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# Strategy to Achieve Computer Integrated Construction in Singapore

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Keywords: *computer-integrated-construction, vertical integration, value-for-money, seamless transition, islands of automation, value-added-networks.*

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## *Computer and Construction*

It is only lately that information technology has emerged as a powerful strategic tool that enhances business competitiveness for design and construction firms. Computers are now increasingly used in conceptual modelling, design, analysis and drafting by design offices and for costing, project management and building maintanence by contractors. Today, 41% of architect firms in Singapore have at least one CAD workstation compared to 14% two years ago.[1]

Figure 1 shows all the typical phases in a contruction project. The flow of information between these phases and between the participants in each phase are where computer applications will have the greatest impact in the future. Information gathering begins at the project initiation phase and as the project progresses more information are created and used. The flow of information is greatest during the design and contruction phase. As the work progresses from design to contruction, the growth in data should reflect the emerging form and detail of the project. Once completed and in operation, the data will continue to be used by owner and tenant to plan its maintenance and operation and even future renovation or refurbishment work. The overlap in data requirement of architects, engineers and contractors and the different ways of capturing and presenting them is at the same time a challenge and a source of untapped potential. Imagine the quantum leap in productivity if all these data can be shared and the activities integrated [Chin, 1990].

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1 Cham, Tao Soon, 3 September 1990, Guest-of-Honour opening speech at the offical opening of CIDB's Design Support Centre.

Computer integrated processing is common in manufacturing and other production activity today. How this concept of integration can be applied to the construction industry is still a relatively new field of study. Construction activities are in many ways different from that of the manufacturing and other production activitives. They are characterised by the 4 Ds[Chow, 1990] -

* Discontinuous - no guarantee of a next job;
* Dispersed - organisational structure and activites dispersed to various sites;
* Diverse - multidisciplinary, diverse organisations whose interests do not always co-incide participate in planning, design and construction activities.
* Distinct - a construction project is a *Job-shop* . Each project is unique.

This contrasted sharply with factory based production process where activitives can be centralised (physically and organisationally), standardised and volume is sustained. As such, integration is markedly easier in manufacturing where rationalisation of the design and production processes is easier to achieve than in construction.

### *Integrating Information Needs In Construction*

The goal of *computer-integrated-construction* is to *vertically integrate* the data, design decisions and knowledge through all the different phases of development of a construction project. This is to improve the efficiency and quality of design and provide *value-for-money* to the client. Integration of computer application is more than just transfering and sharing of information. It involves automating the decision-making functions in each phase. This will require the introduction of more knowledge-based systems.

Computer integrated process is more easily achieved at the company level than at industry level. In some large international construction firms, CAD drawings generated by the design department are passed on to the engineering department for analysis and contracts department for estimating and contract preparation. The benefits to these firms of information integration by electronic means are clear and direct and so they have a stake in making it work. This concept is simple and logical. But unfortunately, it is still not widely practised in industry.

There are several reasons why this is so. Firstly, as a result of the separation of design and construction responsibility in traditional construction contracts, no single party has sufficient vested interest or involvement in all phases of the project to want to (and be in position to) implement a *seamless transition* from one phase to the next. Secondly, the proliferation of proprietory systems, from software platforms to design solutions, has resulted in different input/output format and structure and hence the information is not easily shared. There are currently many research work been done particularly in the areas of information structuring [Bjork, 1990] and environment for integration [Fenves et al, ].

### *The Need For A Construction IT Strategy*

Singapore is a small city state with a population of about 2.7 million people. The construction sector contributes about 5.5% to the Gross National Product of the nation. Last year the construction demand is about S$5.5 billion. This is expected to grow by 18% to S$6.5 billion this year. In absolute terms, the construction market in Singapore is small compared many countries in the world (Figure 2). The number of registered[2] contractors in

[2] All contractors, Singapore or foreign, who intend to tender for certain size of public sector construction contracts must register with CIDBin the relevant grade. They must comply with the requirements on track records, financial and personnel resources in order to be registered in a particular

Singapore numbered about 1600 while the number of professionals (engineers architects quantity surveyor) is about 1400. These figures show that the industry is made up of la number of medium to small sized firms. The largest contractor in Singapore has an ann turnover of about S$205 million[3] (Figure 3).

The development of an IT strategy for the construction industry in Singapore influenced by the following considerations:

a) the construction industry must embrace IT as a strategic tool to increase busin competitiveness. This dovetails with the national IT strategy to positi Singapore industries as world class exploiters of IT ;

b) the greatest strategic impact on raising productivity and competitiveness can achieved through development of industry wide systems and *value-adde networks(VANs)* ;

c) in Singapore, the resources of individual firms cannot support the development VANs. The process by which a market leader can pioneer the development VANs and demonstrate the benefits is therefore not available.

