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APPLICABILITY OF AUTOMATION AND INFORMATION TECHNOLOGIES IN CONSTRUCTION SECTOR FOR DEVELOPING COUNTRIES

İlker ÖZDEMİR[1]

ABSTRACT: *One important aspect of automation in construction has been the search for Computer Aided Construction (CAC). The achievement of CAC requires a combination of strategic and tactical developments. One of the strategic considerations relates to the planning frames by which computer integration and Information Technology (IT) is enabled or encouraged. Reflecting the concerns of global enterprises in a competitive economy, describes the planning stage as those relating to: awareness, opportunity and positioning. This paper discusses the results of an initial analysis of how these planning stages can be used in construction. The discussion is illustrated throughout the paper with a number of examples of conceptual planning frames developed at these levels.*

KEYWORDS:*, Planning Stages, Strategic Planning, Tactical Planning, Computer Integrated Construction, Information Technologies.*

GELİŞMEKTE OLAN ÜLKELER İÇİN İNŞAAT SEKTÖRÜNDE OTOMASYON VE BİLGİ TEKNOLOJİLERİNİN UYGULANABİLİRLİĞİ

ÖZET: *Yapıda özdevinim konusunda önemli hususlardan biri de Bilgisayar Destekli İnşaat (BDİ) olanaklarının araştırılmasıdır. BDİ'yi başarabilmek için stratejik ve taktiğe dayalı geliştirme çalışmalarının ve bilişim teknolojilerinin (BT) birarada düzenlenmesi gerekmektedir. Bilgisayarın katılımıyla gerçekleşecek planlama çerçevesiyle ilgili stratejik düşüncelerden biri de bu konuya inanmak ya da cesaretle yaklaşmaktır. Rekabetçi ekonomide geniş iş hayatının bağlı olduğu planlama aşamaları genelde ödüllendirme, fırsat yaratma ve uygun işe yerleştirme biçiminde tanımlanmakta ve bunlarla ilgili olarak karşımıza çıkmaktadır. Bu makale, sözkonusu planlama aşamalarının yapıda nasıl kullanılabildiği hususunda yapılan bir ön incelemenin sonuçlarını vermektedir. Çalışma, sözü edilen aşamada, kavramsal planlama çerçevesini gösteren örnekleri ele almaktadır.*

ANAHTAR KELİMELER: *Planlama Aşamaları, Stratejik Planlama, Taktik Planlama, Bilgisayar Destekli İnşaat, Bilişim Teknolojileri.*

Osmangazi Üniversitesi, Mühendislik Mimarlık Fakültesi, İnşaat Mühendisliği Bölümü, Batı Meşelik Kampüsü, 26480 ESKİŞEHİR

I. INTRODUCTION

The need for automation in construction is made by the increasingly sophisticated demands for quality and time that are made by construction clients and by the shortages in skilled construction workers in some parts of the world. One aspect of the drive towards automation has been an attempt to apply IT. CAC has been used as a goal in our efforts to use IT for automation. The aim of this paper is to demonstrate how the strategic IT planning frameworks used in other business sectors apply to construction. Research and practice in CAC requires tactical and strategic developments. It is argued here that much of our preoccupation to date has been with the tactical issues that relate to technology.

CAC is a goal towards which we are all working but we must recognise the variety of problems that contribute to its achievement. These include matters of technology and how to integrate. This is the area where we are concentrating our efforts at present. We appear to be developing sophisticated and extensive answers to this question. We must also recognise that where, why and who are important questions to ask. This paper attempts to provide some ideas about what the answers to these other, currently unanswered, questions might be.

