INTELLIGENT BUILDINGS

An evaluation on their capability to meet the needs of organisations and end users

By

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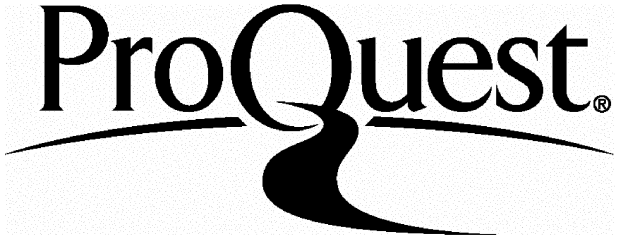

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ABSTRACT

The concept of "intelligent building" was first introduced in the early 1980s as a marketing tool to promote a building that had adopted the latest computer technology and automation system. Though the term "intelligent building" has become commonly used globally since then, it continues to mean different things to different people. Many articles have been written about intelligent building and offering several definitions, yet there are quite a confusion on the understanding of what makes a building intelligent or unintelligent.

To a certain degree, the concept of intelligent building has been commonly associated with advance technology and building automation (Donald, 1996). The push for this concept has come from developers, manufacturer and IT suppliers with a technical bias towards IT system and integration. This has led to the provision of much sophisticated and complex technology, with the present of many gimmicks and gadgets in intelligent buildings. By doing so it was believed that this can make the building to be more attractive than ordinary building and enable the owners and developers to lease out their buildings more easily. Except for a few applications, there is still a great doubt whether those sophisticated intelligent building systems installed today can really add value to organisations and end users.

Intelligent buildings, similar to any other building development, are substantial investments. The poor decisions about the facilities in intelligent buildings can cost millions of pounds and worst still they can be a stumbling block to organisations in achieving their basic objectives. On the supply side, the lack of understanding of the actual business needs of organisations may lead to the provision of inappropriate technologies and systems in intelligent buildings. On the demand side, the lack of understanding and awareness by the users on the original intent of the design may lead to under-utilisation of the systems.

This report examines the concept of intelligent buildings to both the supply and the demand side in order to identify the similarity and differences between them. The benefit of intelligent buildings as claimed by the supply side is compared with the actual benefits experienced by the existing users. The constraining factors for implementing intelligent building strategies are analysed in order to identify various possible means to overcome them. The report concludes with the key findings and some speculations on future directions of intelligent buildings.

Keywords: Intelligent buildings, supply and demand side, technological features, respond to change, organisations and business needs, building performance, benefits and constraints.

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ABBREVIATIONS

AI	Artificial Intelligence
BAS	Building Automation System
BEMS	Building Energy Management System
BIFM	British Institute of Facilities Management
BMS	Building Management System
BQA	Building Quality Assessment
BRE	Building Research Establishment
BRM	Building Rating Method
CAFM	Computer Aided Facilities Management
CIB	Computer Integrated Building
CIBSE	Chartered Institution of Building Services Engineers
CIDB	Construction Industry Development Board
EBRD	European Bank for Reconstruction and Development
EIBG	European Intelligent Building Group
FM	Facilities Management
IBI	Intelligent Building Institute
IBs	Intelligent Buildings
IT	Information Technology
ITN	Independent Television News Limited
LANs	Local Area Networks
NTT	Nippon Telegraph & Telephone
REDAS	Real Estate Develops' Association of Singapore
RIBA	Royal Institute of British Architect
RICS	Royal Institute of Chartered Survey
STS	Shared Tenant Services

CHAPTER ONE: INTRODUCTION

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CHAPTER 1: INTRODUCTION

1.1 SETTING THE SCENE

The intelligent building, a concept that was first introduced more than a decade ago, continues to catch the attention of various parties such as designers, IT manufactures, developers, facilities managers, academia etc. The launching of an MSc in Intelligent Building, by the University of Reading is just one of the many examples on the amount of attention paid to intelligent buildings.[1] Despite all these activities, it continues to mean different things to different people.

To the IT suppliers and manufacturers, intelligent buildings would mean marketing opportunities for their products. To the developers and landlords, intelligent buildings would mean leasing out their property more easily, quickly and perhaps at a higher rental value. To some consultants and designers, intelligent buildings would mean another publicity for themselves and their works. This supply led concept of intelligent buildings, which often emphasises the application of advanced microelectronics; computers and associated technology have resulted in many sophisticated features, gadgets and gimmicks installed in many buildings. Although this concept has excited many peoples' imaginations, the lack of understanding of the needs of organisations and end users may lead to the provision of inappropriate technologies and redundant systems in intelligent buildings.

To many organisations, end users and occupiers, intelligent buildings would promise of many benefits which include better working environments, extra capability for their businesses and works, etc. But the degree of complexity and sophistication in intelligent buildings may deter many organisations and end users from realising the real benefits of intelligent buildings. On the other hand, the lack of awareness and understanding by organisations and end users on the intelligent buildings may result in their reluctance to accept those systems that might be of beneficial to them.

1.2 RESEARCH DIRECTION

Previous works

Past seven years, several research works have been carried out by various consultants taking a user-based approach to intelligent buildings. This approach draws on the experience and demands of organisations and end users, to capture their current and future needs. This was followed by the development of workplace solutions using the technologies, products and services available from suppliers. One particular example of such research work includes *The Intelligent Building in Europe* which was conducted by DEGW (London), Teknibank (Milan) in association with the European Intelligent Building Group (EIBG) in 1992. Since then, an alternative view to the concept of intelligent building was offered. This has resulted in a gradual shift from product and building focused, to process and organisation focused in intelligent buildings.

Parallel to this development was the realisation by organisations in mid 1980s, on the importance of facilities management (FM) in integrating facility planning and management with corporate decision-making.[2] The main focus of FM since then was on the effective planning, design, management, maintenance and adaptation of building stock to serve human and organisational needs more appropriately and effectively.[3]

Aim of the report

As we draw near to the year 2000, how far has the concept of intelligent buildings shifted from being product and building focused to process and organisation focused? To what extent has the concept of intelligent buildings been understood by organisations and end users? To what degrees have the users-based approach to intelligent buildings benefit organisations and end users? To answer these questions, this report therefore evaluates the concept of intelligent building with the organisations and end users in mind. Critical issues relating to the implementation of building intelligence strategies are identified and examined in an objective manner.

Objectives of the study

In view of the limitations such as time, personal resources etc., imposed on this report, the objectives of the study will be subjected to the following:

1. To review the various prominent concepts and development trends of intelligent buildings.
2. To examine the perceptions of intelligent buildings from both the supply (e.g. developers, manufacturers, suppliers, designers etc.) and the demand side (e.g. organisations, end users, tenants, facilities managers, etc.).
3. To evaluate the degree to which the user based concept of intelligent buildings benefits organisations and end users.
4. To identify the constraining factors encountered by organisations and end users in implementing building intelligence.

1.3 SCOPE AND LIMITATIONS OF STUDY

It is neither the purpose of this report to derive at a list of features for an intelligent building, nor is it the intention to conclude with a rating tool to measure the intelligence of buildings. The scope of study can be generally classified into two levels namely:

- **Macro level** - This is concern with the general review of the prominent development trends of intelligent buildings globally. The report also provides a brief comparison of the similarity and differences of these concepts and development trends across the three continents (i.e. USA, Japan and Europe). Various critical issues involved in intelligent buildings are identified and outlined too.

- **Micro level** - The study then concentrates on UK context to draw on the experiences of the supply and the demand side in the aspect of intelligent buildings. Performance of different building categories is compared to determine the intelligent building features that served best the needs of organisations and end users. The constraining factors in implementing intelligent building strategies are and analysed in order to derive at a framework for better implementation of building intelligence. The major driving forces behind each of these development trends were also identified.

As the concept of intelligent building is widely applied to various types of buildings such as retail, industrial, educational, hotel, residential, office etc. This report will only examine the issues of intelligent buildings in the context of commercial office buildings.

1.4 RESEARCH METHODOLOGY

Various research studies relating to intelligent buildings have been carried out in many different ways. A review on some previous research shows that the approach adopted in this report (i.e. literature review, interview, questionnaire survey and building visits) is consistent with other research studies as summaries in Table 1.1 below:

Research Area	Brief Description of Research	Year of Research	Research Methodology
Market awareness of intelligent buildings in Singapore. [4]	Market survey by Construction Industry Development Board (CIDB), Singapore.	1990, March/April	• Questionnaires.
Survey of intelligent buildings technological advances in USA and Japan. [5]	13 days' mission to USA and Japan by Construction Industry Development Board (CIDB) and Real Estate Developers' Association of Singapore (REDAS), Singapore.	1990, October	• Building visits.
Learning building research programme. [6]	Consortium of nine companies includes: Thorn lighting, Thorn Security workplace Technologies, British Aerospace, Skanska, ABB Indoor Climate, Kone Elevators, Matthew Hall and Ericsson, UK.	1991	• Questionnaires. • Workshops.
Intelligent buildings technologies: Japan and Singapore. [7]	Overseas Science and Technology expert mission by Department of Trade and Industry, UK.	1992, June	• Structured interview with building owners. • Building visits.
The intelligent buildings in Europe. [8]	Multi-client study by DEGW (London) and Technikbank (Milan) in association with the European Intelligent Building Group, UK.	1992, September	• Literature review. • Telephone and face to face interview. • Building case studies. • Interview with intelligent building experts.
Intelligent buildings in South East Asia. [9]	Multi-client study by DEGW International Consulting Ltd, Ove Arup and partners and Northcroft, UK.	1996, March	• Building case studies. • Building visit. • Questionnaires. • Workshops.

Table 1.1: Some previous intelligent buildings research projects.
Source: Derived from published articles and reports in trade magazines and professional journals

Literature Review

Literature search through the Electronic Library System and the World Wide Web was found to be useful in providing access to a great variety of published works relating to intelligent buildings. The materials which have been carefully selected based on comprehensive background to the concepts and development trends of intelligent buildings

were used for review. The following sources were found to be very useful in providing an insight into the topic of intelligent buildings:

- Publications by various experts of this field.
- Journals published by professional bodies.
- Conference papers.
- Trade magazines.
- Newspapers.

Interviews

A total of nine occasions of formal face to face interviews (Appendix A) has been conducted using interview checklists (Appendix B). Those interviewed were from both the supply and the demand side of buildings. The former, which normally involves giving advice to building owners in respect to the building design and specifications, include building services engineers, IT consultants, architects and quantity surveyors. The latter were mainly building owners' representatives which include facilities managers, location engineers and property managers who manage the facilities and support services.

This method helps to examine the opinions and perceptions of intelligent buildings by various representative parties in greater length.

Questionnaires

A set of questionnaire (Appendix C) was designed with the objective to collect primary data relating to organisations' awareness on the concepts of intelligent buildings. The degree to which the buildings meet their objectives was measured through this method.

The importance of intelligent buildings features in helping to achieve those organisational objectives were examined from their perspectives using standard scoring system which was partially similar to that of Building Quality Assessment (BQA).[10] This scoring system was selected for the questionnaires as it provides a simple and consistent scoring method for the respondents. Furthermore it enables the qualitative issues of intelligent buildings to be measured in a quantitative way.

An arbitrary total number of 100 corporate organisations, mostly based in London, were selected on a random basis[11] to provide their feedback on intelligent buildings through the postal survey.

Buildings Visits

This was done with the permission of the building owners' representatives. This involved a general walk through of the buildings accompanied by the facilities managers. This has provided a greater understanding towards the organisation's functions within the buildings and their buildings' strategies which was incorporated into the building design in helping to support the organisations' functions. A small demonstration on the operating of the building management system was observed at site to understand how such system functions.

The approach adopted in this report as described above can be summed up by Figure 1.1 below:

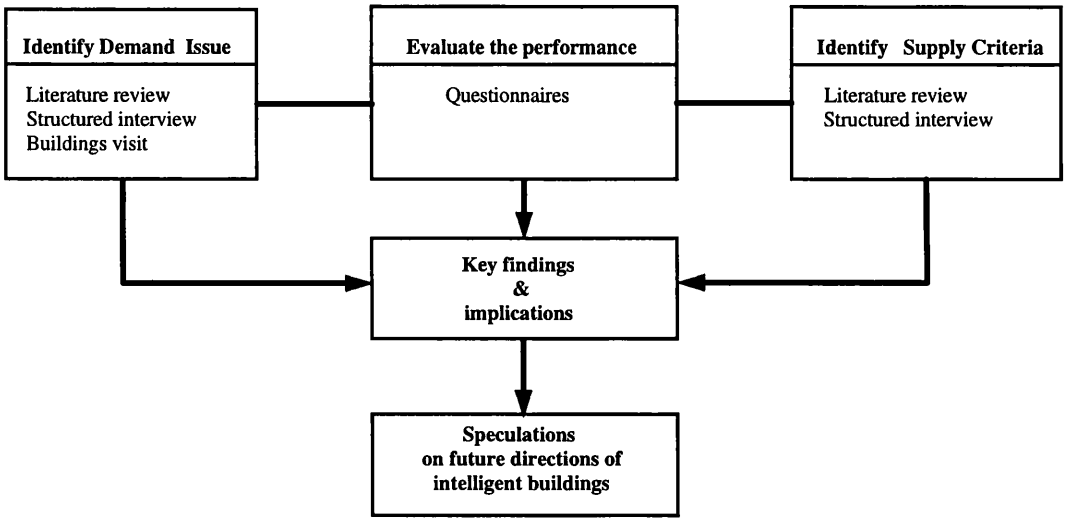

Figure 1.1: Summary approach adopted for investigation
Source: Author

1.5 CONTRIBUTIONS TO BE MADE BY THE RESEARCH

This report hopes to contribute to the field of knowledge of intelligent buildings by clarifying the concepts of intelligent building with the needs of organisations and end users in mind. It is the hope that the feedback obtained from the experiences of various organisations and building users will contribute toward a better understanding on the benefits and constraints of intelligent buildings. It is the hope that the framework drawn out from this study can add to the many efforts by others, in achieving a closer match between the supply and the demand side of intelligent buildings.

1.6 REFERENCES AND NOTES

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[9] "Intelligent Building in South East Asia - Executive Summary.", March 1996, DEGW International Consulting Ltd., Ove Arup & Partners and Northcroft, UK.

[10] CLIFT, Michael, "Building Quality Assessment (BQA) for Offices.", *Structural Survey*, Vol. 14, No. 2, Pg. 22-25, 1996, MCB University Press, UK.

[11] The sample was derived from "The Phone Book - London Postal Area.", British Telecom, April 1997. A random selection was done on the basis of sector as follows:

Legal	4
Telecommunication	4
TV Broadcasting	4
Accounting	5
Advertising	9
Property Developer	9
Insurance	12
Bank and Finance	27
Others (entertainment, transportation, pharmacy, etc.)	26
Total	100

CHAPTER TWO: LITERATURE REVIEW

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CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION: WHAT IS AN INTELLIGENT BUILDING?

Before going into the lengthy discussion of the meaning of intelligent buildings, first the word "intelligence" needs some clarification.

> Intelligence - refer to the power of learning, understanding and reasoning; mental ability.
>
> Oxford Advanced Learner's Dictionary[1]

This word has generally been used to describe the ability of a person to learn, to comprehend and to think. It was until the invention of computer that this word found its applications in computing vocabulary. The word "intelligent system or workstation" [2] is then commonly used to refer to the computer or software that can store knowledge gained from past experience and apply it in different circumstances.

What does it mean when one use the term "intelligent buildings"? On the surface, the word seems to refer to buildings with the capability to learn, understand and respond to stimuli within and without the buildings. A report on Japanese construction industry in 1987[3] has identified three attributes that an intelligent building should possess:

1. Building should **know** what is happening inside and immediately outside.
2. Building should **decide** the most efficient way of providing a convenient, comfortable and productive environment for the occupants.
3. Building should **respond** quickly to occupants' requests.

Without explaining how a building can possess these attributes, the term "intelligent building" may portray an image of a futuristic building with many sophisticated features and state-of-the-art technology, within the mind of many people. This was exactly the way Philip Kerr, a great novelist, in his novel *Gridiron*[4] has painted a picture of what a futuristic vision of intelligent building may look like. This includes the use of complex building management system (BMS) that controls everything from the bomb-proof cladding with its weather and temperature sensors, the lifts, thermostat and fragrance control right down to the superloos that wash and blow-dry users and automatically run drugs tests (Kerr, 1995).

According to Kerr, ninety-nine per cent of the features described in his book is technically possible and they are already happening in many buildings around the world.[5]

There is no doubt that the integration of advanced technology into commercial office environment will continue to develop. However, the questions often asked, not only by the sceptic but by the end users are: What are the real benefits of these features? How can all these features add value to organisations and end users? Ultimately, this concept will have to face the acid test of whether they can deliver the real benefits and add value to the organisations and end users who have invested in it.

Besides for reading pleasure, Kerr's book may provide a warning on the likely problems and nightmares one would encounter, when the building gets so smart that it can have its own mind and take over the total control.

2.2 DEFINITIONS OF INTELLIGENT BUILDINGS

To date, there is still very little consensus of what actually constitute intelligence in buildings. Definitions range from marketing opportunities for supplier to the environmental responsibilities of users. For the purpose of this report, three prominent definitions of intelligent buildings were examined below:

Intelligent Buildings Institute (IBI), Washington DC, 1988 [6]

> *"An intelligent building is one that provides a productive and costs effective environment through optimisation of its four basic elements: structure, systems, services and management, and the interrelationships between them. Intelligent buildings help building owners, property managers and occupants realise their goals in the area of cost, energy management, comfort, convenience, safety, long term flexibility and marketability."*

This definition has focused on the characteristics and guidelines on the potential scope of applying intelligent design and technology to building. It also takes into account the interest of various people such as designers, suppliers, owners, users' community. This definition advocates the insufficiency of building to be a passive element of workplace. It must function as a dynamic medium that supports management by supporting the people who are responsible for accomplishing an organisation's mission.