A sensible approach is therefore to go for industry-wide systems and standardisatio Two criteria however have to be met. Firstly, there must be a critical mass of computerisatio in the industry. There must be a minimal level of computerisation for the different wor processes in planning, design and construction. Secondly, the information flow within th industry must be structured. Currently, information generated within the constructio process are frequently firm and project-dependent, with no attention paid to the structuring information to allow for communication with other parties in the construction process. T enable integration, it is neccessary to establish an industry wide standard and a commo information structure so that cross-firm information flow can take place without unnecessar manual intervention.

With this approach in mind, the Singapore Construction Industry Development Boar (CIDB) formulated a Construction Information Technology strategy aimed at achievin higher level of computerisation for the industry, increasing strategic use of IT, and moving the industry towards integrated design and construction.

### *State of Computer Utilisation in Construction Industry in Singapore*

In 1989, CIDB carried out a survey on the level of computer utilisation in the industry. The survey involved about 76% of all construction related firms in Singapore. The more important findings are summarised here:

* **59%** have at least one piece of computer equipment (compared with **67%** for manufacturing industry, figure 4);

* The number of computer installation is projected to **double** in the next two years (figure 5);

* Only **10%** used computers for construction related applications. The remaining 90% used them for accounting and office automation functions.

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grade. This registration system was first introduced in 1985 to enable the government to have a reliable pool of contractors to carry out public works. The registration system, however, has indirectly resulted in the building up of track records, technical and financial commitments in several Singapore general and specialist contractors; with the result that they are now able to carry out projects of considerable size.

[3]This ranks it 168th in the top 250 International Contractor worldwide - ENR, 1989

* Only 2% have an IT budget exceeding 5% of their annual turnover.

Several implications arise from these findings. Firstly, the level of computer usage is in pace with development in other sectors. However, the strategic applications of computer is still low at 10%. Secondly, with the projected growth, the industry will achieve a critical mass of strategic users in the next few years. This brisk pace of computerisation drives home the need to formulate a national policy to respond and guide this growth. Thirdly, the results showed that only a small percentage of the firms are willing to spend on computer. This suggests that firms are yet to be totally convinced about how computerisation can significantly improve their competitiveness. Both promotional and developmental work will be needed - promotional incentives will help firms to reduce the cost of investing in computerisation; development of generic applications and VANs for the industry will add value to these investments.

### *IT Development Strategy*

CIDB adopts a three phase development strategy. Each phase corresponds to a specific level of computerisation of the industry.

*a. Mapping of information flow*

Information flow is central to any computer-integration process. Given that construction process is often characterised by the 4 Ds (dispersed, diverse, distinct and discontinuous), it is necessary to know the information needs of various players in the industry, the common data requirements, how they are exchanged and the volume and frequencies of the flow. This mapping will provide the framework for rationalisation of data requirements, identification of potential activities for automation and to support an industry wide information flow system.

*b. Create islands of computerisation*

Electronic integration presupposes that individual work processes are by themselves computerised. The mere exchange of data electronically without a system to process these data and islands of computerisation should not be viewed as a piecemeal approach. Rather it helps to sustain the momentum of computerisation in the industry and is a small but definite step towards the objective of full integration.

*c. Integrating islands of computerisation*

Creating islands of computerisation will bring about some benefits to the firms. By integrating these islands, the benefits to the industry will increase many folds because of the synergies that existed among firms can be tapped. This phase is the most sensible but it is also the most difficult to implement. Integration involves communication and that means hardware interface, and more importantly, standards and rules for data exchange.

### *IT Development Programmes*

Based on the existing state of industry computerisation, CIDB together with other principal members of the industry such as Singapore Contractors Association, Singapore Institute of Architects, Institute of Engineers of Singapore and Association of Consulting Engineers are developing a National Construction IT Programme. Several projects are in place.

*a Incentive Schemes to Increase Computerisation Level*

To improve the level of computerisation, CIDB and the National Computer Board (NCB) administer a set of incentive schemes to encourage more computer acquisition. The Investment Allowance Scheme which allows companies to offset

their cost of acquisition through tax refund. The Requirement Assessment Scheme provides consultancy services to identify computerisation areas at nominal cost to the firms. These schemes are intended to provide technical expertise and to make acquisition of computer less expensive so as to encourage more to embrace IT as part of their strategic tool in achieving competitiveness.