II. A FRAMEWORK FOR (CAC)

One of a growing number of contributions that has been made to the thinking in managing IT and applying it strategically has been made by Earl [1]. Other writers include Wiseman [2], Daniels [3] and Gerstein [4]. Amongst the issues raised by many is the need for IT to be applied for strategic advantage and the need for frameworks to be used to support this. Earl describes a series of frameworks to support a range of IT management issues. They are drawn widely from different leading IT strategists as we shall see. Earl has labelled these frameworks awareness, opportunity and positioning. The contribution that he suggests they can make to our management of IT is as set out in (Table 1). Daniels gives frameworks embracing: changes to industry structure, creation of competitive advantage, and the generation of new businesses [3]. Earl suggests frameworks are important in making the "technology - strategy connection" which is an expression also advocated by Gerstein [4]. Each of Earl's frameworks and the models within them are a means of changing the way we look at IT. None of them in themselves offers a complete answer as Earl acknowledges. They will not revolutionise the way we look at or use IT. However, they do contribute to a different way of thinking about technology and together represent a powerful collection of tools by which to analyse strategic possibilities.

Until now, in the construction IT research and practice communities, we have not really explored these types of frameworks or the strategic issues in any depth. Do they apply to us? If

so, do they apply in a different way to us than to other sectors? Who will implement and apply the models and frameworks? and what impact will they have on our current and previous research efforts towards CAC?

Table 1. A framework for CAC

	FRAMES		
ATTRIBUTE	**AWARENESS**	**OPPORTUNITY**	**POSITIONING**
Purpose	Vision	Ends	Means
Scope	Possibility	Probability	Capability
Use	Education	Analysis	Implementation
Construction Example	An Impact Model	Data Flow Diagrams	Strategic Impact analysis

Earl's framework may be useful to classify and categorise our separate and disparate research efforts. Where do product and process models fit in this picture? The construction examples above have been chosen because they reflect some of the work that has been done by the author, and others, towards CAC in developing countries. The work was initially done in ignorance of the planning frameworks described. They have proven useful to us in classifying and relating our different areas of research. They may similarly prove useful to others and to us all collectively in giving an overview of where our CAC research is taking us. Nowadays some serious meetings, courses and conferences have been made in those countries and Turkey simultaneously [5].

III. AWARENESS FRAMEWORKS

This first category of models is the most conceptual of the three. They are intended for executives to explore the potential impact of IT and to be of pedagogical value in educating us of areas of impact. They deal with the possibilities and the why rather than the how. They are visionary tools that are used to help change mind-sets, to suggest the scale of possible changes, and to indicate the strategic scope to a business or a sector. Earl, classifies them into three categories of refocusing frameworks, impact models, and scoping models [1].

III.1. Refocussing Models

These are based on asking two fundamental questions about the use of IT. One relates to whether it can be used to significantly change current business as opposed to continuing with traditional products and processes. The second concerns whether IT should be used to change either the approach to the market place or our internal operations. The combination of answers

to these two questions are demonstrated by the matrix in (Figure 1) which Benjamin et al [6] coined the strategic opportunities framework. They have entered the names of four key strategic IT systems that illustrate each of the four approaches.

	Competitive Market Place	Internal Operations
Significant structural change	XX	XXX
Traditional products and processes	XX	XXX

Figure 1. Strategic Opportunities Framework

These four examples illustrate the way IT is used strategically in some other sectors. A short description of some of these examples, taken from Earl, will help illustrate principles discussed in this paper and its potential for construction [1].

The value of the strategic opportunities framework is in raising general awareness rather than in identifying opportunities and allowing them to be implemented. Why rather than who, where or how?

Earl considers this to be too general for firm-specific use and that it needs to be tailored for different sectors. Its possible application in construction is to help us think of what form of strategic IT systems we may develop. There are two ways we can do this. First by observing and classifying the type of IT systems being used by us now. Second, to identify, speculate on and specify the type of IT systems that should and could be used in the future.

III.2. Impact Models

These models primarily address the question of who our IT systems should be developed by and for. A detailed example of an impact model quoted by Earl is that of Parsons [7]. It suggest a number of different levels at which IT can be applied. Our knowledge of construction requires us to extend these levels further as (Table 2 and 3) shows.

Table 2. The Tree-Level Impact of IT

Level 1	Industry Level
Level 2	Firm Level
Level 3	Strategy Level

Table 3. Five Level Framework for Strategic Applications of IT in Construction

Level 1	National Construction Industry
Level 2	Professional Institution
Level 3	Construction Enterprise
Level 4	Construction Project
Level 5	Constructed Product

To explain the five level framework in more detail, the globalization of construction means that nations, and more specifically their construction industries, need to undertake strategic IT planning and devise IT strategies. For strategic use of IT at the national level requires fundamental policy-making initiatives of a national body.