The four basic elements of intelligent building according to IBI definition include the following:

1. *Building Structures.* This comprises of structural components, architectural features, and interior finishes and furnishings (e.g. riser space, slab to slab ceiling heights, raised floors and dropped ceilings, fixtures, finishes and furnishing etc). These elements are viewed as the foundation to intelligent building as they may affect the ability of the building to meet the basic occupants' needs and accommodate changing technology.
2. *Building Systems.* This includes the use of various electrical and electronic systems (e.g. HVAC, lighting, telecommunications, access control, security etc). The main concern on these is the provision of wiring networks which allow the connection and interconnection between each system.
3. *Building Services.* This is generally related to various support services in the building (e.g. voice, data, video communications, E-mail, cleaning & maintenance etc). The concern is on the provisions of various facilities to enable the efficiency and effectiveness of the occupants in carrying out their tasks.
4. *Building Management.* This includes the management of various functions (e.g. maintenance, property, leasing, information, energy etc). This is focused on the applications of management strategies, both long term and short term, to the operations of the building.

European Intelligent Building Group (EIBG), 1997[7]

> *"An intelligent building incorporates the best available concepts, materials, systems and technologies. These elements are integrated together to achieve a building which meets or exceeds performance requirements of the building stakeholders. These stakeholders include the building's owners, managers and users as well as the local and global community."*

The European Intelligent Building Group (EIBG) on the other hand adopted a generic definition of intelligent buildings which maybe applied any kind of building by any stakeholder. All office building can be considered intelligence if they create an environment which allows the organisation to achieve their business objectives, while maximising the effectiveness of their occupants and achieving minimum life-cycle costs.

The approach adopted by EIBG on the intelligent building concept can be summarised by Figure 2.1 below:

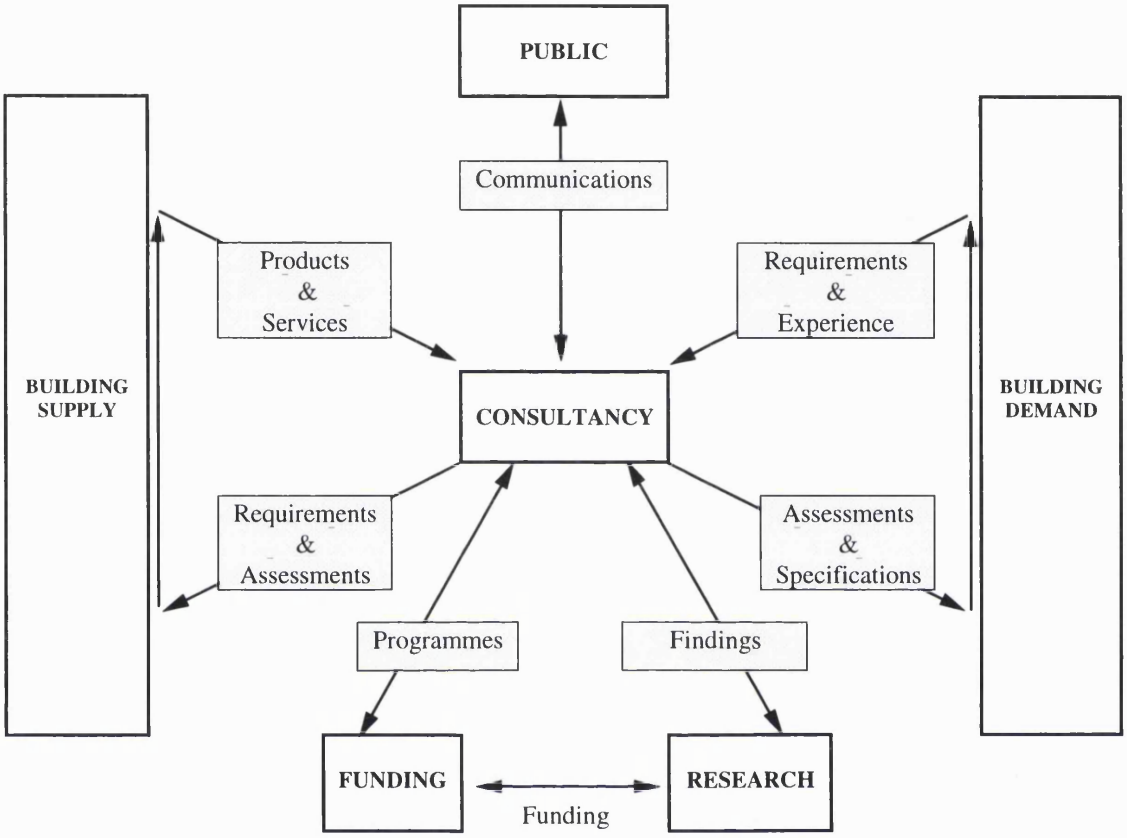
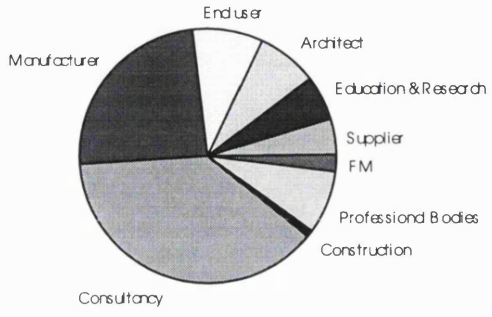


Figure 2.1: The EIBG Field of Operations
Source: EIBG Brochure

Though EIBG approach to intelligent building aimed to balance between the building supply and the building demand, analysis on their membership's distribution as at July 1997 (Chart 2.1) revealed that the institute is still very much a supply led organisations.

Chart 2.1: Distributions of membership for EIBG
Source: EIBG membership list



DEGW (London) & Teknibank (Milan), 1992[8]

> *"An intelligent building provides a responsive, effective and supportive environment within which organisation can achieve its business objectives. The building, space and business technologies are the tools that help this happen."*

The summary in Figure 2.2 shows the definitions of intelligent buildings resulted from the development of information technology as follows:

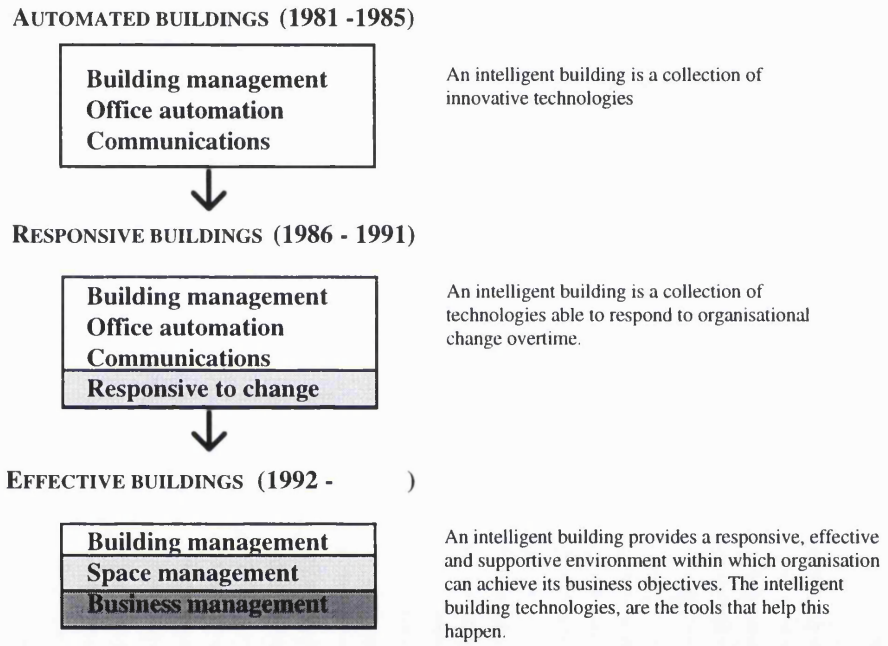


Figure 2.2: The development of intelligent building concept
Source: DEGW (London) & Teknibank (Milan), 1992

Though the three definitions above were used for different contexts and purposes, it can be seen from the above that these definitions generally address three important aspects of intelligent buildings:

1. purposes of intelligent buildings,
2. means to achieve the purposes and
3. the ultimate beneficiary.

A comparison on the definitions of intelligent buildings as described above can be summaries by Table 2.1 below:

	The purpose	The means	The beneficiary
IBI	To provide a productive and cost effective environment that realises the following goals: • cost • energy management • comfort • convenience • safety • long term flexibility • marketability.	Optimising the four basic elements and their interrelationships: • structure • systems • services • management	• building owners • property manager • occupants
EIBG	To achieve a building which meets or exceed performance requirements	Incorporating the best available concepts, materials, systems and technologies.	Stakeholders: • Building owners • manager • users • local and global communities
DEGW/Teknibank	To provide a responsive, effective and supportive environment that achieves business objectives in three aspects: • building management • space management • business management	Three levels of design and management strategies: • effective building shell. • applications of IT: building automation systems, space management systems and business applications. • Integrated technologies and services.	Corporate organisations

Table 2.1: Comparisons of three definitions of intelligent buildings.
Source: Derived from IBI, EIBG, DEGW & Teknibank

2.3 BRIEF HISTORICAL DEVELOPMENT OF INTELLIGENT BUILDINGS

Intelligent buildings in USA

The concept of intelligent buildings was first introduced in US during the early 1980s. It was generally associated with the use of office automation and advanced telecommunications in the buildings as marketing tools by developers and IT suppliers in a saturated market to promote their buildings and products respectively.[9] The common name for this is Shared Tenant Services (STS), which is basically concerned with the provision of on-site centralised technology and services that can be shared by all tenants and that serve to enhance tenant productivity or reduce costs.[10] It was believed then that this concept can help developers to lease out their buildings more easily and quickly.[11] The main reason behind this emphasis on tenancy and services by the American was due to

the deregulation of the US telephone network in 1984. It has caused a rapid competition among the telecommunications suppliers, bringing a huge range of communication system into the market. This has resulted in the ability of landlord for large building to supply private telecommunications utility such as long distance carrier services at wholesale rates and retail to end users. The main benefit offers by this concept was the reduction in distance telephone charges passed on to the tenant from the developer's bulk telephone traffic discount. The concept of STS was then extended to other services which includes:

- rental of personal computer;
- use of central computer system and Local Area Networks (LANs);
- use of photocopying and printing;
- use of message centre;
- use of building management services etc.

Though this concept continues to prevail through the 90s in US, it has not been entirely successful due to following reasons:

1. The resistance to the concept of sharing by the tenants as each one has their own preferred system.
2. The concerns by the tenants for information security and system reliability.
3. The problems experienced by users on the installation and commissioning, and training for operators has not been able to keep abreast of fast-moving technological developments.

Intelligent buildings in Japan

The concept of intelligent buildings in Japan was different from that of USA in a considerable way. Most of the examples of intelligent buildings in Japan were found to be showcase buildings for system suppliers and construction companies who incorporated many bespoke experimental systems in their buildings. [12]

The large scale of obsolescence experienced in office accommodation forces the Japanese Ministry of Construction to offer financial incentives to developers who provide buildings which meet their criteria for intelligence. These include: [13]

- sophisticated information and communication facilities and systems, or built-in provision for them,

- sophisticated maintenance and control functions for energy saving; provision of disaster recovery facilities and security equipment; environmental controls and
- ability to communicate with other buildings or sites through intelligent networks.

As a result of that, the Japanese Ministry of Construction has invested of $300 billion in intelligent buildings during the 1990s, of which more than 50 per cent was accounted for by the associated cabling, electronic equipment and services.

The partial deregulation of NTT (the Japanese telecommunications provider) in 1986 has been an important factor in the growth of intelligent building developments. The increasing dependent on rapid innovation by the Japanese economy has also resulted in a fundamental need for the development application of information technologies. [14]

The shift of Japanese economy, from a reliance on energy and labour intensive industries (such as shipbuilding and textiles) to a high value added industries (such as semi-conductors, electronics based products and computers) has accounted for the major organisational changes experienced by many companies.[15] This has an important implication on their needs for space as well as information networks with appropriate infrastructure. It was believed that intelligent buildings play an important role in improving the efficiency of office workers just as previously automation system had in the manufacturing sector.

Beside the applications in buildings, the concept of intelligence has extended beyond to a larger city scale.

Intelligent buildings in Europe

The concept of intelligent buildings in Europe was very much different from that in Japan and the US. The difference for Europe was more of organisational focus. This was due to the enormous influence of widespread industrial democracies in Europe, on the quality of life. [16]

The buildings in Europe tend to be of custom-built, innovative layouts with a mix of open plan and cellular space. The trend of building tends to be towards more domestic office environments with the influence of environmental and health legislation on office design.

The factors which account for different emphasis of intelligent building in Europe include:[17]

- buildings in Europe tend to be much smaller (under 100 000 sq. ft);

- telecommunications were still regulated in many countries etc.

Due to the strict regulations, the STS concept was not workable for Europe as legislation has prohibited the provision of discounted services on long distance telecommunications. Besides building users were unwilling to share data networks for security reasons. The integration of building management functions such as fire and security within one system have been delayed by the reluctance of authorities to grant approval.

Despite all these obstacles, a widespread concern about controlling energy costs has made building management systems the most accepted component of intelligent building in Europe. The concern for healthy and quality of working environment has resulted in the need for provision of individual environmental control system.

	Main focus	Characteristic	Driving forces for intelligent building development
USA	Speculative buildings for multi tenanted with shared tenant services (STS) includes office automation, advanced telecommunication and building automation system.	Large centralised system for shared tenant services in speculative office development.	• The deregularisation of telecommunications. • Rapid competition of real estate in a saturated market. • Existence of innovative producers of electronic components and control systems.
JAPAN	Showcase buildings for owners occupied with the applications of bespoke advanced electronic and information technologies.	Large centralised bespoke systems based on mainframe computers for owner occupiers.	• The deregulation of telecommunications. • The liberalisation of financial services leads to the need for new high speed digital communication networks. • Increasing demands for swift national and global communications facilities. • Government sponsorship and promotion of information technology industries.
EUROPE	Custom-built building with the emphasis on the quality of working life.	Smaller decentralised systems with a trend towards distributed networks driven by personal computers.	• The influence of environmental and health legislation on office design in Northern Europe. • Complex building procurement and construction process that allow collaborative ventures between construction companies or developers and system suppliers.

Table 2.2: Comparisons of the intelligent building concepts across three continents.
Source: Derived from Duffy 1988[18], Owen 1990[19], Hawkins 1988[20] and Gann 1994[21]

2.4 VARIOUS ISSUES OF INTELLIGENT BUILDINGS

Artificial Intelligence

[22]Artificial intelligence (AI) is associated with the development and use of computer program which contain 'knowledge' in the form of facts, relationships and rules, about some specific area of human expertise (Shaw, 1988). It is capable of making reasoned

deductions or inferences for the user and can explain its line of questioning and can justify its conclusions. Sometime known as expert system, it was believed to be the key to better building management systems (BMS) and hence provide a more intelligent environments[23] (Owen & Harrison, 1990). Research by Building Research Establishment (BRE) in UK has shown that there is a need for combining the conventional BMS components with AI techniques at all levels. This ranges from the control loops level to man-machine interface level. For example at control level this would minimise the amount of data carried between sensors. At man-machine level, it would allow the building management system to learn from failures and identify functional treads overtime.

Computer Integrated Buildings (CIB)

In the past, fully integrated building (which refers to the combinations of all the electronic system into a unified whole to serve the users and building) has been a rising concern of engineers. Previous study has proposed a technology revolution model to the integration of various systems as shown in Figure 2.3 below:

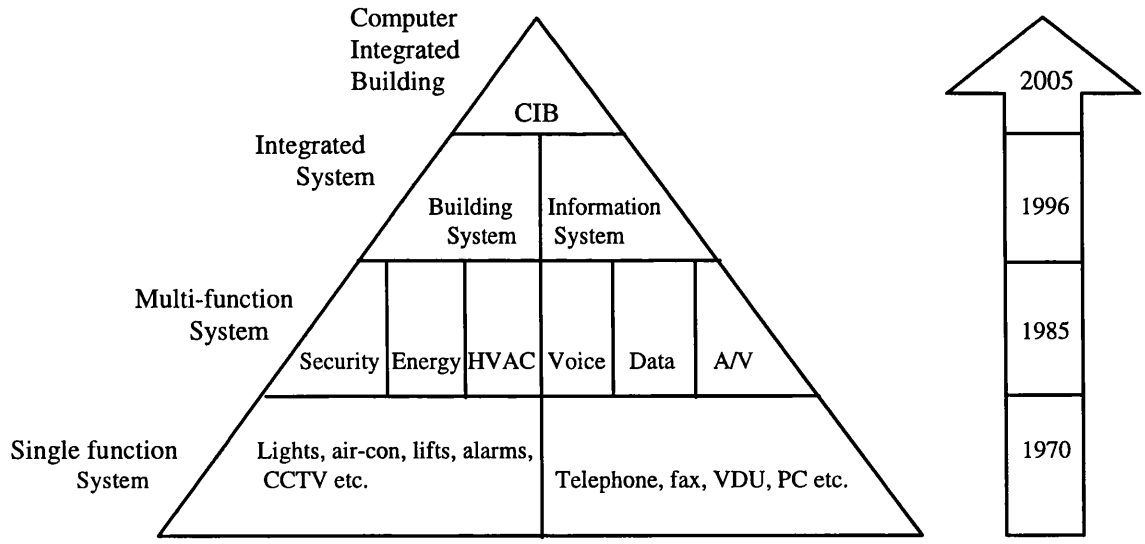


Figure 2.3: Technology Evolution Model
Source: Ove Arup Partnership, 1996[24]

The main concern for integration is on the use of a single cabling network, for the communications of various building systems as illustrated in the figure above. The advantage of this is that cabling within the building is minimised.

