Space Utilisation: Intensification and Diversification

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Introduction

This paper examines how space use is changing in the United Kingdom building stock. The process of space intensification and diversification is examined in the light of socio-economic and technological changes. Implications for buildings across the study sectors are examined, and brief conclusions offered.

Definitions

Intensification is where existing, refurbished and newly created space is used for more activities, which may be carried out over longer periods of time and/or at higher densities than in the past. Diversification is where activities are spread over a greater number of spaces in a larger number of geographical locations than before..

Intensification and diversification are both are features of the same underlying processes of social and economic change. They seem to be leading to:

- more highly-serviced spaces both for living and working;
- more prolonged use of space over time, with buildings occupied for longer periods during the day;
- much greater use of communications infrastructures;
- increasing demand for faster and more reliable transportation;
- wider geographical spread of organisations and social networks.

However, there is no single trend or vector: buildings in different sectors are affected to varying degrees. In the office sector, for instance, organisations with a well-developed knowledge of information technology are much more likely to both intensify (by introducing address-free working) and diversify (with remote-access working). Organisations not taking full advantage of IT may intensify into a single headquarters site (in the search for reduced occupancy costs) but fail to take advantage of diversification.

Similarly, organisations which have potential for diversification (such as soft drinks manufacturers, where production plant is relatively indifferent to location) can over-centralise, in the mistaken belief that economies of scale can be found in one large plant. In the domestic sector, diversification by office-based organisations may lead to greater use of the home for office work, but this may be countered by carrying out more activities outside the home (as with eating out, for example) so that the home tends to be used as a base.

Effects of intensification on occupant densities of buildings vary with more equipment and supporting space and services. At any time occupant densities may be in fact lower. However, with increased occupancy hours and greater throughput of people, a given building may support more people. The diversification of more people spending more time outside the intensified building may increase the use of other spaces - homes and hotels, for example, which may consequently expand to cater for the demand, again lowering densities.

Minimising Cost and Adding Value

The process underlying spatial decision-making has been expressed as “minimising cost and adding value” [Reference 2], although this oversimplifies the dynamics involved (see later). Most spatial decision-making, geographical as well as architectural, involves variations on themes of cost and value [Reference 3]. Cost minimisation often produces clustering through economies of scale, especially through reduction of transport costs; however, it can also send work long distances away

when premises and labour costs are lower elsewhere and where information can be moved about easily and cheaply. This is one example amongst many others of paradoxical counter-trends which are found in spatial processes.

Adding value often results in searches for additional amenity value, in more highly-valued but lower-cost locations close to the green belt, for instance. People have often sought ideal building types and/or locations which trade-off cost minimisation against added value within the existing social, technical and cost constraints (in particular, that of accessibility). This process has always been a feature of 20th-century spatial change, witness suburban expansion in the 1920s and 1930s. Outcomes are seldom optimal because costs and benefits fall upon different people at different times. For instance, each wave of suburban expansion lowers the amenity values which had been enjoyed by the previous phase of settlement.

The intensification-diversification (I-D) process, is often unstable, because it usually has positive feedback loops built into it. Cost minimising activities carry side effects which often result in the transfer of disbenefits to others, thereby ultimately reducing, rather than adding, value. The distribution of externalities effects which can result from cost minimising activity is a fundamental feature of the process of spatial and environmental change. Its modern manifestations are NIMBY (not in my backyard) and BANANA (build absolutely nothing anywhere near anyone). Negative effects become more obvious once environmental carrying capacities reach their upper limits, such as with population growth or the destructive effects of pollution, for instance. Often, full implications of spatial decisions are not understood at the outset, as with the location of nuclear power plants, for example. Once made, spatial decisions have considerable geographical inertia, and can be extremely difficult to stop or reverse.

Simplistic cost-minimising objectives seemingly drive an increasing number of spatial decisions, which are often taken with short-term profits and higher productivity as prime motives. At the same time, activities like building procurement, design and management are all becoming more complicated and seem to be affecting more people. Two types of complexity, one arising from spatial activities (that is, spatial densities, interactions, adjacencies and combinations of existing activities) and the other from increasing uncertainty about future actions, are involved.

Complexity

Building users usually want multi-functional spaces which respond positively and quickly to their changing requirements. This applies as much to constantly occurring, high-frequency decisions with small-scale effects (such as when occupants want to switch the lights or adjust the temperature, for instance) as to low-frequency decisions with large-scale effects (perhaps made once every 20 years when an organisation may want to refurbish its building or move to a new one on another site). Nowadays, moves are often made to accelerate a change in culture, and not necessarily because the buildings themselves are technically outmoded.

Faced with this, designers have tended to create buildings which they perceive to be both more spatially diverse and more responsive. The term "flexibility" is often applied both by designer and client to indicate a desire for improved responsiveness to changing but uncertain needs. Flexibility implies the capability to accommodate higher spatial densities and cope with greater uncertainity. Often, buildings designed this way will be more automated or "intelligent" than previously, in the belief that adding automation (which often involves taking direct control away from many of the occupants) will achieve more spatial diversity, greater responsiveness and less uncertainty.

However, many modern buildings fail to meet these expectations. Recent research evidence from office buildings suggests that in some buildings with greater complexity the environment is sometimes less responsive, harder and more costly to manage and disliked by the occupants [Reference 5]. As designers are faced with increased uncertainty (through proliferation of technological choice, among other factors), their strategies also tend to embrace "normal", predictable, operating conditions whose parameters are easier to define (legislation and standards often prescribe them). Buildings prescribed in this way also seem easier to automate, which often means that too much control is inappropriately taken away from the occupier and user and placed under automatic supervision.

These circumstances lead designers increasingly towards assuming:

a) that they can work to a normal "envelope" of physical and behavioural performance criteria, quantitatively defined and largely context-free (as for thermal comfort criteria);

b) that buildings will usually stay within this envelope in use; and

c) that the mechanical systems should operate to keep conditions within the required tolerance envelope [Reference 7].