The professional institutions influence many national construction industries in a very significant way. Although major deregulation appears inevitable, for now we must still take note of this professional level in IT planning. This is because some countries, have their most strategic IT developments at this professional level. Professional level implementation is the responsibility of the institutions. Professional objectives are survival and inter-professional advantage.

A case could be made, in strategic IT planning, to treat the national and professional levels as one. That may be more appropriate in identifying strategic opportunities for the future. For now, and because the nature of this paper is to review past, present and future developments, the professional level is an important and distinct one for us to consider.

The construction enterprise or company is the level that equates best with the analysis used throughout this paper, much of which is drawn from enterprise-based industries. The most significant and common examples of current strategic IT planning in construction occur at this level. They are usually from major international contracting firms but also include component and materials suppliers.

The vast majority of construction enterprises, of a design or construction nature, are very small. The extent to which strategies can embrace both ends of this spectrum is a problem. Future implementation at the enterprise level may be of most commercial significance in the short term but we must recognize the variability that exists between enterprise size. Many innovative strategic initiatives for using IT will emerge in the immediate future if business development and strategic planning departments become widespread. The consequences of this will be restructuring, the creation of new businesses and the emergence of new information intensive products and services.

In contrast to business and manufacturing industries, the fundamental operating level of construction is the project, regardless of size of enterprise. This level equates with the industry

process. This explains our current pre-occupation in our research with project or process models. At the project level, implementation and consequences will differ again. Regular developers and owners of construction will have opportunities to exploit strategic IT planning. New owner demands based around IT are conceivable. There will be software houses and project information management consultants with potential to exploit competitive advantage through IT.

Finally, the increasing importance given above to product information intensity means finished buildings are a level at which IT can be used strategically. Much of our CAC research has concerned product models. The building implementation level is one where project, product and component designers have scope for applying the methodology. The short timescale and one-off nature of construction activity inhibits applications at this level. Again, possibilities exist for competitive advantage to be gained by developers and other industry participants with the objective in this case being better buildings. We therefore have a five-level framework to examine opportunities.

These different levels have been used in a strategic IT plan for construction in many developing countries. As a contribution to the extensive national infrastructural planning efforts [3], a communications network, in the form of an impact model, was drawn up for distribution and discussion among the local industry members. Those framework is described in detail elsewhere as has its scope and problems in its implementation [8]. The principles of the framework are depicted in (Figure 2). As an extension of the research project of which this framework was part, each of the major professions and types of enterprises have been examined for their current activities and these have been classified as areas where the impact model could support the current processes as in (Table 4).

III.3. Scoping Models

These are again a means of exploring general awareness of strategic potential within a sector by means of analysing the information component of a sector's processes and products. The suggestion is that there is little scope for exploitation of IT in a sector or part of a sector where the information content is low.

Where are the high information components of the construction sector and are we applying our CAC research efforts to these areas? (Figure 3) attempts to address this question by analysing which aspects of construction have the greatest information content in their process or product. The results of this analysis may seem obvious but are we aware of this in identifying areas for our CAC research? The number of object-oriented papers in the research literature that seem to address doors and windows because they fit the technology rather than the need and scope

DESCRIPTION	GOVERNMENT INFORMATION SYSTEM		PROFESSIONAL INFORMATION SYSTEM	
Consultant appointment - notify Details of workload and available			X	
Recruitment of new staff			X	
Preparation of Specifications - a national standard specification			X	
Nomination of contractors for tendering – standardised pre-qualification methods	X			
Final accounts for completed Projects	X			
Maintain records of material Prices	X			
Results of price enquiries to Suppliers			X	
Compile building tender price Index	X		X	
Compile building materials cost index	X		X	
Application for permits before site commencement	X			

Figure 2. An Impact Model for Construction in Developing Countries

Table 4. Analysis of Industry Information Systems Requirements

Information Content Of Product	L O W	Delivery and assembly of low-tech building sub-systems e.g. Windows, doors, concrete beams, excavation, casting,...	Delivery and assembly of high-tech building sub-systems e.g. elevator, access control system, remote maintenance monitoring system,...
Information Content Of Process	H I G H	Construction process in planning, estimating, managing and control stages.	Architectural and engineering design. Software development. Database creation and distribution.

suggests this form of model may have application in providing us, the research community, with a clearer idea of the strategic scope.