*b Study on information flow within the industry*

A project is currently being undertaken by the National University of Singapore to define the contents of information systems at the project and enterprise levels. Information flow diagram is used to trace and analyse the activities that take place within a system. The study hopes to re-design the way in which information and data flow take place within an enterprise so to achieve better efficiency and more importantly to prepare the way for computer integration. It will also identify activities where knowledge-based systems can be developed to automate decision processes. This project will be expanded to include classifying the information needs of different grouping of firms (consultants, contractors etc and by size) and to identify and develop industry wide applications.

*c Design Support Centre*

In order to encourage more strategic applications, CIDB sets up a Design Support Centre (DSC) to specifically support the industry in the use of computer in the design process. The centre maintains a graphical database aimed at assisting architects in this process. This computerised database contains all the commonly used graphical details for the construction professionals. Through a simple operation of "cut and paste" the user can lift details from the database and incorporates them into their drawings electronically. This service not only raises drafting productivity but also create an industry standard for detailing in the process which can be communicated between architects, engineers and contractors.

The centre is also developing common management software for the industry. This is an attempt to provide a common standard to the managment of project information. In addition to such software development, the centre also provides a bureau support service to promote CADD and specialised engineering applications by making available the use of software and hardware facilities at low cost. All these services provided by DSC will give the industry more reasons to computerise and to make it worthwhile.

In times to come, DSC will be the centre to promote industry wide standards in communication, drawing details and information format in addition to its role in promoting strategic application of computer.

*d ILUS - Industry-wide data base*

Another project under development since 1986 is the Integrated Land Use System (ILUS). This S$36 million system is aimed at computerising all the information on land, building, developing constraints and other parameters needed for development projects in Singapore. ILUS aims to become the main information source on land development for the industry. By putting all the data into one database, problems related to data compatibility will be reduced. This type of information is only part of the total information needs of the industry. Further work is being planned to incorporate more information into the database.

*e. Buildnet*

One of the necessary development in achieving integration is the setting up of a industry-wide network system. CIDB and the National Computer Board of Singapore (NCB) is currently working on a project to set up a such a network. The network called BUILDNET will link all the industry participants together. The objective of this network is to provide the electronic communciation links between industry's particpants. The first phase of the project involves the transfer of textual

information while graphic exchange will take place in the second phase. When the project is completed it will be the only construction EDI network in Singapore. It is envisaged that when the system becomes operational, it will link to ILUS and also other databases.

### *Conclusion*

The development of computer-integrated-construction is not an easy process. The characteristics of the industry are such that it does not lend itself too easily to integration. Still great strides have been made in the development of computer applications in traditional activities like designing and engineering analysis. With the increasing pace of development, it is imperative that to achieve some form of integration, the industry must adopt a concerted effort now before it is flooded with too many systems which will build up more barriers. A three phase approach suggested in this paper is being implemented in Singapore and because the size of the industry is small, it is possible to adopt it at the industry level. The construction industry holds no dream about achieving industry integration overnight, but even when full integration cannot be realised now, the programmes adopted will still improve the industry's overall efficiency. These measures will serve as a premise for achieving the more ambitious objective of a full computer-integration-construction system for the industry.