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CHAPTER THREE: PERSPECTIVES FROM THE INTERVIEW

CONTENTS

CHAPTER 3: PERSPECTIVES FROM THE INTERVIEW

3.1 THE INTERVIEW

This chapter draws upon the experiences of many practitioners (Appendix A), in the field of intelligent buildings. To identify the similarities and differences, the study focuses on the attributes of intelligent buildings, to the interviewees from both the supply and demand side. The interview results shows how the concept, benefits and constraints of intelligent buildings are experienced by various representative parties. Various issues related to the future development trend of intelligent buildings are explored through the interview.

3.2 ATTRIBUTES OF INTELLIGENT BUILDINGS

This section examines the concept of intelligent buildings in term of the quality it possessed. It is interesting to observe the strong sense of agreement between the respondents from both the supply and the demand side towards the attributes of intelligent buildings. Mr Jim Read, Arup Communications in his interview summed up the attribute of intelligent buildings:

> [1] *"A truly intelligent building is one that is adaptable so that it can* ***respond to changes****. This does not necessary mean that it should have fancy system for lowering the blind when the sun comes out or fancy system that recognises who you are when you get into the lift."*

The consensus among the respondents is that intelligent building is one that possessed the capability to respond to various changes. Technology is viewed as one of the means to achieve this capability in building. The various changes that an intelligent building is capable to respond to are outlined below:

1. Organisational change

Mr Andrew Mawson[2], Advanced Workplace Associates Limited, stressed that the building will have to accommodate more changes to support a more transit style of occupations (i.e. high mobility). In this aspect, Mr Andrew Harrison[3], DEGW viewed intelligent building as a bigger network that allows organisations to work in different way at different location and time. This means that the building will have to be flexible to support various management structures and patterns of working as required by the organisation.

On this point, Dr David Boyd, University Central England, has a different view. Instead of seeing building as capable to respond to organisational change, he sees the need for the organisation and occupant to dealing with the compromise between the building systems and the needs of organisation. He explained:

> [4] *"The organisation has to relate to building in a symbiotic way. The organisation has to adapt itself slightly for the building and the vice versa. By forcing the structure of an organisation into the building which is not suitable for that structure will result in internal conflict."*

2. Market change

This is reflected in the business needs of organisations to expand or shrink based on the market conditions. Mr John Sudworth[5], European Bank for Reconstruction and Development (EBRD) explained that the business for an organisation can be very busy with many projects and therefore need much space. This emphasis may shift due to market conditions and results in a need for business to shrink overnight. The building will have to be flexible enough to adapt to this change and allow the surplus space to be dispose of quickly without major alteration to the services.

3. Technological change

This is reflected in the capability of the building to incorporate new technology. Mr Jim Read[6] said that the revolution in the IT industry has resulted in tremendous changes in the IT systems, but building will be there for 50 years regardless of what is happening. It is therefore important to design the building intelligently to adapt to this change. Mr John Sudworth[7] also stressed the importance to design the building to enable the opportunity for organisations to add on additional functions to the existing functions as and when required.

4. Functional change

According to Mr John Mitchell[8], Corporations of Lloyd's of London, intelligent building is one that respond to functional change realistically and quickly without major refurbishment and capital investment. It will be a challenge for designers to come out with intelligent building that can change it existing function to another. According to Mr Peter Wicking[9] of Johnson Control Limited, this is exactly the case for ITN where the building originally used for newspaper publication but later adopted for television and radio broadcasting purposes.

5. Environmental change

This is concerned with how the building reacts to the various changes externally and internally in terms of the thermal, air, visual and aural quality. According to Mr Patrick Moore[10], BSC Consulting Engineer, the building systems need to be able to respond to these changes quickly enough so that the occupants will not feel uncomfortable. Mr. Eric Loe[11] of Northcroft, stressed that it is a very important factor in building to increase the efficiency of the occupants. This can be done by providing an environment which is more conducive for carrying out their tasks.

3.3 BENEFITS & CONSTRAINTS OF INTELLIGENT BUILDINGS

This section examines the benefits and constraints of intelligent building based on both supply and demand side. Observations made during the site visit will be quoted to illustrate the point as appropriate.

Benefits of intelligent buildings

The interview result shows that there are four common benefits of intelligent buildings as seen by both the supply and the demand side as described below:

1. Provide better management over energy and other resources in the building.

This is generally the benefit provided by the used of Building Automation System (BAS) such as Building Management System (BMS), Building Energy Management System (BEMS) as well as Computer Aided Facilities Management (CAFM) system.

For Corporation of Lloyds' of London, these systems have enabled their building to control the supply of essential services and utilities to specific areas as needed by the tenants. At the same time these systems enable the billing to be more accurately done. (Mitchell, 1997).

In terms of energy conservation, there are limitations on how much energy can be saved in a building. Despite that, study in Europe shows that a saving up to 50% in energy cost can be achieved in an intelligent building (Loe, 1997).

2. ***Provide flexibility to facilitate organisational churn.***

At One Exchange Square, EBRD has achieved the flexibility by using design features such as demountable partitioning systems, structural cabling, raised flooring system, grid ceiling and modular furniture (Sudworth, 1997). These systems not only have eased the reconfigurations of office space, they have reduced the cost for refurbishment to a very great extent and helped to convert the surplus space into revenue.

At One Lime Street whenever there is a change in space layout, there is no need for physical alteration to the air conditioning supply system (Mitchell, 1997). All that needed is just reconfigure the layout through computer system.

3. ***Improve the environmental control that results in high quality, healthy, comfortable and conducive workplace.***

From the interview there are two approaches that can contribute to this benefits i.e. centralised control and individual control. For ITN building at 200 Gray Inn Road, various environmental systems are controlled from one point (Wicking, 1997). Temperature and lighting can be altered from the centralised control system whenever there is a complaint by the users.

For EBRD, each user has access to lighting and temperature control through their telephone system (Sudworth, 1997). This system has reduced the number of complaints by the users, on the quality of their working environment.

4. ***Improve the users' morale and hence result in the increase of productivity and efficiency of their works.***

The feedback from the occupants at ITN building was very encouraging as most people like the building and enjoy working in the building (Wicking, 1997). This is mainly because of the high quality work environment provided by the intelligent building systems. This is also the case for One Exchange Square where the building has increased the staff morale. People feel that they want to come to work as it is a nice place to work in (Sudworth, 1997).

Other benefits

Table 3.1 shows the other benefits of intelligent buildings as commented by the supply and the demand side.

Supply side	Demand side
• Provide opportunities to developers in leasing out their buildings quickly. • Provide the necessary back up and support that allows different ways of working. • Provide opportunities in business by offering new services to the customers. • Improve image of organisations to outsiders. • Improve the ease of communications. • Allow preventive approach to maintenance. • Ability to store information.	• Provide continuity in work flow and services supply to users. • Reduce the cost of maintaining and operating the buildings. • Reduce the need for help desk by using more individual environmental control. • Replace the human routine works with computer. • Reduce the number of maintenance staff required.

Table 3.1: Other benefits of intelligent buildings identified from the interview
Source: Abstracted from interview transcription

Constraints of intelligent buildings

There are four aspects of constraints in intelligent buildings that are similar to both the supply and demand side.

1. Large capital outlay and expensive to run the system

It was estimated that it will cost 60% more to create intelligent building in term of the cost of technology (Read, 1997). Many controls and IT systems are expensive because they are mostly customised system. At the moment there is no "off-the-shelf" product that can meet the standard users needs and therefore cannot generate economies of scale by mass production. Besides that, more money will be needed to keep the system in the building running.

In terms of construction cost, studies done by Northcroft based on computer integrated buildings shows that the construction cost varies from 30% to 60% as compared to standard building (Loe, 1997). Most of these costs are contributed by the services and the control system to a certain extent contributed by the raised flooring and building structure.

2. Lack of the ability to inter-operate between different systems.

It was commented that most of the system produced by the building control industry were proprietary systems and they cannot inter-work with other IT system and each other (Read, 1997). The problem of lack of open protocol used by the manufacturers is a major hindrance towards integration of various systems in the building (Mitchell, 1997). EBRD building at One Exchange Square is a good example of costly solutions to the problem of integration which is based on customised design product (Sudworth, 1997).

3. Lack of evidence of the real financial benefits and pay-back.

Though many benefits of intelligent buildings have been mentioned, the lack of evidence on the real financial benefits (in figures) provides by intelligent building remain unconvincing enough to persuade developers to adopt intelligent building strategies. Most building owners and developers today are interested in how their buildings can help them to save money (Read, 1997). The developers and building owners will be more likely to consider intelligent building if it can be proven to them that by adopting intelligent systems can save them money. At the moment there is not yet a method available to determine the costs and benefits of intelligent building (Loe, 1997). This is exactly what Northcroft is trying to develop for the Building Rating Method (BRM) in the Intelligent Building Asia project.

4. Systems installed are complex and sophisticated.

There are few problems that associated with this constraint. Firstly, due to much complexity and sophistication in intelligent building systems, specialised skill and knowledge are needed by the users to operate the systems installed. In many cases when failure occurs in the sophisticated systems, even the expert could not correct the faults fast enough to prevent losses incurred by the organisations (Moore, 1997).

Secondly, the lack of understanding among the users, on the original intent of the design of various systems has resulted in the inability to use the building systems to its maximum benefits by the users. There are also cases where the control systems in a building are shut down completely. This is because the person who takes over the responsibility of running the building does not understand completely the original intent of the system (Loe & Harrison, 1997).

Other constraints

Other constraints quoted by the demand side includes the difficulties to let out intelligent building to normal tenants. This is because they are not prepared to pay the high premium for systems that only benefits the developers and the building owners (Mitchell, 1997). Developers and building owners in this case will need to identify a very specific sector of the market to implement intelligent building strategies. Dr. David Boyd commented the case of a speculative development, where the building will run a high risk of failure in meeting the needs of organisations. This is because the buildings are often designed with no specific types of tenant in mind.

Suggestions to overcome the constraints

The respondents have given their view points and suggestions to overcome the constraints as follows:

1. To develop common protocol and standardise product.

To achieve this there is a need for collaboration among the IT manufacturers and the building control industry (Read, 1997). The supply side sees the need to consolidate all technology available and address the issue of integration more seriously (Harrison, 1997). To achieve the objective of fully integrated building, with the technology available it is not much a problem (Read, 1997). The only difficulty is in the lack of initiative and co-operation among the manufacturers and suppliers in funding the research to explore the issue more thoroughly. There is a lack of push on the issue of integration to move the concept forward fast enough as each sector is busy with their own development. It is believed that the development of common protocol and standardised products can help bringing down the initial cost due to economies of scale from mass production.

2. To provide what is required and eliminate what is complex.

To reduce complexity and sophistication, it is important to keep the control system separately in terms of dependency (i.e. the system can stand alone). The systems can be integrated in terms of communications and sharing of information with other systems (Moore, 1997). Beside this it is also important for the design team to capture the client's needs at the early design stage by studying and understanding their business operations.

The design team should also have the occupants' and organisations' needs in mind when approaching the design and to link the capability of the building with the business needs (Mawson, 1997).

3. To provide more training to the users.

Generally there are two aspects of training which are lacking (Loe, 1997). Firstly, more training is needed by those responsible for the running of building in operating the various intelligent buildings systems. In this aspect, all higher learning institution can play an important role in closing the gap.

Secondly, there is a need for organisations to have induction procedure for their staff so to brief them on the various systems in the building. This will help them in understanding how they can use the intelligent building system as intended by the design.

4. To create greater awareness among organisations in understanding of how various systems can meet business needs.

Organisations like European Intelligent Building Group (EIBG); Royal Chartered Institute of Architect (RIBA); Royal Institute of Chartered Surveyor (RICS); Chartered Institute of Building Services Engineers (CIBSE); British Institute of Facilities Management (BIFM) etc., can play an important role in increasing the awareness of organisations on the benefits of intelligent buildings. This can be done through the educating organisations to understand how intelligent building can help in their business operations (Loe, 1997).

Contrary to that there is a need for major commitment from organisations when implementing intelligent building strategies (Harrison, 1997). Organisations need to involve themselves right from design process through to the management of the building to ensure that systems installed are working efficiently. The owners and users should be involved as early as possible so that they can understand what the design team is trying to achieve and how the design can link to their business needs.

3.4 FUTURE DEVELOPMENT TRENDS OF INTELLIGENT BUILDINGS

Future development trends

1. Move towards a total open protocol and standard system that enable one system to communicate with another.

On the control side there will be a further move towards standardisation in the use of technology such as Echelon chips, standard networking and BACnet standard network (Read, 1997). For the IT side, there will be no immediate progress in the development of intelligent building system as the main focus is still on the development of desk top applications.

In the future, there is a likelihood that consortium will be formed to investigated the benefits of Computer Integrated Building (CIB). Through this type of co-operation, the development towards total open protocol and standard system will not be very far away and this will definitely drive down the cost of various control systems (Sudworth, 1997).

2. Increasing capability of building in supporting new ways of working.

In the future the fixed location office will start to disappear (Loe, 1997). Not only that the building can support a more mobile type of occupations (Mawson, 1997), it will eventually serve as a bigger network that supports new patterns of working (Harrison 1997). The building in the future will be able to cope with the changing working practices and will be designed for multi-functional uses (Mitchell, 1997).

3. Increasing in users control and usability.

This is because people wanting to feel that they have the influence over their working environment (Harrison, 1997). Systems that make use of telephone, computer terminals, switch panel etc., in allowing user access to environmental control will certainly be the things that many users are looking forward to.

There will be further move toward the provision of individual environment control system. This enables greater freedom to end users to adjust the temperatures and lighting to suit their needs (Wicking, 1997).

Some driving forces for the development of intelligent buildings

1. Increasing demand for high quality workplace.

People are increasingly demanding more from their building for a better environment that is easier to work in (Read & Wicking, 1997). This is a very fundamental need for organisations to have a space with the right built environment to support their core business. Besides, the increasing pressure from workplace legislation has forced organisations to look at the quality of working environment more seriously (Mitchell, 1997).

2. Increasing rate of change in business.

There is also an increasing demand on building that is adaptable and easier to reconfigure which resulted from increasing competitions in business (Mawson, 1997). Due to the increasing in the world challenges which can be difficult to cope with, some businesses may have to change their strategies and emphasis over night. Therefore organisations will need their building to adapt to these changes more easily and quickly (Read & Mitchell, 1997).

3. Increasing demand by large corporations on the capability of their buildings.

There is another driving force which comes from large corporate organisations or users who want their buildings to have the same ability to those buildings in elsewhere e.g. Far East, America etc. (Loe, 1997). As organisations becoming more global, there is a great demand by large multinational organisations on their buildings which can support global ways of doing business (Mitchell, 1997).

4. Increasing pressure to turn real estate portfolio from being an overhead to an effective part of the production process.

Everywhere there is a strong pressure on organisations to turn their real estate portfolio from being an overhead that accommodates people to being an effective part of the production process (Harrison, 1997). That means looking at every piece of space that occupied and evaluate whether it is working for organisations or whether it is providing the appropriate support needed.

5. Declining cost of technology.

The reduction in the cost of IT, control and communication systems will cause organisations to be more ready to accept new ways of doing things. The lowering of the cost of electronic products will result in widely use of fibre optics in building (Moore, 1997). There will be more flat screen technology coming into the office as it gets cheaper. This will eventually reduce the amount of space required and ultimately making building smaller and simpler (Loe, 1997).

Stumbling blocks to overcome

Beside those constraints of intelligent buildings, the respondents also outline some stumbling blocks to the development of intelligent buildings. These include:

1. The attitude of reluctance to change or to take on new things by the management of many organisations.

This is a common symptom of many organisations in an established economy. There is a tendency for organisations to repeat what they have done before, instead of striving for something that is new (Loe, 1997).

2. Un-sustainable tenants and landlord relationship in a traditional property market.

This includes the following (Mitchell, 1997):

- Long and inflexible leases.
- Limited source of funding for buildings development.
- The developers' view of their profit and tenants' concern for their security.

Offering no absolute solutions, the respondents commented that these stumbling blocks need to be addressed more seriously to allow intelligent buildings development to move forward in a faster pace.

3.5 SOME CRITICS ON INTELLIGENT BUILDINGS

Towards the end of the interview some respondents gave their critics on the terms intelligent buildings as follows:

> *"The conclusion about intelligent building concept was a bit of technology strain. It was associated with the automatic control of lighting and etc. It has a very low added value but very gimmicky. The whole issue of building design is not about labelling the building. The market needs building that will really support the performance of individuals and organisations. If technology is part of the solutions then it is just part of the solutions. Technology is not all." (Mawson, 1997)*

> *"In a way the word intelligent building is an irrelevant word because it is all about building. A building should be designed to adapt and to meet the needs of the people inside it. If this definition is used, to certain extent every building is an intelligent building." (Harrison, 1997)*

> *"Intelligent building was in the sense an advertising slogan at one point and it may need to move on a little bit from this. It is an inappropriate name and does not correctly reflect the issues today. The term intelligent building has got inappropriate connotation." (Boyd, 1997)*

> *"The term intelligent building is something that needs to be demystified. It has always been associated with something that is advance and mysterious almost like a joke. At the fundamental level an intelligent building is no more and no less than a good environment to be in. Perhaps it is a wrong phrase to use and we have got stuck with it." (Loe, 1997)*

From the critics above it seems that the respondents, particularly from the supply side have a common agreement towards the inappropriateness of the term intelligent buildings. Generally the critics call for a shift from focusing on the technology and labelling of buildings to focusing on the fundamental needs of organisations in building design. The critics also summed up the need to shift from using the term intelligent buildings as advertising slogan, to concentrate on the performance of buildings. There is a need to focus on those things that can really help to add value to organisations and reflect the real issues faced by organisations.