These assumptions and judgements are now more frequently assisted by mathematical models and simulations which test out various scenarios of use. Relentless intensification of use, though, can have opposite effects. It can drive the actual performance of buildings to move outside the designed-for envelope. When this happens, the physical, human and management systems are often not responsive enough to ensure that the building copes properly with needs.

Intensification also increases the chances that discrete functions will conflict with each other's performance. This may help to explain why so few buildings seem to achieve in use the performance standards which were predicted for them, and this is one reason why buildings seem to be more uncomfortable and unhealthy for their occupants. Many open-plan office spaces, for instance, quickly become hotter, dirtier and noisier, and reach a lowest common denominator of performance (in which people compromise and accept lower standards because they are not prepared to give time and effort towards reaching reasonable solutions). Once a building reaches this state, it is extraordinarily difficult to change it for the better, which is one reason why organisations move and attempt to start again from a "higher" base.

Rather than design for average requirements, strategies will increasingly be employed which are aimed at responding to thresholds of change, so that buildings and spaces within them are able to switch from one state to another in response to demand. These thresholds apply to individuals (who, triggered by discomfort, may need to alter heating, lighting and ventilation settings, for instance) or to groups (who may want to reconfigure quickly their workstations or production processes) or to larger-scale changes in building use over time, where a space may need to be rapidly changed to serve a different purpose. The potential for modal switching is becoming an increasingly important feature of modern buildings, and is one of the responses to intensification.

Dynamics

The intensification-diversification process is described here in more detail as nine stages, A-I. Stages A and B are about minimising costs and adding value; stages C-I are about the emergent dynamics.

A Minimise cost

B Add value

C Hidden negative interaction effects of A on B (value subtracted through excessive external costs).

D Legislation to stabilise or prevent C.

E Negative effects of D on A (where legislation is perceived to increase cost, therefore increasing pressure to reduce costs of D)

F Increasing spatial complexity (in part response to uncontrolled A).

G Increasing strategic awareness to increase responsiveness to cope with increasingly uncertain change (in part a combined response to both B (quality criteria) and A (management cost)).

H Hidden negative interaction effects of F on G (less responsiveness possible with increased cpatial complexity).

I Positive interaction effect of G on F (producing "simpler" and more robust design strategies as a response to increasing complexity and higher management costs).

The extent to which an individual or organisation is conscious of or participates in this process, depends on their respective roles and positions and how far they proceed through the stages. To some managers or clients, for example, stage A (minimise costs) will be all that matters; they will go no further. Developers may have a strategy which stresses B to the marketplace, while pursuing profit maximisation for themselves and their investors. Increasingly, building legislation is forcing all participants in the process to consider stages C, D and

E as well (although enlightened developers are also beginning to realise the market potential of buildings which work well for C, D and E, and are exploring I. [Reference 8]). Managers in touch with the consequences of poor coordination between design decisions and user requirements are more aware of F and G, and in rare cases, understand H well enough to insist on design strategies which also go as far as stage I.

In the future, as knowledge of building performance and its social and environmental consequences increases, more buildings will reach stages F,G,H and I, but more often will be driven by management and organisational criteria than by the building industry, including the design professions. For example, there is increasing evidence to show that organisations with clear-cut missions, resolutely carried through in everyday management practice, are more likely to have buildings which are comfortable, healthy and energy-efficient.

These organisations will insist on rapid response in the total building system (including the management systems), even if they have to by-pass the design or consultant teams to achieve it. Some will be happy to "drive" complex solutions but most will insist on simplicity and manageability. This is more likely to happen where tenants can "take ownership" of some operational features of the building, and this seems to happen best in buildings which are let to them in advance of fit-out. [Reference 5].

Changing demand

The intensification-diversification process will both help promote new technological developments and, in turn, be affected by changing social and technological requirements. Some of the most prominent of these are listed below, and covered in more detail in subsequent sections.

Client/server networks

Rapidly increasing demand for information technology, with broader communications bandwidths (for multi-channel graphics, voice and video) and uncongested communications gateways will lead to much more sophistiated client/server computer network relationships based on advanced document management [Reference 40], with wide-area and wide-bandwith networking becoming much more important.

Working groups

Working groups and project teams will increasingly become the organisational focus in all kinds of working contexts - commercial as well as industrial, short term and long term, and will tend to supersede both the individual and the department for planning and design purposes [Reference 38].

Demand sensitive use of space

Use of space will be much more context-dependent and demand sensitive, leading to rapid reconfiguring and switching between changing uses and different states. This will increasingly emphasise the different requirements of space/services supply and user demand in buildings, the interfaces between them and different materials cycles inherent in site, fabric and services.

Unhindered access

Unhindered access to transportation infrastructure will be increasingly essential. Although activities will intensify, they will also be more segregated, leading to the need for greater accessibility on demand between places. However, with improving electronic communications and pressure to reduce the environmental impact of motorised transport, many of these movements will be over shorter distances or irregular or replaced by rapid information transfer.

This may stimulate interest in optimum sizes for cities, perhaps leading to existing large cities, such as London, dividing into smaller units (based on, say, Westminster, Croydon, Hammersmith, Lewisham, Stratford and Islington/Camden). The geographic extent of these places may be defined by tramway/metro systems (as now in Manchester and Newcastle, and in the near future in Sheffield and Croydon).

Security

Greater physical security will be required, both in buildings and information systems.

Organisal cores

Organisations will increasingly focus on spaces occupied by their core businesses, which will increasingly be highly-serviced and specialist, and will be more integrated with their mission or image. However, their building services may

become simpler. The non-core businesses shed will create new opportunities for other organisations, for redundant staff and for new businesses.

Redundancy

Non-essential space, especially space which is poorly-used or costly to maintain, will be released, leading to a greater proportion of stock which is under-used or obsolete. Demolitions will increase, and there will be more strategic thinking on redevelopment and re-use.

Cost of time

Time-dependency, time management and the cost of time will increasingly affect locational and space decisions. High labour cost activities will increasingly intensify and agglomerate; low cost and non-locationally critical activities will increasingly diversify and disperse, and the old economies of scale will be less appropriate.

