WHAT DO WE MEAN BY INTELLIGENT BUILDINGS?

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Abstract
Various common definitions of intelligent buildings are discussed. A systems view of building design is a starting point for considering business, space and building management. An intelligent building helps an organisation to fulfil its objectives by facilitating the management of these resources and thereby increasing the effectiveness and efficiency of the organisation. At an even more fundamental level intelligent buildings can copy with social and technological change and also are adaptable to human needs.

Keywords
Intelligent building; performance; management; technology; design; human needs; facilities management; systems.

Introduction
Technology has been viewed at various stages of civilisation as leading to future progress. The rate of change of technology is faster today than at any other time in history. It not only enters our work life, but that of our home life too, where advanced communication systems are becoming common. The world is shrinking by ever quickening communication highways. Verbal and numeric languages are being used in the plethora of computer languages which now feature on the timetable at schools, as well as at universities and in industry. The networked society is dawning. Intelligence is becoming an overrated word which can be used to describe modem buildings, cameras or car cockpits. We are not even sure what human intelligence is, so how can be ascribe this description to products? It is possible that people will reject some of these forms of intelligent hardware in favour of using their own creative impulses. For example consider taking a photograph. One can rely on a set of program cards which has been produced to meet every eventuality of lighting but this takes away the human judgement that makes photography an art. Technology must enhance the opportunity to explore not usurp human creativity. It is therefore important for each civilisation or culture exemplified in different countries, not to copy so called progress in other highly developed countries, but to map out their own creative future learning from lessons in history and from a critical appreciation of what other societies in other ~countries may give priorities to.

Kell (1996) states that the intelligent building is increasingly viewed as one that provides a responsive, effective and supportive environment within which an organisation can meet its performance objectives. The technology, although still generally considered to be fundamental, is now seen as the enabler rather than as an end in itself.

The term 'intelligent buildings' was first used in the United States in the early 80's and a definition given by the Intelligent Building Institution in Washington is:

> *An intelligent building is one which integrates various systems to effectively manage resources in a coordinated mode to maximise: technical performance; investment and operating cost savings; flexibility.*

More recently CIB Working Group W98 on Intelligent and Responsive Buildings stated:

> *An intelligent building is a dynamic and responsive architecture that provides every occupant with productive, cost effective and environmentally approved conditions through a continuous interaction among its four basic elements: Places (fabric; structure; facilities): Processes (automation, control; systems): People (services; users) and Management (maintenance; performance) and the interrelation between them.*

Michael Davies of Richard Rogers Partnership created the following image of tomorrow's buildings at a lecture that he gave at the World Teleport Association Conference in 1987 entitled, 'Design for the Information Age':

> *'Look up at a spectrum washed envelope whose surface is a map of its instantaneous performance, stealing energy from the air with an iridescent shrug, rippling its photogrids as a cloud runs across the sun, a wall which, as the night chill falls, fluffs up its feathers and turning white on its north face and blue on the south, closes its eyes but not without remembering to pump a little glow down to the night porter, clear a view patch for the lovers on the south side of level* 22 *and to turn* 12 % *silver just before dawn.* '

Attempts to express technological terms poetically are difficult but some valid points are made about the future. There are other definitions but they all emphasise integration responsiveness, flexibility, process and management of business, space and people.

But first, what do we mean by intelligence? One view is that intelligence is considered to be an innate general cognitive ability underlying all processes of conventional reasoning. Piagei defines intelligence not as an attribute, but as a complex hierarchy of information processing skills, underlying an adaptive equilibrium between the individual and their environment. There are other views too but Piaget has defined something that can be extended to understanding how people work or live in buildings and interact with their micro- climate, the building fabric and the external environment. Without embarking on the argument about the validity of artificial intelligence, there now exists knowledge based expert systems which are used to perform tasks requiring expertise, but not demanding insight or originality. An intelligent building demands intelligence applied at the concept, construction and operation stages of a project by clients, design consultants, contractors and facilities managers.

Is an igloo an intelligent building? For the eskimo it was, in the sense that its shape and structure moderated the climatic impact; the internal layout and use took advantage of the temperature gradient, but it would not have responded well in less extreme or more variable conditions. The new Helicon building in London attempts to cater for retailing and office use, whilst offering responsive comfort and energy measures for occupants and staff. The Atrium in the Kajima Corporation in Tokyo attempts to provide an environment which respects the iterative cycle of human mental needs for freshness,

concentration and relaxation in order to work effectively. Intelligent buildings can be simple or technologically sophisticated depending on the circumstances.

The starting point of establishing a model of an intelligent building is people, because they determine the mind force of the building against which machines have to act. The effect of an environment at any moment is dependant on ones past experiences. People are not passive recipients of their environment but adapt physiologically and behaviourally. The body has five basic senses -sight, hearing, touch, smell and taste. They are part of the physiological-psychological system which regulates the human response to environmental stimuli. People react individually and any response may be a transient one or one that becomes an experience stored in the long term memory. The building and its environment, the social ambience, the work and its management process all trigger the response system. Senses are to be enjoyed but they are also employed to achieve fulfilment in work hence an intelligent building will be sensitive to this demand.