3.6 REFERENCES AND NOTES

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CHAPTER FOUR: PERSPECTIVES FROM THE SURVEY

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CHAPTER 4: PERSPECTIVES FROM THE SURVEY

4.1 THE SURVEY

This chapter draws out the perspectives of intelligent building from the survey results (Appendix D) obtained. As the survey form was designed to collect quantitative data, the respondents were asked to provide their answers by using the score appropriate to the respective questions on a scale of 1-5. The data analysis showed how the concept and benefits of intelligent buildings are perceived by corporate organisations in UK. The scores for performance of building under different categories are compared and measured against the score for the degree of importance. Various common intelligent building features are examined in order to understand to what extent they are used as compared to their importance. The factors that constrained the implementation of intelligent building strategies are also determined.

4.2 ORGANISATIONAL BACKGROUND

This section investigates the organisational background of different categories of building users, with respect to their sector, country of incorporation, number of employees and annual turnover. This is to identify if there is any relationship between the background of the organisations and the types of building they occupied. For the purpose of this survey, the buildings are classified simply under three categories as buildings with few technological features[1] , buildings with certain technological features[2] and buildings with high technological features[3].

Table 4.1 shows the organisations' background in relation with the types of building they occupied.

Buildings with few technological features

Organisations occupying this type of building make up 15.8% of the total survey received. They are generally from the trading, insurance and advertising sectors which are mainly incorporated in UK. With less than 100 and business turnover of less than £100 million annual, these organisations do not own the buildings.

Background information / Description of Building	Simple with few technological feature	Simple with certain technological features	Sophisticated with high technological features	
Sector				
Legal	-	-	5.3%	5.3%
Trading	5.3%	5.3%	-	10.5%
Insurance	5.3%	-	5.3%	10.5%
Accounting	-	10.5%	5.3%	15.8%
Advertising	5.3%	-	-	5.3%
Bank/Finance	-	10.5%	10.5%	21.1%
Entertainment	-	-	5.3%	5.3%
Transportation	-	5.3%	-	5.3%
TV Broadcasting	-	5.3%	10.5%	15.8%
Telecommunications	-	5.3%	-	5.3%
	15.8%	42.1%	42.1%	100.0%
Country of Incorporation:				
UK	10.5%	15.8%	26.3%	52.6%
USA	-	5.3%	-	5.3%
Canada	-	-	5.3%	5.3%
Japan	-	5.3%	5.3%	10.5%
France	-	5.3%	-	5.3%
Not available	5.3%	10.5%	5.3%	21.1%
	15.8%	42.1%	42.1%	100.0%
Number of employees:				
Less than 100	10.5%	-	-	10.5%
100 to 249	-	15.8%	-	15.8%
250 to 499	5.3%	10.5%	5.3%	21.1%
500 to 749	-	5.3%	10.5%	15.8%
750 to 999	-	-	-	0.0%
More than 1000	-	10.5%	26.3%	36.8%
	15.8%	42.1%	42.1%	100.0%
Annual Turnover of Business:				
Less than £100 million	10.5%	10.5%	5.3%	26.3%
£100 to £250 million	-	-	-	0.0%
£250 to £500 million	-	-	-	0.0%
£500 to £750 million	-	-	10.5%	10.5%
£750 to £1000 million	-	-	5.3%	5.3%
More than £1000 million	-	21.1%	15.8%	36.8%
Not available	5.3%	10.5%	5.3%	21.1%
	15.8%	42.1%	42.1%	100.0%
Ownership of Building:				
Self owned	-	15.8%	5.3%	21.1%
Self owned with tenancy	-	-	5.3%	5.3%
Leased	15.8%	21.1%	26.3%	63.2%
Leased with sub-tenancy	-	5.3%	5.3%	10.5%
	15.8%	42.1%	42.1%	100.0%

Table 4.1: Correlation between organisations' background and types of building occupied
Source: Author (Abstracted from the survey results)

Buildings with certain technological features

Organisations under this category make up 42.1% of the total survey received. They are generally from the trading, accounting, bank/finance, transportation, TV broadcasting and telecommunications sectors. These organisations are mostly incorporated in UK, USA, Japan and France. Though their number of employees mostly falls between the range of 100 to 749, few of these organisations have employed more than 1000 staff. In term of annual business turnover these organisations show two extremes, i.e. either less than £100 million or more than £1000 million. Except for 15.8% of the respondents, most of these organisations generally do not own the buildings.

Buildings with high technological features

A total of 42.1% of the respondents occupied building under this category. They are generally from legal, insurance, accounting, bank/finance, entertainment and TV broadcasting sectors. Most of these organisations are UK incorporated with a small fraction incorporated in Canada and Japan. Though majority of these organisations employed more than 1000 staff, there are a few organisations have employed 250 to 749 staff. Their annual business turnover varies from the range of £500 million to more than £1000 million. Only a smaller proportion of the organisations has an annual turnover of less than £100 million. As for ownership of the building, a small percentage of the organisations owned this type of building.

Points of interest

The following are some points of interest observed on the background of organisations occupying building with certain or high technological features:

1. They are generally comprising of all sectors.
2. Besides UK incorporated, all the non-UK incorporated organisations occupied these categories of buildings.
3. None of the organisations with less than 100 employees fall under these categories.
4. Though most organisations with a higher annual business turnover tend to occupy these categories of buildings, some organisations with annual turnover of less than £100 million also occupied these types of buildings.
5. Not many organisations surveyed owns these categories of buildings.

4.3 AWARENESS OF INTELLIGENT BUILDINGS

This section examines the respondents' awareness and understanding of the concept of intelligent buildings. The correlation between technologies, building intelligence and building performance are observed and verified. From the survey results, 89.5% of the respondents' replied that they are aware of the concept of intelligent buildings irrespective of what it means to them.

Perceived correlation of building intelligence, technology and performance

The analysis in Table 4.2a shows that the respondents perceived a direct correlation between the degree of technological features installed and the degree of intelligence possessed by their buildings. Except for a smaller fraction of the respondents (21.1%) who do not equate technological features directly with building intelligence.

A further analysis in Table 4.2b only shows a stronger evidence of a direct correlation between the building performance and the degree of technological features installed. A comparison of Table 4.2a and Table 4.2b shows that though a building may not be classified as intelligent by the organisation, but in term of satisfying their business needs the building can perform equally well. The result also shows that otherwise can happen to those building with certain or high degree of intelligence.

Description of building \ Degree of intelligence	None	Some degree	High degree	
Simple with few technological feature.	15.8%	-	-	15.8%
Simple with certain technological features.	5.3%	36.8%	-	42.1%
Sophisticated with high technological features.	-	15.8%	26.3%	42.1%
	21.1%	52.6%	26.3%	100.0%

Table 4.2a: Perceived correlation between technology & building intelligence
Source: Author (Abstracted from survey results)

Description of building	Building Performance: Very Poor/Poor	Fair	Good/Excellent	
Simple with few technological feature.	5.3%	10.5%	-	15.8%
Simple with certain technological features.	10.5%	26.3%	5.3%	42.1%
Sophisticated with high technological features.	-	-	42.1%	42.1%
	15.8%	36.8%	47.4%	100.0%

Table 4.2b: Perceived correlation between technology & building performance
Source: Author (Abstracted from survey results)

Various responses towards implementing building intelligence

Table 4.3 shows the varying responses by different organisations toward the possibility of implementing building intelligence in the near future. In order to understand how building performance affect organisations' decisions, a correlation between their building performance and their responses is examined.

From the analysis, those who responded positively towards the possibility of implementing building intelligence make up a total of 36.8% of the responses received. They are basically those organisations who already have certain or high technological features in their buildings. Most of these buildings at present are performing satisfactorily in meeting the business needs. Only a smaller proportion of the respondents has a poorer performance in their buildings.

For those organisations that are in the process of considering the possibility of implementing building intelligence, they are also from existing organisations who have certain or high technological features in their buildings. These responses make up a total of 15.8% of the overall survey received.

The 21.1% of the respondents who indicated that they have no plan to implement building intelligence are mainly organisations who have few technological features in their buildings. A small percentage of them has certain technological features in their

buildings. Though some of these organisations' buildings performed poorly in term of satisfying their business needs, the respondents do not seem to think that building intelligence can help to improve their buildings' performance.

The remaining respondents who have no intention to implement building intelligence are generally organisations who already have building intelligence in place. Their buildings at present are performing well in meeting their business needs.

Description of building	Planning to impliment intelligent building policy in future	Yes	Consider	No	Already in place	
Simple with little technological features.		-	-	15.8%	-	15.8%
Simple with certain technological features.		26.3%	10.5%	5.3%	-	42.1%
Sophisticated with high technological features.		10.5%	5.3%	-	26.3%	42.1%
		36.8%	15.8%	21.1%	26.3%	100.0%
Building Performance						
Very Poor/Poor		5.3%	-	10.5%	-	15.8%
Fair		15.8%	10.5%	10.5%	-	36.8%
Good/Excellent		15.8%	5.3%	-	26.3%	47.4%
		36.8%	15.8%	21.1%	26.3%	100.0%

Table 4.3: Various responses toward the possibility of implement building intelligence
Source: Author (Abstracted from survey result)

Points of interest

1. The respondents show high awareness of the concept of intelligent buildings.
2. The respondents perceived a stronger correlation between building technology and building performance as compared to the correlation between building technology and building intelligence.

3. Though some buildings are not classified by the respondents as intelligent, but in terms of performance, they performed equally well with those classified as intelligent.
4. Those organisations currently occupying building with certain or high technological features are most likely to implement building intelligence in the future.

4.4 COMPARISONS OF BUILDING PERFORMANCE

This section evaluates the performance of the respondent's buildings in terms of how well they satisfy the organisations' requirements.

Organisational requirements: efficiency

Chart 4.1 shows the comparison of building performance based on efficiency requirements. The result shows that generally building with few technological features are performing poorer as compared to buildings from the other two categories. This applies to building with certain technological features when compared to that of high technological features. The only exception is observed on the aspect of reducing the need for storage space, where the result of building with certain technological features shows otherwise.

The comparison between performance of buildings and importance of efficiency requirements showed that generally there are still gaps between what the organisations think are important and how the buildings perform. The exception applies to the requirement on increasing the value of building where both the performances of building with certain and high technological features exceeded the degree of importance. The result from the survey shows that though technological features can help to increase the value of a building, but this is not an important requirement to the respondents.

Organisational requirements: effectiveness

Chart 4.2 shows the building performance based on effectiveness requirements. The result generally shows a direct correlation between how well a building performed and how much technological features it possessed. The exception applies to the buildings with few technological features where the building performed better in term of

improving profitability as compared to that of certain technological features. For buildings with high technological features, their performances have exceeded the degree of importance in the two efficiency requirements, i.e. improving customers' satisfaction and reducing absenteeism.

Other requirements

Chart 4.3 again shows a similar trend as chart 4.2 in term of the performance and the technological features possessed by the buildings. By comparing the buildings' performance with the importance of these requirements, the result shows that buildings with high technological features have performed well in the following aspects:

1. improving the accessibility to information
2. supporting a wide range of work settings and work patterns
3. reducing the disruption of work flow
4. extending the building usage which results in increased working hours
5. improving the image of organisation to outsiders

Points of interest

1. The result again shows a direct correlation between building performance and technology.
2. Though building intelligence can help in increasing the value of buildings but this is not an important requirement to organisations.

Chart 4.1: Comparisons of building performance based on efficiency requirements

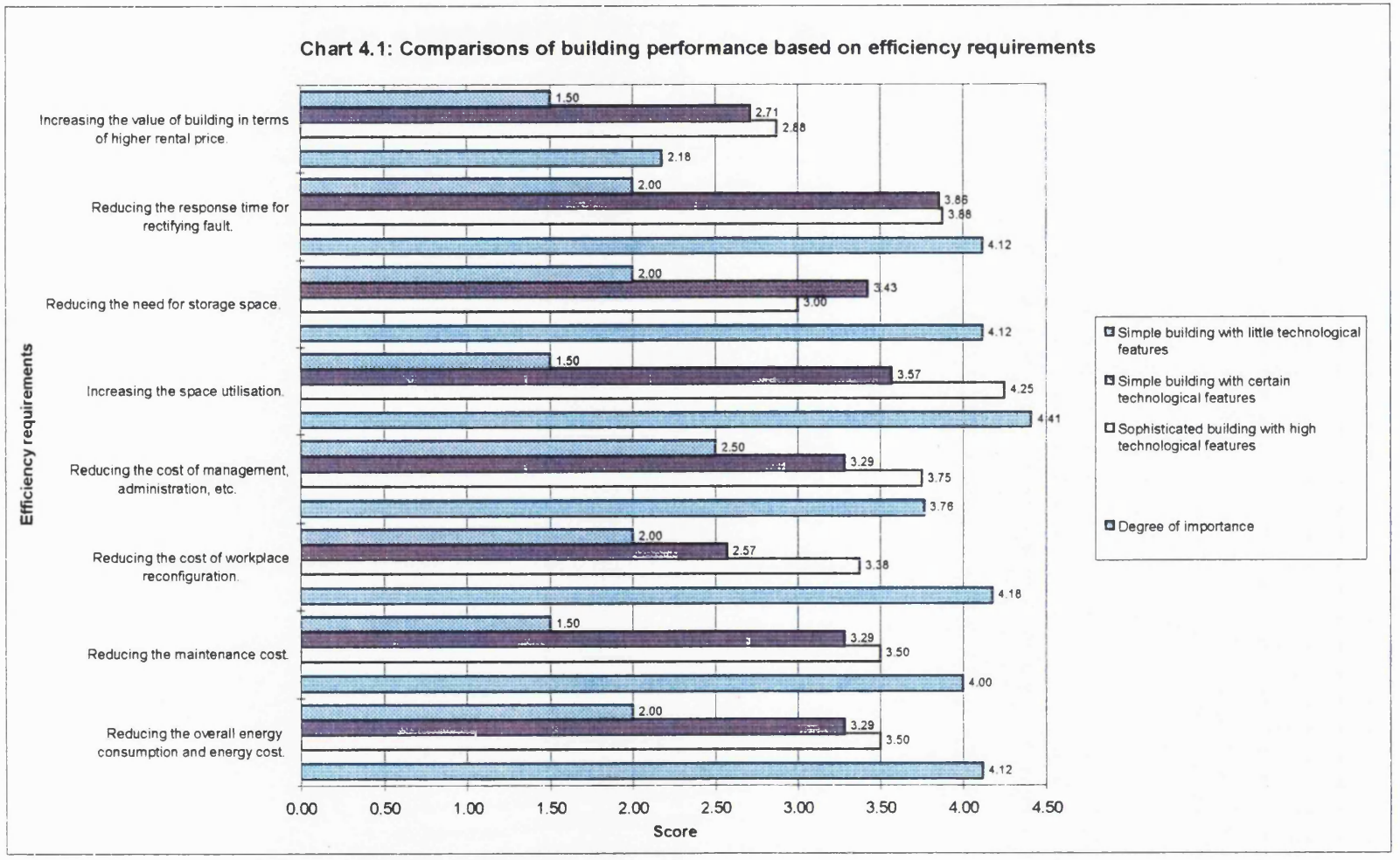
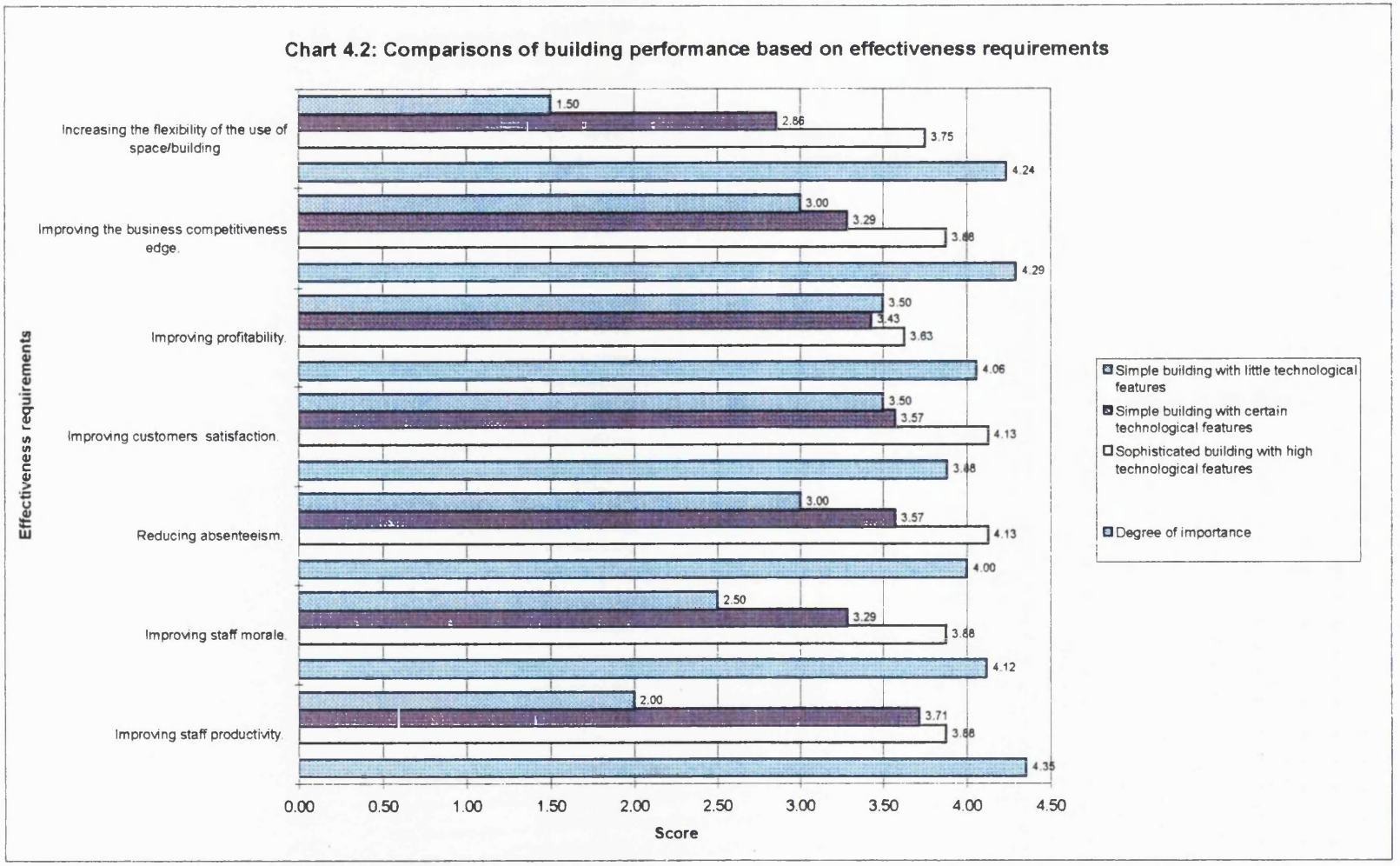