Coupling

There will be "tighter coupling" (that is, increased connectivity between and inter-dependency) of human and physical systems, leading to increased likelihood of breakdown or failure and greater attention to risk management. This is a marked trend, with more and more buildings failing because of inaappropriate integration between physical and management systems.

Client/server dynamics

Intensification-diversification is most clearly seen in client/server arrangements in information technology networks. The "server" machine is usually a central store and management system for data and software. These data are distributed (in the form of electronic mail or data files, for instance) to "clients" over a local network (usually within a building) or a wide-area network (which can be anywhere in the world).

Server machines intensify the use of space because they require security, back-up and specialist technical support. They must also be well-managed with stable, reliable and constantly accessible communication pathways.

Client machines may be located in the same office, or anywhere that has reliable and economical communications pathways to the server system. Client machines thus have the potential for spatial diversification. Activities which are information-hungry, such as libraries, banking, media and insurance, have the potential for rapid intensification-diversification. Offices in these sectors, for instance, will become more like mail, meeting and message centres (with the server intensively serviced); libraries will become nodes and local delivery points in global communication systems. Access to systems will increasingly be made via communications services using ISDN (Integrated Services Digital Network) and equivalent facilities [Reference 10].

Until these systems are stable and proven, many buildings will operate concurrently, with client workstations retained within buildings alongside servers as well as using "traditional" computing or filing arrangements. Increasingly, client workstations will move to remote locations once the cost effectiveness, reliability and usefulness of networks have been proven. Server locations will be in buildings which are intensively serviced and managed, secure, and operate for 24 hours a day. Client locations will be less-intensively serviced, lower cost, less secure (security will still be important but not critical) and often operating on demand.

Organisations will be increasingly identified with their high-cost, server addresses, but far more organisations will use virtual arrangements with a headquarters address front-end and dispersed working for the majority of staff. These arrangements will increasingly highlight those differences between buildings and spaces which are critical to organisational effectiveness, and those which are not. This will lead to smaller organisations and space shedding (see also below under core business and redundant space).

Building types and sectors especially prone to intensification-diversification will be:

- offices (especially in high technology and IT industries);
- higher and further education (especially for mature or part-time students or professional staff involved with continuing professional development);
- libraries;
- media industries;
- some retailing and banking operations (mail order and automatic teller functions).

What do you think will be the next "big one", the next huge success, in the software world?

Bill Gates: Group productivity, advanced mail stuff - a lot of opportunity there … In this client/server thing, the idea of seeing corporate data graphically, being able to browse around it very easily, and have it sort of remember what stuff you like to see and make it easy to call up. That whole way of seeing your corporate data - nobody's really done very well with that. That's a big area. some people call it database front end, but that's just because they are using an old label on a new thing", September 1990.

[Reference 9]

Industry will not be immune, especially where the necessary components , supplies and information can be sent to local production units.

Working groups and project teams

Whereas server locations and client locations will be increasingly differentiated, groups of "clients" will come closer together. As predicted by Gates, Handy and others [References 9, 11 and 12], working groups will be increasingly important. Buildings will increasingly serve the needs of groups and teams, which will be in constant change and flux. There will be a greater distinction between buildings and spaces which serve the needs of teams, and those that serve individual needs, such as requirements for privacy and concentration.

The sizes and dynamic form of working groups will differ radically from one building type to another and between different organisations. However, there will be basic similarities. For example, in higher education, seminar groups of 12 people were common 15 years ago, but are now often over 20 in size. These groups still involve many (students)-to-one (teacher) relationships. With the increasing use of IT, it will be increasingly possible to take the teaching to the student and tempting to reduce labour costs through so doing.

In offices, groups of 4-6 appear to be optimal for many tasks (although the best group size varies between different organisations). In hospital wards, groups of 26 patients are common, although there is increasing potential for just-in-time health care and patient hotels which reduce the need for wards. All such groups will have to be accommodated satisfactorily, at the same time as keeping levels of space utilisation as high as possible. For higher educational buildings see [Reference 13] and hospital buildings [Reference 14].

"In ten year's time, in most successful businesses, the workers will truly "own" the means of production because those means will be in their own heads and at their fingertips …Large parts of organisations could ultimately become a collection of project teams, harnessing the intellectual assets around a task or an assignment, rather as a consultancy company or advertising agency does now".

Charles Handy [Reference 11]

The focus on the working group is a radical change from past practice. It has been common, for instance in offices, to base space planning calculations on room densities using numbers of individuals, or perhaps individuals aggregated in departments. Findings from Stanhope plc [Reference 15] point to measured densities in offices being 20-30 per cent lower than design densities. This may be the result of working groups eventually requiring more space *pro rata* than individuals, many people being out of the office for long periods and some individuals occupying more than one workstation, for instance. It is still rare to find detailed studies of the needs of working groups in offices, higher education and health buildings.

Demand-sensitive space and services

There is evidence to show that organisations are becoming more aware of the cost consequences of building strategies based on "supply-side" criteria [Reference 16]. Increasing interest in demand management is not only being stimulated by awareness of the global consequences of profligacy in energy use, but also as a design strategy for coping with the management and cost consequences of unnecessary complexity [Reference 5].

Careful demand management (a symptom of which is rapid response to user's complaints), is associated with higher quality buildings and better occupant performance [Reference 17]. There are many components to demand in buildings, not least of which are the different requirements of individuals, groups, departments, visitors and occupants (across many building types) and the ways these requirements complement and conflict with each other. Buildings which are sensitive to demand will a) respond to abnormal requirements much faster and b) be capable of rapid switching between uses. This will mean that greater understanding will develop of baseload provision (for human comfort, energy supply and so on) and of how to adapt buildings and spaces quickly, cheaply and easily for exceptional demands beyond basic requirements.