A model like this one identifies where our first steps towards CAC should be made, if we are to be working with the strategic business forces rather than against them. It shows where the scope in construction is. These areas are identified as being in architectural and engineering design, software development, database creation and distribution. These areas are characterised by high information intensity in both the process and product. They are not the areas where we usually concentrate our CAC research. They may appear peripheral to the mainstream activity of much of construction. However, the model suggests that this is where we should concentrate our research and that we should avoid those areas that the scoping model is drawing our attention away from. The depth and sophistication of the analysis in (Figure 3). Many of the other figures and tables presented in this paper, is insufficient for the purpose of us making a final commitment and more careful and detailed analysis is now required by us all. What this and other figures do is make a start in the strategic planning analysis required within our sector?

IV. OPPORTUNITIES FRAMEWORKS

These tools are of a different nature to those described above. They are not intended to be visionary or educational but represent the next planning stage. They are intended to be more practical in helping us analyse our sector's activities in more detail as a prelude to implementation. The frameworks are classified into four types:

1.) Systems analysis frameworks for information analysis across a business or sector.
2.) Applications search tools which examine a business or sector for good fit with technology generally.
3.) Technology fitting frameworks which are specific technologies looking for problems to solve.
4.) Business strategy frameworks which attempt to combine IT with potential economic benefits.

These opportunity frameworks are concerned more with identifying the ends rather than the means of achieving them. They are also concerned with establishing probabilities rather than the possibilities of awareness frameworks. They are more of an analytical nature. They attempt to address the question how.

IV.1. Systems Analysis Frameworks

These can take on one of three basic approaches.

1.) The strategic approach is typified by the value chain.
2.) The information flow approach is represented by data flow diagrams.
3.) The technology approach is typified by process and product models.

Value chains can be used to identify potential for competitive advantage within individual parts of the whole firm. The value chain is a structured way of analyzing a business's constituents and its links to outside organizations. Value is defined as what a company creates, measured by the amount buyers are willing to pay for a product or service. The difference between value and cost determines profitability.

Value chains can be used to identify lower cost, higher value and value channel linkage applications. The parts of the chain include an organization's infrastructure as well as different categories of its direct productive processes.

The use of data flow diagrams is one of a number of means by which information flow within processes can be traced. The application of this technique to parts of the quantity surveying enterprise's activities for developing countries is shown in (Figure 4). This was drawn in support of the impact model in (Figure 2 and Table 4).

The study that was made to trace information flow within the primary enterprise types in the construction industry. It was based on extensive, iterative, site-based studies within a sample of organisations. This was done for architects, contractors and quantity surveying enterprises. Others have looked at the information flow process using other techniques. These information flow frameworks help home in on opportunities.

IV.2. Applications Search Tools

These help identify where IT applications should be made within an economic process. An example (Table 5) is the Life Cycle Checklist proposed by Ives and Learmonth [9].

This views the life cycle of an economic process from the customer's viewpoint rather than the producers. This will usually entail a broader view than that normally taken by organisations particularly within highly fragmented sectors like construction. Many IT strategists suggest that systems beyond current boundaries of organisations offer strategic opportunities. Our first reaction to this table should be to ask ourselves where we are doing all our work. The answer appears to be mostly within individual parts of the life cycle relating to single organisations. Why is this the case? The answer appears to be the fragmented nature of the industry and IT may change this obstacle. In many ways the message of this model is that CAC requires it.