Chart 4.2: Comparisons of building performance based on effectiveness requirements



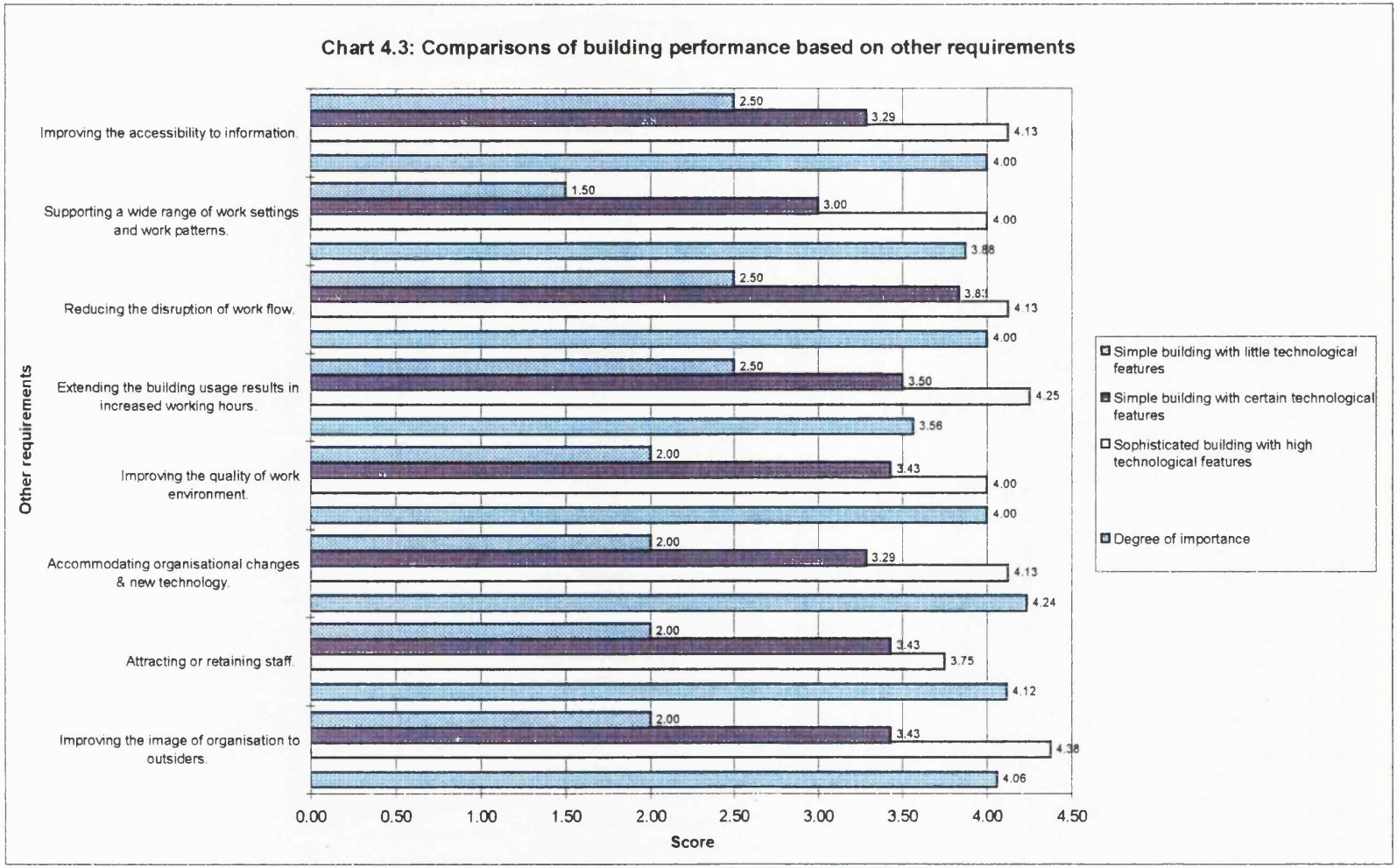


Chart 4.3: Comparisons of building performance based on other requirements
Other requirements
Improving the accessibility to information.
Supporting a wide range of work settings and work patterns.
Reducing the disruption of work flow.
Extending the building usage results in increased working hours.
Improving the quality of work environment.
Accommodating organisational changes & new technology.
Attracting or retaining staff.
Improving the image of organisation to outsiders.
2.50
3.29
4.13
4.00
1.50
3.00
4.00
3.88
2.50
3.81
4.13
4.00
2.50
3.50
4.25
3.56
2.00
3.43
4.00
4.00
2.00
3.29
4.13
4.24
2.00
3.43
3.75
4.12
2.00
3.43
4.38
4.06
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
Score
Simple building with little technological features
Simple building with certain technological features
Sophisticated building with high technological features
Degree of importance

4.5 COMMON INTELLIGENT BUILDING FEATURES

This section examines the extent of use of various intelligent building features used by the respondents. Their degrees of importance are determined to assess the potential intelligent building features that are likely to be implemented by the respondents in the future. Chart 4.4 shows the extensiveness of intelligent buildings features used as compared with their importance by the respondents.

The result shows three intelligent building features that scored the same in terms of their extent of use and their degree of importance. These three features include the Local Area Networks (LANs), electronic mailing system and office furniture with data, voice and electrical cables. The next feature on the line that shows closer matches between the score is voice messaging system.

Among those intelligent building features showing mismatch between the extent of use and the degree of importance, two features that show a huge gap are computer aided facility management (CAFM) system and video conferencing. The result indicates that though these features are important to the respondents but at the moment they have yet to be used extensively.

In terms of the degree of importance, from high to low, the following are the order as shown by the result:

1. fitting-out elements
2. office automation and telecommunications systems
3. office furnishing
4. building automation system
5. facility management system
6. building shell

It can be seen from the result above that the respondents have placed a high degree of importance on the fitting out elements. This includes the feature such as demountable partitioning system; raised flooring system; structured cabling etc, which can provide much flexibility for the users in space usage.

The next important feature that follows is office automation and telecommunications systems. This includes Local Area Networks (LANs), Voicing messaging system,

Electronic mailing system, video conferencing etc. This system generally used to increase the capability of organisations to communicate effectively both internally and externally. They have the potential to allow organisations to implement new ways of working (e.g. home working, hot desking, etc.). Besides communications, these systems can help organisations to assess information more readily and easily.

The next intelligent building feature that is important to the respondents is office furnishings. This includes furniture that incorporates data, voice and electrical cables etc. This feature again can provide the flexibility that needed by the organisations in managing their space usage.

Building automation system which generally has been one of the main feature of intelligent building has ranked lower compared to other features above. This feature usually includes energy management system; security system; disaster prevention system; building management system; individual workstation environmental controller; etc, which can provide added capability to control, adjust and modify their working environment. These systems can also use to help improve the energy efficiency of the building.

The next feature follows is facility management system. This includes the computer aided facility management system which mainly concerns with the use of computer software and database programme to facilitate the management of space, cabling, leases, project, maintenance operations etc. The main capability that this system can provide to the users includes the efficiency in managing the facility resources and support services.

Building shell which ranked last in term of importance by the respondents indicates that at the moment the respondents do not have any problem in this area.

Points of interest

1. The high ranking of fitting out elements in intelligent building features indicates the importance of flexibility in building to the respondents.
2. The high ranking of office automation and telecommunication system indicates the importance of building in facilitating organisations with the ease of communications and access to information.

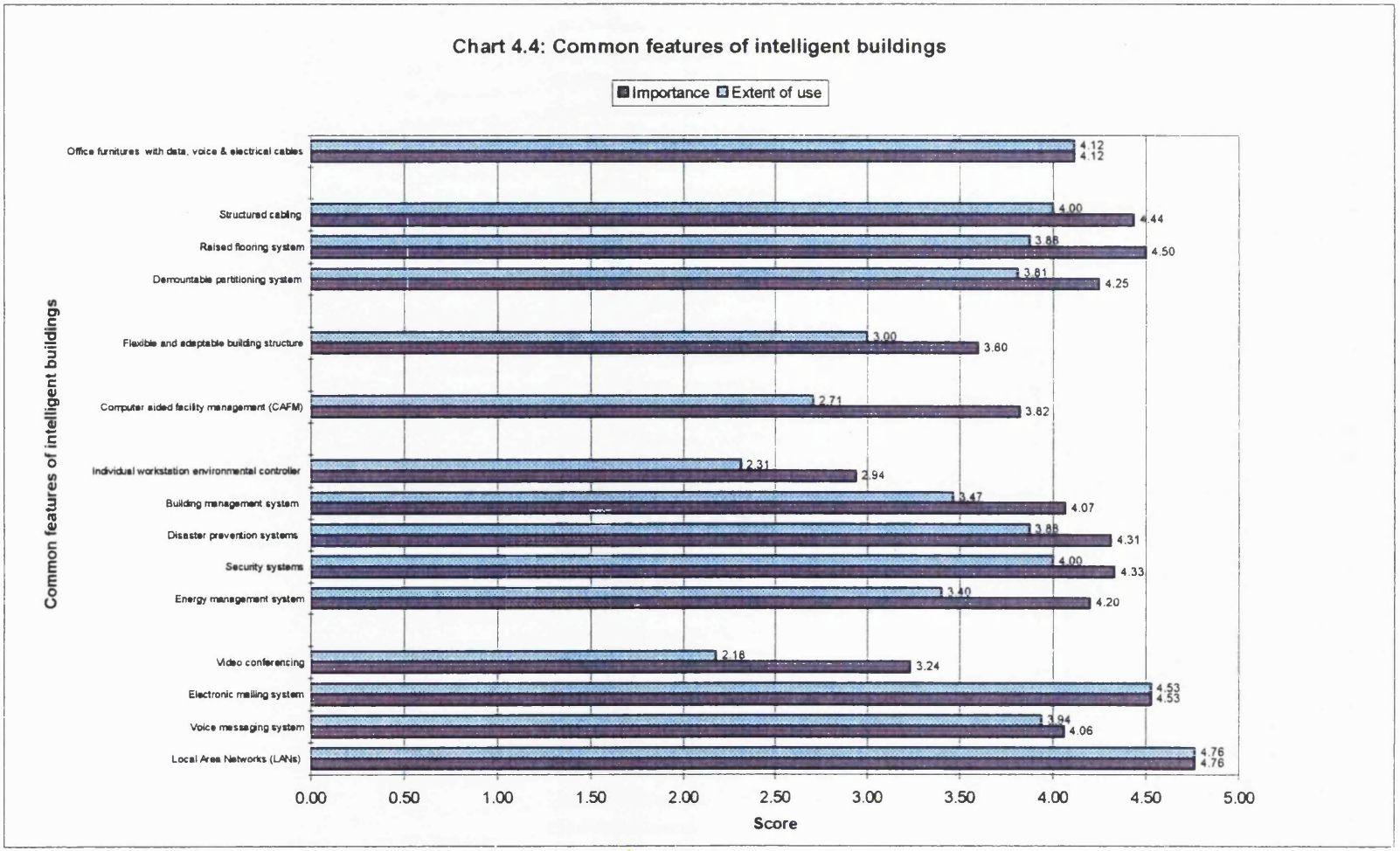


Chart 4.4: Common features of intelligent buildings
Importance
Extent of use
Common features of intelligent buildings
Office furnitures with data, voice & electrical cables
4.12
4.12
Structured cabling
4.00
4.44
Raised flooring system
3.88
4.50
Demountable partitioning system
3.81
4.25
Flexible and adaptable building structure
3.00
3.80
Computer aided facility management (CAFM)
2.71
3.82
Individual workstation environmental controller
2.31
2.94
Building management system
3.47
4.07
Disaster prevention systems
3.88
4.31
Security systems
4.00
4.33
Energy management system
3.40
4.20
Video conferencing
2.18
3.24
Electronic mailing system
4.53
4.53
Voice messaging system
3.94
4.06
Local Area Networks (LANs)
4.76
4.76
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Score

4.6 CONSTRAINING FACTORS FOR INTELLIGENT BUILDINGS

This section examines the relevance of each constraining factor to the respondents in developing intelligent building strategy. The result is presented in Chart 4.5 based on the responses by users of different building types. The following statements are used to examine their degree of relevance to the respondents:

Lack of standards and terms of reference. This does not just refer to the lack of technological standards for systems communication and inter-operability. It refers to the lack of previous experience available to organisations for their references in decision making. This problem also includes the lack of standard for defining the quality of a system installed and the quality of service provided by the suppliers.

Lack of coordination between different functions/suppliers. This problem usually occurs at the design and installation stage as there are so many sub-systems exist in a building. The lack of co-ordinations among different system at design stage may result in the provision of redundant cabling where there is a possibility for different systems to share the same cabling system.

Lack of interfaces between different systems. The fact that there is yet a common protocol in the market place has resulted that systems from different manufacturers and suppliers are unable to interconnect and inter-operate with each other.

Lack of know-how and experience in supporting the system. This reflects the nature of sophistication in many intelligent building systems that need special skill and know-how from the supply side to provide the necessary support.

Large initial capital outlay. This factor reflects that many potential intelligent building users are unwilling to invest in something that they are uncertain or unconvinced of the real benefits they can get out of the systems.

Lack of expertise in operating the intelligent building systems. This problem not only prevents potential users from implementing intelligent building strategy, it also

prevents the existing users from realising the maximum benefits from the systems installed.

Technology provided not appropriate. This problem arises due to lack of understanding between the supply and the demand side of intelligent buildings.

The survey result shows that the most relevant constraining factor encountered by the three categories of building users in implementing the intelligent building strategy is the large initial capital outlay.

For building users with few technological features are more concerned with the lack of know-how and experience in supporting the system and the lack of co-ordinations between different functions/suppliers.

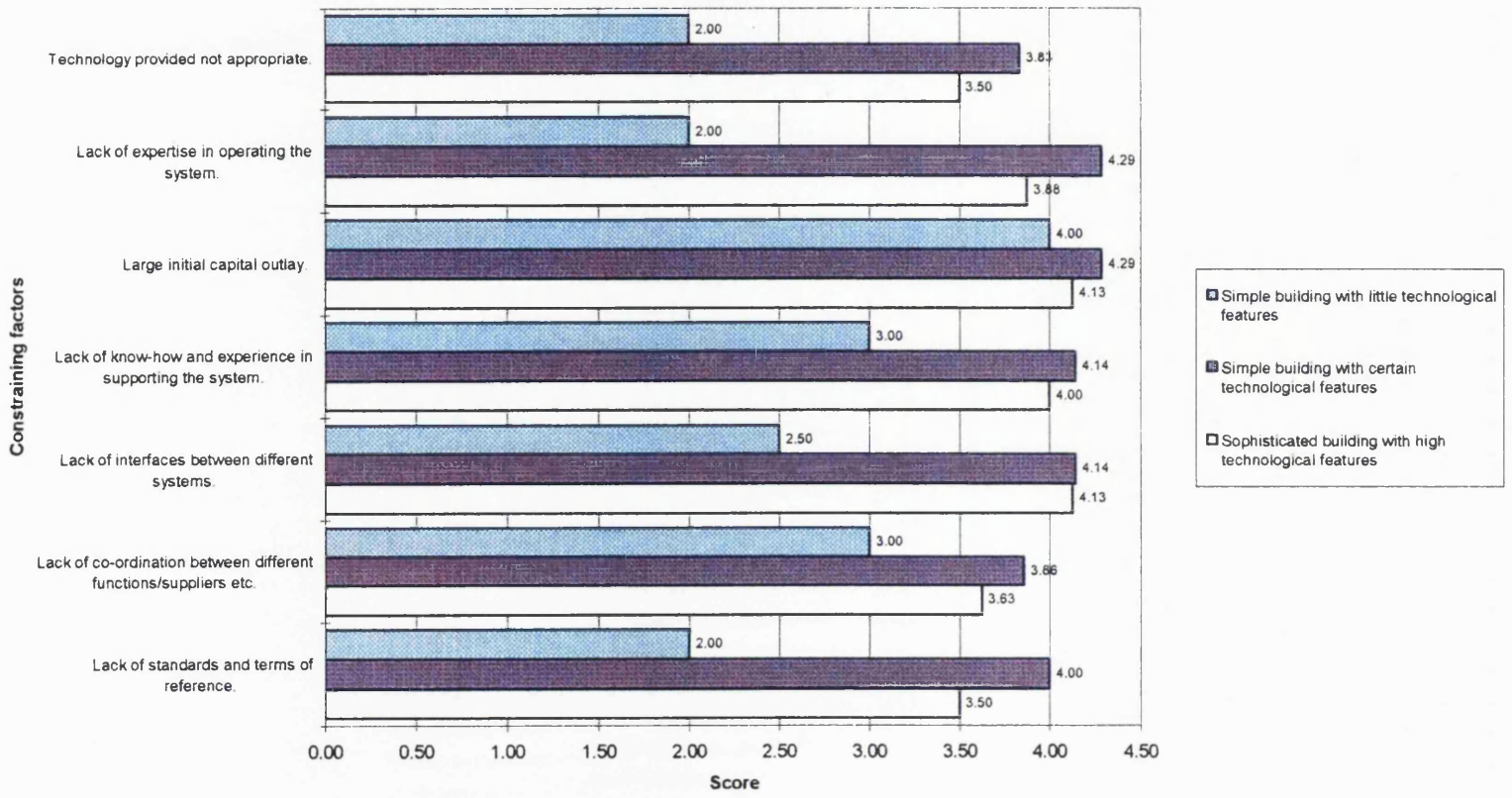
For building users with certain technological features the concern for the lack of expertise in operating the system rank the same as the concern for large initial capital outlay. This is followed by the lack of know-how and experience in supporting the system, and the lack of interfaces between different systems.