The systems view of building design by Markus (1967) defines a *clients objectives system* and these give rise to user requirements. Another set of systems comprising construction, services and contents constitute the *building system,* which in turn gives rise to the spatial, physical and visual environments. The interface between the *environmental system* and the *user activity system* (work flow, communication) is crucial. Similarly the interaction between the building and the environmental systems is important. The Markus model can be interpreted in terms of building, space and business management -the goals of an intelligent building defmed in the DEGW /Technibank report of 1992.

The building, its services systems and management of the work process all contribute to the wellbeing of people within an organisation. Productivity relies on there being a general sense of high morale and satisfaction with the workplace. Health, wellbeing and comfort are all important. Intelligent buildings have a vital role to play in helping to achieve this by enhancing human resources, by providing environmental systems which support the productive, creative, intellectual and spiritual capacities of people. Yesterday's environments supported mechanisation and extended our capacity to produce goods and products; tomorrows environments which are emerging now extend the capacity of human resourcefulness to create ideas, visions and inventions.

The individuals view of the world has changed rapidly in this century as communications and travel have increased their awareness of distant nations. With the increase in world population and the realisation of how we pollute the environment with waste products, as well as increasing wealth encouraging the individual to consume more non-renewable resources, concern is now felt for our failure to appreciate the finite and finely balanced nature of the biosphere. Developers, designers and contractors are responsible for the resource demands of the environment they create, whereas owners and occupants are responsible for the waste products they produce. Everyone has to contribute towards evolving a sustainable workplace. Intelligent buildings must stem from a belief in sustainability and the need for social responsibility.

Most of the failures in building design are due process. An integrated systems approach is feature within this integration process. In a occupants perceived their own comfort levels to a lack of a systems approach in the design fundamental. Control strategies are a key survey (Bordass et al 1995) of 11 buildings occupants perceived their own comfort levels. The buildings were divided into 2 groups comprising five airconditioned offices and six which were naturally ventilated. In both groups of buildings, and particularly in the naturally ventilated group the most comfortable buildings also tended to be the most energy efficient. Satisfaction and comfort can also be linked with better health and productivity, so virtuous clusters begin to emerge where comfort control, productivity and energy efficiency enforce one another. In this study the best buildings, judged by overall comfort and energy efficiency criteria, are ones that are well managed. It was also noted that an acceptable comfort range can be provided for most occupants for most of the time, so long as people do not need to change things too much and this is more likely to occur in airconditioned buildings. There are ways to alleviate discomfort quickly when it occurs, and this happens more frequently in naturally ventilated buildings.

The four main areas in which control systems should aim to perform, cover functions which maybe classified as manual or automatic, and as reactive or anticipatory. Automatic reactive control includes feedback proportional and integral control; automatic anticipatory control includes timeswitches and optimisers to prepare the system for operation in advance; manual anticipatory control includes opening a window for night cooling or changing the programme of the controller; and manual reactive control includes light switches, window blinds or opening windows.

Advanced sensor systems will enable people to adjust and run buildings more effectively and thus reduce the variations due to occupancy variations. Centralised intelligent building may use sophisticated technology, but cannot respond effectively to the many changes that occupants need during the course of a working day. De-centralised control allows the environment to be managed in zones, but the ultimate refinement is the user intelligent building, where local centres are linked to the central information processes and give the individual some choice. Buildings of the future will use equipment having fibreglass optic links with centralised knowledge based systems, analogous to the nervous system and brain within the body. A background environment will be achieved by the use of dynamic adaptive building envelopes, leaving the local controls for the user to adjust in order to meet their personal requirements.

During recent decades efficiency was fashionable in the 1960's; costs in use in the 1970's; quality and effectiveness in the 1980's; now in the 1990's buildings are considered as providing a milieu for human creativity. Flexibility, adaptability, service integration and high standards of finishes offer an intelligence threshold. An intelligent building can be described as one that will provide for innovative and adaptable assemblies of technologies in appropriate physical, environmental and organisational settings, to enhance worker productivity, communication and overall satisfaction.

Research by DEGW (IBE 1992) showed that there is a mismatch between what users expect from an intelligent building and what the suppliers are able to deliver. One of the main reasons for this mismatch is that the intelligent building has generally been defined in terms of its technologies, rather than in terms of the goals of the organisations which occupy it. If the user is subservient to the technologies, this usually leads to situations where the technology is inappropriate for the users needs, and this

can adversely affect productivity and costs. An intelligent building is more than just the technologies it uses. The building shell must be adaptable to cope with change over time both in terms of a single space evolving over time, or different organisations moving into the space,.

