system and an interventionist economic model for each of the best and worst cases of the recession and recession recovery. This methodology resulted in four different scenarios which differ from the other three scenarios provided by the other groups. However the group provided a valuable and comprehensive in depth thinking of different outcomes and relationships between different events and outcomes. Although the methodology was different than the others, the discussions are believed to enable the group members to have an understanding of 'what might come round the corner' and progress to the vision planning stage. The discussions brought up by the group are summarised below:

Before analysing the future scenario, it was intended to look at the current global economy and to picture how it might look like in the future. Two scenarios have been developed for the best and worst cases of the economic landscape, which were called as "Long March" and "Slash and Burn" respectively. These scenarios and how the future will occur in these scenarios considering the existence of a fragmented resource and environmental management system and an interventionist economic model are explained below.

BEST ECONOMIC LANDSCAPE- LONG MARCH



In the best case, the recession continues for 5 years which will be followed by high public investment.. Unlike the worst scenario, it was considered that China might be suffering during the recession period as well as the others. Following the high public investment, there will be some new economic partnerships formed in the middle term resulting in a new global financial framework. With the intervention and global government investment, some robustness returns to the economy and a long term sustainable economic growth starts.

The group came up with a best case and worst case scenario if a fragmented resource and environmental management system and an interventionist economic model are considered for the long march scenario. The best case is called as "Scrubbing" whereas the worst case is called as "Chameleons".

Chameleons:

Due to the fragmented approach, companies are developing their own things 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.

Scrubbing:

There are already some efforts in CO2 scrubbing use in energy in some countries. The emerging technology will enable cleaning up the gases. The major industrialised countries will use these technologies to scrub all the carbon emissions.



SCENARIO TWO CONT'D- BEST AND WORST CASE THINKING

WORST ECONOMIC LANDSCAPE- SLASH&BURN



In the worst case, the recession continues for 25 years. Therefore by 2030, the traditionally strong economies will have gone bankrupt. If they are not completely bankrupt, then the economic growth rate they have will be very slow. On the other hand, the emerging robust economies are expected to take advantage of this situation and to invest heavily in the west using all of west's resources and knowledge to get stronger everyday in this newly evolving commercial world. The group named this scenario as "Slash and Burn" considering that the west will become a body shop for these emerging economies.

The group came up with a best case and worst case scenario if a fragmented resource and environmental management system and an interventionist economic model are considered for the slash and burn scenario. The best case is called as "Green Shoots" whereas the worst case is called as "Who cares Kyoto?".

Who cares Kyoto?:

There is rapid continuous growth among the Asian and emerging economies all around the world, which results in huge amount of increase in pollution. Since the economic situation is really depressing in Europe and most of these economies will have gone bankrupt, their primary goal will be on the survival. Therefore there is an abandonment of the environmental control and hence the Kyoto principles.

Green shoots:

The emerging technologies results start to have second thoughts and becomes more considerate to the environmental issues related to the investments in the new power stations and heavy plants, and getting CO2 reclamation from the emission gases. Due to the fragmentation, the countries and regions focus on their own region only, therefore the changes remain only in their own domain and does not create big changes. However, the individual efforts result in some green shoots

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".



The current recession period will continue for a while but around 2012, the recession will 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 SMEs and the future will be left with 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 the 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. SMEs 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.

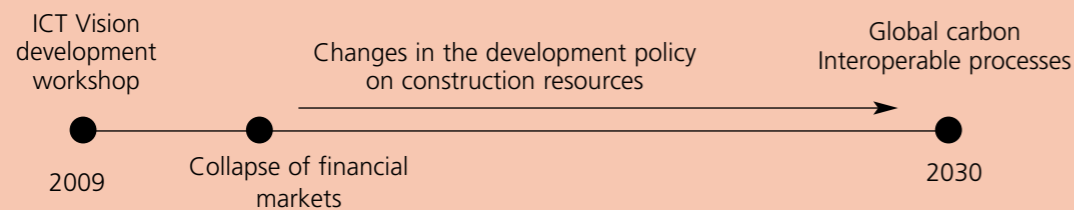
There will be fragmented ways of looking at sustainability since the environment and resource management is also fragmented. Each company will have their own methods to define and measure sustainability as well as different ontology. If compared to the extent of sustainability approaches in construction 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's, 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.



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 was 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.



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.

3.6 Develop preferred construct-IT vision

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 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. The vision would be built from four strands: People, processes, technology and places. The participants worked in four groups for this stage and each group was assigned one of these strands.



Figure 7: Environment issues



ICT VISION-PEOPLE STRAND

Defining the ICT vision for construction, IT is considered as means or an enabler to deliver projects not the end goal in itself. People processes will be much more part of the planning. The people strand was broken into five key areas which had some overlaps in between: working practices in future, skills required, activities carried out, roles changing, and interaction between IT and people.