For building users with high technological features, the concern for the lack of interfaces between different system rank the same as the constraining factor of large initial capital outlay. This is followed by the lack of know-how and experience in supporting the system, and the lack of expertise in operating the system.

Points of interest

1. There is a general consensus by different users on the constraining factors in developing intelligent building strategy.
2. The result shows the top four common constraining factors in implementing intelligent building strategies are:
   - Large initial capital outlay.
   - Lack of expertise in operating the system.
   - Lack of know-how and experience in supporting the system.
   - Lack of interfaces between different systems.

Chart 4.5: Comparisons of constraining factors for intelligent buildings



4.7 NOTES

[1] *Buildings with few technological features.* The characteristics of these categories of building include simple structure with not much use of building automation and facilities management systems. Other common features include small degree of office automation and telecommunications.

[2] *Buildings with certain technological features.* These categories of buildings possess only some degree of building automation, office automation and telecommunications systems. There are not much use of facilities management system but in term of fitting out elements these buildings use some degree of demountable partitioning systems, raised flooring systems and structural cabling.

[3] *Buildings with high technological features.* There are extensive use of office automation and telecommunications systems. These include Local Area Networks, electronic mailing systems and voice messaging system. In terms of building automation systems features such as energy management system, security systems, disaster prevention systems are used extensively. Most of these buildings have extensive use of facilities management system. In terms of building structure they are highly adaptable. Office furnitures used are mainly modular system with the incorporation of cabling for data, voice and power supply.

CHAPTER FIVE: CONCLUSIONS

CONTENTS

CHAPTER 5: CONCLUSIONS

5.1 KEY FINDINGS

What is meant by intelligent building?

Throughout this research, the concept of intelligent building has been examined from both the supply and demand side perspectives. The interview result shows that much coherence existed in the intelligent building concept as perceived by both sides. In general the concept of intelligent building has shifted from the initial approach which is of technological and product focused to organisational and process focused. The former views intelligent building as a structure that incorporates the latest technology. The latter views intelligent building as a continuum of development phases to the building capability and performance as illustrated conceptually in Figure 5.1.

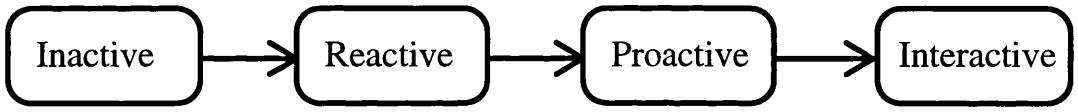


Figure 5.1: Different phases of development & improvement on building capability and performance
Source: Author

The capability of the building to respond to changes is identified as the main attribute of intelligent building by the respondents. This attribute is the result of the shift from viewing building as a passive structure to an active entity that support the business needs of an organisation. The five facets of change which an intelligent building is capable of responding to are identified as follow:

1. *Organisational change.* This is concern with the change in the management structure (e.g. from task orientated to people orientated etc.) and the change in work practices within an organisation (e.g. flexible working, team working, multi-locational working etc.)

2. *Market change.* This involved the change cause by global competitions and fluctuation in the economic situations of a particular sector. These changes have a direct effect on the size of the organisation hence the workplace required due to the need to expand or downsize.

3. *Technological change.* Rapid change in technology development can render a building obsolete. The building will therefore need to have the basic infrastructure that can accommodate new technology easily and economically as required by the organisation.

4. *Functional change.* This is concerned with the change in the functional use of building. For example, a more drastic change in the functional use of a building will be the change from an office to a residential use.

5. *Environmental change.* This is concerned with changes in the immediate external and internal environment of the building which have direct effect on the thermal, air, visual and aural quality of the workplace.

Figure 5.2 illustrates the various facets of change that an intelligent building is capable of responding to:

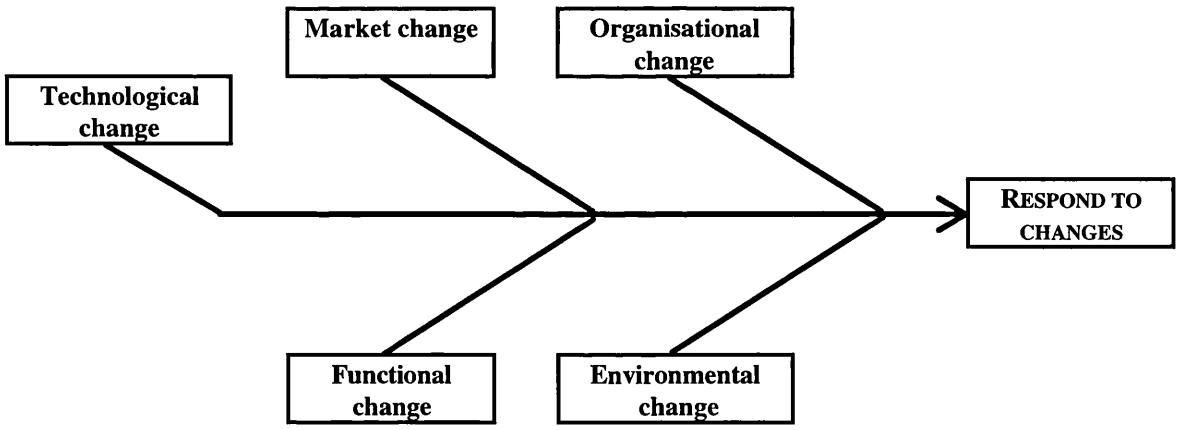


Figure 5.2: Various facets of change in intelligent buildings

Source: Author

Though the emphasis of intelligent building has shifted away from technology focused, the survey result reveals that there is a strong correlation between technological features and building performance as perceived by the respondents. This indicates that technology will continue to be viewed by the users as an important means to achieve high performance in building to meet the business needs of organisations.

In term of the technological features that make up an intelligent building, the survey results reveal that the emphasis today is not so much on what technology should a building

possess. Rather, the emphasis of an intelligent building is on the provision of appropriate level of technological features to meet the needs of organisations and end users. The appropriateness of the technology in a building was found to be very different from one organisation to another. This is very much depending on the current and future needs of the organisations, and the priority placed by each organisation on the different facets of change as described earlier.

Benefits of intelligent buildings

The interview results have identified a list of benefits provided by intelligent buildings. These benefits can be categories as either tangible or intangible benefits and range from organisational level to individual level as illustrated in Figure 5.3 below:

	Tangible Benefits	**Intangible Benefits**
Organisational level	• Energy efficiency • Increase flexibility to facilitate churn • Reduce in operating and maintenance costs • Increase the value of building and help to lease out building easily etc.	• Improve image to outsider • Improve customer satisfaction • Provide new services to customers • Provide continuity in work flow and services supply etc.
Individual level	• Increase productivity • Facilitate different ways of working • Improve ease of communications • Increase work efficiency etc.	• Improve staff morale • Improve quality of working environment • Provide individual environmental control etc

Figure 5.3: Classifications of benefits of intelligent buildings
Source: Author

The categories of benefits provided by intelligent building can be described as below:

1. Organisational level
   - *Tangible benefits.* These are the benefits that are distinct and have direct impact on the efficiency of an organisation in carrying out the business activities.

- *Intangible benefits.* These are the benefits that are not very obvious but have an indirect impact on the effectiveness of an organisation to remain competitive and successful in business.

2. Individual level
   - *Tangible benefits.* These are the benefits that are distinct and have direct effect on the execution of the work by an individual.

   - *Intangible benefits.* These are the benefits that have indirect effect on the work performance of an individual.

Constraining factors for intelligent buildings

From the interview, the most critical constraining factors (mostly technology related), encountered by various building users in implementing intelligent building strategies are identified as follows:

1. *Large capital outlay and expensive to run.* This arises because most intelligent building systems (especially those features related to building automation) are customised products. In the absence of standardised products, the economies of scale through mass production cannot be achieved.

2. *Lack of the ability to inter-operate between different systems.* The lack of open protocol use in various proprietary systems results in the lack of inter-link and inter-operate between different products. This would mean that more provision on cabling and ducting will be needed to incorporate different intelligent building systems. This will add to the constraint of high cost encountered by the users. Besides that, data and information which are common to all systems cannot be shared among each proprietary system.

3. *Lack of evidence of the real financial benefits and pay-back.* This constraint arises because there is not yet a method available to determine the financial benefits provided by the intelligent building system. Without concrete evidence to prove the benefits of

intelligent building as against non-intelligent building, many potential users may be reluctant to adopt intelligent building strategies.

4. *System installed are complex and sophisticated.* This arises partly due to the previous emphasis of sophisticated technology in intelligent building. This has resulted in huge gaps in terms of the skill and knowledge available to operate, support and maintain the system.

It was interesting to note that three out of four of the constraining factors identified from the interview were similar to that from the survey (Table 5.1). This reinforces the urgency to address these issues more seriously by the supply side to make the implementations of intelligent building strategies more favorable.

The interview	The survey
1. Systems need large capital outlay and expensive to run.	1. Large capital outlay.
2. Lack of the ability to inter-operate between different system.	2. Lack of interfaces between systems.
3. Systems installed are complex and sophisticated	3. Lack of know-how and experience in supporting and operating the systems.

Table 5.1: Various constraining factors identified from different approaches of research methods

Source: Derived from the interview and survey results

Prospects for intelligent buildings

The survey result shows that the prospect for intelligent buildings will generally be from those organisations who are currently occupying buildings with certain or high technological features and with acceptable level of performance. The result also revealed that only small percentages of the prospective organisations are having poorer performance in their buildings.

Figure 5.4 shows the categories of building users that are likely to implement intelligent building strategies.

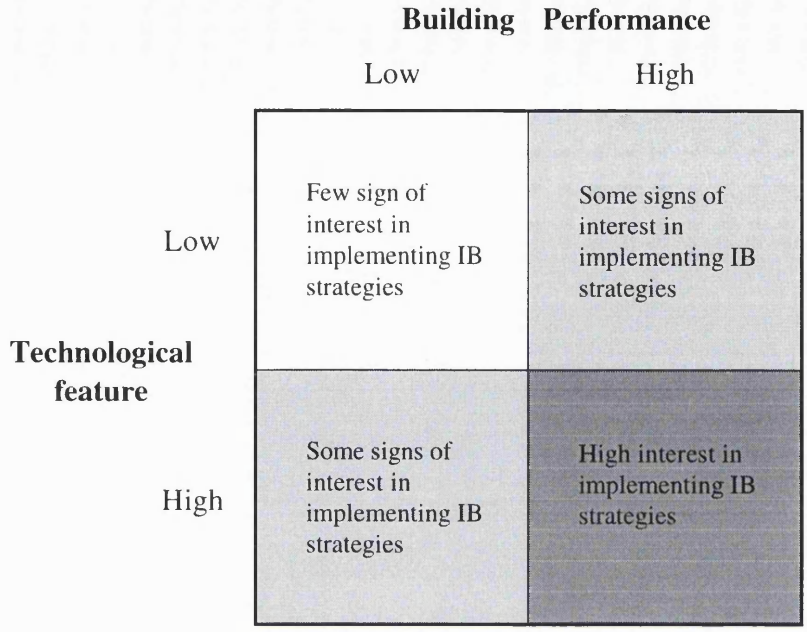


Figure 5.4: Categories of building users likely to implement intelligent building strategies
Source: Author (Derived from the survey results)

For the background of those prospective organisations, the result shows that non-UK incorporated organisations have a higher tendency to implement intelligent building strategies. This is because these organisations would expect their buildings to performance as equally well as those building in their country of incorporation.

In terms of size, the survey results shows that the number of staff employed by and the annual turnover of an organisation are important in the decision by organisations in implementing intelligent building strategies.

For ownership of the building, the result reveals that there are very few owners occupied type of intelligent buildings. Most organisations prefer to have their office accommodations leased from the developers or building owners as they do not have to worry about the large capital outlay needed to incorporate various intelligent building systems.

5.2 IMPLICATIONS OF THE FINDINGS

Supply side

In matching the organisations' needs with the design solutions, a holistic approach to the design process of intelligent building will be needed. This includes capturing the current and future needs of organisations during the early design briefing process. The priority on various facets of change encountered by the organisations will need to be sorted out in order to come out with appropriate level of technological features in intelligent buildings. In specifying various building systems there is also a need to assess the various potential risks existed that can threaten the operations of the organisations especially when failures occurred to the system.

Besides focusing on new built, there is also a need to investigate the opportunity of implementing intelligent building strategies in existing building. One particular example of this will be the use of wireless technology which may provide a great opportunity to organisations and building owners in adopting intelligent building strategies in their existing building stocks.

In terms of overcoming the constraints of cost, greater collaborations among manufacturers and suppliers in developing standard products will contribute towards the lowering of the cost of various systems. Besides that, there is a need for the supply side to develop a standard method to work out a stronger evidence on the real benefits of intelligent building systems to convince organisations and end users.

In terms of sophistication in intelligent building systems, the finding indicates that there is a need to reduce the complexity in intelligent building systems. This will allow more easy operation by the users and the operator. Besides, it can reduce the risk impose on the organisations by the sophisticated technology.

In terms of the lack of skill and knowledge in operating and maintaining the system, initiative will have to come from the supply side to provide the necessary training to the users.

Demand side

On the demand side, greater commitments from the organisations are needed when considering implementing intelligent building strategies. By involving at the early design development stage, organisations can understand better the various intents of the design and hence comprehend how the systems specified can meet their organisational and business needs.

Continuous commitment towards the training of staff who are responsible for the maintaining and running of the building systems are needed from the organisations. Besides that, a greater co-operation between the facilities and personnel departments are needed in conducting induction programme to brief the staff in the use of various intelligent building systems. This will ensure that various systems installed in an intelligent building are used to the maximum.

5.3 SPECULATIONS ON THE FUTURE DIRECTIONS OF INTELLIGENT BUILDING

This section speculates on some future possibilities which might have impact on the design, management and operation of intelligent buildings.

Those speculations on the development of intelligent building are discussed under the following heading:

Integration versus Segregation

The results of the interview show a strong argument from the respondents on the likely development of computer integrated building in intelligent building concept. This is mainly concern with the linking of various building services (particularly data and voice communications, fire detection and intruder detection systems, along with heating and ventilation system) into centralised control and database.

Though it is technically possible to integrate various sub-systems together, the fundamental assumption on the better performance of the building through integration needs to be examined. Beside the concern over the increase in complexity and sophistication in intelligent building, the high degree of integration may result in increasing

in the dependency of the building on the systems. This will inevitably increase the risk faced by the organisation (Moore, 1997).[1]

The development of system integration in providing more control in building may need to take into account the likely risks impose to organisations. Perhaps the aim of future development of intelligent building should be the reduction of the complexity and redundancy in intelligent building. This can be done by segregating the system in terms of their dependency on each other and integrated in terms of the sharing of data, and cabling system.

Standardisation versus Customisation

The research result also calls for a greater standardisation of various systems by different manufacturers and suppliers in the future. This arises because customised systems and products are very expensive and costly to maintain. It was argued that the development of standardised products and common protocol can result in economies of scale through mass production. Though the development of off-the-shelf products may drive down the cost of various systems, the concern on the ability of standardise products in meeting the different needs of various organisations cannot be ignored. Besides, the low profit margin of the product caused by standardisation may make the development of standard product unattractive to manufacturers and suppliers.

Other concern on the standardisation and customisation is on the intelligent building itself. Past experience on the failure of speculative development in commercial office indicated that there is a need for custom-built building. The problem often faced by developers in any development is on the uncertainties of the likely tenant occupying the building. The adoption of shell and core approach, which allow more freedom to the tenants in fitting out the building based on their needs, seems to be a workable and applicable approach to intelligent building development.

Centralisation versus Decentralisation

The result of the research shows that at the moment there are two opposing trend in the development of intelligent building control. In building with centralised control, the users can benefit by reducing the number of maintenance staff to go around the building. For building with individual control, the users can enjoy a greater freedom in adjusting the quality of their working environment. Besides that, it helps to reduce the number of complaints by the users and hence cut down the workload of the help desk. Though some predicted a move towards the use of individual environmental control systems in the future, the feedback from the survey shows that there is no great concern by the users on this. Perhaps a mixture of both centralisation and decentralisation may continue to be the trend of intelligent building in the future.

Green versus High-tech

The emergence of green building or sustainable building over the past several years has been on the concern for:

- provision of healthy indoor environment
- reduction of building's impact on the environment
- reduction of construction and operation cost
- re-use of materials, products and entire building structures

According to the ASTM Green Building sub-committee[2], green buildings are structures that designed, constructed, operated, and demolished in an environmentally enhanced manner.