IV.3. Technology Fitting Frameworks

These forms of framework require examining current systems and emerging technology to identify chances for technological progression. They should be based on evolutionary rather than revolutionary system development. These frameworks appear to be our preoccupation at the moment. The research community seems more concerned with looking to fashionable

LIFE CYCLE STAGE	TYPICAL QUESTION	CONSTRUCTION EXAMPLE
Requirements Establish Requirements Specify Requirements	How much of the resource is required? What are the required resource's Particular attributes?	Feasibility Design Specification
Acquire Select source Order Authorize Acquire Test and accept	From whom will the customer obtain the resource? How will the customer order the product? How will the customer pay for the product? How, where and when will the customer take possession of the resource? How does the customer ensure the resource conforms to specifications?	Procurement Model Selection Tendering Negotiation Alternative Design Proposals Design Competitions
Stewardship Integrate Monitor Upgrade Maintain	How is the resource merged with inventory? In what ways can the customer monitor the resource? How will the resource be enhanced if conditions change? How will the resource be repaired if it becomes necessary?	Commissioning Use, Property Management Facilities Management Refurbishment, Maintenance
Retirement Dispose of Account for	How will the costomer move, return, sell or dispose of the resource when it is no longer required? How much is the customer spending on the resource?	Demolition Disposal Redevelopment Life Cycle Costing

Figure 3. Example of a Data Flow Diagram

Table 5. Customer Resource Life Cycle

PROCESS	PIS	EIS	IISG	IISP
Draft scope of work	X			
Decide on professional fees		X		
Conduct feasibility study based on market data	X			X
Produce spatial requirement and brief	X			
Amend spatial requirement and brief	X			
Propose various designs	X			
Decide on form of procurement	X			
Select contractor	X			

Legend: PIS - Project Information System,
EIS - Enterprise Information System
IISG- Industry Information System (Government)
IISP- Industry Information System (Professional)

technologies like expert systems, neural networks, object-oriented systems and desperately trying to find problems that the technology can solve. This is not the wrong approach but we

must recognise that it is only one approach. The way that management, business and technology are coming together in many spheres of economic activity has highlighted the difference between "technology-push" and "strategy-pull" as the principal drivers of technological innovation. This form of framework is based on the "technology-push" driver.

The analysis in (Table 6) shows the way in any sample country analysed the activities of valid architectural profession and its enterprises to force possible applications of expert system technology. These resulted from analysis of the data flow diagrams examples of which are shown in (Figure 3). The data flow diagrams were themselves in support of the impact model in (Figure 2). This shows the way models and frameworks, at these different levels and stages, interrelate. In our case this link was made retrospectively.

IV.4. Business Strategy Frameworks

The five forces model can be used as a means of positioning an enterprise in relation to market forces particularly through exploiting industry changes. The five forces within the model are buyer power, supplier power, threat of new entrants, product substitution and jockeying for position. The model can be used to identify where IT can be used to prevent new competitor entrants, to exert buyer or supplier power relationships, to offer substitute products, and to help in jockeying for position between competitors. The combination of business forces in (Figure 4) shows the nature of the competition within an industry segment. This is seen as a key framework by which to explore potential IT applications (Table 6). (Figure 4) illustrates Earl's interpretation of how IT can apply to these five forces [1].

COMPETITIVE FORCE	POTENTIAL OF IT	MECHANISM	CONSTRUCTION EXAMPLE
New Entrants	Barriers to Entry	Erect Demolish	Softwares *Professional*
Suppliers	Reduce Power	Erode Share	Softwares *National/Enterprise*
Customers	Lock In	Switching Costs Customer Information	Building Products *Product*
Substitute Products and Services	Innovation	New Products Add Value	Enterprise Corporation *Enterprise*
Rivalry	Change the basis	Compete Collaborate	Project Information Management *Project*

Figure 4. Five Forces Model

Table 6. Exploiting IT in the Competitive Arena

Strategic Impact in the Future	L O W	***Support*** Accounting Systems Office Otomation Word Processing *All Levels*	***Turnaround*** CAD *Professional*
Strategic Impact at Present	H I G H	***Factory*** Bills of Quantities Systems *Enterprise*	***Strategic*** System Maintenance Management *Product*

In the construction examples, IT systems development for subscribing members of professional bodies, is for their individual benefit. These examples come from the quantity surveying (QS) profession.