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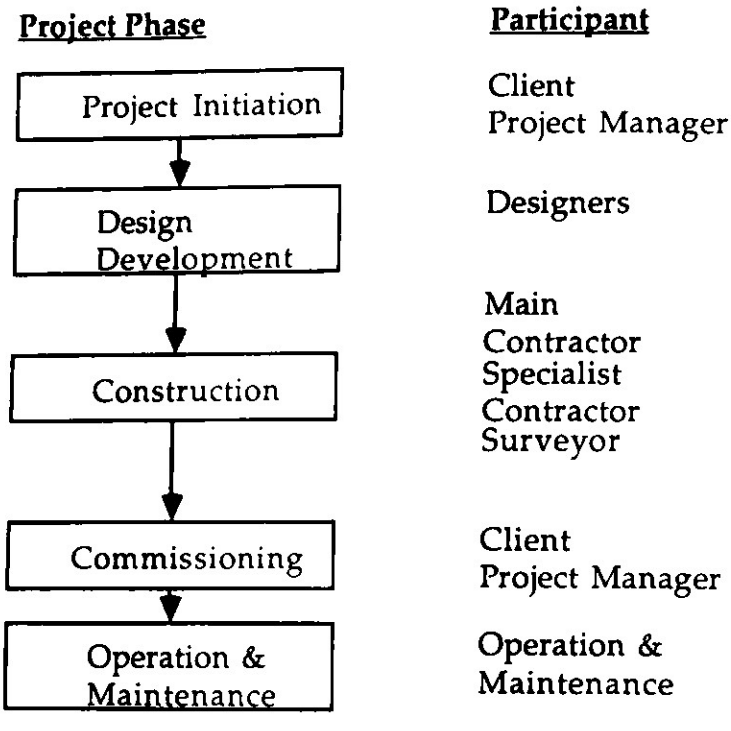
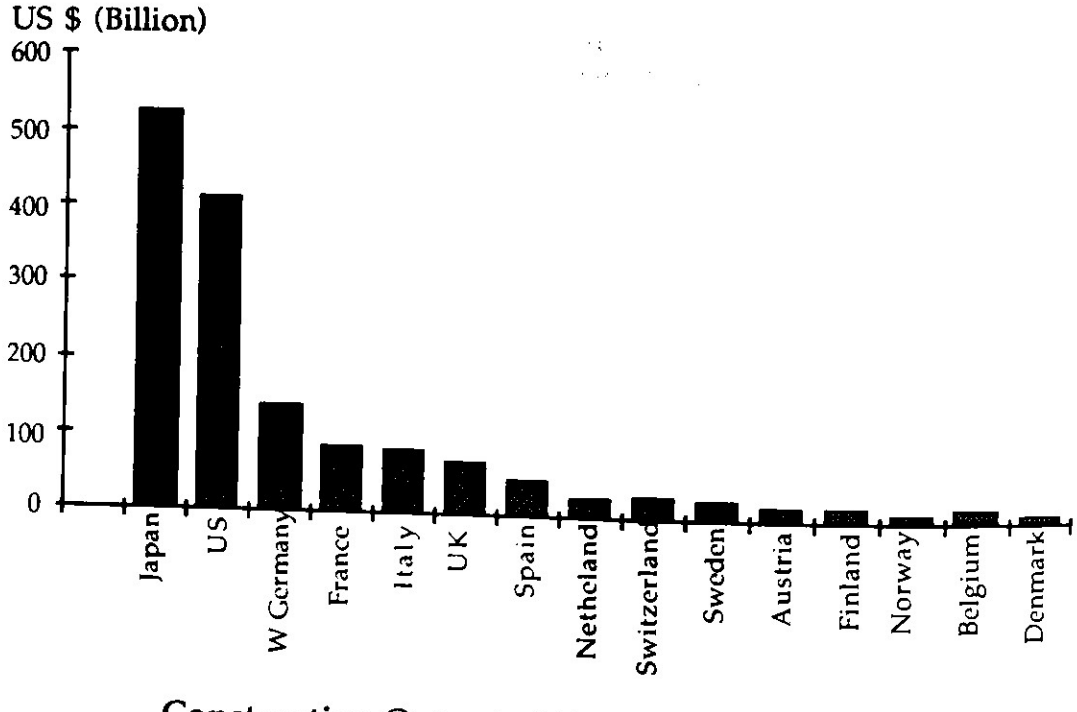