Energy Consumption by final user

	1960	1992
Domestic	29%	29%
Industry	42%	25%
Transport	17%	32%
Other final users	12%	14%

Based on table 7, Digest of UK Energy Statistics, 1993

Consumption of space by different modes of transport, occupancy and speed

Mode of transport	Speed Km/h	Space m2 per person
Pedestrian	5	0.8
Cyclist	10	3.0
Car (fully occupied)	10	6.2
Car (1 person)	40	20.0
Car (1 person)	10	18.7
Car (1 person)	40	60.0
Bus (Full)	10	3.1
Bus (1/3 full)	10	9.4
Bus (Full)	30	9.4
Bus (1/3 full)	30	28.1
Light rail (Full)	30	2.2
Light rail (1/3 full)	30	6.9

Buildings which are capable of switching quickly between supply-led and demand-led states will often be intrinsically more useful and efficient. Thus modal switching over time will be increasingly important, and will complement increasing interest in mixed-mode servicing strategies. Demand modes are likely to be increasingly linked to other cycles. It has been suggested, for example, that long-lasting building components would be linked to the mineral cycle, whereas short-lasting components would be part of the renewable cycle [Reference 18].

Access to infrastructure

As space use intensifies and diversifies, so the demand for transportation and communications infrastructure continues to rise (see box). Regular patterns of day-to-day commuting are seemingly in decline, but the "24-hour rush" is more likely. Space intensification fuels this process both for physical accessibility and also for accessibility via communications channels.

Whereas the proportion of time that people spend on transportation appears to be stable, increases in efficiency and speed mean that transportation systems consume much more space than they have in the past [see box, Reference 19]. It is likely that mature IT will reduce the demand for some physical communications, as information can travel rather than people and goods.

Yield management techniques (see below under redundancy) are part of the intensification process, but they also make organisations increasingly reliant on efficient transportation and communications infrastructures, thereby increasing the risk that the system may fail (see below, under coupling).

Core business

Driven by cost and productivity imperatives amongst others, many types of organisation have been actively reviewing space usage and increasingly regarding it as a normal (rather than exceptional) part of their planning and review processes. "Space productivity" is a term heard more frequently in the speculative office market, for example, and is thought by some to be crucial to the medium-term future of the UK property market [Reference 20]. Similar thinking has pervaded the retail, banking, insurance, health and to some extent educational sectors in recent years, leading to widespread "downsizing" or at least rationalisation strategies, affecting both numbers of employees and amount of space. It is probably not an exaggeration to say that there is a revolution underway in the UK here.

Outcomes are likely to be:

a) further specialisation and intensification (along the lines discussed previously);

b) release of non-essential floorspace and land;

c) focus on core activities of main businesses, especially where these involve highly specialised and intensively serviced space;

d) development of "design missions" compatible with organisational missions (to develop closer interaction between management systems and physical systems);

e) greater emphasis on long-term strategic planning of space and property;

f) insistence by occupiers on higher quality and value for money in buildings that are owned or leased; and

g) more partnerships between occupiers, landlords and service providers, especially in the use of highly specialised space.

The divide between highly-serviced, specialised, secure space and less-specialised space will increase. The function of less-specialised space will become increasingly problematical especially:

a) where it can be provided at lower cost locally, and

b) where it is embedded in another building types (student housing on campus and office accommodation in hospitals, for instance).

Organisations will be constantly evaluating the pros and cons of contracting services out to the local marketplace or keeping them in house. They will become much more adept at evaluating and costing the risks involved in these decisions, and in maximising yield from marginal cashflows and available capital. More attention will be given to revenue expenditures, especially on long-term maintenance. Future maintenance liabilities may lead to large-scale disposals of properties which are marginal to the core business.

Non-essential space and redundancy

The activities described above will lead to a much more realistic assessment of the value of space and its attributes. Techniques aimed at increasing utilisation and stripping out redundant or under-utilised spaces will be commonplace. These techniques are used by airlines to maximise income from trade-offs in price/occupancy ratios of seats. Yield management techniques are now found in buildings (leisure centres, theatres, cinemas and schools, for instance), and their use is spreading. They include the following.

- Booking systems (for rooms and seats).
- Space charging (for demand management).
- Hot desking/ address-free office working (to increase occupancy).
- Building evaluation/benchmarking (of suitability for purpose).
- Building performance measures (of performance in use, especially cost).
- Timetabling and scheduling.
- Improved facilities management.
- Queuing models (for lift management, bank/check-in queues).
- Transportation algorithms (for optimised routing).
- Inventory management (increasingly Just-in-time (JIT) methods).

Yield management introduces new terminology. For example, the following terms will be more commonplace in building analysis.

Theoretical capacity
When all spaces are completely full at all times, but allowing for cleaning etc - obviously never met, even in hospital wards where the target is often for 100 per cent bed occupancy;

Design or system capacity
The capacity at which the building and its occupying organisation was designed to run.

Effective capacity
Often a reduction from the design capacity to reflect typical operating conditions; and,

Utilisation

The actual level of use (also called load factor), which would normally be less than the effective capacity, but when it exceeds it would create.

Bottlenecks

Where utilisation is greater than effective capacity). Output (utilisation) divided by input (design capacity), and utilisation divided by effective capacity, are two measures of the efficiency or

Yield of the system.

Measuring yield poses the question of how much extra capacity (or "redundancy") the system needs in order to function properly. (Redundancy is used here as in information theory to measure the extra information that needs to be carried by a message in order that it can be efficiently and economically decoded. The Bible, for instance, has been estimated to be 41.3 per cent redundant! [Reference 22]).

Some building systems (used here in the sense of the total system of building, site, occupiers and organisation) require relatively high levels of redundancy, usually because the systems operating within them are both complex and "loosely coupled" (see below). Building Use Studies estimates that higher educational buildings often operate at 40 per cent utilisation (= 60 per cent redundancy) and are still perceived to be full!

In loosely-coupled building systems - universities are a case in point - spaces are often under-utilised because they are often used as "buffering" to simplify management and to protect individuals or groups against perceived inefficiencies or threats to them from others - hence the tendency to "defend" territories rather than behave co-operatively or altruistically.

Yield management techniques (along with value engineering techniques) will increasingly expose the extent to which systems are redundant, and raise the question of which of two strategies should be employed:

Tight fit	Spaces designed around processes.
Loose fit	Spaces designed to accommodate a wide range of uses and processes.

Redundancy in space comes in three forms.