To a certain extent, green building and intelligent building both shared the same concern for environmental impact and healthy indoor environment in building.

Though with good intent, the green building concept can easily fall into the same trap as intelligent building by becoming a popular marketing tool to promote the buildings and different products. Though the green building concept will continue to gain much attention, along with the increase in environmental awareness by many organisations, it may not replace the concept of intelligent building. This is because there are other equally important concerns (e.g. the need for flexibility in building; ease of communications; new patterns of working etc) need to be addressed. Perhaps the merges of these two concepts

will continue to drive the development of office building and workplace into greater heights.

Inactive building versus Interactive building

The development and applications of Artificial Intelligent (AI) in intelligent building will eventually change the man-made passive shelter into an active entity. There may come to a stage where intelligent building systems can provide a greater degree of interaction with the users. The system that design based on pre-conceived assumptions made on the users' need may eventually be replaced by the those systems that can comprehend the actual needs of users and organisations. The use of Artificial Intelligent in intelligent building may result in the increase in the capability of building to respond quickly to the needs of organisations and end users.

5.4 REFERENCES AND NOTES

[1] Moore, Patrick, Interview Transcription, 30/6/97, BSC Consulting Engineer, London.

[2] Reed, William G, Green Buildings, The Hillier Group, Washington, D.C, Internet Search, 17/9/97, http://www.hillier.com/hot-gree.htm

APPENDIX A: LIST OF PEOPLE INTERVIEWED

Supply Side

1. Mr. Patrick Moore	BSC Consulting Engineer
2. Mr. James Read	Arup Communication
3. Mr. Andrew Mawson	Advance Workplace Technology Limited
4. Mr. Andrew Harrison	DEGW
5. Mr. Eric Loe	Northcroft

Demand Side

6. Mr. Peter Wicking	Johnson Control Limited on behalf of ITN Limited
7. Mr. John Mitchell	Corporation of Lloyds' of London
8. Mr. John Sudworth	European Bank for Reconstruction and Development

Academia & Researcher

9. Dr. David Boyd	University Central England

About The Interviewees

Patrick Moore

As a director for BSC Consulting Engineer he has involved in designing systems and services for both speculative and specialist buildings. He has considerable experience of many types of buildings and particular experience in sophisticated buildings with complex computer and dealing room environments. His work currently has moved towards providing specialist support for client in the area of risk management which part of the responsibility is to look at business operations and identify what building systems that are essential for business, how sensitive the business is to these esential systems and what countermeasures are needed to reduce the overall risk.

Jim Read

Associate Director, Arup Communications of Ove Arup & Partners. As an IT and Telecommunications consultant, his active involvement in the research projects for intelligent buildings includes *Intelligent Buildings in South East Asia* from 1995 - 1996, which examined IT and building services trends in the region. He was part of the building of the building case study and the rating method team. His recent articles published includes:

1. "Building Controls: The Standard Problem", *Facilities World*, March 1997, Issue 3, The Journal of the British Institute of Facilities Management.
2. " The Future of Intelligent Buildings", *The Arup Journal*, 1996, Vol. 31, No. 4, Ove Arup Partnership.

Andrew Mawson

Managing Director for Advanced Workplace Associates Limited. His works includes providing strategic consultancy services to organisation in public and private sectors. He was previously Manager of intelligent buildings with ICL. With the specialised knowledge and understanding on the future trends in economics and technology, and their impacts on business and the workplace, he shouldered the role of group leader for the learning building research programme. He has speak regularly on future building issues. His articles written includes:

1. "Investing in Building Capabilities - The Learning Building Research Programme", *Facilities Management*, 1994, Centre for Facilities Management, University of Strathclyde.
2. "A Flesh look at intelligent buildings", *Facilities*, Vol. 12, No. 2, 1994, MCB University Press.

Andrew Harrison

Associate Director, DEGW International Consulting Ltd; he was the Information Technology Manager who responsible for the planning and implementation of DEGW's computer strategy. His activities in intelligent building includes research into building, organisational and IT issues for a range of clients. He also represents DEGW at the European Intelligent Building Group and sits on its Executive Committee.

Eric Loe

Director, Northcroft, Construction Cost Consultants. He has being actively in giving construction cost consultation to clients from South East Asia Region. Many of the projects he involved in are intelligent buildings. He is an active member of the European Intelligent Building Group and was a member of the research team for *Intelligent Building in South East Asia*. His publications includes:

1. "Costs of Intelligent Buildings", Intelligent Building, 1994, Unicom Limited, UK.
2. "The Business Case For Adding Building Intelligence.", LuskReview.
3. "The Intelligent Building - A Business Rationale", Conference on Building Intelligence and Profit: Developing building for the nation's 2020 vision held on 8 - 9 December 1992 at Hyatt Saujana, Subang Jaya.

Peter Wicking

Location Engineer, Johnson Controls Limited, based at ITN headquarters. He is responsible for the day to day running of the 250,000 sq. ft. building located at 200 Gray's Inn Road, London. Beside procuring various sub-contractors for the maintenance works, his responsibility includes coordinating the works of the contractors to prevent the unnecessary disruption to the operations of the organisations within the building. Regularly he obtained feedback from the tenants and end users pertaining to the quality of their working environment. He is well-versed with various services and building management system.

John Sudworth

Principal Manager for Property and Facilities Management Division, European Bank for Reconstruction and Development (EBRD). He is currently responsible for the 400,000 sq ft gross headquarter building for EBRD at One Exchange Square. His main responsibility includes locate property to establish the office for the Bank as well as the on going building management of the existing building. He is a member of the European Intelligent Building Group. He was involved in the briefing and specification for One Exchange Square.

John Mitchell

Facility manager for Corporation of Lloyd's of London. He looks after the engineering, space planning, support services, security system and the built environment for three types of buildings of a total one million sq.ft. He has spent two years together with DTI (Department of Trade and Industry) in Brunnel to put together a team to look at the applications of Artificial Intelligent to run the building. The research work basically looked at the possibility of putting a high level knowledge base platform to sit on top of all other computer system in building so that the building systems will have the ability to learn, to know, to understand and to respond more effectively to the occupants' needs.

David Boyd, Dr.

Dr. David Boyd currently the Deputy Head of School of Property and Construction was the former Director of Intelligent Building Research Group, University Central England. He specialises in the design of buildings, from an understanding of users' and organisational needs, and in the judicious use of technology in buildings. The research work he was involved includes buildings evaluations and rating method for intelligent buildings. More recent work also includes looking at adaptability of buildings. His other works also involved the research on intelligent controls, using fuzzy logic that helps control system to learned from the operations of the building. His publications includes:

1. "The Limits of Intelligent Office Refurbishment", *Property Management* Vol. 11, No. 2, 1993.
2. "What Are Really Intelligent Buildings*?" Intelligent Buildings Today and in the Future*, Proceedings of a conference organised by the University of Central England in Birmingham, 7th Oct 1993.
3. "Intelligent Buildings", 1994, Unicom Limited, UK.

APPENDIX B: STRUCTURED INTERVIEW CHECKLIST

TARGET GROUP:

Supply side: Architects, IT Suppliers, Developers/Building Owners, Cost Consultants and M & E/Building Services Engineers.

Demand side: Corporate organisations.

PURPOSE OF SURVEY:

To identify the perceptions of intelligent buildings from the supply and demand side.

Part 1: Background Information

Name of respondent :_____

Position :_____

Name of company :_____

Nature of business :_____

Activities related to Intelligent Buildings:

_____

_____

Part 2: Concept of Intelligent Buildings

1. What is an Intelligent Building?

_____

_____

_____

_____

2. What are the common attributes of Intelligent Buildings?

_____

_____

_____

_____

3. How do you distinguish between Intelligent Buildings from buildings without intelligence?

_____

_____

_____

_____

4. What criteria do you normally use to measure the appropriateness of Intelligent Buildings design to organisations and end users?

Part 3: Benefits and constraint of Intelligent Buildings

5. What are the potential benefits and/or constraints of Intelligent Buildings to the organisations and end users?

6. How do you think the development of Intelligent Buildings can facilitate and /or constraint the new patterns of work (e.g. sharing of workspaces and technology, and the use of multiple locations as workplace.)?

7. How do you think the constraints in Intelligent Buildings can be overcome?

8. How do you think Intelligent Buildings can add value to organisations occupying them?

Part 4: Future development of Intelligent Buildings

9. What are the likely development trends of Intelligent Buildings in the near future?

10. What are the main driving forces behind the development and use of Intelligent Buildings?

11. What are the stumbling-block to the development of Intelligent Buildings?

12. What strategies do you suggest, to the supply side of the Intelligent Buildings as a whole, to help overcome the problems mentioned above(Q 11)?

13. Any other comments?

APPENDIX C: SAMPLE OF SURVEY FORM

INTELLIGENT BUILDINGS SURVEY

I would be grateful if you could complete this survey form and return it by **Friday, 15 August 1997.**

Please send your completed survey form in the enclosed pre-paid envelope to:

LAIK Heng Juan
Flat 19, Hawkridge, Warden Road, Kentish Town, London NW5 4SA
Tel: 0171 482 0217 ext. 2180, Fax: 0171 916 1887

Thank you for your co-operation.

---

1. Background information

Name of Organisation: _____

Address: _____

_____

Respondent's Name: _____ Position: _____

Sector, (e.g. financial, insurance etc.): _____

Country of Incorporation of Parent Company: _____

a) Number of employees at this location:

- ☐ Less than 100.
- ☐ 100 to 249.
- ☐ 250 to 499.
- ☐ 500 to 749.
- ☐ 750 to 999.
- ☐ More than 1000.

b) Annual Turnover of Business:

- ☐ Less than £100 million.
- ☐ £100 to £250 million.
- ☐ £250 to £500 million.
- ☐ £500 to £750 million.
- ☐ £750 to £1000 million.
- ☐ More than £1000 million.

c) Ownership of Building Occupied by the Company: (Please tick one box only.)

- ☐ Self owned.
- ☐ Self owned with tenancy.
- ☐ Leased.
- ☐ Leased with sub-tenancy.

d) Which of the following describes the building occupied by your organisation?

- ☐ Simple building with little technological features.
- ☐ Simple building with certain degree of technological features.
- ☐ Sophisticated building with high degree of technological features.
- ☐ Others (Please Specify)

_____

2. Awareness of Intelligent Buildings

a) Have you come across the term "Intelligent Buildings" before? ☐ Yes. ☐ No.

b) What degree of intelligence does your building currently possess?

☐ None. ☐ Some degree. ☐ High Degree

c) How well does the building you occupy satisfy your business needs?

☐ Very poor. ☐ Poor. ☐ Fair. ☐ Good. ☐ Excellent.

d) Are you planning to implement an intelligent building policy in the future?

☐ Yes. ☐ Considering. ☐ No. ☐ Not sure.

3. Current performance of your building

Please rate the performance of your building in achieving the objectives listed below. Also indicate how important you think achieving these objectives is to your overall business strategy. (Please circle the appropriate score.)

Score of performance: 1 = Very poor, 2 = Poor, 3 = Fair, 4 = Good, 5 = Excellent.

Score of importance: 1 = Not important, 2 = Little importance, 3 = Some importance, 4 = Important, 5 = Essential.

a)	Efficiency	Performance	Importance
i)	Reducing the overall energy consumption and energy cost.	1 2 3 4 5	1 2 3 4 5
ii)	Reducing the maintenance cost.	1 2 3 4 5	1 2 3 4 5
iii)	Reducing the cost of workplace reconfiguration.	1 2 3 4 5	1 2 3 4 5
iv)	Reducing the cost of management, administration, etc.	1 2 3 4 5	1 2 3 4 5
v)	Increasing the space utilisation.	1 2 3 4 5	1 2 3 4 5
vi)	Reducing the need for storage space.	1 2 3 4 5	1 2 3 4 5
vii)	Reducing the response time for rectifying fault.	1 2 3 4 5	1 2 3 4 5
viii)	Increasing the value of building in terms of higher rental price.	1 2 3 4 5	1 2 3 4 5

b)	Effectiveness	Performance	Importance
i)	Improving staff productivity.	1 2 3 4 5	1 2 3 4 5
ii)	Improving staff morale.	1 2 3 4 5	1 2 3 4 5
iii)	Reducing absenteeism.	1 2 3 4 5	1 2 3 4 5
iv)	Improving customers' satisfaction.	1 2 3 4 5	1 2 3 4 5
v)	Improving profitability.	1 2 3 4 5	1 2 3 4 5
vi)	Improving the business competitiveness edge.	1 2 3 4 5	1 2 3 4 5
vii)	Increasing the flexibility of the use of space/building	1 2 3 4 5	1 2 3 4 5

c)	Others	Performance	Importance
i)	Improving the image of organisation to outsiders.	1 2 3 4 5	1 2 3 4 5
ii)	Attracting or retaining staff.	1 2 3 4 5	1 2 3 4 5
iii)	Accommodating organisational changes & new technology.	1 2 3 4 5	1 2 3 4 5
iv)	Improving the quality of work environment.	1 2 3 4 5	1 2 3 4 5
v)	Extending the building usage results in increased working hours.	1 2 3 4 5	1 2 3 4 5
vi)	Reducing the disruption of work flow.	1 2 3 4 5	1 2 3 4 5
vii)	Supporting a wide range of work settings and work patterns.	1 2 3 4 5	1 2 3 4 5
viii)	Improving the accessibility to information.	1 2 3 4 5	1 2 3 4 5

4. Features of Intelligent Buildings

To what extent does your building use the following features?
How important are these features to your organisation? (Please circle the appropriate score.)

Extent of use: 1 = Not at all, 2 = Small degree, 3 = Some degree, 4 = Large degree, 5 = Extensive degree.

Level of importance: 1 = Not important, 2 = Little importance, 3 = Some importance, 4 = Important, 5 = Essential.

a)	Office Automation and Telecommunications systems	Extent of use	Importance
i)	Local Area Networks (LANs) Data network interconnecting terminals and computers within the building.	1 2 3 4 5	1 2 3 4 5
ii)	Voice messaging system Voice mailbox and voice response facilities available from telephone system.	1 2 3 4 5	1 2 3 4 5
iii)	Electronic mailing system Non-interactive communication between users that is transported electronically.	1 2 3 4 5	1 2 3 4 5
iv)	Video conferencing Face to face communications between people at different geographical locations.	1 2 3 4 5	1 2 3 4 5

4. Features of Intelligent Buildings (Continued)

b)	Building Automation Systems	Extent of use	Importance
i)	Energy management system (e.g. the use of centralised controlling and monitoring system for energy use.)	1 2 3 4 5	1 2 3 4 5
ii)	Security systems (e.g. the use of closed-circuit television for internal and exterior surveillance, intrusion detectors, security gateways, identification card, access control etc.)	1 2 3 4 5	1 2 3 4 5
iii)	Disaster prevention systems (e.g. the use of fire protection, uninterrupted power supply, etc. to protect the business and occupants.)	1 2 3 4 5	1 2 3 4 5
iv)	Building management system (e.g. integrating the control and monitor of heating, ventilating, air-conditioning system; lighting; lifts; fire; security etc.)	1 2 3 4 5	1 2 3 4 5
v)	Individual workstation environmental controller (e.g. the use of controller to allow individual to adjust the lighting, temperature, etc.)	1 2 3 4 5	1 2 3 4 5

c)	Facilities Management System	Extent of use	Importance
i)	Computer aided facility management (CAFM) The use of computer software and database programme to facilitate the management of space, cabling, lease, project, maintenance operations, etc.	1 2 3 4 5	1 2 3 4 5

d)	Building Shell	Extent of use	Importance
i)	Flexible and adaptable building structure Accommodating the changing business needs (e.g. expanding, downsizing, subletting, change of functional use of building, accommodating new technology etc.)	1 2 3 4 5	1 2 3 4 5

e)	Fitting-out Elements	Extent of use	Importance
i)	Demountable partitioning system Partitioning system that allows flexibility of reconfiguring the layout of workplace.	1 2 3 4 5	1 2 3 4 5
ii)	Raised flooring system The use of raised floor space to accommodate various services.	1 2 3 4 5	1 2 3 4 5
iii)	Structured cabling The use of single modular, adaptable, future-proof cabling infrastructure for voice, data, video communication and services.	1 2 3 4 5	1 2 3 4 5

f)	Office Furnishings	Extent of use	Importance
i)	Office furnitures The use of furniture system that accommodates data, voice and electrical cables.	1 2 3 4 5	1 2 3 4 5

5. Constraints of Intelligent Buildings

Please indicate how relevant the following statements are in constraining the development of an
'intelligent building' strategy. (Please circle the appropriate score.)

Level of relevancy: 1 = Not relevant, 2 = Little relevance, 3 = Some relevance, 4 = relevant, 5 = Very relevant.

	General problems	Relevancy
i)	Lack of standards and terms of reference.	1 2 3 4 5
ii)	Lack of co-ordination between different functions/suppliers etc.	1 2 3 4 5
iii)	Lack of interfaces between different systems.	1 2 3 4 5
iv)	Lack of know-how and experience in supporting the system.	1 2 3 4 5
v)	Large initial capital outlay.	1 2 3 4 5
vi)	Lack of expertise in operating the system.	1 2 3 4 5
vii)	Technology provided not appropriate.	1 2 3 4 5

6. Any other comment?

Thank you for your time in completing this survey form.