Intelligence needs to focus on user and organisational goals. The emphasis will shift from the integration of different technologies towards integrating these and the technologies of business and space management to serve the overall effectiveness or organisational performance. IBE 1992 believe this will require.

Better user briefs

- More responsibility for suppliers to convince users of the benefits of intelligence
- Better comparative performance data on both efficiency and effectiveness
- Better understanding of user and building life cycle interactions
- New forms of procurement
- Re-definition of facility management to interpret organisational goals

Suppliers will need to have a much better understanding of the changing organisational structures, working patterns, use of information technology and wider user concerns over issues such as environmental control, individual comfort and satisfaction at the workplace. Integrated intelligent services will become highly responsive to users' needs.

Intelligence is not necessarily building based. The concept of the intelligent building implies that the intelligence is constrained within the building. However, as patterns of work change to include a wider variety of work settings, and as the use of portable communications increases still further, it may be more useful to think of intelligent systems or intelligent networks rather than buildings. The building thus becomes a node in an organisational netwo!k. The concept of a distributed building intelligence network extends to linking a number of buildings belonging to a single organisation together, both in terms of communications systems and building automation systems, hence, creating a 'virtual building' which maximises both efficiency and effectiveness gains.

Facilities Management for Intelligent Buildings

Facilities Management comprises numerous integral measures that are necessary to ensure effective use of property for owners and tenants. The qualitative and quantitative individual goals of the clients are considered throughout the complete life cycle of the building. This means that the economic execution of the organisational, financial and operational processes as well as the continuous fulfilment of the quality, security and environmental requirements, constitute the principal elements of facilities management. Experience shows that operating costs of technology centres, as a percentage of the insured value of the building, varies from 3.5% to just over 4% for old buildings; and between 3.9 and 5.5% for new ones. The improvements after the introduction of computer aided facility management (CAFM) are highly significant throughout the design, production and operation processes (Bochsler et al

1994).

The term 'facilities management' was coined to identify managers of change, and is concerned with preventing building obsolescence brought about by functional or technological obsolescence. This role contrasts directly with the role of the maintenance manager, who combats the effect of physical deterioration in an attempt to maintain the status quo of the building. Periodic maintenance allows the building capability to be recovered to a level comparable with the building's initial condition. However, a gap continues to emerge throughout the building's life because user expectations increase and organisations change. This may result from innovations in information technology imposing greater demands on the building or organisation and thus requiring a readjustment of functional capability. The maintenance gap only arises once the building is initially commissioned, whereas the technological and functional gaps can arise from the point of design inception partly due to the time lag between inception, during which time, changes may arise. The facilities manager does, however, have a key contribution to make at the inception stage ensuring that knowledge relating to changes of previous buildings are considered in the new building. The facilities manager is emerging as a key role in ensuring that the building, the systems and the people work and interact effectively.

Kell (1996) states that intelligent buildings need facilities management to define requirements, justify investment, and deliver benefits. At the same time, facilities managers need intelligent buildings to control building performance, manage distributed services, adapt rapidly to changing requirements, and provide crucial management information.

New Environments for Working

A recent research project carried out by DEGW, the Building Research Establishment and a number of sponsors, (Laing 1996) has attempted to define the implications of new ways of working for office buildings and environmental systems. The starting points are the importance of specifying appropriate and responsible servicing; developing model briefs for environmental systems and controls for new kinds of organisations; identifying products likely to be most in demand.

The inter-relationship between work pattern, environmental systems and building forms was studied. The work pattern variables contrasted open plan and cellular offices; classification of building forms by the plan aspect ratio; environmental systems considered convective and radiant types, and those that used a mixed mode approach. By studying the expected demands of the various types of work spaces; making an assessment of environmental services systems and hence evaluating the features that could be met by various kinds of system, the relationship can be mapped out between environmental systems and patterns of work, and also between building forms and environmental systems.

This research project has shown how important it is to recognise and analyse the diversity of user requirements, including varying occupancy patterns. The basic psychological factor that users want more individual control over their comfort and wellbeing is well established. By studying the inter-relationship between workpatterns, environmental systems and building forms an adaptable model results which can cope with changes as they occur at social and architectural levels. Innovations can be accommodated so that technological change can be incorporated easily. This way of working results in a better integration of the various disciplines

and an improved performance over time for users; it also achieves economic advantages by relating effectiveness to cost in use.

Conclusions:

Buildings affect people in various ways. They can help us to work more effectively ; they also present a wide range of stimuli for our senses to react to. If this is a common: vision then it is essential for architects, engineers and clients to work closely together throughout the design, construction and operational stages of the conception, birth and life of the building. There has to be an understanding of how patterns of work are best suited to one building form or another served by the appropriate environmental system. There are a host of modem technologies emerging that help these processes but in the end it is how think about achieving responsive buildings that matters. Intelligent buildings can cope with social and technological change and are adaptable to short-term and long-term human need. This is the fundamental meaning of the term intelligent building.

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