Useful	Extra spatial or volumetric capacity or adjustability which gives inherent flexibility and adaptability (such as floor- to floor- heights which enable additional building services or a mezzanine floor to be added, if required).
Generous	Where the organisation prefers to be generous rather than intensify its space management requirements.
Superfluous	Extra space or building elements which serve no really useful function.

Intensification could well result in less useful redundancy within buildings, as "nice-to-have" features are removed on cost grounds, leading to growing obsolescence of whole or parts of buildings. At present, vacant or obsolete floorspace appears to be increasing. For example. the Open University's study of Bury St Edmunds, Tamworth and Manchester found that on average 12.5 per cent of non-domestic floorspace was vacant [Reference 23]. It is not known what proportions of this vacant space are likely to be re-usable or obsolete.

Vacant space is especially apparent in building types where potentially conflicting functions co-exist alongside each other. For example, many high streets have ground floors in use as retail premises, but the living accommodation above is unoccupied [Reference 21] and with modern just-in-time distribution techniques has ceased to be useful as storage.

University campuses and hospital estates often have a small proportion (say 10 per cent of the usable space) devoted to highly specialised functions (such as laboratories), but have many buildings which are either under-utilised (such as large halls and sometimes student accommodation if it is not attractive to conference or holiday uses when not otherwise occupied) or marginal (such as boathouses, gazebos and stables left over from when the site was once a large house with outbuildings). Increasingly, marginal buildings are coming under scrutiny. For some their only valuable function in the future may be aesthetic, as desirable landscape elements, for instance.

Diversification, on the other hand, increases demand for change of use. Some farm buildings, for instance, are becoming vestigial, in use as homes or holiday accommodation, rather than for agricultural purposes. Some of these homes will also incorporate an office, perhaps networked to a file server or email gateway in another location, and be thought of as "telecottages".

Intensification of office space goes together with diversification of this type. It is increasingly common to find offices where nobody "owns" their space. Staff come in and find a place that suits them, log on to the file server and work from there. They may have a locker or cabinet for personal belongings. Work areas are not personalised. The advantages are that less space is needed, and that staff can log into the management system from wherever they wish - home or hotel, perhaps, as well as office. The central office is intensified in use, but uses are also diversified at remote or temporary locations.

In time, the common information technology infrastructure required for different uses may make it possible to switch spaces between uses relatively quickly. In higher education, for example, it is possible to have teaching rooms cabled for 10-20 computer workstations equipped with a local file server which can be rapidly changed over into office or conference accommodation.

Organisations which have seasonal demand (conferences in the summer and teaching and administration in the rest of the year) may seek out this potential for switching. This will lead designers to think much harder about "where they put the value-added" (that is, where they put needed but costly redundancy).

This will lead to buildings with some or all of the following physical characteristics:

- spatial zones sized according to characteristically dominant patterns of user groups (use zones);
- use zones closely matched with control zones for lighting, heating, cooling, ventilation, noise, physical security and disturbance (control zones);
- both use and control zones capable of rapid and logical switching between types of use (user modes) and in accordance with seasonal or external conditions (climatic modes);
- linking of different parts of the building system to different resource cycles (the longer-lasting fabric will be treated differently from the interior, for instance, so that different management strategies can be applied to them) with especial emphasis on separation of waste streams;
- greater separation of complex elements and components from simple elements, with a much greater emphasis on the function and performance of the building, especially the fabric [References 25 and 26] (design for manageability);
- hence simple, but adaptable spaces for all but the most complex environments, with additional equipment and services added as necessary;
- greater separation of the total building system (human as well as physical) into "supply-side" and "demand-side" elements with much more focus on the latter, especially with respect to energy management;
- a corresponding emphasis on interfaces, especially control devices.

Buildings with these characteristics can rapidly adopt different internal states and respond to changing demand. Occasionally, state-switching will be very rapid, requiring flexible technological solutions. Often, simple and easy adaptability will be sufficient. Recent research has shown that office buildings which are more responsive to demand are also likely to be energy efficient, comfortable, healthy and clean [Reference 6].

Time dependency

The cost of building occupants' time is becoming a more important consideration. Staff salaries are by far the most expensive part of most organisations' costs - in offices the proportion may be upwards of 75 per cent of annual costs, and in schools even higher, perhaps 80 percent. Using people's time effectively is becoming an important consideration, especially where time is being spent wastefully, as in unnecessary building management, for instance. The "productivity of space" is a term gaining wider currency, by which is meant the ability of buildings to accommodate functional requirements efficiently [Reference 20].

Although statistics on this topic may be unreliable, free time has increased appreciably for both men and women between 1990 and 1992 (see box). People who are "time poor", that is those working long hours, but also relatively wealthy, have different behaviour patterns. They tend to "time shifting" activities, through the use, for example of video recorders, so that they displace activities and try to use time more efficiently. They may also be

"There seem to have been four factors that together combined to create the Grand National fiasco on Saturday: animal rights protesters getting on to the course; the foul weather; the inadequate starting mechanism; and the man who did not flag. Statistically these four factors were not independent of each other, but it would be realistic to say that the chance of all four factors happening together might have been something between 100-1 and 1,000-1 against. Few people would back a horse with odds like these".