APPENDIX D: SURVEY RESULTS BASED ON COMPLETED SURVEY FORM

1. Summary of the survey results

	Number	Percentage
Completed survey forms	17	17%
Incomplete survey forms		
a) Completed Section 1 & 2 only	2	2%
Other responses		
a) Survey form received after dateline	1	1%
a) Not relevant to the firm	5	5%
b) Not willing to impart information	4	4%
c) Person incharge on leave	1	1%
d) Change of address	2	2%
e) No response	68	68%
Total	100	100%

2. List of respondents who have completed the survey forms.

Key	Company Name
A	KPMG
B	Coopers & Lybrand
C	Marot & Co.
D	European Bank for Reconstruction and Development
E	Midland Bank PLC.
F	Banque Nationale De Paris
G	CIBC Wood Gundy PLC.
H	Sony Pictures Entertainment
I	Prudential Assurance Co. Limited
J	Prudential Portfolio Managers
K	Clifford Chance
L	AT & T (UK) Limited
M	British Airways
N	Mitsubishi Corporation
O	Channel Four TV
P	Channel Five TV
Q	ITN Limited
R	Sanyo International Limited (incomplete survey form returned)
S	Ernst & Young (incomplete survey form returned)

3. Tabulations of the survey results

1. Background information - Organisation	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	Total	Percentage
a) Sector																					
Legal											✔									1	5.3%
Trading														✔				✔		2	10.5%
Insurance									✔	✔										2	10.5%
Accounting	✔	✔																	✔	3	15.8%
Advertising			✔																	1	5.3%
Bank/Finance				✔	✔	✔	✔													4	21.1%
Entertainment								✔												1	5.3%
Transportation													✔							1	5.3%
TV Broadcasting															✔	✔	✔			3	15.8%
Telecommunications												✔								1	5.3%
																				19	100.0%
b) Country of Incorporation of Parent Company:																					
i) UK		✔	✔						✔	✔	✔		✔		✔	✔	✔		✔	10	52.6%
ii) USA												✔								1	5.3%
iii) Canada							✔													1	5.3%
iv) Japan								✔						✔				✔		3	15.8%
v) France						✔														1	5.3%
vi) Not available	✔			✔	✔															3	15.8%
																				19	100.0%
c) Number of employees at this location:																					
i) Less than 100.			✔															✔		2	10.5%
ii) 100 to 249.	✔											✔				✔				3	15.8%
iii) 250 to 499.								✔		✔				✔					✔	4	21.1%
iv) 500 to 749.						✔	✔								✔					3	15.8%
v) 750 to 999.																				0	0.0%
vi) More than 1000.		✔		✔	✔				✔		✔		✔				✔			7	36.8%
																				19	100.0%
d) Annual Turnover of Business:																					
i) Less than £100 million.	✔		✔							✔		✔					✔			5	26.3%
ii) £100 to £250 million.																				0	0.0%
iii) £250 to £500 million.																				0	0.0%
iv) £500 to £750 million.							✔								✔					2	10.5%
v) £750 to £1000 million.								✔												1	5.3%
vi) More than £1000 million.		✔		✔	✔				✔				✔	✔					✔	7	36.8%
vii) Not available.						✔					✔					✔		✔		4	21.1%
																				19	100.0%

1. Background information - Building	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	Total	Percentage
e) Ownership of Building:																					
Self owned.						✔							✔	✔	✔					4	21.1%
Self owned with tenancy.																	✔			1	5.3%
Leased.	✔	✔	✔		✔		✔	✔	✔	✔	✔	✔						✔	✔	12	63.2%
Leased with sub-tenancy.				✔												✔				2	10.5%
																				19	100.0%
f) Brief description of building:																					
Simple building with little technological features.			✔							✔								✔		3	15.8%
Simple building with certain degree of technological features.	✔				✔	✔						✔	✔	✔		✔			✔	8	42.1%
Sophisticated building with high degree of technological features.		✔		✔			✔	✔	✔		✔				✔		✔			8	42.1%
																				19	100.0%

2. Awareness of Intelligent Buildings	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	Total	Percentage
a) Come across "Intelligent Buildings" before?																					
Yes.	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔	17	89.5%
No.						✔										✔				2	10.5%
																				19	100.0%
b) Degree of intelligence the building possess?																					
None.			✔							✔				✔				✔		4	21.1%
Some degree.	✔				✔	✔			✔			✔	✔		✔	✔	✔		✔	10	52.6%
High Degree		✔		✔			✔	✔			✔									5	26.3%
																				19	100.0%
c) Degree in which the building satisfy business needs?																					
Very poor.																				0	0.0%
Poor.			✔		✔														✔	3	15.8%
Fair.	✔									✔		✔	✔	✔		✔		✔		7	36.8%
Good.		✔				✔	✔	✔	✔						✔					6	31.6%
Excellent.				✔							✔						✔			3	15.8%
																				19	100.0%
d) Planning to implement an intelligent building policy in the future?																					
Yes.				✔	✔	✔	✔					✔	✔	✔						7	36.8%
Considering.	✔								✔							✔				3	15.8%
No.			✔							✔								✔	✔	4	21.1%
Not sure.																				0	0.0%
No, already in place.		✔						✔			✔				✔		✔			5	26.3%
																				19	100.0%

3. Current performance of your building

How well does the building perform in term of achieving the following objectives?

Score of performance: 1 = Very poor, 2 = Poor, 3 = Fair, 4 = Good, 5 = Excellent.

a)	**Efficiency**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Reducing the overall energy consumption and energy cost.	3	3	1	4	3	5	4	2	4	3	4	3	4	2	3	3	4	55	3.24
ii)	Reducing the maintenance cost.	3	3	1	4	3	5	4	3	3	2	4	3	3	2	4	4	3	54	3.18
iii)	Reducing the cost of workplace reconfiguration.	3	3	1	5	3	4	3	3	2	3	4	2	2	1	4	3	3	49	2.88
iv)	Reducing the cost of management, administration, etc.	3	4	1	4	3	4	5	2	3	4	4	3	3	3	4	4	4	58	3.41
v)	Increasing the space utilisation.	4	5	1	5	4	5	4	4	4	2	3	2	4	3	5	3	4	62	3.65
vi)	Reducing the need for storage space.	4	3	1	4	4	5	4	3	3	3	3	2	2	4	1	3	3	52	3.06
vii)	Reducing the response time for rectifying fault.	4	4	1	4	4	5	3	4	4	3	4	4	3	3	4	4	4	62	3.65
viii)	Increasing the value of building in terms of higher rental price.	3	2	1	3	3	1	3	4	2	2	1	4	3	2	3	3	5	45	2.65

b)	**Effectiveness**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Improving staff productivity.	4	4	2	4	4	5	3	4	4	2	4	3	3	3	4	4	4	61	3.59
ii)	Improving staff morale.	3	3	3	4	3	5	3	4	3	2	5	3	2	3	5	4	4	59	3.47
iii)	Reducing absenteeism.	3	5	3	4	3	5	4	4	3	3	5	4	3	3	4	4	4	64	3.76
iv)	Improving customers' satisfaction.	3	5	3	4	4	5	4	4	3	4	4	3	3	3	5	4	4	65	3.82
v)	Improving profitability.	3	4	2	3	5	3	5	3	3	5	4	3	3	3	3	4	4	60	3.53
vi)	Improving the business competitiveness edge.	3	4	2	3	4	5	5	4	2	4	5	2	2	3	4	4	4	60	3.53
vii)	Increasing the flexibility of the use of space/building	4	4	1	4	2	5	4	3	3	2	4	2	2	1	5	4	3	53	3.12

c)	**Others**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Improving the image of organisation to outsiders.	3	5	2	4	2	5	4	4	4	2	5	4	3	3	5	4	4	63	3.71
ii)	Attracting or retaining staff.	3	4	2	3	2	5	4	4	3	2	5	4	3	3	3	4	4	58	3.41
iii)	Accommodating organisational changes & new technology.	4	4	1	4	3	5	4	4	3	3	5	3	2	2	4	4	5	60	3.53
iv)	Improving the quality of work environment.	3	5	2	4	3	5	3	3	3	2	5	4	2	3	5	4	4	60	3.53
v)	Extending the building usage results in increased working hours.	4	4	2	4	4	3	4	3	5	3	5	3	3	-	4	4	5	60	3.75
vi)	Reducing the disruption of work flow.	4	5	2	4	4	5	5	3	3	3	4	3	3	-	4	4	5	61	3.81
vii)	Supporting a wide range of work settings and work patterns.	3	4	1	5	3	5	5	3	3	2	4	2	2	-	4	3	4	53	3.31
viii)	Improving the accessibility to information.	3	4	2	3	3	5	5	3	4	3	5	3	4	2	5	3	4	61	3.59

3. Current performance of your building

How important are these objectives to the overall business strategy?

Score of importance: 1 = Not important, 2 = Little importance, 3 = Some importance, 4 = Important, 5 = Essential.

a)	**Efficiency**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Reducing the overall energy consumption and energy cost.	4	5	2	5	5	5	5	5	5	3	5	3	4	4	1	5	4	70	4.12
ii)	Reducing the maintenance cost.	4	5	2	5	5	5	4	4	4	3	5	3	5	4	2	5	3	68	4.00
iii)	Reducing the cost of workplace reconfiguration.	5	5	4	5	3	3	5	4	4	4	5	4	4	4	3	5	4	71	4.18
iv)	Reducing the cost of management, administration, etc.	4	5	4	4	3	3	4	4	3	2	5	3	3	4	4	5	4	64	3.76
v)	Increasing the space utilisation.	5	5	4	5	4	5	4	5	3	3	5	5	5	4	4	5	4	75	4.41
vi)	Reducing the need for storage space.	5	5	4	4	4	5	5	2	3	3	5	4	5	4	3	5	4	70	4.12
vii)	Reducing the response time for rectifying fault.	4	5	2	4	5	5	4	5	4	4	5	3	3	4	4	5	4	70	4.12
viii)	Increasing the value of building in terms of higher rental price.	1	2	1	3	3	1	1	3	1	2	1	1	3	4	1	5	4	37	2.18

b)	**Effectiveness**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Improving staff productivity.	4	5	4	4	4	5	5	4	5	4	5	4	4	4	4	5	4	74	4.35
ii)	Improving staff morale.	4	5	4	4	4	5	4	4	4	3	5	4	3	4	4	5	4	70	4.12
iii)	Reducing absenteeism.	3	5	4	4	3	5	4	4	4	3	5	4	4	4	3	5	4	68	4.00
iv)	Improving customers' satisfaction.	4	5	3	3	5	5	4	4	5	1	5	5	5	2	1	5	4	66	3.88
v)	Improving profitability.	4	5	3	3	4	5	4	3	4	4	5	4	5	4	2	5	5	69	4.06
vi)	Improving the business competitiveness edge.	4	5	4	3	4	5	5	5	4	4	5	4	5	4	3	5	4	73	4.29
vii)	Increasing the flexibility of the use of space/building	4	5	4	4	3	5	4	5	5	3	5	5	4	4	3	5	4	72	4.24

c)	**Others**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Improving the image of organisation to outsiders.	4	5	3	3	2	5	3	5	4	3	5	5	3	4	5	5	5	69	4.06
ii)	Attracting or retaining staff.	4	5	4	3	3	5	4	4	4	4	5	4	4	4	3	5	5	70	4.12
iii)	Accommodating organisational changes & new technology.	4	5	4	4	3	5	4	4	4	3	5	5	5	4	3	5	5	72	4.24
iv)	Improving the quality of work environment.	4	5	3	4	3	5	4	4	3	3	5	4	4	4	4	5	4	68	4.00
v)	Extending the building usage results in increased working hours.	4	4	2	4	3	3	2	4	4	3	5	3	3	-	3	5	5	57	3.56
vi)	Reducing the disruption of work flow.	4	5	3	4	4	5	5	3	3	3	5	3	4	-	3	5	5	64	4.00
vii)	Supporting a wide range of work settings and work patterns.	4	4	4	4	3	5	3	3	4	3	5	4	5	-	4	3	4	62	3.88
viii)	Improving the accessibility to information.	4	4	3	3	3	5	5	3	3	4	5	4	5	4	4	5	4	68	4.00

4. Features of intelligent buildings

To what extent does your the building use the foiiowing feactures?

Extent of use: 1 = Not at all, 2 = Small degree, 3 = Some degree, 4 = Large degree, 5 = Extensive degree.

a)	**Office Automation & Telecom. systems**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Local Area Networks (LANs)	5	5	4	5	5	5	5	5	5	4	5	5	4	4	5	5	5	81	4.76
ii)	Voice messaging system	3	5	3	4	3	5	4	5	3	3	5	5	3	2	5	4	5	67	3.94
iii)	Electronic mailing system	5	5	3	5	3	5	5	5	4	5	5	5	5	3	4	5	5	77	4.53
iv)	Video conferencing	2	5	1	2	1	3	2	2	1	1	5	2	2	2	1	1	4	37	2.18

b)	**Building Automation Systems**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Energy management system	-	-	1	5	3	1	4	5	4	2	5	2	4	2	4	4	5	51	3.40
ii)	Security systems	-	-	2	5	5	5	5	4	4	2	5	4	4	3	4	3	5	60	4.00
iii)	Disaster prevention systems	-	5	1	4	4	5	5	5	3	4	5	4	4	1	4	3	5	62	3.88
iv)	Building management system	-	-	1	5	4	1	5	5	4	4	5	1	2	2	5	3	5	52	3.47
v)	Individual workstation environmental controller	-	2	1	5	1	5	1	3	2	1	5	2	1	1	1	3	3	37	2.31

c)	**Facilities Management System**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Computer aided facility management (CAFM)	2	5	1	4	5	1	5	1	2	1	5	2	2	2	1	4	3	46	2.71

d)	**Building Shell**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Flexible and adaptable building structure	-	-	1	5	3	1	2	5	4	2	4	1	3	2	4	4	4	45	3.00

e)	**Fitting-out Elements**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Demountable partitioning system	-	4	1	4	5	5	5	5	3	3	5	1	4	4	5	3	4	61	3.81
ii)	Raised flooring system	-	5	1	5	4	5	5	5	1	4	5	1	5	2	5	4	5	62	3.88
iii)	Structured cabling	-	5	1	5	4	5	5	5	4	3	5	5	3	2	5	4	3	64	4.00

f)	**Office Furnishings**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Office furnitures	4	5	1	5	3	5	5	5	3	4	5	5	5	2	5	4	4	70	4.12

4. Features of intelligent buildings

How important are these features to the organisation?

Level of importance: 1 = Not important, 2 = Little importance, 3 = Some importance, 4 = Important, 5 = Essential.

a)	**Office Automation & Telecom. systems**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Local Area Networks (LANs)	5	5	5	5	5	5	5	5	5	4	5	5	4	4	4	5	5	81	4.76
ii)	Voice messaging system	3	5	4	4	2	5	5	5	4	2	5	5	3	4	5	4	4	69	4.06
iii)	Electronic mailing system	5	5	3	5	3	5	5	5	5	5	5	5	4	4	4	5	4	77	4.53
iv)	Video conferencing	3	5	2	4	2	3	4	3	2	1	5	3	3	3	3	5	4	55	3.24

b)	**Building Automation Systems**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Energy management system	-	-	2	5	5	5	5	5	4	3	5	4	4	4	3	4	5	63	4.20
ii)	Security systems	-	-	3	5	4	5	5	5	4	2	5	5	5	4	4	4	5	65	4.33
iii)	Disaster prevention systems	-	5	3	4	5	5	5	5	3	4	5	4	5	3	4	4	5	69	4.31
iv)	Building management system	-	-	2	5	4	5	5	5	4	3	5	3	3	4	4	4	5	61	4.07
v)	Individual workstation environmental controller	-	2	2	5	1	5	3	4	3	3	5	4	1	1	1	4	3	47	2.94

c)	**Facilities Management System**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Computer aided facility management (CAFM)	4	5	2	4	5	5	5	4	4	2	5	4	4	4	1	4	3	65	3.82

d)	**Building Shell**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Flexible and adaptable building structure	-	-	2	5	3	1	3	5	5	2	4	5	4	4	3	4	4	54	3.60

e)	**Fitting-out Elements**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Demountable partitioning system	-	4	3	4	4	5	5	5	4	3	5	5	4	4	5	4	4	68	4.25
ii)	Raised flooring system	-	5	4	5	4	5	5	5	3	4	5	4	5	4	5	4	5	72	4.50
iii)	Structured cabling	-	5	4	5	4	5	5	5	5	3	5	5	4	4	5	4	3	71	4.44

f)	**Office Furnishings**	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	**Total Score**	**Average**
i)	Office furnitures	4	5	2	5	4	5	5	5	3	4	5	5	4	3	4	4	3	70	4.12

5. Constraints of Intelligent Buildings

How relevant the following statements are in constraining the development of an intelligent building strategy?

Level of relevancy: 1 = Not relevant, 2 = Little relevance, 3 = Some relevance, 4 = relevant, 5 = Very relevant.

	General problems	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	Total Score	Average
i)	Lack of standards and terms of reference.	5	2	1	5	3	3	3	3	4	3	5	3	5	5	3	4	3	60	3.53
ii)	Lack of co-ordination between different functions/suppliers etc.	4	2	2	5	3	3	3	4	3	4	4	4	4	5	4	4	4	62	3.65
iii)	Lack of interfaces between different systems.	4	3	2	4	3	4	3	4	5	3	5	4	5	5	5	4	4	67	3.94
iv)	Lack of know-how and experience in supporting the system.	5	4	3	4	4	3	3	3	5	3	5	5	3	5	5	4	3	67	3.94
v)	Large initial capital outlay.	4	4	4	5	4	5	4	5	3	4	4	5	3	5	3	4	5	71	4.18
vi)	Lack of expertise in operating the system.	5	4	2	4	4	5	3	3	4	2	4	4	4	4	5	4	4	65	3.82
vii)	Technology provided not appropriate.	4	1	2	3	3	5	4	3	4	2	5	3	4	-	5	4	3	55	3.44

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