Working practices:

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. Virtual reality and possibly holograms will become 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. In summary, it is expected to have less geographically dependent work practices in future.

People skills:

The future will require multi-skilling of people. 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. Therefore, 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.

Activities carried out:

IT will enable people having less drudge leading to more creative and more stimulating work. The construction industry will be perceived as more around design and innovation rather than manual labouring. Off site construction will increase. Robots will be doing the major work increasing the health and safety on site. The processes will become more efficient and streamlined through the help of IT. 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.

Roles changing:

IT will enable the checking of regulations such as fire and planning regulations and manage to eliminate waiting for fire and planning officers to approve the design. Likewise 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.

Interaction between IT and people:

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. Collaboration between geographically dispersed teams will be more possible.

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 IT.

ICT VISION-PROCESSES STRAND

The vision for 2030 is best practice of new integrated business processes which are consistent and compatible. Regardless of the client type, the future processes will make the most of new technologies like wireless technologies and ubiquitous intelligent frameworks. Processes will be all integrated. The best use of emerging technologies will be enabled through adaptable processes. The extent of changes required for technology implementation will be determined before deciding on implementation.

The group also provided some assumptions related to this vision. Based on the current economic situation, it is expected that the government will be more interventionist and will determine specific tools developed by specific enterprise organizations resulting in a prescribed automation and prescribed processes. Therefore, the way people work will be different than today. Most of the tasks carried out by manual workers now will be carried out by the robots or in the factories.

It is also expected that there will still be some work taking place without the intervention of the government. In the post depression period, there will be some work sponsored by private sector clients and these will mainly be carried out by a number of small teams collaborating. Since they will not be dependent on the public funding, they will be more flexible in choosing the tools, technologies and processes they want to work with.

ICT VISION-PLACE STRAND

The group considered places equivalent to spaces and broke it down into some categories during analysis:

- 1) Personal spaces and group spaces;
- 2) Internal spaces and external spaces;
- 3) Adaptable spaces, fixed spaces and cost of flexibility;
- 4) Virtual space, physical space and related interactions (within the virtual space; between the physical space and augmented reality)

Appropriateness of the space for the functions and activities carried out in that space is defined as the performance measure for all of these spaces listed above.

The group then looked into the opportunities for construction IT and came up with an ICT vision within context to places. These are categorised below:

- 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



ICT VISION-TECHNOLOGY STRAND

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.

These will enable the construction professionals to focus on what they do rather than how they do it. 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. For this reason, the technologies were divided into three as basic, external and distinctive technology. The basic technologies are technologies like Microsoft Outlook that people do not need to know how it actually works. External technologies would be the technologies people need to have an understanding of the input and output and how they are connected. i.e finite element stress analysis software. The distinctive technologies are the technologies making a company more competitive compared to its rivals.

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.

Intelligent buildings will be more common in 2030. Through the embedded sensors in the buildings, it will be possible to manage self healing/ self correcting buildings.

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

3.7 Identify policies and actions

This stage focused on what should be done to achieve the preferred vision defined in the previous stage. For this reason, each participant was asked to list three action areas for each strand forming the vision on sheets which were collected at the end of the workshop. When analysed, it has been realised that some key action areas were frequently occurring in these sheets. These areas are provided below:

1. Manage change and innovation

- 👉 Promote innovation
- 👉 Be open minded to new ideas
- 👉 Encourage new ideas
- 👉 Adapt change
- 👉 Incentivise to change behaviour
- 👉 Realise behavioural change
- 👉 Control the acceptance of change
- 👉 Find solutions that add real value
- 👉 Encourage creative use of IT

2. Enhance communication and collaboration between people

3. Develop multi-disciplinary and cross-functional teams

- 👉 Use organizational virtual models in order to set the right team to solve tasks
- 👉 Develop multidisciplinary and team collaboration skills

4. Connect people

5. Improve education

- 👉 Understand the need for education on all levels in our organizations
- 👉 Align the training & education plans to future work requirements
- 👉 Educate for better skills and values
- 👉 Educate for collaborations
- 👉 Educate/ train people in real world issues and challenges rather than in 19th century silos
- 👉 Develop educational programs which facilitate impaired industry use of IT
- 👉 Educate to use tools
- 👉 Educate to understand implications

6. Support flexible working

- 👉 Support home/ remote working where appropriate
- 👉 Support mobile working

7. Capture knowledge and reuse

8. Motivate and enable people

- 👉 Understand people's needs
- 👉 Motivate people
- 👉 Enable people
- 👉 Increase people satisfaction

9. Manage training

- 👉 Manage training
- 👉 Enable lifelong and self directed learning
- 👉 Enable re-training