Robert Eastaway,
Letter to Independent April 4, 1993

Time Use in a Typical Week: by Employment, Status and Sex 1992-1993

Great Britain	Full time employees	
	M	F
Weekly hours spent on:		
Employment and travel 1	47.1	42.2
Essential cooking, shopping and housework	13.0	25.5
Essential childcare, personal hygiene and other shopping	13.2	20.0
Sleep 2	49.0	49.0
Free time	45.7	36.8
Free time per weekday (1990-91 in brackets)	5.0 (4.5)	3.3 (3.0)
Free time per weekend day (1990-91 in brackets)	12.1 (10.3)	10.3 (8.2)

1 Travel to and from work 2.. Assumes average of 7 hours sleep per night.

Source Social Trends Table 10.2 1992

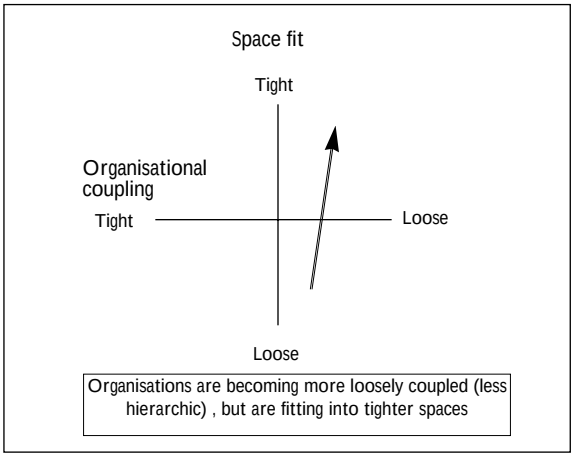
more hurried and tend to carry out more than one activity at a time. Time-poor people consume more space, both because they travel greater distances (although they do not necessarily spend more time on travel) and because they are more likely to have more than one place of work and more than one home. Additional space consumed travelling at higher speeds must not be forgotten (see box, page 11), as this is one of the environmentally most serious consequences of intensification-diversification as currently practiced, where the physical communications infrastructure carries too much of the burden of dispersal and the electronic infrastructure as yet too little.

Coupling

Systems have varying degrees of "coupling" [Reference 29] - the extent to which elements within them are connected together. Buildings are systems which have the peculiar property of being relatively tightly coupled in some respects - their structure and fabric, for instance - but loosely-coupled in most others. HA Simon called them "nearly decomposable systems" to describe this property, for example, interconnectedness of some components is critical to structural stability and weathertightness, but the number of components which are connected together in this way are a small proportion of the total building system [Reference 28).

The trend, however, has been for buildings as total systems to become more tightly coupled. This comes about for several reasons.

- Modern buildings are more tightly coupled in the engineering sense because of greater automation, and attempts (not always successful) at greater integration of services systems through, for instance, building management systems.
- In order to occupy spaces at higher carrying capacities, greater inputs of management resources are required (cleaning and repair of wear and tear, for instance). Organising these inputs effectively means that space use must be programmed and timetabled more rigorously, which increases dependencies of one part of the system on another.Some of the consequences are that:
- More interactions and dependencies increase risk of failures. Buildings are only rarely subject to catastrophic failures such as structural collapse. There are, however, frequent small-scale failures, many of which go unnoticed or unrepaired. Collectively, adverse effects of failures can be greater than the sum of their parts and their consequences can be hard to correct, especially in complex, poorly designed and badly-managed buildings. Although we have no means of measuring this, we believe that the number of small-scale failures may be increasing, leading to more widespread discomfort and inefficiency.
- People have traditionally resolved complexity in their lives by behaving habitually. Increased complexity, though, makes habitual behaviour less possible, thus increasing inefficiency and producing more complexity. Positive feedback loops of this type contribute to an increasingly hyperactive society, the personal costs of which are measured in stress and breakdown. The conse-



quences include more retreats and longer holidays, and greater segregation of lives in space (holiday resorts and tourism) and time (longer holidays). Increasingly, the costs and inefficiencies of this system (in both human and environmental terms) will mean that relaxation and leisure time will be increasingly merged with work, so that there is much less distinction between work time and leisure time, and people have far more control over the use of their own time. [For further development of these themes, see Reference 33

Effects

This section covers some of the foreseeable effects of the I-D process on the building types and sectors covered in reference 1.

Housing

Although the number of households is expected to increase, average household sizes are will continue to decline. Average space per household (90 sq m per household in 1991) is likely to stay constant or to rise slightly, both of which will increase the space per person.

Intensification of use of offices and educational buildings will mean that more knowledge-based work will be based at home during the day, but the home may be used less during the early evening and weekends with the trend towards more outdoor activities, increased eating out and less television watching continuing. This may spread occupancy of the home over a longer period, reduce commuting distances but increase use of heat, light and power. This will dampen demand peaks, but raise baseloads, especially for equipment like faxes, modems, computer CPUs, time clocks, answerphones and security systems which are left running continuously to service home working.

Offices

Increasing intensification of use of the home will depend on the costs of use of the car, penetration of information technology based on wide-area networking, and changes in employer's attitudes. A further significant factor will be the productivity of key individuals, and the need to provide them with uninterrupted periods of time to carry out key tasks. As time becomes scarcer and more expensive, people will be much more conscious of organising their time effectively, which will mean phasing workloads - many meetings in one place on one given day, concentrated work in another, for instance. This will lead to:

- Offices designed primarily for client and work-group meetings, for technical support of remote tasks for highly-specialised activities and for *ad hoc* project teams.
- Decline in "informal" and "serendipitous" workplace-related meeting places (lunch and coffee places, for instance), disappearance of the formal lunch break and coffee break, but possible increase in local facilities for home-working and *ad hoc* meetings (see also hotels).
- Step-change improvements in information processing and data transfer services for offices (especially company databases and filing systems).
- Greater emphasis on costs, especially the opportunity costs of wasted or inefficiently-used time. Activities which are tiring or environmentally damaging will be avoided where possible (this applies especially to commuting and unnecessary travel). It will become fashionable not to travel.
- Smaller, more secure, offices, with mixes of open plan and cellular spaces using natural ventilation, where possible, and mixed-mode where not, with full air conditioning rarer.

> "… the supermarkets expect you to drive to awkward locations, find and collect your own purchases, lift them onto the counter for the price to be read, lift them back into your trolley and wheel them out to the car. This takes much longer, makes you buy more and spend more time and money on travelling, and rots whatever is left of your soul".
> [Reference 31]

Retail

Retail floorspace development has passed through a period of intensification especially in shopping mall and superstore construction. This market is now approaching saturation, and schemes are either being abandoned (for example, Tesco, Plymouth) or increasingly opposed on social and environmental grounds. The DoE now also seems to be opposing more out-of-town shopping. It is possible that different retail development strategies will emerge in the near future. Increased diversification is likely to lead to renewed interest in the revival of local, independent retailers in town and city centres.