In any project is an on-line data sharing service of elemental cost analyses for design stage cost estimating. It is open to all profession members. This is an example of an inter-organizational information system. Its aim is to improve the design stage building price estimating service. A second initiative was participation by the QS profession in the other research program. The project was to build an expert system to aid in early project decision making. Access to the research product was denied to non-members of the profession as an attempt to erect a barrier to new entrants offering quantity surveying services. There is no evidence to date of the profession exploiting technology for links between their members and those of others in the industry.

CLIENT is a recently developed commercial product, by a software supplier, CSSP Pty Limited. It provides total project information management and acts as a central monitor of the status of information production and circulation between all members of the project team [10]. As many as eight individual organizations including architect, engineer, QS, builder and subcontractors use a dedicated terminal and modem link. All project communications at design and construction stage are through the system and monitored by the owner or project manager. The owner pays for the terminals, modems and software used by all the participants, treating it as a project overhead. The system is marketed not to architects, engineers and builders but to owners. Owners choosing to use the system are stipulating compulsory use of the software to all other organizations when discussing engagement terms. It is being used on several major projects in Australia and East Asia. It is a system that exploits value chains and buyer power as well as being influenced by and influencing the rivalry and nature of jockeying for position between industry members.

Wiseman's strategic option generator can also be described as a business strategy framework [2]. This consists of a series of questions that ask of the strategic target, the strategic thrust, the

mode of strategy implementation and the direction of use. The strategic target equates to Porter's three generic strategies [11]. The strategic thrust combines these with Chandler's growth strategies [12]. The model asks whether the thrust is offensive or defensive while direction describes whether the system is for the organisation's use or for the target's.

V. POSITIONING FRAMEWORKS

Up to now, the models and frameworks described have been general. When move from the general to particular, several actual models and frameworks become more practical. These third-stage positioning frameworks are managerial in orientation. They relate more closely to means rather than ends. They concern implementation and capability and refer more to the question how but from a procedural rather than a technological point of view. The range of positioning frameworks cover scaling, spatial and temporal. These relate to how far to take an IT implementation in terms of its context within the organisation and placing a new system in the context of other current systems.

V.1. Scaling Framework

A scaling framework refers to how far to take an IT system in terms of their strategic importance to an organisation. Are they critical to the business activity of the organisation or more simply systems that aid the business process? This can be addressed by again answering two questions. McFarlan suggest these can be framed by asking how quickly failure in an IT system would come to the chief executive's attention and secondly by whether IT development is one of the five things that must be right for the future survival of the organisation [13]. He provides an example of a major American financial institution for whom failure in their IT systems was immediately notified to their Committee of Education Operating (CEO) on the Friday afternoon when it happened. Business failure may have resulted if the system had not been reinstated soon after business resumed on Monday morning. This systems was clearly of high strategic impact at present.

In the grid in (Figure 5), some examples of generic and proprietary types of IT systems in construction have been classified. To describe these examples, accounting systems were one of first and remain our most common construction IT applications. Their strategic impact is limited and is likely to remain so. Computer Aided Design (CAD) as currently used is of limited strategic impact at present although important as a productivity aid. However, they are likely to be of key importance to the future of the design professions. Bills of Quantities systems, as used by quantity surveyors and contractors in different parts of the world, are unlikely to be of key strategic importance in the future as professional demarcations, deregulate and as CAC data

exchange becomes more sophisticated. However, in some cases at present, IT systems are of critical importance as manual systems have been extensively imitated and automated by these systems in some enterprises. In the rush of preparing a key tender, failure of one of these systems at a time that the bid is to be submitted, could be of strategic significance.

V.2. Spatial Framework

These are more closely related to analysing whole industry sectors and their general characteristics. Earl has commented on sector level assessment of IT impact with a classification of metaphors for the strategic context of IT in different sectors [1]. (Table 7) illustrates this and includes some examples from construction that we can apply to the metaphors.