10. Build trust

11. Enable automation of processes

12. Focus on benefits of the processes

- 👉 Understand benefits/implications of alternative processes
- 👉 Focus on value adding processes
- 👉 Develop sustainable processes
- 👉 Publicise ROI/ savings through process enhancement

13. Plan the processes considering the environment

- 👉 Impose environment friendly processes
- 👉 Understand full environmental impact of construction activities
- 👉 Develop new processes with reduced environmental impact

14. Improve and innovate processes

- 👉 Build dynamic processes
- 👉 Accept ongoing process improvement
- 👉 Keep evolving
- 👉 Develop adaptable processes

15. Integrate the processes

16. Link the processes with technology

- 👉 Integrate process with technology
- 👉 Integrate technology to support existing processes
- 👉 Use IT sparingly in processes but in practical and innovative ways

17. Promote standardisation of processes

- 👉 Encourage use of standard industry processes
- 👉 Develop standards for processes

18. Streamline the processes

19. Increase transparency of the processes

**20. Achieve interoperable, integrated and holistic IT**

- 👉 Define open standards
- 👉 Integrate IT
- 👉 Solve interoperability issues
- 👉 Implement holistic solutions
- 👉 Improve pervasiveness
- 👉 Use agile technologies
- 👉 Integrate processes with technology

21. Develop easy to use IT

- 👉 Develop user friendly/ fun/ nice solutions
- 👉 Choose intuitive interfaces

22. Set up virtual collaboration

- 👉 Investigate how collaborative business processes could be facilitated within virtual workspace
- 👉 Develop new methods for collaboration which support multiple channels- voice, video etc
- 👉 Develop unobtrusive, affordable hardware to support collaboration
- 👉 Enable open access virtual spaces
- 👉 Carry out more workshops and conferences for sharing and collaborating
- 👉 Carry out virtual space, second life meetings

23. Enhance flexible and reconfigurable workspaces**24. Go greener**

- 👉 Define clear incentives/ sanctions/ rebates/ grants for environmental projects
- 👉 Focus on green places
- 👉 Aim less energy demanding places
- 👉 Mandate a focus on whole life carbon costing rather than pure capital cost
- 👉 Create sustainable construction
- 👉 Re-use materials
- 👉 Set environment targets for new buildings

25. Enable ubiquitous collaboration

- 👉 Use inclusive technology in community everywhere
- 👉 Make the technology more accessible
- 👉 Have new screen technology available everywhere
- 👉 Focus on ubiquitous computing and collaboration
- 👉 Enable useful applications e.g. travel data at bus and train stops
- 👉 Implement virtually real spaces

26. Focus on end-users of places

- 👉 Pay attention to the changing demographics and trends
- 👉 Study how people can use space/place and assess the importance of customization/ flexibility on use
- 👉 Create spaces which are more human
- 👉 Use spaces to "bring people together"
- 👉 Focus on user satisfaction
- 👉 Focus on the needs of users

27. Develop intelligent buildings

4. Conclusion

This report has presented the findings of the ICT Vision Planning Workshop held on 26th January 2009. The workshop benefited from the synergy between 28 participants consisting of technical and non-technical researchers and industry professionals. The aim of the workshop was to identify the possible futures construction industry might face and so to start developing a construction IT vision for the year 2030.

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, each group was asked to agree on three themes that will have the highest impact on shaping the future. 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). Three scenarios were developed for the three quadrants of the axes. For the scenario planning efforts in the second quadrant, a different approach was followed by the group members with the addition of 'economic landscape' as a third dimension and focusing on the best and the worst case scenarios. Although this group followed a different methodology than the other three, in-depth discussions on the possible outcomes of future also enabled thinking out of the box.

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.

Places were considered as spaces by the participants. One distinction which was not recognised by the participants was that the places could be considered as the product of the construction activities as well as the places in which we function and we do business. For this study, not much explanation was provided to the participants on what is meant by technology, people, process or places intentionally in order to let the participants think without any boundaries.

During the workshop, some key action areas were also determined in order to achieve the 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.

Feedback from the attendees will be requested regarding the workshop itself and potential avenues of development. The workshop report, this is it in draft, will be finalized according to the feedback received from the participants.

The workshop was run in collaboration with ITcon special issue "Next Generation Construction IT: Technology Foresight, Future Studies, Roadmapping, and Scenario Planning". A book will be published on the same theme as well.

It is 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 our vision of the future. The resulting scenarios and the vision are supported by the action areas that have clearly benefited from the different expertise brought together on the day. The workshop is not the end of the process. The event created an enthusiasm and momentum that together with a range of follow on activities should be used to develop and refine our vision for the future of construction IT. The final IT vision will also inform the future research activities.



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