In the past thirty years, the average time spent on shopping in Britain has doubled, from 20 minutes a day to 40. It is claimed [reference 31] that this is not just because there is more to buy, but because retailers have been pushing distribution costs onto their customers (see box). With Sunday trading (which releases more time for shopping), this pattern will probably remain until a point when true social and environmental costs of car-based transport are more widely known and treated more as a cost to the individual than a benefit.

Possible scenarios are:

- new mixes of retail, service and location types emerging to service foci such as airports, railway termini, supermarkets at ports and borders, schools, universities, hospitals and garages);
- new retail developments with smaller, low cost, intensively-serviced, lightweight, modular, pre-fabricated and short-lasting buildings (for example, Forte (Happy Eater), BP/Shell forecourts);
- local convenience shopping based on freshfood and fastfood outlets (combined butchers / bakers / greengrocers / fishmongers) to serve people increasingly based at home for daily requirements. A revival in home cooking may be prompted by food poisoning and health scares (formally notified cases of food poisoning have increased four-fold in Britain between 1981 and 1992 [Reference 32]);
- development in town and city centres, serving daily, weekly and seasonal needs. Some revival in local and village shops serving daily needs;
- growth in mail order, teleshopping, on-line access and data delivery, email and delivery services with local franchises.

Patterns of shopping will divide more clearly between regular daily convenience demand (necessity shopping prompted by increase use of the home) and weekend and seasonal (leisure) demand from sub-regional or tourist markets.

Entertainment/sports

With increased distribution of large bandwidth optical fibre cables to homes and satellite channels, along with integrated computer / television / audio systems, there will be an inevitable focus on entertainment in the home, though not necessarily any extra demand for domestic floorspace. This trend will be countered to some extent by increased interest in "live" spectator or audience entertainment either in theatre, cinema or sport performances or in "social" viewing of performances transmitted by television (as with sports viewing in pubs, for instance).

Although leisure, pubs and clubs, and sports and recreation accounts for 7.7 per cent of current floorspace (and there are other uses embedded in hotels), changes in this sector will probably be only marginal, thus no large-scale effects will be seen. Possibly, the major influence of the entertainment/leisure sector will be promoting the penetration of email, on-line services (such as remote banking, mail order and databases) and other computer-based services into the home. In many homes, they will have been first introduced for entertainment purposes.

Hotels

As business use increasingly diversifies and constraints on individual's use of time become tighter, hotels, conference centres, resorts, schools, universities, leisure centres and restaurants will become increasingly used as short-term meeting places. These locations will be used for intensive half-day or day-long training and staff development sessions, or for project team work. As

organisations cut space back to core business requirements, they will be more likely to hire conference facilities in hotels for occasional requirements, rather than carry the (under-utilised) space overhead themselves. Hotels and conference centres will quickly come to understand the importance of providing seamless connectivity with office computer networks (these facilities are notoriously lacking at present) so that ready access can be had with base or headquarters. These trends will probably create more well-defined differences between hotel types (luxury, holiday, business/conference, business/travel. family and so on).

Hotels will be innovators in space management and utilisation techniques, developing charging schemes similar to those used by airlines to ensure that rooms and other facilities are kept at maximum occupancy. This will lead to more innovations in use within particular market niches. Hotels and offices will become more similar as building types. Other organisations, such as hospitals and universities will utilise hotels to a much greater extent (patient hotels for short term patient care, and hotels attached to business schools, for example). There will be greater diversification of the hotel industry into these markets.

Health

The health sector in the UK has been undergoing management changes similar to those which are now affecting education (see next section). Current thinking [References 13 and 37] emphasises:

- disposal of surplus land;
- increasing utilisation of poorly utilised or under-utilised building stock;
- reducing maintenance backlogs (estimated at up to £2,000m.);
- emphasising the advantages of refurbishment of the existing stock rather than unnecessary new building;
- improving strategic thinking about property planning and recognising the role of estate planning in the management of change.

These are characteristic intensification-diversification trends. Hospitals are trying to cut back to "core". They are examining the role and cost of perceived non-essential activities, such as research laboratories (which could be shared with, say, the nearest university or pharmaceutical company) and accommodation for nurses.. It is likely that hospitals will increasingly cut back to highly specialised, technologically- and professionally-intensive spaces (such as renal units, operating theatres, casualty units and intensive care) and move other activities, such as patient outcare, off-site. Many hospital sites now have significant traffic bottlenecks created by large visitor populations. It is becoming increasingly necessary to move excessive traffic-generating activities off-site to locations which are closer to the people they serve.

In future, hospital "core buildings" will be highly-serviced, specialised and technically complex, although the buildings will become less complex as medical technologies become more packaged. Simpler buildings (such as wards or outpatient departments) will be increasingly spatially separated and managed differently.

Education

The I-D process is now being accelerated in education in schools (with the introduction of local management of schools in 1989-91) and in higher education (with the strategic space requirements of the funding councils, which require that all universities to produce a strategic property plan). Trends include:

- increased security provision;
- use of buildings over longer periods of time;
- emphasis on making better use of under-utilised space, especially general teaching space;
- questionable viability of specialist laboratory space for small groups;
- increased likelihood of "distance-learning" in higher education;
- growing influence of information technology, especially multi-media;
- growing awareness of role as service providers, competition between establishments, and growing emphasis on image and presentation;
- fashion for mission statements.

These are leading to:

- growing similarities between different types of space and their servicing requirements (especially between office space and general teaching space);

- more rapid changeovers between uses, and increased rental and hiring of facilities;
- higher occupant densities of teaching spaces;
- increased wear and tear on facilities, leading to greater emphasis on management and repair;
- higher space standards;
- closer matching between space provision and functions;
- more spatial zoning, and growing consciousness of the need to efficiently mothball space not in use.