V.3. Temporal Framework

CAC is not achieved in one step. Research sometimes presumes this to be the case. The achievement of CAC must be managed and gradually achieved. These frameworks address and relate to time and the level of managerial and technological progression. Their importance and contribution is to help us understand the nature of our gradual progression towards achieving CAC.

STRATEGIC CONTEXT	CHARACTERISTIC	METAPHOR	CONSTRUCTION EXAMPLE
IT is the means of Delivering goods And services in the sector	Computer-based transactions systems underpin business operations	*Delivery*	CAD Software ***Professional***
Business Strategies increasingly depend on IT for their implement.	Business and functional strategies require a major automation, information or communications capability and are made possible by these technologies	*Dependent*	Building Products ***Product***
IT potentially Provides new strategic opportunities	Specific applications or technologies are exploited for developing business and changing ways of managing	*Drive*	CAD data exchange Between design team Members with Industry organisation ***National/Professional***
IT has no strategic Impact in the sector	Opportunities or threats from IT are not yet apparent or perceived	*Delayed*	Assembly work on building sites ***Project***

Figure 5. Position of Information Systems: Construction Example

Table 7. Sector Framework for IT

Stage/Factor	Technology Identification and Investment	Technological Learning and Adaptation	Rationalisation or Management Control	Maturity or Widespread Technology Transfer
Challenge	Identify technology of potential interest and fund a pilot	Encourage user Experimentation on broader base	Develop tools and Techniques for Efficient use of Technology	Adaptation and of technology
Goals	Technical expertise and early application	User insight on Potential User awareness of technology	Value for money Reliability and Longevity	Diffusion Integration
Management	Lax planning and control	Encouragement and Observation	Standards, analyses And studies	Organisational Processes
Growth Processes	Technologic advance Application testing	Applications Advance User Learning	User advance Management Learning	Management Advance
Construction Example	Neural networks for planning and estimating	Expert Systems	CAD	Project Management Software

The construction examples are classified in this way to help us appreciate the nature of our research and development with different technologies. The classification should help us to understand and appreciate the stage and nature of implementation of different technologies and why they are at different stages. It can be drawn an analogy here adapted from Armstrong [14].

VI. CONCLUSION AND DISCUSSION

The aim of this paper was to examine how the range of frameworks and models used by IT strategists apply to construction industry of developing countries (especially Turkey's). The speculation was that they may provide a strategic contribution to our current technological progress towards CAC. A specific aim was to see how they could be used to coordinate research carried out.

Much more analysis remains to be done. In doing so we must address which is a problem of methodology. This concerns the question of whether our analysis of strategic opportunities should be based on our observation of what is happening or speculation and specification of what could and should happen. In the latter case, the problem is who should speculate and

specify implementations and under what authority they do so. This should be economic and business authority rather than theoretical and technical authority. We are also constrained whether our strategic speculations should be based on our current industry organisation or our assumptions of how the industry will be organised in the future. As we have seen, the fragmented current picture is a strategic barrier to CAC.

The main results of the analysis in this paper are that many of the models and frameworks do apply. We can classify much of our research and practice in construction by these models. The models do cause us to sit up and think about the research we are doing. They particularly cause us to ask the questions where, why and how far to go with IT applications. These questions have not been asked extensively before now. The major way in which this analysis shows the needs of construction to be different from other sectors lies in the answer to the question who. There are more possible answers to this for us and the five-levels we have identified each have quite different requirements. We have attempted to show the requirements of all five in this paper but in doing so we are only scratching the surface of the problem.

The analysis of all the models within each of the three types of frameworks could be made separately at each of the five levels. This gives rise to a problem we will continue to face. The overwhelming scale of opportunities and possibilities may prevent us focusing on the best. The achievement of CAC may be technologically possible but to be a business proposition it requires rationalising the implementation issue.

A conclusion that we can draw from our analysis is that the construction examples we have used are exceptional. The general picture is that much of our current construction IT practice is immature compared to other sectors and to the theory. The implications of these conclusions are that CAC research may currently be misguided in being too technologically oriented.

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