**Project Phases and Participants in each**

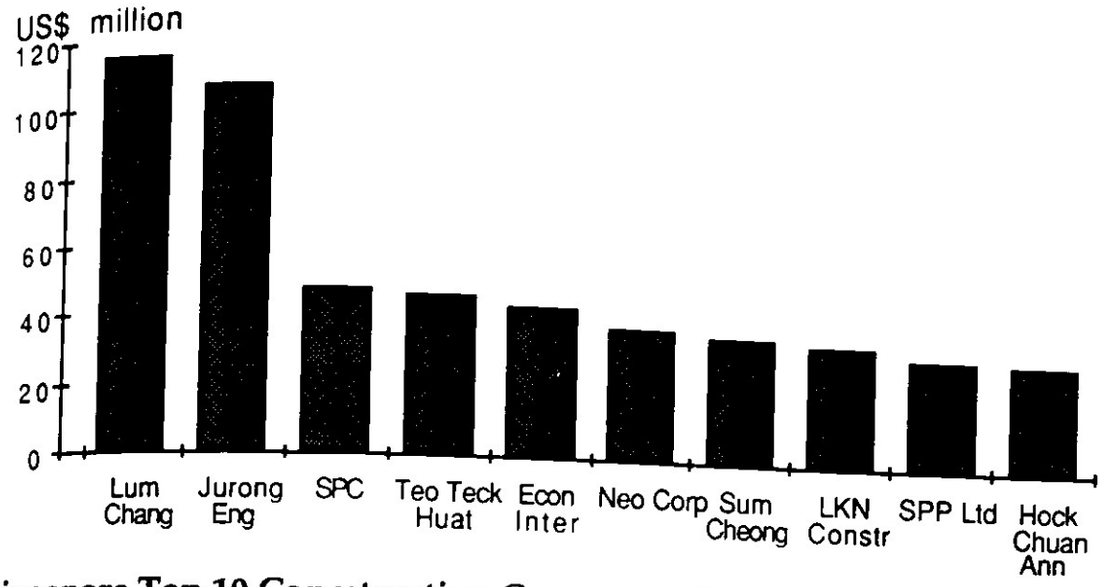
Figure 1




**Construction Output of European Countries**

Figure 2

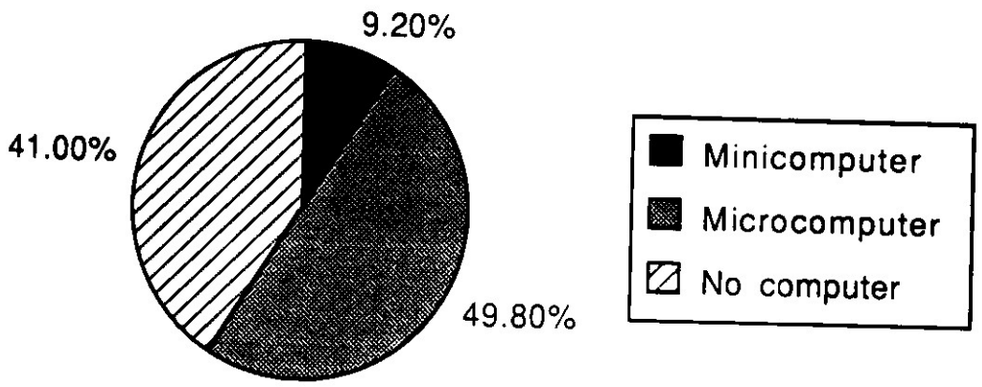
Source : Construction Industry International - May 1990




**Singapore Top 10 Concstruction Companies (Based on 1988 Turnover)**

Figure 3

Source : Singapore Construction Industry Development Board




**Level of Computer Usage in Construction Industry**

Figure 4

Source : Singapore Construction Industry Development Board

Source: CIDB Technology Development Division



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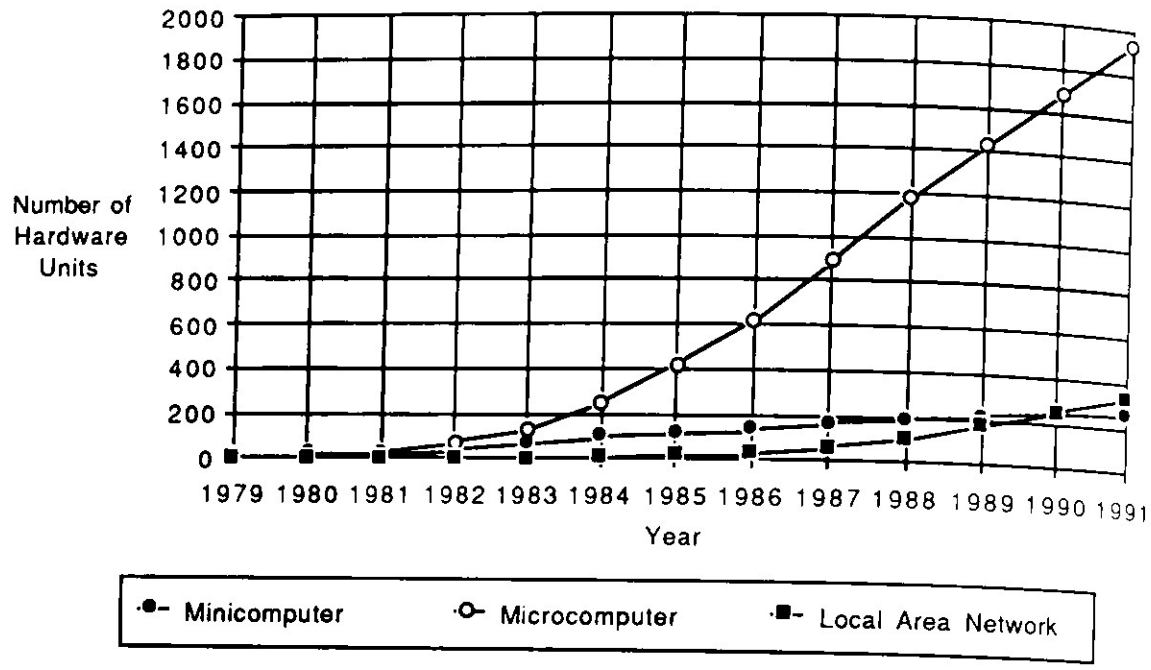


**Computer Installation growth in Construction Industry**

Figure 5

Source : Singapore Construction Industry Development Board