Factories and warehouses

Factories are the second highest users of floorspace next to housing - just under 10 per cent of the total (housing accounts for 63 per cent). Freeman [Reference 34] distinguishes:

- shifts towards information-intensive rather than energy- and materials-intensive products and processes which favour designs which economise on materials, energy and moving parts which utilise electronics, bringing about shifts in product mixes and in relationships between manufacturing and services, as well as a transformation of the production process;
- changes from inflexible, dedicated mass-production systems towards more flexible systems capable of manufacturing a diverse range of products as efficiently as a single product, which have consequences for the rapid evolution of product design and products and for ”economies of scope” in production lines;
- changes in the pattern of business organisation, involving integration of office and plant, of design, production and marketing, closer communication links between assembly plant and suppliers, manufacturers and distributers, permitting a faster response to demand conditions, better stock control and a wider range of inputs into the design and development process. [Reference 34, based also on Reference 35]

Such changes increasingly emphasise the redesign process, with products and commodities progressively simplified in the number of parts they have and the length of the assembly process. Value engineering is at the heart of this approach, examining parts of processes which add cost but not value, and trying to remove them or make them contribute more effectively.

The implications are that:

- large parts of factory buildings will become more similar to other building types such as laboratories and offices, a trend which has been clear in the electronics industry for some time;

> “… The machines in the (Ford, Michigan) factory are flexible enough to build the (twelve) different engine models with just minor adjustments …The trick to this capability has been the redesign” and simplification of the new engines to reduce 25 per cent of the parts and keep about 350 of the remaining parts in common. [Reference 36]

- production systems in factories will be much more sensitive to changes in demand, making them ”rapid-response’ environments where the building is fitted around the process equipment and needs of the supervising staff (sometimes they will need to be less intensively serviced, but frequently processes requiring special services will have these services integral to the process);
- factories will be much more automated;
- they will probably be smaller;
- production processes will be more tightly coupled with human, organisational, utilities and transportation infrastructures;
- demand for floorspace will be lower, but
- energy costs (because of increased use of technology) will stay about the same with a trend away from fossil fuel to electricity for many requirements;
- warehouses will again become smaller and more localised for industrial and retail purposes, although storage for agricultural and mineral products may increasingly intensify in transnational depots.

Conclusion

Drivers of change

Intensification and diversification have been identified as constant features of spatial change. There is a dynamic interplay between spatial clustering and higher densities, on the one hand, and dispersion and lower densities, on the other. They often appear as alternatives or opposites, but they are frequently complementary.

Minimising cost and adding value are also a fundamental part of spatial decision-making. Again, they are alternatives or opposites in some contexts and complementary in others.

Recently, sustainability has been explicitly added to spatial decision-making and will become of increasing importance as attitudes change and environmental legislation bites (although sustainability has always been a part of non-intensive agricultural and economic systems).

How will these processes affect buildings in the UK in the foreseeable future? The key will be the extent to which thinking about cost, value and sustainability become congruent and part of the same decision-making and resources system.

There is evidence that this is happening, first through the global influence of management science methods which have revolutionised the understanding of cost and value in manufacturing and service industries (especially with value engineering techniques), and secondly between cost, value and sustainability in the influence of environmental thinking. Although these are often still separate "systems" driven by different motives and agendas, they have potentially important common links, the most important of which is avoiding waste.

Avoiding or minimising waste is common to value engineering methods (cutting out unnecessary costs without reducing perceived value) and to sustainable strategies (especially through conserving non-renewable resources and minimising pollution). As the economic and social value of these approaches comes to be fully appreciated, there is likely to be a major change in attitudes towards waste avoidance. This change will happen within the near future. This will "drive" increased emphasis on *total* cost and value (for individuals, organisations, investors, developers and wider social and environmental costs and benefits).

When this congruence occurs, it will rapidly accelerate many of the change processes talked about in this paper. In particular it will:

- reduce unnecessary physical movement, shifting a far greater proportion to information and communication highways;
- rapidly accelerate I-D in the sectors best suited to it - offices especially;
- stress local and "federal" structures;
- rapidly improve efficiency across systems (see below);
- focus on life cycles (see below);
- encourage "mode-switching" and rapid state changes;
- make many building types much more similar in form and servicing, thereby reducing the number of generic types;
- increase use of buildings over time, thereby improving total occupancy.

Total systems thinking will become the norm so that the consequences of actions in one area can be understood in their effects on others [Reference 39]. A critical part of this process is the improvement in *feedback* and *monitoring* techniques across a wide range of disciplines, especially in complex, "cross-disciplinary" areas like buildings where the consequences of actions in one area have not been fully appreciated in their effects on others. For example, there is little evidence available on the costs and benefits (to investors, developers and occupants) of re-using historic buildings as opposed to new build.

Systems thinking and total cost accounting is also likely to lead to more emphasis on *life cycles*. This involves understanding inter-relationships between cycling processes and their inputs and outputs, such as for energy, hydrology, nutrients, minerals, ecology, and social and economic cycles. Buildings are complex, dynamic systems which play a (sometimes significant) part in many natural and artificial cycles and systems. With increasing emphasis on true costs and rapid-switching between different demand states, it becomes much more important to understand how different states of buildings intervene in different systems. For example, the building fabric is usually long-last-

Qualitative system dynamics

"… To create and examine feedback loop structure of systems using resource flows, represented by level and state variables, and information flows, represented by auxiliary variables."

"… To provide a qualitative assessment of the relationship between system processes (including delays), information, organisational boundaries and strategy."

"…To estimate system behaviour and to postulate strategic design changes to improve behaviour."

[Reference 39]

ing, and part of a long-term cultural cycle as well as the physical, economic and construction cycles which produced it. The building interior is altered much more frequently, and is part of another set of cycles, concerned with day-to-day use. Systems dynamics and life cycle thinking is likely to contribute to increased concern about the costs and value of the existing building stock.

The focus on minimising and avoiding waste will not only emphasise efficiency gains in processes, it will examine the value, costs and benefits of the existing building stock, and will consequently lead to more thought about redundant stock, obsolescence, demolitions and disposals. This is a much neglected area and is likely to be the locus of much activity in the near future.

Intensification and diversification have been a constant feature of settlement and city evolution. The near future will see a radical acceleration of I-D trends into their sub-optimal states brought about because of perceived crossovers and commonalities between systems based on cost, value and sustainability, all of which have previously been treated as separate or incompatible.

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